# Strategic Environmental Assessment of the Multi-Annual Energy Plan

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# 0. Non-technical summary of strategic environmental assessment

## 0.1. General presentation of the PPE

### 0.1.1. The Multi-Annual Energy Plan framework set by law

The Law on Energy Transition for Green Growth (LTECV)[1] sets the energy policy framework. It defines a framework that will enable France to fulfil its European and international commitments.

In this framework, the Multi-Annual Energy Plan (PPE) takes the form of a decree[2] that defines the government's priorities for changes to the energy system in mainland France over the successive five-year periods 2019-2023 and 2024-2028. The energy policy objectives that the PPE will implement are as follows:

- Ensure security of supply. This requirement refers to the need to guarantee that French consumers, whether individuals or companies, have the energy they need as and when they need it: electricity, supply of petrol stations with fuel, gas deliveries, etc.
- Improved energy efficiency and reductions in primary energy consumption [3], especially fossil fuels:
    - 40% reduction in GHGs between 1990 and 2030 and 75% reduction ("factor 4") between 1990 and 2050. The government has recently set the goal of achieving carbon neutrality by 2050;
    - 20% reduction in final energy consumption between 2012 and 2030 and 50% reduction between 2012 and 2050;
    - 30% reduction in primary energy consumption of fossil fuels between 2012 and 2030.
- Increase the share of renewable energy to 32% of gross final energy consumption[4] in 2030. Currently, the objective breaks down as follows:
    - ✓ 40% of electricity production;
    - ✓ 38% of final heat consumption;
    - ✓ 15 % of final fuel consumption;
    - ✓ 10 % of gas consumption;
- Reduce the share of nuclear energy in electricity generation to 50% by 2025.
- Develop networks, storage and management of energy demand in a balanced way.
- Safeguard consumer purchasing power and competitive corporate prices;
- Evaluate professional skills needs in the energy field.

### 0.1.2. The framework of the strategy for the development of clean mobility set by the law

The law introduces a number of mobility policies and objectives with the aim of limiting energy consumption, greenhouse gas emissions and atmospheric pollutant emissions from the transport sector. The State must define a strategy for the development of clean mobility (SDMP), annexed to the PPE. This strategy relates to the development of low emissions vehicles, improved energy efficiency of the vehicle fleet, modal shifts, the development of collaborative modes of transport, and increased vehicle fill rates.

The SDMP shall, in particular[5]:

- include an evaluation of the existing supply of clean mobility;

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1 Law No. 2015-992 dated 17 August 2015.

2 Article L141-1 of the energy code.

3 Primary energy is the "potential" energy contained in natural resources before any transformation. It is distinguished from final energy, which is the energy actually consumed and billed to users after taking account of losses during fuel processing, production and transportation.

4 This objective comes from Directive 2009/28/EC, the term "gross final consumption" designates the final energy consumption from all sources, including renewable sources.

5 Article 40 LTECV

- set targets for vehicle development and infrastructure deployment, intermodality and freight vehicle fill rates;
- define the priority territories and road networks for the development of clean mobility.

### 0.1.3. Coordination of the PPE with other plans and programs

The PPE must be consistent with the national low carbon strategy that provides guidance for achieving carbon neutrality by 2050. It is part of an existing public policy framework that it reinforces. The fields of action of these different plans and programs have interfaces with that of PPE:

- Some national strategy documents need to be taken into account in the development of the PPE in that they set objectives for energy policy, or because they provide information that is needed. These same documents may need to be revised following the adoption of the PPE so that they can also appear in the 3rd category;
- Some planning documents need to be considered in the project design stage that will result from PPE as they include recommendations for zoning or techniques used. Since the PPE does not develop projects directly, it cannot take account of these land use planning documents. The EES reiterates these issues;
- Some sectoral documents are based on the objectives of the PPE for developing a policy related to the energy sector. This coordination explains that the PPE does not develop certain aspects that are more specifically addressed in other documents. Sometimes the link is also the other way around when the PPE relies on information presented to it by these sectoral plans.

The table below explains the existing link with these documents.

| Link with PPE | Titled | Description |
|---|---|---|
| **Taken into account by the PPE** | Climate Plan | Updates / complements the LTECV climate goals that the PPE implements. |
| | National Low Carbon Strategy (SNBC) | Defines the roadmap for climate action and gives the carbon budgets that the PPE must respect (compatibility link) |
| | National Biomass Mobilisation Strategy (SNMB) | Communicates the amount of biomass available as part of the development of biomass use and organises its mobilisation |
| | National Climate Change Adaptation Plan (PNACC) | The PPE anticipates adaptation to climate change in the field of energy installations. |
| | National Atmospheric Pollutant Emissions Reduction Plan (PREPA) | The PPE measures for reducing the use of fossil fuels and the SDMP measures in favour of cleaner mobility are part of PREPA's air quality improvement objectives. |
| **Taken into account in project design** | National Guidelines for Green and Blue Belts (ONTVB) | Defines areas to be avoided in order to preserve ecological continuity. |
| | Action Plan for Marine Environment (PAMM) | Defines areas to be avoided in order to preserve marine biodiversity. |
| | Regional Scheme for Planning, Sustainable Development and Inter-Regional Equality (SRADDET) | Defines regional objectives for renewable energy |
| | Regional intermodality schemes | Coordinates sustainable mobility policies at regional level. |
| | Planning, Development and Urban Development Documents (PCAET, SCOT, PLU). | Provides guidelines for urban planning. |
| **Takes account of the PPE** | National Biomass Mobilisation Strategy (SNMB) | Takes account of the amount of biomass devoted to energy production in its calculation of the available stock. |
| | National Forest Wood Program (PNFB) | Takes account of the amount of biomass mobilised for energy consumption in its guidelines for forest maintenance. |
| | Resource Scheduling Plan (Resource Plan) | Must take account of the amount of resource mobilised in its calculation of available stocks. |
| | National Radioactive Waste And Materials Management Plan (PNGMDR) | Takes account of the evolution of the quantity of radioactive waste to be processed based on changes in the nuclear park. |
| | National Strategy for Energy Research (SNRE) | Defines the lines of energy research according to the priority guidelines of the PPE. |
| | Ten-year Electric Transport Network Development Scheme (SDDR) | Must take account of the objectives of the PPE in its network development projects. |
| | Buildings Energy Renewal Plan (PREB) | Based on the objectives of the PPE in terms of energy renewal. |
| | Employment and Skills Programming Plan (PPEC) | Defines the skills and employment development requirements in the territories and professional sectors, in respect of the ecological and energy transition. |

*Table 0-1: Strategic guidance documents related to the PPE*

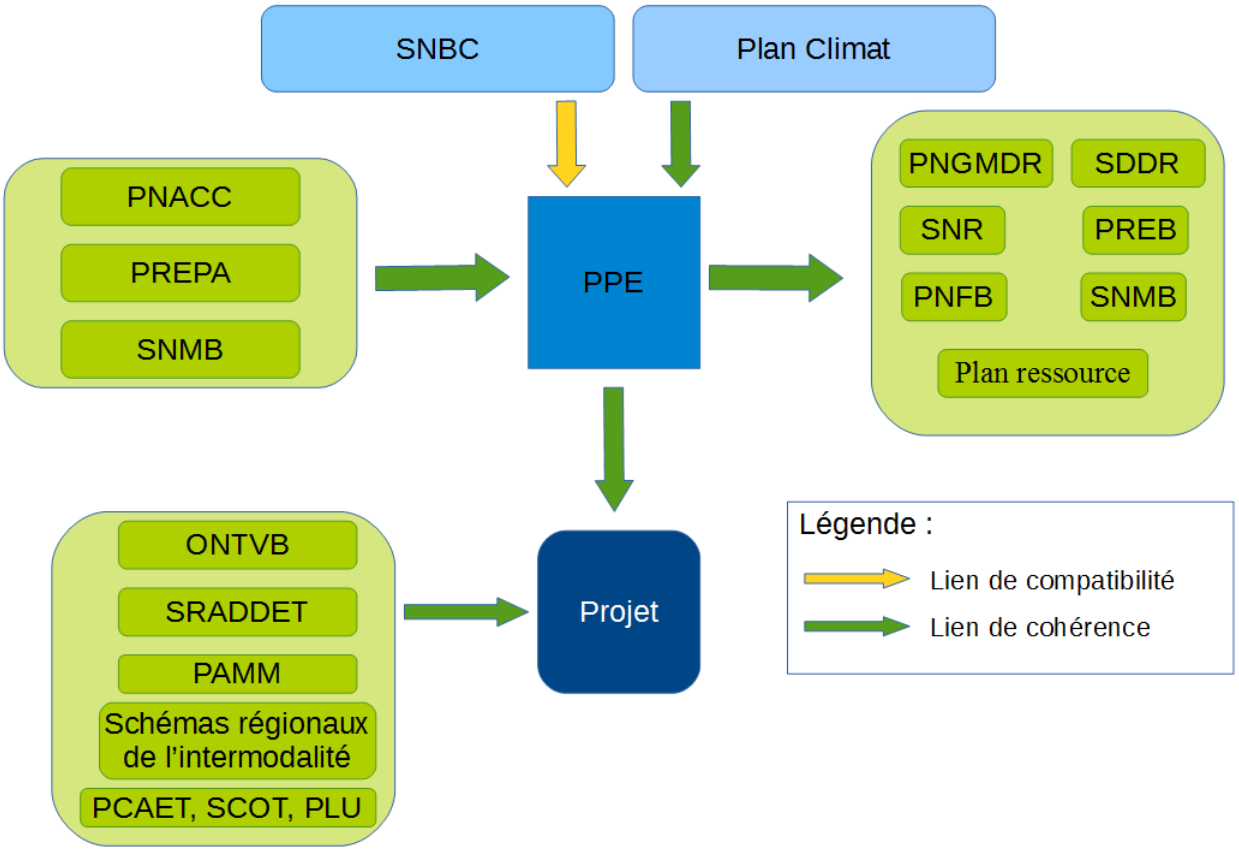


*Figure 0-1: Simplified model of the coordination of the PPE with other plans and programs (This model focuses on the PPE and the projects that flow from it)*

## 0.2. Environmental issues related to action of the PPE: likely significant effects

The objectives of the LTECV whose implementation is ensured by the PPE, commit France in the fight against climate change and for the preservation of the environment while ensuring the security of supply and viability of the mix. The PPE provides for reductions in energy consumption, as well as in the use of fossil fuels, and also plans to develop renewable energies. As a result, the PPE measures reduce greenhouse gas emissions and air pollutant emissions in the energy sector. To this end, the PPE is a plan for reducing the impacts of human activity on the environment.

The likely significant effects on the environment are viewed according to whether they are positive or negative, direct or indirect, temporary or permanent and short, medium or long term. These impacts are assessed in light of the expected impact of the sector based on the objectives that the PPE attributes to it. For the sake of simplicity, positive and negative character are symbolised here as follows:

| | |
|---|---|
|  | The expected evolution of the sector or the PPE projects will reduce the impact of human activity on the environmental issue under study |
|  | The anticipated evolution of the sector or the PPE projects will increase the impact of human activity on the environmental issue studied |

When the evolution of a sector should not have a significant impact on an environmental issue, it is not mentioned in the corresponding table.

### 0.2.1. The PPE issues

| | Probable significant effect | Effect type | Duration | Timescale |
|---|---|---|---|---|
| **Effect of the PPE on climate and energy** | | | | |
| Improvement in energy efficiency |  | Direct | Permanent | ST |
| Decrease in fossil energy consumption |  | Direct | Permanent | ST |
| Increase in renewable heat - Wood |  | Indirect | Permanent | ST |
| Increase in renewable heat - Heat Pumps |  | Indirect | Permanent | ST |
| Increase in renewable heat - Geothermal |  | Indirect | Permanent | ST |
| Increase in renewable heat - Thermal solar |  | Indirect | Permanent | ST |
| Increase in renewable heat - Waste recovery |  | Indirect | Permanent | ST |
| Increase in renewable liquid fuels - Biofuels |  | Indirect | Permanent | ST |
| Increase in renewable gas - Biogas |  | Indirect | Permanent | ST |
| Increase in renewable electricity - Hydropower |  | Indirect | Permanent | MT |
| Increase in renewable electricity - Terrestrial Wind Turbines |  | Indirect | Permanent | MT |
| Increase in renewable electricity - Photovoltaic |  | Indirect | Permanent | MT |
| Increase in renewable electricity - Offshore renewable energy (including offshore wind energy) |  | Indirect | Permanent | MT |
| Reduction in fossil fuel thermal facilities |  | Direct | Permanent | ST |
| Increase in electricity storage |  | Indirect | Permanent | MT |
| Increase in curtailment |  | Indirect | Permanent | MT |
| Increase in heating and cooling networks |  | Indirect | Permanent | MT |
| Evolution of electricity grids |  | Indirect | Permanent | MT |
| **Effect of the PPE on human health and disturbances** | | | | |
| Improvement in energy efficiency |  | Direct | Permanent | ST |
| Decrease in fossil energy consumption |  | Direct | Permanent | ST |
| Increase in renewable heat - Wood |  | Direct | Permanent | ST |
| Increase in renewable heat - Heat Pumps |  | Indirect | Permanent | ST |
| Increase in renewable heat - Thermal solar |  | Indirect | Permanent | ST |
| Increase in renewable heat - Waste recovery |  | Direct | Permanent | ST |
| Reduction in fossil fuel thermal facilities |  | Direct | Permanent | ST |
| Increase in electricity storage |  | Indirect | Permanent | MT |
| Increase in curtailment |  | Indirect | Permanent | MT |
| Increase in heating and cooling networks |  | Indirect | Permanent | MT |
| Evolution of electricity grids |  | Indirect | Permanent | MT |

| | Probable significant effect | Effect type | Duration | Timescale |
|---|---|---|---|---|
| **Effect of the PPE on water resources and aquatic environments / biodiversity and natural habitats / soils and subsoils / landscape and heritage** | | | | |
| Improvement in energy efficiency |  | Indirect | Permanent | MT |
| Decrease in fossil energy consumption |  | Direct | Permanent | MT |
| Increase in renewable heat - Wood |  | Direct | Permanent | MT |
| Increase in renewable heat - Thermal solar |  | Indirect | Permanent | LT |
| Increase in renewable heat - Waste recovery |  | Direct | Permanent | ST |
| Increase in renewable electricity - Terrestrial Wind Turbines |  | Direct | Permanent | ST |
| Increase in renewable electricity - Photovoltaic |  | Direct | Permanent | MT |
| Increase in renewable electricity - Offshore renewable energy (including offshore wind energy) |  | Direct | Permanent | ST |
| Reduction in nuclear |  | Direct | Permanent | ST |
| Reduction in fossil fuel thermal facilities |  | Direct | Permanent | ST |
| Increase in electricity storage |  | Indirect | Permanent | MT |
| Increase in curtailment |  | Indirect | Permanent | MT |
| **Effect of PPE on exhaustible resources (excluding fossil energy) and waste** | | | | |
| Improvement in energy efficiency |  | Direct | Temporary | LT |
| Increase in renewable heat – Wood |  | Direct | Permanent | MT |
| Increase in renewable heat - Waste recovery |  | Indirect | Permanent | ST |
| Increase in renewable liquid fuels - Biofuels |  | Indirect | Permanent | ST |
| Increase in renewable gas - Biogas |  | Direct | Permanent | ST |
| Increase in renewable electricity - Wind Turbines |  | Direct | Permanent | LT |
| Increase in renewable electricity - Photovoltaic |  | Direct | Permanent | LT |
| Reduction in nuclear |  | Direct | Permanent | LT |
| Increase in electricity storage |  | Direct | Permanent | LT |
| Increase in curtailment |  | Indirect | Permanent | MT |
| **Effect of the PPE on natural and technological risks** | | | | |
| Decrease in fossil energy consumption |  | Direct | Permanent | MT |
| Increase in renewable heat - Heat Pumps |  | Indirect | Permanent | MT |
| Increase in renewable heat - Thermal solar |  | Indirect | Permanent | MT |
| Increase in renewable electricity - Terrestrial Wind Turbines |  | Indirect | Permanent | MT |
| Increase in renewable electricity - Photovoltaic |  | Indirect | Permanent | MT |

| | Probable significant effect | Effect type | Duration | Timescale |
|---|---|---|---|---|
| Increase in renewable electricity - Offshore renewable energy (including offshore wind energy) | | Indirect | Permanent | MT |
| Reduction in nuclear | | Direct | Permanent | MT |
| Reduction in fossil fuel thermal facilities | | Direct | Permanent | MT |
| Increase in electricity storage | | Indirect | Permanent | MT |
| Increase in curtailment | | Indirect | Permanent | MT |

## 0.2.2. The SDMP issues

| | Probable significant effect | Type of effect | Duration | Timescale |
|---|---|---|---|---|
| **Effect of the SDMP on climate and energy** | | | | |
| Management of the growth of mobility demand | | Indirect | Permanent | MT |
| Development of low-emissions vehicles | | Direct | Permanent | MT |
| Deployment of alternative fuel distribution infrastructures | | Indirect | Permanent | MT |
| Development of supply of multi-modal mobility and enhancement of active modes | | Indirect | Permanent | MT |
| Development of collective, shared and collaborative modes of transportation | | Indirect | Permanent | MT |
| Development of bulk modes for freight | | Direct | Permanent | MT |
| Increase in freight vehicle filling rates | | Direct | Permanent | ST |
| Making clean mobility accessible to sparsely populated areas and unleashing innovation | | Indirect | Permanent | MT |
| **Effect of the SDMT on human health and disturbances** | | | | |
| Management of the growth of mobility demand | | Indirect | Permanent | MT |
| Development of low-emissions vehicles | | Direct | Permanent | MT |
| Deployment of alternative fuel distribution infrastructures | | Direct | Permanent | MT |
| Development of supply of multi-modal mobility and enhancement of active modes | | Direct | Permanent | MT |
| Development of collective, shared and collaborative modes of transportation | | Direct | Permanent | MT |
| Development of bulk modes for freight | | Direct | Permanent | MT |
| Increase in freight vehicle filling rates | | Direct | Permanent | ST |
| Making clean mobility accessible to sparsely populated areas and unleashing innovation | | Direct | Permanent | MT |

| | Probable significant effect | Type of effect | Duration | Timescale |
|---|---|---|---|---|
| **Effect of the SDMP on water resources and aquatic environments / biodiversity and natural habitats / soils and subsoils / landscapes and heritage** | | | | |
| Management of the growth of mobility demand |  | Indirect | Permanent | MT |
| Development of low-emissions vehicles |  | Indirect | Permanent | MT |
| Deployment of alternative fuel distribution infrastructures |  | Direct | Permanent | MT |
| Development of supply of multi-modal mobility and enhancement of active modes |  | Indirect | Permanent | MT |
| Development of bulk modes for freight |  | Indirect | Permanent | MT |
| Increase in freight vehicle filling rates |  | Direct | Permanent | ST |
| **Effect of SDMP on exhaustible resources (excluding fossil energy) and waste** | | | | |
| Management of the growth of mobility demand |  | Indirect | Permanent | MT |
| Development of low-emissions vehicles |  | Direct | Permanent | MT |
| Deployment of alternative fuel distribution infrastructures |  | Direct | Permanent | MT |
| Development of collective, shared and collaborative modes of transportation |  | Indirect | Permanent | LT |
| Increase in freight vehicle filling rates |  | Direct | Permanent | MT |
| **Effect of the SDMP on natural and technological risks** | | | | |
| Management of the growth of mobility demand |  | Indirect | Permanent | MT |
| Development of low-emissions vehicles |  | Indirect | Permanent | MT |
| Development of bulk modes for freight |  | Direct | Permanent | MT |
| Increase in freight vehicle filling rates |  | Direct | Permanent | ST |

## 0.2.3. Summary of PPE and SDMP environmental issues

### A plan for reducing environmental impacts

The objectives that the law on energy transition for green growth assigned to the Multi-Annual Energy Plan and the Clean Mobility Development Strategy form a plan for reducing environmental impacts. By 2028, measures to control the energy demand, particularly fossil energy, and the diversification of the energy mix, in particular to organise the penetration of renewable energies, have positive impacts on:

- the decrease in energy consumption: -347TWh;
- the decrease in the energy consumption of fossil fuels, which are exhaustible resources: -267TWh;
- the decrease of the impact of the energy sector on the greenhouse effect: -59Mte $CO_2$;
- the decrease in air pollutant emissions related to energy consumption.

To move towards carbon neutrality, the PPE also increases the use of biomass resources. The significant orientation of this PPE is towards better use of biomass waste which should reduce the environmental impacts of these wastes when managing their end of life and enable them to be used instead of fossil fuels, particularly biogas and biofuels.

### Vigilance required on certain issues

The penetration of renewable energies, especially electricity, electricity storage, electric mobility, the use of new technologies in the management of networks, should increase the consumption of mineral resources and rare metals. Recycling channels are being set up and need to be supported. This subject should be monitored over time, particularly through the implementation and monitoring of the Circular Economy Roadmap.

The increase in the use of forest biomass for energy purposes must be part of rational forestry management in accordance with the National Forest Wood Program and with optimisation of the use of forestry products among the various possible uses.

Decentralised energy production takes up more space than centralised power generation. Incentives for priority deployment of projects on degraded areas (brownfields, etc.) must be maintained and the overall development of land use must be monitored so that it does not occur at the expense of agricultural land.

#### The environmental issues which must be monitored in the projects to be implemented in application of the PPE

The PPE is not territorially based. It is the SRADDETs that deal with land use planning issues. In order for the projects resulting from the PPE, especially in decentralised renewable energies, to be accepted by the populations, they must be incorporated into territorial projects.

Beyond land use issues, the projects may address issues relating to land or marine biodiversity or the creation of disturbances for residents. French regulations include numerous provisions for the control and monitoring of environmental pressures that the projects generate so that they meet socially acceptable thresholds in terms of their impact. It is imperative that these regulations be rigorously implemented.

## 0.3. Explanation of reasons for the decision

### 0.3.1. Ambitious demand management objectives

Demand management means that GHG emissions from energy production and consumption can be avoided. France aims to reduce its energy consumption by 20% between 2012 and 2030.

In order to define sufficiently ambitious objectives for demand management, the potential growth margin of each sector has been analysed, based on macro-economic assumptions.[6] These measures nonetheless serve as a basis for discussion on the defining of an ambitious, but achievable, scenario, given the observed behavioural dynamics, the abilities of our economic actors to implement actions, and costs. The PPE takes account of these elements and reduces energy demand by 17% between 2012 and 2030. The PPE update in 2023 may be an opportunity to accentuate this trajectory in order to reach the 20% target by taking account of the evolution of technologies and practices.

One of the main sources of GHG emissions is the burning of fossil fuels. France has a target of a 30% reduction in primary energy consumption of fossil fuels between 2012 and 2030.

To achieve the fastest possible reduction in emissions from fossil fuel facilities, it was decided to prioritise the shut-down of power plants, based on the quantity of discharges. Thus, coal-fired power plants will be the first to be closed because they are the sources of most GHG emissions. Additional actions have been taken to enable this abandon of coal to assist individuals still using coal as well as businesses, while ensuring their competitiveness. The reduction in coal consumption will have a significant positive impact on both greenhouse gas emissions and air pollution.

The goal is then to reduce the use of oil, mainly consumed in transport sector. This includes for instance the replacement of diesel and petrol with low carbon fuels.

There is no specific measure for reducing gas consumption because it is the least carbon-intensive fossil energy. This should result from demand management actions not targeting a specific energy vector, in particular the renovation of buildings. In addition, carbonaceous natural gas will have to be replaced by biogas with its neutral carbon footprint.

6 These assumptions include demographic projections and economic growth assumptions provided by INSEE, as well as energy efficiency assumptions provided by the DGEC.

Reduction efforts are therefore distributed so as to enable the fastest possible reduction in the amount of greenhouse gas emissions. The PPE aims at a more ambitious objective of 40% reduction of fossil energy consumption between 2012 and 2030.

## 0.3.2. Mix diversification objectives taking account of deposits, costs, acceptability and integration into the system

In order to limit the cost of the energy transition, emphasis is on the development of the most profitable energies (wind and ground-level PV). However, it has been decided to develop all sectors in order to diversify energy sources and to remain open to the possibility of progress in other sectors.

In addition to the costs associated with construction and operation of energy production facilities, it is necessary to take account of the indirect costs related to the impact of different technologies on the network.

Intermittent energy based facilities, such as solar energy, whose activity varies with the number of daylight hours, and wind turbines, which depend on wind regimes, do not guarantee continuous production of electricity .In order to cope with peak consumption and ensure security of supply, controllable facilities such as hydropower stations with tailings dams, play an important role in the renewable electricity mix.

The development of the use of biomass, energy recovery from waste and renewable gas (power to gas or biogas) makes it possible to increase the share of renewable energy that can be easily stored. The choice to diversify energy sources makes it possible to reinforce the resilience of the energy system in the event of a generic failure of a type of facility.

| | Issue | | | | Deposits still to be developed |
|---|---|---|---|---|---|
| | **financial**[7] | **environmental** | **Feasibility** | **integration into the electrical system** | |
| **Hydroelectricity** | 30 → 130 €/MWh | Preservation of ecological continuities | Mature technology | controllable energy | limited |
| **Terrestrial Wind Turbines** | 50 → 80 €/MWh | Landscape and biodiversity impact | Limited acceptability | Variable energy production | non-limiting in the medium term |
| **Photovoltaics** | 45 → 75 €/MWh (ground)<br>75 → 120 € MWh (roof) | Impact on land use | Good acceptability | Variable energy production | non-limiting in the medium term |
| **Biomass** | Variable costs depending on the sector (waste, wood energy, biogas) | Resource management requiring prioritisation of biomass uses) | Medium feasibility constraints | controllable energy | Limited in the medium term |
| **Geothermal electricity** | 170 → 340 €/MWh | Impacts related to drilling | Difficult prospecting of deposits | controllable energy | limited |
| **Offshore wind energy** | 70→ 150 €/MWh | Impacts on marine environments | Acceptability constraint | Variable energy production | Non-limiting |

*Table 0-2: Summary representation of environmental, economic and technical considerations that led to the choice of the renewable electricity mix of the PPE*

7 Ademe, Cost of renewable energies, 2016 updated by DGEC knowledge.

| | Issue | | | Deposits still to be developed |
|---|---|---|---|---|
| | financial[8] | environmental | Feasibility | |
| **Solid biomass** | 45 → 110 €/MWh (individual)<br>62 →125€/Mwh (collective)<br>45 → 80 € / MWh (industrial) | Constraints on prioritizing uses of biomass and environmental quality of forest management | Limited development in urban areas due to air pollution issues | non-limiting in the medium term |
| **Heat pumps** | 105 → 170 €/MWh (individual)<br>50 → 130 € / MWh (collective) | Small environmental impact (linked to the electricity mix) | Strong | non-limiting |
| **Deep geothermal energy** | 65 → 120 €/MWh | Difficult prospecting of deposits | Good integration into heat networks | non-limiting in the medium term |
| **Biogas** | 96 → 167 €/MWh | Constraints on prioritizing uses) | Strong demand from the agricultural world | non-limiting in the medium term |
| **Thermal solar** | 155 → 451€/MWh (individual)<br>46 → 260 €/MWh (collective) | No environmental impact | Competition from heat pumps and PV (uses of the roofs) | non-limiting in the medium term |

*Table 0-3: Summary representation of environmental, economic and technical considerations that led to the choice of the development objectives of the renewable and recovered heat sectors of the PPE*

Key: Strong constraint | Medium constraint | Weak constraint

NB: Costs are shown within a range that takes account of the different technologies available. Significant reductions are expected especially in offshore wind energy, PV and thermal solar.

## 0.4. Monitoring of PPE environmental issues

Monitoring indicators of the evolution of pressures on environments will be used to monitor the impact of the PPE on the environment over time. The objective is to identify indicators using existing and easily usable data in order to enable regular and effective monitoring. A restricted number of representative indicators of trends was preferred to a much higher number which would be difficult to group and equally difficult to interpret. Although not exhaustive, the main point of these indicators are the alerts that they will give about evolutionary trends, so that a response can be provided in the event of increased pressure on environments.

As the main environmental issues of energy policy have increased pressures on resources and land use, indicators have been identified to monitor the evolution of these impacts:

- The monitoring of space consumption related to PV and wind turbines enables assessments of the impact of the development of decentralised energy production facilities on land use.
- Monitoring the evolution of GHG and air pollutant emissions is used to verify the positive nature of the impact of the PPE and the SDMP on climate and air pollution.
- The monitoring of the main risks using the ARIA database is only used to track accidents / incidents that contribute to using feedback as a tool for risk prevention and reduction. This database is used to track trends in the risks associated with energy production facilities.
- For the impact on biodiversity and natural habitats, the indicator of pressure on wood resources chosen is the rate of wood used for energy compared to forest renewal rates.
- It is not currently possible to monitor the amount of resources used to set up renewable energy facilities. The indicator to monitor issues of resource availability would be the recycling rate of the industries and the reuse rate of electric vehicles batteries at the end of lifetime for other purposes.

# 1. General presentation of the Multi-Annual Energy Plan and of the strategic environmental evaluation

8 Ademe, Cost of renewable energies, 2016 actualised by DGEC knowledge.

## 1.1. Objectives and content of the Multi-Annual Energy Plan and of the strategy for the development of clean mobility

### 1.1.1. The Multi-Annual Energy Plan framework set by law

The Law on Energy Transition for Green Growth (LTECV)[9] sets the energy policy framework. It defines a framework that will enable France to fulfil its European and international commitments.

In this framework, the Multi-Annual Energy Plan (PPE) takes the form of a decree[10] that defines the government's priorities for changes to the energy system in mainland France over the successive five-year periods 2019-2023 and 2024-2028. It seeks to reconcile the different energy policy issues and sets priorities for action by the public authorities to meet the objectives related to France's climate, security of supply and economic competitiveness.

The energy policy objectives that the PPE will implement are set out in article L.141-2 of the Energy Code:

- Ensure security of supply. This requirement refers to the need to guarantee that French consumers, whether individuals or companies, have the energy they need as and when they need it: electricity, supply of petrol stations with fuel, gas deliveries, etc.
- Improved energy efficiency and reductions in primary energy consumption[11], especially fossil fuels: The PPE shall contribute to the quantified objectives set by the LTECV (article L100-4 Energy Code):
  - 40% reduction in GHGs between 1990 and 2030 and 75% reduction ("factor 4") between 1990 and 2050. The government has recently set the goal of achieving carbon neutrality by 2050;
  - 20% reduction in final energy consumption between 2012 and 2030 and 50% reduction between 2012 and 2050;
  - 30% reduction in primary energy consumption of fossil fuels between 2012 and 2030.
- Development of the use of renewable and recovered energies. The PPE shall contribute to the quantified objectives set by the LTECV (article L100-4 Energy Code):
  - Increase the share of renewable energy to 23 % of gross final energy consumption[12] in 2020 and 32% in 2030. Currently, the objective breaks down as follows:
    - ✓ 40% of electricity production;
    - ✓ 38% of final heat consumption;
    - ✓ 15 % of final fuel consumption;
    - ✓ 10 % of gas consumption;
  - Reduction in the share of nuclear energy in electricity generation to 50% by 2025.
- Develop networks, storage and management of energy demand in a balanced way.
- Safeguard consumer purchasing power and competitive corporate prices;
- Evaluate professional skills needs in the energy field.

### 1.1.2. The framework of the strategy for the development of clean mobility set by the law

Part III of the LTECV "Developing clean transport to improve air quality and protect health" introduces a number of guidelines and objectives relating to mobility, with the aim of limiting energy consumption in the transport sector. Article 40 of the law provides for: "The State to define a strategy for the development of clean mobility (SDMP)". The article also specifies that the SDMP is annexed to the PPE, and that it relates to the

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9 Law No. 2015-992 dated 17 August 2015.

10 Article L141-1 of the energy code.

11 Primary energy is the "potential" energy contained in natural resources before any transformation. It is distinguished from final energy, which is the energy actually consumed and billed to users after taking account of losses during fuel processing, production and transportation.

12 This objective comes from Directive 2009/28/EC, the term "gross final consumption" designates the final energy consumption from all sources, including renewable sources.

development of low emissions vehicles, the improvement of the energy efficiency of the vehicle fleet, modal shifts, the development of collaborative modes of transport, and increased vehicle fill rates.

The SDMP shall, in particular[13]:

- include an evaluation of the existing supply of clean mobility;
- set targets for vehicle development and infrastructure deployment, intermodality and freight vehicle fill rates;
- define the priority territories and road networks for the development of clean mobility.

The actions listed in the SDMP will improve energy efficiency in the transport sector, while developing the use of renewable energies, in order to reduce greenhouse gas emissions and transport-related air pollutant emissions.

## 1.2. Coordination of the PPE with other plans and programs

Article L141-1 implementing the PPE provides that it must be compatible with the National Low Carbon Strategy and carbon budgets. This legal association means that the PPE cannot take measures that are directly contrary to SNBC's guidelines, and more broadly, its effect must be to strengthen its action.

In addition to this legal association, the PPE is part of an existing public policy framework that it reinforces. The fields of action of these different plans and programs have interfaces with that of PPE: Although not bound by a legal association, it is useful, in order to guarantee the effectiveness of public action, to verify the consistency of the PPE with the different planning exercises.

- Some national strategy documents need to be taken into account in the development of the PPE in that they set objectives for energy policy, or because they provide information that is needed. These same documents may need to be revised following the adoption of the PPE so that they can also appear in the 3e category;
- Some planning documents need to be considered in the project design stage that will result from PPE as they include recommendations for zoning or techniques used. Since the PPE does not develop projects directly, it cannot take account of these land use planning documents. The EES reiterates these issues:
- Some sectoral documents are based on the objectives of the PPE for developing a policy related to the energy sector. This coordination explains that the PPE does not develop certain aspects that are more specifically addressed in other documents. Sometimes the link is also the other way when the PPE relies on information presented to it by these sectoral plans.

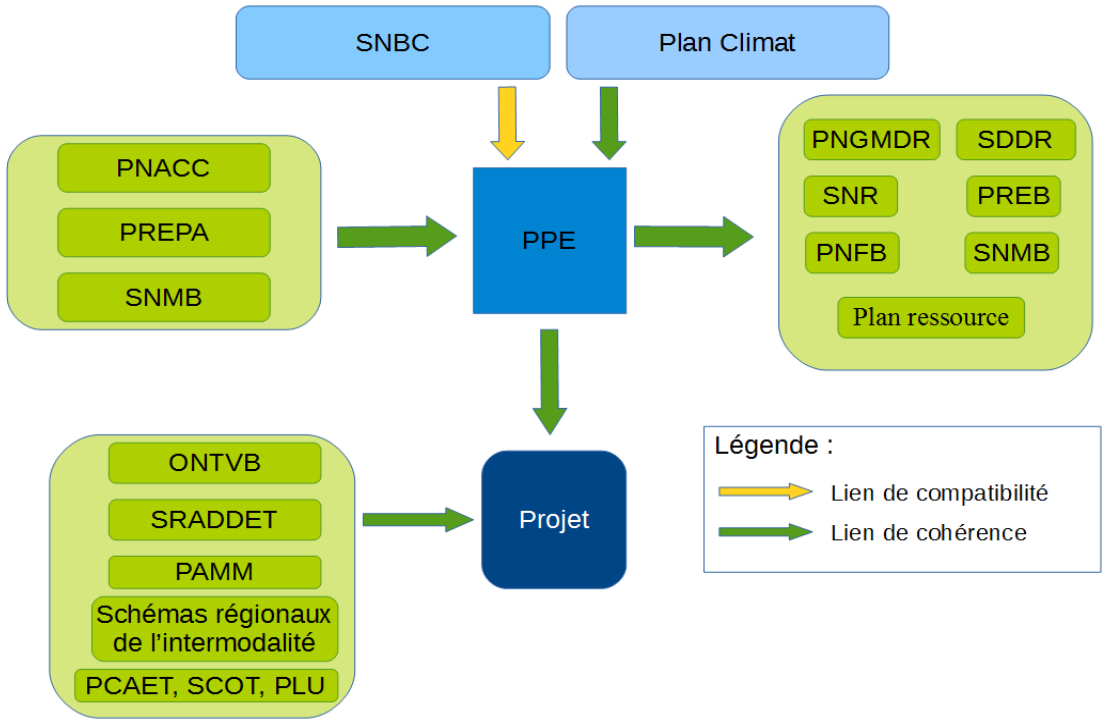
| Link with PPE | Titled | Description |
|---|---|---|
| **Taken into account by the PPE** | Climate Plan | Updates / complements the LTECV climate goals that the PPE implements. |
| | National Low Carbon Strategy (SNBC) | Defines the roadmap for climate action and gives the carbon budgets that the PPE must respect (compatibility link) |
| | National Biomass Mobilisation Strategy (SNMB) | Communicates the amount of biomass available as part of the development of biomass use and organises its mobilisation |
| | National Climate Change Adaptation Plan (PNACC) | The PPE anticipates adaptation to climate change in the field of energy installations. |
| | National Atmospheric Pollutant Emissions Reduction Plan (PREPA) | The PPE measures for reducing the use of fossil fuels and the SDMP measures in favour of cleaner mobility are part of PREPA's air quality improvement objectives. |
| | National Guidelines for Green and Blue Belts (ONTVB) | Defines areas to be avoided in order to preserve ecological continuity. |

13 Article 40 LTECV

| | | |
|---|---|---|
| **Taken into account in project design** | Action Plan for Marine Environment (PAMM) | Defines areas to be avoided in order to preserve marine biodiversity. |
| | Regional Model for Organisation, Sustainable Development and Inter-Regional Equality (SRADDET) | Defines regional objectives for renewable energy |
| | Regional intermodality models | Coordinates sustainable mobility policies at regional level. |
| | Planning, Development and Urban Development Documents (PCAET, SCOT, PLU). | Provides guidelines for urban planning. |
| **Takes account of the PPE** | National Biomass Mobilisation Strategy (SNMB) | Takes account of the amount of biomass devoted to energy production in its calculation of the available stock. |
| | National Forest Wood Program (PNFB) | Takes account of the amount of biomass mobilised for energy consumption in its guidelines for forest maintenance. |
| | Resource Scheduling Plan (Resource Plan) | Must take account of the amount of resource mobilised in its calculation of available stocks. |
| | National Radioactive Waste And Materials Management Plan (PNGMDR) | Takes account of the evolution of the quantity of radioactive waste to be processed based on changes in the nuclear park. |
| | National Strategy for Energy Research (SNRE) | Defines the lines of energy research according to the priority guidelines of the PPE. |
| | Ten-year Electric Transport Network Development Scheme (SDDR) | Must take account of the objectives of the PPE in its network development projects. |
| | Buildings Energy Renewal Plan (PREB) | Based on the objectives of the PPE in terms of energy renewal. |
| | Employment and Skills Programming Plan (PPEC) | Defines the skills and employment development requirements in the territories and professional sectors, in respect of the ecological and energy transition. |

*Table 1: Strategic guidance documents related to the PPE*

Figure 1:




Simplified model of the coordination of the PPE with other plans and programs (This model focuses on the PPE and the projects that flow from it)

## 1.2.1. National plans and programs which the PPE takes into account

The PPE is legally bound only by its associated compatibility with the SNBC. The associations made as part of this evaluation contribute to making the PPE conform with the public policy framework in which it operates.

### Climate Plan

The Climate Plan adopted by the government on 6 July 2017 sets out the measures to be taken to accelerate the implementation of the Paris Agreement, in particular by setting the objective of achieving carbon neutrality by 2050. The SNBC scenarios that guide the dynamics of the PPE include this objective.

In terms of the PPE, this plan aims, among other things, to reduce France's dependence on fossil fuels by shutting down coal-fired power plants by 2022 and by banning the issuance of new hydrocarbon operating permits. At the same time, the Climate Plan provides for the acceleration of the deployment of renewable energies as well as research in the field of energy transition.

Regarding the SDMP, this plan provides for the creation of a sustainable mobility fund and for the introduction of tax measures favourable to alternative fuels.

### National Low Carbon Strategy (SNBC)

Also created by the LTECV[14], the SNBC defines the procedures to be followed to reduce French greenhouse gas (GHG) emissions. It targets carbon neutrality by 2050 in accordance with the Climate Plan

In France, the energy sector accounts for 70% of greenhouse gas emissions. For this reason, the legislator requires that the PPE be legally compatible with the SNBC[15], meaning that it cannot take any direction that contradicts it. The State has devised a prospective energy outlook scenario common to the PPE and the SNBC. Both documents are revised simultaneously every 5 years. The measures taken by the PPE are operational at 10 years. The scenario runs until 2050, when the SNBC makes recommendations. The PPE complies with the carbon budgets.

Both policies therefore work to control demand and decarbonise energy production. The PPE specifies the operational measures to achieve these objectives:

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14 Article 173 LTECV.

15 Art L141-1 Energy: The PPE "is compatible with the greenhouse gas emissions reduction targets set in the carbon budget mentioned in Article L. 222-1 A of the Environment Code, and with the low-carbon strategy mentioned in Article L. 222-1 B of the same code."

- Reduce energy consumption, in particular by improving energy efficiency;
- Decrease fossil energy consumption;
- Develop renewable energies and avoid investments in new thermal means, the development of which would be inconsistent with the medium-term GHG emissions reduction objectives;
- Improve the flexibility of the system to increase the share of renewable energies.

Within the energy sector, the transport sector represents 40% of GHG emissions. The Clean Mobility Development Strategy (SDMP), devised in conjunction with the PPE, also complies with the carbon budgets set by SNBC. In general, the SDMP recalls and specifies the five levers identified by SNBC for the reduction of the climate impact of the transport sector.

### National Biomass Mobilisation Strategy (SNMB)

The PPE component dedicated to the production of renewable energy through biomass is associated in particular with the National Biomass Mobilisation Strategy (SNMB) created by LTECV in 2015[16].

The SNMB aims to present the compatibility between biomass supply and demand in order to ensure the sustainability of the available stock. Adopted in March 2018, it provides for the distribution of biomass according to different uses (energy, construction, agriculture). The PPE takes account of the maximum amount of available biomass indicated by the SNMB. In return, the SNMB will adapt to the biomass demand defined in the PPE during its revision, a maximum of one year after the revision of the PPE (articles D211-1 and D211-2 of the Energy Code).

This strategy is subject to environmental assessment (Art R122-17 8°bis).

### National Climate Change Adaptation Plan (PNACC)

The climate in the national territory will change over the next century[17]. The National Climate Change Adaptation Plan (PNACC) aims to anticipate the effects of climate change on the economy and society, and to prepare the national territory as much as possible to support them by 2050 and 2100[18]. It is revised every 5 years. The PNACC2 will be adopted by the end of 2018.

The PNACC addresses the challenges that climate change will raise for energy and transport infrastructures but does not specify the necessary forms of response. There is no legal association between the two documents, but the ability to plan for the future of the PPE is linked to consideration of predictable climate changes that form the basis of the PNACC. These changes may indeed have a significant impact, particularly on energy production infrastructures.

### National Atmospheric Pollutant Emissions Reduction Plan (PREPA)

The PREPA in its current form is a document provided by LTECV[19], put in place in 2017 and revised every 5 years. It sets air pollutant emissions reduction targets for 2020, 2025 and 2030 for industry, transportation, residential-tertiary and agriculture.

The PPE, by organizing the reduction of the share of fossil fuels in the energy mix and by promoting the development of renewable energies, contributes to the reduction of emissions of atmospheric pollutants[20]. Particular attention must however be paid to the development of biomass from the point of view of atmospheric emissions.

The SDMP component of the PPE, which encourages active mobility and shared transport, as well as the use of less polluting vehicles, contributes to the fulfilment of the PREPA's emission reduction measures.

## 1.2.2. Plans and programs which are taken into account by projects undertaken in application of the PPE

16 Article 175 LTECV.
17 Reference is made here to the fifth IPCC report, dated November 2014.
18 This plan was put in place by Article 42 of the Grenelle1 law of 3 August 2009
19 Article 64 LTECV
20 Article L100-4 6: "the national energy policy aims to contribute to meeting the air pollution reduction objectives provided by the PREPA."

These localised plans generally provide for zoning that is taken into account in the location of infrastructure projects.

### National Guidelines for Green and Blue Belts (ONTVB)

The objective of the ONTVBs is to preserve ecological continuity of terrestrial and aquatic environments by limiting construction of structures likely to segment natural areas. These guidelines were adopted in 2014. The green belt includes protected areas as well as the ecological corridors connecting them. The blue belt covers rivers and some wetlands.

These continuities will be impacted in particular by hydroelectric projects (blue belts) and wind and photovoltaic projects (green belts). They are taken into account in project design during the impact study.

These guidelines are subject to environmental assessment (Art R122-17 14°).

### Marine Environment Action Plans (PAMM) and Seaboard Strategic Documents (DSF)

The PAMM is the environmental component of the Seaboard Strategic Documents provided for by the National Strategy for the Sea and the Coast. The PAMMs audit the environmental issues on the four seaboards (Eastern Channel - North Sea; North Atlantic - Western Channel; South Atlantic; Mediterranean).

The marine renewable energy development projects planned by the PPE must comply with the DSF and the zonings defined in the PAMM in order to limit the impact that the presence of the energy production infrastructure has on biodiversity.

### Regional Model for Organisation, Sustainable Development and Inter-Regional Equality (SRADDET)

The SRADDETs provided for by the NOTRe law of 7 August 2015 are intended to bring together different regional schemes to ensure consistency. They are subject to environmental assessment (Art R122-17 38):

- *Regional Climate Air Energy Plan (SRCAE)*

These plans set out broad guidelines for mitigating climate change and improving air quality. They break down development objectives for renewable energies at local level by taking account of specific issues in their respective areas.

These plans were subject to environmental assessment (Art R122-17 §1 9).

- *Regional Ecological Coherence Scheme (SRCE)*

These schemes guaranteed that the territory's environmental characteristics were taken into account. They managed local usage conflicts that could be associated with the development of power generation, networks and storage infrastructures. These schemes determined the zoning for management of the implementation of projects provided for by the PPE and were therefore taken into account as part of the dedicated impact study.

They took account of the national guidelines for the preservation of green and blue belts, as well as the Water Development and Management Master Plan (SDAGE).

These plans were subject to environmental assessment (Art R122-17 §1 15).

- *Regional Intermodality Scheme (SRI)*

*These schemes presented the objectives of the SDMP in respect of the development of intermodalities.*

- *Regional Waste Prevention and Management Plan (PRPGD)*

The PRPGD was used as a global planning tool for the prevention and management of all waste produced in the territory, whether by households or by economic activities. Its role was to put in place the conditions for achieving the national objectives of reducing waste at source as a priority, with improved waste sorting and recovery rates as a secondary goal.

The purpose of these schemes is to develop the regional territory in line with the main national political objectives, including those of the PPE. They set the objectives and the locations of renewable energy projects.

## 1.2.3. Plans and programs that take account of the PPE

### National Biomass Mobilisation Strategy (SNMB)

As specified above, the SNMB takes account of the wood energy demand set out in the PPE in its biomass mobilisation objectives.

### National Forest Wood Program (PNFB)

The PNFB was put in place by the laws of 13 October, 2014, for agriculture, food and forestry and is subject to environmental assessment (Art R122-17 25 and 26 for its regional breakdowns). Adopted in 2017, it will be revised by 2026.

The purpose of the PNFB is to oversee forestry operations in France in order to ensure sustainable management of the resource. It assesses all the impacts in terms of biodiversity involved in the use of stocks of wood-energy resources and provides measures to reduce its impact. Although it is not legally associated to the PPE, its annexes (Appendix 4b) anticipate increased mobilisation of the resource in connection with the guidelines of the energy policy.

### Resource Scheduling Plan

The Resource Scheduling Plan devised in 2017 as part of the National Strategy for Transition to the Circular Economy (SNTEC)[21] updated every 5 years, assesses issues related to non-food biomass, soils and non-energy mineral resources. Its objective is to anticipate potential tensions over resources, particularly in the context of energy transition.

Its first version does not detail the resource stocks, but it would be desirable, in the long term, to include the objectives of the PPE in the evaluation of needs.

### National Radioactive Waste and Materials Management Plan (PNGMDR)

Established by the law of 28 June 2006, the PNGMDR addresses the management of radioactive materials and waste. It sets requirements for the improvement of existing solutions and the development of new management methods. Updated every three years, it is a priority tool for ensuring sustainable management of radioactive materials and waste.

Its main purpose is to draw up a regular review of the management policy for these radioactive substances, to evaluate new needs and to establish the objectives to be achieved in the future, particularly in terms of studies and research. The PNGMDR must therefore take account of the guidelines of the PPE on the evolution of the share of nuclear power in the national electricity mix to assess the needs of the sector in terms of management capacity and treatment of radioactive waste.

This plan is subject to environmental assessment (Art R122-17 21).

### National Strategy for Energy Research (SNRE)

SNRE sets the main guidelines and priority areas for research in France, in order to meet scientific, technological, environmental and societal challenges identified as important priorities[22]. This strategy, adopted in December 2016, is reviewed every 5 years. Challenge No. 2 of the current SNR relates to energy (Challenge No. 2) and is developed as part of the National Energy Research Strategy. Challenge No. 6 is about sustainable transport and urban systems.

The national research strategy must take account of the guidelines of the energy and climate policy defined by the national low-carbon strategy and the Multi-Annual Energy Plan (Article L144-1 of the Energy Code). The guidelines of the PPE and the SDMP will therefore be taken into account during the next revision of this strategy.

### Ten-year Electric Transport Network Development Scheme (SDDR)

The SDDR, adopted in 2016, lists the network development projects that RTE proposes to implement and commission within three years and presents the main electricity transmission infrastructures to be envisaged in the next ten years; beyond this, it sketches the possible adaptation needs of the network based on different

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21 Article 69 LTECV: "*Every five years, the Government presents Parliament with a national strategy for transition to the circular economy, including a Resource Scheduling Plan necessary for the key sectors of economic activities, which is used to identify the potentials of prevention of the use of raw, primary and secondary materials, in order to use resources more efficiently, as well as strategic resources in terms of volume or value, and to identify the actions needed to protect the French economy.*"

22 Established by Article 183 of the LTECV, it appears in Article L144-1 of the Energy Code.

energy transition scenarios. Thus, the SDDR must schedule the infrastructures necessary to meet the requirements of the PPE.

- In parallel with the development of renewable energies in the PPE, the ten-year plan foresees an adaptation of the transport network so that these new facilities can be accommodated.
    - Hosting areas have been developed to facilitate the connection of future wind or photovoltaic farms.
    - Interconnections are enhanced at local and international levels to pool production risks related to meteorology.
    - The networks are adapted to allow self-production and self-consumption practices.
- From the perspective of the development of more decentralised energy production, the network will be adapted to the reduced need for infrastructure capacity serving major power plants. The SDDR thus takes account of the PPE objective to reduce fossil energy generation.

This plan is subject to environmental assessment (Art R122-17 §1 2).

#### Buildings Energy Renewal Plan (PREB)

Adopted in April 2018 and revised every 5 years, this plan aims to improve the energy performance of buildings by promoting their renovation[23]. It thus contributes to the demand management objective based on the renovation objectives set out in the PPE. Its action is aimed in particular at creating the conditions for mass renovation to accelerate energy savings in buildings. As such, it aims to simplify the channels, incentives and grants for renovation and to encourage staged renovation when more ambitious operations are not possible.

It also contributes to combating fuel poverty by prioritizing public support for disadvantaged households.

#### Employment and Skills Programming Plan (PPEC)

The PPEC is provided for in Article 182 of the LTECV. It is under development and is expected to be published by the end of 2018. It aims to identify the skills and employment development requirements in the territories and in the professional sectors, in respect of the ecological and energy transition.

The reduction in the use of fossil fuels and the development of renewable energies and improvements in energy efficiency will see some jobs disappear, others created and some skills evolve. The PPEC takes account of the guidelines set by the PPE (Article 182 II) in order to anticipate these changes and to assess training needs.

## 1.3. Environmental Assessment Method

### 1.3.1. The approach of strategic environmental assessment

#### An iterative process that takes account of environmental factors

The environmental assessment of plans and programs known as "Strategic Environmental Assessment" (SEA) is governed by European Directive 2001/42/EC of 27 June 2001 and the French Environmental Code. It meets the requirements of Article R122-20 of the Environmental Code. It is defined as an approach to take account of the environmental impact of a program being developed in order to limit that impact. As part of this exercise, the environmental components are (art L122-1 of the Environmental Code):

- Population and human health;
- Biodiversity, especially protected species;
- Environments: land, soil, water, air and climate;
- Material assets, cultural heritage and landscape;
- Interaction between all the above factors.

Evaluation takes the form of a back and forth process between the author of the program and the evaluator, which continues throughout its design. This exchange makes it possible to change the plan upstream in order

23 Provided by Article 4 of the LTECV, it appears in Article 101-2 of the Construction and Building Code

to anticipate the main barriers to its implementation. Environmental assessment is not, therefore, an impact assessment once the strategy is established, but a tool supporting the development of the strategy.

The strategic environmental assessment is also a tool supporting decision-making. By integrating the environmental component into the decision-making process, the pros and cons of the program as a whole can be appraised.

Finally, by giving access to the parameters guiding decision-making, the assessment is a transparent public information tool facilitating citizen involvement in the policy in question and in the acceptability of projects that result from it.

The SEA is carried out under the responsibility of the Authority in charge of the production of the PPE, the Directorate General of Energy and Climate of the Ministry of Ecological and Solidarity Transition with the support of the Directorate General of Infrastructure, Transport and Sea for the part relating to the SDMP. It must be understood essentially as a preventative, non-normative approach in itself, which enables better appreciation of the consequences of energy policy on the environment.

The environmental report resulting from these reflections is submitted to the Environmental Authority, which gives a verdict on the quality of the environmental assessment. This verdict addresses the quality of the environmental assessment, its completeness, its relevance to the issues of the plan and program, and the way that the environment is considered in the program.

### Criteria for analysing the SEA

The SEA requires the identification and assessment of significant environmental impacts of the program, from its preparation phase and before its validation. All environmental issues are to be considered. As a result, 9 evaluation themes have been established according to the specifics of the PPE and the provisions of Article R122-20 of the Environmental Code defining the SEA exercise:

| | | |
|---|---|---|
| Climate and energy | Natural and technological risks | Soils and sub-soils |
| Water resources and aquatic environments | Human health | Biodiversity and natural habitats |
| Pollution: air pollution, olfactory, sound and light | Resources and waste | Landscapes and heritage |

*Table 2: Strategic environmental assessment analysis criteria*

These themes have been used to evaluate the different PPE items:

- Improvement in energy efficiency and lower fossil energy consumption;
- Development of the use of renewable and recovered energies;
- Security of supply;
- Network and storage infrastructures.

For each of the selected themes, the initial state of the environment made it possible to identify the main issues and to highlight evolutionary trends. The probable significant impacts of the implementation of the PPE on each theme could therefore be assessed against a trend scenario.

The assessment leads, when the potentially negative impacts are identified, to changes in the options selected or measures taken to avoid, reduce and, as a last resort, offset these negative impacts. Monitoring the PPE and these measures ensures the best possible protection of the environment by limiting or even eliminating the direct or indirect harm that may be caused by the program.

## 1.3.2. The scope of the SEA of the PPE in relation to the SEA of the SNBC

The PPE and the SNBC are developed jointly within the Directorate General of Energy and Climate. These two policies are based on the same scenarios but have different timescales: the PPE covers the period 2018-2028 while the SNBC projects forward to 2050 with carbon budgets between 2018 and 2033. The geographical scope of these two policies is also different insofar as the PPE only deals with the metropolitan continental French mainland[24], while the SNBC covers the entire French territory.

24 Specific PPEs are produced for Corsica and each overseas territory.

The link between the PPE (including the Clean Mobility Development Strategy) and the SNBC on energy issues is complex (see diagram below). Two aspects differ: the scopes of the thematic components addressed and the degree of operational capacity of the recommendations made.

Concerning the scopes of the thematic components, 3 types of case appear:

- Some thematic components are more specific to the PPE, even if they are the source of GHG emissions: for example, it is essentially the PPE that addresses the choices of primary energy sources for the energy mix and the associated network infrastructures.
- Some thematic components are unique to the SNBC, such as non-energy GHG emissions: e.g. carbon sequestration in soils or biomass, or $N_20$ and $CH_4$ emissions from agriculture.
- In some areas the scopes of the two policies overlap, so they are then addressed by both the SNBC and the PPEs, especially demand management: e.g. demand management is addressed by both policies. It is detailed in the "Demand Management" component of the PPE and broken down into sectoral recommendations of the SNBC.

In respect of how each of the thematic components is approached, the SNBC has a strategic approach, while the PPE is operational: for example, in energy generation, the SNBC does address in detail the development of renewable energies, particularly in the choice of the energy mix. It defines general "carbon-free energy" objectives, with general guidelines on the targeting of biomass resources, heat from the environment and carbon-free electricity. The PPE goes as far as to specify the schedule of calls to tender for electrical renewable energies as well as the power capacities that will be required.

The link between the metropolitan PPE and the SNBC implies that a number of environmental watch points mentioned in the SNBC and in its SEA will be developed in more detail by the PPE and by this document.

Thus, the following environmental watch points mainly relate to the PPE and its SEA:

- Consumption of non-energy mineral resources required for the development of renewable energies (batteries, photovoltaic panels etc.)
- The environmental impacts of the selected energy mix (solar, wind, nuclear, etc.) and the measures to be put in place (location areas to be prioritised, avoidance, reduction, compensation measures, etc.). The main environmental issues involved are land use (and issues of biodiversity, quality of the related environments, although they are not addressed in great detail at this level) and the management of resources and waste related to energy transition.

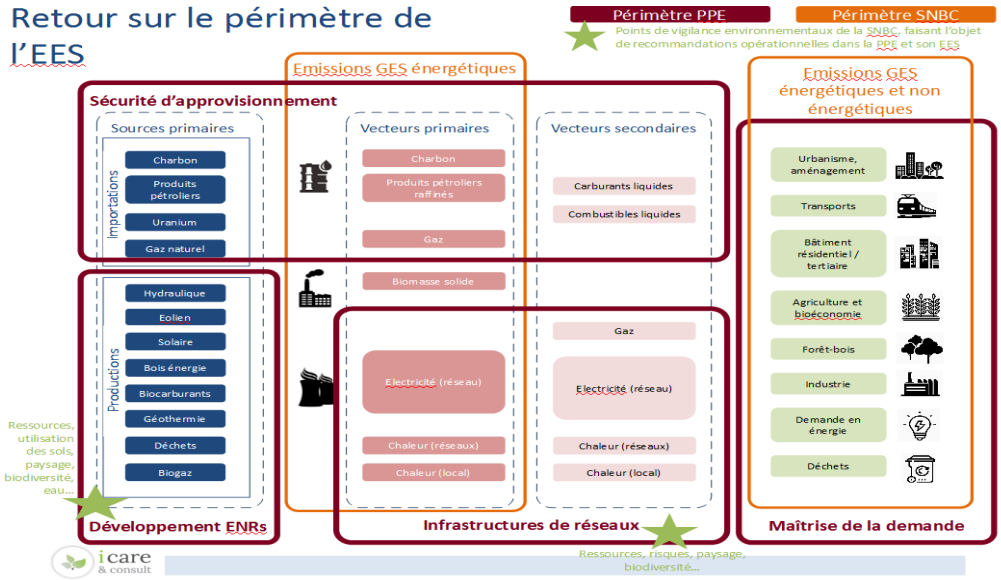



*Figure 2: The respective scopes of the SEA of the PPE and of the SNBC*

# 2. Initial state of the environment

A summary description of the territory and identification of the main environmental issues associated with the SNBC.

The intrinsic focus of the SNBC is the reduction of greenhouse gas emissions to mitigate climate change, so the initial state begins with a presentation of the problem related to climate and energy which lies at the heart of the development of a national low-carbon strategy. Each environmental theme is then detailed in terms of the pressures exerted by human activities.

## 2.1. Climate and Energy

### 2.1.1. Climate in France

Within this part, each sub-section will include a focus on the outcome's indicators of the first version of the SNBC. These indicators represent most recent data tracing developments in climate and energy issues studied in recent years.

#### Initial state: the different types of climate in France and climate change

*The different types of climates in France*

France enjoys a so-called temperate climate, with rainfall distributed throughout the year and relatively mild temperatures. However, the climate varies greatly by region depending on latitude, altitude, proximity to the sea or mountains. There are four main types of climate in metropolitan France (see Map below):

- The **oceanic climate**, which is temperate, is characterised by cool, wet winters and mild summers with variable weather, with maximum rainfall during the cold season;
- The **altered oceanic climate,** a transition zone between the oceanic, mountain and semi-continental climates. Temperature differences between winter and summer increase with distance from the sea. Rainfall is lower than on the seaboard, except near the uplands;
- The **semi-continental climate**, with hot summers and harsh winters, with a large number of days of snow or frost. Annual rainfall is relatively high, except in Alsace, which is sheltered by the Vosges. Rainfall is higher in summer and is often stormy in nature;

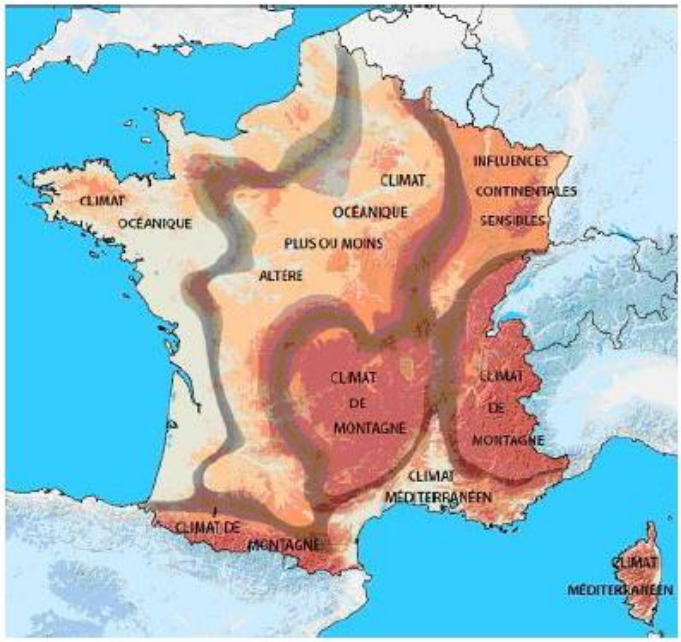



*Figure 3: climate zones in metropolitan France (Source: Météo France)*

- The **mountain climate**, where the temperature falls rapidly with altitude. Minimal cloud in winter and maximum cloud in summer. Winds and precipitation vary significantly by location;
- The **Mediterranean climate**, with mild winters and hot summers, significant sunshine and frequent high winds. There are few rainy days, irregularly distributed over the year. Dry winters and summers are followed by very wet spring and autumns, often in the form of storms.

*Recent climate changes*

In metropolitan France, the rise in temperatures since 1900 is slightly higher than the world average and subject to large disparities between the North and South of the country. Currently, no change in the patterns of storms or strong winds has been detected, but heat waves have already been experiencing significant change since the start of the century. For precipitation, current projections for metropolitan France do not reveal a marked trend in the annual average. Nevertheless, some models anticipate lower rainfall in summer (State of the Environment, 2014). Strong winds should not see discernible change in the metropolis. In the French overseas

territories' tropical territories, the frequency of strong winds is not expected to change. On the other hand, their intensity should increase (State of the Environment, 2014).

By 2071-2100, all of these phenomena are expected to increase.

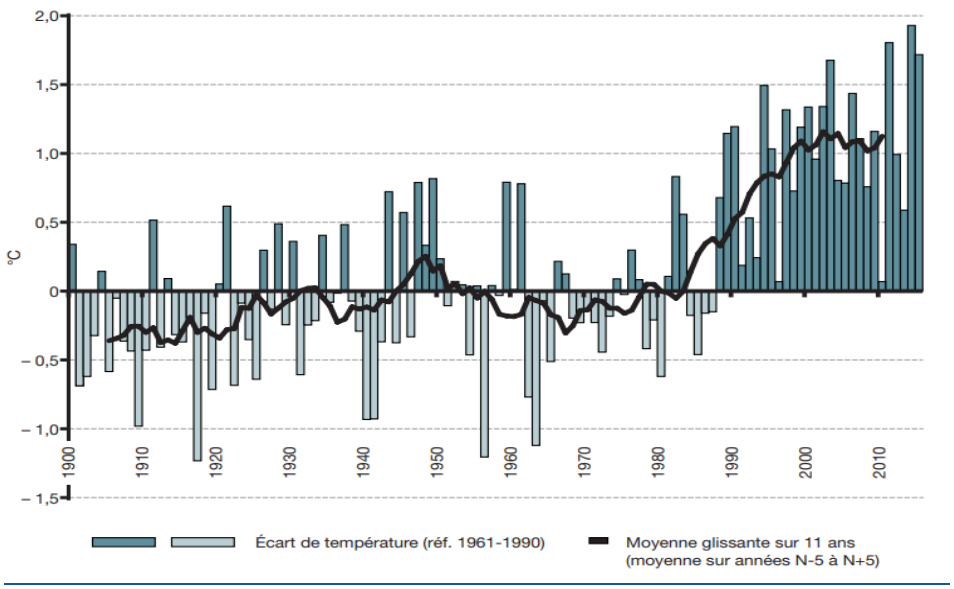



*Figure 4: Evolution of the average temperature in Metropolitan France. Source: SDES, Key climate figures - France and World, 2017.*

## Threats and pressures: greenhouse gas emissions and climate change

### *Impact of greenhouse gases on climate change*

Greenhouse gases (GHGs) are naturally present in the atmosphere. They enable the Earth's temperature to stay at an average of 15°C. However, excessive greenhouse gases emissions into the atmosphere has the effect **of increasing the average temperature and causing considerable global changes**. This is called climate change. Since the industrial revolution, GHG emissions have increased exponentially. Tracking and reducing these emissions have become paramount.

**Box 1: Sources of greenhouse gases covered by the Kyoto Protocol**

| GHG | Sources |
|---|---|
| Carbon dioxide ($CO_2$) | Natural: breathing, putrefaction, fires...<br>Anthropogenic: fossil fuel combustion, some industries (cement production, etc.) |
| Methane ($CH_4$) | Natural: plant and animal decomposition, animal digestion<br>Anthropogenic and other: livestock, wood combustion, rice cultivation, household and composted landfills, oil and gas exploitation |
| Nitrous oxide ($N_2O$) | Natural: wet zones<br>Anthropogenic: use of nitrogen fertilizers (agriculture), certain chemical processes |
| Hydrofluorocarbons (HFC) | Exclusively anthropogenic: aerosol refrigeration system; and insulating foams |
| Sulfur hexafluoride | Exclusively anthropogenic: metallurgy, semiconductor manufacture; |
| Perfluorocarbons (PFC) | Exclusively anthropogenic: air conditioners, some refrigeration units and fire extinguishers |

Human activities are explicitly highlighted as the main cause of this rapid change in climate. Globally, the greenhouse gas emissions covered by the Kyoto Protocol ($CO_2$, $CH_4$, $N_2O$, HFC, PFC, $SF_6$, $NF_3$) have

increased by 80% since 1970 and by 45% since 1990, reaching 54 Gt $CO_{2eq}$. in 2013[25] compared to 49 Gt $CO_{2eq}$. in 2010.

*Distribution of GHG emissions by sector*

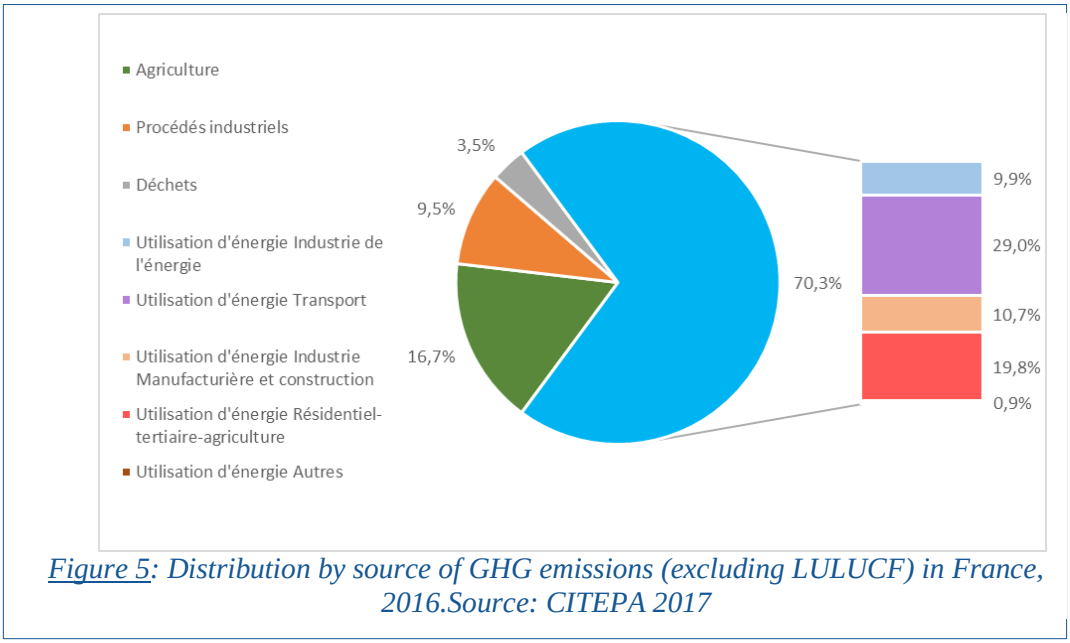



*Figure 5: Distribution by source of GHG emissions (excluding LULUCF) in France, 2016.Source: CITEPA 2017*

In 2016, the share of GHG emissions from energy use represented 70.3% of total emissions - 321.9 Mt $CO_2$ equivalent. They consist mainly of $CO_2$. Emissions related to energy use decreased by 12.5% between 1990 and 2016. They result mainly from fuel consumption and, marginally, from certain combustions and leaks generated during the extraction, processing and distribution of fuels, known as "fugitive emissions".

In 2016, the contribution of the different sectors was as follows[26]:

- Share of transport: 30%, of which 95% is from road transport of passengers and freight;
- Share of manufacturing and construction industry: 17%:
- Share of residential and tertiary (heating, air conditioning, etc.): 20%;
- Share of the energy industry: 11%, of which 59% is power generation and district heating and 20% refining; the low contribution of electricity generation to GHG emissions in France is explained by the importance of nuclear power generation;
- Share of agriculture/forestry: 19 %. The agricultural sector is the largest emitter of $N_2O$ and $CH_4$. $N_2O$ emissions from this sector are decreasing due to the lower amounts of mineral fertilisers used on cultivated soils and the $CH_4$ emissions in agriculture, resulting from the digestion of ruminants and the management of animal manure, as well as due to the decline in livestock;
- Waste share (consisting of 87% $CH_4$): 3 %. Primarily from organic waste landfills and sewage/sludge processing, they have been stable since 1990.

## Measures and actions to reduce French greenhouse gas emissions by 40% by 2030

Countries signing the Paris Agreement pledged to limit the increase in average temperature to 2°C, and, if possible, to 1.5°C. To do this, they undertook, in line with the IPCC's recommendations, to achieve carbon neutrality in the second half of the 21st century. Developed countries are urged to achieve carbon neutrality as soon as possible. In France, the Law on Energy Transition for Green Growth (LTECV) sets a greenhouse gas emissions reduction target of 40% by 2030 and 75% by 2050, compared to 1990, by accelerating in particular the development of renewable energies, by encouraging greater energy efficiency in all sectors, and through

25 SoeS, Key climate figures - France and World, 2017 edition.

26 CITEPA 2017, SECTEN inventory, available at: https://www.citepa.org/fr/activites/inventaires-des-emissions/secten

the development of the bioeconomy. The overseas departments must aim for energy self-sufficiency in 2030, with a target of 30% renewable energy from 2020 in Mayotte and 50% in The Reunion Island, Martinique, Guadeloupe and Guyana, compared to 23% in mainland France.

These measures include in particular the renovation of buildings and the development of more environmentally friendly transport. Targets include making 7 million charging points available for electric vehicles by 2030, ensuring that 10% of energy consumed in all transport modes comes from renewable sources by 2020 and 15% by 2030, or ensuring that all new buildings meet the "low-energy building" (BBC) standard by 2050.

In this context, the first national low-carbon strategy, published in November 2015, defines the way forward for reducing GHG emissions throughout France and for complying with the set reduction objectives. For 2015-2018, 2019-2023 and 2024-2028, it sets carbon budgets of 442, 399 and 358 Mt of $CO_2$eq. respectively per year. The first carbon budget makes it possible to meet the French commitments by 2020. The levels of the second and third carbon budgets take account of the objective adopted for 2030 and are part of the European contribution to the 2015 international climate agreement, namely the reduction of at least 40% in greenhouse gas emissions by 2030 compared to 1990. These budgets are broken down by major sectors[27] and by each gas with a GHG effect, when justified by the issues. The indicative breakdown by activity sector is as follows:

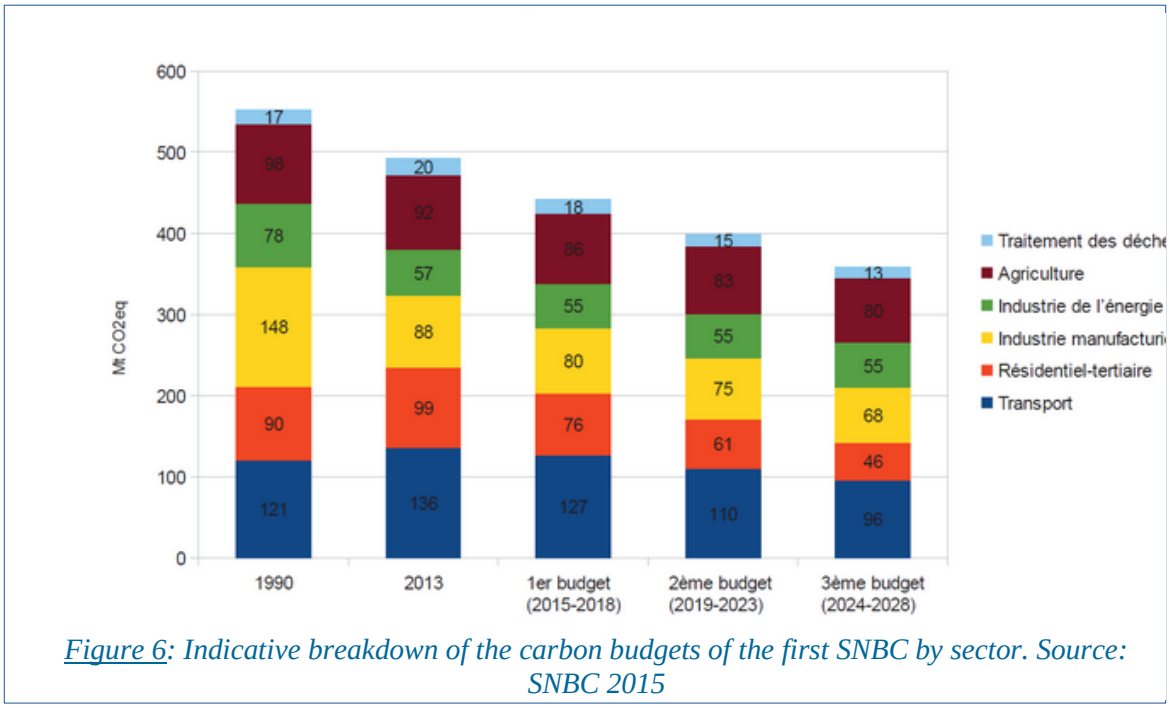



*Figure 6: Indicative breakdown of the carbon budgets of the first SNBC by sector. Source: SNBC 2015*

The adaptation of the territory to climate change is an essential complement to actions to reduce greenhouse gas emissions. The **National Climate Change Adaptation Plan (PNACC)**, in accordance with article 42 of the law of 3 August 2009 on the Grenelle Environment Forum Program, presents tangible operational measures to prepare France to address and take advantage of new climate conditions. This national plan is **currently being revised** to define France's adaptation policy in accordance with the Paris Agreement. The aim is to ensure effective adaptation, from the middle of the 21st century, to a regional climate in both France and the Overseas Territories consistent with a temperature rise of 1.5 / 2°C at global level compared to the 19th century.

Lastly, at regional level, **the PCAET (Climate Air Energy Territory Plans)** are now mandatory for EPCIs with their own taxation of more than 20,000 inhabitants. The PCAET is a planning tool that aims to mitigate climate change, develop renewable energies and control energy consumption. Its contents, divided into four sections, is set by law: diagnosis, territorial strategy, action plan and monitoring and evaluation system.

## Trends and future outlooks: ongoing climate change despite a general downward trend in French emissions

*Climate change: average temperature rise, but regional disparities*

27 ETS (Emission Trading Scheme); sectors covered by the "Sharing of effort" Directive (sectors not covered by the common emissions market); LULUCF (land use, land use change and forestry)

For metropolitan France, the various studies carried out to date[28] make it possible to identify the following climatic changes by 2050:

- **An increase in temperatures from 0.3°C to 2°C by 2050**

Temperatures are expected to increase in France over the next century. By 2050, the average increase in the territory will be between 0.3°C and 2°C. This increase will continue to reach 1°C - 3°C in winter and 1.3°C - 5 °C in summer at the end of the century following the different scenarios envisaged. This rise in temperature will not be uniform over the territory and could, for example, greatly exceed 5°C for the South-East region in summer.

- **A decrease in extreme cold days and more heatwaves**

By contrast, the number of days of extreme cold is expected to decrease, especially in the North of the country, and the number of days of extreme heat is expected to increase, particularly in the southeastern quarter of the country where heatwaves of more than 20 consecutive days may occur.

- **A change in precipitation patterns**

For rainfall, the different climate models do not all agree, thus demonstrating the difficulty of accurately forecasting global developments on this point. However, two trends seem to be emerging: increased rainfall in winter and a decrease in summer. Moreover, the European "multi-model" foresees an increase in extreme rains that may cause floods.

- **Rising sea levels**

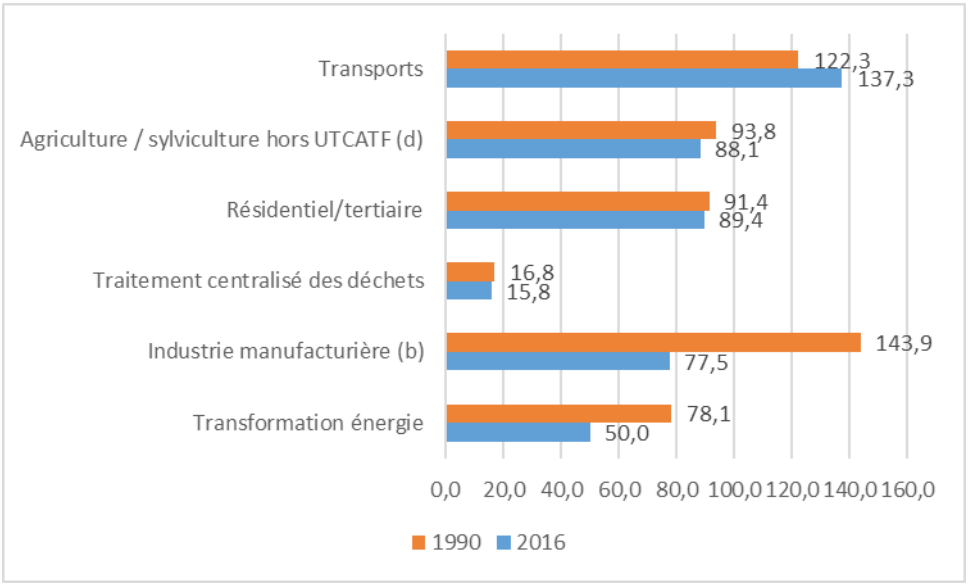
For rising sea levels, the most likely range is between 0.3m and 0.8m. It should be noted, however, that this increase is mainly due to the expansion of the oceans (itself due to the increasing temperature of the oceans). Indeed, the outcome of the melting of the ice caps cannot be predicted with certainty and the IPCC estimates that the critical temperature increase that would cause a major melting of these ice caps is most likely above 1°C and probably under 4°C.

The regional distribution of sea level changes is difficult to estimate because it depends on local changes in several parameters: ocean temperature, salinity, ocean currents, surface pressure, the contribution of continental waters or changes in the level of the ocean floor and earth movements. Although major trends in these phenomena have been studied at global level, it is not yet possible to draw precise conclusions for France.

*Trends in French GHG emissions*

Over the period 1990-2016, there was a **decrease in GHG emissions but with disparities by sector** however. Emissions from the transport sector increased by 12%, while those in the residential sector decreased by 2% and those in the waste sector by 6%. Globally, since 2007, the trend in greenhouse gas emissions across all sectors has been declining.

28 MTES, 2014. The climate of France in the 21st century - Volume 4 - Regional Scenarios: 2014 edition for metropolitan France and overseas territories.




## Global Trends: focus on the outcome indicators of the first SNBC version

In all the graphs below, the "past trend" curve refers to the prolongation of actual trends observed while the "SNBC scenario" curve refers to the former AMS ("With Additional Measures") provisional scenario of SNBC 1. The anticipated trend for the future is the extension of the "past trend" blue line.

*Global GHG emissions*

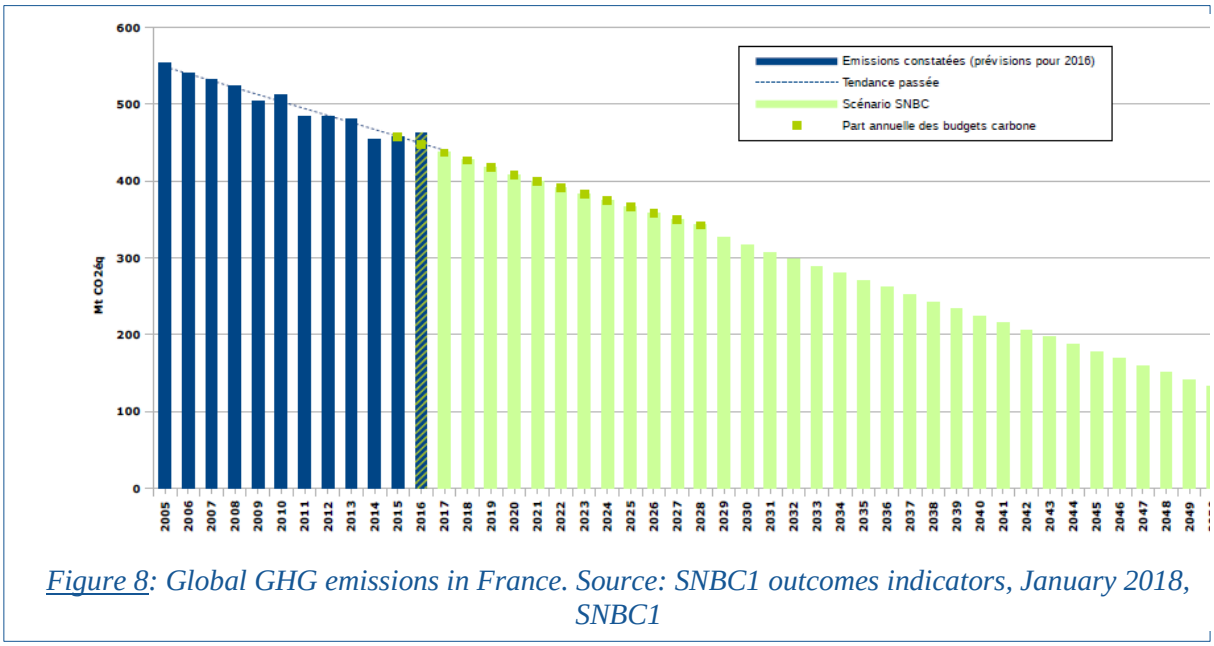



*Figure 8: Global GHG emissions in France. Source: SNBC1 outcomes indicators, January 2018, SNBC1*

The discrepancies from the indicative annual budgets (provisionally adjusted in 2018) are estimated at 3 Mt $CO_2$eq. for 2015, 13 Mt $CO_2$eq. for 2016 and 31 Mt $CO_2$eq. for 2017.

**Box 2: Carbon footprint**

Carbon footprint characterizes the pressure exerted by a population in terms of greenhouse gas emissions, depending on consumption. It differs from emissions measured in the territory (the traditional way of estimating emissions) and takes into account emissions linked to the production and transportation of goods and services consumed in France. The difference between the two indicators is the balance of emissions related to imported goods and services consumed in France and that of emissions related to goods and services produced in France and exported for consumption in another country.

## Trends by sector: focus on the outcome indicators of the first SNBC version

*Transport*

For the transport sector, from 2015 there was a deviation from the SNBC trajectory, above the indicative share of carbon budgets by sector. The 2016 emissions show that the annual target was exceeded by 6%.

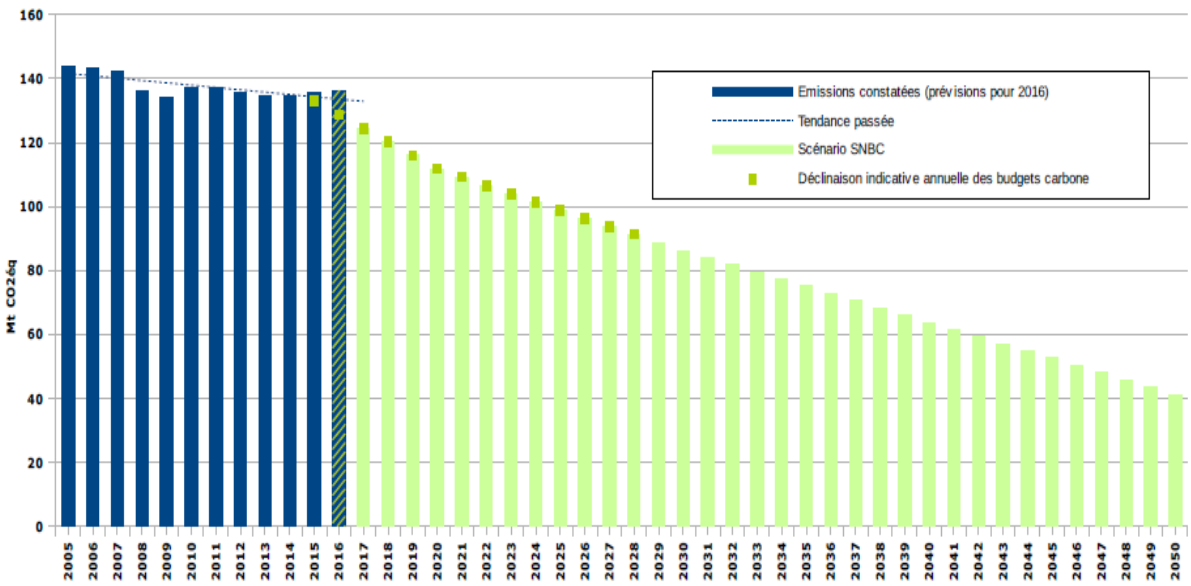



*Figure 10: GHG emissions in the transport sector. Source: SNBC1 outcomes indicators, January 2018, SNBC1.*

*Residential - tertiary*

For the building sector, results from 2015 show a deviation from the SNBC trajectory, above the indicative share of carbon budgets by sector despite favourable weather conditions. The 2016 emissions show that the annual target was exceeded by 11%.

**Box 3: Summary of the impact of the trend scenario (AME 2018) on the climate**

For about ten years, French GHG emissions have been declining. However, in the short term, in the last two years, emissions have stabilized.

Under the SNBC2, the trend scenario modeling GHG emissions, known as the AME 2018 ("with existing measures"), tends towards a 32% reduction in GHG emissions in 2030 and then 35% in 2050 compared to 1990. This will not achieve the SNBC 2 objective of carbon neutrality by 2050 (see graph below).

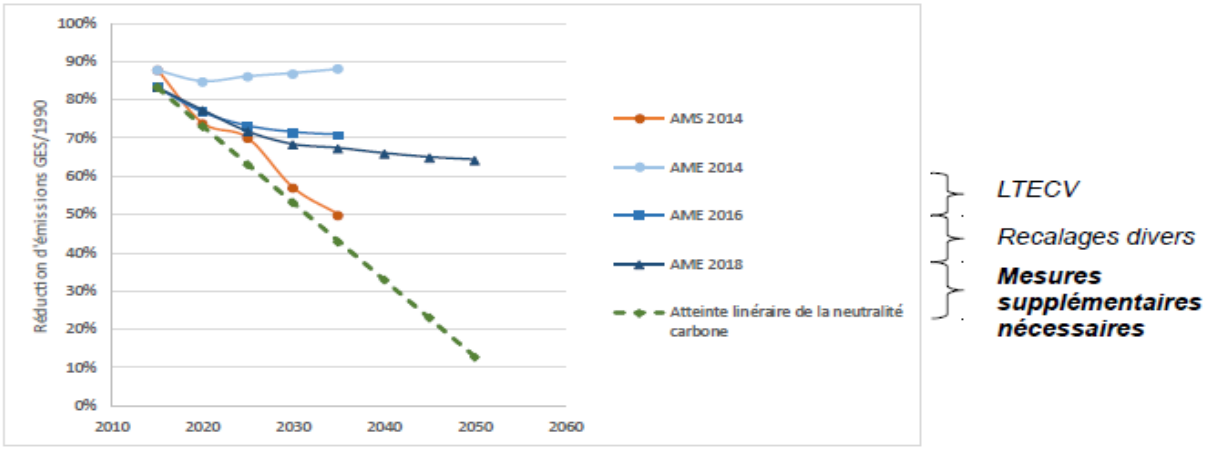



*Figure 14: Comparison of the reference scenarios (AMEs) and scenarios with supplementary measures (AMS) of the previous SNBC (1) and the current SNBC (2). Source: DGEC, preparatory work for SNBC 2, 2018.*

### *Agriculture*

For the agriculture sector, results from 2015 show a slight deviation from the SNBC trajectory, above the indicative share of carbon budgets by sector. The 2016 emissions show that the annual target was exceeded by 3 %.

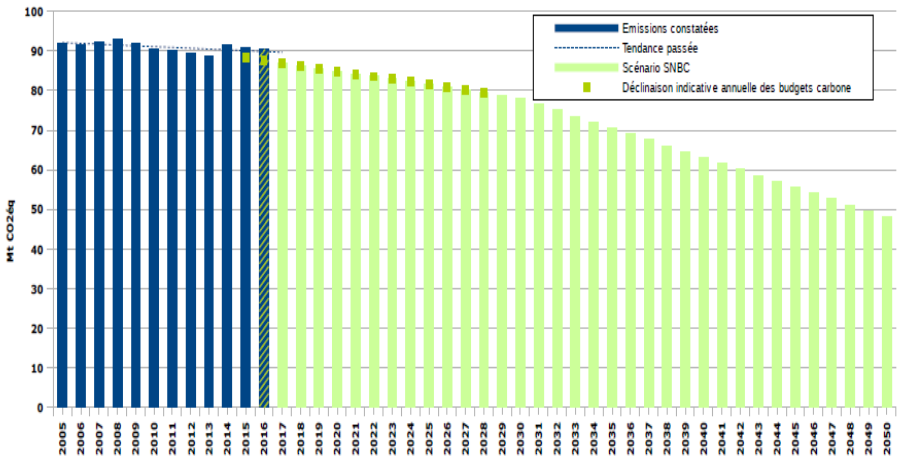



*Figure 12: GHG emissions in the agriculture sector. Source: SNBC1 outcomes indicators, January 2018, SNBC1.*

### *Industry*

For the industry sector, the 2015 results and the 2016 emissions are close to the targeted objectives (margin of around 1%).

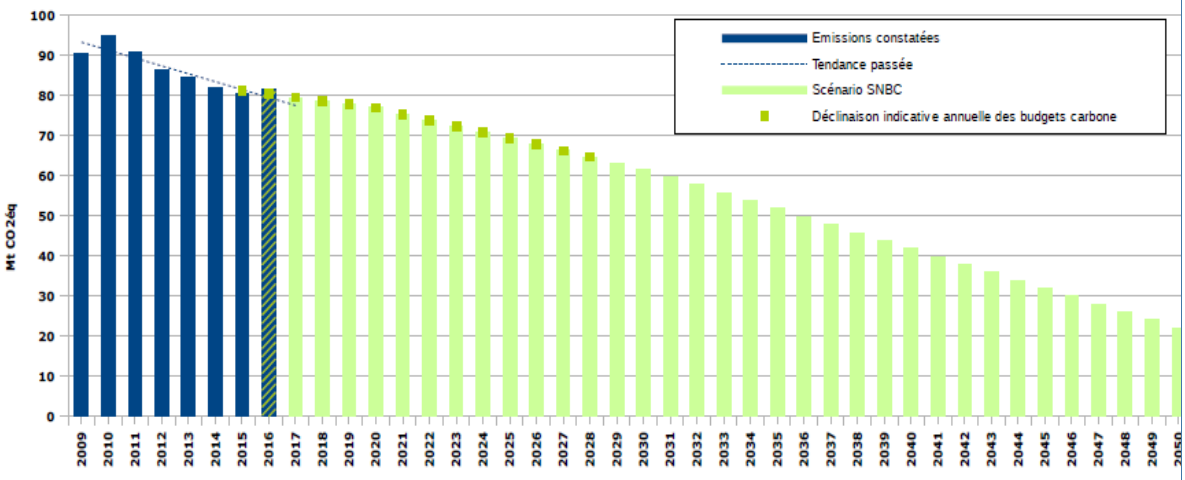



*Figure 13: GHG emissions in the industrial sector. Source: SNBC1 outcomes indicators, January 2018, SNBC1.*

## 2.1.2. State of energy production and consumption in the national territory[29]

During the second half of the 2000s, while GHG reduction objectives were targeted, a strong link was created between climate and energy policies: at national level, through the creation of the Directorate-General of Energy and Climate and in the territories through the introduction of air-energy climate schemes and plans. It is now clear that energy is one of the main levers for combating climate change, through three courses of action: lower energy consumption, improved energy efficiency and decarbonised energy sources.

29 All the figures in this section come from France's Energy Balance report 2016 (Edition 2018).

## Initial state: energy production and consumption in France

*Sources of primary energy production*

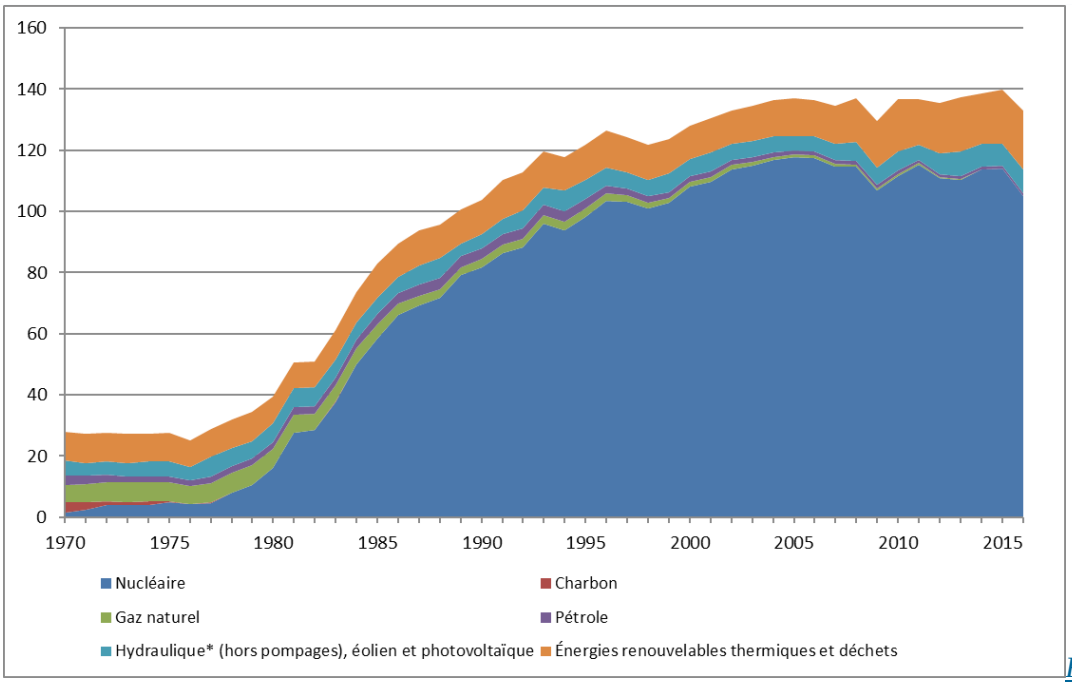



*Figure 15: Primary energy production by energy in France (Mtoe = Source: Energy Balance of France 2016 (2018 edition)*

Following the establishment of the nuclear program, national primary energy production increased from 44 Mtoe in 1973 (9% of which was nuclear) to 133 Mtoe in 2016 (79% of which was nuclear). Oil, coal and natural gas production continued to decline, reaching zero for the last two items. Primary production of energy from renewable sources has been increasing steadily since the mid-2000s, particularly with the development of wind power, photovoltaics, biofuels and biogas.

*Energy consumption*

After a steady increase until 2005, reaching a peak at 271 Mtoe, primary energy consumption adjusted for climate variations has fallen slightly over the past ten years. This downward trend was interrupted in 2015. The long-term trend is very different depending on energy sources: since 1990, coal and oil consumption fell by 58% and 19% respectively. On the other hand, gas consumption increased by 43%, primary electricity increased by 32% and thermal renewable energies and waste increased by 75%.

During 1990-2016, the share of industry (including iron and steel) in final energy consumption decreased from 24% to 19%, while the transport sector was relatively stable at 30% in 1990 and 31% in 2016. The share of the residential-tertiary sector gained nearly four points (43% to 47%), while agriculture remained around 3%. **Final energy consumption, adjusted for climate variations, all uses combined, fell in the second half of the 2000s** and has been relatively stable since, at around 141 Mtoe. In 2016, it was 141 Mtoe.

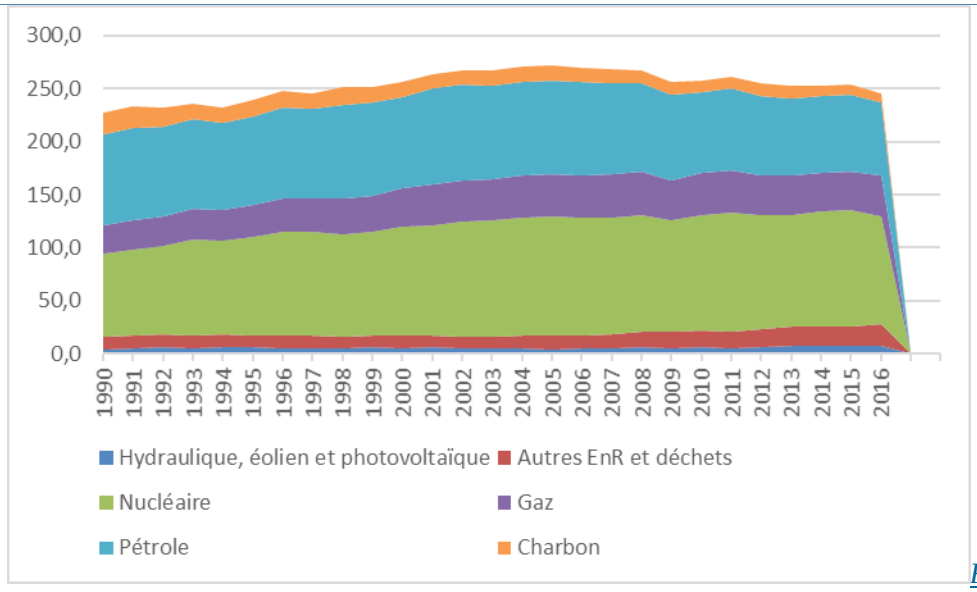



*Figure 16: Primary energy consumption (adjusted for climate variation) by energy in France (Source: Energy Balance of France 2016 (2018 edition)*

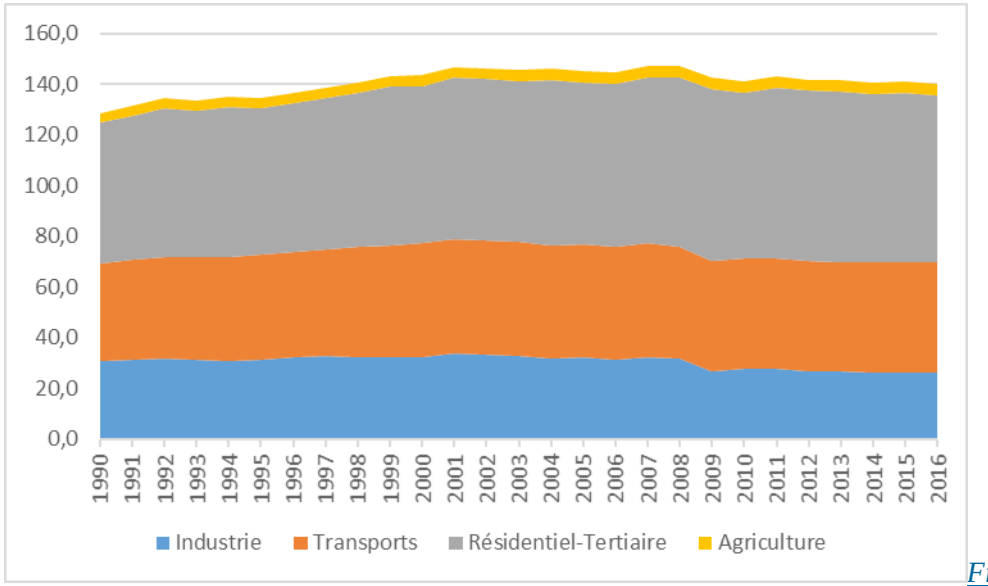



*Figure 17: Final energy consumption (adjusted for climate variations) by sector in France (Source: Energy Balance of France 2016 (2018 edition)*

*Focus on GHG emissions specifically related to energy use (source: CITEPA)*

In 2016, 70.3% of total GHG emissions were due to the use of energy, or 321.9 Mt $CO_2$ equivalent. The transport sector contributes 41% of GHG emissions related to energy use. The other main emission sectors are the use of residential-tertiary-agricultural buildings (28%), manufacturing and construction (15%) and the energy industry (14%).

Transport emissions increased rapidly between 1990 and 2004, averaging + 1.2% per year, reaching 143 million tonnes (Mt) $CO_2$eq. This increase was caused by strong growth in road traffic over the period (+ 1.8% per year), responsible for more than 90% of transport emissions. These emissions then decreased between 2004 and 2009, due to the fall in the development of passenger and freight road traffic (+ 0.6% per year between 2004 and 2009), more than offset by the renewal of the car fleet, supported by the ecological and scraping bonuses, on the one hand, and the explosion in oil fuel prices and the deployment of biofuels, on the other hand. Since 2009, transport emissions have stabilised at around 132 Mt $CO_2$eq. while road traffic continued to grow at a rate of 0.7% per year between 2009 and 2012.

Emissions from the residential-tertiary sector come mainly from heating in buildings: they are therefore particularly sensitive to weather variations. Between 1990 and 2004, they increased to 116MteCO , and since

then they have been slowly decreasing. In 2016 they were 90.5Mte $CO_2$. Since the late 1970s, the share of oil and coal products in the residential-tertiary sector energy mix has declined in favour of natural gas and electricity, which emit less $CO_2$. This has helped to contain the sector's emission rates, while its energy consumption is steadily growing.

Emissions related to fuel consumption in manufacturing and construction fell by one third compared to 1990. This fall accelerated significantly as a result of the 2008 economic crisis. Improved energy efficiency in production processes and rebalancing of the energy mix at the expense of oil and coal have also contributed to a fall in emissions for the sector over a long period. They have been increasing for the last two years: +5 % in 2015 and +8 % in 2016.

70% of emissions from energy combustion in the energy industry come from electricity and heat production, the rest are from oil refining and coke production. In 2016, these emissions amounted to 45.2 Mt $CO_2$eq. As in the residential-tertiary sector, they fluctuate a lot depending on heating demand and weather conditions. The vast majority of electricity production in France is provided by the nuclear and hydro sectors that do not emit GHGs in the production phase. Thermal power plants, which mainly burn oil, coal and natural gas, are used as semi-bases and back-ups, covering energy needs at peak consumption times.

In 2016, fugitive emissions were 1.3% of energy-related emissions compared to 2.9% in 1990. This decline is due to the gradual closure of coal mines, which were sources of $CH_4$ releases $CO_2$ from catalytic cracker regeneration for oil refining and $CH_4$ emissions escaping from the natural gas transmission and distribution networks now represent the majority of fugitive emissions[30].

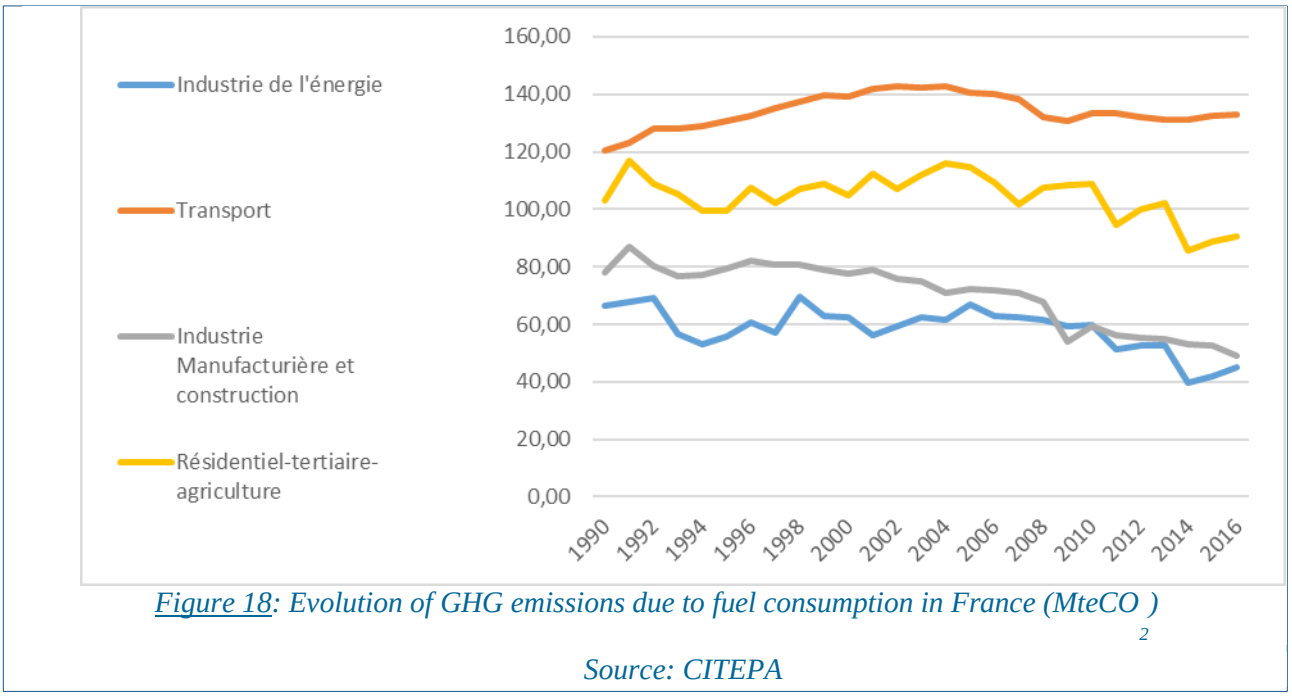



*Figure 18: Evolution of GHG emissions due to fuel consumption in France (MteCO 2 )*

*Source: CITEPA*

## Actions and measures prior to SNBC 2

SNBC1 is complemented by the Multi-Annual Energy Plan (PPE), published in October 2016, for 2016-2023, which sets the government's priorities for management of the different energy sectors. It is currently being developed for 2019-2028 (see Chapter 2 on the coordination of plans and programs with the SNBC).

It should be noted that Corsica, Guadeloupe, Guyana, Martinique, Mayotte, the Reunion Island and Saint-Pierre and Miquelon each have their own Multi-Annual Energy Plan (PPE). These PPEs, with the exception of Corsica, constitute the energy component of the regional climate, air and energy schemes (SRCAE), in order to avoid a proliferation of planning documents. In the same vein, Prerures, forerunners of SRCAEs in the Overseas territories, have been repealed.

30 Source: Initial state of the environment 2014

**Box 4: Summary of the impact of the energy trend scenario**

The estimated trend is a continued decline in GHG emissions, including the planned closure of oil and coal plants, plus growth in renewable energies and energy efficiency efforts. However, without additional measures, it is unlikely that this decline will be sufficient to achieve the decarbonization of the sector by 2050.

## Trends and future outlooks

### *Energy production*

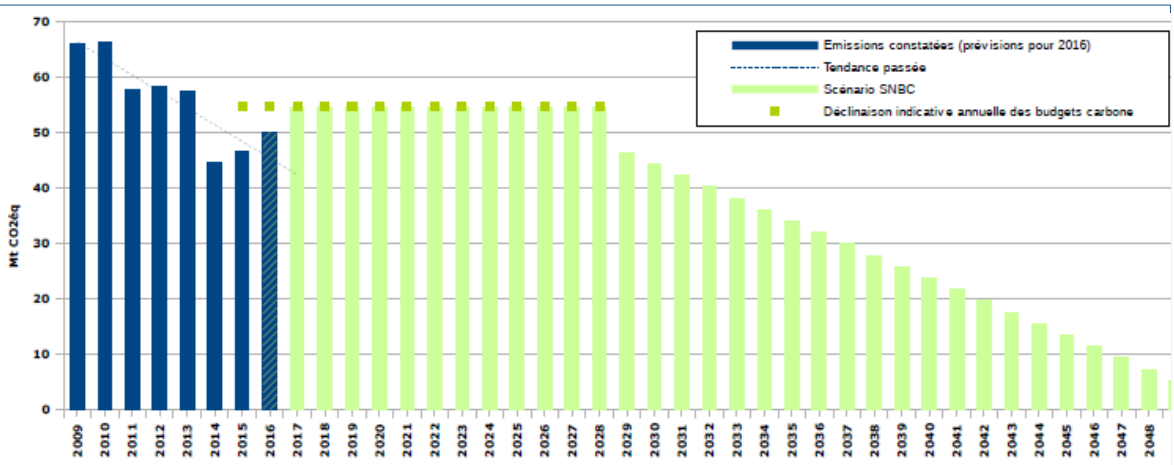



*Figure 19: GHG emissions in the energy production sector. Source: outcomes indicators, January 2018, SNBC1.*

For the energy production sector, the 2015 results and the 2016 forecasts, respectively, offer a margin of -15% and -8% compared to the annual objectives.

### *Final energy consumption*

There was a decrease of around -1% per year between 2013 and 2015, while the SNBC 1 initial state scenario foresees a drop of about -1.5% per year.

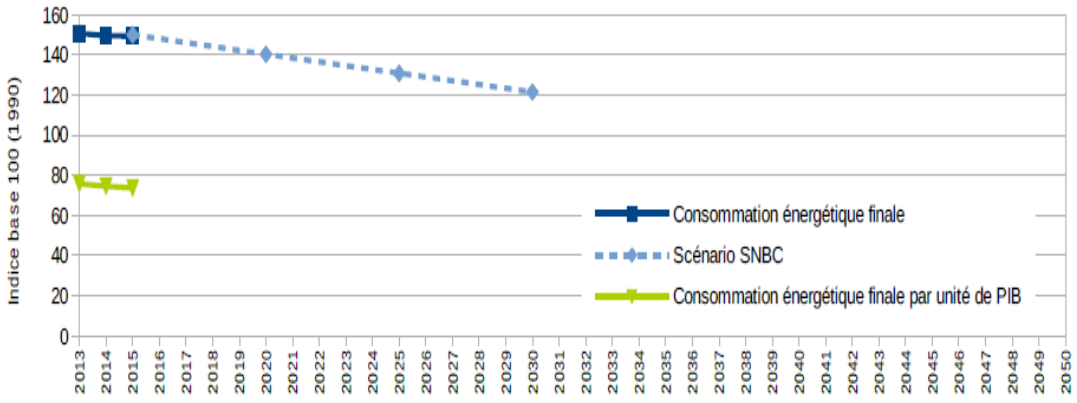



*Figure 20: Final energy consumption per unit of GDP. Source: outcome indicators, SNBC*

| | |
|---|---|
| **Transport** | • Different types of transport (road / air / sea and river / rail) use greenhouse gas emitting fossil fuels.<br>• Land artificialisation linked to transport infrastructure limits carbon storage capacity in soils |
| **Residential-Tertiary Sector** | • Greenhouse gas emissions are mostly due to the use of energy. Different uses are distinguished: electricity, heating, cooking, domestic hot water.<br>• Urban forms and the preservation of natural spaces in urban areas have an impact on local climates (e.g. heat islands). |

| | |
|---|---|
| **Transport** | • Different types of transport (road / air / sea and river / rail) use greenhouse gas emitting fossil fuels.<br>• Land artificialisation linked to transport infrastructure limits carbon storage capacity in soils |
| | • Urbanisation also contributes to land artificialisation, limiting carbon storage capacity. |
| **Agriculture** | • The use of mineral fertilisers spread on cultivated land<br>• The digestion of ruminants and the management of animal waste,<br>• Burning, incineration of crop residues |
| **Forestry - wood - biomass** | • The forest-wood-biomass sector contributes to the mitigation of GHG emissions using four levers: carbon sequestration and storage in living and dead biomass, storage in wood products, material replacement or chemical molecule, energy substitution.<br>• Forests play a role in the regulation of local climates (rainfall, temperatures, etc.) |
| **Industry** | • GHG emissions in industry are mostly due to use of energy.<br>• Industrial processes are also a source of GHG emissions |
| **Energy production** | • Most GHG emissions are due to energy and heat production (plant operation), as well as refining, fugitive emissions and the transformation of SMF (solid mineral fuels). |
| **Waste** | • The disposal of organic waste and the treatment of sewage sludge are responsible for most GHG emissions.<br>• Wastewater treatment is also a source of emissions. |

*Table 3: Threats and pressures on the climate and greenhouse gas emissions*

# 2.2. Physical environments

## 2.2.1. Water resources and aquatic environments

### Initial state: a mixed assessment of water quality in France

*State of inland waters*

With regard to the Water Framework Directive (WFD) adopted in October 2000, the good quality of surface water bodies (management and assessment units defined in the Directive) is defined based on the quality of their ecological status (depending on the biological, chemical and hydro-morphological quality of the water body in question) and their chemical status (compliance with the pollutant concentrations threshold values set at European level). The good condition of groundwater bodies is also the result of good chemical status (compliance with the threshold values) and the good quantitative status (when the volumes of water extracted do not exceed the renewal capacity of the resource and preserve the supply of ecosystems) of these water bodies[31].

In 2013, 44% of surface water bodies was in good ecological condition and 50% in good chemical condition. At the same time, 67% of groundwater bodies were in good chemical condition and 90% were in good quantitative condition[32].

31 CGDD, 2014. The environment in France, edition 2014.
32 Ibid.

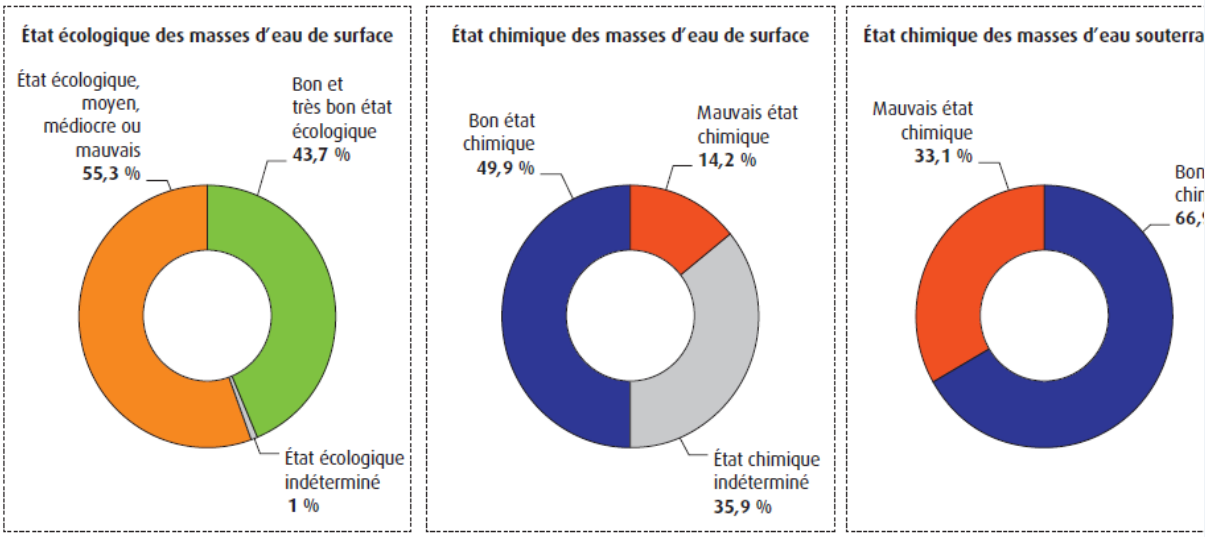



*Figure 21: Ecological, chemical and quantitative condition of French surface and groundwater bodies in 2013, excluding Guadeloupe, Martinique and Mayotte. Source: CGDD 2014, The environment in France 2014, according to Water Agencies - Water Boards - Onema, March 2014. Processing: SDES, 2014*

### *Condition of marine waters*

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 called the "Marine Strategy Framework Directive" requires Member States of the European Union to take the necessary measures to reduce the impacts of human activities on this environment to achieve or maintain a good ecological condition for the marine environment by 2020 at the latest.

The ecological condition of coastal water bodies is better than the average ecological condition of all surface water bodies with 57% of French coastal water bodies, DOM included, in good or very good condition. The situation is less positive for transitional waters and estuaries where less than 30% are in good or very good ecological condition and one third are in poor condition.

Of half of the coastal water bodies assessed, three-quarters are in good chemical condition (the other half of the water bodies have not yet been evaluated). Of the evaluated 70% of transitional water bodies, about one in two bodies has a poor chemical condition, especially on the North Sea and Eastern Channel shorelines.

### *Threats and pressures: multiple quantitative and qualitative pressures from all sectors*

The main sources of pollution of inland waters consist of discharges from urban or industrial wastewater treatment plants, rainwater run-off, diffuse pollution from agricultural sources or atmospheric debris, as well as bank and water course development (flow obstacles). This causes the excessive presence of various pollutants[33]: pesticides, nitrates, phosphorus, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) etc.

In marine waters, more than 80% of pollution comes from the land via rivers or spills from coastal areas. This pollution consists of suspended particles likely to stifle ecosystems, nutrients causing the proliferation of algae or macro-waste that can cause the death of marine mammals by ingestion (plastic bags, etc.).

Water resources are also under quantitative pressure associated with possible episodes of marine drought, flood and / or submersion. These topics are addressed in the section on natural hazards.

Climate change is also a major threat to water resources. The Intergovernmental Panel on Climate Change (IPCC) shows a decreasing precipitation trend in metropolitan France on average between 1979 and 2005. It also shows a trend towards widespread increases in heavy precipitation events, caused by an increase in atmospheric water vapor which is consistent with the warming observed by the IPCC.

These climatic factors should also promote an increase in water temperatures and thus exacerbate many forms of water pollution including pesticides, nutrients, etc.

33 CGDD, 2014. The environment in France, 2014 edition.

| | |
|---|---|
| **Transport** | • Soil sealing and runoff;<br>• Pollution from runoff waters. |
| **Residential-Tertiary Sector** | • Pollution from runoff waters and the problem of soil sealing;<br>• Discharges from urban sewage treatment plants;<br>• Development of banks and watercourses (obstacles to flow);<br>• Emerging pollution: drugs, endocrine disruptors, etc. |
| **Agriculture** | • Pollution of surface waters and groundwater related to agricultural inputs: nitrates, phosphorus, pesticides, etc.;<br>• Flooding and runoff issues related to soil management (compaction, etc.);<br>• Water Pollution due to suspended matter related to runoff on farmland;<br>• Extraction of water resources (irrigation). |
| **Forestry - Wood - Biomass** | • Flooding and runoff issues related to soil management (compaction, etc.);<br>• Pollution of water by suspended matter related to runoff. |
| **Industry** | • Discharges from industrial sewage treatment plants;<br>• Pollution due to chlorinated solvents. |
| **Energy production** | • Bank and watercourse developments (obstacles to flow) in the case of hydropower, associated with changes in water temperature in the case of nuclear generation.<br>• Modification of the marine habitat at marine energy sites: erosion of the seabed, resuspension of sediments and modifications of the hydrosedimentary system, risk of pollution with chemicals and lubricants related to the coatings used for the installations.<br>• Qualitative and quantitative pressures on water resources related to biofuel production. |
| **Waste** | • Pollution from runoff waters (leaching). |

*Table 4: Threats and pressures on water resources and aquatic environments by sectors*

## Trends and future outlooks: organised management struggling to achieve satisfactory results

### *Actions taken*

The Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) provide a legal system through which Member States undertake to protect and reclaim the quality of water and marine aquatic environments. They impose an obligation of result on Member States, so the objective is not only to implement policies and regulations for the preservation of water resources but above all to prevent the deterioration of water courses, to restore them to good condition, to reduce surface water pollution due to priority substances and to progressively phase out releases of priority hazardous substances.

In France, the law of 16 December 1964 defined the six river basins and their management by basin committees and water agencies. The law of 3 January 1992 imposed water use planning to achieve sustainable management with the implementation of Master plans for the development and management of the water system (SDAGE), valid for 6 years. As the WFD was inspired by these French laws, this has made it possible to harmonise water management for all Member States by submitting a water report every 6 years, in accordance with the criteria of the WFD defined by the European Commission. The most recent assessment dates from 2015 on the condition of the basins in 2013[34].

Other directives support the Framework Directive, including Directive 2006/118 / EC of 12 December 2006 on the protection of groundwater against pollution and deterioration and Directive 2008/105 / EC of 16

34 Blard-Zakar, A., 2015. Baseline study 2013. Summary of basin data.

**Box 5: Summary of the impact of the trend scenario on water resources and aquatic environments**

The trend scenario is a prolongation of current trends, as described in the State of the Environment (2014):

**Inland waters**:

- a decrease in most macropollutants in watercourses;
- the ecological quality of surface waters is stabilizing (43.7% are in good and very good ecological condition, 53% in average, mediocre or bad ecological condition);
- nitrate pollution persists;
- pesticides remain highly problematic;
- other micropollutants also degrade water condition (metals and metalloids, hydrocarbons, PAHs, PCBs etc.).

**Marine waters:**

- Less phosphorus arrives at sea but the quantity of nitrogen is the same;
- The microbiological quality of coastal waters remains at a high level;
- The positive effect of restrictions on the use of certain substances;
- Fewer discharges into the sea from boats;
- A not insignificant contribution of pollutants resulting from the dredging of harbor enclosures;
- Still a lot of macro-waste.

December 2008 setting forth environmental quality standards in the area of water. For marine waters, the Marine Strategy Framework Directive (MSFD) is the legal framework for coastal water management.

To reduce the impact of agriculture on water quality and to comply with Council Directive 91/676 / EC of 12 December 1991 on the protection of waters against nitrate pollution from agricultural sources (Nitrate Directive), the Ministry of Agriculture and the Ministry of the Environment have set up an action plan for the protection of water against nitrate pollution of agricultural origin. This action plan was recently amended by the decree of 11 October 2016 modifying the decree of 19 December 2011 on the national action plan for implementation in vulnerable zones to reduce water pollution by nitrates from agriculture. This amendment follows the judgment of the Court of Justice of the European Union dated 4 September 2014 which condemned France for failing to properly implement a number of measures of the Nitrate Directive.

*Evolutionary trends*

The trends observed of different pollutants contaminating rivers are not homogeneous. Indeed, pollution of watercourses by organic and phosphorus matter decreased significantly between 1998 and 2012 even if this is still insufficient, as phosphates (from fertilisers, industrial sources, detergents or phosphate detergents, etc.) remain an important source of degradation of the ecological quality of rivers[35].
The ecological quality of surface waters is stabilizing. Over the 2010-2011 period, the condition of diatoms (unicellular algae, ecological quality indicators) improved slightly compared to the 2009-2010 period. Fish quality is also a good indicator of the ecological condition of watercourses and this trend is improving: in 2009-2010, more than half of fish quality measurement points are in good or excellent condition.

Pollution from agriculture remains a concern. In particular, nitrate pollution is not improving but is stabilizing after an increase until 2004. Pollution of watercourses by phosphorus-based matter has greatly decreased over the past ten years.

The implementation of specific measures to limit pollutant discharges and to restrict or even prohibit the use of certain substances has led to improvements in several water quality parameters (phosphorus, discharges into the sea by boats, quality of coastal waters, etc.) but the situation is still worrying for other parameters (nitrogen, pollutants from dredging of harbour enclosures, macro waste, etc.).

In the long term, the prospective exercise, "Aqua 2030", conducted by the CGDD[36] envisages in its trend scenario an extension of these heterogeneous trends.

## 2.2.2. Soils

35 CGDD, 2014. State of the Environment, 2014 edition.
36 http://www.territoire-durable-2030.developpement-durable.gouv.fr/index.php/td2030/programme/?id=aqua#ext-main

## Initial state: varied and unevenly degraded soils

### *Typology of metropolitan soils*

The soils of the territory have varied characteristics involving different fertility and different sensitivities to environmental pressures. In metropolitan France, the soil consists of:

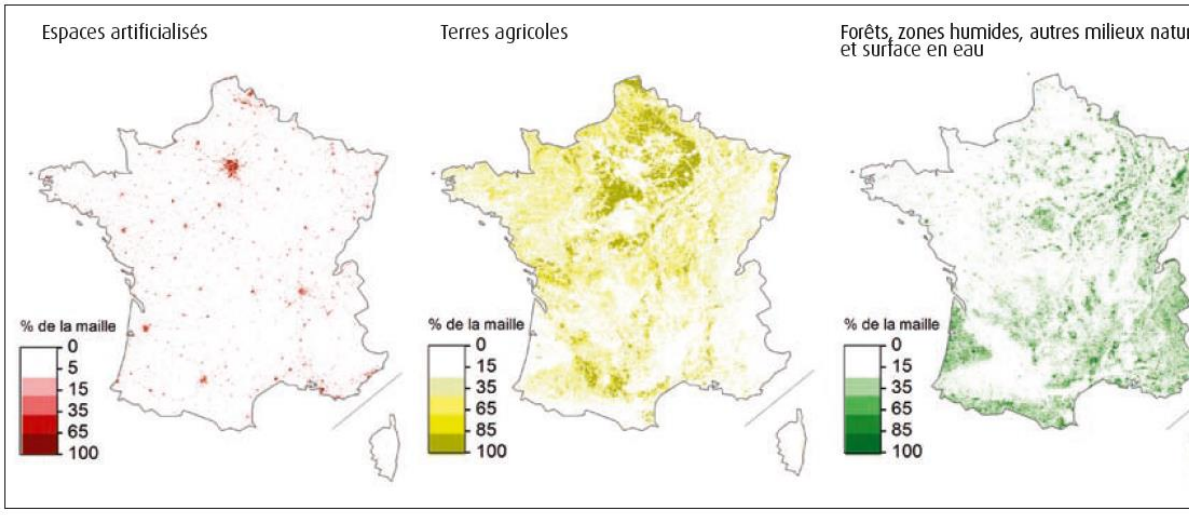
- 25% limestone rocks (Paris Basin, Midi);
- 25% soils of poorly differentiated alteration;
- 20% fertile loam formations (Beauce, Île-de-France, Picardy);
- 7% sandy soils (Landes, Sologne);
- 11 % clay soils (Sud-Ouest, Nord-Est);
- 16% other soils.

In forest environments, humus, layers of fragments of more or less transformed dead plants, are strongly linked to soil types.

In 2012, the metropolitan surface consisted of:

- 60% agricultural land (33 million hectares - Mha). In 2014, utilised agricultural land (UAL) represented 27 million hectares (ha). 68% of this area is used as arable land, 4% for permanent crops and 28% as grassland.;
- 34% forest and semi-natural environments (19 Mha);
- a little less than 6% are artificialised areas (3 Mha).
- About 1% is wetlands and water areas.

These proportions have been stable overall since 1990.




*Note : taux d'occupation en niveaux de couleurs par maille hexagonale de 2 km de côté.*

*Source: UE-SoeS, CORINE Land Cover*

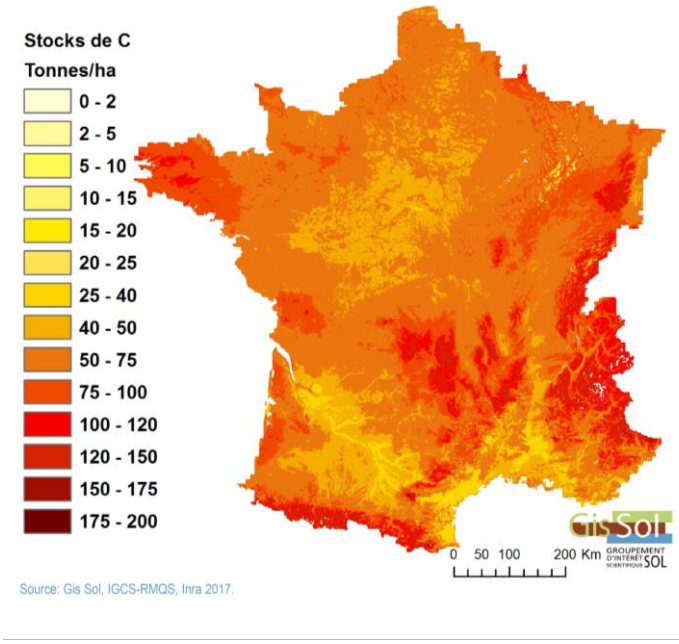
*Figure 22: Land use in Metropolitan France in 2012, by theme*

The properties of soils largely explain their agricultural use. Major crops mainly occupy the deep silty soils of the sedimentary basins (Aquitaine, Paris, Limagne). Cattle, pig or poultry breeding (West) and more extensive beef cattle breeding (Central Massif, Piedmont) is found on soils with little differentiation. Vine cultivation mainly takes place on gravelly soils of ancient terraces (Bordeaux region), on stony soils (Rhône), on shallow calcareous soils (Champagne-Ardenne) and on limestone rock soils (Mediterranean rim). Finally, fruit crops are well established on recent alluvial soils rich in organic matter - in Provence - Alpes - Côte d'Azur.

### *Storage of organic carbon in soils, synonymous with climate change mitigation and increased fertility*

The organic matter of the soil mainly consists of organic carbon and offers several services: it sequesters carbon and contributes to combating climate change, it increases the biological, chemical and physical fertility of soils. In sufficient quantity, it enables biological activity to be maintained. When it decomposes, it releases the nutrients necessary for plant growth. Part of this material is transformed to form a clay-humic complex, which improves the structural stability of the soil. The soil then becomes less sensitive to degradations such as compaction and runoff, and it can also retain more water. Organic matter improves soil buffering against other environments by retaining water, nutrients, pollutants and contaminants. It also increases the resilience of the soil to external pressures.

Soil carbon stocks are relatively variable within the French territory, because of the significant variability in climate-type determinants of soil-land use. The soils of the French mountains (Alps, Ardennes, Jura, Massif




*Source : Gis Sol, IGCS-RMQS, Inra 2017.*

*Figure 23: national map of organic carbon stocks in metropolitan soils (excluding Corsica and from 0 to 30 cm deep) included in the world map of the FAO.*

Central, Pyrenees, Vosges), contain the largest stocks (more than 13 kgC / m², or 130 tC / ha, in the first 30 cm), because of adverse weather conditions that discourage microorganism activity. The agricultural soils of the Greater Paris Basin and Aquitaine have relatively low stocks of C because of use by field crop systems that are historically associated with the export of straw. They contrast with the soils of the west with their larger carbon stocks due to the concentration of livestock and return of effluents to the soil. Forest soils also contribute to carbon storage.

### *A reservoir for biodiversity*

Soil organic matter also consists of microbial biomass. A soil contains several thousand animal species and as many as hundreds of thousands of bacterial species and fungi, which provide a formidable biodiversity reservoir. Soil microbial biomass is highly dependent on land use and associated cultivation / forestry practices. Grasslands contain more abundant microbial biomass than forests with variability depending on species (Hardwoods> Conifers). Monocultures, orchards and vines are characterised by the soils with the least abundant biomass.

### *Chemical fertility of soils*

Soil provides the essential nutrients for plant growth, in particular nitrogen (N), phosphorus (P) and potassium (K). When their content is depleted in cultivated soils, the use of mineral or organic fertilisers (manure, slurry, etc.) is necessary. Nevertheless, when used to excess, N and P combine with water either in dissolved form (mainly N), or attached to soil particles (mainly P) and contribute to eutrophication. Nitrogen can also cause air pollution problems, with $NH_3$ as a precursor of particles. In France, agricultural production systems requiring large amounts of nutrients and chemical and / or organic fertilisation is systematic. N levels used, are moreover, constantly in excess of plant needs. For P, the soils of certain regions (Brittany, Nord-Pas-de-Calais, Alsace) contain large quantities (because of the widespread contribution of livestock effluents and metallurgy slag). Conversely, P levels are low in most cantons in many regions: Aquitaine, Burgundy, Centre, Franche-Comté, Languedoc-Roussillon, Limousin, Lorraine and Midi-Pyrenees. These levels are insufficient to ensure adequate yields without fertiliser, regardless of crop type.

### *Soil pollution due to human activity*

Agricultural soils are a particularly important issue because they are subject to many changes (inputs of livestock effluents, sludge, compost etc.) and can affect human health directly or indirectly or via transfers in produced food. For example, animal waste is the leading cause of metals in agricultural soils, because of the dietary supplements used in cattle, pig or poultry farming. Mineral fertilisers are a major source of Cadmium, Chromium and Selenium.

Moreover, some of the pesticides used on crops are transferred into the environment via the atmosphere, in water or retained in the soil and its organic matter. This is the case of Lindane, which was used for 50 years but is considered toxic for humans and the environment, and has a degradation period of more than 40 years. Chronic contamination of soils, waters and ecosystems by Chlordecone in the West Indies is an environmental, health and economic problem (it was used more than twenty years ago to control the banana weevil, a pest insect). Chronic soil pollution affects nearly one fifth of the utilised agricultural area of Guadeloupe and two fifths in Martinique.

Finally, metals (cadmium, lead, etc.) and metalloids (boron, arsenic, etc.) are naturally present in soils. Discharges from industry, households, transport or agriculture contribute to diffuse metal contamination in soils. They are toxic at varying doses for humans, fauna and flora, and can therefore contaminate ecosystems via food chains (livestock) and water resources.

En kg

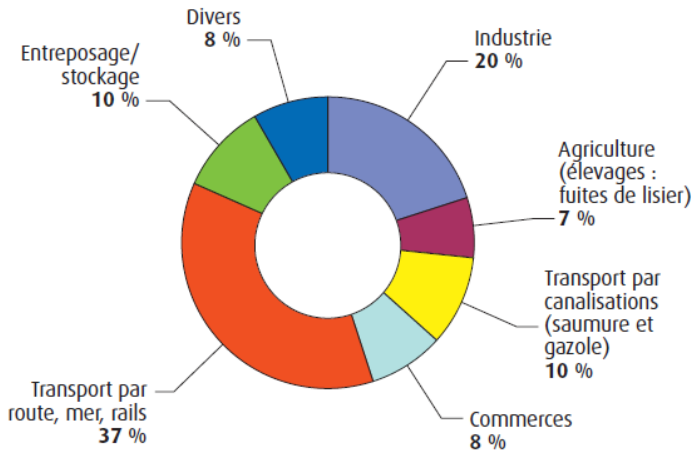
| Famille de polluants | Polluant | Secteur | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Bois, papier, carton, imprimerie | Construction | Eau, déchets et dépollution | Industries agroalimentaires | Industries chimiques et pharmaceutiques | Tertiaire et services | To |
| **Alkylphénols** | Nonylphénols | | | 38 | 1 | | | |
| **Azote total (N)** | | 121 608 | 52 886 | 1 651 791 | 805 109 | 221 992 | 311 628 | 3 165 |
| **Biphényles polychlorés (PCB)** | | 7 | | 9 | | 1 | 1 | |
| **Phosphore total (P)** | | 64 302 | 76 003 | 1 988 434 | 551 963 | 21 555 | 279 317 | 2 981 |
| **Métaux et leurs composés** | | 810 728 | 74 368 | 1 219 872 | 566 675 | 160 596 | 153 501 | 2 985 |
| Aluminium (Al) | | 545 640 | | 14 524 | | | | 560 |
| Arsenic (As) | | 185 | | 209 | 292 | | 59 | |
| Cadmium (Cd) | | 170 | | 50 | 15 | | | |
| Chrome (Cr) | | 4 417 | | 3 872 | 637 | 211 | 475 | 9 |
| Chrome hexavalent (Cr) | | 35 | | 56 | | | | |
| Cuivre (Cu) | | 20 075 | 389 | 26 697 | 4 842 | 1 473 | 2 849 | 56 |
| Fer (Fe) | | 138 172 | 72 840 | 1 085 102 | 121 779 | 155 721 | 140 306 | 1 713 |
| Manganèse (Mn) | | 34 047 | | 2 246 | 152 962 | | 1 642 | 190 |
| Mercure (Hg) | | 15 | 2 | 100 | 4 | | 15 | |
| Nickel (Ni) | | 2 296 | 31 | 2 354 | 565 | 181 | 354 | 5 |
| Plomb (Pb) | | 12 947 | 79 | 8 019 | 527 | 22 | 714 | 22 |
| Titane (Ti) | | 5 427 | | 210 | | | | 5 |
| Zinc (Zn) | | 47 302 | 1 027 | 76 432 | 285 052 | 2 988 | 7 087 | 419 |

*Note : il s'agit des masses émises supérieures aux seuils de déclaration réglementaires, déclarées par les ICPE soumises à la déclaration annuelle de polluants. Les stations d'épur traitent exclusivement les eaux résiduelles domestiques ne sont pas des ICPE et sont donc exclues de cette déclaration. Les stations de type ICPE sont soit des installations colle traitement d'effluents industriels (dont au moins une installation industrielle est une ICPE soumise à autorisation) soit des stations mixtes (stations traitant des eaux résiduaires dom et industrielles à partir de certains seuils).*

Source : DGPR, registre national des émissions polluantes et des déchets. Traitements : SOe

*Tableau 5: Emissions of pollutants into the soil in 2011, declared by the ICPE. Source: The environment in France, edition 2014*

Human activity, mainly industrial, can cause localised pollution: accidents during handling or transportation of pollutants, poor confinement of toxic products on industrial sites, fallout of fumes from factory chimneys. These polluted sites and soils, which can result from current or old activity, are a real or potential risk for the environment and human health in accordance with the uses that are made of them.

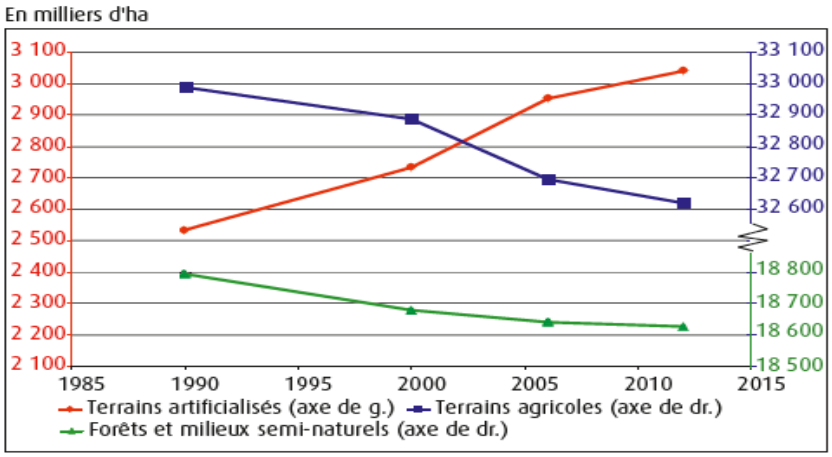



Source : DGPR/Barpi, base Aria, octobre 2012. Traitements : SOeS, 2013.

*Source: The environment in France, edition 2014*

*Figure 24: distribution of sectors or activities causing soil-contaminating incidents in 2011*

Artificialised soils, including built, paved and stabilised soils (forest and agricultural tracks, roads, car parks, etc.) increased by 490,000 ha between 2006 and 2014, or 60,000 ha per year on average, at the expense of agricultural soils mainly, totalling 9.3% of the metropolitan territory in 2014.




*Note : la superficie des terrains métropolitains artificialisés est passée de 2,5 Mha en 1990 à 2,7 Mha en 2000. Dans le même temps, celle des terres agricoles est passée de 33,0 Mha à 32,9 Mha.*

Source : UE – SOeS CORINE Land Cover

*Figure 25: evolution in total surface area by type of use 1990 - 2012. Source: CGDD, Update on land use in France, No. 219, December 2015.*

49 % of artificialised land between 2006 and 2014 was used for housing (the vast majority of which, 46%, was for private housing), 20% for transport networks (16% for roads), and the remainder divided among other economic and leisure activities 31%[37]. When analysed in terms of sealed soils (built, groomed or paved), the housing share is lower: 34% vs 28% for transport networks and 38% for other economic and leisure activities. In fact, lawns and gardens represent 57% of new land in private housing.

The loss of agricultural land is greater in the south-east of France, where agricultural abandonment is increasing (the regions of Languedoc-Roussillon and Provence-Alpes-Côte d'Azur have structurally weaker agricultural land) and where the growth of private housing has increased the most.

Part of the abandoned agricultural land has been transformed into natural areas (brownfields, woodlands, etc.), which explains why natural surfaces (woods, heaths and brownfields, etc.) have remained relatively stable over time.

### *Soils vulnerable to wind and water erosion, landslides and compaction*

Wind and water erosion cause soil loss: they truncate the surface soil (the most fertile), reducing its thickness (and therefore the amount of water it can retain). Soil losses are observed in certain regions (the silty agricultural soils of the Paris and Aquitaine basins and the Piedmont and Mediterranean areas in particular) and eventually threaten agro-ecological systems. Soil erosion due to water has caused 1.5 t/ha/yr of soil loss on average[38]. Some cultural practices have been identified as causing soil erosion (lack of soil cover in winter for example), as well as compaction (use of agricultural machinery, for example).

Compaction is mainly due to mechanisation in agriculture and forestry. It depends on the soil, the climate and farming practices. In addition to declining production, soil compaction promotes nitrate leaching, nitrous oxide emissions, runoff and erosion. It also affects soil biodiversity.

Landslides occur during the displacement of destabilised soils or rocks caused by natural climatic, geomorphological or geological phenomena, or by human activity. All of France's regions are sensitive to landslides and subsidence, although there are significant disparities between territories.

37 Agreste, 2015. Agreste Primeur No.326, Use of the territory.
38 DGEC, 2014. The environment in France, edition 2014.

| | |
|---|---|
| **Transport** | • Consumption of agricultural and natural spaces, artificialisation and soil sealing,<br>• Pollution from metals, metalloids and hydrocarbons. |
| **Residential-Tertiary Sector** | • Consumption of agricultural and natural spaces, artificialisation and soil sealing,<br>• Pollution from metals and metalloids |
| **Agriculture** | • Artificialisation;<br>• Excessive phosphorus and nitrogen inputs;<br>• Decrease in organic matter content of soils;<br>• Diffuse pesticide contamination;<br>• Pollution with metals and metalloids (via fertiliser applications);<br>• Stimulation of bacterial resistance (input of antibiotics via fertiliser application). |
| **Forestry - Wood - Biomass** | • Soil compaction related to the use of forestry machinery;<br>• Decrease in organic matter content of soils (in the case of mass export of forest residues). |
| **Industry** | • Artificialisation and soil sealing;<br>• Pollution from metals, metalloids and hydrocarbons. |
| **Energy production** | • Artificialisation and soil sealing;<br>• Pollution from metals, metalloids;<br>• Potential additional tension brought about by the use of utilised agricultural area for the development of solar photovoltaic or the production of biomass energy (CIVE, biofuels, etc.);<br>• Pollution related to the management of nuclear waste and the decommissioning of nuclear power stations. |
| **Waste** | • Pollution from metals and metalloids |

*Table 6: Threats and pressures on soils and subsoils by sectors*

## Trends and future outlooks: growing awareness but a persistent rate of artificialisation

*The absence of a global framework and a sub-thematic approach (carbon storage, artificialisation, resources, etc.)*

Taking account of the soil resource first requires a better knowledge of it. The IGCS Program (Inventory, Management and soil conservation) managed GIS Sol[39], seeks to identify, define and locate the main soil types in a region or territory, and to characterise their properties of interest to agriculture and the environment.

The draft framework directive on soil protection was a draft European directive of the European Parliament and the Council proposed by the commission on 22 September 2006 and adopted on its first reading on 14 November 2007 by MEPs. It aimed to fight against soil regression and degradation on a European scale. This directive has, however, been withdrawn because of the opposition of several Member States which claimed that they already had regulatory tools to combat soil pollution.

The 4 for 1000 initiative, launched by France, involves pooling the efforts of all public and private sector voluntary actors (States, local authorities, companies, professional organisations, NGOs, research institutions, etc.) under the framework of the Lima-Paris action plan. This research program focuses on carbon sequestration in soils, with the objective of reconciling "food security and the fight against global warming". Its name comes from the following calculation: if the organic C in soil increased by 4/1000 a year, this would offset current global greenhouse gas emissions.

The Biodiversity Plan of July 2018 provides for a future target of zero net artificialisation. The Grenelle 2 law provides for the protection of natural, agricultural and forest areas and indicates that this protection must be among the objectives of territorial coherence schemes (SCOT). The Agricultural Modernisation Law (AML) of 2010 provides for a 50% reduction in agricultural land consumption by 2020, a more reasonable goal, largely

39 https://www.gissol.fr/

taken up by local and regional authorities. The roadmap for the ecological transition, published in 2012, indicated that it wished to curb the artificialisation of soils to achieve stability by 2025, with an 80% reduction in 2035 and a halt beyond that. At European level, the objective is to bring it to an end in 2050.

*Trends and future outlooks: the ongoing artificialisation of soils and the risks related to climate change*

Land artificialisation is mainly reflected in the loss of agricultural land. These losses have declined in recent years, from 114,000 hectares of farmland lost between 2006 and 2008 to 42,000 hectares between 2010 and 2012[40]. This fall is attributable to the drop in activity in the construction and public works sectors and to the effects of town planning policies stemming from the Grenelle Environment Forum Program. Nevertheless, between 2012 and 2014, these losses amounted to 80,000 ha per year on average. The CGDD has undertaken some prospective work: "*Sustainable Territories 2030*" outlining several forecast scenarios. According to the scenarios, the surface losses of farmland linked to an urban growth range from 4-6% (of the current land area) for the territorial cooperation and high metropolitanisation scenarios, to 35% for an urban exodus scenario and relocation of countryside activities by 2030.

Higher temperatures and atmospheric $CO_2$ levels, lower average precipitation, increased frequency and magnitude of extreme events are all effects of climate change in France that could degrade soils. The increase in frequency and magnitude of extreme events also poses a significant risk of increasing wind erosion and decreasing soil water resources.

## 2.2.3. Subsoil resources

### Initial state

France remains highly dependent on imports of mineral energy resources (fossil fuels: oil, gas or coal): they currently represent 0.02% of the world's resources - compared to just over 2% of total primary energy consumption. The already low stocks in its subsoil are almost completely depleted and cover only an infinitesimally small part of its needs. Additionally, the exploitation of French fossil resources must stop by 2040, as announced in the Climate Plan of 4 July 2017.

French non-energy mineral materials are particularly sought after because of their integration in transport infrastructure and equipment, housing and various consumer goods (household appliances, computers, etc.), energy production tools (nuclear, wind, solar), the technical equipment of the productive apparatus and agriculture (nitrogen, phosphorus, potassium hydroxide, etc.).

Non-metallic mineral materials extracted from the subsoil include various materials (clay, gravel, sand, slate, limestone, chalk, dolomite, granite, sandstone, gypsum, marble, etc.). The total extraction of these materials was about 370 Mt in France in 2012, covering slightly more than 90% of non-metallic mineral needs[41]. The extraction of sand and gravel represents a little over 90% of all these mineral resources. These materials are mainly used in the building and public works sector.

The extraction of ferrous and non-ferrous minerals almost ceased in France in the early 2000s. Only two bauxite operations remain, for cement production. Also, in order to meet its needs (extraction in the territory + imports), amounting to 51 Mt in 2012, France is almost entirely dependent on its imports.[42]

| | |
|---|---|
| **Transport** | • Consumption of fossil resources, and of non-energy mineral resources (metallic and non-metallic), particularly in the context of the development of electric mobility and alternative fuels (batteries of electric vehicles). |
| **Residential-Tertiary Sector** | • Consumption of fossil and non-energy mineral resources (metallic and non-metallic) |
| **Agriculture** | • Consumption of fossil resources and non-energy mineral resources for synthetic fertilisers |
| **Forestry - Wood - Biomass** | • Consumption of fossil resources |

40 Agreste, 2014. *Land use in Metropolitan France,* Agreste Primeur, No. 313, June 2014.
41 CGDD (2014). The environment in France, 2014.
42 Ibid.

| | |
|---|---|
| **Industry** | • Consumption of fossil and non-energy mineral resources (metallic and non-metallic) |
| **Energy production** | • Consumption of fossil resources and of non-energy mineral resources (metallic and non-metallic), for example: the development of renewable energies is likely to lead to increased use of certain rare metals such as indium, selenium or tellurium, used for part of high-performance photovoltaic panels.<br>• Tension in relation to the world's uranium resources for nuclear production |
| **Waste** | • Landfill-related pollution. |

*Tableau 7: Threats and pressures on subsoils by sectors*

### Trends and prospects for development

The preservation of subsoil resources involves the development of the circular economy. The "Circular economy brochure: the successes of the energy transition law for green growth" is a contribution, summarizing progress to date, to the establishment of the national strategy for transition to the circular economy. It also sets up the "2025 waste reduction and recovery plan" and is fully in line with the essential aim of making progress in applying the waste treatment methods hierarchy. In December 2015, the European Commission also published an ambitious "Action Plan", consisting of a large number of actions to be rolled out during 2016-2018 on different work themes related to the circular economy (definition of objectives and waste prevention and management plans, implementation of a European plastic waste strategy, fight against food waste, etc.). France is focusing in particular on recycling metals to ensure production in an area where it has insufficient provision. Thus, 1.79 Mt of non-ferrous metals were recycled in 2016 and 12.1 Mt of ferrous scrap was collected in 2016[43].

The trend scenario is a prolongation of current trends, as described in the State of the Environment (2014):

- The ongoing artificialization of the soil (today 10%, which would rise to 14% in 2050)
- Aggravation of the physicochemical changes of the related soils
- Development of recycling and bio-based materials, but mineral and fossil resources in the subsoil continue to decline.

## 2.3. Natural environments

This part addresses the environmental themes of the natural environment, namely biodiversity and natural habitats, with a focus on the Natura 2000 network. Ecosystem services and landscapes are also discussed.

Generally, the initial state of the natural environment in France is strongly influenced by its interconnections with the surrounding natural environments, as well as at other levels: continental or global. However, in line with the national scale of the SNBC, the condition, threats and measures put in place at the French level are prioritised here. For European and world level monitoring, it is possible to refer, respectively, to the work of the European Environment Agency and the Convention on Biological Diversity.

### 2.3.1. Biodiversity and natural habitats

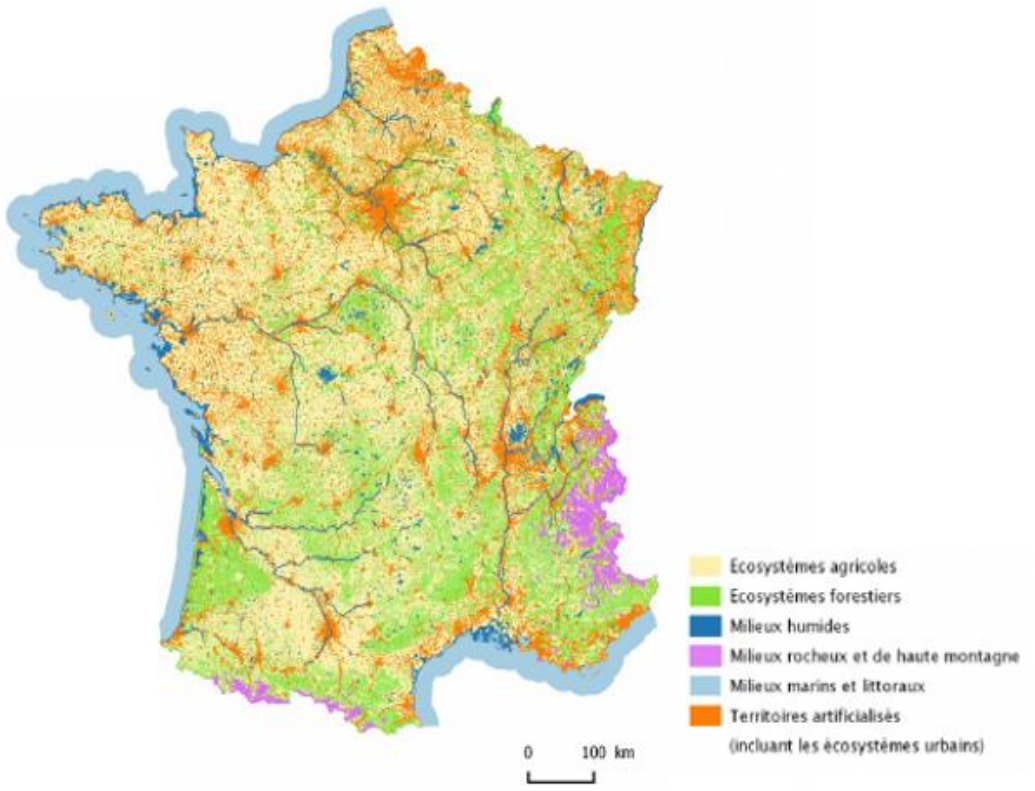
#### Initial state: exceptional but threatened diversity

*Exceptional diversity of natural habitats*

The territory of Metropolitan France, with its large surface area (550,000 km²), significant variations in latitude, altitude, distance from the sea (climate diversification factors), its highly varied geology (soil diversification factor), not to mention human influences, hosts a wide variety of ecosystems. It has four biogeographical zones: Atlantic zone, continental zone, Mediterranean zone, mountain zone.

43 FEREREC, 2016, The recycling market in 2016, FEDEREC Statistical Observatory.

6 major types of ecosystems are found in France: forest ecosystems, agricultural ecosystems, urban ecosystems, wetlands, marine and coastal environments, rocky and high mountain areas (see map below). Some ecosystems are particularly emblematic, rare or threatened and require special attention: for example, seagrasses, wetlands, some agro-pastoral environments, cave environments, etc.




*Source: EFESE 2016, interim report (Mapping based on CORINE Land Cover data 2012 - GIP implementation by Ecofor)*

*Figure 26: Distribution of main types of EFESE ecosystems in metropolitan France*

*A rich genetic and species diversity as a result of the diversity of French geo-climatic conditions*

According to the National Inventory of Natural Heritage (INPN)[44], France hosts around 6,000 species of native vascular plants, which puts it close to three other Mediterranean countries: Spain (7,500 species), Italy (5,600 species) and Greece (5,000 species). 900 moss species and 1,700 algae species have also been recorded.

The fauna of metropolitan France is rich and diversified - characteristic of both the northern and Mediterranean regions of Europe. It is difficult to enumerate all the animal species in France, particularly because there is insufficient knowledge about invertebrates (there are at least 40,000 insect species). The number of vertebrate species is better known: About 1,500 species have been identified.

France is home to large populations of certain species, so it has major responsibility for European natural heritage. For example, 58% of bird species nesting in Europe breed in France[45].

However, for vertebrates, only about 15 species (about 1% of the world's species) are found in France. The number of invertebrates is also low. The rate of endemism is therefore low, except in Corsica, the Pyrenees and the Alps.

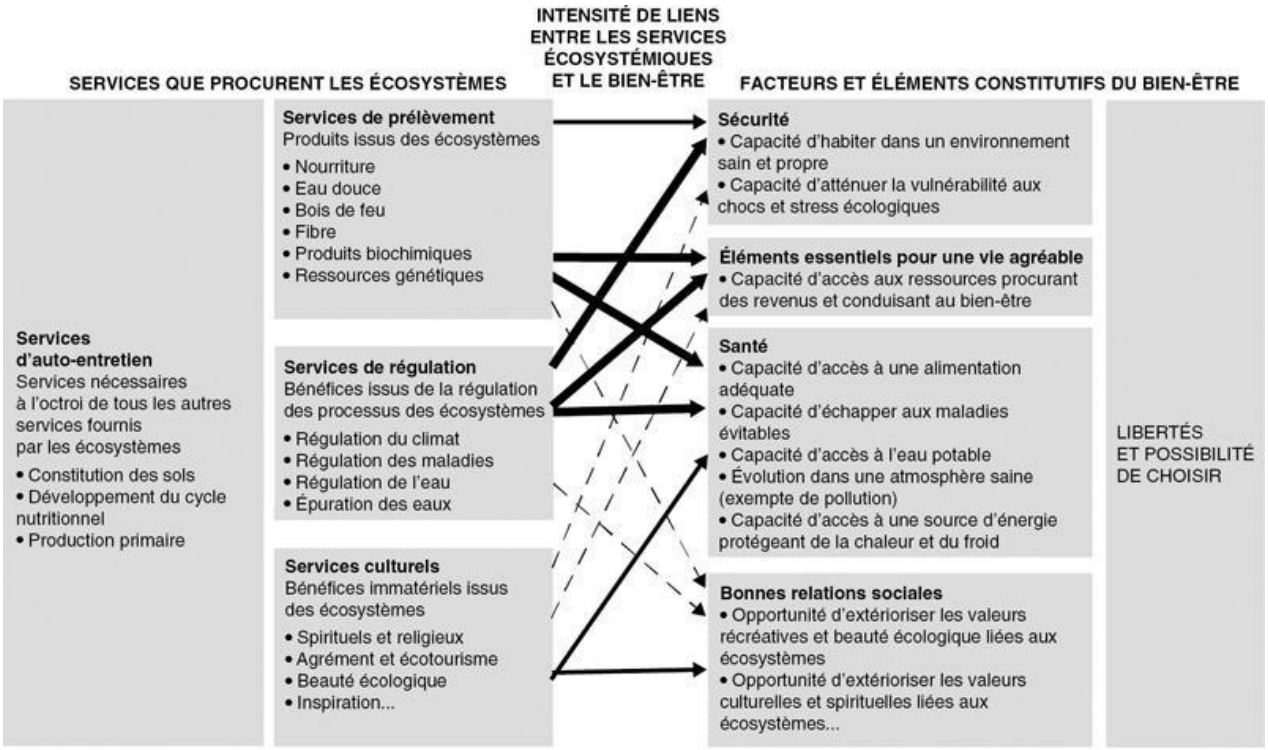
The degree of threat faced by most invertebrate species is unknown. For vertebrates, the situation varies greatly from one group to another. It is estimated that about 20% of indigenous vertebrates evaluated to date are threatened with extinction at the French level (according to the Red List of threatened species in France), ranging from 9% for mammals to 27% for birds.

44 https://inpn.mnhn.fr/
45 https://inpn.mnhn.fr/informations/biodiversite/france

The genetic heritage of species present in France is still poorly known, except for farmed breeds and cultivated or planted varieties, including old ones. Its diversity is however the condition of species adaptability in a changing environmental context and is an essential element of biodiversity.

### *Ecosystem services in France*

The expression "services provided" by ecosystems or ecosystem services was defined in the Millennium Ecosystem Assessment, a study coordinated by the United Nations Environment Program in 2005, as "the benefits that humans receive from ecosystems". The services provided to the population are sources of tangible or intangible benefits and of wellbeing for humans. They are the result of ecological functions provided by ecosystems (forests, grasslands, lagoons, coral reefs, etc.). The quality and effectiveness of these services depend on the general "good health" of natural environments, as well as on their surface area, location, degree of connectivity to other environments or the socio-economic context such as population density.




*Source: Méral and Pesche 2016, based on the Millennium Ecosystem Assessment (MEA, 2005)*

*Figure 27: Summary of interactions between ecosystem services and human wellbeing*

At national level, in 2012, the Ministry of Ecology initiated the "French Evaluation of Ecosystems and Ecosystem Services" (EFESE) Program, which brings together a series of assessments for better understanding and communication of the condition of French biodiversity and its multiple values so that they are better taken into account in public and private decisions.

*The diversity of remarkable French landscapes and everyday landscapes*

The remarkable landscapes of France bear witness to the diversity of semi-natural habitats, along with the cultural elements of the territory: historical elements, ancient practices, etc.

The everyday landscapes that surround us also contribute to the richness of the metropolitan landscapes. Their quality and diversity are a key issue for land use planning. They are vulnerable to several degradation elements (proliferation of peripheral commercial zones, urban sprawl and homogenisation of housing, etc.).

Two types of landscapes rub shoulders in France: more or less artificialised landscapes (artificialised rural areas, artificialised coastline, crop areas strongly marked by building, etc.) and natural or semi-natural landscapes (grasslands, forests, large open fields, etc.), as identified on the map below.

The pressures threatening these landscapes are many (degradation, standardisation, destructuring) and are attributable to many factors, such as the development of urbanisation; the evolution of agricultural practices; natural dynamics linked, for example, to the aging or abandonment of a site and the gradual disappearance of farms in abandoned areas; commercial tourism or over-frequentation, etc.

*Five main factors of pressure on biodiversity*

According to the 3rd report of the Secretariat of the Convention on Biological Diversity on the global biodiversity outlook[46], the 5 major causes of loss of global as well as national biodiversity are:

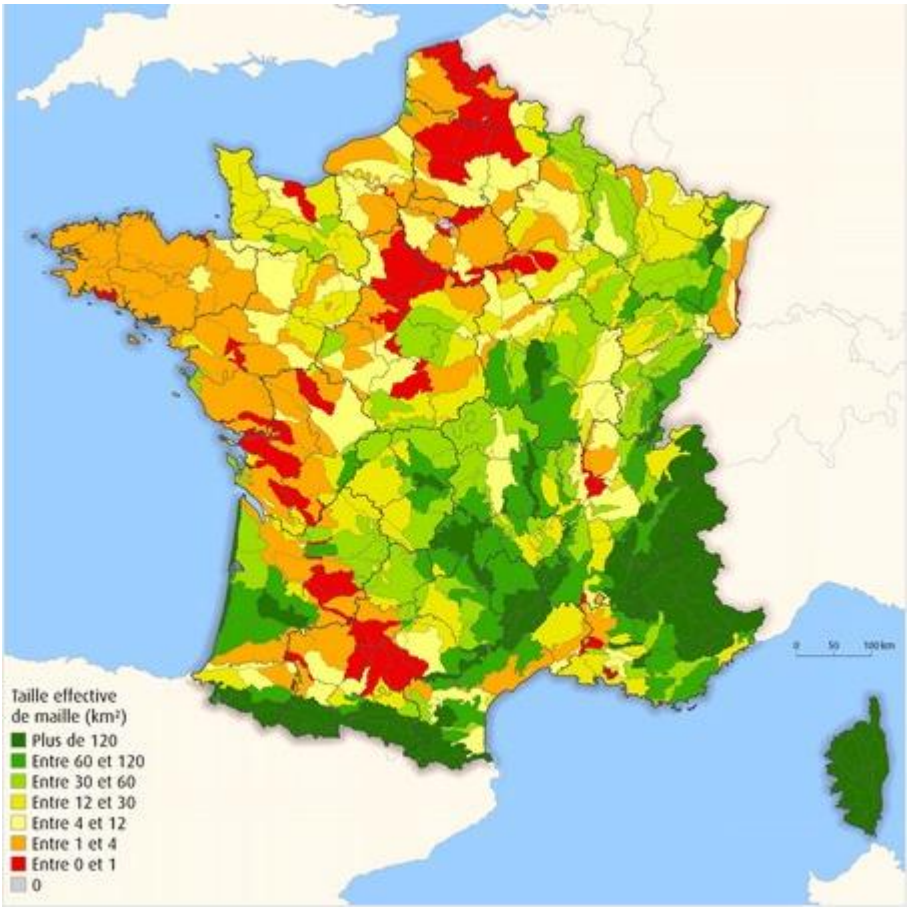
- The loss, degradation and fragmentation of natural habitats: according to the WWF[47], worldwide, the loss, degradation and fragmentation of natural habitats is the chief source of the threat of extinction of 85% of the populations evaluated in the report (3,430 populations). In inland water ecosystems, habitat loss and degradation are mainly due to the unsustainable use of water resources and the drying of land for conversion to other uses, such as agriculture and human settlement. Agricultural production is a major cause of the loss and degradation of natural habitats (crops or grasslands);
- Overexploitation of biological resources, the main pressure on marine ecosystems; from the beginning of the 1950s until the mid-1990s, fish catch volumes quadrupled. The total catch volume then decreased, despite increased fishing efforts, suggesting that many stocks are no longer able to recover (Secretariat of the Convention on Biological Diversity 2010);
- Pollution, especially the accumulation of nutrients: Nitrogen deposition is considered to be a key driving force behind specific developments in different ecosystems in temperate regions, especially the grasslands of Europe. In inland and coastal ecosystems, the accumulation of phosphorus and nitrogen, mainly from agricultural runoff and wastewater pollution, stimulates the growth of algae and certain types of bacteria, which jeopardises the provision of services by lake and coral ecosystems, causing a decline in water quality;
- The harmful effects of invasive alien species (IAS), non-native species, whose intentional or accidental introduction by humans, establishment and propagation, threaten native ecosystems, habitats or indigenous species with negative ecological, economic, environmental or health consequences. Climate change and acidification of the oceans, associated with the increase in greenhouse gases in the atmosphere;
- Climate change will have a certain impact on ecosystems through changes in the way they function: carbon stocks, tree mortality and loss of forest habitats, risks of invasion by invasive alien species (IAS)... and their quantity and distribution.

*Focus on a major challenge in France: the fragmentation of natural environments*

Surface depletion and splitting up of natural environments increase their fragmentation, a factor that often leads to loss of ecosystem functionality, linked in particular to population isolation and confinement.

46 Secretariat of the Convention on Biological Diversity, 2010. 3rd edition of the Global Biodiversity Outlook. Montreal.

47 WWF, 2014. Living Planet Report, publication 2014.




Accordingly, several animal or plant species may encounter difficulties in completing their life cycle or in adapting to climate change.

The fragmentation of the territory is measured in particular by the actual size of the networks of natural environments, i.e. the average network of non-fragmented natural areas. Metropolitan France had an actual network size of 99.97 km² in 2006 compared to 100.44 km² in 1990, reflecting increased fragmentation of natural environments (see map above).

The fragmentation of natural habitats may also affect rivers (to date, 76,800 validated obstacles out of an estimated 120,000 have been logged in the database managed by the National Office of Water and Aquatic Environments).

| | |
|---|---|
| **Transport / Residential-Tertiary / Industry** | • Loss or modification of natural habitats;<br>• Landscape fragmentation;<br>• Disturbance of species (visual and auditory);<br>• Risk of collisions;<br>• Pollution linked to maintenance of infrastructure verges (herbicides)<br>• Pollution linked to water flows<br>• Deterioration of landscapes<br>• Greenhouse gas emissions;<br>• Atmospheric pollution;<br>• Effects linked to the production of materials (extraction, processing, etc.). |
| **Agriculture** | • Loss or modification of natural habitats (meadows, hedges and isolated trees, etc.;<br>• Soil and water pollution caused by inputs (fertilisers, pesticides, etc);<br>• Soil disturbances (meadow conversion, composting, etc.);<br>• Modification of landscapes. |
| **Forestry - Wood - Biomass** | • Loss or modification of natural habitats (dead woods, old woods, etc.);<br>• Disturbance of species, visual and auditory disruption;<br>• Soil disturbances (meadow conversion, composting, etc.);<br>• Deterioration of landscapes. |
| **Energy production**[48] | • Loss and modification of habitats (notably hydroelectric energy, bio-energy and biofuels due to direct and indirect changes in soil use; the latter may be considered within the concept of the carbon footprint.);<br>• Mortality and trauma (notably wind energy, bio-energy and marine energy);<br>• Disturbance of biological behaviours (notably solar and wind energy);<br>• Competition for water use (notable hydroelectric and nuclear);<br>• Water and soil pollution;<br>• Chemical, noise and electromagnetic pollution in the case of installations in marine environments;<br>• Modifications to local micro-climates (notably solar energy and nuclear);<br>• Greenhouse gas emissions (methane and carbon dioxide emissions from reservoirs of hydroelectricity, bio-energy and biofuels, in certain cases);<br>• Atmospheric pollution (notably bio-energy and biofuels);<br>• Deterioration of landscapes. |
| **Waste** | • Water and soil pollution;<br>• Atmospheric pollution;<br>• Visual and auditory disturbances. |

*Table 8: Threats to biodiversity and pressures on natural habitats by sector*

## Trends and prospects for development: strong protective measures remain insufficient to slow down deterioration

### *Increase in protected areas*

France has an exceptional wealth of natural heritage to protect. According to the National Inventory of Natural Heritage, 13.7% of land in mainland France is covered by at least one of the following protective measures:

- Regulatory protection: orders issued by local prefectures regarding the protection of biotopes, untended nature reserves in national parks and core zones, biological reserves (whether tended or untended by the National Forests Office), regional nature reserves, national hunting and wild fauna reserves, townships affected by the "Coastline" law, and townships affected by the "Mountains" law.

48 FRB, 2017. Summary of "Renewable Energy and Biodiversity: implications for achieving a green economy", summary of article by Alexandros Gasparatos, Christopher N.H. Doll, Miguel Esteban, Abubakari Ahmed, Tabitha A. Olang. 2017. *Renewable and Sustainable Energy* Reviews 70, 161–184.

- Contractual protections: regional nature parks, peripheral zones around national parks and marine nature parks;

- Protection via property development management: coastline conservation areas, natural spaces conservation areas, sensitive natural spaces designated by individual Departments;

- Protections provided under European or International conventions and agreements: the Natura 2000 Network, wetlands with international importance (Ramsar sites), UNESCO biosphere reserves, the Bern convention.

The proportion of land area in mainland France classed as "protected areas" (high level of protection) has increased slightly in recent years, rising from 1.27% of land in 2011 to 1.35% in 2016[49].

*Protection of species in France*

At the international level, the CITES convention on international trade in species of wild flora and fauna threatened with extinction regulates the passage of some 35,000 plant and animal species across national borders. The objective of CITES is to guarantee that international trade in animals or plants (whether living or dead) listed in the appendices of the treaty, as well as parts thereof or products derived from them, does not impede biodiversity conservation and is based on sustainable use of wild species.

At the European level, Appendices I and II of the Habitats Directive (92/43/EEC) designate habitats and species, some of which are classed as priority cases in terms of conservation efforts, which require the designation of special conservation areas (See paragraph on Natura 2000). Appendix IV of this directive indicates the animal and plant species that must be the subject of strict protective measures, while the removal (hunting, picking, harvesting) of species listed in Appendix V must be regulated.

At the national level, Article L. 411-1 of the Environmental Code outlines a strict protection system for species of wild flora and fauna listed in the ministerial order. In particular, the capture, transport or intentional disturbance of these species is prohibited. These bans may be extended to habitats of protected species, and regulatory texts can allow for bans on the destruction, deterioration or alteration of such habitats. Failure to adhere to these rules can lead to criminal penalties, as outlined in article L. 415-3 of the Environmental Code.

The National Action Plans aim to define necessary actions for the conservation and restoration of the most at-risk species. This biodiversity protection tool has been in use in France for the last 15 years. The plans were reinforced following the Grenelle de l'Environnement lawmaking conference.

Finally, the 2011-2020 National Biodiversity Strategy aims to incite a major commitment from various stakeholders at all territorial levels, both in mainland France and in overseas territories, in order to achieve the objectives set. It establishes the shared ambition to preserve and restore, enhance and galvanise biodiversity, ensuring sustainable and equitable use of natural resources by successfully guaranteeing the involvement of all stakeholders across all sectors. Six additional strategic directions have been identified:

A. Generate desire to take action for biodiversity
B. Preserve living things and their ability to evolve
C. Invest in the common good and ecological capital
D. Ensure sustainable and equitable use of biodiversity
E. Ensure coherence between policies, and effectiveness of actions taken
F. Develop, share and enhance knowledge on the subject.

*Implementation of Green and Blue belts*

In order to combat the fragmentation of natural environments, France's national and local governments are contributing to the implementation of a green and blue belt, at various levels of public action. These belts are formed by terrestrial and aquatic ecological continuities, i.e. Biodiversity reservoirs and corridors (articles L. 371-1 and R. 371-19 of the Environmental Code). They are indexed in various planning documents.

Law no. 2010-788 of 12 July 2010 on the national commitment to the environment outlines the development of national positions on the preservation and restoration of ecological continuities, which must be taken into account in regional ecological adherence plans, co-developed between the regional governments and the State. Planning documents and projects carried out at the national level, in particular the State's major linear infrastructures and public establishments, must be compatible with these national positions. The first French SRCE (Regional Climate and Energy Plan) was approved by the Regional Council of Île-de-France on 26

49 Observatoire national de la biodiversité / French National Observatory on Biodiversity, 2016 data.

September 2013. As of 2016, all French regions had adopted their own SRCE. These SRCEs must now be integrated into Regional Schemes for Organisation, Sustainable Development and Inter-regional Equality (SRADDETs), which are currently being drawn up in all French regions.

*Measures and actions to preserve natural landscapes*

A number of measures exist to preserve and enhance remarkable landscapes, which in regulatory terms are identified and recognised through measures such as the "Grands Sites de France" scheme, registered and classified sites, UNESCO world heritage sites, etc.

The regulatory establishment of a compendium of such landscapes in each Department enables the identification, qualification and characterisation of all the landscapes within a given area, in order to contribute to the acquisition of new knowledge, raise awareness among stakeholders and make appropriate decisions regarding territorial development.

*Various trends in the evolution of pressure on biodiversity*

| | Destruction et fragmentation des habitats | Pollutions | Surexploitation des ressources biologiques | Changement climatique | Espèces exotiques envahissantes |
|---|---|---|---|---|---|
| Écosystèmes forestiers – Métropole | → | ↘ | → | ↗ | ↗ |
| Écosystèmes forestiers – Outre-mer[3] | → | → | → | ↗ | ↗ |
| Écosystèmes agricoles | ↗ | → | → | ↗ | ↗ |
| Écosystèmes urbains | ↘ | → | → | ↗ | → |
| Milieux humides | ↗ | ↘ | → | ↗ | ↗ |
| Milieux marins – Manche, Mer du Nord et Atlantique | ↗ | → | ↘ | ↗ | ↗ |
| Milieux marins – Méditerranée | ↗ | → | → | ↗ | ↗ |
| Milieux marins – Outre-mer | → | ↗ | → | ↗ | ↗ |
| Littoral | ↗ | → | → | ↗ | ↗ |
| Zones rocheuses et de haute montagne | → | → | → | ↗ | → |

*Clé de lecture : Les informations rapportées dans ce tableau visent à faire ressortir les impacts actuels (niveau) et à venir (tendance) les plus significatifs au niveau national pour les différents écosystèmes. Les éléments rapportés sont établis à dire d'experts en ayant recours, autant de possible à des données documentées. Les données mobilisées pour étayer ces choix sont reportées dans la section 3.1.*

*Figure 29: Relative importance (colour) and current developmental trends (arrow) of the presumed impact of various change factors in the general development of biodiversity within French ecosystems (Source: EFESE 2016, intermediary report).*

At the national level, the five direct change factors contribute to altering biodiversity to various degrees across all French ecosystems. The table below summarises the significance of the ecological impacts associated with these factors within various ecosystems, and the current trajectory of their development.

*Decline in ordinary biodiversity, and sustained levels of exceptional biodiversity within conservation islands*

There is currently no modelled and quantified scenario for the evolution of the state of biodiversity at the national level over the coming years. However, it is possible to define a baseline scenario based on the trend-based scenario developed during the "Biodiversity and Regions 2030" collective forecasting exercise.

In the trend-based scenario, the environment is considered a second-rank policy; environmental regulation is stronger but rulings still tend to favour socio-economic concerns. The resulting projections for 2030 show a drop in ordinary biodiversity due to environmental fragmentation and artificialisation, but also an increase in generalist species, which are the only ones capable of resisting increasing artificialisation. Exceptional biodiversity will be sustained within a few conservation islands.

**Box 7: Summary of impacts in the trend-based scenario on biodiversity and natural habitats**

The trend-based scenario is based on the continuation of trends in ecological pressures, as described in the report on the state of biodiversity compiled by the French National Observatory on Biodiversity in 2017:

- The destruction, deterioration or normalisation of natural habitats continues (with 67,000ha destroyed on average each year via artificialisation in mainland France);
- The increase in invasive exotic species in mainland France continues at a rate of at least six additional species per department every ten years, as has been the case for the past 30 years;
- Pollution continues to negatively affect biodiversity, with contrasting developments (decrease in pollution of waterways by nutrients and pesticides);
- Demographic pressure persists, notably along coastlines;
- The effects of climate change are becoming more and more acute: frost, which has a very significant impact on species, is becoming less frequent; glaciers in mainland France are shrinking, etc.

The rate of biodiversity deterioration is holding steady, for example,

- in specialist bird species (e.g. losses of between -9% and -32% of common specialist bird populations between 1990 and 2015). In generalist species, the situation is more contrasting;
- for threatened mammal species: in 2017, 33% of terrestrial species and 32% of marine species were listed as under threat or at-risk, up from 23% and 25% respectively in 2009.

A few individual cases of trend stabilization or improvement have also been observed: for example, coral reefs or some threatened species are showing more favourable results (monk vulture, Eurasian spoonbill, Iberian ibex, greater horseshoe bat, etc.).

The 2017 report compiled by the French National Observatory on Biodiversity[50] confirmed these trends. In terms of species, this report shows a drop of almost a quarter (-23%) in the number of common birds sensitive to ecosystem deterioration between 1989 and 2015; this was also the case for almost half (-46%) of bat populations between 2006 and 2014. Around a third (31%) of species evaluated under the UICN-MNHN Red List are under threat, with significant disparities between groups of species. As of 2016, 5% of the territory of mainland France was affected by the presence of a large predator (wolf, lynx, bear).

Regarding habitats and natural environments, the situation is not much more encouraging. Over half of wetland habitats (52%) and less than half of surface waters (43%) are in a healthy state, while only 22% of all natural environments of European interest are deemed to be in a healthy state of conservation. Monitoring stations report that two thirds (64%) of coral reefs were stable or in a state of improvement. The loss of surface area of natural environments in exceptional nature sectors (ZNIEFF) in mainland France stood at -36,749ha between 1990 and 2012.

As regards agricultural territory – which represents half of the land in mainland France – large planted spaces fell significantly, by -7.9% between 2000 and 2010 and -3.3% between 2010 and 2013, while the status of the 12% of meadows, woods and heaths in agricultural areas, which were also under pressure but still present in 2012 (first assessment carried out in 2015 by the ONB), is not yet known.

## 2.3.2. Natura 2000 network

### Baseline status: A solid network with 1758 sites in France

The Natura 2000 network is made up of European nature zones, both terrestrial and marine, which have been identified due to the rareness or fragility of their natural habitats and wild species of plants or animals. Natura 2000 sites are covered by two European directives:

- The "Birds" Directive (directive 2009/147/EC of the European Parliament and Council of 20 November 2009), outlining the designation of Special Protection Zones (SPZs) for the conservation

50 French National Observatory on Biodiversity, 2017 data. 2017 Report on the state of biodiversity in France

of wild bird species listed in Appendix 1 and regularly-appearing migratory species not listed in Appendix 1, as well as the habitats necessary to their survival;

- That "Habitats" Directive (Council directive 92/43/EEC of 21 May 1992) outlining the designation of Special Conservation Zones (SCZs) whose aim is to facilitate the conservation of the types of natural habitats and animal or plant species listed in Appendices I and II.

The Natura 2000 network covers up to 18.4% of land in the European Union: 5491 sites are classed as Special Protection Zones for birds (SPZs), 22, 594 sites are classed as Special Conservation Zones (SCZs). 233 habitats, 1563 animal species and 966 plant species are recognised as being of Community interest.

In France, 1758 terrestrial sites are listed, of which 392 fall under the Birds directive and 1366 are covered by the Habitats directive. They cover 12.6% of landmass, and are notably spread over 30% of agricultural land, 32% of forests and 16% of heaths and open landscapes – areas which may potentially be affected by biomass mobilisation activities.

Threats and pressures on these sites are identical to those indicated in the "Biodiversity and natural habitats" topic (See table above showing corresponding threats and pressures).

## Trends and prospects for development: conservation status struggling to improve

*Measures and actions implemented:*

The implementation, as well as the maintenance or re-establishment, of conservation status for these sites is an obligation for France with regard to the European Commission. The aim is to enhance biodiversity by ensuring the maintenance or re-establishment of conservation status favouring natural habitats and Community interest species.

Each Natura 2000 site is overseen by a director designated during the site's creation. A steering committee, made up of representatives of stakeholders for the site, monitors the application of regulations and proper management of the site. The "Objectives" document reports on the state of affairs for the site and establishes management objectives for the conservation of natural heritage, as well as public information and awareness campaigns. Natura 2000 contracts are drawn up with various stakeholders for each site. These define the nature and terms of governmental aid available, as well as services to be provided in return by the recipient.

*Government assessment of the state of habitat and species conservation*

In addition to the designation and preservation of Natura 2000 sites, the Habitats-Fauna-Flora Directive (92/43/EEC) and Birds Directive (2009/147/EC) require Member States to carry out regular assessments of the status and trends of species and habitats classed as being of Community interest. These evaluations are carried out every seven years by each country; France's last evaluation was in 2013.

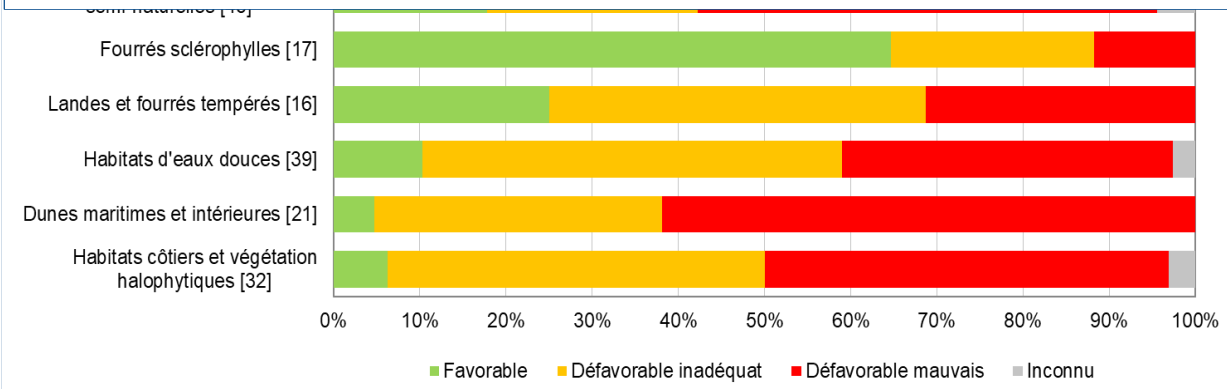
As defined in the Directive, the global objective to be achieved is a favourable conservation status for all types of habitats and all Community interest species. This status may reflect a thriving location, habitat type or species (based on qualitative and quantitative criteria), in which prospects for the vitality of species populations or habitat structures are favourable, and in which the ecological elements intrinsic to host ecosystems, or the geoclimatic conditions for its habitats, are favourable. The evaluation is carried out across Europe based on a common protocol.

For habitats analysed during the latest evaluation in 2013, the global state of conservation remained the same as in the previous evaluation (2007): only a fifth of evaluations found a favourable habitat status (See graph below). Broken down by type of environment, the most-affected areas were peat bogs, wetlands, agro-pastoral areas and coastal habitats. Conversely, sclerophyll thickets (populated by bushes and undergrowth typical of Mediterranean landscapes), as well as rocky environments and caves, are well-preserved. Heaths, scrublands and forests showed slightly improved status.

**Box 8: Impact summary of the trend-based scenario on the Natura 2000 Network**

The trend-based scenario is based on the continuation of current trends described in the last European report exercise assessing the conservation status of community interest habitats and species (Habitats-Fauna-Flora Directive, article 17) and on the scale of the Natura 2000 sites (article 5 of the same Directive).

The conservation status of Community interest natural habitats and species is stable, but insufficient: developments over the 2007-2012 period show that only 22% of Community interest natural habitats and 28% of Community interest species (aside from birds) enjoy healthy conservation status in France. These figures are similar to those documented in 2001-2006.

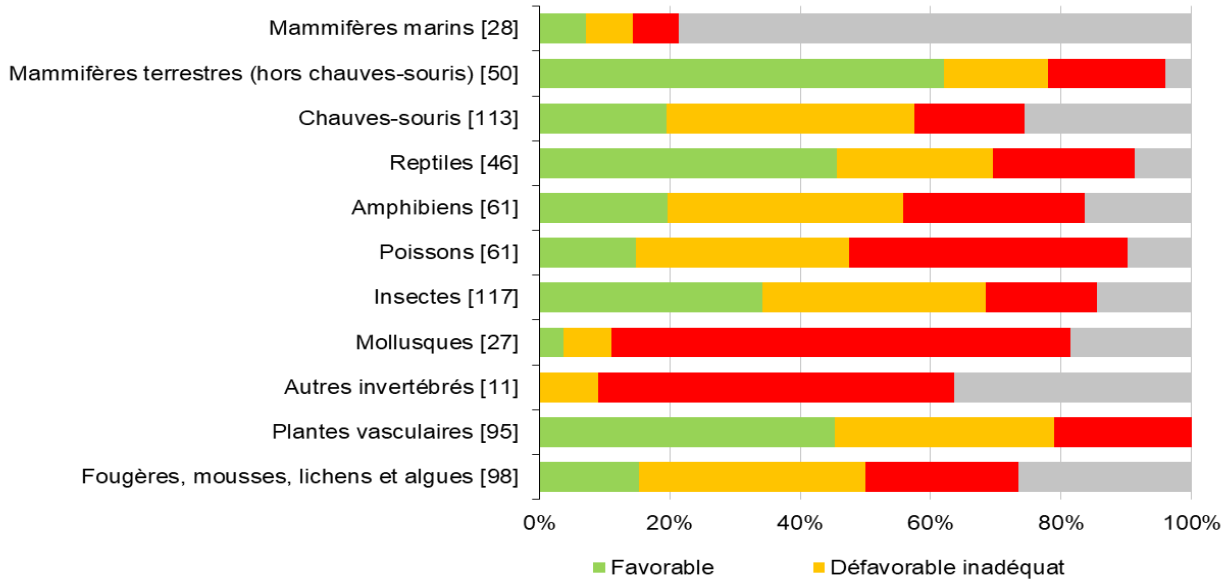



**Note** : Les nombres entre crochets indiquent le nombre d'évaluations réalisées. Résultats toutes régions biogéographiques confondues.
**Source** : MNHN (SPN), 2013. Traitements : MNHN-SOeS.

*Figure 30: Conservation status of Community interest habitats by wider environment type (2007-2012 period) - Source: MNHN (SPN), 2013.*

Elsewhere, over half of the species assessments showed an "unfavourable" conservation status (31% inadequate and 24% poor), while 27% were in a "favourable" state and 18% were "unknown." The latter category mostly refers to marine species, lichens and certain species of invertebrates.

## 2.4. Human environments




**Note** : Les nombres entre crochets indiquent le nombre d'évaluations réalisées. Résultats toutes régions biogéographiques confondues.

*Figure 31: Conservation status of Community interest species by taxonomic group (2007 – 2012 period). Source: MNHN (SPN), 2013, processed by: MNHN – SDES*

This section deals with environmental topics in human-inhabited areas, i.e. natural and technological risk factors, pollution (atmospheric, noise and light), human health, and architectural, cultural and archaeological heritage.

## 2.4.1. Natural and technological risks

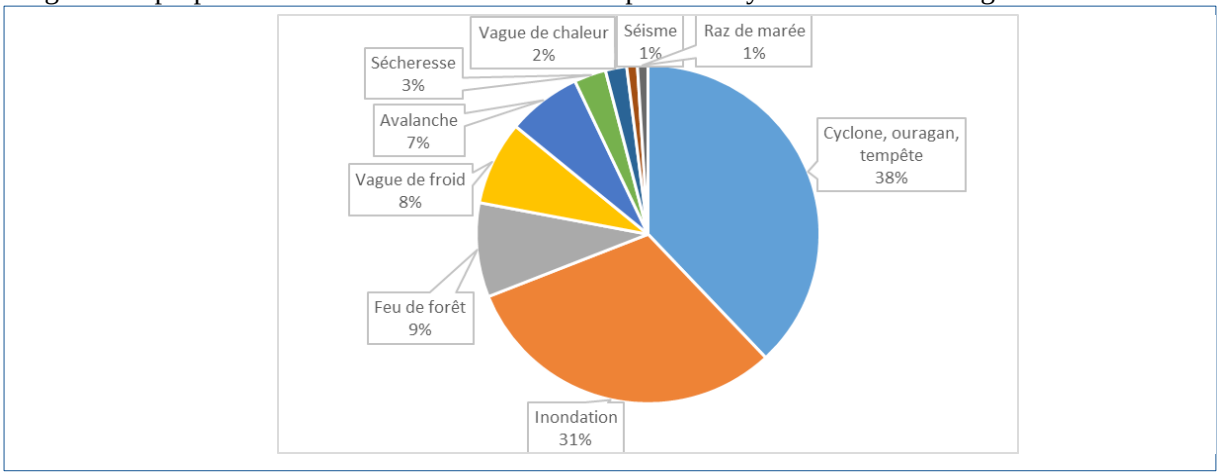
### Initial state

A risk factor is a potential danger (to a certain degree predictable), which may cause human, material or environmental damage[51]. These risk factors are divided into two categories: natural and technological risks.

*Natural risks*

The most common natural disasters to occur in France are **storms and floods:** Of all the level-3 events (very serious events causing between 10 and 99 deaths and between €30 to €300 million worth of material damage) recorded between 1900 and 2012, 31% were floods and 38% were storms. Over this same period, forest fires accounted for 9% of events, while droughts made up 3% of the total number of 130 harmful natural events.[52]

This significant proportion of the occurrence of floods is particularly linked to increasing urbanisation in flood-




prone areas, which is accompanied by the prevalence of non-draining surfaces; 20,000 towns (over half of townships in mainland France) are now exposed to the risk of flooding.

| | |
|---|---|
| **Transport** | • Non-adaptation of transport infrastructures to climate change-related natural risks |
| **Residential-Tertiary Sector** | • Non-adaptation of building stock to seismic activity, tsunamis and cyclones |
| **Agriculture** | • Non-adaptation of agriculture to instances of major flooding<br>• Non-adaptation of agriculture to instances of drought |
| **Forestry - Wood - Biomass** | • Non-adaptation of silviculture to instances of major flooding<br>• Non-adaptation of silviculture to periods of drought<br>• Non-adaptation of silviculture to storms |
| **Industry** | • Non-adaptation of industrial facilities to the most destructive natural risks: fires, tsunamis, cyclones, seismic activity, avalanches, etc. |
| **Energy production** | • See Industry<br>• Modification of the use of renewable energy depending on climate conditions |
| **Waste** | • See Industry |

*Table 9: Summary of threats and pressures regarding exposure to natural risk factors, by sector*

*Technological risks*

51 Lopez-Vazquez, E., 1999. *Perception of risk, stress and adjustment strategies for subjects at risk of natural or industrial catastrophes, using a social psychology approach to risk.* Université de Toulouse II.

52 Ministry for Energy and Solidary Transition (2012). Harmful natural events Consulted on 26 February 2018 at the following address: http://www.statistiques.developpement-durable.gouv.fr/lessentiel/ar/368/1239/evenements-naturels-dommageables.html.

As opposed to natural risk, technological risk refers to risks that are solely man-made. Five major sources of technical risks exist in France: industrial facilities, nuclear facilities, large dams, transport of hazardous materials and mining sites. The most frequent types of accidents to occur are fires, hazardous material spillages and explosions[53].

In 2016, 827 such accidents and incidents were recorded in French facilities, down from 846 in 2015.

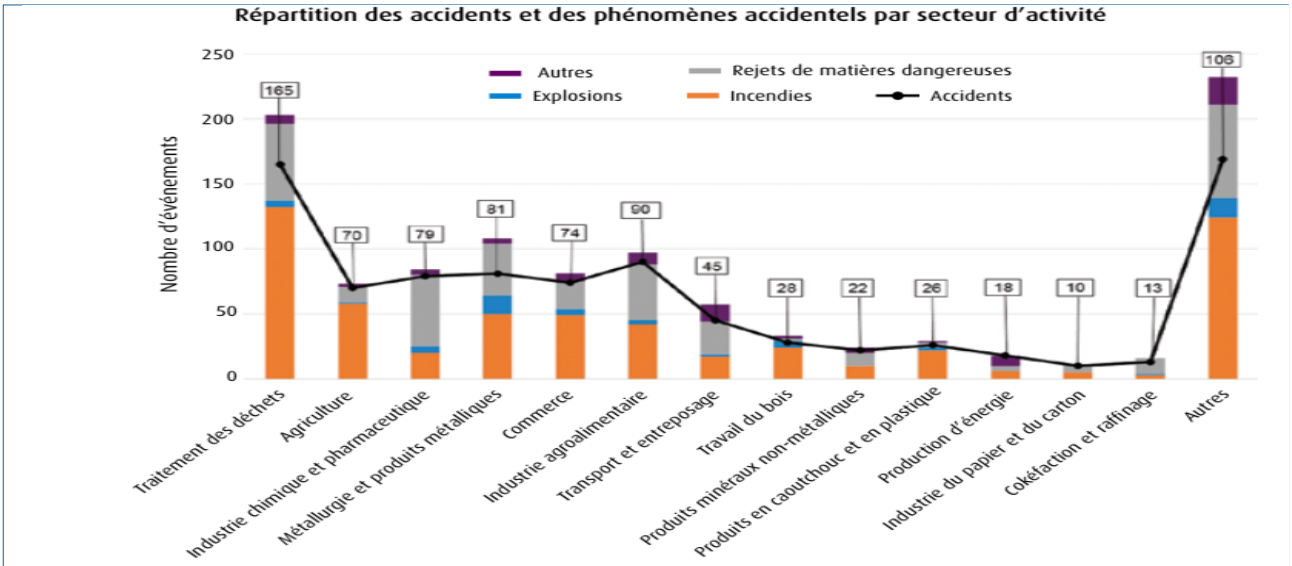



*Figure 33: Breakdown of accidents and accidental phenomena by sector of activity in 2016 Source: Bureau d'analyse des risques et pollutions industriels / Risk and Industrial Pollution Analysis Office, 2017.*

The year 2016 saw a significant number of external natural barrages: 31 establishments incurred flood damage between 29 May and 15 June, equivalent to €347 million in material damage and profitability losses. A number of establishments were also affected by lightning and forest fires.

| | |
|---|---|
| **Transport** | • The transport sector accounted for 45 accidents in 2016, or 5% of all accidents and incidents occurring that year.<br>• The transport of hazardous materials was the most likely activity to expose goods and individuals to technological accidents. In 2016, 142 of these accidents were recorded in France, one of which occurred on a waterway and one at sea. 50% of accidents resulted in human injury or death. |
| **Residential-Tertiary Sector** | • The lack of technological risk prevention around residential zones may exacerbate the impact of a technological accident by causing human and material losses in these zones.<br>• Commercial premises were the source of 74 technological accidents in 2016, or 9% of all accidents and incidents occurring in that year. |
| **Agriculture** | • Agriculture was the source of 70 technological accidents in 2016, or 8.5% of all accidents and incidents occurring in that year.<br>• This sector is particularly subject to the risk of fire and spillages of dangerous materials. |
| **Forestry - Wood - Biomass** | • Wood production was the source of 28 accidents in 2016, or 3% of all accidents and incidents occurring that year.<br>• This sector is particularly subject to the risk of fire. |
| **Industry** | • The manufacturing industry is the most affected by technological risks, with 308 technological accidents or incidents recorded in 2016, or 37% of all accidents and incidents occurring in that year. |
| **Energy production** | • Energy production was the source of 31 accidents or incidents in 2016, or 4% of all accidents and incidents occurring in that year. |

53 Bureau d'analyse des risques et pollutions industriels / Risk and Industrial Pollution Analysis Office, 2017. *Inventory of technological accidents in 2016* 20p.

| | |
|---|---|
| | • Hydraulic facilities are set apart from regulated facilities in terms of the type of risk factors they carry. In 2016, 48 events occurred and caused damage to certain work sites, flooding of a protected zone and deterioration of embankments due to flooding of the Loing and Seine rivers. The probability of a major disaster occurring remains low.<br>• The transport of gas via pipeline led to 11 events in 2016, and the urban gas distribution network saw 89 events. Roadworks being carried out near facilities were responsible for 68 leaks or instances of damage to pipeline connections.<br>• Nuclear risk - The probability of a major disaster is low. |
| **Waste** | • Waste management is another sector particularly affected by technological risks, with 165 accidents or incidents recorded in 2016, or 20% of all accidents and incidents occurring that year.<br>• This sector is particularly vulnerable to fire risks. |

*Table 10: Summary of threats and pressures regarding exposure to technological risks by sector*

## Trends and prospects for development

### *Natural risks*

Natural risks, although difficult to predict, are the subject of a regulatory framework aiming to prevent these types of risks. In 1982, the law regarding compensation for victims of natural disasters paved the way for the "risk exposure plan", which in 1995 would become the Natural Risk Prevention Plan, developed under the authority of local prefects along with their local councils. The prevention plan aims to reduce exposure to these risks, while also making people and property less vulnerable to their effects. The plan identifies zones exposed to the effects of predictable natural risks, whether direct or indirect, and characterises the potential intensity of these phenomena. Even in the absence of a Risk Prevention Plan (natural, technological or mining), the Local Urbanisation Plan (PLU) may define at-risk zones and specific rules to be observed in these areas[54].

Climate change represents a significant factor in the evolution of natural risks (see fig. below).


Climate change is likely to increase the frequency of extreme weather events:

54 Ministry for Energy and Solidary Transition, 2017. Natural risk prevention. Consulted on 1 March 2018 at the following address: https://www.ecologique-solidaire.gouv.fr/prevention-des-risques-naturels

- In overseas territories, an increase in both the frequency and intensity of violent winds has been observed;
- Heatwaves;
- Rising sea levels leading to floods, threatening low-lying areas of mainland France (areas hatched in blue on the map);
- Major risk of drought in areas indicated in yellow (half of the southern portion of the country), with significant consequences for agriculture and frequency of forest fires.

*Technological risks*

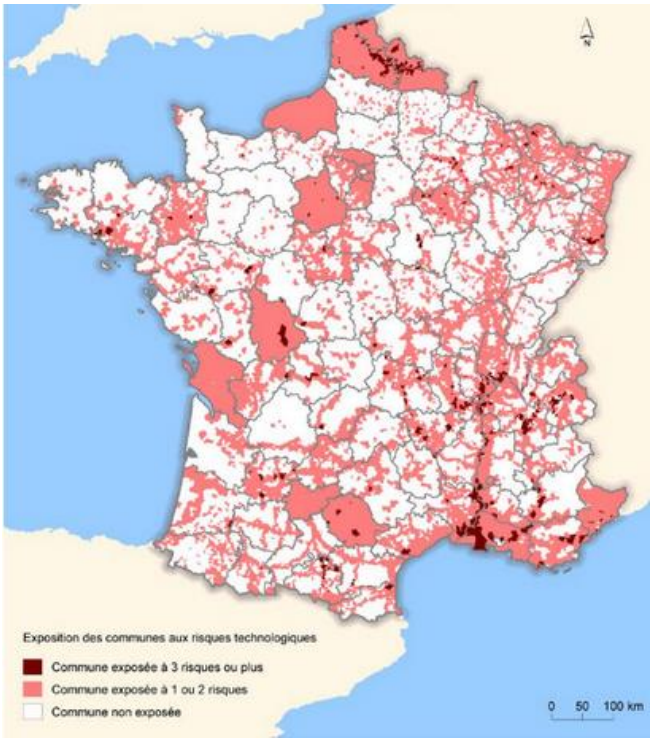
Technological risks are covered by a wider regulatory framework, due to the fact that they may vary widely in nature. As we have previously seen, the majority of technological risks are industrial in nature, in particular involving Regulated Environment Protection Facilities (ICPE). The ICPE nomenclature constitutes a regulatory framework for facilities with the potential to affect the environment. Such facilities may be classed at one of three levels: declaration, registration or authorisation. These three groups indicate the hazard level posed by the facility to the environment, with "authorisation" representing the highest level of danger (this group also includes a classification enabling regulation of the most dangerous facilities, which are also referred to as SEVESO facilities). This nomenclature thereby guarantees safety standards in these facilities by allowing the local prefect to determine safety rules to be applied. These safety and security rules are also applied via other regulatory texts, pushing industrial operators to improve their systems in order to lower their facilities' risk level as much as possible.

At local level, Technological Risk Prevention Plans (PPRT) are implemented in order to resolve challenging situations in terms of urbanism, with the objective of providing a more solid framework for future urbanism in order to reduce, as far as possible, the level of exposure of individuals, goods and environments to technological risks. As such, the PPRTs can define protective zones for both present and future populations living near SEVESO sites, such as;

- Future urbanisation control zones;
- Sectors in which property development measures will be implemented for existent buildings (expropriation, abandonment);
- Advisory zones for existent buildings.

The chart below indicates towns exposed to technological risks[55]:

55 Ministry for Energy and Solidary Transition (2012). Technological risks. Consulted on 7 March 2018 at the following address: http://www.statistiques.developpement-durable.gouv.fr/lessentiel/s/risques-technologiques.html




Technological risks are managed via the implementation of public policies. The baseline status indicates a decrease in the number of accidents between 2015 and 2016.

Finally, the number of accidents and their breakdown across the various sectors of activity is fairly stable year on year, aside from:

- The food production and processing industry, which saw a rise of 30%;
- Wood production and paper/cardboard production, which dropped by 35 to 45%.

## 2.4.2. Pollutants: air, noise, odour and light pollution

### Initial state

Phenomena or substances are classed as pollutants when they are damaging to quality of life, or pose a significant danger to human health or the environment. Pollution therefore covers air, noise, odour and light pollution.

◆ Air pollution

In the Environmental Code, atmospheric pollution is defined as the "direct or indirect human introduction, into the atmosphere and enclosed spaces, of harmful substances with the potential to endanger human health, damage biological resources of ecosystems, influence climate change, damage material goods, or provoke excessive olfactory discomfort or distress."

External air pollution is harmful to human health but also to the environment, via the acidification or eutrophication of water or soil, and may also contribute to decreasing agricultural yields. Interior air pollution is also a major public health issue. Indeed, most individuals spend 85% of their time in an enclosed environment, the majority of which is in their living environment.

When examining the issue of atmospheric pollution and air quality, it is necessary to distinguish between two fundamental notions:

- Pollutant emissions refer to a quantity of pollutants (often expressed in tonnes or kilotonnes) directly produced via human activity (transport, wood burning, industry, etc.) or natural means (volcanoes, sea spray, forest fires, sand storms, etc.)
- Concentrations of pollutions indicate the quality of the air we breathe; they are most often expressed in micrograms per cubic metre ($\mu g / m^3$). However, these concentrations depend heavily on two factors, particularly as regards exterior air quality: meteorological conditions and the quantity of pollutants

emitted into the atmosphere. For interior air quality, the level of exposure for occupants depends on the ventilation and aeration conditions, as well as the structure's proximity to sources of pollution.

The link between emissions and concentrations is neither proportional nor linear.

Atmospheric pollutants are divided into two categories: primary pollutants, which refer to pollutants emitted directly into the atmosphere, and secondary pollutants, which are those substances formed from the physico-chemical reactions between primary pollutants under certain specific meteorological conditions.

Atmospheric pollutants may be emitted by human activity or natural events, but this report will focus primarily on man-made sources. These sources of man-made emissions often originate from the combustion of organic material (wood, waste) or fossils (coal, oil, gas, etc.) for transport, heating of buildings, or industry, but may also originate in agricultural operations (working the soil and spreading of pesticides or mineral / organic fertilisers). Certain pollutants are also emitted by solvents, etc. and are particularly problematic in terms of interior air quality.

The report on ambient air quality in mainland France for the year 2016 showed that emissions of primary pollutants had decreased overall between 2000 and 2016, except for emissions of ammonia, which have tended to stagnate (as illustrated in the graph below).

*Source: CITEPA (mainland France)*

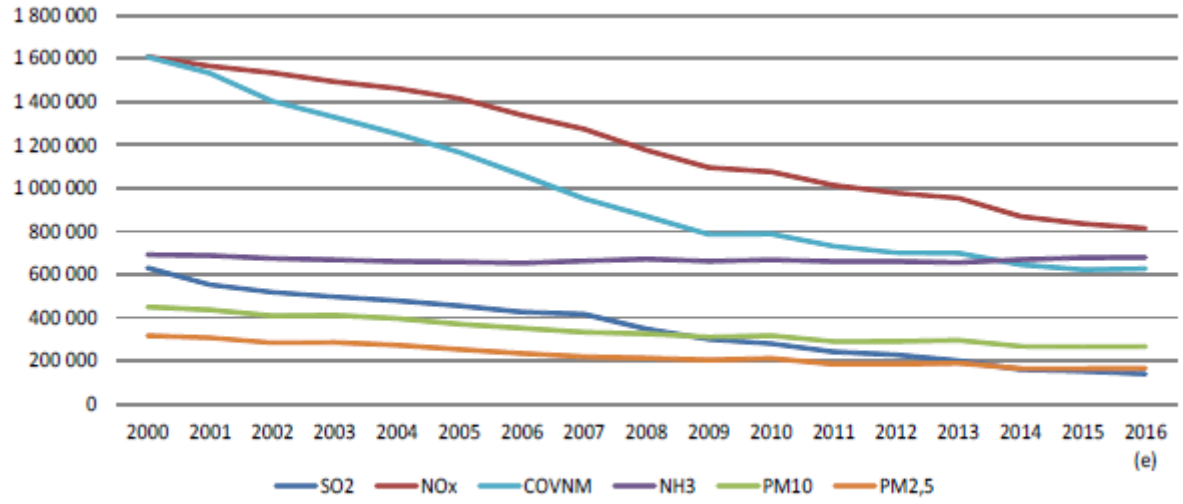
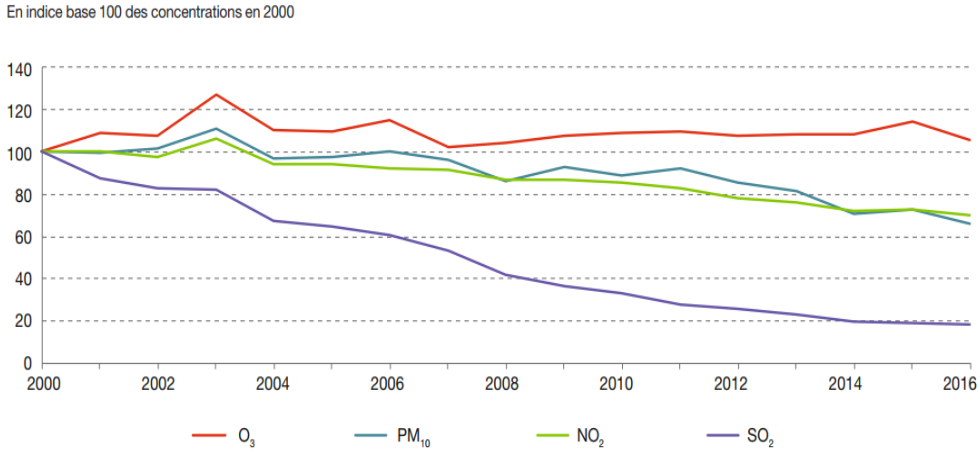



*Figure 36: Evolution of emissions (in t) of sulphur dioxide (SO2), nitrogen oxides (NOx), ammonia (NH3), PM and PM particles*
*10* *2.5*

Concentrations of pollutants also fell over the 2000-2016 period, except for concentrations of ozone in metropolitan areas:

In metropolitan areas, despite an overall decrease in concentrations of pollutants, a number of regulatory thresholds (particularly for NO , PM and O ) set for human health were still not being met in large cities (due
2 10 3

to the significant number of pollution sources present), as well as in other areas in which geographical and meteorological conditions allow for build-ups of pollutants[56].




*Notes : pour l'$O_3$, les concentrations utilisées sont celles des périodes estivales (moyenne du 1er avril au 30 septembre) ; la méthode de mesure des $PM_{10}$ a évolué en 2007 afin d'être équivalente à celle définie au niveau européen. Malgré ce changement, la construction de l'indicateur ci-dessus permet de ne pas avoir de rupture de série.*
*Champ : France métropolitaine hors Corse.*
***Source :** Géod'Air, juillet 2017. Traitements : SDES, 2017*

*Figure 37: Evolution of concentrations of sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), ozone ($O_3$) and $PM_{10}$ particles over the 2000-2016 period*

| | Principales sources primaires | Respect de la réglementation en 2016 | Nombre d'agglomérations en dépassement en 2016 |
|---|---|---|---|
| $SO_2$ | | ✓ | 0 |
| $NO_2$ | | ✗ | 16 |
| $O_3$ | | ✗ | 26 |
| $PM_{10}$ | | ✗ | 3 |
| $PM_{2,5}$ | | ✓ | 0 |
| CO | | ✓ | 0 |
| $C_6H_6$ | | ✓ | 0 |
| As | | ✓ | 0 |
| Cd | | ✓ | 0 |
| Ni | | ✗ | 1 |
| Pb | | ✓ | 0 |
| B[a]P | | ✗ | 2 |

*Notes : l'$O_3$ n'a pas de source d'émission directe dans l'atmosphère. C'est un polluant exclusivement secondaire qui se forme sous l'effet du rayonnement solaire et de réactions chimiques complexes entre différents polluants ; les normes prises en compte sont celles fixées pour la protection de la santé à long terme ; Pb = plomb.*
***Sources :** Géod'Air, juillet 2017 ; Citepa, mise à jour avril 2017, format Secten ; SDES*

*Figure 38: Summary of human health protection standards not being upheld*

Regarding interior air quality, the pollutants involved are not exactly the same: carbon monoxide (CO), acetaldehyde, acrolein, benzene, n-decane, n-undecane, 1,4-dichlorobenzene, ethylbenzne, hexaldehyde, styrene, tetrachloroethalyne, toluene, xylene, tricholoroethylene, fine particles. The sources of these emissions

56 CGDD, 2017. *Review of Air Quality in France, 2016.*

also vary: heating equipment, smoking, construction products, furnishings and decor, maintenance products, paint, varnish, etc.

A national inquiry into the state of air quality in French households carried out in 2007 revealed that 50% of households had $PM_{2.5}$ levels greater than 19.1µg / $m^3$, and over 31.3µg / $m^3$ for $PM_{10}$. The percentage of French households registering higher internal concentrations of volatile organic compounds than present in the external atmosphere varied between 68.4% (trichlorethylene) and 100% (formaldehyde). Aldehydes were among the most common and most concentrated molecules found in households[57].

| | |
|---|---|
| **Transport** | • Use of combustion engine vehicles, source of NOx emissions and fine particles<br>• Diesel vehicles are particularly problematic in that they emit higher quantities of fine particles than petrol engines, and therefore are considered to have a greater impact on public health (See 3.3.3). |
| **Residential-tertiary sector** | • The use of low-performance wood heating units is a significant factor in the deterioration of interior and exterior air quality. These types of devices produce mediocre combustion of fuel and emit a significant quantity of fine particles (and other emissions), meaning they have a significant impact on human health.<br>• Open-air burning of green waste is also a significant source of pollution, as the combustion process is even less efficient than in a heating unit, and the combustible materials have not been dried beforehand.<br>• Internal air quality can also be altered by poor building ventilation and exposure to pollutants emitted by construction materials and furnishings.<br>• Domestic use of solvents is a significant source of NMVOC emissions. |
| **Agriculture** | • Activities pertaining to working the soil emit fine particles.<br>• Animal waste and the spreading of fertilisers are responsible for the majority of ammonia emissions (64% and 34% respectively).<br>• There is insufficient information available in France regarding the impact of the spreading of phytopharmaceutical products on air quality, but it should be noted that 30 to 50% of these substances are lost into the atmosphere once sprayed.<br>• Finally, the use of open fires in agriculture (slash and burn, land clearing) are also sources of highly-localised emissions of fine particles, volatile organic compounds and other hazardous pollutants, for the same reasons as open-air burning of green waste by individuals[58]. |
| **Forestry - Wood - Biomass** | • Silviculture has a very marginal impact on air pollution. Only the vehicles used in silviculture are considered to have any significant impact on pollution. Otherwise, this sector produces natural emissions of volatile organic compounds.<br>• Biomass combustion is a major source of fine particles emissions (See residential-tertiary sector). |
| **Industry** | • The industrial sector is responsible for the majority of sulphur dioxide emissions, due primarily to metalworking with ferrous metals (12%), the production of non-metallic minerals and construction materials (11%) and the chemicals industry (10%).<br>• Industry is also responsible for some slight emissions of fine particles (PM10 and PM2.5) |
| **Energy production** | • Oil refineries and electricity production mainly emit sulphur dioxide (29.2% of $SO_2$ emissions) and persistent organic pollutants (the incineration of domestic waste with energy retention emits 49% hexachlorobenzene – HCB). |

57 Observatory of indoor air quality (2007). *National inquiry into air quality in French households*.
58 CITEPA, 2017. SECTEN inventory, 2017. Consulted at the following address: https://www.citepa.org/fr/activites/inventaires-des-emissions/secten

| | |
|---|---|
| **Waste** | • The waste processing sector remains the primary contributor of organic pollutants, with 28% of polychlorobiphenyl (PCB) emissions originating in this sector. |

*Table 11: Summary of threats and pressures on air quality by sector*

### *Noise Pollution*

Sources of noise are multiple, but noise caused by transport is often cited as the main source of noise pollution by 54% of French citizens (survey carried out by TNS-Sofrès in May 2010, entitled "Noise pollution and the French" on behalf of the Ministry of the Environment).

Exposure to noise pollution can have significant impact on human health, both physical and mental. Repeated exposure to noise disturbs sleep patterns, provokes arterial hypertension, reduces the field of vision, and increases nerve irritation leading to fatigue and depression. According to the WHO, noise pollution is the second leading cause of morbidity, after atmospheric pollution, out of all environmental risks in Europe. [59]

| | |
|---|---|
| **Transport** | • Road transport represents the source of noise pollution to which the largest number of inhabitants are exposed. As such, there is a significant challenge in terms of regional planning in order to improve noise levels in the most affected zones.<br>• Air transport is also a significant source of noise. Even if technological progress allows aircraft to operate less noisily, in certain areas the local population is exposed to up to 500 flights per day, at a noise level that is almost continuous and more intense than that of a vehicle highway[60]. However, the number of inhabitants exposed to this type of pollution is lower than for road transport. |
| **Residential-Tertiary Sector** | • Noise pollution examined in this sector refers to noise generated by neighbours. Collective accommodation naturally requires increased proximity between inhabitants, which can cause significant disturbances where there is no soundproofing between apartments. |
| **Agriculture** | • Agricultural activity can be a source of disturbances for neighbouring areas in rural zones, due to agricultural machinery and animal noise. |
| **Forestry - Wood - Biomass** | • Silviculture operations may be considered as sources of noise pollution due to the equipment used in this industry. However, for this to cause a disturbance there must be housing located nearby. |
| **Industry** | • Proximity between industrial and residential zones can be a source of conflict. Industrial activity emits noise that can disturb neighbouring households (operation of equipment, presence of heavy vehicles for the transport of raw materials, etc.) |
| **Energy production** | • See Industry<br>• Wind turbines can present issues in terms of noise pollution. |
| **Waste** | • See Industry |

*Table 12: Summary of threats and pressures on the auditory environment by sector*

### *Olfactory disturbances*

Smell is the brain's interpretation of signals provided by the olfactory receptors when stimulated by odorous substances[61]. "Aside from the toxicity aspect, olfactory disturbances are often ranked as an everyday nuisance

59 Bottin, A., Joassard, I., & Morard, V. (2014). *The environment in France*.

60 Centre for noise information (sine data). Air transport noise. Consulted on 2 March 2018 at the following address: http://www.bruit.fr/boite-a-outils-des-acteurs-du-bruit/bruit-des-transports-aeriens/

61 Achimi, B., 2008. *Best Practices Guide for Methanisation Projects* Consulted at the following address: http://www.gimelec.fr

much like noise, despite the fact that they can provoke very real physical and vegetative symptoms (nausea, headaches, loss of appetite), and can also cause stress." - [62]

| | |
|---|---|
| **Transport** | • Combustion-engine vehicles contribute significantly to the presence of odours in cities. |
| **Residential-Tertiary Sector** | • Olfactory disturbances may be considered as neighbourhood problems in residential environments. |
| **Agriculture** | • The spread and storage of organic material (livestock effluent) emits intense odours, which may bother local residents. |
| **Forestry - Wood - Biomass** | • N/A. |
| **Industry** | • Certain factories emit odours caused by the chemical products they use, which may not necessarily be toxic to humans but can produce very unpleasant odours. |
| **Energy production** | • Energy transformation operations (such as oil refining) can emit sulphurous odours.<br>• The process of methanisation requires the handling and transport of foul-smelling materials, along with the storage of organic materials in certain agricultural operations. |
| **Waste** | • Pumping, water purification and sewage processing stations can represent significant sources of olfactory pollution when operating in proximity to residential or tourism zones;<br>• Dumping or movement of waste containing organic materials. |

*Table 13: Summary of threats and pressures on the olfactory environment by sector*

### *Light pollution*

Artificial lighting in towns and cities plays a valuable role in society (pedestrian and road traffic safety at night, traffic signalling, decoration, etc.). However, external lighting, which has become considerably more widespread in the second half of the 20th century, with more light and more types of light source available, can cause disturbances for both humans and the environment.

Light pollution is defined under French law (article 41 of law no. 2009-967 of 3 August 2009, on planning pertaining to the implementation of the Grenelle de l'environnement initiative) as "emissions of artificial light of a type which may present dangers or cause excessive harm to persons, fauna, flora or ecosystems, leading to energy wastage or preventing the observance of the night sky (...)."

According to the CGEDD (General Council for the Environment and Sustainable Development), "artificial light constitutes a pollutant, counteracting the environmental asset that is the night. The loss of quality of this asset can therefore lead to a loss of environmental quality (abandonment of nests, modifications to intra- and inter-species balance, loss of biodiversity, or – from a health point of view – the disturbance of several metabolic functions via hormonal desynchronisation." - [63]

Light pollution affects biodiversity in multiple ways. In a general sense, sudden changes in luminosity can dazzle or blind individuals, leading to increased risks of collision and vulnerability to predators. Light pollution also causes displacement of certain photophobic species (which flee from light sources), such as certain species of bat, for example. Artificial light can also disturb the orientation of migratory birds. Similarly, lighting near beaches, combined with coastal development, reduces crossing areas for turtles.

62 Delmas, V., & Léger, C., 2011. Les odeurs : Mieux les connaître pour pouvoir les combattre. ("Understanding odours to prevent their occurrence") *L'Air Normand*, 6p.

63 CGEDD, 2014. *Foreign legislation and regulations combating light pollution*.

| | |
|---|---|
| **Transport** | • The lighting of roadways is a major contributor to light pollution and disturbances to the nocturnal environment.<br>• Considering the characteristics of light diffusion, lighting of roadways along coastlines can also disturb the environment across a large area beyond the coast. |
| **Residential-Tertiary** | • Lighting of offices and commercial premises that are unoccupied at night contributes to light pollution and disturbances to the nocturnal environment. |
| **Agriculture** | • N/A |
| **Forestry - Wood - Biomass** | • N/A |
| **Industry** | • Lighting of certain industrial facilities during the night contributes to light pollution and the disturbance of the nocturnal environment. |
| **Energy production** | • See Industry. Wind turbines are particularly concerned. |
| **Waste** | • N/A |

*Table 14: Summary of threats and pressures on the nocturnal environment by sector*

## Trends and prospects for development

### *Air pollution*

Emissions of atmospheric pollution are regulated at international level by the Convention on Long-Range Trans-Boundary Air Pollution, and more specifically by the Gothenburg Protocol. This convention has been transposed into European law via Directive 2016/2284/EU of 14 December 2016, which sets a number of new objectives in terms of atmospheric pollution emissions for the 2020-2029 period and from 2030 onwards, as well as objectives for $PM_{2.5}$. This Directive imposes commitments to reduce Gothenburg Protocol emissions, amended in 2012 for 2020, as well as more ambitious objectives for 2030.

Regulation regarding concentrations of pollutants is contained in Directive 2008/50/EC on ambient air quality and cleaner air for Europe. This Directive establishes various types of regulatory threshold in order to reduce concentrations of pollutants in the air. Adherence to these thresholds indicates improved air quality. Any failure to meet the targets set by this Directive can result in legal action being taken. Based on the foundations of this Directive, France is currently involved in a legal dispute with the European Commission for failure to respect $PM_{10}$ thresholds (formal warning) and $NO_2$ thresholds (formal notice) for several areas in France. The European Union is also working to improve the environmental performance of road vehicles (EURO standards) and ships (Directive 2012/33/EU of 21 November 2012, amending Directive 1999/32/EC regarding the sulphur content of marine fuels). Industrial manufacturing and production / transformation facilities are subject to regulations regarding "Regulated Environment Protection Facilities" (ICPE), which impose thresholds on emissions of atmospheric pollutants. As regards emissions in the agricultural sector, certain facilities are also subject to ICPE regulations. Regarding pesticides, the National Agency for Health, Food Safety and Working Conditions (ANSES) has recently put forward, at the request of the ministries of Agriculture, Ecological Transition and Health, a list of 90 priority substances to be monitored in ambient air which would enable harmonisation of the measurement of pesticides in the air [64].

France has also implemented several action plans at the national level (National Atmospheric Pollutant Emissions Reduction Plan (PREPA), Action Plan for Active Means of Transport), as well as at local level: Regional Air Energy and Climate Scheme (SRCAE), Atmosphere Protection Plan (PPA), Local Air Energy and Climate Plan (PCAET), in order to contribute to the improvement of air quality. Urban planning documents (Territorial Coherence Plan (SCOT), Local Urbanism Plan (PDU), Urban Travel Plan (PDU)), are also affected by requirements in terms of air quality: the PDU, in particular, must include objectives for the reduction of pollutants contained in the PPA, where relevant.

The entirety of this legislative and political arsenal contributes significantly to the reduction of emissions and concentrations of atmospheric pollutants, even though several areas of France continue to exceed the $NO_2$,

64 ANSES. (2017). *Proposed methods for monitoring pesticides in ambient air*. 306p

$PM_{10}$ and $O_3$ thresholds to various extents. Air quality is tending to improve across France as a whole, as demonstrated by the evolution of emissions and concentrations since 2000.

*Noise*

European Directive 2002/49/EC regarding the assessment and management of environmental noise requires noise maps for major terrestrial transport infrastructures, large airports and within large urban zones as defined by Insee, in order to better evaluate persons exposed to noise pollution.

As such, the following are affected:

- The 34,800km of roadways hosting traffic of more than 3,000,000 vehicles per year;
- The 7000km of railways hosting annual traffic of over 30,000 trains;
- The 24 urban areas with over 250,000 inhabitants, which together account for 23,000,000 inhabitants;
- The 36 urban areas with a total population of between 100,000 and 250,000 inhabitants, which together account for 5,400,000 inhabitants;
- Aerodromes with annual traffic of over 50,000 flight plans (9 aerodromes).

For urban areas whose total population is between 100,000 and 250,000 inhabitants and for which noise maps have been drawn up, the primary source of noise pollution also appears to be road transport, and to a lesser extent rail transport.

The National Anti-Noise Action Plan of 6 October 2003 specifies actions to be taken by the State regarding soundproofing of accommodation units subject to excessive noise from transport, as well as combating everyday noise (information, awareness, regulation), and preparing for future challenges via support for research programmes.

Noise monitoring is carried out at a local level; there is no national overview of the evolution in the population's exposure to noise pollution.

*Odours*

There is currently no national evaluation or observatory of odours capable of providing an indication of the limitation of olfactory pollution for the activities in question. However, the limitation of offensive odours can be ensured via regulation and best practices. The limitation of odours from industrial facilities and certain agricultural operations is guaranteed under the ICPE regulations. As such, odour-producing activities are subject to legal orders enabling olfactory pollution to be reduced as much as possible. Agricultural best practices such as, for example, covering of slurry pits, enable operators to limit both emissions of atmospheric pollution and odours. In order to ensure regulatory requirements are properly implemented, local initiatives have been drawn up with the support of Air Normand or the SPPPI Estuaire Ardour, which have established systems allowing citizens to alert industrial facilities when residents are affected by the odours they produce.

*Light pollution*

The law stipulates that the minister can prohibit or limit, via decree, either temporarily or permanently, the use of certain light sources based on their nature or local characteristics. These decrees are issued upon the advice of the National Council for the protection of nature, and may only affect:

- Light-emitting installations such as sky tracers, whose output exceeds 100,000 lumens, or laser beams;
- Light installations located in protected natural spaces and exceptional astronomical observation sites.

Since 2013, regulation has limited the duration of non-essential lighting of building facades, store windows and unoccupied buildings[65]. At the local level, under the framework of Territorial Air Energy and Climate Plans, when the combined local authorities behind the plan exercise legal authority over light emissions, the action plan includes a specific section pertaining to the control of energy consumption for public lighting and associated light pollution.

According to the monitoring efforts carried out by the National Association for the Protection of the Sky and Nocturnal Environments (ANPCEN), the overall level of night-time light emissions is constantly rising, as is

65 The decree of 25 January 2013 regarding nocturnal lighting of non-residential buildings limits light pollution and energy consumption.

the number of light points and the overall light emissions detected by nocturnal species between 1992 and 2012[66].

## 2.4.3. Public health

### Initial state

According to the World Health Organisation (WHO), health is a state of complete physical, mental and social well-being, and does not consist solely of the absence of disease or infirmity. Its physical, mental and social aspects are linked to the biological and genetic characteristics of each individual, but also to environmental and socio-economic factors affecting that individual. The table below presents the main causes of morbidity and mortality in France in 2013, using the latest data then available.

| | | Number of deaths | Variations over 2002-2013 (%) |
|---|---|---|---|
| 1 | Malignant tumours (malignant tumours or the larynx, trachea, bronchial tubes and lungs) | 272.2 | -15% |
| 2 | Diseases of the circulatory system (Ischemic cardiomyopathy, cerebro-vascular diseases) | 222.9 | -33.9% |
| 3 | Diseases of the respiratory system (flu, pneumonia, chronic diseases of the lower airways and asthma) | 62.5 | -19% |
| 4 | Violent deaths (accidents, suicides and other external causes of death) | 59.1 | -25% |
| 5 | Endocrine, nutritional and metabolic diseases (diabetes) | 31.6 | -23.2% |
| 6 | Infectious and parasitic diseases (tuberculosis, AIDS, viral hepatitis) | 17.4 | -19.5% |
| 7 | Undefined symptoms and morbidities (sudden infant death syndrome) | 84.6 | +16.7% |

*Table 15: Main causes of death in France (excl. Mayotte) in 2013.*

| | Under 25 years | 25 - 64 years | 65 years or older |
|---|---|---|---|
| Asthma | 9.1% | 7.7% | 11.6% |
| Chronic bronchitis, COPD or emphysema | 3.4% | 4.3% | 10.5% |
| Myocardial infarction | 0.9% | 0.6% | 3.2% |
| Coronary artery disease, angina pectoris | 0.1% | 0.9% | 6.3% |
| Arterial hypertension | 0.5% | 10.2% | 35% |
| Stroke | 0.1% | 0.4% | 3.4% |
| Non-spinal osteoarthritis | 0.3% | 13.9% | 38.1% |
| LBP or other chronic back issue | 12.9% | 30.2% | 38.1% |
| Cervicalgia or other chronic cervical issue | 5.8% | 15.6% | 22.5% |
| Diabetes | 3.4% | 8% | 19.8% |
| Allergies | 15.2% | 14.3% | 13% |
| Cirrhosis of the liver | 0% | 0.1% | 0.4% |
| Urinary incontinence | 1.1% | 3.2% | 14.5% |
| Renal problems | 0.5% | 1.7% | 4% |
| Depression | 2.7% | 6.3% | 6.6% |

66 National Association for the Protection of the Sky and Nocturnal Environment, 2015. *Constructing a policy of prevention and limitation of light pollution in France*.

| | | | |
|---|---|---|---|
| Other chronic diseases | 3.4% | 9.3% | 16.6% |
| No pathology or health problems declared | 63% | 38.6% | 12.8% |

*Table 16: Main causes of morbidity declared in 2013 by age group.*

**Box 9: A closer look at causes of death due to selected environmental factors**

*Heatwave*

The heatwave that occurred between 17 - 25 June 2017 led to a 6% increase in mortality (or 580 deaths), and more precisely, a 13% rise in deaths among 15 to 64-year olds (or 215 deaths). During the 2015 heat wave period (three heat waves occurred between June and August), a 6.5% spike in mortality was recorded (or 3300 additional deaths compared to the number anticipated during heatwave periods).

*Air pollution*

Atmospheric pollution represents a major environmental risk for public health and ecosystems, as well as a lesser (but distinct) risk to architectural heritage. According to Public Health France, atmospheric pollution linked to fine particles ($PM_{2.5}$) is responsible for 48,282 additional deaths in France among adults aged 30 or over. The finer the particles, the more dangerous they are for our health, due to their ability to penetrate and lodge themselves deep within lung tissue, even to the point of penetrating the pulmonary barrier and entering the bloodstream (for the finest particles: $PM_{2.5}$ and $PM_{1}$).

Moreover, numerous epidemiological studies have also shown the impact of ozone on human health. This pollutant is created via the physico-chemical transformation that occurs between volatile organic compounds and nitrogen oxides when they come into contact with UV rays and heat.

As such, peak periods of ozone pollution are very frequent during the summer, often coinciding with heat waves. Acute exposure to high concentrations of ozone can lead to higher numbers of deaths from respiratory or cardiovascular causes.

*Vector-borne diseases*

The gradual spread of Aedes albopicus (tiger mosquito) across mainland France is an effective vector for the transmission of viruses, and requires a reinforcement of the links between public health, animal health and environmental management. This also requires adapted measures to combat the spread of vector-borne diseases; otherwise, these illnesses will be likely to occur more frequently as a result of global warming

| | |
|---|---|
| **Transport** | • Various modes of transport using fossil fuel combustion engines have a significant impact on public health, in terms of respiratory and cardiovascular diseases (as previously indicated in the section on air pollution).<br>• The lack of regular physical activity that accompanies the use of cars for daily journeys (along with a sedentary working life) can have an impact on mental health, quality of sleep, cardiovascular diseases and diabetes.[67] |
| **Residential-Tertiary Sector** | • As previously indicated, accommodation is the source of a multitude of harmful elements: interior air quality, noise from neighbours, water quality, available safety equipment, etc.<br>• The high density of accommodation units linked to low densities of green spaces, as well as low-quality housing, leads to heightened levels of psychological distress for their inhabitants[68]. |

67 Aquatias, S., Arnal, J., Rivière, D., & Bilard, J., 2008. *Physical activity: contexts and effects on health Institut National de la santé et de la recherche médical / French National institute for health and medical research* Consulted at the following address: http://lara.inist.fr/handle/2332/1447

68 Berry, H. L., 2007. "Crowded suburbs" and "killer cities": a brief review of the relationship between urban environments and mental health. *New South Wales public health bulletin*, *18*(11-12), 222-7. https://doi.org/10.1071/NB07024

| | |
|---|---|
| **Agriculture** | • Numerous epidemiological studies have demonstrated a link between exposure to pesticides and certain chronic pathologies (cancers, neurological diseases, problems with reproduction and infant development)[69].<br>• These health risks affect, in particular, farmers who apply these pesticides to their crops, as well as the families of said farmers.<br>• The exposure of the general public to pesticides is characterised by low-dose exposure repeated over long periods of time. According to the WHO, food is the primary source of exposure to pesticides. However, other sources of exposure should not be overlooked, and it is therefore difficult to determine the role of pesticides in overall exposure[70]. |
| **Forestry - Wood - Biomass** | • N/A |
| **Industry** | • Industrial waste and emissions can affect public health, notably in the case of atmospheric emissions (see 3.3.2) and environmental contamination (see 3.1 and 3.2) |
| **Energy production** | • See Industry |
| **Waste** | • See Industry |

*Table 17: Summary of threats and pressures on human health by sector*

### Trends and prospects for development

It is difficult to trace future trends in the state of national public health, as this subject is influenced by a myriad of factors. However, it is possible to demonstrate how the public health effects of climate change will evolve if new measures are not implemented.

The National Observatory for the Effects of Climate Change (ONERC) mentions, for example, a higher incidence of heatwaves in France, while storms, cyclones and floods also represent a growing threat to the health and safety of the general public. The increase in greenhouse gas emissions could also have an effect on the concentration levels of atmospheric pollutants. Urban planning therefore plays a highly important role in the adaptation of infrastructures to global warming, notably via the limitation of urban heat islands, the implementation of environmental performance standards for buildings, and the management of water and urban atmospheric pollution.

In order to address these new public health challenges, the National Health & Environment Plan (PNSE) and the National Plan for Adaptation to Climate Change (PNACC) outline adaptive measures designed to limit the effects of climate change on public health. The PNSE takes into account the increased risks of epidemics of vector-borne diseases in the context of climate change. The PNACC, which is currently being revised, aims to strengthen preventative measures and resistance to climate change, including via increased recognition of its public health effects: combating the effects of urban heat islands, improving suitability of buildings, and redoubling exploratory research efforts on the topic of "heat in cities."

## 2.4.4. Architectural, cultural and archaeological heritage

### Initial state

Within the baseline status established by the SNBC's environmental evaluation, the focus on architectural heritage has emerged as a priority. However, the level of impact on cultural and archaeological heritage does not appear critical in this context, and so here we will only discuss architectural heritage.

France's architectural heritage is an extremely important factor, given the country's history and the vast number of historic buildings that carry listed status due to their historic, artistic, architectural, technical or scientific interest. The "historic monument" status is a sign of the nation's recognition of a building's heritage value. This protective status implies a shared responsibility between the owners and the local council regarding

69 ANSES, 2016. Exposure to pesticides from agricultural occupations. Vol. 1, 215p.

70 ANSES, 2014. *OPINION of the National Agency for Environmental and Food Health and Working Conditions, and work relating to the updating of indicators used to measure dietary risks associated with pesticide residues*. 122p.

its preservation. As of 1 February 2015, 43,600 buildings were listed as French historic monuments, of which 29.6% were places of worship and over half were private properties. Their owners are therefore responsible as the contracting authority for all upkeep and restoration work on these buildings, although the Ministry of Culture is in charge of the renovation of major monuments such as cathedrals and large national estates. [71].

Older buildings not listed as national monuments are still part of the country's architectural heritage, but it is more difficult to establish an inventory of these buildings.

| | |
|---|---|
| **Transport** | • Discolouration of buildings can be caused by pollution generated by combustion-engine vehicles and the fine particles of nitrogen oxide they emit. |
| **Residential-Tertiary sector** | • Discolouration of buildings can be caused by pollution generated by households and the emissions of fine particles (notably soot) they generate via low-performance wood-burning heating units.<br>• The Energy Transition for Green Growth Act has introduced an objective to carry out 500,000 major renovations per year. Given that these types of renovations may potentially alter aspects of historic architectural heritage, the law stipulates that listed historic buildings, or those listed on the historic inventory, are not required to adhere to thermal performance regulations in cases where this would require an unacceptable modification to their character or appearance. However, a significant amount of heritage buildings exist that are not classed as historical monuments, but are listed in the Heritage PLU or are the subject of a Heritage Review, or which are adjacent to a historical monument or located in a protected district. It is for these buildings in particular that conflicts may arise regarding energy renovation operations. |
| **Agriculture** | • N/A. |
| **Forestry - Wood** | • N/A. |
| **Industry** | • Sulphur dioxide emissions from the industrial sector contribute to the discolouration of building facades, as well as to a loss of transparency in glass and superficial damage to ancient stained glass made using potassium and calcium (acid rain). However, this type of phenomenon occurs much less frequently in the present day. |
| **Energy production** | • See Industry.<br>• The integration of energy production facilities within the landscape can also pose problems in terms of landscape heritage (notably wind turbines, for which a "landscape" component is included in impact studies). |
| **Waste** | • N/A |

*Table 18: Summary of threats and pressures on the quality of architectural heritage*

## Trends and prospects for development

Regarding the impact of air pollution on building facades and glass windows, trends are showing improvement due to the fact that the emissions and concentrations of pollutants that cause this type of damage have been in decline for around ten years, or even longer in the case of sulphur dioxide.

In accordance with France's ambitions in terms of energy-efficient building renovations, alterations to the facades of old buildings remain possible. However, methods exist to limit the impact this type of renovation will have on building facades. For example, the insulation of wall interiors, roofs, attics and wood floors can enable energy-proofing without direct alteration to the building's facade.

71 Ministry of Culture and Communication (sine data). Historical monuments Consulted on 5 March 2018, at the following address: http://www.culturecommunication.gouv.fr/Thematiques/Monuments-historiques-Sites-patrimoniaux-remarquables/Presentation/Monuments-historiques

# 3. Environmental challenges related to the action of the PPE: Probable notable effects

The LTECV objectives, the implementation of which is guaranteed by the PPE, assure France's commitment to combating climate change and to preserving the environment, while ensuring supply security and the viability of the mix. The PPE aims to reduce energy consumption as well as the use of fossil fuels, and to develop renewable energies. The measures of the PPE aim to reduce GHS and atmospheric pollutant emissions in the energy sector. In that way, the PPE plans to reduce the impact of human activity on the environment.

The global impact of the PPE is therefore positive for the climate and the environment, but it would be wise to reduce, as far as possible, the localised effects of implementing these equipment and infrastructure projects. The risks of environmental impact linked to the roll-out of projects in each of the areas covered by the PPE are detailed below, and will be the subject of particular scrutiny during the implementation of each project.

Article R. 122-20 of the Environmental Code stipulates: “The likely notable effects on the environment are examined based on their positive or negative character, whether direct or indirect, temporary or permanent, occurring in the short, medium or long-term, or based on the repercussions arising from the accumulation of these effects."

These impacts are weighed in relation to the expected impact of the sector in question, based on the objectives attributed to that sector by the PPE (PPE impact) and in terms of the expected effect of projects that will be carried out in order to apply the PPE (project impact). The qualitative summary table includes two lines, each indicating one of these impacts. In the event that the impact cannot be attributed to a particular project, the table will only include a single line to qualify the overall impact of the PPE. Conversely, in certain cases the probable effect of the PPE will be neutral, and therefore no notable impact is likely. However, for projects requiring a higher level of scrutiny, an analysis will be presented.

In order to make these easier to read, the positive, negative or neutral effect is symbolised here as follows:

| | |
|---|---|
|  | The planned development of the sectors or projects covered in the PPE should reduce the impact on the environmental issue studied |
|  | The planned development of the sectors or projects covered in the PPE should increase the impact on the environmental issue studied |
|  | The planned development of the sectors or projects covered in the PPE should not have any significant impact on the environmental issue studied |
|  | Applies only to projects, and indicates increased operational vigilance: the project in itself will likely generate pressure on the environmental challenge in question, but adherence to existing regulations will enable the project to maintain a level that is considered impact-neutral. |

## 3.1. Improvement in energy efficiency and reduction in fossil energy consumption

### 3.1.1. Improvement in energy efficiency

The PPE includes measures to effectively manage energy demand, notably in the building (renovation) and transport sectors.

| ***Climate and Energy / Public health and Pollutants*** | | | | |
|---|---|---|---|---|
| | Probable notable effects | Type of effect | Duration | Timescale |

| | | | | | |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Project impact |  | Positive | Direct | Permanent | Short-term |

The PPE's actions to effectively manage energy demand will lead to a decline in energy consumption, and will therefore decrease both the use of environmental resources necessary to produce this energy and the consequences arising from its production and use. These effects will be felt primarily in terms of greenhouse gas emissions, waste production and air quality.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Project impact |  | Neutral | | | |

**The drop in energy consumption and atmospheric emissions will lead to a reduction in the level of environmental pollutants, and will therefore reduce pressure on biodiversity.**

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Negative | Direct | Temporary | Long-term |
| Project impact |  | Operational vigilance | Direct | Temporary | Medium-term |

The measures to ensure effective management of energy demand require investments in terms of infrastructure and new technologies, which will require significant quantities of materials for their construction. The scale of renovations envisaged in order to improve the energy efficiency of buildings requires careful forward planning to handle the waste that will be produced. Similarly, the widespread use of electric vehicles will have an impact on demand for lithium, a resource necessary for the production of batteries for this type of vehicle. The projects could mitigate these impacts by adopting an eco-design approach.

## 3.1.2. Decrease in consumption of fossil fuels

The PPE includes specific measures to decrease fossil fuel energy consumption.

| ***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Project impact |  | Positive | Direct | Permanent | Short-term |

The reduction in the use of fossil energies should have a positive impact across all environmental subjects. The decline in greenhouse gas emissions and atmospheric pollution caused by the combustion of fossil fuels

will contribute to mitigating climate change, and enable improvements in the state of various environments adversely affected by this type of pollution. This improvement in physical environments (soils and sub-soils, aquatic environments, air quality) will have an impact on both natural spaces (biodiversity and natural habitats) and human environments (public health, landscapes and heritage).

| *Natural and technological risks* | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Medium-term |
| Project impact |  | Positive | Direct | Permanent | Short-term |

The decline in fossil-based energy production, if replaced by renewable energy sources, will help reduce technological risks.

# 3.2. Development of the use of renewable and recovered energies

## 3.2.1. Heat and cold

The PPE plans to increase the proportion of renewable energy used to produce heat: solid biomass, heat pumps, geothermal, energy recovery from waste and residues. These will take the place of either fossil fuels or electricity.

### Heat production using wood

The PPE aims to increase the production of energy using wood. Challenges regarding the production of electricity from biomass are similar to those concerning heat production.

| *Climate and Energy* | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Operational impact |  | Operational vigilance | Direct | Temporary | Long-term |

The impact of wood combustion on climate change is considered to be neutral, as the $CO_2$ emitted will be captured by vegetation as part of the renewal process.
Using wood to produce energy could replace the use of fossil fuels. The overall carbon footprint of wood-energy varies based on the mode of energy production and the way in which resources are utilised. There are currently no studies that provide a quantitative indication of the wood (and wood-energy) sector's overall carbon footprint in France. Available studies tend to focus on the uncertainties that exist, and possible methods of action to improve the carbon footprint of the wood-energy sector.[72].

In order to reduce the impact of the use of wood on the environment, it will be necessary to manage forests in a sustainable manner and steer the use of wood energy towards more efficient methods. Indeed, studies show that effective forest management enables greater carbon stability over the long-term, compared to an

72 See ADEME's opinion on Forestry - Wood Production, which is based largely on the following sources: The Research Agency of the Forestry Commission, Review of literature on biogenic carbon and life cycle assessment on forest bio-energy (2014); European Commission Joint Research Centre (JRC), Carbon accounting of forest bio-energy (2013); International Energy Agency, Timing of Mitigation Benefits of Forest-Based Bio-energy (2013); IGN CITEPA: Development of emissions and greenhouse gas absorption levels linked to the forestry sector and development of biomass energy in France, by 2020 & 2030 (2014); CdC Climat, Carbon recovery and the Wood-Forestry sector in France (2010).

unmanaged or poorly-managed forest (although a phenomenon of carbon debt can be observed in the short-term due to heavy use of wood and early felling operations that require a period of several years to recover)[73]. If the use of wood-energy can be steered towards more efficient forms of use, the long-term gains in terms of greenhouse gas emissions could be substantial. However, the increase in the use of wood-energy could, in the short-term, lead to global increases in $CO_2$ emissions if the demand on the resource outstrips the growth of carbon sinks.

Provisions have already been implemented in order to mitigate the effects of biomass on climate change. As such, for collective, tertiary, industrial and agricultural installations (which benefit from the Heat Fund), operators must use a minimum quantity of certified wood.

| ***Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Combustion impact |  | Positive | Direct | Permanent | Short-term |

The PPE aims to develop the use of wood, as well as the replacement of old fireplaces with high-performance units. These measures would have a positive impact on air quality, as traditional wood burning heaters emit high levels of atmospheric pollutants. The new units are much better-performing in terms of energy efficiency and reduction of atmospheric emissions. Special attention should be paid to the roll-out of new wood heating systems. Indeed, replacing oil or gas heating systems by wood heating systems increases pollutants emissions. In order to reduce the impact on air quality from the development of the wood-energy sector, the PPE's strategy will be to:

- Pursue efforts to replace individual units, notably in areas where air quality represents a serious issue. The Energy Transition tax credit already requires recipients to adhere to the 5-star "green" certification; in addition, the eco-design directive will impose new requirements on water heaters and independent wood-burning units as of 1 January 2020;
- Promote biomass heating in collective residences, tertiary and industrial buildings, provided that the units are equipped with filters designed to reduce emissions of atmospheric pollutants;
- Promote supply methods that limit emissions from combustion (untreated dry wood) and transport of the combustible materials;
- Organize a public-awareness campaign on the proper domestic use of wood which is a key factor to reduce air pollutant emissions.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | | | |
| Operational impact |  | Operational vigilance | Direct | Permanent | Short-term |

The use and production of wood should not have any impact on soils or biodiversity, provided that actions are carried out in accordance with the PNFB.
In this regard, projects should pay careful attention to certain issues:

- The choice of vehicle fuel (fuels not adapted to the local environment or medium- / long-term climate developments, which could disrupt the functioning of local ecosystems in the medium-term).

73 Op.cit.

- Limiting trampling and disturbance of local fauna caused by forestry operations;
- Limiting the artificialisation of ground surfaces when creating roads and access paths to the plots of land being used, which can damage soils and water quality (runoffs), as well as landscapes and biodiversity.

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Medium-term |
| Operational impact |  | Operational vigilance | Direct | Permanent | Short-term |

Developing the use of biomass will enable recovery from a number of waste types, which are currently unused. The mobilisation of biomass must respect sustainable management of forests and agricultural zones, and limit vulnerability to imports. Increasing the use of wood energy within the overall energy mix will allow the supply of energy to metropolitan areas to be supplemented using resources produced in France. This will enable us to reduce our vulnerability in terms of fuel supplies and our dependence on imports, particularly in terms of fossil fuels.

Local availability of resources in the medium-term is the reason behind the establishment of the Regional Biomass Schemes (SRB). These schemes, along with the SNMB, take into account the multitude of uses that depend on wood resources. Conflicts regarding the use of biomass could emerge within mainland France, meaning that imports could increase (at least for a temporary period) due to the lack of availability of biomass for wood-energy. Were this the case, a re-examination of the sustainability criteria might need to be applied.

### Geothermal heat pumps (GSHP)

The PPE aims to increase the number of aerothermic heat pumps being installed, continuing the current level of deployment. The number of geothermal heat pumps installed should eventually increase, but to a less significant degree.

| ***Climate and Energy / Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Impact of heat pumps |  | Operational vigilance | Direct | Temporary | Short-term |

The PPE aims to develop the use of heat pumps (HP). These pumps generate 2.5 units of renewable heat per unit of electricity consumed[74]. HPs therefore enable a reduction in primary energy consumption, and as such bear the same advantages in terms of energy management. The scale of their environmental benefit depends on the method of heating they replace. Assuming that they are used to replace fossil-based energy sources, HPs will contribute to reducing both GHG emissions and atmospheric pollution.
In the medium- to long-term, the use of HPs will enable the production of renewable cool air in the summer, which is significant given the predicted rise in temperatures.

74 By using an external supply of heat / cold, HPs produce a yield rate of more than 1. This means that their effectiveness is superior to the energy input. Any device that surpasses the yield factor of 1 is considered a renewable energy source. An HP becomes 100% renewable when the energy it consumes also comes from a renewable source.

However, the frigorific fluids used in cooling systems have serious potential to exacerbate global warming. It is therefore essential to avoid any leakage of these liquids. To this end, it has been decided that all installations with a capacity of 12kW or more will be subject to regular inspections[75].

When active, heat pumps can produce a slight amount of noise. This factor should be taken into consideration with regard to the installation of heat pumps, which are subject to the same regulations as traditional heating units[76].

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Medium-term |
| Impact of aerothermic heat pumps |  | Neutral | Direct | Permanent | Medium-term |
| Impact of geothermic heat pumps |  | Operational vigilance | Direct | Permanent | Medium-term |

The majority of heat pumps installed are aerothermic models, which draw heat from the ambient air, or surface-level geothermic pumps (at a depth of less than 1m).
Certain heat pumps are equipped with vertical geothermic sensors, which (in rare cases) can have an adverse effect on the soil by removing too much subterranean heat. Such alterations to the thermal gradient can affect biodiversity. These installations do not have any impact on water resources. Research is underway to document the effects of a multiplication in shallow-depth installations.

In order to mitigate the risks associated with these types of devices, legislation requires the sinking of heat pumps to be approved by an expert, or given official authorisation in sensitive geographical areas[77].

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Operational impact |  | Neutral | | | |

Heat pumps do not pose any risk, and – when used to replace combustion heating – can also reduce the technological risks associated with these types of heating systems.

## Geothermal electricity and heat

The PPE plans to increase the use of geothermal energy.

***Climate and Energy***

**75 Decree no. 2010-349 of 31 March 2010 on the inspection of air conditioning systems and reversible heat pumps**

76 Eco-design regulation issuing from EU Directive 813-2013

77 Decree no. 2015-15 of 8 January 2015 allows the installation of shallow-depth heat pumps provided they are officially declared, as long as the area in question is not listed as a sensitive zone in terms of sub-soils.

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Operational impact |  | Neutral | Direct | Temporary | Short-term |

The use of geothermal devices does not generate any GHG emissions, and can replace the use of fossil fuels (particularly for heat production). Its development will therefore enable a decline in GHG emissions, as well as decreasing France's dependence on imports of combustible fossil fuels.
The digging and equipping of geothermal wells is the cause of most GHG emissions from this sector. These emissions are due to the use of fossil fuels for digging and drilling machines, as well as the road transport necessary to evacuate the earth removed from the site[78]. At this point, the emission levels involved are comparable to those generated by the installation of a fossil fuel well.

***Public health and Pollutants***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | | | |
| Operational impact |  | Operational vigilance | Direct | Temporary | Short-term |

The trial phase can lead to emissions of atmospheric pollutants (CO, $CO_2$, NOx).

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | | | |
| Impact of drilling |  | Operational vigilance | Direct | Permanent | Short-term |

Drilling into geothermal wells carries the risk of bringing separate aquifers into contact with one another. In order to avoid risk to subterranean bodies of water, soils and sub-soils, the development of new geothermal projects is subject to rules and authorisation applicable to drilling operations[79], as well as by the recommendations included in the SDAGE.
Overly-intensive removal of heat from below the surface could cause this thermal resource to dry up. In order to plan ahead for thermal wells drying up, possible ways of re-injecting heat into the wells are being studied. As is the case for heat pumps, the possibility exists of using geothermal stations to create cold air by inverting their mode of operation.

***Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Medium-term |

78 Pratiwi, Ravier, Genter - Life Climate change impact assessment of EGS plants in the Upper Rhine Valley, 2018
79 Article L. 112-1 of the Mining Code

| | | | | | |
|---|---|---|---|---|---|
| Project impact |  | Operational vigilance | Direct | Temporary | Short-term |

The construction of a geothermal well requires large quantities of steel, concrete and asphalt[80]. A large number of such drilling operations would therefore have an impact on demand for materials, although this can be offset over a 30-year period of use.
During the operational phase, certain materials can enter the wells and be put to use. This can include resources such as lithium, which is usually supplied via imports.

| ***Natural and technological risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | | | |
| Operational impact |  | Operational vigilance | Direct | Temporary | Medium-term |

The development of geothermal projects can have localised seismic effects. The trial phase can lead to emissions of atmospheric pollutants (CO, $CO_2$, NOx). In addition, their operation can lead to the unearthing of radioactive materials.

However, these risks are marginal and are already accounted for in regulations applicable to oil and gas drilling[81], under the framework for local authorisations.

### Thermal solar

The PPE will increase heat production via solar thermal energy.

| ***Climate and Energy / Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Impact of panels |  | Positive | Indirect | Permanent | Short-term |

The production of heat via solar energy does not emit any greenhouse gases or atmospheric pollutants, and contributes to reducing GHG emissions by decreasing the use of fossil fuels.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | Indirect | Permanent | Long-term |
| Impact of panels |  | Operational vigilance | Direct | Permanent | Short-term |

The installation of solar thermal panels on buildings can have an effect on architectural heritage. The nature and extent of this impact depends on the local urban context in which the solar measures are being implemented.

80 Pratiwi, Ravier, Genter - Life Climate change impact assessment of EGS plants in the Upper Rhine Valley, 2018
81 Decree no. 2006-649 of 2 June 2006

Solar thermal energy has no impact on landscapes (nor on the use of soils and associated biodiversity issues) as these panels are only installed on roofs.

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of panels |  | Operational vigilance | Direct | Permanent | Short-term |

The development of the solar thermal sector requires the use of materials for the construction of panels. It is therefore necessary to immediately begin planning for the recycling of these panels, in order to ensure the resources they contain are reused. Solar thermal panels do not require any rare resources.

| ***Natural and technological risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Operational impact |  | Neutral | | | |

Heat pumps do not pose any risk, and – when used to replace combustion heating – can also reduce the technological risks associated with these types of heating systems.

### Energy recovery from waste

The PPE aims to increase the quantity of waste and residue (in particular liquid manure) from which energy is recovered.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Impact of energy recovery from waste |  | Operational vigilance | Direct | Permanent | Short-term |

Energy recovery from waste can replace the use of combustible fossil fuels to produce energy. Incinerating waste in an ICPE would enable a reduction in GHG emissions caused by the end-of-life management of this waste (notably storage emissions and emissions arising from inefficient recovery), and by replacing fossil fuels.

The recovery of energy from liquid manure would also help reduce methane emissions from muck spreading.

| ***Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| **PPE impact** |  | **Positive** | **Direct** | **Permanent** | **Short-term** |

| | | | | | |
|---|---|---|---|---|---|
| Combustion impact |  | Operational vigilance | Direct | Permanent | Short-term |

The combustion of waste generates emissions of atmospheric pollutants (nitrogen oxides, dioxins, dust, etc.), which must be properly treated for public health reasons. These emissions are covered by regulations regarding the Regulated Environment Protection Facilities (ICPE), which have enabled a decrease in their occurrence. This also enables a reduction in the environmental impact of waste disposal. Waste items can become contaminated over the course of their lifetime. This is why they must be recovered in ICPE facilities, which carry the necessary safety guarantees.

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage / Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Impact of energy recovery from waste |  | Positive | Direct | Permanent | Short-term |
| Combustion impact |  | Operational vigilance | Direct | Permanent | Short-term |

Increased energy recovery from waste will mean less pressure on the supply of combustible materials, provided that energy recovery operations only use waste that could not have been recycled or reused in other ways. The incineration of waste also frees up space and avoids the need to develop storage facilities for non-hazardous waste, which can have an impact on landscapes and create water quality risks due to liquid run-off.
Particular attention must be paid during the energy recovery process to ashes (which contain concentrations of pollutants left over from the combustion process), in order to avoid any pollution of soils and sub-soils.

## 3.2.2. Liquid fuels

### Oil-based products

The PPE aims to decrease the use of oil-based products.

***Climate and Energy***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Direct | Permanent | Short-term |

The use of petroleum products, particularly in transport, accounts for 30% of GHG emissions, as well as a significant proportion of atmospheric pollutants ($SO_2$ during refinement, COV, NOx and PM during combustion). These pollutant emissions have an indirect effect on various natural environments (water, soils, biodiversity), as they cause modifications to the chemical composition of organisms.
Combustion-engine vehicles will gradually be replaced by electric vehicles, which do not emit GHG. Given that electricity has a low carbon footprint in France, the net result is positive in terms of the greenhouse effect.

The decrease in the use of petrol and diesel means less use of oil, which is a non-renewable resource, overall.

***Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Long-term |

The growth in electric transport will increase pressure on rare resources needed to produce batteries. Public policy must remain vigilant in this regard, encouraging further research to reduce consumption of these resources, as well as promoting more economic solutions using less rare and more recyclable materials.

### Biofuels

The PPE does not aim to increase the use of first-generation biofuels (created using edible plants), but does aim to increase the use of second-generation biofuels (created using agricultural waste and residue).

| ***Climate and Energy / Non-renewable resources (aside from fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Combustion impact |  | Positive | Direct | Permanent | Medium-term |

The combustion of biofuels is considered to be GHG-neutral, as the $CO_2$ emitted is absorbed by biomass during the growth phase. The use of biofuels therefore enables a reduction in vehicle GHG emissions, as they can replace the use of fossil fuels.

The effect of biofuels on climate change depends on the inputs used to create them: 1st-generation biofuels created from agricultural crops have a greater ecological impact than 2nd-generation biofuels (which are produced using waste residue), as the former can lead to changes in the way farmland is used and therefore reduce the number of carbon sinks available. 2nd-generation biofuels do not have this effect, as they only use existing waste residue.

The PPE does not aim to increase the use of 1st-generation biofuels, but does aim to increase the use of 2nd-generation biofuels. This will replace the use of other resources, particularly fossil fuels.

## 3.2.3. Gas

### Natural gas

The PPE aims to decrease the consumption of natural gas.

| ***Climate and Energy / Public health and Pollutants / Natural and Technological Risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Medium-term |

The use of natural gas causes emissions of atmospheric pollutants (in 2016 this stood at 500 tonnes of $SO_2$, 6400 tonnes of NOx, 35,000 tonnes of CO[82]) and GHGs (73Mt $CO_2$e in 2016[83]).

Given that the gas is 95% methane, its accidental release into the air poses the risk of increasing climate change. Its use also carries other risks, due to its flammable and explosive properties (when compressed). A reduction in the consumption of natural gas will therefore reduce greenhouse gas emissions.

The use of natural gas also makes France dependent on its suppliers. It is a fossil resource, and supply is finite. A reduction in its use via the PPE will have a positive impact on the preservation of gas resources.

### Biogas

The PPE aims to increase the production and consumption of biogas.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Short-term |
| Impact of anaerobic digesters |  | Operational vigilance | Direct | Permanent | Short-term |
| Combustion impact |  | Neutral | Indirect | Permanent | Medium-term |

The use of biogas can act as a replacement for natural fossil gas. The effect of biogas combustion on global warming is considered to be neutral, as the $CO_2$ emitted (0.8kg $CO_2$ /kg[84]) will be absorbed during the renewal of the biomass stocks from which the gas is obtained. In addition, by using liquid manure as an energy source, biogas reduces the methane emissions generated by this substance.
Biogas is composed of methane, and as such must be subject to the same precautions in term of production, storage and distribution as natural gas, in order to avoid leaks (as this gas has a potential global warming factor of 25). Various strategies exist in order to limit GHG emissions.

- During the methanisation phase: reducing storage time and opting for storage in closed buildings with air conditioning.
- During recovery: optimisation of motor settings.
- Installation of torches, enabling any gas released due to over-pressurisation to be burned.

Methanisation facilities are covered by the ICPE regulatory framework in order to manage accidental pollution and disturbances.

| ***Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | Direct | Permanent | Medium-term |
| Impact of anaerobic digesters |  | Operational vigilance | Direct | Temporary | Short-term |

82 Secten Report – Combustibles 2017. Source: CITEPA
83 Ibid
84 ADEME carbon database
http://www.bilans-ges.ademe.fr/documentation/UPLOAD_DOC_FR/index.htm?renouvelable.html

The recovery of waste or other biomass resources to produce biomethane can, in certain cases, cause olfactory disturbances for neighbouring residents. The methanisation process itself does not generate odours, but improper care in the storage and transport of effluent matter can cause these types of disturbances. These types of incidents are covered by regulations applying to Regulated Environment Protection Facilities (ICPE).
The recovery of liquid slurry to produce energy will reduce the quantities available for spreading, and thereby reduce the olfactory pollution associated with this practice.

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Impact of anaerobic digesters |  | Positive | Direct | Permanent | Short-term |

The increase of renewable gas in the energy mix will enable a reduction in waste sent to ISDNDs (dumps) or UIOMs (incinerators), as well as in the resulting environmental impact. It involves recovering substances that are traditionally not seen as energy resources, and thereby means less use of non-renewable resources.
It is important to organise the management of this sector, so as to avoid any possible conflicts regarding the availability of biomass for the development of renewable energy sources (biogas, biofuels, wood-energy, etc.), in order to ensure that these uses do not compromise the production of biomass for food. In France, the use of edible biomass resources is limited to a maximum of 15% of a facility's overall supply. Biogas is therefore generated using mostly waste and residue.

## 3.2. 4. Electricity

The PPE aims to increase the capacities of renewable electricity installations, which should increase their contribution to the electrical mix and lead to a relative decrease in the proportion of nuclear energy used, via the closure of reactors.

### Hydroelectricity and STEPs

The storage of electricity in pumped energy transfer stations (STEPs) presents the same challenges as in dam-operated power stations. The PPE aims to prioritise the optimisation of existing hydroelectric facilities, as well as the equipment of dams that do not currently produce electricity.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of hydroelectric power stations |  | Positive | Direct | Permanent | Medium-term |

The hydroelectric sector should undergo slow growth, meaning that the net impact of this sector is neutral.
The use of hydraulic energy does not cause GHG emissions. Power stations equipped with a retaining dam also have the advantage of being controllable, which means they can replace fossil fuels to ensure security of supply during periods of peak consumption.

The stagnation of water in the retention basins can occasionally encourage the development of $CO_2$-emitting aquatic flora. These effects vary depending on the location, the size of the installation and the frequency of their use.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of dams |  | Operational vigilance | Direct | Permanent | Short-term |

The development of hydroelectricity and STEPs storage stations can cause adverse effects on aquatic environments, during both the construction and operational phases: disruption of ecological continuity, alteration of the hydromorphology of waterways, localised warming of bodies of water, and modifications to aquatic and alluvial habitats upstream and downstream from the dams.
The ecological health of waterways can be severely affected by physical objects that prevent the flow of water, impede transport of sediments and disrupt the life cycles of aquatic species. The scale of these effects may vary depending on the location and size of the facility, and occur mainly due to the presence of hydroelectric power stations using a retention basin.

Management of the environmental impact of hydroelectric power stations is taken into account during the environmental authorisation process for these facilities. This authorisation process ensures that environmental factors are taken into account during the project development phase, as well as the facility's compatibility with the Waterways Management and Development Plan (SDAGE) and the National Operations for the Preservation and Restoration of Ecological Continuity (ONPRCE).

Regulations pertaining to the preservation of ecological continuity stipulate that water flow rates must remain sufficient to mitigate the impact of dams on sediment circulation and aquatic species. Regulations also require passageways to be left for fish, so as not to disturb migratory patterns of catadromous species (those which move between salt and freshwater environments) who come to rivers to reproduce.

In the longer term, climate developments may well influence hydroelectricity production capacities (modification of pluviometric and hydrological cycles, increased frequency of droughts, etc.). Maintaining the ecological health of waterways is therefore an essential step to ensuring the long-term sustainable production of hydroelectric energy (by making waterways more resilient to climate change).

### Terrestrial wind turbines

The PPE will increase the power capacity of wind turbine installations, and – to a lesser extent – their number. This increase will not be proportional, however, as wind turbines are becoming more and more powerful.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of wind turbines |  | Positive | Direct | Permanent | Medium-term |

The production of electricity via wind energy does not emit any greenhouse gases or atmospheric pollutants, and contributes to reducing GHG emissions by decreasing the use of fossil fuels.

| ***Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |

| | | | | | |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

Due to their height and the movement of their blades, wind turbines can cause disturbances for residents, including noise, electromagnetic waves, projection of shadows, stroboscopic effects, etc. Studies conducted so far show that these negative effects are negligible at a distance of 500m, which is the minimum distance to be maintained between wind turbines and residences, as stipulated under French law[85].
In addition to the challenges identified, the perception of these negative effects by residents is a major issue in the feasibility of these projects. Getting local populations involved in the early stages of the project helps make it easier for them to accept the presence of turbines.

Due to the rapid movement of metallic parts in operational wind turbines, the structures can cause electromagnetic disturbances capable of disrupting radar signals. Although stationary, the masts also play a role in radar interference. This interference can affect meteorological radar readings, as well as civil aviation and military radars. The level of interference could worsen as the turbines increase in size. This is an important issue to keep in mind during project development.

All these disturbances are taken into account in ICPE regulations, which have been applicable to wind turbines since 2011.

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Negative | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

A wind farm can have negative effects on biodiversity, and project developers must remain vigilant to these risks: disturbances to avian species and chiroptera (birds and bats), occasional destruction of vegetation at the installation site, disturbance of local fauna, etc. Aside from the risk of collision from flying species (which is relatively low compared to other structures of the same height)[86], it is wise to pay close attention to the "barricading" effect of the widespread deployment of wind farms. The cumulative effects of wind farms can disturb the migration paths of certain species, which may take detours in order to avoid them.
It should be noted that the extent of negative effects on biodiversity will vary greatly depending on the geographic location of the turbines. Wind farms are subject to advance planning and a specific management process, as part of the administrative authorisation procedure applied to each project. Any plan to erect a wind farm is subject to a comprehensive examination of how the turbines will be integrated into the local environment, as well as whether operational risks have been properly accounted for. An impact study is also carried out. Projects must take into account zoning laws stipulated by various environmental protection plans:

- Application of the "National Orientations for the Preservation and Restoration of Ecological Continuities" initiative (ONPRCE) stipulates that wind farms should not be erected in areas that fall within daily flight routes or bird migration paths;
- Observation of the Natura 2000 zones helps lessen the impact of turbines on protected species.

Finally, the authorisation permit can include specific advisory provisions in order to reduce the negative effects identified, and may even implement compensatory measures. In particular, the following provisions may be included:

85 As such, French regulations are among the most protective in this regard, making wind turbines subject to ICPE legislation (Decree 2011-984 of 23 August 2011, adopted following the "Grenelle 2" law).
86 A 2017 study carried out by the Bird Protection League on "French wind farms and their impact on avian species" estimates that wind farm-related mortalities account for between 0.3 to 18.3 bird deaths per turbine per year, compared to 80 to 120 birds killed per year for every kilometre of high-voltage power lines. https://eolien-biodiversite.com/IMG/pdf/eolien_lpo_2017.pdf

- Incitement to install wind turbines within intensive agricultural zones. One of the notable advantages of this measure is to reduce the number of collisions, as well as to minimise the land use requirements of wind farms, whose presence does not preclude the use of land for other activities (such as farming);
- Encouragement of "repowering", which helps limit the impact of the turbines' installation by situating them on sites that are already being used for such purposes, and which do not pose any problems to bird species. Conversely, it is preferable for old wind farms located in sensitive areas to be moved.

***Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

Due to their height, wingspan, position and numbers, wind turbines modify the landscapes on which they are erected. It is therefore necessary to carefully plan the installation of wind farms, taking into account the context of the local landscape, the feelings of the local population, and the presence of other wind farms (existing or planned) in the area. Any project that fails to take these factors into account cannot receive authorisation. In order to improve the integration of wind farms into their landscapes, it is recommended that local residents be involved in the process of selecting the location of the farm.
In the long-term, the development of wind energy does carry risks in terms of territorial saturation. Once the most mutually-favourable sites for the development of wind energy have been made operational, new project developers may well turn their attention to less consensual locations. It is important that this consideration not be overlooked as the sector continues to develop.

***Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Negative | Direct | Permanent | Long-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

The development of the wind energy sector requires an increase in the use of a large number of materials for the construction of the turbines, notably including the use of rare earth metals. It is therefore necessary to immediately begin planning for the recycling of the materials used in turbine construction, in order to ensure these resources are reused:

- The blades are made up of glass and carbon fibre, which at present are difficult to recycle. Currently-available solutions involve recovering these resources as heat sources, or grinding them down to produce cement;
- At the end of a turbine's life cycle, the reinforced concrete foundations are only levelled off to a height of 1 metre, meaning that the remainder of the structure is left in the ground (roughly 3-4 metres of reinforced concrete). It would be worthwhile to support any projects that aim to reuse these foundations during the repowering of a wind farm site. This would not only reduce the cost of the facility, but would also alleviate the need to engage in further invasive use of the soil after the abandonment of 1m-deep concrete structures.

In the same way, the issue of repowering should be studied regarding offshore wind farms;

- The rotors of certain wind turbines (primarily those located offshore) operate using permanent magnets made from rare earth metals (dysprosium, neodymium), and it will be necessary to improve options for reprocessing these materials in order to limit the environmental impact of their extraction. The Bureau for Geological Research and Mining estimates that the construction of a 7MW wind turbine

requires the consumption of about one tonne of rare earth metals.[87]. The same is true, albeit in a more long-term fashion, for the copper reels used in the rotors.

| ***Natural and technological risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Operational impact |  | Neutral | | | |

Wind turbines do not pose any risk, and – when used to replace thermal or nuclear methods of electricity production – can also reduce the technological risks associated with these methods.

### Photovoltaics

The PPE aims to increase the number of solar panels installed.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of panels |  | Positive | Indirect | Permanent | Medium-term |

The production of electricity via solar energy does not emit any greenhouse gases or atmospheric pollutants, and contributes to reducing GHG emissions by decreasing the use of fossil fuels.
The production of solar panels causes the majority of GHG emissions in this sector, particularly during the silicon refining process[88]. It is therefore important to make the production process as efficient as possible.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Negative | Direct | Permanent | Medium-term |
| Impact of ground panels |  | Negative | Direct | Permanent | Short-term |
| Impact of roof panels |  | Neutral | Direct | Permanent | Short-term |

The establishment of solar farms with ground-mounted panels increases the solar sector's use of land, as well as affecting biodiversity in and around the host site. In order to reduce this impact, it is preferable to give priority to installations in areas with low agronomic and ecological value. It should be noted that the use of ground space by these installations can be reduced by developing additional uses of the land in question. Solar panels may be elevated above ground level or set in the "shield" position (inclined towards the sun), both of which are compatible with animal farming activities.
Increasing the use of roof-mounted solar panels helps avoid all conflicts regarding land use.

87 Geo-scientific issues report, "Rare Earth metals" - BGRM, 2017
88 Solar energy systems: production and environmental impact - HESPUL, 2009

***Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of panels |  | Operational vigilance | Direct | Permanent | Short-term |

Ground-mounted solar panels modify the landscape in which they are installed. It will be necessary, therefore, to include landscape-related considerations in the development phase of these infrastructures. Any project that fails to take these factors into account cannot receive authorisation.
When solar panels are installed on buildings, they can have negative effects on architectural heritage, depending on the urban context in which the solar facilities are being developed.

***Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| **PPE impact** |  | **Negative** | **Direct** | **Permanent** | **Long-term** |
| Impact of panels |  | Operational vigilance | Direct | Permanent | Short-term |

The development of the solar panel sector requires the use of a wide range materials for the construction of panels. It is therefore necessary to immediately begin planning for the recycling of these panels, in order to ensure the resources they contain are reused (as has already been outlined in both national and European regulation). The recyclability rate has already reached 95%[89]. Certain technologies (which at present are not commonly used in France) require the use of rare metals such as silver (CdTe[90]) or indium (CIGS[91]), which risk increasing the demand pressure on these resources. In order to reduce the demand for rare resources, it is necessary to continue improving recycling methods and researching manufacturing techniques which are less resource-intensive (or which use materials with less limited supply).
The most commonly-used technique in France requires the use of silicon, whose chemical processing currently constitutes the main source of $CO_2$ emissions and pollutants in this sector. Replacing this chemical processing technique with physical procedures is both feasible and preferable in order to limit the environmental impact of this sector's development. While silicon supplies are generally not considered to be under great pressure, the level of purity required for the development of monocrystalline panels (which offer higher energy yields) could potentially put pressure on silicon supply.

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Operational impact |  | Neutral | | | |

Solar farms do not pose any risk, and – when used to replace thermal or nuclear methods of electricity production – can also reduce the technological risks associated with these methods.

89 Source: PV Cycle, the leading operator in the recycling of PV solar panels.
90 Cadmium telluride (potentially toxic).
91 Copper, indium, gallium, selenide.

## Renewable marine energy (including offshore wind turbines)

The PPE aims to increase the use of offshore wind turbines. The challenges regarding resources and waste from this sector are addressed jointly with onshore issues.

***Climate and Energy***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of wind turbines |  | Positive | Indirect | Permanent | Medium-term |

The production of electricity via wind energy does not emit any $CO_2$, and contributes to reducing GHG emissions by decreasing the use of fossil fuels.

***Public health and Pollutants***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

Due to the movement of metallic parts in operational wind turbines, the structures can cause electromagnetic disturbances capable of disrupting radar signals. Even when stationary, the masts also play a role in radar interference. This interference can affect meteorological radar readings, as well as civil aviation and military radars. While the exact extent of this interference depends on the technical and physical characteristics of the wind farm and the type of radar in question, it is necessary to take these considerations into account in order to ensure the successful development of this sector, from the identification of favourable sites to the development of future farms.

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Negative | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

Information regarding the negative effects of renewable marine energy is currently insufficient to establish a clear diagnostic analysis. Offshore wind is the most well-documented sector, and is subject to the environmental authorisation system.
The installation of offshore wind farms carries two types of environmental impact:

- During construction: the noise generated by the installation of “monopile” structures, as well as resuspended sediments, can endanger certain species. Measures can be taken to suspend installation work during the reproductive cycles of local fauna.

These impacts on biodiversity do not apply to floating wind farms, which require only minimal anchoring to the sea floor;

- During the operational phase: collisions and the "barricading" effect created by multiple installations can disturb the migratory patterns and life cycles of birds and bats. A study is currently being carried out in order to plan the implementation of migration corridors (which may include measures to temporarily suspend the operation of the wind farm) in order to limit these effects.

Throughout the operational phase, products used to protect the submerged structures (anti-fouling paint, galvanic anodes) can also affect the quality of the surrounding water. It is recommended that the use of priority hazardous substances (cadmium, nickel, lead and mercury), which are commonly used for port facilities, be avoided.

Taking into account the potential impact of offshore wind farms on biodiversity (within the framework of a prior public debate on the determination and location of development bids) contributes to an approach that will reduce wind energy's negative impact on the environment.

More generally, the negative effects of the mobilisation of other marine energy sources on biodiversity remain highly uncertain, inasmuch as these emerging sectors are still in the R&D stage in France. Research work is being carried out in order to produce a clearer picture of these effects.

***Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Neutral | Direct | Permanent | Short-term |
| Impact of wind turbines |  | Operational vigilance | Direct | Permanent | Short-term |

The development of marine energy production facilities, especially offshore wind farms, can have an impact on coastal landscapes. Due to their large size and high visibility, wind turbines have an impact on the landscape they occupy, and this factor should be taken into account in each project. Any project that fails to take these factors into account cannot be green-lit.

The organisation of a prior public debate in order to determine the location of proposed bids would help to get local populations more involved in the development of projects, and therefore enhance support for wind energy on a local level.

It should be noted that floating wind turbines, which can be installed at greater depths, represent significant benefits in terms of landscape impact compared to fixed wind turbines, as they can be set up further from the coast at distances of over 20-25km (which is currently the maximum distance for French wind farms presently in development). However, further research and development regarding the tethering of these installations to the sea floor is necessary before these distances can be safely achieved. The long-term development of floating wind farms represents an opportunity in terms of coastal landscape preservation.

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Operational impact |  | Neutral | | | |

Renewable marine energy does not pose any risk, and – when used to replace thermal or nuclear methods of electricity production – can also reduce the technological risks associated with these methods.

## Nuclear

The PPE aims to reduce the production of nuclear energy.

| ***Climate and Energy*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Neutral | Direct | Permanent | Long-term |
| Impact of closures |  | Neutral | Direct | Permanent | Medium-term |

The production of electricity via nuclear energy causes virtually no emissions of GHGs or atmospheric pollutants. In terms of life cycle analysis, nuclear energy emits only 6g / kWh $CO_2e$, placing it in the same order of magnitude as renewable energy[92].
The PPE is built around the principle that nuclear energy will be replaced by renewable energies. The impact of the PPE on this issue is therefore neutral.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Impact of closures |  | Positive | Direct | Permanent | Short-term |

The PPE will lead to a relative decrease in the production of electricity from nuclear energy, and will therefore reduce the negative impacts it carries.
Nuclear power stations have negative effects on water resources, in that they remove water from the environment to cool their reactors. This water is then released into the natural environment at a different temperature, and contains chemical residues that may disturb the ecological health of bodies of water. However, this wastewater is covered by industry regulation.

In the longer term, the increase in temperatures and the global warming of water bodies could affect the productivity of nuclear power stations, as they might have to lower their production rates in order to avoid the risk of overheating. One of the consequences of global warming could therefore be a decline in nuclear electricity production.

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Long-term |
| Impact of closures |  | Positive | Direct | Permanent | Long-term |

The reduction in electricity produced via nuclear energy would lead to a decrease in the use of uranium and nuclear waste to be processed.
The long periods for which radioactive elements remain active implies that our current methods of energy production will have a major impact over extremely long time frames. The persistent nature of this risk could

92 ADEME carbon database
http://www.bilans-ges.ademe.fr/documentation/UPLOAD_DOC_FR/index.htm?renouvelable.html

eventually lead to serious health problems or environmental damage (sub-soils) if storage facilities were shown to be deficient.

While a sector does exist to recycle combustible nuclear materials, research work is currently being carried out in order to optimise this reprocessing cycle. Waste generated during the dismantling of nuclear power stations should be handled by a processing sector specially adapted to the nature of this waste. It should be noted that this waste is made up of 80% standard waste, notably rubble and metals, and 20% radioactive waste.

| ***Natural and technological risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Medium-term |
| Impact of closures |  | Positive | Direct | Permanent | Medium-term |

A reduction in the production of electricity via nuclear energy will lead to a decline in the risk of generic technical failures and accidents.

The risk level associated with nuclear power stations is extremely serious, but low-probability. The dismantling of nuclear power stations could produce new risks, which must be thoroughly anticipated. Long-term operational life of reactors will be subject to periodic reviews of France's Nuclear Safety Authority (ASN).

In the long-term, climate change could influence the exposure of nuclear facilities to risk (extreme climate events, droughts, floods, etc.) and lead to an increase in exposure to "Natech" risks. [93] This long-term perspective will be taken into account in ASN examinations.

### Fossil-fuelled thermal power stations

The PPE will decrease the production of energy from fossil fuels, and will therefore reduce the environmental impact of these facilities. In particular, those facilities with the highest emissions levels – i.e. coal power stations – will be closed.

| ***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Direct | Permanent | Short-term |
| Impact of closures |  | Positive | Direct | Permanent | Short-term |

Thermal power stations are sources of GHG emissions and atmospheric pollutants. Emissions from combustion required to produce the equivalent of 1kWh of energy are[94]:

- Oil: 283g $CO_2e$
- Coal: 346g $CO_2e$ (364g $CO_2e$ for lignite)
- Natural gas: 205g $CO_2e$

93 "NaTech": increase in technological risks cause by the rise in natural risks.

94 GHG report by ADEME; values are valid only for the combustion phase.

NB: The production of 1kWh of energy does not equate to 1kWh of electricity, meaning that each facility's yield rate must also be taken into consideration.

In 2016, emissions of atmospheric pollutants from thermal power stations burning fossil fuels stood at[95]:

- NOx: 13kt. Nitrogen oxides affect the respiratory system, and are potentially 40 times more harmful than CO[96]. These gases exacerbate global warming by participating in the formation of photochemical ozone and acid rain.
- SO$_2$ : 5kt. Sulphur dioxide affects the respiratory system, causing irritation. It also contributes to the acidification of natural habitats[97].
- PM (10 and 2.5): 0.5kt. Due to their size, fine particles can penetrate deep within the respiratory pathways and cause serious health problems depending on their chemical makeup (the term "fine particle" refers only to their size)[98].

These emissions represent a major issue in terms of climate change, as well as a threat to human health and natural environments. Measures to limit their prevalence are enshrined within the regulatory framework governing Regulated Environment Protection Facilities (ICPE).

The use of fossil-based energy also makes France dependent on its suppliers. Stocks of these resources are limited. A reduction in their use via the PPE will have a positive impact on the preservation of resources.

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Direct | Permanent | Medium-term |
| Impact of closures |  | Positive | Direct | Permanent | Medium-term |

The PPE's reduction of the use of fossil-fuelled thermal power stations will lead to a decrease in the risks associated with these facilities.
Risks associated with fossil-fuelled power stations are due to the high concentration of combustible materials in the same location. Coal power stations represent a major fire risk. Gas and oil power stations carry the risk of fire and explosion. These risks must be considered alongside the physical proximity of some of these facilities with other ICPE installations.

Regulations governing Regulated Environment Protection Facilities (ICPE) take careful consideration of the risks associated with these types of facilities.

## 3.2.5. Supply security

### Electricity storage (not including STEPs)

The PPE aims to increase electricity storage levels.

***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| **PPE impact** |  | **Positive** | **Indirect** | **Permanent** | **Medium-term** |
| Impact of storage measures |  | Neutral | Direct | Permanent | Medium-term |

95 Secten report – Combustibles 2017. Source: CITEPA
96 Nitrogen oxides – NOx. Source: CITEPA
97 Sulphur dioxide – SO2. Source: CITEPA
98 Airborne dust particles Source: CITEPA

Storage facilities do not emit any GHGs, and as such it is feasible to predict that increasing the capacities of storage facilities would indirectly contribute to a reduction in emissions of greenhouse gases and pollutants. Indeed, in the medium-term, this would enable a move away from thermal energy sources and increase the proportion of renewable energies.

***Non-renewable resources (excluding fossil energy sources) and waste***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Negative | Direct | Permanent | Long-term |
| Impact of storage measures |  | Operational vigilance | Direct | Permanent | Medium-term |

The batteries used in innovative storage technologies are made up of strategic materials (rare earth metals, lithium, nickel, etc.), the use of which will increase under PPE objectives. Some of these materials require specialised recycling processes. Methods currently used to recycle these materials are suited to existing technologies, but could, in the medium-term, become ill-adapted to the needs of new storage technologies. The recycling of certain types of lithium battery cells, in particular, still poses problems.
It is necessary to continue researching manufacturing techniques that are less resource-intensive, or those which use resources with less limited supply. In addition, efforts aiming to recycle these materials – in order to ensure that the development of electricity storage does not lead to increased pressure on reserves of strategic materials – should be continued. While the potential negative effects of this kind of pressure would be felt in the medium-term, anticipation of these risks is essential in the short-term (notably via the use of a resource plan). The National Circular Economy Strategy should contribute to structuring recycling sectors.

The development of storage capacities will also enable a reduction in demand for the resources necessary to construct certain extensions of the transport and electricity distributions networks.

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of storage measures |  | Neutral | Direct | Permanent | Medium-term |

The technological risks associated with peaking power plants, which are necessary to respond to peaks in demand, may also be reduced in comparison to development trajectories (no need to build new plants)
There are no particular risks associated with electricity storage facilities.

## Load management

The PPE aims to increase the use of load management methods.

***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage / Non-renewable resources (excluding fossil energy sources) and waste / Natural and Technological Risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |

Real-time navigation of demand is one possible method of avoiding the use of peaker plants (which are often gas-burning and emit high levels of GHG and pollutants) in order to respond to peaks in demand for electricity. The marginal gains involved would be significant, considering that hours of peaking production currently represent 15% of GHG emissions in the electricity production sector (for around 1/16th of consumption hours).

Developing the use of load management should contribute to a reduction in pressure on resource supply during peak demand times. Pressure on resources used for the construction of peaking power plants, as well as certain network infrastructures, would also be reduced, as would associated construction waste.

There are no particular risks associated with electricity load management.
The technological risks associated with peaking power plants, which are necessary to respond to peaks in demand, may also by reduced in comparison to development trajectories (no need to build new plants)

## Energy infrastructures

### *Heating and cooling networks*

The PPE aims to further develop heating and cooling networks.

| ***Climate and Energy / Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| PPE impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of networks |  | Positive | Indirect | Permanent | Medium-term |

The development of heating networks contributes indirectly to the reduction of greenhouse gas emissions and pollutants. Indeed, using these networks rather than individual devices enables heat resources to be managed in a more efficient fashion, by drawing value from additional resources (notably reclaimed heat). They also offer excellent flexibility of use, thereby contributing to greater flexibility in the energy system as a whole.
In addition, the use of heat networks allows for further development of renewable energies (notably the use of wood energy) while also limiting emissions of atmospheric pollutants. The combustion devices used in collective residences are equipped with filters, which are better maintained and more efficient than those found in individual devices. Their emissions are covered by the ICPE regulatory framework.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| **PPE impact** |  | **Neutral** | **Direct** | **Permanent** | **Medium-term** |
| Impact of networks |  | Operational vigilance | Direct | Permanent | Short-term |

The establishment of heat networks could lead to localised alterations of ecological environments (terrestrial or aquatic), as well as occasional artificialisation of certain natural and agricultural surfaces. The harmful effects of each project over their respective timeframes will be identified and specified within the framework of the authorisation procedures to which these networks are subject.

## Liquid fuel network

The PPE does not aim to make any significant modifications to this network.

## Gas network

The PPE does not aim to make any significant modifications to this network.

## Electrical networks

The distribution network requires certain reinforcements in order to integrate the use of decentralised renewable energies as stipulated by the PPE. Infrastructure plans are also evaluated under the environmental evaluation framework of the Ten-Year Development Plan for the Electricity Transport Network (RTE).

| ***Climate and Energy / Public health*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| **PPE impact** |  | **Positive** | **Indirect** | **Permanent** | **Medium-term** |
| Impact of networks |  | Operational vigilance | Direct | Permanent | Short-term |

The development of electricity networks contributes indirectly to a reduction in emissions of GHG and atmospheric pollutants by increasing the market penetration of non-carbon electricity, at the expense of fossil fuels. The main connection projects being planned aim to enable the integration of decentralised renewable energies; as such, their construction will contribute to the energy transition.
The sulphur hexafluorides ($SF_6$) used to insulate electrical lines have a global warming potential of 22800. Particular care must be taken not to allow these substances to escape into the environment during insulation operations.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| **PPE impact** |  | **Neutral** | | | |
| Impact of electrical lines |  | Operational vigilance | Direct | Permanent | Short-term |

Major linear infrastructures extending over large distances can have an impact on ecological continuities. The growing use of submerged (buried) networks could help limit the impact on landscapes.
Building these infrastructures will have an impact on biodiversity during the construction phase, whether the lines are buried or not. The installation of electrical substations will have an impact on the use of soils and on associated biodiversity issues.

During the operational phase, aerial electricity lines represent a danger to bird species through collisions. The maintenance or these lines (both aerial and submerged) involves removing trees from the vertical spaces above or below the lines in order to avoid interference. These cleared sectors have an effect on the landscape and the continuity of green belts.

The ecological effects of infrastructure plans are specified and evaluated at a local level as part of the assessment procedures to which they are subject. It should be noted that every major infrastructure project must be compatible with the strategic directions set by the green and blue belts. All such projects must take into account local regulations and ecological concerns (as identified within the SRCE, Natura 2000 zones, etc.). Distribution infrastructures will not be built if they are shown to have a negative impact on biodiversity.

## Recharging infrastructures for alternative fuels

These aspects are covered in more detail in the following section on the Clean Transport Development Strategy.

## 3.3. Implementation of the Clean Transport Development Strategy (SDMP)

### 3.3.1. Managing growing demand for transport

The SDMP includes a number of measures designed to help manage the growth in transport demand. These measures will help to:

- Reduce the number of journeys taken;
- Modify behaviours and modes of transport in favour of options that have less impact on the environment;
- Take transport issues into account when making consumption choices;
- Suggest organisational models that enable a reduction in negative environmental effects.

***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage / Non-renewable resources (excluding fossil energy sources) and waste / Natural and Technological Risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Positive | Indirect | Permanent | Medium-term |
| Project impact |  | Positive | Indirect | Permanent | Short-term |

The reduction in the need for transport will help to slow down urban sprawl, and consequently in the levels of energy consumption and atmospheric pollution associated with this phenomenon.
The reduction in energy consumption via transport will limit the use of fossil fuels and France's dependence on imported fossil fuels.

The modification of behaviours and methods of consumption is an effective strategy in decreasing road traffic (in particular of merchandise) and infrastructure requirements. The transport sector's impact on regional development, land use, biodiversity and landscapes will therefore be reduced, as will pollution and the risk of transport-related accidents.

### 3.3.2. Developing low-emission vehicles and fuel-delivery infrastructures, and improving energy efficiency of vehicles nationwide

The sections examining the development of low-emissions vehicles and those using alternative fuels can often cause near-identical effects. In order to avoid any analytical redundancy, negative effects directly linked to vehicles themselves are presented in the first section, while incidences linked to the development of the infrastructures needed or to supply sectors are presented in the second.

#### Development of low-emissions vehicles

The PPE and the SDMP aim to replace the combustion-engine vehicle fleet with low- $CO_2$ emissions vehicles.

***Climate and Energy / Public health and Pollutants***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Positive | Direct | Permanent | Medium-term |

| | | | | | |
|---|---|---|---|---|---|
| Impact of vehicles |  | Positive | Direct | Permanent | Short-term |

The widespread deployment of low-emissions vehicles would help limit emissions of greenhouse gases and atmospheric pollutants, in that the vehicles themselves produce less pollution during their operational phase than traditional vehicles. Replacing combustion-engine vehicles with low-emissions vehicles could therefore have a positive impact on climate change. The level of reduction achieved depends on the type of fuel used:

- Fuel-efficient combustion vehicles emit less pollutants and greenhouse gases;
- Electricity, when sourced from renewable or nuclear energy, does not cause any emissions of GHG or atmospheric pollutants;
- Hydrogen does not cause any emissions of GHG or atmospheric pollutants (provided electrolysis is achieved via renewable or nuclear energy);
- When consumed, natural gas emits 205g / kWh $CO_2e$, which is lower than the 270g / kWh $CO_2e$ emitted by liquid fuels[99]. Emissions of atmospheric pollutants from natural gas are generally around ten times lower than those from liquid fuels.

By diversifying the energy sources used in the sector, the development of low-emissions vehicles using alternative fuels will help reduce France's dependence on oil imports (to which the transport sector is particularly sensitive), which would also contribute greatly to supply security for oil-based products. However, where NG vehicles are used, oil imports would simply be replaced by imports of natural gas, as France relies on imports for practically its entire gas supply.

***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage / Natural and Technological Risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Positive | Indirect | Permanent | Medium-term |
| Impact of vehicles |  | Positive | Direct | Permanent | Short-term |

Noise levels of low-emissions vehicles can vary depending on the type of vehicle in question, but their noise emissions are generally lower than traditional combustion-engine vehicles. Low-emissions vehicles therefore represent an opportunity to reduce transport-related noise pollution, which not only affects populations but also animal species.

At low speeds (<25km/h), vehicles equipped with electric motors (electric, hybrid and hydrogen vehicles) run almost silently[100], which offers the possibility of reducing noise pollution caused by traffic in urban areas.

Vehicles running on NG are also less noisy than traditional combustion engine vehicles. A study by ADEME comparing the various technological sectors[101] found that *"The combustion of natural gas fuel occurs more slowly than that of other hydrocarbons. This leads to a significant reduction in vibrations, and consequently decreases the noise generated by these types of engines. The noise level is lowered by around 4 decibels, which is half the level generated by a diesel engine."*

***Non-renewable resources (excluding fossil energy sources) and waste***

99 ADEME – GHG report

100 ADEME, 2012: Development (using life cycle analysis) of forecasts for energy use, GHG emissions and other environmental impacts across all electric vehicle sectors and combustion-engine vehicles by 2012 and 2020

101 ADEME, April 2007: Environmental Advisory Reports - Energy: technological sectors for the coach industry

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Negative | Direct | Permanent | Medium-term |
| Impact of electric vehicles |  | Negative | Direct | Permanent | Short-term |

Increased use of electric and hybrid vehicles using batteries made of strategic materials (cobalt, manganese, lithium, etc.) requires planning for their recycling, in order to ensure that the development of clean transport does not lead to increased pressure for imports of these materials. *The management of waste, notably lithium batteries, remains a significant issue in the development of electric transport.*

### Deployment of recharging infrastructure for alternative fuels

The PPE and SDMP aim to increase the development of recharging infrastructures for alternative fuel vehicles, in particular electricity, hydrogen and natural gas (LNG[102] and CNG[103]).

| ***Climate and Energy / Public health and Pollutants*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| **SDMP impact** |  | **Positive** | **Indirect** | **Permanent** | **Medium-term** |
| Impact of recharging stations |  | Positive | Indirect | Permanent | Short-term |

Vastly increasing the number of recharging solutions available to everyone will help boost the number of electric cars on the road, by making journeys easier to plan and complete (particularly over long distances). The deployment of electric transport solutions will help achieve the objective of halting sales of GHG-emitting vehicles by 2040. As a result of this measure, air quality in urban areas will improve, notably due to the reduction in fine particle emissions.

The development of electric transport solutions could also bring indirect benefits in terms of climate change. Indeed, the integration of electric vehicles into the network could improve its flexibility, by serving as energy storage devices. This increase in flexibility could, in time, help facilitate the integration of intermittent renewable energy sources.

A certain level of vigilance will be necessary regarding storage, in order to avoid any leakage of natural gas. Both LNG and CNG are composed primarily of methane ($CH_4$) whose global warming potential is 25 times greater than that of $CO_2$.

| ***Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage / Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Negative | Direct | Permanent | Medium-term |
| Impact of electric charging stations |  | Negative | Direct | Permanent | Short-term |

102 Liquefied Natural Gas
103 Compressed Natural Gas

| | | | | | |
|---|---|---|---|---|---|
| Impact of hydrogen charging stations |  | Negative | Direct | Permanent | Short-term |

Electrical charging stations take up much less space than hydrogen stations (as they are connected to a network and do not require large storage spaces), and are generally installed within spaces that have already been artificialised (car parks, collective or individual parking spaces); however, they will also be much more numerous than hydrogen charging stations. Electric charging stations will therefore have an impact on land use in urban areas, except in cases where they are installed in users' home parking facilities.
The development of hydrogen charging infrastructures will have an impact on land use, as well as biodiversity and landscapes in the areas they occupy. Increasing the number of charging points will require the artificialisation of new surfaces.

In the same vein, the construction of new charging stations will require the use of additional resources.

***Natural and technological risks***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Neutral | Direct | Permanent | Medium-term |
| Impact of electric charging stations |  | Neutral | Direct | Permanent | Short-term |
| Impact of hydrogen charging stations |  | Negative | Direct | Permanent | Short-term |

The development of alternative fuels does not imply an increase in the risks linked to the use of vehicles, as these fuels are no more and no less hazardous than traditional fuels. The challenge lies in managing the specific risks associated with their use.
For example, hydrogen is a highly flammable gas; it is very light and often transported and handled when highly pressurised. It also possesses specific corrosive properties, requiring certain precautions regarding the materials used for its transport and handling. Adaptive measures will therefore be necessary, without significantly increasing the overall risk.

Electric charging stations pose no risks. Hydrogen charging stations are covered by regulations applying to Regulated Environment Protection Facilities (ICPE).

## 3.3.3. Promoting modal shifts for passenger and freight transport

The SDMP aims to increase the number of available options for the modal shift of passengers and freight:

- Passengers: road → active, collective, collaborative and shared modes of transport.
- Freight: road → mass modes of transport such as river and rail transport.

### Promoting modal shifts for passenger transport

*Developing multi-modal transport options and promoting the use of active modes*

***Climate and Energy / Public health and Pollutants / Water resources and aquatic environments / Biodiversity and natural habitats / Soils and sub-soils / Landscapes and Heritage***

| | | Probable notable effects | Type of effect | Duration | Timescale |
|---|---|---|---|---|---|
| SDMP impact |  | Positive | Indirect | Permanent | Medium-term |

| | | | | | |
|---|---|---|---|---|---|
| Project impact |  | Positive | Direct | Permanent | Short-term |

Actions undertaken to promote a modal shift must enable a reduction in the number of passenger-kilometres travelled by road transport, thereby limiting emissions of GHG and atmospheric pollutants over the same journey travelled.
As regards passenger transport, the modal shift from road transport (94t $CO_2$ / Mpass-km) towards active, collaborative, shared and collective modes of transport (16t $CO_2$ / Mpass-km for collective modes[104]) should enable a reduction in emissions caused by the use of individual private vehicles. The development of active transport will have a positive impact on human health by increasing physical activity amongst users.

The replacement of road transport with rail and active transport options is likely to cause a decline in residual aquatic pollution, caused by the flow of rainwater polluted with hydrocarbon particles from roads into waterways.

The decrease in road transport achieved via the modal shift should also reduce noise pollution caused by vehicles.
*Developing collective, shared and collaborative modes of transport*

| ***Climate and energy / Human health and Pollutants / Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Positive | Indirect | Permanent | Medium-term |

The increase in the occupation rate of individual vehicles and the use of car-sharing should enable a reduction in the number of motorised vehicles in circulation, thereby reducing emissions of GHG and atmospheric pollution caused by their use.

The development of car-sharing schemes is likely to reduce urban noise and atmospheric pollution, since car-sharing helps reduce the number of vehicles on the roads.

104 Data calculated based on transport statistics (SDES) by multiplying energy intensity by energy carbon content.

## Promote the modal shift and efficiency of freight transport

*Develop bulk modes for freight*

| ***Climate and Energy / Public health and Pollutants / Natural and Technological Risks*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Positive | Direct | Permanent | Medium-term |
| Project impact |  | Positive | Direct | Permanent | Short-term |

Actions to promote modal shift should reduce the number of tonne-kilometres travelled on the road and thus limit GHG and air pollutant emissions.
For freight, the modal shift from road transport (84 $tCO_2$/Mt-km) to river (69.3 $tCO_2$/Mt-km) or rail transport (7.3 $tCO_2$/Mt-km) would limit transport of goods by truck-related emissions[105].

The reduction in road transport permitted by the modal shift should reduce the noise pollution related to road traffic, the main source of noise in France.

| ***Non-renewable resources (excluding fossil energy sources) and waste*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Neutral | Direct | Permanent | Medium-term |
| Project impact |  | Operational vigilance | Direct | Permanent | Short-term |

Modal shift measures reduce the need for road infrastructure but increase the need for rail and river infrastructure. The construction of this new infrastructure will require many resources but will have a reduced impact on land use.

| ***Water and Aquatic Resources / Biodiversity and Natural Habitats / Soils and Subsoils / Landscape and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Positive | Indirect | Permanent | Medium-term |
| Project impact |  | Operational vigilance | Direct | Permanent | Medium-term |

The substitution of rail, river and active transport means for road transport is likely to lead to a reduction in residual water pollution due to the run-off of rainwater contaminated with hydrocarbons on the roadways.
The increase in the number and size of barges linked to the increase in river freight is likely to increase the pressure on aquatic environments due to the multiplication of pollutant discharges into the water.

The increase in port and river traffic may involve the use of larger shipping and river vessels, requiring greater channel depth and hence the dredging of certain waterways and port areas. This is likely to destabilise or even alter marine and river ecosystems to the extent that substantial volumes of materials from the bottom of water bodies will be displaced. Ballast water taken on board prior to departure and discharged upon arrival is likely

105 Data calculated based on transport statistics (SDES) by multiplying energy intensity by energy carbon content.

to disturb aquatic ecosystems by altering the characteristics of the water and introducing foreign organisms into the environment.

The development of new railway lines is likely to interrupt, on an ad hoc basis, certain ecological continuities and to alter or destroy certain natural environments that contribute to the overall functioning of the green and blue corridor. These issues must be taken into account when drawing lines.

*Increase the filling rate of freight vehicles*

| ***Climate and Energy / Human Health and Disturbances / Resources and Waste / Soils and Subsoils / Biodiversity and Natural Habitats / Landscapes and Heritage*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Positive | Direct | Permanent | Short-term |

The increase in the fill rate and use of freight vehicles reduces the number of vehicles in circulation and the emissions of GHGs and air pollutant emissions associated with road traffic. The reduction of traditional fuel consumption linked to the optimisation of existing vehicles will limit France's dependence on imported fossil fuels.

Optimizing existing networks should reduce the need for infrastructure and so reduce the impact of the sector on land use, biodiversity and landscapes. Disturbance and the risk of accidents related to transport will also be reduced.

## 3.3.4. Making clean mobility accessible to sparsely populated areas and unleashing innovation

Promoting the emergence of new mobility solutions, especially in rural areas, should enable landlocked areas to benefit from their own mobility as well.

| ***Climate and Energy / Public health*** | | | | | |
|---|---|---|---|---|---|
| | | Probable notable effects | Type of effect | Duration | Timescale |
| SDMP impact |  | Positive | Direct | Permanent | Medium-term |
| Project impact |  | Positive | Direct | Permanent | Short-term |

Placing rural and low-density areas at the heart of these innovations would avoid the development of two-speed mobility and reduce the cases of fuel poverty related to transport for vulnerable groups.
In these areas, where cars remain the preferred means of transportation, bringing new solutions based on cleaner modes would reduce GHG and air pollutant emissions.

Facilitating the experimentation of new mobility solutions would have an indirect impact on the environment, depending on the nature of the experimentation and its need for natural and spatial resources.

# 4. Explanation of reasons for the decision

## 4.1. Demand management

LTECV sets the objectives of the French energy policy. One of the objectives is to fight climate change by reducing GHG emissions. The government has strengthened these objectives by setting 2050 as the date for achieving carbon neutrality. The PPE must make it possible to put France on the trajectory to reach this objective which thus serves as a guideline to the elaboration of the prospective energy.

In order to implement these objectives to reduce greenhouse gas emissions, the PPE provides for measures to control demand, particularly fossil fuels, as well as measures to diversify the energy mix, including the penetration of renewable energies. These measures have the indirect effect of improving air quality by also reducing the release of air pollutant emissions.

### 4.1.1. Ambitious demand management objectives

Demand management means that GHG emissions from energy production and consumption can be avoided. France aims to reduce its energy consumption by 20% between 2012 and 2030.

In order to define sufficiently ambitious objectives for demand management, the potential growth margin of each sector has been analysed, based on macro-economic assumptions.[106] These measures nonetheless serve as a basis for discussion on the defining of an ambitious, but achievable, scenario, given the observed behavioural dynamics, the abilities of our economic actors to implement actions, and costs. The PPE takes account of these elements and reduces energy demand by 17% between 2012 and 2030. The PPE update in 2023 may be an opportunity to accentuate this trajectory in order to reach the 20% target by taking account of the evolution of technologies and practices.

### 4.1.2. Reducing fossil fuels

One of the main sources of GHG emissions is the burning of fossil fuels. France has a target of a 30% reduction in primary energy consumption of fossil fuels between 2012 and 2030.

To achieve the fastest possible reduction in emissions from fossil fuel facilities, it was decided to prioritise the shut-down of power plants, based on the quantity of discharges. Thus, coal-fired power plants will be the first to be closed because they are the sources of most GHG emissions. Additional actions have been taken to enable this abandon of coal to assist individuals still using coal as well as businesses, while ensuring their competitiveness. The reduction in coal consumption will have a significant positive impact on both greenhouse gas emissions and air pollution.

The goal is then to reduce the use of oil in both electricity generation and transportation. Given the difficulty of reducing mobility demand, it has become necessary to replace diesel and petrol with low-carbon fuels.

There is no specific measure for reducing gas consumption because it is the least carbonised fossil energy. It should result from non-targeted demand management actions on a specific energy vector, particularly building renovation. In addition, carbonaceous natural gas will have to be replaced by biogas with its neutral carbon footprint.

Reduction efforts are therefore distributed so as to enable the fastest possible reduction in the amount of greenhouse gas emissions.

## 4.2. Diversifying the energy mix

France aims to increase the share of renewable energy to 23% of final energy consumption in 2020 and 32% in 2030.
The objectives for increasing the share of renewable energies correspond to the maximum development potential of each sector, taking into account environmental, technical, social and economic criteria.

106 These assumptions include demographic projections and economic growth assumptions provided by INSEE, as well as energy efficiency assumptions provided by the DGEC.

French Environment & Energy Management Agency (ADEME) studies[107] show that the optimal mix never saturates a technology because of the complementarity between sectors concerning their impact on the environment, their contribution to the network, their consumption of resources and their feasibility. The assessment of these multiple criteria makes it possible to construct a balanced energy mix that does not prejudge the choices that can be made thereafter.

### 4.2.1. The determination of the available potentials according to the environmental constraint and the realities of the sectors

The development potential of a sector generally corresponds to the exploitable deposit or potential. The determination of this potential takes into account the environmental constraint when its use is likely to increase the pressure on the environments. The potentials are thus determined so as to control the environmental stakes related to the deployment of the sectors (land use, biodiversity, etc.). The choice to diversify the sources of energy makes it possible not to saturate any one type of environment.

Except for the use of biomass, the quantitative issue of the exhaustible resources mobilised by these different sectors has not been a determining factor in the choices made for this Multi-Annual Energy Plan since it is not yet critical. However, it is the subject of particular attention and will be taken into account in the context of the implementation of the circular economy roadmap. The development of recycling channels will be supported.

#### Electricity mix

On the 2050 horizon, carbon neutrality will require the electrification of many applications. In the shorter term, efforts to control demand should be higher than or equal to these first transfers, which will lead to a stable or slightly lower electricity consumption.

*The diversification of the mix and decentralisation of production will be continued for the full term of the PPE while gathering speed over the 2nd period*

France is engaged in diversifying its electricity mix in order to make it more sustainable, increase its resilience and foster technological progress. This development of renewables should enable us to produce more energy from sources present on French territory and progressively reduce the share of nuclear.

The development of renewables is a global movement and particularly present in Europe, a continent which is at the cutting-edge of the fight against climate change. The European Union has therefore set a goal of 32% renewable energy across Europe for 2030 (on all energies: electricity, gas, heat). This dynamic has contributed to a sharp drop in the production costs of electricity from renewable energy, making ground-based solar or wind the most competitive sources today, as long as the electricity systems do not need the addition of storage to manage the intermittent nature of these electricity sources.

*The government is committed to an unprecedented development of its renewable electricity production while paying careful attention to environmental issues, local feasibility, conflicting uses*

The Energy Transition for Green Growth Act set a target of 40% electricity from renewable sources in national production in 2030. In 2017, renewables accounted for 17 % of national production (2017 RTE electricity balance). The main channels that can enable this goal to be met are hydroelectricity, photovoltaic solar (PV) and onshore wind power, then progressively offshore wind power whose production will increase during the second PPE period. These are the most competitive channels: the sharp drops in costs observed in these channels make it possible to develop significant capacity with less public support compared to previous projects (for which we are currently paying because the support to electric renewables is granted during 15 to 20 years after the beginning of production). The pace of their rollout is intended to increase compared to the objectives of the previous PPE, which are at 3 GW/year for PV and 2 GW/year for onshore wind.

Photovoltaic solar will be proportionately more developed in big solar power stations than it is nowadays, because it is the most competitive channel and big projects (>50MW) will progressively be developed without

107 ADEME, October 2015, A 100% renewable electricity mix? Analyzes and optimizations

subsidy which will increase the average size of the systems. The government will ensure that these projects respect biodiversity and agricultural land, by prioritising the use of industrial wasteland, neglected motorway space, military areas or even the solarisation of big roof areas which will gradually become mandatory.

Wind power will be developed partly through renovation of existing systems that have reached the end of their life, which will enable us to increase the energy produced while keeping an identical or smaller number of masts. In total, the transition from 15 GW in 2018 to 34.1 GW in 2028 will lead to a progression in the wind farm capacity from 8,000-masts at the end of 2018 to approximately 14,500 in 2028, i.e. an increase of 6,500 masts.

Marine energies will provide a significant complement, all the more so because their level of availability (>4000hrs/year) will enable the electricity network to be stabilised, particularly in the Brittany peninsula. The first 6 offshore wind projects, which were subject to renegotiation, will all be operational at the start of the 2nd period of the PPE. In order to capitalise on the industrial channel created in this way, 3 calls for tender for fixed equipment and 3 calls for tender for floating equipment, totalling 3.25 GW, will be launched in the first period of the PPE. The floating farms in Brittany and in the Mediterranean will be world firsts, and will ensure France becomes a leader in these technologies with a very big market potential.

Hydroelectricity still accounts for the biggest part of the renewable electricity produced in France. Its development is however limited by physical capacity. During the period of the PPE, the reopening of competition for franchises that have passed their deadline and work connected with the extension of the Rhône franchise will enable the installed power to be pushed up by developing new capacity without new damming of water. Furthermore, research into optimising the existing sites will be carried out and some new projects will be developed.

Considering the costs of producing geothermal and biomass electricity, support for these sectors will be reserved for heat production in order to optimise the overall cost of meeting the renewable energy goals and encourage the most energy efficient solutions. Innovative projects, where appropriate, may be supported within the framework of provisions for R&D. Equally, tidal power technologies do not appear sufficiently mature to stimulate commercial development in sustainable economic conditions before the end of the PPE.

*The government is defining a credible and realistic program for reducing the share of nuclear energy in electricity production with a goal of 50 % in 2035*.

The Fessenheim nuclear power station should be shut down with effect from spring 2020, by applying a cap to installed electronuclear power and to enable the commissioning of the Flamanville EPR.

Beyond this first stage, the government is pursuing a goal of diversifying the electricity mix to reach 50 % electricity production from nuclear. This diversification policy is a response to several different issues:

- A more diversified electricity system, if it succeeds in integrating an increased volume of variable renewable energies, can be an electricity system that is more resilient to external impacts such as, for example, a drop in the production capacity of reactors following an incident or a generic failing leading to the non-availability of several reactors;
- The vast majority of the nuclear electricity power station system was built over a short period of time, about 15 years. We should therefore anticipate the shutdown of certain reactors in the existing system to avoid a “cliff edge“ effect which would not be sustainable, neither in terms of social impact nor for the electricity system. This anticipation is also necessary to spread out investment in new electricity production capacity;
- Several channels for electricity production from renewable sources have shown their ability to compete and will make up a significant part of the long-term electricity mix, at least until a massive electricity storage need appears;
- Diversification on this scale towards renewable energy should be smoothed out over the course of time because the new renewable capacity will be installed in a diffuse and decentralised way by means of small projects and channels requiring a gradual stepping up in power.

It seems impossible to reach the goal of 50% of electricity in production being sourced from nuclear by 2025, except by risking disruptions to France's energy supply or by restarting the construction of combustion power plants which would run contrary to our goals to fighting climate change.

Therefore, the government has set the achievement of 50 % electricity from nuclear in the mix as an objective for 2035. Such a progression is consistent with our climate commitments: it will be completed without building any new fossil fuel thermal power plants, it will not lead to an increase in greenhouse gas emissions from our electricity production and it is compatible with the closure of all our coal-fired power plants between now and 2022. It is also consistent with the challenges of maintaining a closed cycle for fuel and sustaining the cycle facilities and will enable the regions and employees to prepare better, to undertake their reconversion well in advance and to structure the dismantling channel.

The government has chosen to show a clear programming for the changes to nuclear capacity, including beyond the term of the PPE (2028), so as not to task our successors with designing the modalities for putting this diversification into action. Therefore, to achieve this 50 % electricity production goal in 2035, the government sets the following guidelines:

- 14 nuclear reactors will be shut down between now and 2035, including those at the Fessenheim plant;
- The final version of the PPE will identify the sites for which these closures will be prioritised. During the PPE consultation period, EDF should send the government a list of the nuclear sites concerned, by prioritising reactor shutdowns that do not lead to the complete shutdown of any site in order to minimise the social and economic impact of these closures. The State's preliminary analysis, based on the age of the sites, the dates of their ten-year inspections, and the industrial and economic vision described by EDF in its contribution to the public debate on the PPE, steers us towards a prioritised closure of 12 reactors from amongst those at the sites of Tricastin, Bugey, Gravelines, Dampierre, Blayais, Cruas, Chinon and Saint-Laurent;
- The general principle will be the shutdown of the 12 reactors (excluding Fessenheim) with a deadline falling at the latest at their 5$^{th}$ ten-year inspection. The shutdowns at the 5$^{th}$ ten-year inspection enable a scenario that is consistent with EDF's industrial strategy which will amortise the accounts of the 900 MW reactors over a period of 50 years, the Government considers therefore that these shutdowns will not give rise to compensation.
- Nonetheless, in order to smooth reactor shutdown to facilitate its implementation socially, technically and politically, 2 reactors will be shut down in advance of their 5$^{th}$ ten-year inspections in 2027 and 2028, except in cases of non-compliance with security of supply criteria or sudden shutdown of other reactors for safety reasons;
- 2 reactors could also be shut down in the next five-year presidency, in 2025-2026, under two conditions: security of supply is assured and if our European neighbours speed up their energy transition, reduce their production capacity from coal and massively develop renewable energy, which would lead to low electricity prices on European markets that could lower the profitability of the extension of existing reactors. These conditions presuppose coordination with our neighbours on the evolution of European electricity systems. The analysis of these conditions will be the subject of a report submitted by the Commission for Energy Regulation (Commission de régulation de l'énergie, CRE) to the government before 1st December 2022 and based on RTE expertise.

The early closures will be confirmed 3 years before their implementation based on data available at that time, in order to ensure that the above-mentioned criteria are complied with. This will begin after the coal-fired power plants have been shut down, since the priority is to decarbonise electricity production. These closures will be systematically supported by the state, principally by means of establishing ecological transition contracts in order to enable the regions to participate in new development dynamics.

Furthermore, the strategy for treating-recycling nuclear fuel will remain over the PPE period and beyond, until the 2040s, when a large portion of the facilities and workshops of the Hague plant will reach the end of their life. To this end, and to compensate for the closures of the MOX fuelled 900 MW reactors over this period, the moxing of a sufficient number of 1300-MW reactors will be undertaken in order to maintain the French cycle sustainable.

Beyond this timeline, the government, in association with the channel, should assess the strategic direction it desires for its fuel cycle policy, based on R&D efforts which will be pursued over the term of the PPE in the field of closing the fuel cycle.

## Heat mix

Heating represented 42% of final energy consumption in 2016, i.e. 741 TWh. The main production source is gas at 40%, followed by renewable energies (biomass, heat pumps, geothermal, biogas, solar thermal) at 21%, electricity and petrol at 18% and 16% respectively, and only marginal amounts of coal at 5%. Achieving decarbonisation in heating is therefore a priority.

The residential-tertiary sector accounts for 65 % of final heat consumption, while industry accounts for 30 %; the share for agriculture is low. As a result of the measures to control energy demand, heating needs should be at 690 TWh in 2023 and 631 TWh in 2028.

The PPE intends to accelerate the growth rate of the share of renewable heat by an average of 1.2% per year, i.e. 1.5 times faster than that recorded between 2010 and 2016. In 2028, renewable heat production should be somewhere between 218 and 247 TWh.

Geothermal potential for heat production is limited due to the difficulty of finding exploitable sites. Prospecting operations are lengthy and costly, as they must involve exploratory drilling in addition to geological analyses in order to find deep enough and sufficiently permeable geological formations where the water has warmed up deep in contact with the rocks.
The biomass potential is assessed under the SNMB (National Strategy for the Mobilisation of the Biomass) based on the potential for renewal. The use of the biomass resource has been favoured for the production of heat rather than for the production of electricity in order to optimise its use in the production facilities benefiting from the best yields. Optimising resources makes it possible to limit the impact of its exploitation on the environment.

The potential of thermal solar is competing with the solar photovoltaic potential on the roof. It also depends on the sunlight conditions, but does not raise any environmental issues. On the other hand, no particular potential limitation prevents from developing heat pumps installation.

### Gas

Natural gas is today crucial to the French energy system. Its storage capacity is vital to meet the demand during heat and electricity spikes in winter. Besides, natural gas is the least carbon-rich fossil fuel and therefore enables us to reduce $CO_2$ emissions and atmospheric pollutants when it substitutes petroleum, for example in transport. However, natural gas is no less a fossil fuel and therefore needs to be replaced in the long term by biogas or new synthetic gas produced with renewable energy: hydrogen or power-to-gas (manufacture of synthetic gas, principally methane, by using renewable electricity).

The advantages of biogas are already evident today, this renewable energy:

- can be stored easily;
- can be produced by farmers, offering them the opportunity to earn some extra income;
- allows waste to be used as fertilizers that would necessary be safe for health and environment;
- allows the use of an energy network already in existence over a large part of the territory which serves industry and transport.

Production costs for renewable gas are today about four times that of natural gas, but prospects of a lower cost have been indicated by players in these channels. Developing a higher production capacity should enable costs to come down, principally by means of economies of scale. The PPE provides for an adaptation of the pace of construction of new production capacity based on real time observations of the costs coming down.

NGV (Natural Gas for Vehicles) is an alternative solution to fossil fuel which enables atmospheric emissions to be limited. Furthermore, through the use of bioNGV, it could become a completely carbon-free fuel. This new use is being developed for heavy vehicles and is destined to grow. It seems sensible for the markets to direct biogas production mainly towards the means of transport that are difficult to make carbon-free rather than towards uses in buildings where other low-carbon alternatives exist.

The objective of the PPE is for biogas to reach 7 % of gas consumption in 2030 if the lower costs targeted in the baseline trajectory indeed come about, and up to 10 % if there is an even greater drop in costs.

### Liquid fuels

Liquid fuels, petroleum derivatives, represent a significant share of French $CO_2$ emissions in uses that are often difficult to substitute: transport in particular is heavily dependent on oil. The 10 years of the PPE are key to developing alternative energies to petroleum products in transport. The drop in consumption and the substitution of liquid fuels by other energy vectors (electricity, gas) will be the main lever, but it is neither sufficient in the short-term nor for certain specific uses like air or long-distance maritime transport: as such more environmentally friendly biofuels also need to be developed.

The consumption of liquid fuel should be about 432 TWh in 2028, driven by energy control measures. The goal of incorporating 1st generation biofuels will not exceed 7% of the energy contained in fuel, by 2023 and 2028. Increasing the share of bio-sourced materials in fuel will thus be done exclusively by developing advanced biofuels, that is to say, those made from waste, residue or non-food primary materials.

There will be a major focus on meeting sustainability criteria and on the traceability of the raw materials to achieve the goals set. In conformity with the European framework, biofuels produced from materials with a high risk of impacting changes in land use will be capped and then reduced to zero

### 4.2.2. An assessment in terms of technology costs and service rendered to the network

In order to limit the cost of the energy transition, the accent is on the development of the most profitable energies (wind and PV on the ground). However, it has been decided to develop all sectors in order to diversify energy sources and to remain open to the possibility of progress in other sectors.

In addition to the costs associated with the facilities and operation of energy production facilities, it is necessary to take account of the indirect costs related to the impact of different technologies on the network.

Facilities using intermittent energies, such as solar energy, whose activity varies with the number of daylight hours, and wind turbines, which depend on wind regimes, do not guarantee continuous production of electricity. It is therefore necessary to continuously develop operating facilities such as run-of-the-river hydropower stations and geothermal power plants that provide stable electricity production as a basis for grid balance. In order to cope with peak consumption and ensure security of supply, the controllable facilities such as hydroelectric plants with dam hold an important place in the renewable electricity mix.

The development of the use of biomass, energy recovery from waste and renewable gas (power to gas or biogas) makes it possible to increase the share of renewable energy that can be easily stored. The choice to diversify energy sources makes it possible to reinforce the resilience of the energy system in the event of a generic failure of a type of facility.

| | Issue | | | | Deposits still to be developed |
|---|---|---|---|---|---|
| | **financial[108]** | **environmental** | **Feasibility** | **integration into the electrical system** | |
| **Hydroelectricity** | 30 → 130 €/MWh | Preservation of ecological continuities | Mature technology | controllable energy | limited |
| **Terrestrial Wind Turbines** | 50 → 80 €/MWh | Landscape and biodiversity impact | Limited acceptability | Variable energy production | non-limiting in the medium term |
| **Photovoltaics** | 45 → 75 €/MWh (ground)<br>75 → 120 € MWh (roof) | Impact on land use | Good acceptability | Variable energy production | non-limiting in the medium term |
| **Biomass** | Variable costs depending on the sector (waste, wood energy, biogas) | Resource management requiring prioritisation of biomass uses) | Medium feasibility constraints | controllable energy | Limited in the medium term |
| **Geothermal electricity** | 170 → 340 €/MWh | Impacts related to drilling | Difficult prospecting of deposits | controllable energy | limited |
| **Offshore wind energy** | 70→ 150 €/MWh | Impacts on marine environments | Acceptability constraint | Variable energy production | Non-limiting |

*Table 19: Summary representation of environmental, economic and technical considerations that led to the choice of the renewable electricity mix of the PPE*

108 Ademe, Cost of renewable energies, 2016 updated by DGEC knowledge.

| | Issue | | | Deposits still to be developed |
|---|---|---|---|---|
| | financial[109] | environmental | Feasibility | |
| **Solid biomass** | 45 → 110 €/MWh (individual)<br>62 →125€/Mwh (collective)<br>45 → 80 € / MWh (industrial) | Constraints on prioritizing uses of biomass and environmental quality of forest management | Limited development in urban areas due to air pollution issues | non-limiting in the medium term |
| **Heat pumps** | 105 → 170 €/MWh (individual)<br>50 → 130 € / MWh (collective) | Small environmental impact (linked to the electricity mix) | Strong | non-limiting |
| **Deep geothermal energy** | 65 → 120 €/MWh | Difficult prospecting of deposits | Good integration into heat networks | non-limiting in the medium term |
| **Biogas** | 96 → 167 €/MWh | Constraints on prioritizing uses) | Strong demand from the agricultural world | non-limiting in the medium term |
| **Thermal solar** | 155 → 451€/MWh (individual)<br>46 → 260 €/MWh (collective) | No environmental impact | Competition from heat pumps and PV (uses of the roofs) | non-limiting in the medium term |

*Table 20: Summary representation of environmental, economic and technical considerations that led to the choice of the development objectives of the renewable and recovered heat sectors of the PPE*

Key: Strong constraint | Medium constraint | Weak constraint

NB: Costs are shown within a range that takes account of the different technologies available. Significant reductions are expected especially in offshore wind energy, PV and thermal solar.

109 Ademe, Cost of renewable energies, 2016 actualised by DGEC knowledge.

# 5. Assessment of the global impact of the PPE

## 5.1. Presentation of the modelling used

### 5.1.1. Overall coordination

The energy and climate scenarios of the Ministry of Ecological and Solidarity Transition (MTES) underlying the work of the Multi-Annual Energy Plan (PPE) and the National Low Carbon Strategy (SNBC) are the "With Existing Measures" (AME) and "With Additional Measures" (AMS) scenarios.

The AME scenario includes all the public policy measures put in place before 1 July 2017. The AMS scenario aims to achieve the country's climate and energy objectives, in particular carbon neutrality by 2050. Both measure energy consumption as well as greenhouse gas emissions and air pollutant emissions in different sectors of the economy.

Regarding renewable energies, AME scenario considers all calls for tenders scheduled in the first PPE and extend deployment pace after 2023. It is assumed in the scenario, that new investments would be needed to renew power generation system. Nuclear production is identical in both scenarios because it is impossible to define the trajectory of nuclear production with existing policies.

Regarding objectives set out by law, AME scenario does not take over the objective of reducing final energy consumption because, even if some measures exist, there are not sufficient to conclude that the objective will be met. However, the objective of 100€/tCO2 is kept for the carbon component of TICPE because there is a dedicated instrument to reach the target.

On the 2019-2028 period, the AMS scenario for the SNBC and the PPE are identical. This means the scenario was designed to:

- be the most realistic, because the PPE is a planning exercise which should lead France in ecological transition without putting at risk security of supply
- commit energy system toward carbon neutrality in 2050. In order to build this scenario, a first reflection was made based on a carbon-neutral France. This allowed to explore several opportunities and to identify necessary steps to reach climate and energy targets in all sectors.

## 5.2. The PPE's impact on the environment

The following section presents the analysis of the likely general and cumulative impacts of implementing the PPE on the environment. These impacts are broken down according to the themes raised in Part 1 and are analysed with regard to the potential pressures identified in Part 2: Initial state of the environment.

The analysis is performed quantitatively when data exists and qualitative synthesized in a table when data is not available.

| | |
|---|---|
|  | The actions carried out by the PPE have the effect of increasing the pressure on the studied environmental theme |
|  | The actions carried out by the PPE have the effect of decreasing the pressure on the studied environmental theme |
|  | The actions carried out by the PPE have no impact on the environmental theme studied with regard to the potential pressure identified. |

It should be noted that an increase in pressure does not necessarily have a negative impact on the environment if it is contained below the threshold generating impacts. Regulatory compliance generally helps to prevent

negative environmental impacts of the activities concerned. Particular attention is paid to these topics in the project design.

### 5.2.1. Climate and Energy

Regarding the reduction of energy demand, the AME scenario would lead to reaching a final energy consumption level of 1,550 TWh in 2028. The AMS scenario would contain energy consumption at a level of 1,418 TWh, a reduction of 132 TWh.

Primary energy consumption drops by an additional 347 TWh in the framework of the AMS scenario compared to the AME scenario.

Primary consumption of fossil fuels is falling faster than primary consumption of total energies. The AMS scenario reduces primary fossil fuel consumption by an additional 267 TWh compared to the AME scenario.

The graph below shows the evolution of energy consumption in one or the other scenario. It shows that PPE should reduce energy consumption, particularly fossil fuels: this involves a reduction of impact on exhaustible resources as well as a reduction of environmental impacts linked to energy consumption.

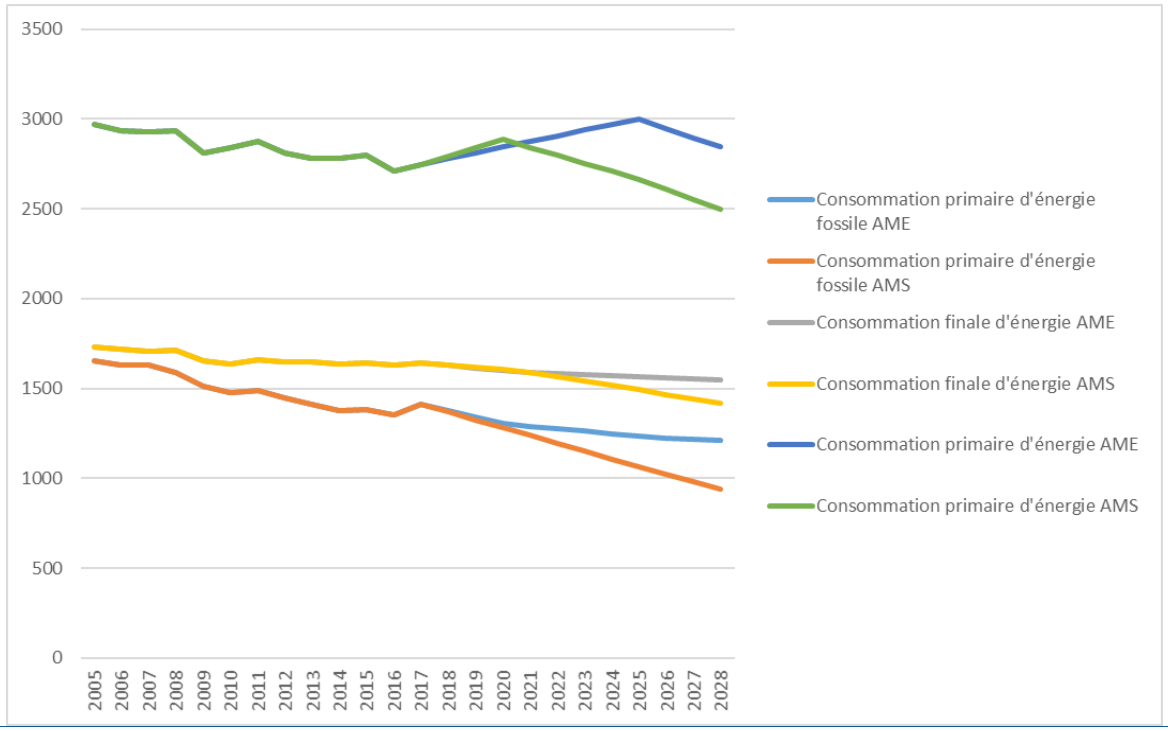



*Figure 39: Evolution of primary energy consumption, primary fossil energy and final energy consumption in the AME and AMS scenarios (TWh) - Data corrected for climatic variations*

Thus, the AME scenario would lead to GHG emissions due to energy consumption of 285 Mt $CO_2$e by 2028. The PPE is expected to contain GHG emissions at a level of 226 Mt $CO_2$e, a reduction of 59 Mt $CO_2$e. PPE leads to a significant reduction of greenhouse gas emissions and thus to a positive impact on climate change.

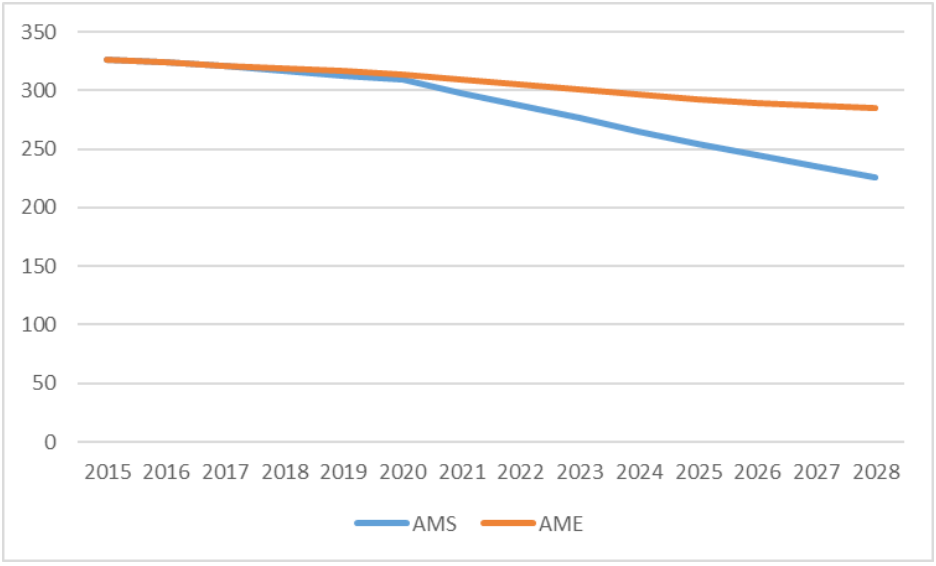



*Figure 40: Evolution of greenhouse gas emissions related to energy combustion (MteCO) – Data corrected for climatic variations*

## 5.2.2. Physical environments

### Water Resources and Aquatic Environments

| | | | |
|---|---|---|---|
| **Transport** | • Pollution from runoff waters. | Decline in the use of fossil fuels | ↘ |
| **Residential-Tertiary Sector** | • Pollution from run-off water and problem of soil sealing,<br>• Effluent from urban sewage treatment plants;<br>• Development of banks and rivers (obstacles to flow);<br>• Emerging pollution: drugs, endocrine disruptors, etc. | The PPE has no impact on these issues | → |
| **Agriculture** | • Pollution related to agricultural inputs: nitrates, phosphorus, pesticides...;<br>• Flooding and run-off issues related to soil management (settlements, etc.);<br>• Water pollution from suspended matter linked to run-off water on farmland;<br>• Extraction of water resources (irrigation). | The PPE has no impact on these issues | → |
| **Forest - wood - biomass** | • Flooding and runoff issues related to soil management (compaction, etc.);<br>• Pollution of water by suspended matter related to runoff. | Development of the exploitation of solid biomass | ↗ |
| **Industry** | • Effluent from industrial treatment plants;<br>• Pollution due to chlorinated solvents. | The PPE has no impact on these issues | → |
| **Energy production** | • Shoreline and waterway developments (impediments to flow) in the case of hydropower, associated with changes in water temperature in the case of nuclear production. | Low hydropower development and nuclear decline | ↘ |

| | | | |
|---|---|---|---|
| | • Modification of marine habitat at sites of marine energies: erosion of the sea and riverbeds, resuspension of sediments and modifications of the hydro-sedimentary regime, risk of pollution with chemicals and lubricants related to coatings used for facilities. | Development of offshore wind energy and marine renewable energies |  |
| | • Qualitative and quantitative pressures on water resources related to biofuel production. | No increase in 1G biofuel production, small increase for 2G biofuels |  |
| **Waste** | • Pollution from runoff waters (leaching). | Reduction of the amount of waste disposed of by energy recovery. |  |

*Table 26: Direction of the evolution of the pressure of human activities by sector on water resources and aquatic environments because of the PPE*

## Soils and sub-soils

| | | | |
|---|---|---|---|
| **Transport** | • Consumption of agricultural and natural spaces, artificialisation and sealing, | Reduced transport demand and reduced need for infrastructure. |  |
| | • Pollution from metals, metalloids and hydrocarbons. | Decline in the use of fossil fuels |  |
| **Residential-Tertiary Sector** | • Consumption of agricultural and natural spaces, artificialisation and sealing;<br>• Pollution from metals and metalloids | The PPE has no impact on these issues |  |
| **Agriculture** | • Artificialisation;<br>• Excessive inflow of phosphorous and nitrogen;<br>• Decrease in organic matter content of soils;<br>• Diffuse pesticide contamination;<br>• Pollution with metals and metalloids (via fertiliser applications);<br>• Stimulation of bacterial resistance (input of antibiotics via fertiliser application). | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • Soil compaction related to the use of forestry machinery;<br>• Decrease in organic matter content of soils (in the case of mass export of forest residues). | Development of the exploitation of solid biomass |  |
| **Industry** | • Artificialisation and sealing;<br>• Pollution from metals, metalloids and hydrocarbons. | Decrease of fossil energy consumption in industry and therefore decrease in discharges |  |
| **Energy production** | • Artificialisation and sealing of soils increasing tension on available land. | PV development, no increase in biofuels. |  |
| | • Pollution from metals, metalloids; | Replacement of the fossil fuel thermal park with renewable energies. |  |

| | | | |
|---|---|---|---|
| | • Pollution related to the decommissioning of nuclear power plants | The decline in nuclear power implies an increase in the amount of waste associated with the decommissioning of nuclear power stations. |  |
| **Waste** | • Pollution from metals and metalloids | Reduction of the amount of waste disposed of by energy recovery. |  |

*Table 27: Direction of the evolution of the pressure of human activities by sector on soils and subsoils due to the PPE*

The rise in the coming years of renewable energies in the French energy system will coincide with a gradual decentralisation of the energy system and will necessarily call into question the organisation of territories and modes of land management. Specific measures are planned within the PPE to anticipate possible conflicts of use with the agricultural, forestry or even housing construction industries in certain territories with high land pressure.

Estimates based on PPE forecasts for the photovoltaic industry show that the corresponding space consumption (based on hypotheses of 1 ha/MW and 3 ha/MW) could represent around 4,658 ha to 13,974 ha by 2018 and from 11,325 ha to 33,974 ha at most by 2023 (upper bound estimates), i.e. an 8-fold increase by 2023 of the surface area currently occupied by ground-based power plants. They will thus represent approximately 0.68% of the artificialised surfaces in metropolitan France[110].

This PPE limits the development of first-generation biofuels to their current level, which avoids an increase in the need for agricultural land.

Demand management for transport will limit new infrastructure needs and thus reduce transport-related land use.

The impact on the soil linked to the increase of logging will be limited so that it respects the recommendations of the PNFB.

### Resources and waste

The development of renewable energies increases the use of certain specific resources, particularly some rare metals such as dysprosium and neodymium for offshore wind turbines using permanent magnets (onshore wind turbines have a much lower consumption of resources because of the technology used). The development of innovative energy storage means will also lead to additional pressure on certain strategic materials such as lithium, cobalt and manganese for the production of electric vehicle batteries.

It is difficult to assess the impact that PPE will have on the demand for resources because of the lack of reporting on the subject. The SURFER project led by the CNRS aims to determine the unitary requirements for raw materials for the various technologies of the main renewable energy sectors.

Continuing to search for less resource intensive technologies or alternative materials and anticipating the structuring of appropriate recycling channels will reduce France's dependence on these resources whose limited reserves are controlled by a small number of countries making supply sensitive to the geopolitical context. Studies carried out (in particular within the framework of the SNRE) will have to take into account the entirety of electromobility and not only individual electric vehicles.

Beyond the use of rare earths, energy transition mobilises a large number of materials necessary for the construction of energy production infrastructures. The implementation of PPE has the effect of increasing the demand for materials such as steel, copper, concrete or cement. In order to limit this consumption of resources, it is necessary to anticipate the recycling of building materials.

Similarly, the transition to sustainable mobility will require anticipating the management of waste associated with major infrastructure projects involving work and the planned reduction of the particular car fleet which will result in a temporary increase in the volume of car wastes. Supporting the transition to sustainable mobility involves further research into the composition and recycling of batteries.

110 Source: SSP - Agreste - Teruti-Lucas study 2012. The artificialized surfaces are estimated at 5 Mha or 9% of the metropolitan territory.

| | | | |
|---|---|---|---|
| **Transport** | • Increase in the consumption of rare earths | Development of electric mobility (lithium batteries) |  |
| **Residential-Tertiary Sector** | • Consumption of fossil and non-energy mineral resources (metallic and non-metallic) | The PPE has no impact on these issues |  |
| **Agriculture** | • N/A | |  |
| **Forest - wood - biomass** | • N/A | |  |
| **Industry** | • Consumption of fossil and non-energy mineral resources (metallic and non-metallic) | Decrease of fossil energy consumption in the industry. |  |
| **Energy production** | • Consumption of fossil resources and of non-energy mineral resources (metallic and non-metallic), for example: the development of renewable energies is likely to lead to increased use of certain rare metals such as indium, selenium or tellurium, used for part of high-performance photovoltaic panels. | Development of wind turbines (dysprosium, neodymium), PV (Cadmium, Indium, Gallium, Selenium) and storage (lithium). |  |
| | • Uranium consumption for nuclear production | Nuclear decline and further research on the closure of the uranium cycle. |  |

*Table 28: Direction of the evolution of the pressure of human activities by sector on soils and subsoils due to the PPE*

### 5.2.3. Natural environments: biodiversity and natural habitats

| | | | |
|---|---|---|---|
| **Transport / Residential-Tertiary / Industry** | • Loss or change in natural habitats;<br>• Landscape fragmentation;<br>• Disturbance of species (visual and auditory);<br>• Risk of collisions;<br>• Pollution related to maintenance of infrastructure boundaries (herbicides)<br>• Pollution related to water runoff;<br>• Deterioration of landscapes<br>• Greenhouse gas emissions;<br>• Effects linked to the production of materials (extraction, processing, etc.). | Reduction of GHGs and air pollutant emissions |  |
| **Agriculture** | • Loss or change in natural habitats (grasslands, hedges and isolated trees, etc.;<br>• Soil and water pollution related to inflows (fertilisation, pesticides, etc.);<br>• Soil disturbances (meadow conversion, composting, etc.);<br>• Modification of landscapes. | The PPE has no impact on these issues |  |

| | | | |
|---|---|---|---|
| **Forest - wood - biomass** | • Loss of or change in natural habitats (dead wood, old wood, etc.)<br>• Disturbance of species, visual and auditory disruption;<br>• Soil disturbances (meadow conversion, composting, etc.);<br>• Deterioration of landscapes. | Development of the exploitation of solid biomass |  |
| **Energy production** | • Loss and modification of habitats (including hydropower, bioenergy and biofuels, with direct and indirect changes in land use); | Low development of hydropower and bioenergy are developed on waste and residues. |  |
| | • Mortality trauma (including wind energy, bioenergy and ocean energy), and disruption of biological behaviours (including solar and wind energy) | Development of wind energy (land and sea) and PV. |  |
| | • Competition for the uses of water (especially hydroelectric and nuclear energy); | Low hydropower development and nuclear decline |  |
| | • Chemical, noise and electromagnetic pollution in the case of installations in marine environments; | Development of offshore wind energy |  |
| | • Greenhouse gas emissions and atmospheric pollution | Replacement of the fossil fuel thermal park with renewable energies. |  |
| | • Deterioration of landscapes. | Development of wind turbines and PV (if the landscape impact is considered unacceptable, the project will not be done) |  |
| **Waste** | • Soil and water pollution;<br>• Atmospheric pollution;<br>• Visual and auditory disturbances. | Reduction of the quantity of waste and their emissions by energy recovery (incineration, biogas) |  |

*Table 29: Direction of the evolution of the pressure of human activities by sector on biodiversity and natural habitats due to the PPE*

The overall improvement of the quality of the air and the water enabled by the reduction of emissions related to the use of fossil energy, promotes the maintenance of biodiversity in the medium-long term.

- The reduction of eutrophication in aquatic and terrestrial environments reduces the proliferation of species that develop at the expense of other living organisms.
- The reduction of the acidity of water and soil makes it possible to guarantee the survival of local ecosystems by limiting the pH change of their living environment.

The development of renewable energies induces a largely decentralised energy production system that generates localised impacts on biodiversity. If biodiversity impacts vary by energy, they are regulated and will be considered in project design in order to reduce them. This approach will involve not only efforts at the local level but also conducting or pursuing in-depth studies on the impacts of each sector and integrating the feedback of projects developed. With regard to energy infrastructure, particular attention should be given to the issue of ecological continuity.

The impact on biodiversity linked to the increase of logging will be limited insofar as it respects the recommendations of the PNFB.

The specific impacts related to transport infrastructure, in connection with the SDMP, should also be anticipated.

## 5.2.4. Human environments

### Natural and technological risks

| | | | |
|---|---|---|---|
| **Transport** | • Non-adaptation of transport infrastructures to natural risks associated with climate change<br>• The transport sector was responsible for 45 accidents in 2016, or 5% of all accidents and incidents in the same year<br>• The transportation of hazardous materials is the most likely to expose people and property to technological accidents. In 2016, 142 events were recorded for France, including one river and one maritime event. 50% of accidents resulted in human injury or death. | Reduction of road transport by promoting modal shift towards "safer" modes of transport (rail, river) |  |
| **Residential-Tertiary Sector** | • Failure to adapt built-up park to earthquakes, tsunamis and cyclones<br>• The lack of prevention of technological risks around residential areas can worsen the impact of a technological accident by causing loss of life and property in these areas<br>• Businesses were responsible for 74 technological accidents in 2016, or 9% of all the accidents and incidents that occurred that same year | The PPE has no direct impact on these issues |  |
| **Agriculture** | • Non-adaptation of agriculture to major flood events<br>• Non-adaptation of agriculture to major drought events<br>• Non-adaptation of silviculture to storms<br>• Agriculture was responsible for 70 technological accidents in 2016, or 8.5% of all the accidents and incidents that occurred that same year<br>• This sector is particularly prone to fire and hazardous materials releases | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • Non-adaptation of silviculture to instances of major flooding<br>• Non-adaptation of forestry to major drought events. This sector is particularly prone to fire risks<br>• Woodwork was responsible for 28 accidents in 2016, or 3% of all accidents and incidents in the same year | The development of the exploitation of solid biomass will have no impact on the overall risk |  |

| | | | |
|---|---|---|---|
| **Industry** | • Non-adaptation of industrial facilities to the most destructive natural hazards: tsunamis, cyclones, earthquakes, avalanches...<br>• The manufacturing sector is the most affected by technological risks with 308 accidents or technological incidents in 2016, or 37% of all accidents or incidents that occurred in the same year. | The PPE has no impact on these issues |  |
| **Energy production** | • Non-adaptation of energy production facilities to the most destructive natural hazards: tsunamis, cyclones, earthquakes, avalanches... | The PPE has no impact on these issues |  |
| | • Energy production was responsible for 31 technological accidents in 2016, or 4% of all the accidents and incidents that occurred that same year | The PPE has no impact on these issues |  |
| | • The risk associated with hydraulic installations exists but the probability of a large-scale incident is very low. | The small increase in hydropower will have no impact on overall risk |  |
| | • Gas pipeline transport experienced 11 events in 2016 and the gas distribution network in the city experienced 89 events. Roadworks near the structures were responsible for 68 leaks or damage to connections. | Reducing gas use should help reduce the risks associated with transportation networks |  |
| | • The risk associated with nuclear installations exists but the probability of a large-scale incident is very low. | Reducing the role of nuclear in the mix should reduce the associated risk |  |
| **Waste** | • Non-adaptation of waste treatment facilities to the most destructive natural hazards: tsunamis, cyclones, earthquakes, avalanches...<br>• Waste treatment is also a sector particularly affected by technological risks with 165 accidents or technological incidents in 2016, or 20% of all accidents and incidents that occurred that same year | The PPE has no impact on these issues |  |

*Table 30: Direction of the evolution of the pressure of human activities by sector on the exposure to natural and technological risks due to the PPE*

## Disturbances

### *Air Quality*

The following charts show the evolution of emissions of pollutants in both AME and AMS scenarios. They show that policies exposed in the PPE should reduce emissions, especially nitrogen oxides emissions, partly because of policies in transports. For ammonia emissions, additional measures are needed to reduce emissions.

It should be noted that scenarios take into account measures and policy to reduce consumption, but only partly measures specific to pollutants emission reduction. Results do not reflect all measures to reduce atmospheric pollution.

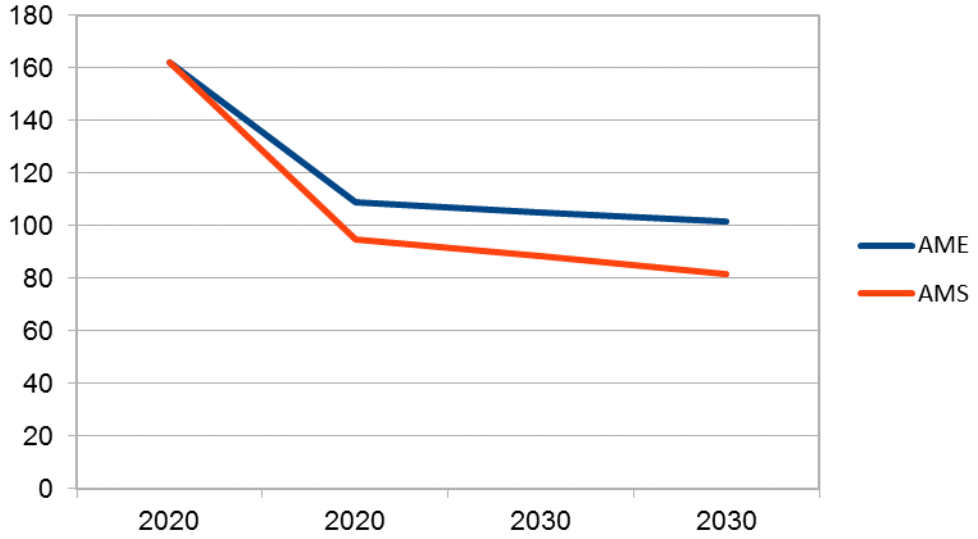



*Figure 41: $SO_2$ emissions (in kt)*

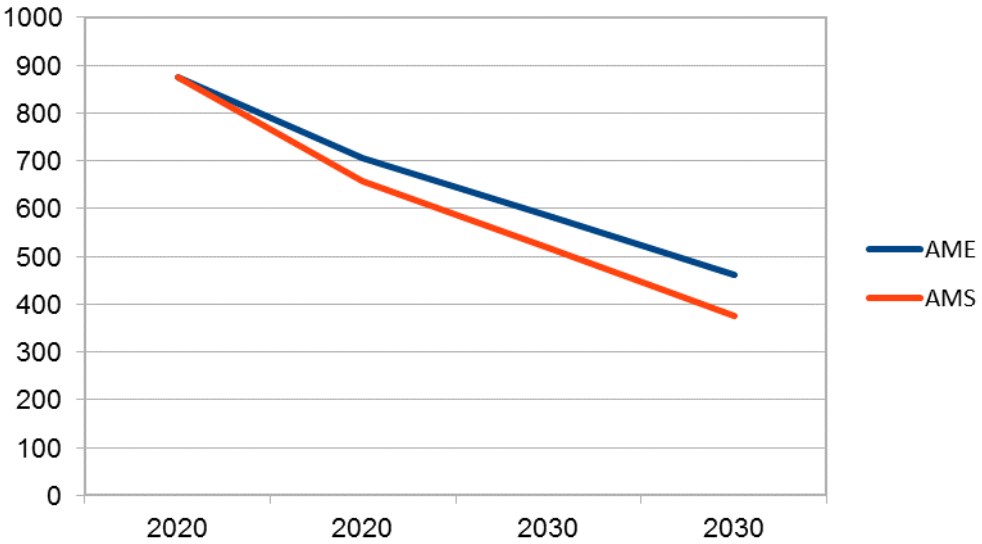



*Figure 41: $NO_x$ emissions (in kt)*

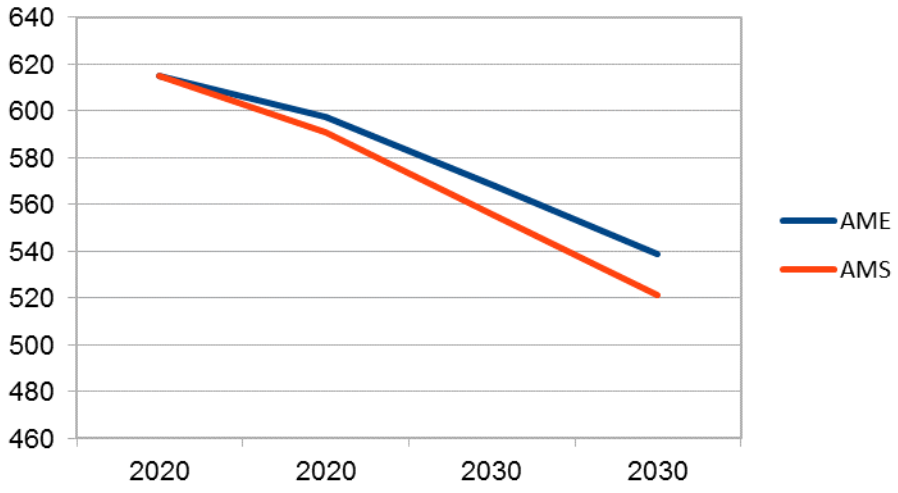



*Figure 43 : NMVOC emissions (in kt)*

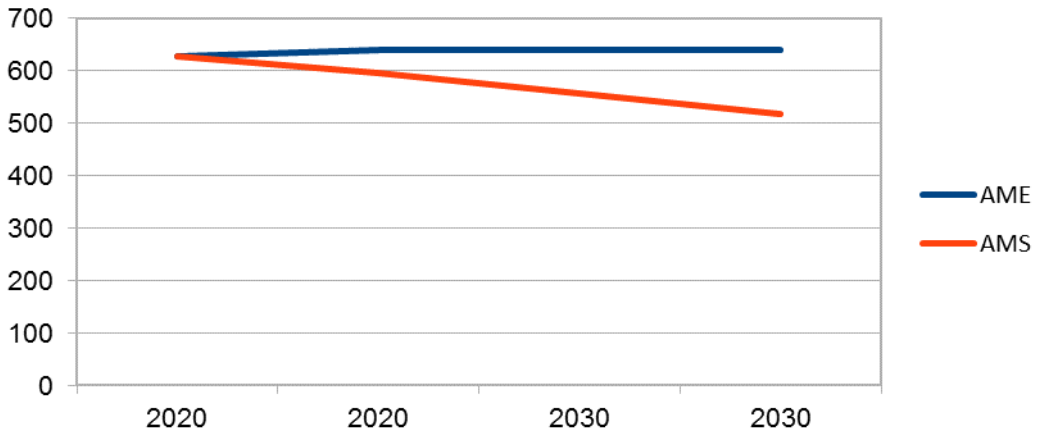



*Figure 44 : $NH_3$ emissions (in kt)*

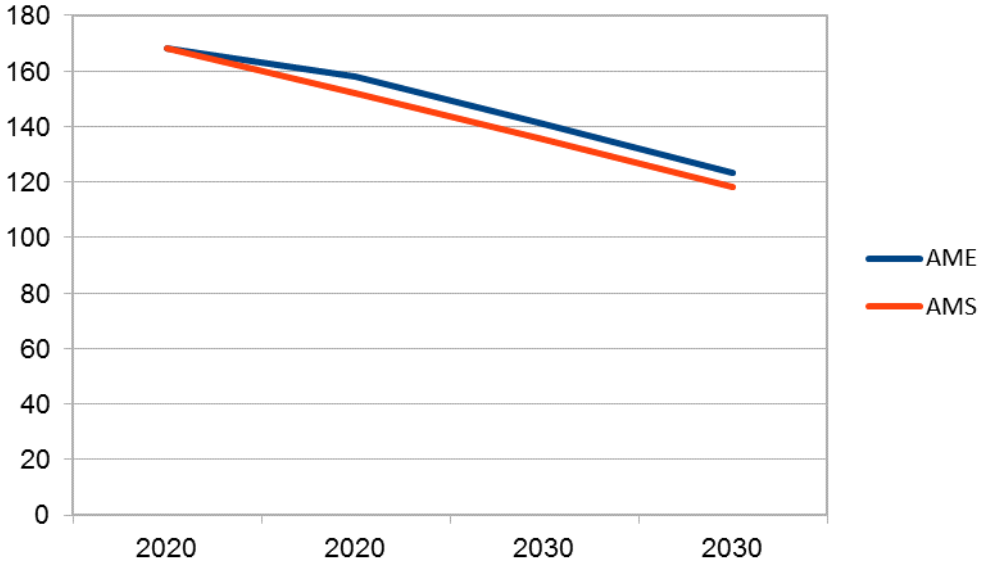



*Figure 41: Fine particles emissions (in kt)*

| | | | |
|---|---|---|---|
| **Transport** | • Use of thermal vehicles sources of NOx emission and fine particles<br>• Diesel vehicles are particularly problematic in that they emit a greater number of fine particles than gasoline vehicles, and the impact on health is considered very significant. | Control the demand for road transport and reduce the use of fossil fuels. | ↘ |
| **Residential-Tertiary Sector** | • The use of wood-burning appliances can lead to the emission of particles in varying amounts depending on the performance of the equipment and the wood used. | Replacement of the most polluting equipment by more efficient equipment or PACs. | ↘ |
| | • Open burning of green waste is a source of significant pollution. | Improving the energy recovery of green waste collected upstream | ↘ |

| | | | |
|---|---|---|---|
| | • Indoor air quality can be affected by poor ventilation of buildings and exposure to pollutants from building and furniture materials. | The PPE has no impact on these issues |  |
| **Agriculture** | • Animal waste and fertiliser applications account for the majority of ammonia emissions (64% and 34% respectively).<br>• Activities pertaining to working the soil emit fine particles.<br>• The impact of the application of plant protection products on air quality is still little known in France, but it should be noted that 30% to 50% of these substances are lost in the atmosphere following their spraying.<br>• Lastly open fires practiced in agriculture (stubble burning, slash-and-burn) are also sources of very localised emissions of fine particles, volatile organic compounds and other dangerous pollutants. | Improvement of energy recovery including slurry |  |
| **Forest - wood - biomass** | • Forestry machinery emissions.<br>• Biomass combustion is a significant source of fine particles emissions | Development of the exploitation of solid biomass |  |
| **Industry** | • The industrial sector is mainly responsible for sulphur dioxide emissions mainly from ferrous metallurgy (12%), non-metallic minerals and building materials (11%) and the chemical industry (10%).<br>• The industry is also responsible for the emission of fine particles to a lesser extent. | Decline in the use of fossil resources |  |
| **Energy production** | • Petroleum refining and electricity generation emit primarily sulphur dioxide (29.2% of $SO_2$ emissions) and persistent organic pollutants | Replacement of the fossil fuel thermal park with renewable energies. |  |
| **Waste** | • The waste treatment sector is the main contributor of organic pollutants with 28% of PCB emissions from this sector. | The PPE has no impact on these issues |  |

*Table 31: Direction of the evolution of the pressure of human activities by sector on air quality due to the PPE*

*Noise pollution*

| | | | |
|---|---|---|---|
| **Transport** | • Road transport | Demand management for road transport and development of electric vehicles |  |
| | • Air transport | The PPE has no impact on these issues |  |
| **Residential-Tertiary Sector** | • Neighbourhood troubles due to lack of insulation | Thermal insulation should have a positive effect on the sound insulation of homes. |  |
| **Agriculture** | • Agricultural activities can be a source of neighbourhood disturbance in rural areas because of agricultural machinery or animal noise. | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • Noise related to forestry machinery | Development of the exploitation of solid biomass |  |
| **Industry** | • Noise related to industrial activity | The PPE has no impact on these issues |  |
| **Energy production** | • Noise related to energy production facilities | The noise associated with wind turbines is regulated so as not to increase noise pollution. |  |
| **Waste** | • N/A | The PPE has no impact on these issues |  |

*Table 32: Direction of the evolution of the pressure of human activities by sector on the sound environment due to the PPE*

The SDMP has levers to act on noise pollution and maximise the potential benefits on the sound environment. As such, the recommended measures should lead to a reduction in noise pollution in city centres and close to major roads, thanks to demand management, modal shift towards public transport or soft mobility, or optimisation measures to increase the fill rate of vehicles. In addition, vehicles running on alternative fuels (electricity, gas) are generally less noisy than traditional thermal vehicles, and their deployment therefore presents an opportunity for the reduction of noise pollution, mainly in built-up areas. However, this feature also presents risks, with a potentially higher accident rate, especially for pedestrians accustomed to hearing vehicles approaching. The EES therefore recommends to anticipate these evolutions and to deploy research efforts on the various possible solutions, reconciling safety and noise pollution.

On the other hand, the impact of the other components of the PPE will be negligible, although risks at local level should be anticipated. The noise and electromagnetic disturbances associated with the operation of wind turbines and the noise associated with the use of heat pumps is of a very low level of impact, provided that projects develop in compliance with applicable regulations (impact studies, respect of the distance of 500 m for houses from wind turbines) and in consultation with the territories concerned.

Noise related to the installation of infrastructures (offshore wind turbines, geothermal drilling...) will be taken into account in project design, but have only a temporary impact.

*Olfactory pollutants*

| | | | |
|---|---|---|---|
| **Transport** | • Thermal vehicles contributing in particular to smells in the city | Control the demand for road transport and reduce the use of fossil fuels. |  |
| **Residential-Tertiary Sector** | • Olfactory pollutants can be considered as disturbances of the neighbourhood in a residential environment | The PPE has no impact on these issues |  |
| **Agriculture** | • The spreading or storage of organic matter (livestock effluents) emits intense odours and is potentially annoying for residents | Energy recovery of slurry reduces the quantities spread |  |
| **Forest - wood - biomass** | • N/A | The PPE has no impact on these issues |  |
| **Industry** | • Certain factories emit odours caused by the chemical products they use, which may not necessarily be toxic to humans but can produce very unpleasant odours. | The PPE has no impact on these issues |  |
| **Energy production** | • Energy processing like oil refining can emit sulphur odours | The PPE has no impact on these issues |  |
| | • Anaerobic digestion leads to the handling and transport of smelly materials in connection with the storage of organic materials in agricultural activities | Increase in the use of anaerobic digestion. |  |
| **Waste** | • Pumping stations, water purification and sludge treatment can be significant sources of odour pollution. | The PPE has no impact on these issues |  |

Table 33: Direction of the evolution of the pressure of human activities by sector on the olfactory environment due to the PPE

*Night time environment*

| | | | |
|---|---|---|---|
| **Transport** | • The lighting of traffic lanes contributes significantly to light pollution disruption of the night environment<br>• Considering the scattering characteristics of light, traffic lane lights along the coastline can disturb the environment over a fairly wide area beyond the coastline. | The PPE has no impact on these issues |  |
| **Residential-Tertiary Sector** | • The lighting of shops and offices unoccupied at night contributes to light pollution and disruption of the night environment. | The PPE has no impact on these issues |  |
| **Agriculture** | • N/A | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • N/A | The PPE has no impact on these issues |  |
| **Industry** | • The lighting of some industrial installations during the night contributes to light pollution and disruption of the night environment | The PPE has no impact on these issues |  |
| **Energy production** | • The lighting of some production facilities during the night contributes to light pollution and disruption of the night environment | Development of decentralised energy production facilities (i.e. wind turbines) that are lit at night |  |
| **Waste** | • N/A | The PPE has no impact on these issues |  |

*Table 34: Direction of the evolution of the pressure of human activities by sector on the night environment due to the PPE*

## Human health

| | | | |
|---|---|---|---|
| **Transport** | • Atmospheric pollutant emissions | Control the demand for road transport and reduce the use of fossil fuels. |  |
| | • Lack of physical activity | Increase in soft modes of transport |  |
| **Residential-Tertiary Sector** | • Lack of green spaces | The PPE has no impact on these issues |  |
| **Agriculture** | • Exposure to pesticides | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • N/A | The PPE has no impact on these issues |  |
| **Industry** | • Pollutant discharges and environmental contamination | Decline in the use of fossil resources |  |
| **Energy production** | • Atmospheric releases (PM, Nox) and environmental contamination ($SO_2$). | Replacement of the fossil fuel thermal park with renewable energies. |  |
| | • Health problems related to fuel poverty | Reduction of fuel poverty |  |
| **Waste** | • Pollutant discharges and environmental contamination | Energy recovery from waste generates emissions into the air that are not generated by storage facilities |  |

*Table 35: Direction of the evolution of the pressure of human activities by sector on human health due to the PPE*

### Landscapes and heritage

| | | | |
|---|---|---|---|
| **Transport** | • Blackening of buildings (NOx and PM) | Control the demand for road transport and reduce the use of fossil fuels. |  |
| **Residential-Tertiary Sector** | • Blackening of buildings (PM related to heating) | Replacement of the most polluting heating equipment |  |
| | • Thermal renovation of outstanding unprotected buildings | The PPE has no impact on these issues |  |
| **Agriculture** | • N/A | The PPE has no impact on these issues |  |
| **Forest - wood - biomass** | • N/A | The PPE has no impact on these issues |  |
| **Industry** | • Blackening of buildings (NOx) | Decline in the use of fossil resources |  |
| **Energy production** | • Blackening of buildings (NOx) | Replacement of the fossil fuel thermal park with renewable energies. |  |
| | • Impact of energy production and transmission infrastructure on landscapes and heritage. | Development of decentralised energy production facilities (wind turbines, PV...) |  |
| **Waste** | • N/A | The PPE has no impact on these issues |  |

*Table 36: Direction of the evolution of the pressure of human activities by sector on landscapes and heritage due to the PPE*

## 5.3. Indicators for monitoring changes in the environment related to the effect of the PPE

Monitoring indicators of the evolution of pressures on environments will be used to monitor the impact of the PPE on the environment over time. The objective is to identify indicators using existing and easily usable data in order to enable regular and effective monitoring. A restricted number of representative indicators of trends was preferred to a much higher number which would be difficult to group and equally difficult to interpret. Although not exhaustive, the main point of these indicators are the alerts that they will give about evolutionary trends, so that a response can be provided in the event of increased pressure on environments.

As the main environmental issues of energy policy have increased pressures on resources and land use, indicators have been identified to monitor the evolution of these impacts:

- Monitoring the evolution of GHG and air pollutant emissions is used to verify the positive nature of the impact of the PPE and the SDMP on climate and air pollution.
- The monitoring of space consumption related to PV and wind turbines enables assessments of the impact of the development of decentralised energy production facilities on land use.

- The monitoring of the main risks using the ARIA database is only used to track accidents / incidents that contribute to using feedback as a tool for risk prevention and reduction. This database tracks trends in the risks associated with risks from energy production facilities.
- For the impact on biodiversity and natural habitats, the indicator of pressure on wood resources chosen is the rate of wood used for energy compared to forest renewal rates
- It is not currently possible to monitor the amount of resources used to set up renewable energy facilities. The indicator to monitor issues of resource availability would be the recycling rate of the industries and the reuse rate of electric vehicles batteries at the end of lifetime for other purposes.

| Affected environment | Indicator | Unit | Methodology | Frequency |
|---|---|---|---|---|
| **Climate and Energy** | 1. Atmospheric emissions related to energy consumption<br>2. Atmospheric emissions from the energy sector<br>3. Atmospheric emissions from transport<br>3.A) Goods<br>3.B) Passengers | **Mt CO2e** | 1. Source: CITEPA (Secten inventory)<br>2. Source: CITEPA (Secten inventory)<br>3. Source: CITEPA (Secten inventory)<br>3.A) Trucks, light commercial vehicles<br>3.B) Personal vehicles and two-wheeled vehicles | Annual |
| **Human health** | | **t NOx, t PM t $_{2.5}$ PM $_{10}$** | | |
| **Resources and waste** | 1. Recycling rate of wind turbines.<br>2. Reuse rate of electric vehicles batteries<br>3. Quantity of recycled solar panels | **Kg** | 1. Survey among professionals<br>2. Survey among professionals<br>3. Source: Ademe, SYDEREP report[111] | 1. Biennial<br>2. Biennial<br>3. Annual |
| **Soils and sub-soils** | Land use linked to the installation of photovoltaic panels | **m²** | Source: CRE, occupied area declaration | Annual |
| **Natural and technological risks** | Number of accidents linked to energy production installations | **Number accidents** | Source: BARPI, ARIA database on sources of energy production. | Annual |
| **Water Resources and Aquatic Environments** | | | | Annual |
| **Biodiversity and natural habitats** | Rate of forest-wood use compared to forest renewal rate<br>Number of onshore turbines equipped with avifauna detection equipment | **%** | IFN | Biennial |

*Table 37: Indicators for monitoring environmental pressures resulting from the PPE*

111 https://www.ademe.fr/rapport-annuel-registre-dechets-dequipements-electriques-electroniques-donnees-2016 (to be changed depending on the year)

# 6. Appendices

## 6.1. ERC measures

### 6.1.1. Wood-based electricity and heat production

Measures to avoid, reduce or offset the impacts of logging to produce energy are provided by other documents with which the PPE is articulated, they are repeated here.

- The SNMB and the PNFB provide the various measures and best practices to adopt to ensure a sustainable supply of the resource.
- PREPA provides measures to limit emissions of pollutants related to wood combustion.

#### Avoid

1. Adapt the periods of exploitation, activity, maintenance of the forest over the year in order to preserve the flora and fauna species when they are the most vulnerable[112].
2. Raise public awareness about good practices on wood heating use to limit air pollutant emissions.

#### Reduce

1. Promote the replacement of the most polluting equipment with more efficient facilities[113].
2. Mark protected arboreal species[114] to preserve them.
3. Adapt operating conditions to limit soil erosion[115] and settlement[116].

#### Compensate

1. Restore ecological corridors[117] during replanting of forest species[118].

### 6.1.2. Geothermal heat pumps (GSHP)

#### Reduce

1. Prevent soil depletion by reducing the number of boreholes in sensitive areas[119].

### 6.1.3. Biogas

Methanisers are installations subject to regulations on classified installations for the protection of the environment (ICPE) of the environmental code, which means that pressures on the environment which they generate are monitored so that they respect socially acceptable thresholds in terms of their impact.

#### Reduce

1. Promote the professionalisation of the sector by means of a training plan for project leaders to limit disturbances and enhance the acceptability of projects.
2. Reduce the pressure on the biomass supply by taking into account SNMB recommendations.

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112 E4.2a and R3.2a - Adaptation of operating / activity / maintenance periods to the year
113 R2.1j and R2.2b- Device for limiting disturbances for human populations
114 R1.2b - Definitive marking or definitive protection of habitats of species or remarkable trees
115 R2.1e - Preventive device for controlling soil erosion
116 R2.1g - Device limiting impacts related to the passage of operating gear
117 C2.1f - Ecological Corridor Restoration
118 C2.1d - Resettlement of degraded environments, replanting, restoration of existing but degraded hedges
119 Decree no. 2015-15 of 8 January 2015 allows the installation of shallow-depth heat pumps provided they are officially declared, as long as the area in question is not listed as a sensitive zone in terms of sub-soils.

3. Reduce storage time and promote storage in closed buildings with air treatment to avoid GHG emissions[120].
4. Installation of torches to burn the released gases in case of overpressure[121].

### 6.1.4. Geothermal electricity and heat

Geothermal drilling is a facility subject to the regulations on classified installations for the protection of the environment (ICPE) of the environmental code, which means that the pressures on the environment they generate are monitored so that they respect socially acceptable thresholds in terms of their impact.

#### Avoid

1. Adaptation of the period of the works over the year[122] in order not to affect fauna and flora species when they are most vulnerable.

#### Reduce

1. Focus on transportation modes that emit less GHG for the transportation of materials and the disposal of drilling muds[123].
2. Set up noise reduction devices (noise merlons)[124]
3. Develop the use of drilling equipment that uses electricity rather than diesel to reduce the carbon impact of the industry.
4. Optimise the management of excavation sludge to limit the need for transportation to evacuate it[125].
5. Reusing an old well, after making a lining of the column to reinforce it, makes it possible not to have to drill a new well.

### 6.1.5. Biofuels

#### Reduce

1. Prioritise the development of second-generation biofuels in order to limit the land-use changes necessary for the cultivation of inputs mobilised by 1st generation biofuels.

### 6.1.6. Hydroelectricity

Hydroelectric installations are supervised installations, according to their size, either by the regulation on the installations, operations, works and activities (known as IOTA) of the environment code, or by the regulation on the hydroelectric concessions of the energy code Thus, the pressures they generate on the environment are monitored to meet socially and environmentally acceptable thresholds.

#### Avoid

1. Avoid the construction of new obstacles to ecological continuity by favouring the optimisation of existing power stations and the operation of existing dams.
2. Avoid the installation of new facilities on watercourses classified in list 1 for the protection of the environment (these zones are not taken into account in the determination of the hydroelectric potential for the new dams)[126].

#### Reduce

1. Maintaining minimum flow at dams permanently guaranteeing the life, circulation and reproduction of species present[127].

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120 R2.1j and R2.2b- Device for limiting disturbances for human populations
121 E3.1a - Absence of release into the natural environment (air, water, soil, subsoil)
122 E4.1a and R3.1a - Adaptation of the period of work over the year
123 R2.1b - Special method for importing materials and/or disposal of materials, excavated material and site residues: river transport, rail transport, etc.
124 R2.1j and R2.2b- Device for limiting disturbances for human populations
125 R2.1c and R2.2n - Optimization of materials management (excavated and fill material)
126 E1.1a - Avoidance of known populations of protected or high-risk species and/or their habitats
127 R2.1l and R2. 2i- Maintaining a minimum "biological" flow of watercourses

2. Arrangements or measures (periods of transparency, fish passes, bypasses, water releases equivalent to a morphogenic flood) in order to ensure ecological continuity, in particular so as not to oppose the movements of migratory species[128].
3. Provide for measures to limit the impact of locks in sensitive areas[129].
4. Consideration of environmental criteria in competitive procedures for hydropower.

### Compensate

1. Equipping existing facilities impacting the same watercourse to allow passage of sediments and migratory species[130]. This equipment consists of implementing reduction measures, but for a work that is not originally concerned by the project.
2. Levelling of certain obstacles, not filling a use, located on the watercourse to restore ecological continuity[131].

## 6.1.7. Terrestrial Wind Turbines

Wind turbines are installations subject to the regulations on installations classified for the protection of the environment (ICPE) of the environmental code, which means that the pressures on the environment they generate are monitored so that they respect socially acceptable thresholds in terms of their impact.

### Avoid

1. **Locate projects taking into account environmental and landscape sensitivities.** Wind farm projects will have to take into account the different zonings determined by the National Guidelines for Green and Blue Belts so as not to destroy the ecological continuities necessary for the preservation of biodiversity[132].

### Reduce

1. Limit impacts on birdlife by maintaining migration corridors that take into account the cumulative effect of different parks[133]. Limit wildlife mortality by taking Natura 2000[134] zoning into account and installing anti-collision devices.[135]
2. Develop ancillary uses of wind turbine sites. Some activities may be compatible with the establishment of a wind farm; it will be necessary to deepen studies on these interactions between wind farms and ecosystems. If the possibility of installing wind turbines in agricultural areas is already known, it is conceivable that other innovative solutions may exist and be developed in order to reduce the footprint associated with the deployment of a wind farm[136]. It is also recommended to conduct studies on electromagnetic disturbances due to wind turbines and to develop technologies that can reduce these impacts.
3. Give priority to "repowering" (replacement of existing wind turbine installations with higher power installations). Renewing the facilities on the same site avoids the emergence of new environmental impacts and better anticipates those related to the location of the project based on feedback. Efforts to allow the reuse of foundations from previous facilities must be pursued to reduce the ground impact associated with the installation of new wind turbines.
4. Reduce the visual disturbances related to the nocturnal signage of the parks[137]. The presence of wind turbines is signalled by means of flash lights that would be better synchronised at the scale of different

128 R2.2h - Fish crossing device
129 R2.2m - Technical device limiting impacts on hydraulic continuity
130 C2.2g - Modification or existing work equipment
131 C2.2h - Leveling or down-leveling of a transverse obstacle, a threshold, a feedthrough
132 E1.1b - Avoidance of sites with major environmental and landscape stakes in the territory
133 R2.2f - Wildlife passage device
134 E1.1a - Avoidance of known populations of protected or high-risk species and/or their habitats
135 R2.2d - Anti-collision and scaring device (excluding specific fencing)
136 E2.2f - Positioning the project on a sector of lower stakes
137 R2.1j and R2.2b- Device for limiting disturbances for human populations

parks to reduce their cumulative effect. The use of a sodium lamp for the lighting of the installations would make it possible to avoid attracting insects, thus also limiting the risk of collision with bats[138].

5. To reduce the auditory pollution related to the operation of wind turbines by favouring models with low acoustic power[139], and by respecting the regulations relating to the distance from residential areas.

### Compensate

1. In the case of implantation on a site previously exploited, it is possible to provide for the removal of foundations that have not been levelled during the decommissioning of previous installations[140].

## 6.1.8. Solar energy

### Avoid

1. Encourage the installation of photovoltaic panels on roofs in order to limit the impacts on the ground and the consequences on the associated biodiversity[141].
2. Prohibit the installations of ground-based solar power plants in agricultural area.

### Reduce

1. Encourage locating projects in order to preserve natural[142] and agricultural areas. Degraded land could thus be privileged in tenders for the implantation of new sites[143].

### Support

1.
2. Continue research of alternative processes to chemical treatment for the manufacture of solar panels composed of silicon crystals[144].
3. Continue efforts to recycle panels to limit resource consumption[145].

## 6.1.9. Offshore renewable energies (including offshore wind power)

The installations are installations subject to regulations on classified installations for the protection of the environment (ICPE) of the environmental code, which means that pressures on the environment that they generate are monitored so that they respect socially acceptable thresholds in terms of their impact.

### Avoid

1. Continue to locate projects outside the most environmentally sensitive and landscaped areas before launching the next tenders. The location should take into account the PAMMs to avoid Natura 2000 areas[146] as well as UNESCO heritage sites[147]. This measure is reinforced by the holding of a public debate prior to the determination of the location of tenders.
2. Give priority to the least harmful implantation techniques for aquatic fauna.
3. Adapt work[148] and operation periods[149] over the year to avoid impacts on bird migration movements or periods of vulnerability (reproduction, nesting) of marine mammals.

### Reduce

138 R2.1k and R2.2c- Wildlife disturbance limitation device
139 E3.2b - Redefinition / Modifications / adaptations of development choices, project characteristics
140 C2.1a - Removal of previous arrangements (deconstruction) other than water works
141 E1.1c - Redefinition of project characteristics
142 E1.1a - Avoidance of known populations of protected or high-risk species and/or their habitats
143 E2.2f - Positioning the project on a sector of lower stakes
144 A4.1c and A4.2c - Financing of research programs
145 A4.1c and A4.2c - Financing of research programs
146 E1.1a - Avoidance of known populations of protected or high-risk species and/or their habitats
147 E1.1b - Avoidance of sites with major environmental and landscape stakes in the territory
148 E4.1a and R3.1a - Adaptation of the period of work over the year
149 E4.2a and R3.2a - Adaptation of operating / activity / maintenance periods to the year

1. Limit noise-related aquatic wildlife mortality associated with foundation piling of wind turbines by soft-start and noise-reduction devices (bubble curtain).
2. Limit the disruption of migratory routes by providing migratory corridors between wind farms[150].
3. Promote the reef effect of the installations by favouring the use of anti-fouling paints less intensive in biocides. Sacrificial anodes to prevent corrosion of submerged parts could be replaced in favour of an impressed current protection[151].
4. Optimisation of the geometry of the project so as to favour its landscape integration (symmetrical installations)[152].

### 6.1.10. Storage

#### Avoid

1. Support the search for storage technologies that consume fewer resources with the help of SNRE.

#### Reduce

1. Continue to structure the recycling of batteries to reduce the pressure on scarce resources needed for their manufacture.

### 6.1.11. Networks

#### Avoid

1. Favour line crossings underground to avoid breaking ecological continuity and impacts on biodiversity[153].

#### Reduce

1. Increase the size of vegetation near power lines to force flying species to gain altitude and avoid collisions with facilities[154].

150 R2.2f - Wildlife passage device
151 E4.2a - Total absence of use of plant protection products and of any product polluting or likely to have a negative impact on the environment
152 E2.2d - Direction measurement of an installation or optimization of project geometry
153 E1.1c - Redefinition of project characteristics
154 R2.2k - Up-over slope planting (green springboard)