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RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE L'ÉCOLOGIE, DU DÉVELOPPEMENT DURABLE ET DE L'ÉNERGIE

Stratégie NATIONALE BAS-CARBONE

Summary for decision-makers







Contents of the summary for decision-makers

Transition to a low-carbon economy

The National Low-Carbon Strategy (SNBC) was established by the Energy Transition for Green Growth Act No. 2015-992 of 17 August 2015. It outlines the approach to be adopted to reduce our greenhouse gas (GHG) emissions. It sets in motion the transition to a sustainable, low-carbon economy. It facilitates the management of policies for reducing greenhouse gas emissions by public decision-makers.

The National Low-Carbon Strategy aims to cut greenhouse gas emissions by 75% by 2050, while making it possible to stay within the carbon budgets set for the periods 2015-2018, 2019-2023 and 2024-2028 and honour the commitment made by France toward the European Union to reduce its GHG emissions by 40% by 2030.

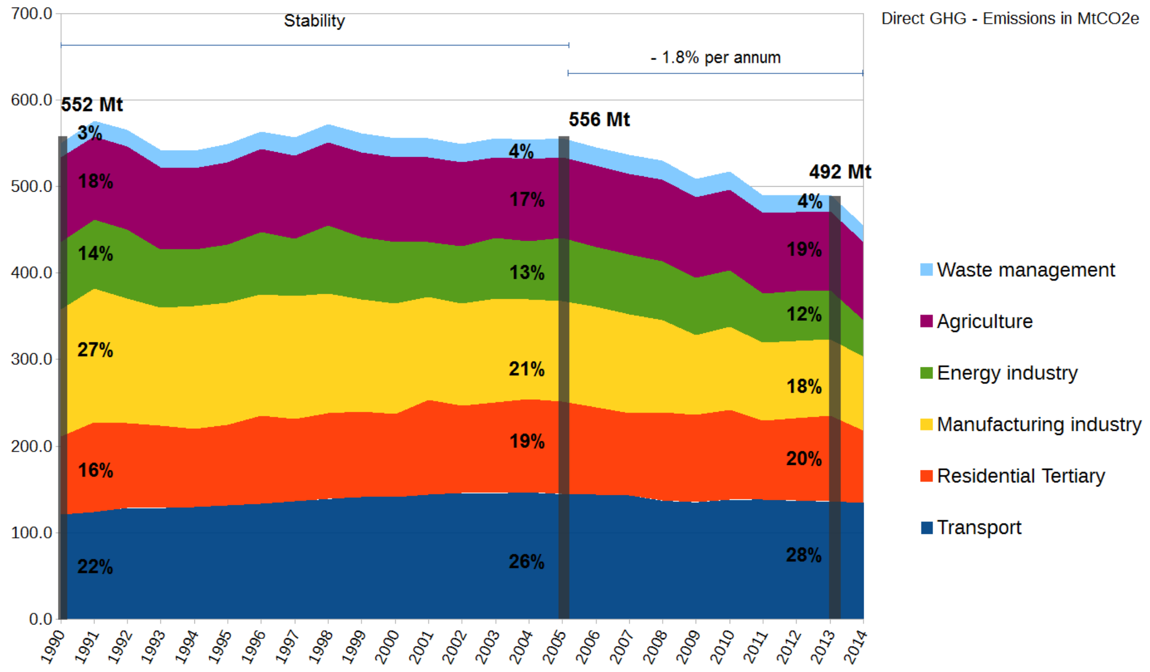
Carbon budgets

Definition: carbon budgets define the upper limits for France’s greenhouse gas emissions, expressed in millions of tonnes of CO2 equivalent per year. They are set for periods of four to five years to enable management of the structural changes in greenhouse gas emissions while reducing certain temporary effects, such as changes in winter weather conditions.

- **Progress made**

Since the early 1990s, GHG emissions have fallen by 11% and the level of per capita GHG emissions in France is one of the lowest among developed countries. This is the result of the commitment made by France to energy management and decarbonisation of the energy mix since the late 1970s.

Evolution of greenhouse gas emissions for France between 1990 and 2013



Source: Climate Plan Format - Kyoto criteria CITEPA







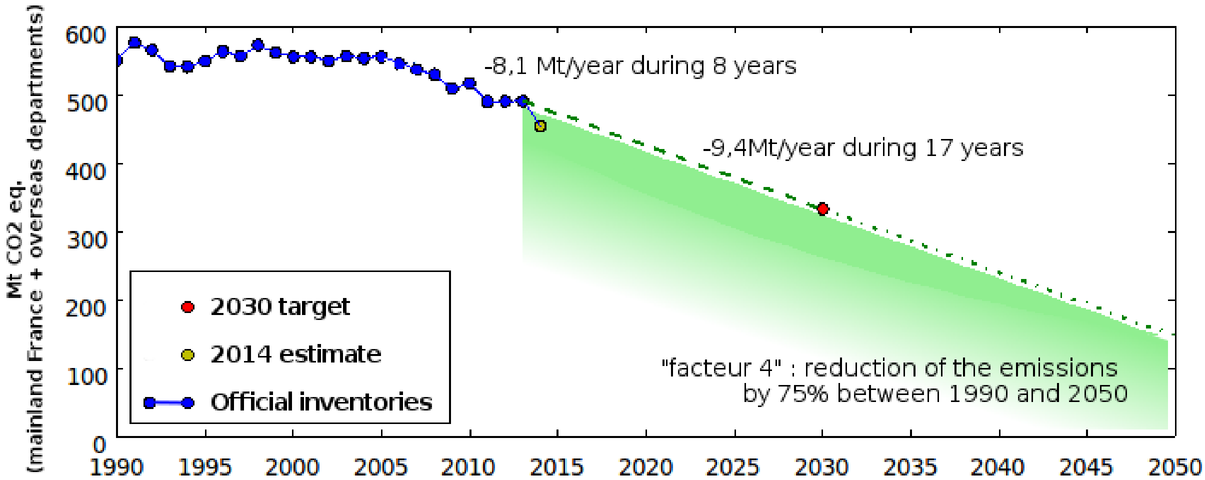
The policies that have already been implemented to mitigate climate change should enable us to achieve our targets for the reduction of national greenhouse gas emissions by 2020. However, we must look beyond this and act to reduce the national carbon footprint, which remained stable between 1990 and 2012 owing to the increase in emissions linked to imports.

• The French Project

Beyond 2020, France has set itself even more ambitious reduction targets, in particular with the Energy Transition for Green Growth Act :

- 40% reduction in its total emissions by 2030 compared with 1990
- 75% reduction in its total emissions by 2050 compared with 1990 (“factor 4” scenario)

Breakdown of France’s commitments



Reducing our GHGs to 140 Mt in less than two generations is a real challenge. It requires average reductions of between 9 and 10 Mt CO2e per year until 2050. This means increasing the pace of reduction compared with the period 2005-2013, while ensuring the continued economic development of our country through green growth, without exporting our emissions by relocating activities that emit the most GHGs abroad, or limiting our ability to meet food security targets.

Therefore, major changes across the entire economy are vital. Massive investment is required and an overhaul in production and consumption patterns is essential.

The transition to a low-carbon economy depends on significantly strengthening energy saving efforts and decreasing the carbon intensity of the energy used. This transition must take into account all aspects of the National Strategy of Ecological Transition towards Sustainable Development (SNTEDD), in particular including the targets relating to the restoration of biodiversity and efforts to tackle air pollution.

This strategy provides the general framework and clarifies the nature of the considered solutions. At a later stage, it must be supplemented by sectoral programmes of action, which will provide opportunities to carefully select the chosen solutions and optimise their implementation.







Over the next 10 years, France will aim to reduce its carbon footprint, in particular through :

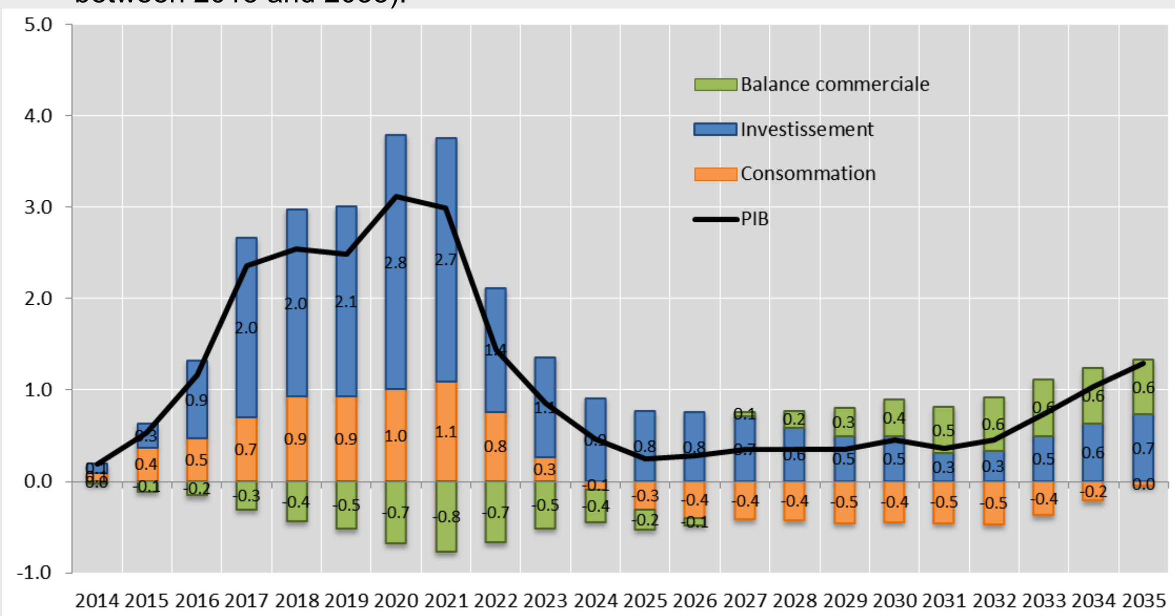
- a reduction in the carbon intensity of the economy: developing renewable energies, using bio-based materials (e.g. timber in construction), encouraging cleaner, more mindful travel, especially via low-carbon technologies, and awareness-raising among consumers ;
- a major development of energy savings in all sectors, especially industry, buildings and transport ;
- the development of the circular economy: eco-design, recycling and reuse.

This approach will be firmly rooted at the local level through the positive energy territories for green growth, regional climate-air-energy schemes, and territorial climate-air-energy plans.

Impact of the National Low-Carbon Strategy on jobs and growth

The energy transition and the development of a low-carbon economy will also enable France to :

- be less dependent on imported fossil fuels, thus reducing its energy bill and its carbon footprint ;
- support growth and thereby increase GDP compared with the trend-based scenario over the next two decades ;
- increase job creation (an average of between 100,000 and 350,000 extra jobs between 2015 and 2035).



Difference in GDP (in %) between the trend-based scenario and the reference low-carbon transition scenario (Seureco)

France is not the only country to put in place measures for the transition to a low-carbon economy. COP21 in Paris was an opportunity for France to call for greater efforts from all countries, to share concrete solutions to achieve this and highlight the mutual benefits it will bring (sharing lessons learnt and reducing carbon footprint, among others).







Many other countries are already actively engaged in the process. The United Kingdom, for example, has established a carbon plan and chosen to structure its mitigation policy around carbon budgets. Very early on, Sweden introduced a significant tax reform, increasing taxes on fossil fuels. More generally, the European Union has set itself the goal of reducing its emissions by 40% by 2030 compared with 1990.

- **Reference scenario - broad outline of France’s strategy**

Origin of the reference scenario

This scenario models an ambitious implementation of all the measures provided for in the Energy Transition for Green Growth Act, as well as those that support energy transition. The scale of ambition of the measures was set to meet the targets contained in the Act. The scenario was discussed with stakeholders and was assessed from a macroeconomic perspective.

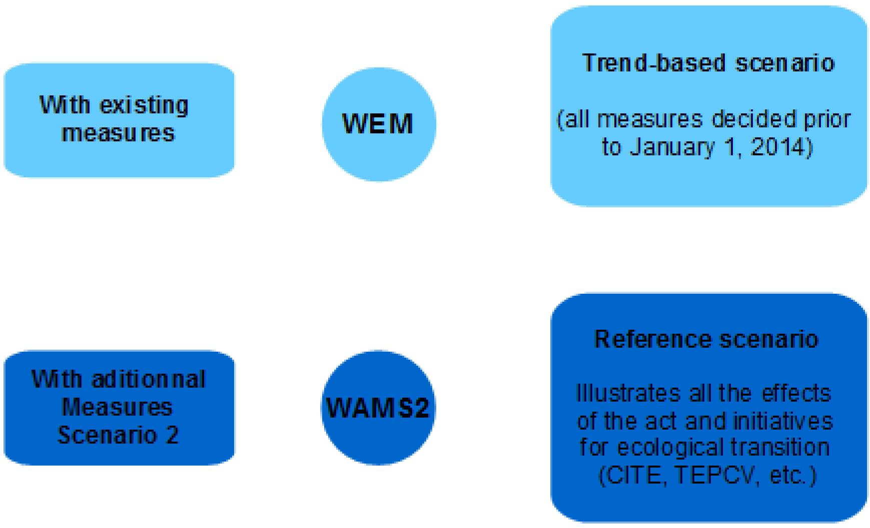
Scope

The scenario illustrates the magnitude of the efforts to be made as well as the expected transformations and co-benefits. **It is not prescriptive**, and primarily constitutes a reference for orientation purposes. In fact, comparative analysis of the measures, both between sectors and within the same sector, and the consideration of fairness, competitiveness and acceptability, which would be useful in order to hone and prioritise these measures, should be pursued and increased, particularly within the context of sectoral or regional planning or programming.

Therefore, the scenario is not an action plan: it rather presents a possible path for achieving our objectives. It will allow qualitative and quantitative analysis of any discrepancies over time, and may contribute to identifying corrective measures.

It will also enable short- and medium-term sector-specific recommendations to be made in relation to this strategy, and is described in section 2.2 of the strategy.

Scenarios studied



Cross-cutting recommendations

- **Reducing the carbon footprint by placing it at the heart of decision-making**

The reduction in national emissions is a valuable monitoring tool, but is not sufficient to fully measure France's contribution to global warming. To take the indirect impacts of France into account, the strategy promotes more systematic consideration of carbon footprint issues and, more generally, environmental footprint issues :

For sectoral policies

- From now on, the financing of public projects should take into account the impact of these projects in terms of emissions. That entails promoting life cycle analysis (LCA) (notably within the regulatory framework and as a project selection criterion for public contracting authorities). This type of analysis is particularly useful for optimising transport infrastructure and buildings.

For regional policies, including in particular the "GHG-neutral" region approaches, which represent an opportunity to mobilise efforts, the recommendation is to :

- promote the consideration of indirect emissions generated by an activity or a region beyond its energy consumption in greenhouse gas emission assessments (consideration of "scope 3").

Awareness-raising among the public on the impact of consumption choices

- Incentivise simple options to reduce emissions :
  - favouring durable or repairable products;
  - triggering a dynamic towards circular economy by focusing on the service rather than on ownership: renting, loaning (including through collaborative platforms), carpooling, etc. allow to meet various needs in a cheaper and less emitting way than by buying;
  - reducing food waste and encourage consumption patterns aligned with seasonal productions;
  - reducing emissions from building (adoption of good habits in relation to the use of energy-consuming devices, development of a public service of energy efficiency, etc.)

- **Implement energy transition by redirecting investment**

Awareness-raising among institutional stakeholders, companies and the public on the impact of their investment choices

The first challenge is to **redirect investment** towards projects that contribute to energy transition rather than hindering it :







- creation of labels and indicators enabling more comprehensive consideration of the elements relating to environmental issues, such as the “energy and ecological transition for the climate” label ;
- improve the operational consideration of “carbon risk”, notably through the implementation of Article 173 of the Energy Transition Act ;
- provide clarification at a very early stage regarding the reduction path that France intends to follow, and thereby raise awareness among investors about the fact that certain assets are susceptible to depreciation, and should not be prioritised in an investment portfolio. It is a question of continuing to support long-term investment issues (and accordingly, low-carbon issues) systematically and repeatedly ;
- make tax benefits conditional on making the use of funds raised more environmentally friendly (e.g. sustainable development savings account).

Strengthen the example set by institutional investors

- Develop analyses of the carbon footprint and green footprint of assets by institutional investors such as Bpi France, improve their non-financial reporting by highlighting the contribution of assets to energy transition and impose a future greening of the investments offered by the various State-controlled bodies (article 173 of the Energy Transition Act) ;
- Increase the importance of environmental clauses in public tenders. In particular, the Energy Transition for Green Growth Act laid down targets and means relating to the example set by public construction and the development of clean vehicle fleets ;
- Have an exemplary policy in development assistance and support for the international development of French companies (climate section in the project portfolio of the Agence Française de Développement, review of the criteria for benefitting from export credits, etc.).

Gradually increase the carbon portion of domestic energy consumption taxes without raising taxes overall

- Gradually increase the carbon portion, based on the fossil carbon content, of domestic energy consumption taxes, to cut greenhouse gas emissions fourfold. This increase will be offset by a reduction in taxes on other products, work or income. The objective is to go from EUR 22/tCO_2 in 2016 to EUR 56/tCO_2 in 2020 and EUR 100/tCO_2 in 2030 (in 2015 EUR). The supplementary budget for 2015 already includes an increase to EUR 30.5/t$C0_2$ in 2017.
- More generally, mobilise price signals (customisation of heating costs, etc.) to encourage consumers to reduce their use.
- Alongside this, increase efforts to combat fuel poverty. The instruments put in place are primarily aimed at a structural fall in consumption, while supporting home energy retrofits and promoting the development of alternative transport in rural areas, such as car pooling. They are supplemented by the social energy tariffs and energy cheques established by the Energy Transition Act.







Maximise the leverage effect of government funding

In particular through the creation and deployment of a guarantee fund for energy transition and the identification of better means of securing already profitable energy efficiency investments.

- **Create conditions for the successful development of a bio-based economy**

The development of the bio-economy (material and energy recovery) using materials such as wood and non-food agricultural production (straw, hemp, etc.) provides both an opportunity for growth for our regions, a channel for growth for a wide range of companies (industrial, agricultural, forestry, construction) and promising solutions that can contribute to reducing the carbon footprint of our consumption.

The contribution from forestry and agriculture earmarked to supply the materials, energy and chemical industry must be made in harmony with existing industries (especially for food production, the primary purpose of agriculture) and balances in production systems must be sought to prevent conflicts of use. To achieve this :

- efficient supply and processing systems must be fostered, enabling the best possible mobilisation and use of bio-resources (envisage intercropping and intermediate crops, use crop residues not required to maintain soil quality, etc.) ;
- furthermore, the sustainability of these sectors must be assessed on a regular basis, in order to ensure high environmental quality for these new sectors and co-benefits for biodiversity ;
- innovation in this area will remain a priority for the public authorities.

- **Identify opportunities for more sustainable land management**

The trend towards soil sealing of agricultural land and the expected development of various non-food uses of biomass from agriculture and forestry requires special vigilance with regard to the conflicts of use that the different expectations and issues facing agriculture and forestry generate, in terms of the production of food, timber, energy and materials, the management of natural resources, the preservation of biodiversity, and the supply of other environmental amenities. The disappearance of agricultural and natural land must be halted over time, and heavily reduced by 2035, in line with the recommendations on territorial and urban development. For agricultural land in decline, it is a question of harnessing innovative recovery techniques enabling sustainable management and enhancing production potential.

- Promote solutions that fulfil people's needs while significantly slowing down the artificial development of land.

- In regional or development projects: implement measures ensuring that the carbon stock in soils is not damaged. In particular, investigate how to bring nature into cities (through the replanting of car parks, for instance) and bring together the residential, employment and leisure sectors to reduce the land take dedicated to transport infrastructure.

- **Support regional project initiatives and bring together all the energy surrounding these projects**

  - Multiply project areas, support project efforts and optimise projects: (development of “positive energy territories for green growth” (TEPCV), “zero wastage zero waste territories” (ZGZD) etc.) experiments, and labelling ;

  - Involve all regions in territorial climate-air-energy plans (PCAET) at the intermunicipal level, and facilitate access to the data required to establish regional carbon audits and action plans (implementation of article 179 of the Energy Transition Act) ;

  - Facilitate and support the involvement of education institutions in the implementation of appropriate actions in regional plans and schemes relating to energy transition for the green growth of their region (PCAET, regional climate-air-energy scheme (SRCAE) in the regional planning, sustainable development and equality between territories scheme (SRADDET), TEPCV, TZGZD, etc.) ;

  - Speed up the transition to sustainable campuses by making higher education institutions exemplary with regard to energy performance and, more generally, social responsibility ;

  - Encourage the establishment of regional approaches to managing jobs and skills, and promote the development of qualifications, particularly in the construction sector.

- **Use ambitious R&D and training policies as a basis**

More generally, efforts to provide structure and support to R&D should be continued and expanded to **encourage the development and rapid dissemination of future technologies**, for a carbon-free world. Training policies and their funding must give high priority to energy transition to establish excellence pathways in renewable and low-carbon energies as well as in energy efficiency. As provided for in the Energy Transition Act, multi-annual energy programming (MEP) will include a component relating to professional transitions. It is vital that France puts itself in a position to take **leadership in these technologies to control consumption and emissions, and to replace fossil fuels**, in order to rapidly gain a foothold in the global market for low-carbon energy services and equipment. This ambition is in keeping with the ambition defined within the context of the Energy Union, which aims to make Europe the global leader in the field of renewable energy.

- **Consider the issues involved in the transition to a low-carbon economy in defining the State’s major strategic directions**

This covers the plans and programmes that have an immediate impact on greenhouse gas emissions, as well as cross-cutting directions, such as the National Energy Research Strategy. Large parts of the energy transition are dependent on significant research and development efforts. This is notably the case with the bio-economy, the increased pace of progress relating to energy efficiency, the major development of renewable energies and the improvement of synergies between transport methods being sought.

Sectoral recommendations

- **Low-carbon transport**

Transport is the sector that emits the most greenhouse gases (27% of GHG emissions in 2013). Compared with 2013, the target in the reference scenario is to reduce transport emissions by 29% by the third carbon budget, and by at least 70% by 2050.

Strategic objectives and immediate actions

To achieve these ambitious targets, the policies put in place must, in particular, make it possible to speed up :

1. the improvement in vehicle energy efficiency (the goal is an average of 2l/100km for new light duty vehicles sold in 2030) ;
2. the transition to low-carbon energies. In particular, it is important to anticipate the time frames for developing refuelling infrastructure (charging points for electric cars and gas delivery units) required for the transition to low-carbon transport, and coordinate its deployment by all parties concerned (State, local authorities, public institutions, businesses, households).

Other levers must also be mobilised :

3. management of travel demand (through remote working, spatial planning and other measures) ;
4. improvement in vehicle occupancy rates (car pooling) and more generally, improved use of existing vehicles and networks (article 44 of the Energy Transition for Green Growth Act) ;
5. the modal shift of people and goods to non-road and non-air transports (such as rail-ways, walking and cycling, etc.), which should be favoured in investment in transport infrastructure and land development choices.

- **Low-carbon buildings**

In 2013, direct emissions produced by the residential-tertiary sector accounted for 20% of GHG emissions (nearly one quarter if the indirect emissions associated with electricity and heat generation for buildings are taken into account). Compared with 2013, the target in the reference scenario is to reduce these emissions by 54% by the third carbon budget, and by at least 87% by 2050.

Strategic objectives and immediate actions

The different action levers should make it possible to reduce energy consumption by 28% compared with 2010 by 2030, and to further reduce the greenhouse gas emissions associated with construction and the long-term use of buildings through :

- the construction of new buildings with high energy and environmental performance : implementation of the 2012 regulations and the future regulation based on a life cycle analysis of the environmental impacts of a building will make it possible to significantly reduce GHG emissions throughout the lifetime of buildings ;







- increasing energy retrofit efforts, by both renovating the building envelope and improving the energy and climate efficiency of systems (e.g. heating, domestic hot water, cooking, etc.) so as to have a fully renovated set of buildings that comply with “BBC (low-consumption building) renovation” standards by 2050 ;

- improved management of consumption relating to behaviours and the use of electricity (in addition to the implementation of European directives (eco-design and labelling)), strengthening of consumer information systems, such as communication activities on hidden consumption, the identification of underperforming devices online, the deployment of connected smart meters, etc.

To achieve this, all the cross-cutting recommendations regarding funding, the development of local chains, professional training and consideration of the carbon footprint must be implemented.

- **Low-carbon agriculture**

Agriculture accounts for around 19% of the greenhouse gas emissions produced by France recorded in the carbon budgets, to which emissions associated with changes in agricultural land use are added.

Compared with 2013, the target in the reference scenario is to reduce agricultural emissions by 12% by the third carbon budget, and twofold compared with 1990 by 2050.

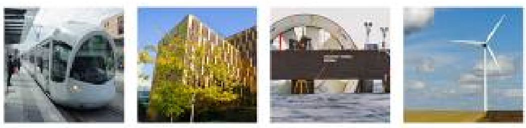
The policies set for the agricultural sector should enable it to join the national effort to reduce GHGs, while retaining its competitiveness and offering green growth and job creation opportunities, since they make it possible to :

- **guarantee food security and support the bio-economy while ensuring the supply of non-food products ;**
- protect the environment and natural resources (water, biodiversity, soils, air, etc.), protect public health, protect the countryside and social dynamics.

Five factors play an important role in achieving the targets :

- cultivation and livestock rearing systems and practices, which, for the same output of agricultural produce, can emit more or fewer GHGs ;
- rural land planning and land use ;
- the efficiency of the entire food supply chain up to the end consumer, which enables waste and indirect emissions to be reduced ;
- food demand (composition of diets, quantities, product origin, etc.), which influences the composition of agricultural production ;
- techniques for adapting to climate change, which enable production systems to be maintained or improved.

The main targets involve reducing the direct emissions of the agricultural sector (N2O, CH4), storing or keeping carbon in soils and biomass, and using biomass over fossil fuels (for the production of bio-based materials or energy).



Strengthened implementation of the agro-ecological project

Achieving these targets requires strengthened implementation of the **agro-ecological project, and in particular** :

- optimisation of the use of inputs (fertiliser, animal feed, etc.) and efforts toward achieving autonomy with local resources (replacement of mineral fertiliser by organic fertiliser, protein autonomy and the optimisation of animal rations, etc.) ;
- the diversification of crop rotation and the development of leguminous plants ;
- the conservation of permanent grassland and the development of agroforestry, hedges and other agro-ecological infrastructure ;
- land cover and an increase in the amount of organic matter in the soil ;
- the development of high added-value production ;
- the energy performance of agricultural buildings and equipment and significant development of agricultural methanisation.

- **Forest-Timber-Biomass**

Today, four levers make it possible to offset around 15 to 20% of national emissions :

1. the replacement of energy-intensive materials with bio-based products ;
2. energy recovery in relation to bio-based products or waste from these products, to replace fossil fuels ;
3. carbon storage in wood and wood-based products ;
4. carbon sequestration in the forest ecosystem.

It is a question of promoting multifunctional forestry, and **in particular, increasing the added value** of uses **while increasing the amount of timber collected** per year and making areas of agricultural decline the subject of sustainable management efforts. Synergies and uses should also be boosted in connection with the development of co-products and waste from bio-based sectors, their recycling and their use for energy generation purposes. More broadly, the management of all biomass uses must be strengthened and optimised. High environmental quality should be aimed for in all projects designed to improve resource mobilisation, taking particular account of biodiversity issues.

The implementation of these objectives is dependent on :

- the consolidation of small forest estates, or at least their management, ensuring they are renewed regularly (redevelopment of wasteland, conversion of coppices, including impoverished coppices, with the modification of species where necessary, etc.) ;
- a tax framework promoting the dynamic and sustainable management of resources ;
- the efficient use of bio-based resources in all economic sectors (industry, construction, furnishing, packaging, energy systems, etc.) ;
- close monitoring of sustainability and in particular, impacts on soils and biodiversity ;
- reinforced and shared monitoring of movements of materials and economic data.







- **Low-carbon industry**

The emissions produced by industry account for 18% of GHG emissions in France. They have fallen by 27% since 1990 (see section 1.1 for the reasons for this). 75% of these emissions are subject to the EU Emissions Trading System (EU ETS).

Compared with 2013, the target in the reference scenario is to reduce industry emissions by 24% by the third carbon budget, and by 75% by 2050.

By 2050, the transition to a low-carbon economy will be achieved through :

- Improving energy efficiency to manage demand for energy and materials by product ;
- Recycling, reuse, the replacement of carbon-intensive materials with less carbon-intensive ones, such as bio-based materials, and energy recovery to reduce consumption of energy and materials ;
- Energy substitution in order to reduce the share of energies with high emission levels in industrial consumption and materials.

In the longer term, the development and deployment of carbon capture and storage (CCS) will play a significant role in achieving targets.

Concerning implementation issues, it is useful to signal :

- the studies published by the French Environment and Energy Management Agency, ADEME, which highlight a significant techno-economic pool that is not exploited due to a lack of financing capacities (companies primarily dedicate their investment capacities to developing their production process rather than energy savings), which could be exploited as soon as innovative funding schemes can be implemented ;
- the need to make the carbon price signals visible and predictable, in order to limit lock-in effects (investment decisions that are not consistent with the necessary medium-term changes) ;
- the need to prevent emission reduction tools from leading to deindustrialisation.

- **Low-carbon energies**

Emissions caused by energy generation account for just 12% of GHG emissions in France, and 85% of these emissions fall under the EU Emissions Trading System (EU ETS). They fell by 27% between 1990 and 2013.

Strategic objectives and immediate actions

By 2050, the work of the 2020-2050 trajectory committee towards a low-carbon economy assumes a reduction by a factor of 20 compared to 1990, i.e. almost complete decarbonisation of the sector. This translates into :

- an acceleration in **energy efficiency gains** (by a factor of two in the Energy Transition for Green Growth Act): a fall in the energy intensity of GDP and the importance of managing carbon energy consumption, transfers of use to electricity.







- **a drastic decarbonisation of the energy mix by 2050 (by a factor of 10)** : (fall in gCO_2/kWh of electricity and heating networks). The ambition that lies behind these scenarios is based on the assumption of a significant deployment of carbon capture and storage (CCS) systems by 2050. If this is not the case, then the efforts to decarbonise energy generation must be transferred to other options, including other sectors of the economy.

In the power generation sector, it is primarily a question of :

- Avoiding investing in new fossil fuel thermal production facilities as much as possible. The multiannual energy programmes should precisely control the need for new thermal production facilities according to the policies set for other sectors, the objectives of security of energy supply and the need for flexibility in the electricity system, while adhering to the carbon budgets and decarbonisation targets of the electricity system over the long term.

- Reducing the emissions produced by existing facilities by making the carbon price high enough.

- Providing for the possibility of deploying carbon capture and storage systems or using carbon for fossil fuel plants which will be in operation by 2050 (by retrofitting where necessary), taking account of the storage options available when choosing where to locate facilities.

- Improving the flexibility of the system without increasing emissions: the integration of renewable energies will eventually require increased flexibility. This notably requires the development of :

    - The flexibility of the hydroelectric sector, since this renewable energy sector enables significant peak production ;

    - Smart networks and storage tailored to needs: weekly storage to deal with the intermittent nature of wind power by 2030, and daily storage to manage photovoltaic generation after 2030, once it reaches significant levels ;

    - Transfers between energy systems (power-to-gas, power-to-heat) ;

    - Connections with neighbouring countries to maximise the proliferation of renewable energy generation.

In the heat generation sector, it is primarily a question of orienting generation towards renewable heat sources and heat recovery, and developing urban heating networks, to enable increased use of renewable energy and recovery through heating systems.

- **Make waste treatment one of the pillars for developing a more circular economy**

The waste treatment sector accounted for 4% of French GHG emissions in 2013. Compared with 2013, the target in the reference scenario is to reduce transport emissions by -33% by the third carbon budget, and by at least 80% by 2050.

The actions levers in order of long-term priority are as follows :

1. Avoid waste production through prevention (eco-design, increasing the lifetime of products, repair, limiting food waste) and reuse (circular economy) ;
2. Increase the material recovery of waste which cannot be avoided (recycling, widespread use of source separation of bio-waste by 2025) ;
3. Recover the energy from unavoidable and non-recoverable waste in material form ;
4. Reduce diffuse methane emissions from landfill sites and sewage treatment plants, including the non-recoverable part in particular ;
5. Cease incineration without energy recovery.

These five action levers must be implemented collectively. **In addition to the fall in direct emissions, they will enable a reduction in emissions in the production and consumption sectors.** The transition to a more circular economic model is at play in the broad sense that it constitutes a paradigm shift in our production and consumption model (material, resource and energy savings; sustaining value, wealth and jobs).These levers must supplement efforts to engage in the short term to ensure the collection and recovery (or flaring) of emissions produced by waste storage facilities and the energy and climate optimisation of sewage treatment plants, when making structural investments in them, in order to achieve much more systematic collection and recovery of the biogas and residual heat produced.







Carbon budgets

- **Definition of carbon budgets**

To achieve its long-term targets, France has adopted ‘carbon budgets’ at the national level, which are broken down into the major activity sectors for information purposes. These are caps on greenhouse gas emissions established to systematically ensure over ten years’ visibility with regard to progress in reducing emissions. They cover five-year periods (four years for the first budget) so that analysis of compliance or non-compliance with them cannot be overly influenced by situational phenomena (a particularly mild or harsh winter, upwards or downwards fluctuations in the price of fossil fuels, etc.).

- **Application**

Carbon budgets are tools for monitoring progress in reducing emissions. They should make it possible to measure progress and check/identify whether France is on the right track towards achieving its targets. In particular, the indicative breakdown by activity sector (resulting from the forward studies set out in the following section) should not be regarded as a rigid compartmentalisation of targets, but as a primary sectoral breakdown to guide overall management. Therefore, this breakdown is an integral component of the set of indicators for this strategy, providing indications about the risk of deviating from the global target and any need for corrective measures, without anticipating the sector in which these additional reductions must take place (see part 4 of the strategy).

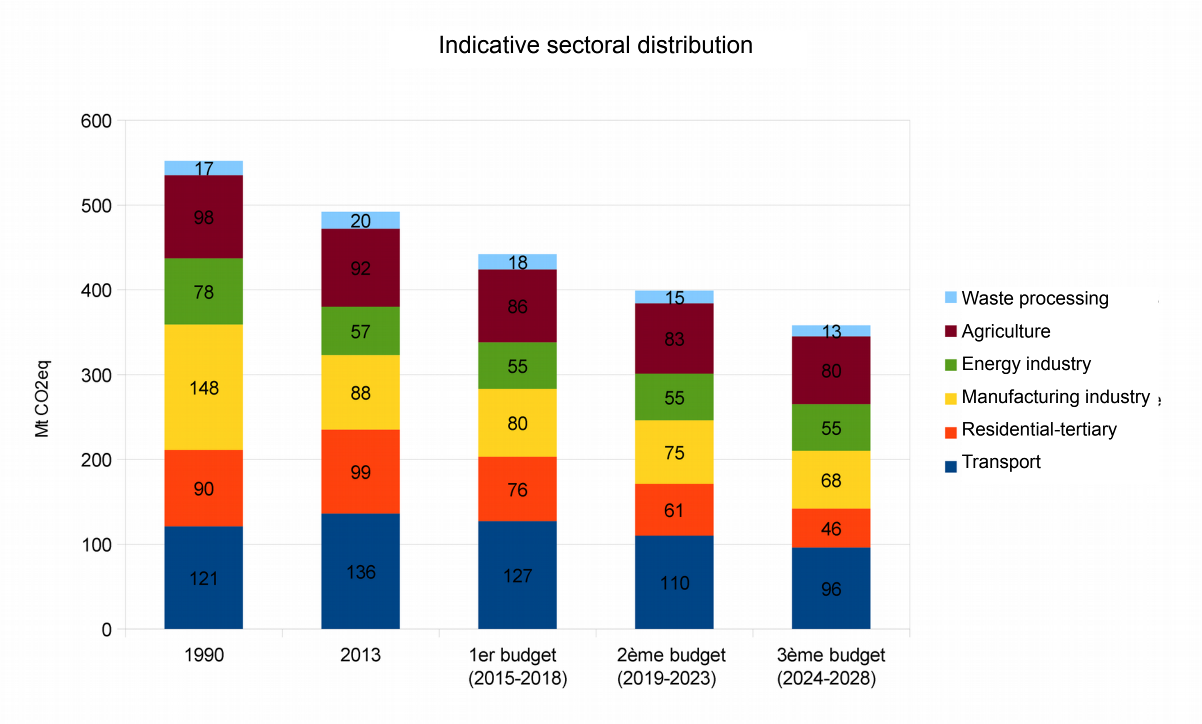
Average annual emissions (in Mt CO2eq)	*1990*	*2013*	*1st budget carbone 2015-2018*	*2nd budget carbone 2019-2023*	*3rd budget carbone 2024-2028*
All sectors	552	492	442	399	358
EU ETS (excluding international aviation)		119	110	n.d	n.d
Other sectors		373	332	n.d	n.d

The distinction between sectors in the EU Emissions Trading System could not be determined for the second and third budgets insofar as the exact shape depends on directives and regulations that will be implemented to apply the decision made by the European Council in October 2014, when a target of a 40% reduction in European emissions was agreed.

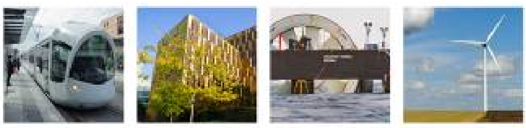








Consistency: Before each update of the strategy, the expert committee must analyse the consistency of the measures implemented with the paths enabling compliance with the carbon budgets previously set (for example, at the end of 2018, the expert committee must deliver an opinion on the consistency of the measures implemented with the carbon budgets for 2015-2018, 2019-2023 and 2024-2028).



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Stratégie
NATIONALE BAS-CARBONE

FRANCE NATIONAL LOW-CARBON STRATEGY

FOREWORD

France has set itself ambitious climate and energy targets, within the framework of the commitments made by the European Union.

Above and beyond these objectives, France is committed to a genuine process of energy transition in order to overhaul our entire energy model and fight back against climate change.

Furthermore, this transition is an opportunity for us to nurture the development of a new, more stable form of growth capable of generating better jobs and improving our quality of life: the green economy.

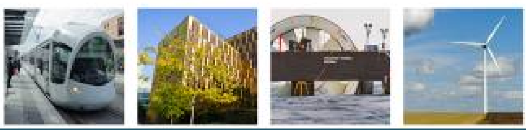
The transition is taking place in our local territories through the initiatives they are leading. The transition will be driven by their commitment to making this new development model a success, bolstered by the capacity of our local authorities to make change happen at ground level.

It is an opportunity for innovation and entrepreneurship, with the industrial and service sectors playing a key role. The transition is the sum of countless concrete, ambitious projects.

It is enshrined in the Energy Transition and Green Growth Act, which shows the way forward and provides our regions and local authorities with the institutional resources they need to launch and nurture green energy projects.

With this new low-carbon strategy, the energy transition gains a broad, unifying steering and coordinating tool which will guarantee the coherency of our efforts.

Set down in law, this strategy will be implemented under the six-party governance system (national government, regional authorities, Parliament, businesses, unions, NGOs affiliated to the National Council for the Ecological Transition). It is a key plank in our national ecological transition, covering the crucial priorities of energy transition and green growth.



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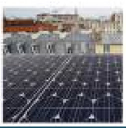
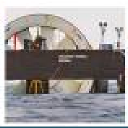
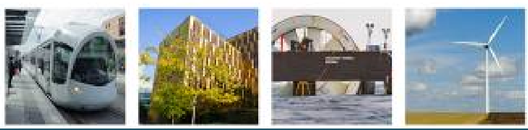




INTRODUCTION: SCOPE OF THE LOW-CARBON STRATEGY

One of the two key pillars of our climate policy

The National Low-Carbon Strategy (French: SNBC) sets out our climate change mitigation policy o, i.e. reducing greenhouse gas emissions and boosting efforts to trap these gases in "carbon sinks." It is, of course, closely linked to our policy on adapting to climate change, helping man-made and natural systems to adjust to the environmental changes brought on by climate transformation. These changes are now inevitable, and our mitigation policy is aimed at limiting global warming to 2°C, or below 1°C if possible. Both policies focus on reducing the impact of greenhouse gases. This process of adaptation is covered by its own specific strategy: the National Strategy for Adapting to Climate Change. Coordination between these two policies will focus on seizing opportunities for synergy and resolving any conflicts between the measures put in place. Close cooperation will be particularly important in sectors which are heavily dependent on natural resources, especially agriculture and forestry.

Furthermore, the SNBC is in total harmony with the National Strategy for the Ecological Transition to Sustainable Development (SNTEDD), particularly with reference to Priorities 2 (a circular, low-carbon economy) and 1 (developing sustainable, resilient territories), acting on several fronts to support and accelerate social change (Priorities 4, 5 and 6) and incorporating education and governance tools in order to encourage widespread engagement with the transition (Priorities 7, 8 and 9). It is entirely consistent with the targets set for restoring biodiversity (Priority 1) in the corresponding national strategy, as well as the national health priority of combating atmospheric pollution and abiding by EU and WHO standards. These areas of overlap are dealt with in greater detail in the accompanying report: § 5.2.iii

Directly binding for the public sector only

The national low-carbon strategy (SNBC) sets out a roadmap for our policy of reducing greenhouse gas emissions, in a manner which is economically sustainable in the medium-to-long term.

Designed to "steer policy," this strategy is aimed primarily at public-sector decision-makers, particularly at national, regional and inter-municipal levels, including public institutions. For this priority target group, the SNBC and its carbon budgets are legally binding and must be respected.

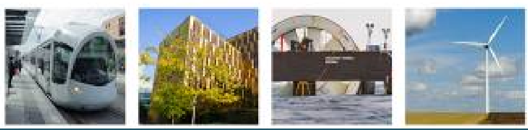
Applicable to all

Strictly speaking, this strategy is only legally binding for the public sector - but all businesses and all citizens are indirectly concerned. They will feel its concrete effects via the many and varied public-sector decisions made in light of this strategy (regulations, financial support, economic policy, education and training etc.).

For businesses and households, the SNBC will serve as a reference document on the government's strategy in this area, providing useful information which may help guide investment decisions.

Obligation to take the SNBC into account

More precisely, the SNBC will be enforced (in the public sector) by an obligation to take its provisions into consideration - with the exception of the energy sector, where the obligation is one



of compatibility.

In positive law, the obligation to take something into consideration requires those concerned "not to deviate from these fundamental principles except, subject to approval by the courts, for reasons derived from the best interests of the operation and justified by these interests." (cf. Council of State 9 June 2004, 28 July 2004, 17 March 2010). The principal consequence of this requirement is that the SNBC cannot be ignored and any deviations (points on which strategy documents are not compatible with the SNBC) must be explained and justified.

As regards energy policy, the law introduces Multiannual Energy Plans (MEPs) which incorporate a compatibility component, making them more restrictive than the obligation to take the SNBC into account. The MEPs nonetheless leave a certain amount of room for manoeuvre in the interpretation of the SNBC, all while ensuring that it is not possible to take measures which directly contradict its central principles and provisions.

To make them easier to understand and apply, these principles and provisions are limited in number and grouped into a series of bullet points in Chapter 3 (particularly Section 3.3 in Part 2). They are also summarised in the recap of points to be monitored in Chapter 4.2. They focus particularly on implementing carbon budgets, and as such it is partly through these provisions that carbon budgets are binding.

The scope of this obligation in the public sector

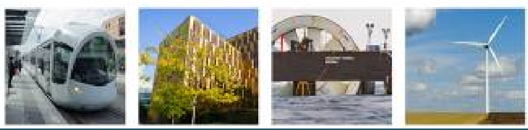
This obligation is of great significance for planning and scheduling documents, which have a major impact on greenhouse gas emissions. This is of particular importance in the sectors listed in Chapter 3 (transport, construction and the tertiary sector, industry, energy, agriculture, forestry, waste management), as well as for territorial planning operations (especially Regional Development, Sustainable Development and Territorial Equality Schemes, as well as Regional Economic Development, Innovation and Internationalisation Schemes).

It also applies to financial support for public projects. Such decisions must now systematically take into consideration, among other factors, a project's impact in terms of greenhouse gas emissions. The principles and calculation methods used for these assessments will be defined in the decree stipulated in Article L.222-1 B of the French Environment Code.

An iterative review process

The low-carbon strategy will be subjected to a comprehensive review cycle every five years. At this point, the perimeter covered by the next two budget cycles may be adjusted if necessary (particularly in light of France's commitments at European level regarding net carbon emissions connected to land usage and related changes). This process includes:

- the opinion from the committee of experts (Article L. 145-1 of the Energy Code) regarding the success of the carbon budgets already in place (the balance of the one now reaching its conclusion, projections for the next two budgets) and how to implement the current low-carbon strategy. These findings will be passed on to the standing committees of the National Assembly and the Senate responsible for energy and the environment.
- a government report covering the review of the low-carbon strategy, a draft for the forthcoming third carbon budget and any adjustments made to the first and second budget cycles. This report will clearly demonstrate how the draft carbon budget and the low-carbon strategy incorporate the objectives set out in Article L. 100-4 of the Energy Code, as well as France's European and international commitments. The report will assess the environmental, social and economic impact of the carbon budget for the coming periods and of the new low-carbon strategy, particularly with regard to the



competitiveness of economic activities subject to international competition, the development of new, local activities, and overall growth. This report will be made public.

- the opinion of the National Committee for the Ecological Transition and its committee of experts.
- a decree setting out the low-carbon strategy and corresponding carbon budgets.
- these decisions will be presented in Parliament, along with a quantitative summary of the most recent carbon budget and an analysis of the results achieved in this cycle.

Exceptionally, the first cycle will last for four years, while subsequent cycles will then last five years. The results of the first review process should be published by decree no later than 1st July 2019. This will ensure that the review (and all subsequent reviews) are conducted relatively early on in the parliamentary term.

Regular reporting

Every two years, a report to the European Commission will provide details of measures taken to reduce greenhouse gas emissions, assessing their effectiveness and identifying medium-term prospects for further reducing emissions, including a scenario which takes account of those measures already put in place. This report will be made public.

Every year, reports will be submitted to Parliament covering:

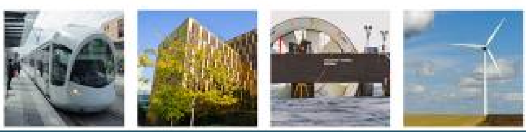
- government spending on climate policy;
- financial backing for the energy transition, quantifying and analysing the public funding and evaluating the private funding allocated to the energy transition, with reference to the levels of funding required to meet the targets and rate of transition prescribed by the law. This report will focus particularly on actions to control energy demand and measures to promote renewable energies, as well as the impact of energy consumption on trends in greenhouse gas emissions and, more generally, on the environment.

The report will be presented to the National Council for the Ecological Transition and the Economic, Social and Environmental Council.

Ongoing monitoring

Via these reports, and within the monitoring framework put in place for the sector-specific policies, the indicators detailed in this strategy document will be analysed and updated regularly. This strategy thus guarantees the coherency of our climate policy on all fronts. It will enable us to hit our stated objectives, providing the necessary resources and facilitating the necessary adjustments in sectoral and territorial policies, wherever discrepancies with the reference scenario are identified.

This will be particularly useful in allowing us to gradually optimise the distribution of mitigation efforts across different sectors (Part 3.3) and territories (Part 3.2.viii) in successive phases. This distribution will depend on the initiatives and commitments of the various parties, as well as the effective implementation of measures and their observed efficacy, not to mention the new opportunities regularly opened up by progress in research and innovation.



CHAPTER 1: WHERE ARE WE COMING FROM, HOW FAR CAN WE GO?

1.1. The story so far

A. Development of emissions in France since 1990

France now has one of the lowest rates of per capita emissions among the world's developed nations. Per capita emissions are higher in 90% of developed nations (taken together, these nations account for almost half of the world's total population). This gives some idea of the scale of decarbonisation efforts already undertaken in France, efforts which will be stepped up between now and 2030, and 2050.

Following the first oil crisis (1973), France realised the importance of moderating the growth of energy consumption and limiting the country's dependency on imported oil. France's National Energy Saving Agency was founded in 1974. Households and businesses were encouraged to minimise unnecessary energy consumption, with a clear impact on the structure of national consumption: final energy consumption intensity declined from Base 100 in 1970 to 52 in 2013.

In the meantime, a large-scale nuclear programme has seen the country's energy supply mix shift from 85% coal and oil to a situation in which these thermal energy sources represent just 10% of total energy production.

These major changes were set in motion in the late 1970s and early 1980s, but the pace of change slowed when oil prices fell (the 1980s oil glut). Energy efficiency once again became a priority in the late 1990s (with the Commission for the National Plan's report on energy consumption, published in 1998), leading to the introduction of climate policies which have been extended and developed in subsequent climate strategies.

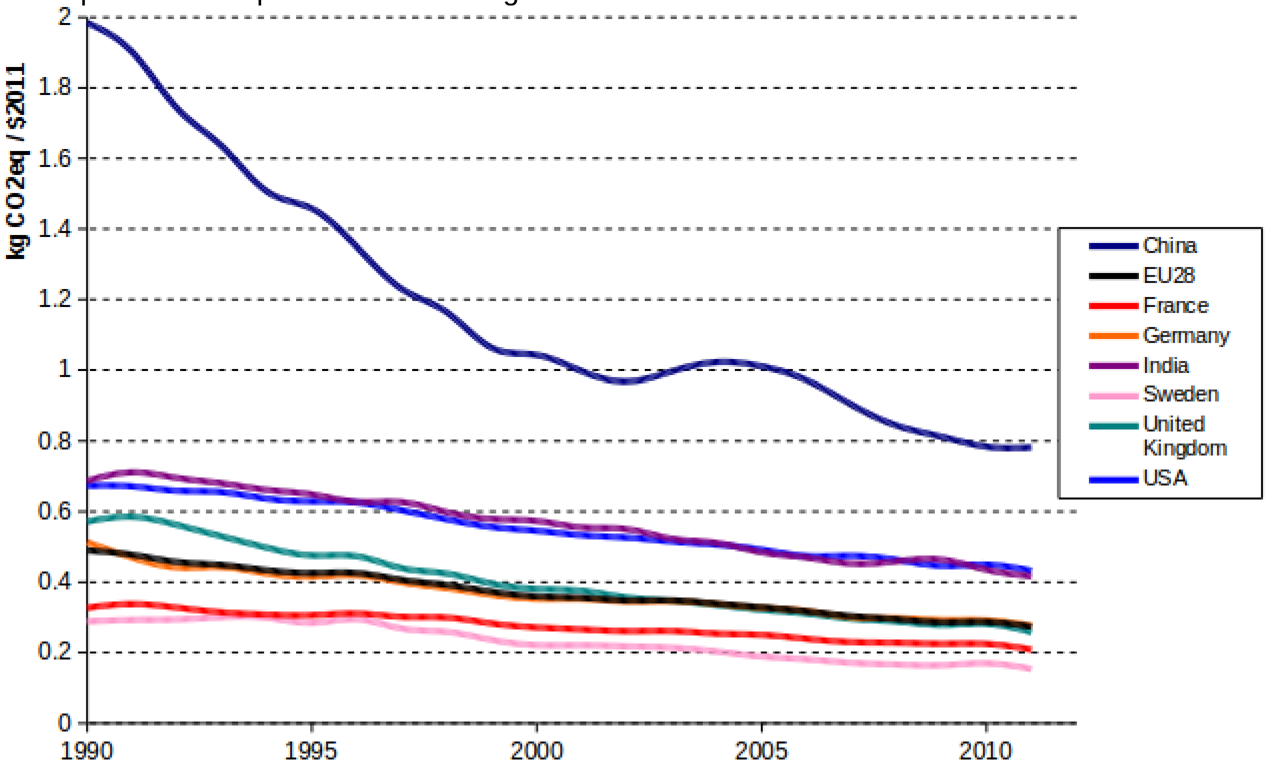
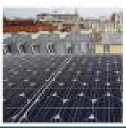


Figure 1.1 : GHG emissions by unit of GDP (PPP). Sources : emissions, excluding LULUCF (UNFCCC – except India and China WRI/CAIT) and GDP (World Bank)







All of which has left France with:

- an economy which is among the least carbon-dependent of the developed nations
- "easy" energy efficiency opportunities already exploited
- more-or-less short-term public policies in all sectors of activity, coordinated by national strategies with clear monitoring indicators,
- experience in the impact of energy prices, and the importance of a more structured, pro-active and sustained policy of reducing emissions,
- development of renewable energies
- growing public awareness.

Greenhouse gas emissions decreased by 10.8% between 1990 and 2013 (cf. figure 1.2 below) (CITEPA/MEDDE/ December 2015 version, Kyoto criteria). In France, in 2013: 74% of these emissions were CO2, 12% CH4, 9% N2O and 5% fluorinated gases.

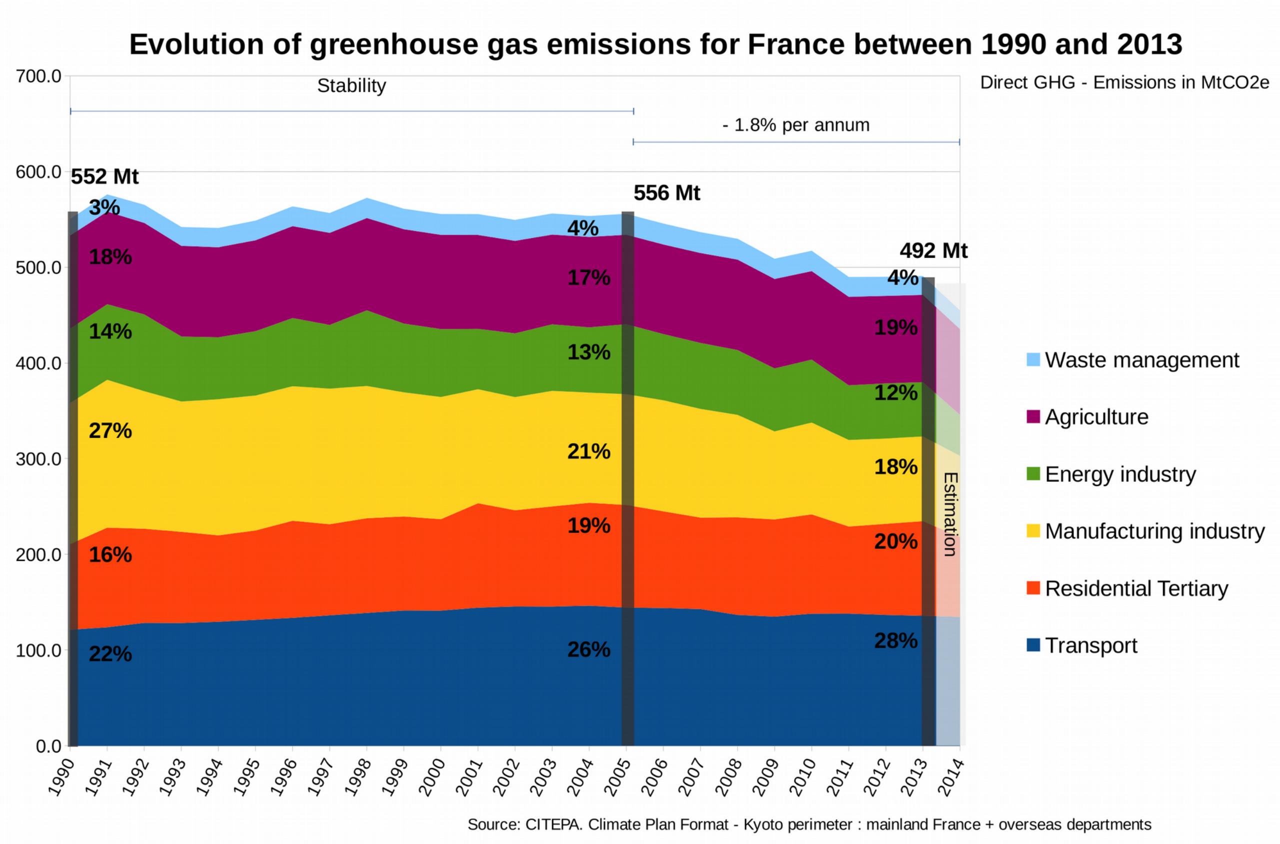
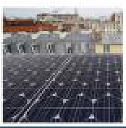


Figure 1.2 : inventories of greenhouse gases of France

Some sectors of activity are liable to see substantial variations from one year to the next. This includes the residential and tertiary sectors, as well as industry. Other sectors, meanwhile, are fairly stable: transport and agriculture. Significant annual fluctuations indicate that a sector is heavily influenced by factors which are liable to change rapidly: for example, the close correlation between residential / tertiary emissions and winter temperatures, or the fact that industrial emissions are greatly affected by the introduction of new production technologies or emission treatment systems, not to mention the economic climate. Transport emissions, on the other hand, are linked to the long-term evolution of lifestyles. They occasionally reflect the impact of sudden price increases (e.g. 2009), but in the medium-term they reveal the influence of policies to take







older vehicles off the road and incentives to use public transport. The impact of these actions can be seen over the long term.

In order to achieve a more detailed analysis of the relationship between France's greenhouse gas emissions and certain factors both endogenous and exogenous to the calculation of these emissions, a study was commissioned from the CITEPA/CEREN consortium in 2015. The principal findings of this study are given here in appendix.

B. Emissions linked to consumption in France

Greenhouse gases at international level are measured using a territorial approach, but other approaches have been developed which allow us to factor in the impact of emissions generated outside the national territory to meet the consumption of good within it. This is the case with the 'carbon footprint' approach. These two approaches complement one another when it comes to analysing and developing climate policy. Carbon footprint is presented as a cross-disciplinary approach in Paragraph 3.2.i.

1.2. Perspectives - lessons to be learned from previous experience

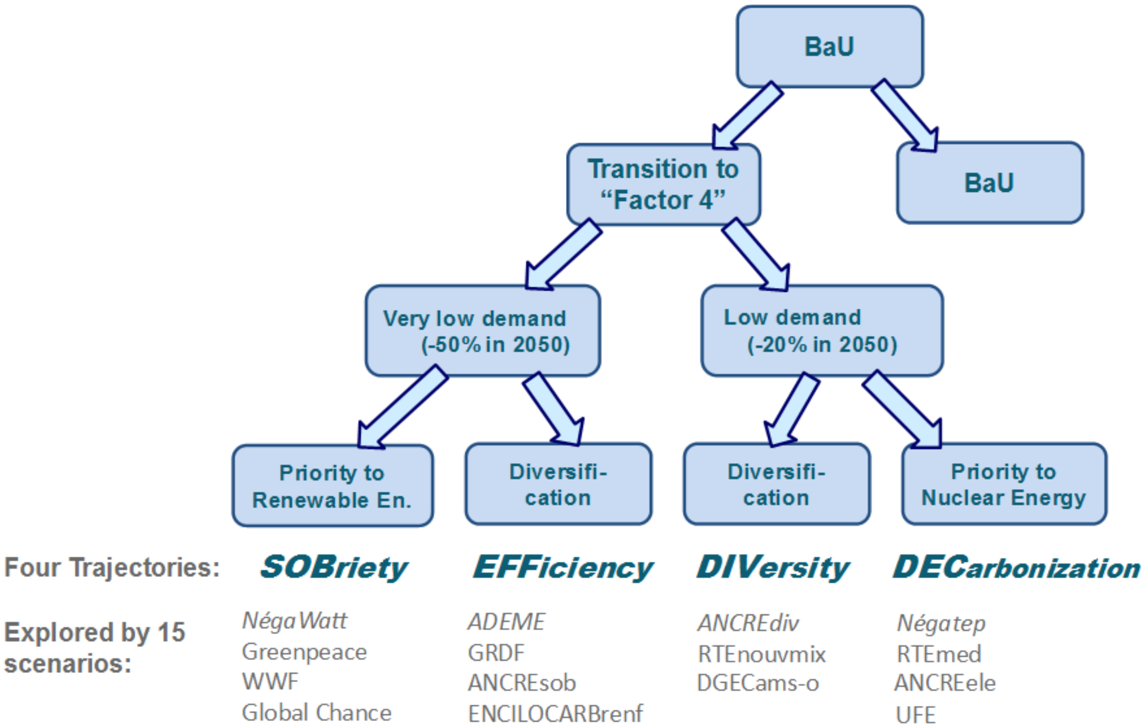
1. Aspects of structural significance

Many prospective reflection taking into account the need to drastically reduce greenhouse gases emissions have been conducted since the beginning of the years 2000 (see among other the first four references in the bibliography at the end of this document).

More recently, the future of energy and climate policy was thoroughly debated within the framework of and in parallel with the National Debate on the Energy Transition (DNTE), which ran from November 2012 to July 2013. Having examined a broad selection of pre-existing scenarios (16 in total), the group of experts selected for the DNTE decided that the major strategic decisions required in the coming years could be illustrated in the form of four 'DNTE Trajectories'. These trajectories represent two contrasting levels of energy demand, and two contrasting modes of energy production which could be used to satisfy this demand (the 'energy mix').

In all of these cases, the 'price signal' sent by the value of carbon, and the way it is received by the underlying economy, appeared to have a decisive impact on results, although more detailed analysis is required. This price signal can be taken literally - as a result of fiscal measures, for example - but it can also be used in the models to express the effects of other changes of equivalent significance induced by a raft of measures which are not individually specified and which may not necessarily be fiscal in nature, instead taking the form of regulations or standards.

To be more precise, certain studies describe an array of measures and behavioural changes, illustrating the potential importance of changes in behaviour. In other scenarios, less restrictive in terms of the options selected, the search for opportunities to reduce emissions is driven by the reaction to a 'carbon price signal'. Finally, it should be noted that some of these scenarios rely heavily on technical developments, while others afford greater priority to changes in lifestyle.



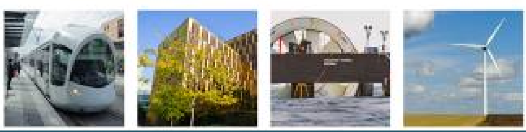


Figure 1.3 : Characteristics of the four family of trajectories identified during France National Debate on the Energy Transition (Source: DNTE Working Group 2 'Scenarios and the Energy Mix', July 2013)[1]

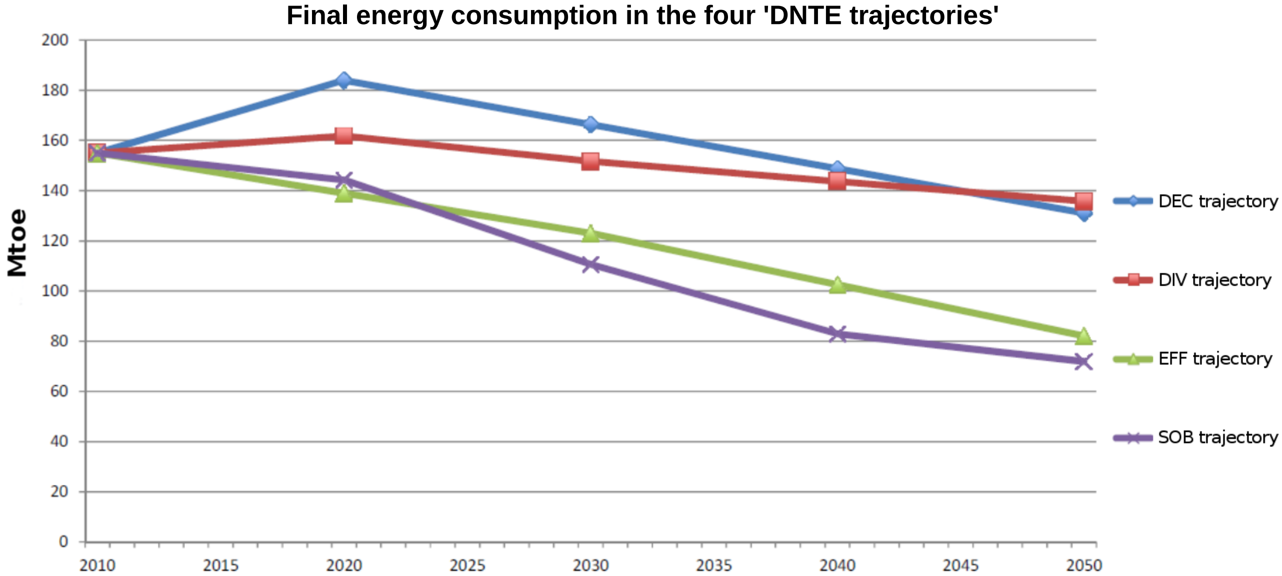


Figure 1.4 : final energy consumption in the four types of trajectories analysed during France National Debate on the Energy Transition (source: DNTE Working Group 2 'Scenarios and the Energy Mix', July 2013)

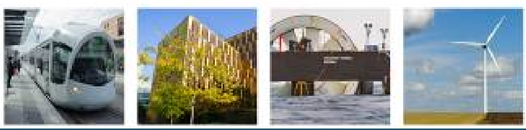
Studies focusing on all forms of greenhouse gas emissions (the 2020–2050 Trajectories Committee: towards a low-carbon economy (2012), ADEME Vision for 2030 and 2050, Negawatt etc.) provide a preliminary overview of the reduction in emissions which can be envisaged in different sectors of activity: achieving our target of cutting all greenhouse gas emissions to a quarter of their 1990 levels by 2050 ('Factor 4') may require an even more substantial reduction in emissions from energy consumption (slashed to 20% of 1990 levels), with a drastic reduction in industrial emissions from centralised energy production (down to 10%) and a less significant reduction in emissions from other sectors such as agriculture (which will nonetheless require significant effort in order to cut emissions in half).

2. 'Citizens' Reading Guide'

One of the problems with this scenario-based approach is that it is often hard to understand for members of the general public who are neither energy experts nor overly familiar with technical economic modelling practices. The DNTE's ' Scenarios and the Energy Mix ' Working Group has adopted an original approach to helping citizens understand these scenarios, proposing a list of criteria which can be used to establish a hierarchy of preferences. With this goal in mind, the DNTE group of experts were asked to translate these "citizens' criteria" into a form which the scenario builders could use in their representations, offering concrete responses. This is a slightly amended version of the resulting list of criteria:

- Economic and macro-economic impact
  - Energy cost and prices, savings and costs of energy services
  - Investments (by sector and segment, nature and timeframe)

[1] Some of these scenarios do not stretch as far as 2050, or do not consider all forms of greenhouse gases. They are not all constructed with reference to the 'Factor 4' target for all greenhouse gases. Nevertheless, this model of four broad trajectories remains a useful way of illustrating the different potential paths towards a major reduction in greenhouse gas emissions.



  - Jobs, professional sectors, career paths
- Environmental impact
  - Management and conservation of resources (including biomass and land)
  - Impact on biodiversity and other environmental impacts
  - Reduction of greenhouse gases
  - Respecting national and international commitments for the environment, locally and globally
- Social impact
  - Social cohesion and justice
  - Lifestyles
  - Territorial autonomy and governance of local systems
- Other impacts
  - Impact on health, risk of accidents, safety
  - Resilience and robustness, reversibility and flexibility of the energy system
  - Energy security
- Feasibility of this scenario: macro-economic, sociological and technological considerations

3. Follow-up actions

The DNTE work on the four 'DNTE Trajectories' did not yield a definitive analysis, but an analysis is outlined in Part 2 of this strategy, based on the scenarios which underpin the carbon budgets. This analysis will help us to identify key indicators, facilitating factors and obstacles (technological 'lock-ins' and problems relating to the public perception of actions, for example). This analysis will facilitate subsequent analyses of the gaps between forecasts and actual results for different variables (emissions, consumption etc.).

Finally, a study focusing on the four DNTE trajectories was conducted after the debate. On the one hand, this study highlighted the need for regular 'loopbacks' between exogenous variables and results, in order to ensure overall consistency. On the other hand, it recommends using the DNTE scenarios to define a set of monitoring indicators which can be used to keep track of the energy transition. Policies and measures can then be defined, monitored and piloted with reference to these indicators.

CHAPTER 2: THE FRENCH PROJECT

2.1. Major decisions taken

The way forward is clearly signposted by the Energy Transition and Green Growth Act and the commitments which France has already made for the period to 2020:

- -14% of emissions (exc. ETS) by 2020, compared with 2005 levels
- -40% reduction on 1990 levels by 2030 (this relative target, identical to the average European target, demonstrates France's commitment to remaining one of the European nations with the lowest per capita greenhouse gas emissions over this period)
- -75% reduction on 1990 levels by 2050 (Factor 4)

It is therefore fully consistent with the policy in place at EU level.

Our first priority is to develop a new mode of green, sustainable growth. Above and beyond France's international objectives and carbon budgets, public policy must also aim to achieve a **reduction in the global carbon footprint.**

The law also introduces the **pragmatic principle of regular reviews**, including a five-year iterative cycle for assessing and revising the carbon budgets and this strategy.

This is a thoroughly balanced approach, combining:

Ambition and realism

Cutting greenhouse gas emissions to 140Mt in the space of one or two generations represents a real challenge. It will require average reductions of between 9 and 10 Mt of CO_2 per year until 2050. This means increasing the pace of reduction compared with the period 2005-2013, without sacrificing the economic development of our country and without exporting our emissions by relocating those activities with the highest emissions overseas.

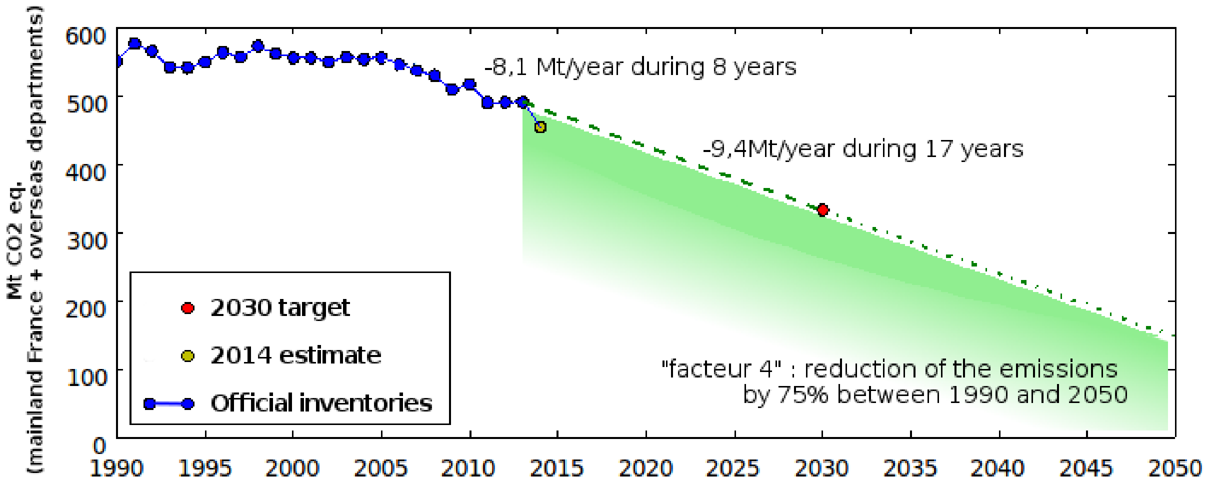
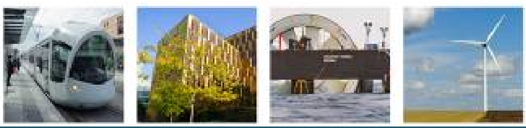


Figure 2.1 : inventories of greenhouse gases emissions (1990-2013), preliminary estimate of 2014 emissions in mainland France and the overseas departments and France emissions reduction targets for the 2030 and 2050 time horizons. Source : CITEPA and MEDDE/DGEC

A broad array of economic sectors are likely to be affected. Massive investment is required and an overhaul in production and consumption patterns is essential. It is therefore crucial that we quantify the stakes at hand, at both the macro-economic (national) and micro-economic (as experienced by businesses and households) levels, extending this exercise in the form of comprehensive



economic monitoring.

The various forward studies which have already been conducted demonstrate that this is possible. While this strategy outlines the general framework, close analysis of the scenarios reveals a large spectrum of possibilities. Many consultations will be required across all sectors in order to determine the best way to proceed, especially as there should be no shortage of new opportunities as technology and its costs evolve.

International Justice

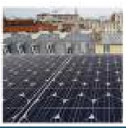
With this ambitious strategy, France is assuming its responsibilities in the fight against climate change and calling upon other governments to do the same, in keeping with the principle that action should be proportionate to our shared responsibilities, but that individual countries should take on different burdens - taking their historical responsibility into account, among other things - in light of their relative capacity for action, including economic capabilities.

According to the report published in November 2014 by the United Nations Environment Programme on the gap between requirements and capacities in terms of emissions reduction (the UNEP Emissions Gap Report), if the targets set by all countries for the coming decades allow us to attain a broadly similar level of emissions per capita all over the world by 2030 or 2050, we should be somewhere in the median range of the scenarios compatible with a 2°C global warming target.

The steering measures for this strategy also underline the importance of taking social impact and redistribution into account, as explained in further detail in Part 5.2.ii).

Diverse technological options

The objective is to lay the foundations for the green economy, based on the four main pillars identified by the World Bank: energy sobriety in all sectors; the use of decarbonised energy for transport, heating and industry; reinforcing natural carbon sinks and bio-based production; decarbonisation of the electricity generation mix.
For example, in the field of renewable energies, no technological option is to be discarded. Encouraging widespread use of the most mature technologies will allow us to transform the energy mix at a lower cost, while continuing to develop technologies which are not yet mature will help us to prepare for the future and establish a strong foothold in these promising markets. This robust approach will help us to adapt to the unforeseen obstacles which will inevitably crop up along the way, and make the most of all the natural resources available to us, including those in our overseas territories (solar power, wind, biomass, geothermal, various forms of marine energy etc.).







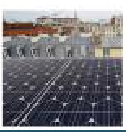
Creating wealth and sustainable jobs

The aim of this transition is not simply to reduce our carbon footprint while capitalising on the accompanying benefits for our economy and environment, but also and above all to transform the process of adapting to carbon constraints into a source of inspiration and dynamism for a new approach to growth: fairer; more sustainable; creating more jobs which are better qualified, more evenly spread across all territories and not liable to be outsourced abroad; in short, more in keeping with the expectations of our fellow citizens.

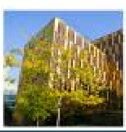
The development of a low-carbon economy will allow France to:

- become less dependent on imported fossil fuels, reducing our energy bill and carbon footprint
- bolster growth and achieve GDP growth which outstrips the projections based on current trends for the next two decades
- boost employment (between 100,000 and 350,000 new jobs created between 2015 and 2035)

In practice, this means that while the current strategy covers all means at the government's disposal in the fight against climate change - State-controlled factors such as standards, regulations and fiscal pressure - we must never forget that one of our top priorities is to expand the capacity for action of those on the front line: businesses, families, local authorities etc. We must endow these civil society partners with the means to develop and expand the countless initiatives already in place.







2.2. The reference scenario

Establishing the reference scenario

This scenario, which is compatible with the targets set down in law, is very directly inspired by the modelling work detailed in the next section, focusing on carbon budgets. These models integrate various sector-specific factors, based on a combination of measures designed to respond to France's greenhouse gas emission reduction targets for the 2030 and 2050 deadlines.

This scenario was developed under the aegis of a steering committee, made up of experts from the relevant ministries and industrial sectors. The steering committee was co-chaired by representatives of the Ministry for the Environment (Energy and Climate Division and the General Commission for Sustainable Development - CGDD) and the Agency for the Environment and Energy Efficiency (ADEME). The group's secretariat was composed of representatives of the Department for the Fight against the Greenhouse Effect, part of the Energy and Climate Division. This steering committee was cross-disciplinary in nature, incorporating sector-specific sub-committees (energy, transport, construction, industry, waste management, agriculture, forestry) when necessary. Throughout the working process - i.e. from the definition of the fundamental hypotheses up until presentation of the final results - the Information and Orientation Committee (CIO) met six times, inviting input from civil society figures regarding modelling decisions and discussing the results obtained. All organisations represented on the National Council for the Ecological Transition (which brings together representatives of employees, employers and consumers, environmental NGOs, territorial authorities and members of parliament) were invited to take part in these CIO meetings.

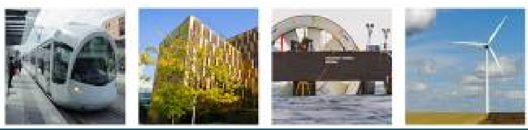
The reference scenario was constructed in successive phases, starting by drawing up a list of policies and measures already in place as of 1st January 2014, then adding those measures included in the draft bill on Energy Transition and Green Growth which could be easily modelled, and any additional initiatives or changes contributing to the attainment of the measures set down in law. Moreover, a series of sensitivity tests allowed the committee to measure uncertainty surrounding the impact of certain factors and determine the level of mobilisation required by different scenarios, based on discussions in the information and orientation committee meetings. Details of the main options selected are presented hereunder.

Scope of the reference scenario: illustrating the major strategic decisions taken

This scenario demonstrates the scale of the efforts which will be required, as well as the transformations and benefits they will yield. It is not prescriptive, and primarily constitutes a reference for orientation purposes

In fact, comparative analysis of the measures, both between sectors and within the same sector, and the consideration of fairness, competitiveness and acceptability, which would be useful in order to hone and prioritise these measures, should be pursued and increased, particularly within the context of sectoral or regional planning or programming. The sector-specific figures and measures presented hereunder are intended to be modified and developed in greater detail as required, within the context of these sectoral and regional policies and with respect for the general strategy embodied in our carbon budgets and long-term orientations.

As such, the scenario is not an action plan.



It provides a cross-disciplinary, concrete and necessarily simplified overview, without claiming to offer a detailed diagnosis of the best possible route to attaining the specific objectives of each sector.

Nonetheless, in addition to its general purpose as an indication of things to come, this scenario has been used to create sector-specific indicators which will facilitate individual monitoring of the various components which combine to make up overall CO2 emissions. These indicators concern all of the sectors covered here, and they should be tracked and taken into account from the very start of the period covered by the carbon budget. They are explained in detail in the various chapters of Part 3, and summarised in the Conclusion (Part 4).

This prospective scenario was used in the definition of the carbon budgets (cf. 2.3 Carbon Budgets), which are implemented by decree.

The scenario has also been used to assess the macro-economic impact of the strategy.

Description of the reference scenario

This section sets out the major orientations and measures used to calculate the reference scenario, on which the carbon budgets and some of the sectoral strategy recommendations are based.

Macro-economic context:

According to the European Commission's recommendations, the macro-economic outlook for France is as follows:

- Over the period 2016-2020, GDP should grow by an average of 1.6% per annum, followed by 1.9% for the period 2021-2025, 1.7% for 2026-2030 and 1.6% for 2031-2035.
- Industrial value added should increase by an average of 1.6% per annum between 2016 and 2020, followed by 2.0% for the period 2021-2025, 1.5% for 2026-2030 and 1.3% for 2031-2035.
- The population is expected to grow to reach 72 million by 2035.
- International fossil fuel prices are expected to see average annual increases of 1.9% for oil, 1.8% for coal and 2.2% for gas over the period 2010-2035 (Data: WEO (2012) 'New Policy Scenario).

In the transport sector:

Factors coming into play in the **medium term (2030-2035):**

- more efficient vehicles on the roads (cars + light commercial vehicles + HGVs). For cars and light commercial vehicles, the average fuel consumption of new vehicles in 2030 is expected to be 2l/100km.
- the development of hybrid rechargeable vehicles (c. 2.5 million by 2030), electric cars (1.9 million by 2030) and gas-powered vehicles (the latter are expected to account for 5% of light commercial vehicles by 2030, as well as 2.5% of HGVs and 1% of cars).
- measures to modernise the transportation of goods: modal transition (20% of freight transportation should be off-road by 2030) and greater optimisation efforts (average load







increased from 7.5 tonnes to 8.7 tonnes by 2035, an improvement of 16%) via voluntary schemes as well as action plans required of haulage companies under Art. 12 of the PLTECV.

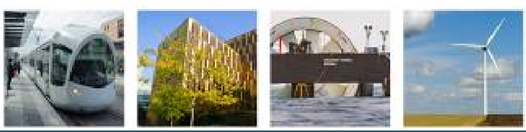
- use of public transport for short journeys in on the increase, thanks in large part to new investments in infrastructure (almost 2,000km of new tram lines and rapid-transit bus lanes) in the regions, and the Greater Paris project for the capital. Alternative scenarios have been modelled in order to document the impact of varying levels of investment in transport infrastructures.
- new habits which will drive down energy consumption and greenhouse gas emissions from the transport sector: 10% of working days conducted 'at home' by 2030. An increase in car-sharing, boosted considerably by company travel schemes, allowing for an increase in the average number of persons per car (increasing the average from 1.8 to 2 per vehicle by 2030). The proportion of short journeys made on foot or by bicycle was 2.7% in 2008, and should rise to 12.5% by 2030. Environmentally-responsible driving habits also help to reduce consumption and emissions.
- reducing speed limits on interurban networks will allow us to cut total energy consumption in the transport sector by 3%.

In the long term (by 2050), while public transport as a proportion of overall transportation should be greatly expanded, particularly for freight, France's roads will nonetheless remain by far the most popular transport option. However, the vehicles we drive should undergo a radical transformation, with a majority of light vehicles consuming under 2 litres of fuel per 100km, made of recyclable and primarily bio-based materials, running on electricity or bio-based fuels.

In the residential sector:

Factors coming into play in the **medium term:**

- for construction:
  - application of RT2012 from 2015 to 2020 and RT2020 from 2021 onwards.
  - 330,000 new homes built each year (of which 130,000 social housing) in the periods 2015-2016 and 2022-2035, and 500,000 per year (of which 196,000 social housing) between 2017 and 2021. Alternative scenarios have allowed us to single out the impact of this measure, which is social in nature and is not related to France's strategy for reducing greenhouse gas emissions. We have also been able to model the potential effects of constructing 850,000 extra homes over a 20-year period. If we were to remove the "500,000 new homes between 2017 and 2021" target from the reference scenario, investment in construction would fall by €17 billion between 2017 and 2019, €26 billion in 2020 and €22 billion in 2021.
  - the fight against urban sprawl, with densification of the urban fabric and controls over the surface area of new homes. A greater proportion of social housing.
- for renovation:
  - incentives for renovation (CIDD, EcoPTZ, ANAH, EcoPLS) until 2035.
  - obligation to perform thermal efficiency renovation when undertaking major construction work.
  - the combined effect of all support systems available (regional platforms, passports, third-party funding, guarantee funds for loans intended for 'energy-efficient renovations in low-income homes and jointly-owned residences', the TEPCV energy-positive territories scheme and reinforced CEE energy certification scheme now extended to



2035), resulting in an improvement in the quality of renovation work.

- ◦ by 2030, 59% of homes in France should achieve "average" levels of energy consumption, while 41% will be "energy-efficient."

This corresponds to a very substantial increase in the number of serious renovation projects undertaken on existing homes (over 600,000 per year in the reference scenario), without affecting the number of homes already subject to renovation work with an impact on energy performance (around 2 million per year in the reference scenario, a level similar to that which prevails at the time of writing). Given the structural importance of this component, and the extent to which the macro-economic results will depend upon the types of measure put in place, sensitivity tests have already allowed us to study the impact of varying levels of household borrowing for the purposes of financing renovation work.

In the long term, French housing will be more densified and highly energy-efficient: widespread presence of energy-positive buildings and neighbourhoods; intelligent homes with electrical consumption and battery charging managed in response to the weather conditions and local consumption; thermal insulation for natural cooling in the summer months, avoiding the need for air conditioning even when temperatures are high; construction methods and materials which allow us to reduce emissions at every stage of a building's life cycle (including during construction and renovation).

In the tertiary sector:

Factors coming into play in the **medium term:**

- application of RT2020 standards for some public buildings before 2020, and for all buildings from 2021 onwards. The introduction of the tertiary-sector decree for buildings of over 1,000m² is expected to facilitate the renovation of 29% of existing buildings by 2030. Changes in usage habits should also allow us to reduce heating and air conditioning consumption by 10%. Sensitivity tests have been used to document the impacts on both greenhouse gas emissions and public budgets of a slower rate of renovation in the tertiary sector.
- All buildings considered, electricity consumption is expected to fall by 15% by 2030.

In the long term, tertiary-sector buildings should have at least the same level of energy performance as residential buildings. Furthermore, heat recovery will become widespread.

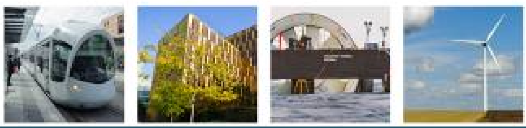
In the industrial sector:

In the medium-term, increased efficiency (thanks to investments made following energy audits) should lead to a decrease of almost 20% in energy consumption by 2030. A sensitivity test has been conducted to assess the impact of an increase in energy efficiency which is less significant than expected in this sector, both in terms of economic impact and the consequences for greenhouse gas emissions. Increased recycling (aluminium, glass and cardboard) and recovery of some waste heat (10TWh in 2030) should also boost the results from this sector.

In the consumer goods sector:

In the medium term: systematic recycling of biowaste from large producers, sorting and recycling of glass, paper-card, plastic, metal and wood; reuse of sorted waste and organic household waste. Existing EPR systems and recycling instructions on packaging will be reinforced. In landfills, the rate of biogas recovery should be increased from 38% in 2010 to 70% in 2030. The rate of recovery of biogas should increase from 59% to 80%.

In the long term, quality labels will help consumers choose products manufactured to high standards in terms of life expectancy and responsible sourcing. In both cases, products will be



widely recycled and reused. The market for second-hand goods will be very active. Repairs will come to represent a significant, highly-structured sector of the economy with a strong focus on digital technologies and logistics: a new industrial revolution.

The recycling economy will enable us to make significant progress in terms of minimising and stabilising waste sent to landfill.

In the agricultural sector:

In the medium term, we can take into account the expected effects of the continuation and reinforcement of existing policies (the Common Agricultural Policy, more support for farmers, the Organic Ambition strategy, the protein strategy etc.) and the effects of rolling out an effective agro-ecological strategy on a grand scale.

The reference scenario predicts several key developments in French agriculture:

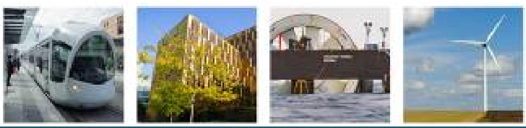
- the of land take should slow significantly by 2035;
- crop rotation will be greatly increased, with particular emphasis on legumes (for animal feed), organic farming and low-input production (efficient and minimal use of nitrates);
- livestock farms will become more efficient, with better feed management, efforts to protect grazing land (especially permanent pastures) and methanisation;
- new methods of carbon capture will be introduced, with the development of agroforestry systems and the protection or even expansion of hedgerows on both livestock and arable farms;
- energy efficiency will be significantly improved in all types of agricultural production (energy-saving practices and renewable energy generation).

Making the reference scenario a reality will require major changes not just for agricultural operators, but for whole sectors and regions. These developments will serve to reinforce the competitiveness of French agriculture and all upstream and downstream sectors, not least by diversifying the available outlets for agricultural goods and ensuring that they are in line with evolving demand from the market.

In the long term, the agricultural sector will make a significant contribution to reducing greenhouse gas emissions in four main ways:

- inputs will be managed with maximum efficiency, and sourced primarily from the circular economy (organic fertilisers and more widespread use of methanisation, by-products for livestock feed, optimised water use, 2nd-generation biofuels etc.),
- agro-ecological practices, particularly those designed to limit nitrogen loss and increase carbon capture by the soil, will become widespread (low-ploughing techniques, permanent ground coverage, hedgerows around all fields, agro-forestry systems etc.),
- new technologies and digital resources will become accessible to all, allowing for more effective management of farm businesses and their performances, particularly thanks to new developments in agricultural equipment and buildings,
- the agriculture and forestry sectors will both contribute to the rise of the bioeconomy, with bio-based products replacing fossil resources.

This transition must also take into account the crucial challenge of adapting to climate change (crop varieties, water management, environmental risks etc.) and preserving the production capacity and competitiveness of French agriculture. To make this scenario a reality, all businesses and chains connected with agriculture (supply, production, transformation, distribution etc.) will need to undergo a transformation - made possible by greater cohesion - while also improving their

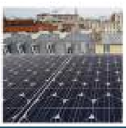


social, economic and environmental performances. These improvements will help to ensure that supply is better tailored to the demand from different markets (local, national, European, other countries), as well as bringing about an evolution in our society's eating habits and expectations. Greater synergy and the integration of new chains into the bioeconomy will allow us to diversify the outlets available for agricultural goods (food, non-food uses) and optimise the use of resources;

In the forestry sector:

Developments will include more effective management of forestry stocks which are currently under-utilised, creating multifunctional forest spaces and ensuring the superior environmental quality of the economic chains created;

> Reminder: this reference scenario is advisory, it is not prescriptive. The explanations given here are provided primarily for information purposes, and in the interests of transparency regarding the methodology used to draw up the carbon budgets.
>
> The legal and practical scope of this scenario is explored in detail in the inset box at the start of Chapter 2.2.







3. Recommendations for public policy

3.1. Instruments to be utilised: stakes and synergies

The drafting of sectoral scenarios, translated into advisory carbon budgets, is the first step towards constructing a national low-carbon strategy. This allows us to identify constraints and stakes, plan ahead for structural transformations in lifestyles and production methods, and identify potential routes to success.

The next stage consists of implementing an appropriate mix of instruments in order to bring about the desired transformation.

Instrument architecture

To successfully regulate diffuse emissions, public policy should be designed to incentivise and boost responsibility, mobilising private stakeholders but maintaining freedom of choice within a regulated framework, while promoting awareness of the consequences of our choices for society and for future generations. This will allow us to guide consumption and investment behaviours.

The diagram below provides an overview, distinguishing between two major types of intervention:

- on the one hand, making carbon pricing an integral factor in our decision-making;
- on the other hand, removing or minimising obstacles to the decarbonisation of the economy.

Aims and instruments of public policies for a low-carbon strategy

Integrating carbon pricing in decision-making	*Removing obstacles to the decarbonisation of the economy*
Establishing true carbon prices: eco-tax or emissions trading below an overall limit	**Ensuring the acceptability of policies:** compensation and support measures
Removing harmful subsidies	**Developing information:** nudges, labels and CSR
Encouraging green decision-making: - standards - subsidies and tax credits - energy savings certificates - calls for tender	**Enabling the transformation of the economy** - R&D, infrastructure, networks - professional training - quality of regulations - finance instruments

In terms of making carbon pricing a natural reflex, this framework places particular emphasis on establishing appropriate carbon prices with reference to greenhouse gas emissions, offering incentives for reducing emissions and rewarding investments which avoid emissions. Introducing a carbon component when setting Domestic Energy Consumption Tax to manage diffuse emissions within the framework of the 2014 Budget Act is a part of this. **The Energy Transition and Green**

Growth Act sets a carbon price target of €56 for 2020 and €100 by 2030 (in 2015 euros)**.** Using this kind of instrument requires us to tackle the issue of energy poverty and the redistributive impact of increasing energy prices. France also actively supports proposals to reform the European CO_2 quota market, to make it more efficient. Setting reference values ("carbon guide prices") to steer decision-making and guide the trajectory of the price signal is a fundamental priority. The current state of play in this field, as revealed in the Quinet report, is explored in detail hereunder. It is also important to bear in mind that other, complementary instruments are available, such as certificate markets, standards (for results or for resources) and budgetary and fiscal support programmes.[2]

One of the major obstacles to decarbonisation is undoubtedly the difficulty of conveying the collective benefits of reducing greenhouse gas emissions, to which everybody can contribute. Individuals do not always spontaneously integrate environmental considerations into their behaviour. Information campaigns thus have a vital role to play.
Moreover, some decarbonisation investments may not provide sufficient benefits to their backers to make them immediately financially viable. We thus need to remove certain acceptability constraints connected with purchasing power and questions of competitiveness.
In terms of financing, the markets are not sufficient and can sometimes make it difficult to get long-term projects up and running. The high degree of uncertainty (environmental, economic, regulatory) can raise concerns in terms of risk valuation, deterring potential investors. Furthermore, changes in behaviour are often driven by the availability of different assets (infrastructure, R&D, human capital etc.).

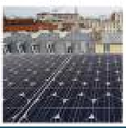
By way of an example, energy renovation in the construction sector requires a combination of instruments in order to:

- raise awareness of the energy savings which can be made
- make energy savings easier to appropriate (in particular by allocating or splitting them efficiently between property owners and tenants, or between joint owners) and finance (financial aid, expanding access to credit),
- take social concerns into consideration (energy poverty)
- boost professional skills in these chains in order to keep costs under control and nurture the development of private models.[3]

Taking all of these dimensions into account requires consistent, effective public policy frameworks.

The action framework drawn up by the OECD for 'green investment' is a good example of a general approach, setting out the different instruments which might be taken into consideration when developing or implementing a low-carbon strategy (it is also important in its own right, because green investment is a key factor in the energy transition).

[2] 'Tools for delivering on green growth', OECD 2011; 'Green growth, principles and instruments of economic policy', CEDD 2014.
[3] 'Energy-efficient renovation of buildings. Public policy and private behaviour' CEDD, April 2013.







Framework of action for green investment
(based on Corfee-Morlot et al., 2012)

1 – Establishing strategic aims and coherency between policies	-Clear, predictable and stable policies -Coherence between aims at all levels -Mobilising the private sector
2 – Enabling attainability of yield from green investment	-Implementing carbon pricing -Removing subsidies for fossil fuels -Energy efficiency
3 – Enabling financing	-Financial regulations that favour long-term investments -Targeted subsidies (with predictable decrease) -Public finance as a lever (loans, guarantees, green requirements)
4 – Mobilising ressources and capacity	-Supporting R&D for green technologies -Developing capacities in support of low-carbon innovation -Vulnerability studies
5 – Promoting green decision-making	-Information policies -Raising awareness among consumers -Corporate reporting, CSR

It highlights the importance of having a clear strategic framework and stable policies.

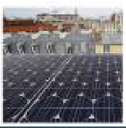
Different economic instruments can be combined to target objectives which have different time-frames and resource requirements.

TIMEFRAME OF ACTIVITIES	NECESSARY RESOURCES	CHOICE OF SOLUTIONS	CHANGE REQUIRED
0 – 1 YEAR	Require willpower, subsidies	Already validated elsewhere, emerging	Local networking, pioneering approach
1 – 5 YEARS	Require capital	Require skills	Public/private or inter-territorial co-ordination challenges
5 – 10 YEARS	Require R&D	Require changes in uses	New economic or societal models?

Analysing timeframes
(source: Rethinking cities for the post-carbon society, CGDD (2013))

By way of an example, adapting to a new signal price may require new infrastructure in terms of energy and transport, extending existing networks (e.g. public transport) but also creating new networks (carbon capture and storage, charging electric vehicles etc.) and adapting existing networks to new operating conditions (adapting to climate change) and the possibilities opened up by new technologies (NICT).

The low-carbon strategy will thus need to combine these different instruments in a coherent manner, avoiding overlap (particularly between the various instruments integrating carbon pricing) and diversifying our action (especially when it comes to reconciling the short and long-term







3.2. Cross-cutting recommendations

i. Carbon footprint

1. What does it mean?

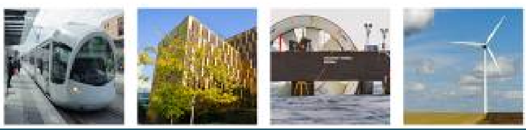
Broadly speaking, the challenge is how best to allocate emissions in import/export relationships: where do we count the emissions generated by the production and transportation of manufactured goods *produced* in one country and *consumed* in another?

The two main approaches to this problem - the 'territorial emissions' method and the 'consumption emissions' method - both have their strong points, and can therefore complement each other:

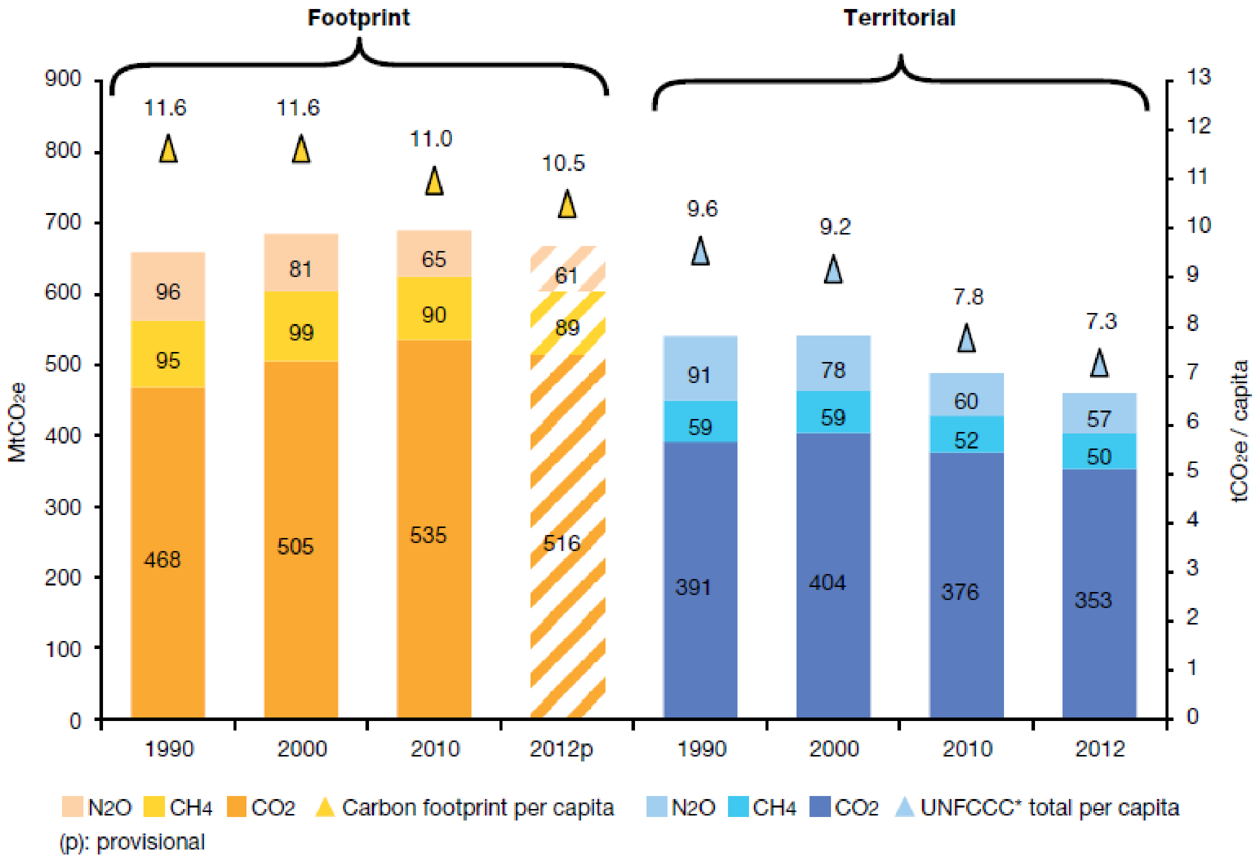
- the **territorial emissions** method places the emphasis on the site of *production*. This is the oldest approach, and the approach most commonly used in international agreements. It is applied when drawing up national inventories of greenhouse gas emissions. It corresponds to the legal responsibility of States (responsible for the production methods used within their territory), who may have signed certain commitments on such matters. **It is therefore used to produce the carbon budgets.**

- the **consumption emissions** method - or **carbon footprint** - places the emphasis on the site of *consumption*. This more recent approach takes into account the practical consequences of our living standards and consumption habits, and thus focuses on consumer responsibility. It is worth bearing in mind that this system is subject to certain technical difficulties, and carries a greater degree of uncertainty than the territorial emissions method.

- While national inventories are universally-recognised instruments of measurement, they are not necessarily objectives in their own right, justifying all measures taken to improve the figures. Indeed, certain actions which might improve this indicator could also have harmful effects for the economy and the climate. This is known as 'carbon leakage'. One particular concern is that the offshore transfer of emissions from production serves only to reduce emissions in the importing country, while the overall climate impact is worse when production conditions in the producing nation are less strict in terms of their greenhouse gas emissions.



- Inversely, an increase in consumption emissions does not necessarily mean that France's policy of reducing greenhouse gas emissions is failing. If the balance of trade and industrial structure remain unchanged, an upturn in international exchanges will necessarily lead to a convergence of greenhouse gas emissions at international level, and thus to an increase in consumption emissions in those countries whose production capacities are less carbonised than the global average.



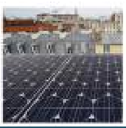
Sources: SOeS calculations based on data from IEA, CITEPA, Customs, Eurostat, INSEE

Figure 3.1 : CO2, CH4 and N2O emissions induced in France and abroad by the consumption of people living in France (carbon footprint) in millions of tons of CO2 equivalent and comparison to the national inventories for those gases (territorial approach, CITEPA, 2014). Source : SOeS

Conclusion:

- Use of the territorial emissions indicator must be accompanied by enhanced vigilance to prevent carbon leakage. Instruments offering incentives to reduce territorial emissions should be designed, calibrated and piloted in such a way as to discourage offshore transfers and carbon leakage.

- Meanwhile, France's action should not be limited to reducing territorial emissions within the country, even if this first level of responsibility does take priority and is already covered by ambitious international commitments. It is also important to give consumers (businesses, organisations, households) the information and the resources they need to step up to their own climate change responsibilities via their consumption of goods and services. Overall carbon footprint should be taken into account at both the sectoral and territorial levels. Last but not least, dedicated action is required at international level, particularly to reduce emissions from international transportation.







2. Public policies

Above and beyond France's international objectives and carbon budgets, public policy must also aim to achieve a **reduction in the global carbon footprint.** This will require a range of actions:

- **for sectoral policies**
  - from now on, the financing of public projects should take into account the impact of these projects in terms of emissions. That entails promoting life cycle analysis (LCA) (notably within the regulatory framework and as a project selection criterion for public contracting authorities). This type of analysis is particularly useful for optimising transport infrastructure and buildings.
  - the development of appropriate methodological tools (particularly for evaluation purposes) to deliver pertinent information to all economic stakeholders, including final consumers. In this respect, initiatives such as CO_2 information for transport and experiments with environmental labels need to be developed and expanded.
  - For the sectors the most exposed to the risk of carbon leaks (delocalisation of activities in location with lower standards of environmental regulation, detrimental for both the environment and local jobs), it is important that the instruments aiming at reducing emissions take into account international competition and do not translate into delocalisations of activities. Targetted and efficient measures need to be continued and developped (see section 3.3.v on industry regarding free allocations under the EU-ETS, but other sectors could also be concerned such as small industry, agriculture and services).

- **for regional policies**

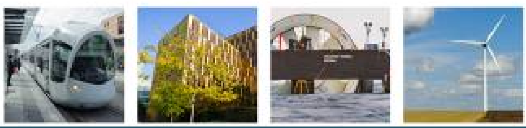
In our regions (cf. 3.2. viii Territorial implementation), it may also be useful to take the different levels (from global carbon footprint down to local impact) into consideration in order to develop pertinent carbon footprint initiatives. A local approach may serve to motivate stakeholders - cf. the various efforts to achieve 'carbon-neutral zones'. As such, it is advisable to:

  - choose indicators with care and a sufficient dose of pragmatism, prioritising coherency with the policies and levers to be introduced and their potential to reduce emissions, rather than focusing on theoretical considerations regarding the intrinsic quality of different indicators.
  - **take 'Scope 3' elements into account, i.e. the indirect emissions induced by an activity or region in addition to the energy consumption covered by the greenhouse gas emission accounts (BEGES) for regions, businesses & organisations and projects**, with reference to the feasibility of implementing corresponding levers and their potential efficiency.

- **in the specific case of emissions linked to international transport**

These extra-territorial emissions are not included in territorial inventories and are not covered by either the Kyoto protocol or carbon budgets. They are, however, counted in the carbon footprint.

  - Reducing these emissions falls within the remit of the IMO (International Maritime Organization) and the ICAO (International Civil Aviation Organization), who are already working on emission-reduction measures. France actively backs the introduction of effective instruments to reduce these international emissions.
  - Concretely, French businesses and organisations are encouraged to take these emissions into account in their action plans, particularly via their Greenhouse Gas Emission Accounts, and by providing information on CO_2 generated by transportation. Major retailers are also encouraged to cut their transport-related emissions, particularly via the Freight 21 programme.



3. At individual level, with changes to the way we consume

(cf. Chapter 3.2.vi Education and Awareness)
Taking all direct and indirect emissions into account, the three biggest contributors to the carbon footprint generated by household consumption are transport, housing (including energy use) and food.

Potential avenues for reducing greenhouse gas emissions at individual level:

Durable goods, transport:

- prioritising durable, repairable products
- committing to a circular economy, favouring services over ownership: leasing, borrowing (use of collaborative platforms), car-pooling, etc., often making it possible to meet service needs more economically and by emitting fewer greenhouses gases than through purchasing.
- Avoid exaggerated use of long-range transport, including international journey. In daily life, increase the share of active mobility (walking, cycling).

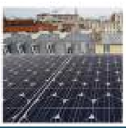
Housing: simple actions are sufficient to adopt virtuous behaviours which enable to decrease direct as well as indirect emissions associated with the consumption of energy (see recommendations for the Residential-Tertiary sector). Realisation of most efficient renovation can also occur on an increasing scale, taking advantage of the public service for energy efficiency, and latter on the deployment of the energy renovation passport (Chapter 3.3. ii)

Investment and savings: our first priority is not to invest more, but rather to invest differently by redirecting funds towards projects that contribute to the energy transition rather than hindering it (Chapter 3.2.v)

Food:

- changing eating habits to consume more seasonal produce (preferably locally-sourced)
- reducing food waste
- reducing our consumption of animal proteins (particularly meat) in favour of more plant-based proteins (e.g. legumes and cereals: beans, peas, lentils etc.). This will help reduce greenhouse gas emissions from livestock farming. A number of studies have demonstrated that adjusting our diets would allow for a substantial reduction in emissions related to food production, while also meeting our nutritional requirements.[4]

[4] Reducing the environmental impact of French consumption by 2030 (ADEME) and A balance of healthy and sustainable food choices for France, Spain and Sweden (LiveWellforLIFE)







ii. Reference price for carbon

1. Evolution of the reference price

A carbon pricing commission, chaired by Alain Quinet, was established in 2008. Its purpose was to outline a trajectory for carbon pricing which would be compatible with our objectives for the 2020-2050 time-frame. Utilising economic theory and various hypothetical models, **the commission decided upon a CO_2 price of €100 (2008 euros) per tonne by 2030, adopting a cost-efficient approach to hitting emission reduction targets by 2050. This figure is dependent on various assumptions regarding energy prices which may make subsequent revisions necessary, particularly if energy prices (especially fossil fuel prices) vary substantially from the levels observed when these calculations were made.**

This relatively high price reflects the ambitious scale of our greenhouse gas reduction targets and the difficulties encountered, particularly at organisational level, in deploying low-emission technologies and successfully changing consumption habits within such a short timeframe. In 2010, the decision was made to select a starting price consistent with the price recommended by the commission chaired by Marcel Boiteux in 2001, i.e. €32 (2008 euros) per tonne of CO_2.
The commission then mapped out a price trajectory for the period 2010-2050 (see figure 3.2) based on the following values:

- **From 2010 to 2030, carbon prices will rise by 5.8% per annum**. This decision is based on the belief that the transition to high carbon prices must be gradual in order to prioritise obvious, low-cost carbon reduction solutions which are already available, to avoid hampering growth and to facilitate the handling of the economic, social and professional transitions required.

- **Beyond 2030:** the projected values are based on Hotelling's theory (carbon prices to rise at discount rate). However, this discount rate was revised by the commission chaired by Emile Quinet charged with the socio-economic evaluation of French public investments in 2013. **The current recommendation is to apply an annual growth rate of 4.5%** (2.5% for the risk-free discount rate and 2% for the risk premium). Based on these hypotheses, carbon prices should increase from €100 (2008 euros) per tonne of CO_2 in 2030 to €240[5] (2008 euros) in 2050;

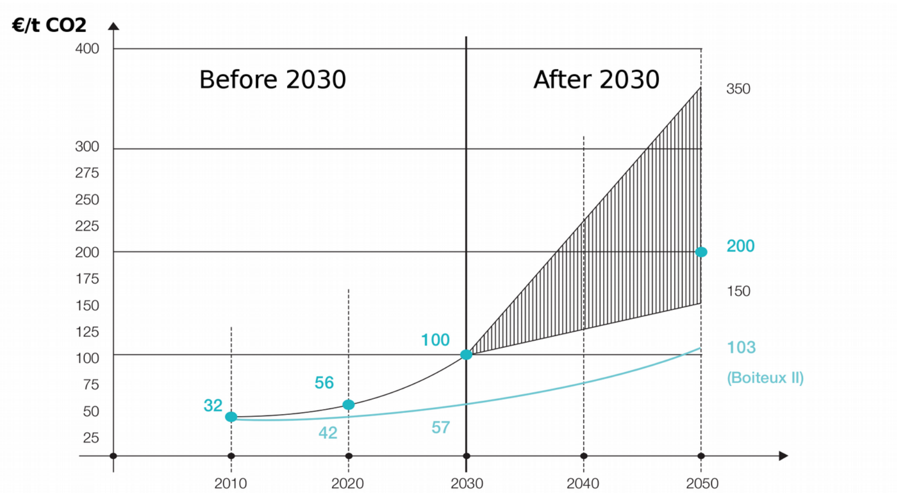


Figure 3.2 : trajectory for carbon pricing recommended by the commission chaired by A. Quinet (2008). Source : Centre d'Analyse Stratégique (nowadays France Stratégie)

[5]Revision based on the values given in the Quinet Report (CAS, 2009) calculated with a discount rate of 4%.

2. Applying the carbon guide price to evaluate public decisions

Carbon guide prices serve first and foremost for the socio-economic evaluation of public decisions, particularly public investments. They are thus already included in the governmental order of 16 June 2014 regarding the evaluation of transport projects. This ensures that the monetary value of the impact which can be ascribed to the greenhouse gases emitted by a given infrastructure project is taken into account when calculating the project's net present value (NPV). As well as analysing investments, this system also allows us to evaluate regulatory choices, consumption behaviours etc.

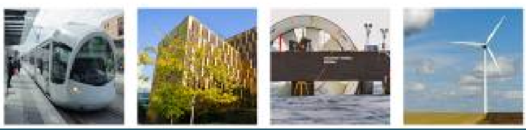
3. Carbon pricing as a point of reference for public policy and economic stakeholders

Carbon prices also provide a point of reference for public policies with an influence on the country's carbon footprint. Here are a few examples:

- **Gradual increase of energy taxes**: this measure is legitimate because energy taxes cover all damages, particularly environmental damage, caused to society as a whole by energy consumption. The introduction of a carbon tax base (based on the quantity of greenhouse gases generated by the consumption of a given amount of energy) would be a useful addition to existing energy taxes, and could be increased over time in line with France's targets for reducing greenhouse gas emissions. The 2014 budget introduced a carbon tax in principle, incorporated into the domestic taxes on fossil fuels (oil products, gas and coal). The rate was set at €7/tonne of CO_2 in 2014, €14.5/ tonne of CO_2 in 2015 and €22/tonne of CO_2 in 2016. This gradual deployment should give businesses and households time to adapt. Nonetheless, in order to stimulate investment a medium-to-long-term price signal needs to be provided. This forecast should be based on the assumption that carbon taxes will continue to rise in line with guide prices. **The Energy Transition and Green Growth Act sets a carbon price target of €56 for 2020 and €100 by 2030** (2015 euros)**.**

- Regulating the carbon quota market. Guide prices could also be used to reform the ETS market in Europe. The current market rate (around €7 per tonne of CO_2) is far below the French guide price, and intervention may be required to prepare investors for future price rises in line with the estimated guide prices required to meet the collective objectives decided upon at European level. In October 2014, the European Council signed off on a new CO_2 emissions reduction target of 43% by 2030 for the sectors covered by the EU ETS system. This will require the introduction of a new mechanism to stabilise the market. The COP21 conference also provided an opportunity to promote the concept of a global carbon price, set high enough to allow us to reach our international climate targets. Such a system would require a network of regional carbon markets and taxes, already up and running or soon to be launched in many countries (cf. Diagram).

Carbon prices will also serve as a source of information for private stakeholders, as one of the components which will determine market values in the medium-to-long term.



With this in mind, it is worth noting that there are already several economic initiatives in place encouraging organisations to incorporate carbon prices into their accounting calculations. In 2013, over 100 businesses from all over the world made declarations to the Clean Development Mechanism (CDM) to the effect that they are already using carbon pricing as a tool to manage the risks and opportunities connected with their current operations and future profitability. According to the World Bank, the business world is in favour of carbon pricing, considering it to be the most cost efficient way of reducing emissions. As such, a coalition was formed in 2014 in support of international carbon pricing. This initiative brings together 73 national governments, 22 cities and other regional entities and over a thousand businesses.

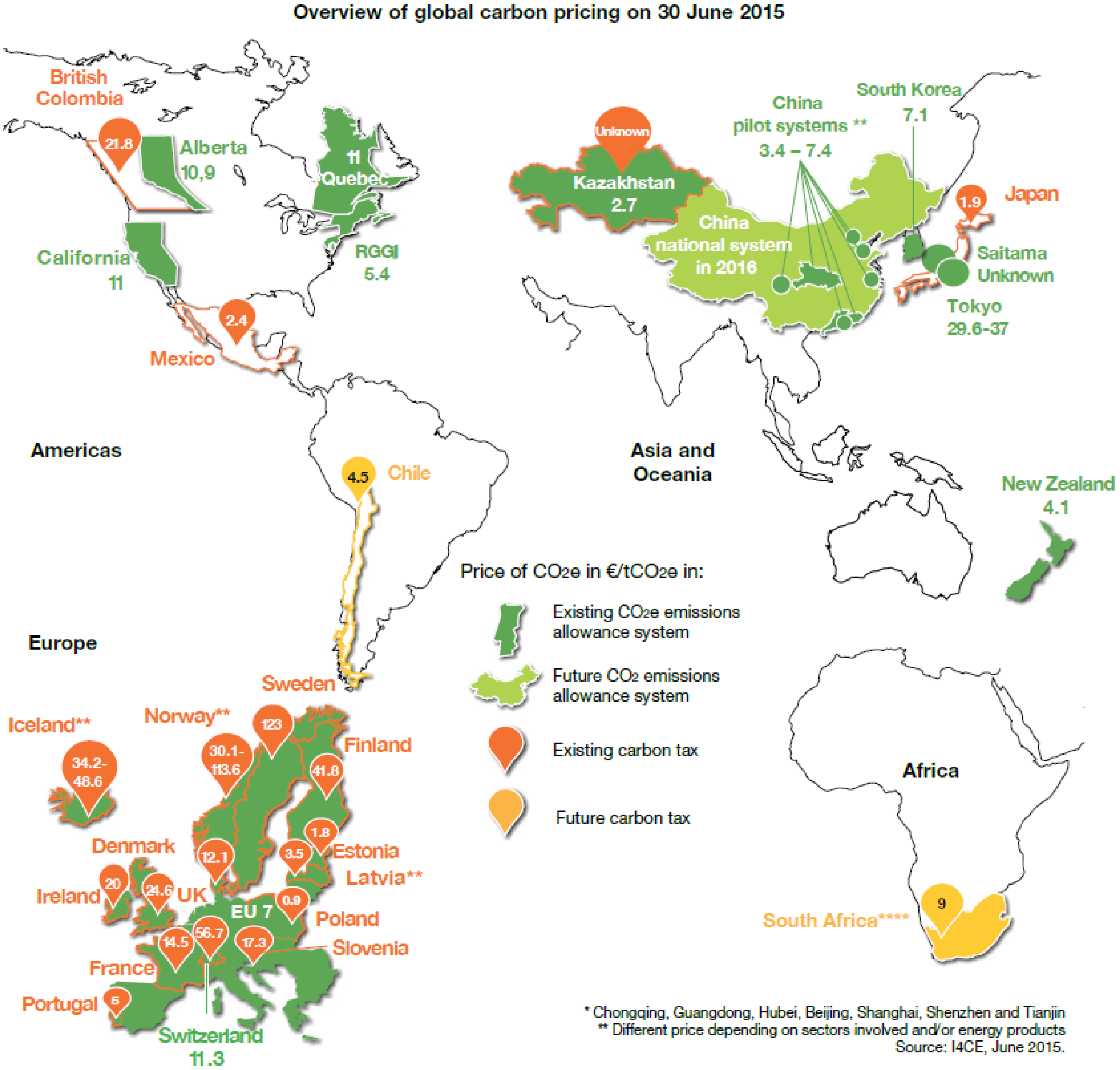
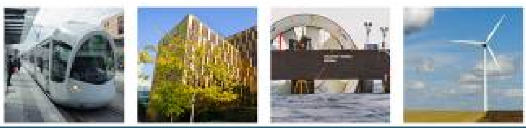


Figure 3.3 : overview of carbon pricing in the World in 2015. Source : I4CE, ex CDC Climat Recherche

Bibliography:

- Reports by Marcel Boiteux (2001), Alain Quinet (2008) and Emile Quinet (2013)
- World Bank (2014) State and Trends of Carbon Pricing - http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/05/27/000456286_20140527095323/Rendered/PDF/882840AR0REPLA00EPI2102680Box385232.pdf



iii. Research and Innovation Policy

1. Our R&D and innovation policy, a crucial asset in the transition to a low-carbon economy

The profound transformation required to make the transition to a low-carbon society a success can only be achieved with a complex combination of technological progress, innovation and profound changes in the consumption habits of all members of society, from individuals to industrial designers.
This interconnection between technological and behavioural developments is particularly evident in the emergence of a functional economy (self-sufficiency, new forms of mobility etc.), an expanded circular economy (more recycling, efforts to capture all forms of waste heat etc.) and a more bio-based economy (energy, materials, intermediate products).

Generally speaking, efforts to structure and support R&D and innovation must be extended and intensified in order to:

- nurture the development and rapid spread of future technologies, moving towards a low-carbon planet
- in accordance with the Energy Union and its ambition of making Europe the global leader in renewable energies, while establishing France's position at the forefront of new technologies to control energy consumption, emissions and alternatives to fossil fuels.

Technological challenges

In technological terms, regardless of the specific circumstances of each scenario, some choices are clear-cut. In energy matters, in terms of both supply and demand, these choices include: energy efficiency, widespread deployment of decarbonised energy sources (particularly renewables), the development of new forms of energy storage, intelligent management of transport networks and the distribution of this energy, R&D initiatives conducive to the widespread development of solutions for capturing and storing or re-using carbon.

A low-carbon economy will also require significant technological progress in order to reduce emissions from non-energy-related sources of greenhouse gases. Systemic change is required in the following areas: agriculture, development of bio-based products including biochemicals and biomaterials, CO_2 recycling and support for organisational innovation.

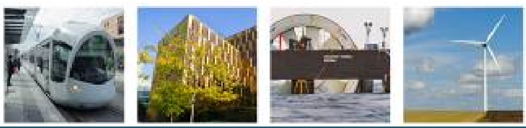
Social and organisational innovation, research in social sciences
Social innovation is also a crucial factor. Certain lifestyle changes which would facilitate the transition to a low-carbon economy require us to rethink social structures, institutions and economic models.

Promoting creativity, experimentation, decompartmentalisation and the sharing of experience are all important factors in developing social innovation.

Research in the social sciences can help us to identify and promote practices conducive to the low-carbon transition, encouraging citizens to get on board with new measures whose social utility has been proven.

2. Existing and upcoming plans and strategies

At the European level, the Strategic Energy Technology Plan (SET-Plan) aims to foster greater cooperation in matters of research and innovation, thus galvanising the cost-efficient development



of low-carbon technologies.
Within this framework, various European Industrial Initiatives (EII) and joint technology firms have been created, focusing particularly on industrial testing and the promotion of new developments in wind energy, solar power, bioenergy, CO_2 capture, storage, transportation and usage, intelligent electrical networks (including storage), nuclear fission (4th generation technologies), smart cities and communities, hydrogen power and biochemical fuel cells.
The SET-Plan is evolving from a "technological silo' approach towards a more comprehensive, strategic vision of the energy system. The task of identifying Member States' shared priorities, which have the potential to become major European priorities in the long term, is accomplished with the help of an integrated roadmap and accompanying action strategy. Strategic priorities are thus extrapolated from national priorities.

In France, the national research strategy (SNR) derived from the Law of 22 July 2013 is structured around ten major societal challenges, including "clean, safe and efficient energy" and "sustainable urban transport and systems." The pre-existing national energy research strategy (SNRE) will be incorporated as the 'Energy' aspect of this plan (Article 183 of the Energy Transition and Green Growth Act), finalised for official adoption in early 2016.

On an operational level, and with regard to research projects still in their infancy (technology which is not yet mature, with a low TRL[6]), for the two priorities mentioned above (energy and sustainable urban transport and systems) the National Research Agency (ANR) will afford priority to those actions identified by the SNR as being especially important. The ANR has created a category entitled 'Exploration of disruptive innovation' to accelerate the development of new technologies with particularly strong potential.

Backing up these sources of funding, further support for applied research (highest TRL ratings) and innovation demonstration is available via the Future Investment Programme (PIA) launched in 2012. Phase two of this scheme (PIA2) was launched in 2014, offering financial backing for "vehicles and transport systems of the future" and "technologies demonstrating the ecological and energy transition." The PIA scheme is run by ADEME, whose own research programme is also focused on nurturing the development and implementation of a national system of energy technologies and services, working towards our goal of a low-carbon society prepared for the challenges of climate change.

In terms of the energy transition, the goal is to demonstrate, in real operational conditions, technologies and practices which allow us to save energy or natural resources and reduce CO_2 emissions while generating the same amount of energy. The goal is to develop these technologies into commercially-viable solutions offering energy production costs similar to those of carbon-reliant options: a general target of €100/MWh has been set for 2020.

3. Existing challenges which the innovation policy must take into account in order to guarantee the success of the low-carbon transition

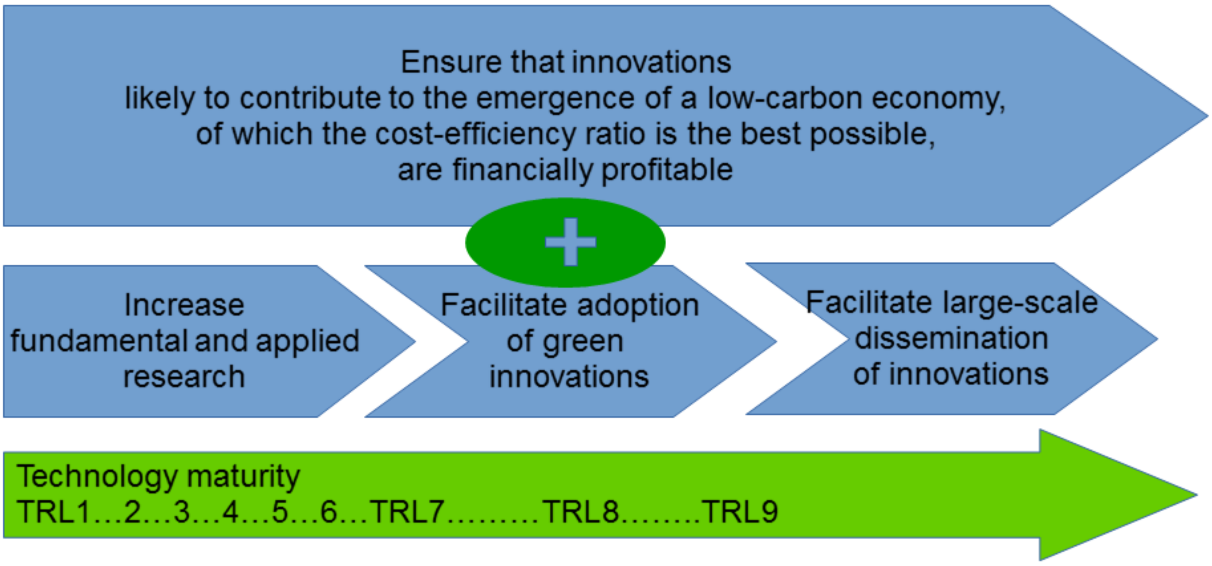
R&D and innovation efforts need to cover a broad spectrum of concepts in order to foster the emergence and widespread adoption of developments which will allow us to attain the energy transition targets set out in Article 1 of the PLTECV (see diagram below). This process will require a detailed but wide-ranging understanding of the major societal (lifestyle changes, resistance to change etc.) and technological (e.g. integrating renewable energies into the grid, interactions between the gas, heat and electrical networks, improving energy efficiency, breakthroughs in the performance of low-carbon technologies at competitive prices) challenges involved.

[6] TRL: Technology Readiness Level, a scale running from 1 (basic principles observed and reported) to 9 (actual system successfully tested in operational conditions), via intermediary stages including experimental proof of concept (TRL3) to prototype demonstration in an operational environment (TRL7).









Broadly speaking, the technology innovation support policy must:

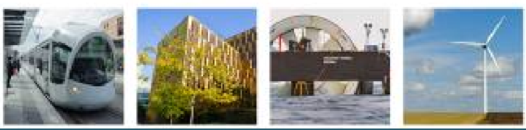
- Be based on high-level fundamental and applied research, particularly by:

- offering continuous support for collaborative projects, above and beyond allocating public resources to R&D (funding public research, supporting private research and taking into account the shared benefits of innovation),
- regularly updating the technological roadmaps and facilitating coordination between stakeholders, who will share the benefits of new innovations,
- offering a long-term strategic vision for the future of research, with stable public policies on low-carbon energy technologies.

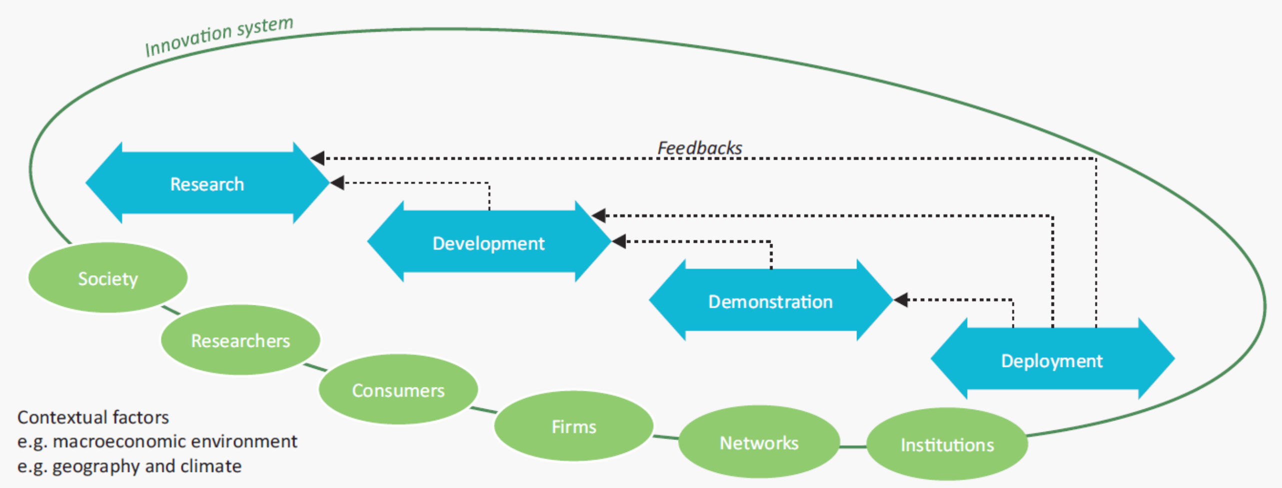
- Support the development of innovative companies capable of producing disruptive technological advances,
- Facilitate the adoption and spread of disruptive innovations conducive to the transition to a low-carbon economy, particularly via financial support for experimentation and the creation of the training structures required to ensure their penetration, development and long-term viability (maintenance, technological development)
- Ensure that consumption habits and lifestyle factors are taken into consideration by research and development projects, as well as technologies and production methods. Develop this approach to support the spread of new technologies (analysing their social relevance and the conditions for their appropriation by consumers, cf. for example Section 3.3 on the residential-tertiary sector) but also upstream in the research phase (analysing the expectations and requirements of stakeholders from a social angle: "making the city;" relationship to work; "intelligent buildings" etc.).

This support for technological innovation should also seek to:

- guarantee the financial profitability of innovations contributing to the low-carbon transition whose socio-economic impact is positive
- ascribe an economic value to reducing emissions (e.g. long-term carbon guide prices, see Section 3.2.ii)
- provide tools capable of estimating reductions in greenhouse gas emissions
- promote infrastructure developments capable of catalysing innovation
- ensure that the risk associated with investing in the deployment of low-carbon innovation is borne by those most able to handle it (see the Investment section)



Generally speaking, it is important that we do not approach this challenge in a segmented manner. Interactions within the innovation system will be beneficial to all stakeholders, as they make the gradual improvements and major technological breakthroughs required to meet our climate targets. Governance which includes representatives of civil society would help foster exchanges between researchers and those bodies represented in the CNTE, particularly when it comes to drafting the national energy research strategy.



Sources: GEA (2012), *Global Energy Assessment: Toward a Sustainable Future*, Cambridge University Press, Cambridge, United Kingdom and New York; the International Institute for Applied Systems Analysis, Laxenburg, Austria.

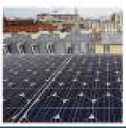
It is vitally important that we remove all obstacles to the adoption and spread of innovation, including incremental innovations. In this respect, we must stress the crucial importance of best practices (training etc.), social innovation and the progress which can be made via gradual improvements to systems of production, including changes spearheaded by employees, citizens and SMEs. In terms of social innovation, the national government's role is both to:

1. act strategically, identifying areas of change which can be achieved in the medium term and supporting positive developments;
2. serve as facilitator and promoter, encouraging experimentation and innovation (life-size decentralised programmes / initiatives from civil society / greater responsibilities for local authorities as project owners).

4. Indicators to monitor the performance of the research and innovation policy

Any number of the following indicators may be used:

- public spending on R&D (including European instruments) linked to the reduction of greenhouse gas emissions (including sums allocated to public-sector R&D in the energy sector)
- number of publications and theses produced in this field
- number of collaborative projects focusing on the energy transition and low-carbon energy (and the sums involved).
- number of patents registered and licences granted for technologies linked to the reduction of greenhouse gas emissions
- number of spin-offs and start-ups created in this field
- value of Future Investments in the energy and ecological transition: knock-on effect on private investment, conclusions of the assessments conducted under the PIA.







iv. Town planning and development policy

National and regional town planning and development policies can also have a major impact on greenhouse gas emissions. Their effects are extremely long-lasting, as changing the structure of an urban development is a difficult and very slow task. The various decisions taken on a day-to-day basis by public and private stakeholders - developing a plot of land, choosing the way it will be used, deciding on the energy performance of the equipment installed, for example - are governed by a complex web of regulations, economic considerations and social aspirations which form a relatively unmoving whole (at least in the short term).
The transition to a low-carbon economy requires us to adjust the balance of this system, identifying mechanisms for change and assessing their impact in the short, medium and long term. A balance needs to be found, with a systemic, integrated approach across all levels of decision-making and regional authority, from regions down to neighbourhoods.

1. National priorities and objectives

a) Halting the artificialisation of natural spaces, while ensuring our ability to meet the needs of our people

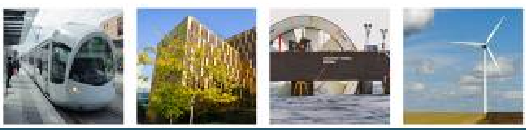
Urban sprawl and the consumption of natural spaces are the fruit of a combination of causes. First and foremost: rurbanisation. This phenomenon is linked to the polarisation of employment and the lack of sufficient accommodation to meet demand, particularly in large conurbations. This also leads to people commuting over longer distances, with a corresponding increase in greenhouse gas emissions.
In France, urban sprawl has taken on different forms in different periods. Peri-urban expansion was at its strongest in the early 1960s. In this period, the desire for a different lifestyle to that offered by the densely-populated city centre was facilitated by the development of new transport infrastructures and the generalisation of motorised transportation reducing journey times (particularly for commuters), as well as the fact that buying a detached house in the suburbs was cheaper than buying in the city centre (cost of construction and cost of land).

This rapid urban spread, structured by the creation of Priority Urbanisation Zones (ZUP) between 1958 and 1968 with strong support from the government, was followed by several decades of informal sprawl.

The urban sprawl has developed under the cumulative effect of socio-economic interactions and specific, local spatial and environmental constraints. While the process was accelerated by the improvement of transport networks and mobility, various micro and macro-socioeconomic factors are also at play: the property market, demographic developments, the attractiveness of urban areas and individual residential preferences.

This trend for urban expansion reflects the aspiration of many families[7] for lifestyles based around owning their own individual, detached home[8]. Construction firms have also prioritised expansion over urban intensification and renewal, primarily for reasons of financial viability and the lack of adequate property opportunities. The process of urban sprawl - which, as well as housing, is also the result of development models based on a vast network of roads and corresponding commercial, logistical and industrial networks - has made land sealing an almost irreversible inevitability.

[7] Source: S. Diefal, S. Eugène, *Être propriétaire de sa maison*, Crédoc (2004)
[8] In the majority of cases, families' residential aspirations are marked by a preference for detached houses. Although the rate of construction slowed between 2003 and 2013, individual houses still account for over 56% of total new house builds (source: SOeS, Sit@del). A key factor in the consumption of agricultural land and the occupation of peri-urban and rural spaces, the spread of widely spaced-out detached houses can also lead to lengthy commutes for those families who are determined to own their own home.



Artificialisation of land today

Rate of artificialisation

Artificial surfaces continue to expand, though this rate of expansion has been stable since 2008. After peaking at 830 km² between 2006 and 2008 (+ 1.8% per year), artificial surfaces grew by 540 km² per annum between 2008 and 2014 (+1.1% per year). This slowdown can be partly attributed to the economic crisis, the decline in the number of farmers taking retirement since 2009 and local development policies aimed at protecting agricultural land, natural areas and forests.

Causes

Looking at the problem in terms of artificialised land, 49% of land converted to artificial use between 2006 and 2014 was destined for housing (of which 46% for detached homes, a huge majority), 20% was converted for transport purposes (16% for roads) and the rest was split between other commercial and leisure facilities (31%). In terms of total land sealing (land built upon, tamped or tarmacked), housing accounts for a smaller proportion: 34%, compared with 28% for transport networks and 38% for other economic activities and leisure facilities. 57% of land taken up by new houses is occupied by lawns and gardens.

Source: Agreste (2015). Agreste Primeur n°326, Land Use.

The consequences of this sealing include a fundamental transformation of the natural environment, with a substantial decrease in the amount of carbon[9] stored by plants and soils.

One of the great difficulties is that the various stakeholders (public and private) take the socio-economic effects of artificialisation into account only partially when presenting their investment decisions. This is particularly true of carbon release and infrastructure development (roads, networks etc.), with the cost of the latter only partially borne by developers. This makes artificialisation more profitable than renovating or reusing areas which have already been urbanised. **Our objective is to halt overall artificialisation,[10] while ensuring that we are still able to meet the requirements of our society, particularly in terms of housing.** The reference scenario is based on a hypothetical 80% reduction in artificialisation by 2035 followed by a total halt hereafter, given the complexity of the challenges involved and the need to disrupt the strong underlying trends and dynamics which drive artificialisation. Efficiently combating the artificialisation of soils raises various questions regarding our capacity to make effective use of available land resources and increase housing capacities while nurturing local development.

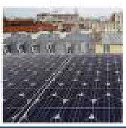
A point to bear in mind: meeting this ambitious target will require strong measures to reform the property and land markets. Special attention must be paid to the redistributive consequences of regulating land use, all the more so since lower-income households are more likely to set up home on the periphery of urban areas, taking into account the price of land, property and transport.

b) Generalising the existing territorial system with a post-carbon approach

Above and beyond the environmental impact of urban sprawl, there is a strong social dimension

[9] On average, a hectare of cultivated land converted to artificial use is held to be equivalent to 61 teq of net carbon release over 20 years. The figure is 134 teq for a hectare of previously untouched land. Artificialisation of one hectare of land can also account for as much as 24 teq CO_2/year in terms of lost plant production.

[10] Considering the land sector (land use and land use changes) as a whole.







which will become increasingly acute in the near future: spending on travel (often under-estimated or ignored when buying a house) combined with high rent/house prices and poor energy efficiency in individual homes could see low-income households facing the risk of both energy and transport poverty.
For local authorities, more diffuse housing also generates urban development costs which can weigh heavily on local finances: extending and connecting rail networks, the electricity grid, digital connections, creating new services and facilities, public transport etc.
In order to halt the artificialisation of land and adapt the existing model, we will need to develop differentiated solutions which respect the diversity of the territories at hand (urban, rural, isolated, mono-functional etc.). We also need to back policies focused on regenerating city centres, consolidating multi-nodal dynamics, multi-functional and natural spaces in towns, up-building, network adaptation etc.

In doing so, we must respond to a series of major challenges and objectives:

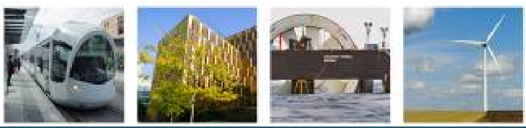
- **Adapting development strategies to local conditions**, prioritising high-density development structured around transport networks, services and jobs in urban centres. **In rural territories**, we can encourage the use of local renewable resources to make bio-based materials and products as well as energy, particularly to help meet the energy requirements of buildings. Nevertheless, developing renewable energies (including bioenergies) will require us to use some land. Incentive policies must therefore take into account all land usage requirements. We also need to adopt a comprehensive approach to land management, considering questions of solidarity between different spaces in order to boost their resilience. There are numerous opportunities for synergy which can have a positive impact on greenhouse gas emissions, for example: producing renewable energy in less densely-populated regions to supply big cities, local distribution networks for food products, supporting local producers and cutting down on transportation requirements.

- **Building in areas already used for construction (brownfield sites) to halt the consumption of greenfield land.** Current policy is firmly focused on renovating the existing urban fabric, reconverting brownfield sites and using land more efficiently to avoid further sprawl while maintaining a high standard of living for city-dwellers.

- **Adapting urban development to local configurations In dense urban zones,** which are by their nature well-connected and well-equipped, other forms of development may be utilised, such as semi-collective housing formats and upwards extension of existing buildings.[11] Semi-collective housing developments, well situated in urban centres, offer higher rates of occupation density (40 to 60 homes/hectare) and strike a balance between effective land use and acceptable population density. **But densification is not desirable in all areas, nor in the same manner.[12]** Some rural and suburban areas need to work on protecting remaining agricultural land and natural spaces, as well as sparsely-populated zones, for the benefit of the population as a whole. **These new forms of urban development will need to incorporate an integrated approach to networks**, taking into account energy networks (heating etc.) and communications networks (digital development).

- **Rethinking the role of nature in the city**, with a comprehensive vision covering all

[11] Upwards extension of existing buildings, though sometimes complex in engineering terms, is nonetheless a useful way of keeping urban sprawl under control and boosting energy performance in some jointly-owned residences, particularly in light of recent regulatory developments (cf. the Order of 3 October 2013 on the development of construction and housing).
[12,] The densification of existing areas can cause problems if it is not handled correctly: traffic, space management, heat pockets etc. The challenge here is not only to densify the existing urban fabric, but to foster the emergence of new living environments which are energy-efficient, suited to the environmental context and well-endowed with transport options to minimise pollution. Not only this, but we must also develop renewable energies to supply the needs of these new buildings.



aspects of the ecosystem. This will allow us to improve quality of living for residents and meet the challenges of adaptation, regulation etc.

- **Bringing residential areas closer to business areas.** We need to promote a multi-functional approach to town planning, cutting down on transport times and sound pollution, protecting air quality and avoiding the formation of urban heat pockets. This also raises the issue of creating more local jobs, as well as nurturing local networks and the circular economy. It is also important to ensure the availability of affordable housing in our metropolises and major conurbations, making sure that low and middle-income households are able to live in urban centres.

- **A new approach to mobility**, with a diverse array of transport options which are an integral component of urban development. In built-up areas, more effective organisation of urban functions should foster the development of public transport. In rural areas, where people are heavily dependent on private vehicles, alternative mobility solutions involving cars can be found: car-sharing, lift sharing etc. In all cases, active forms of mobility (walking and cycling) must take pride of place in territorial development plans. Future urban development needs to take climate change into account (shade in public spaces, drinking fountains etc.) as well as the challenges posed by our ageing population. (for more on mobility and transport cf. 3.3.i)

- **Rethinking commercial zones and large-scale amenities:** many commercial centres, logistical platforms, airports and ports are located on the outskirts of towns and cities, with a major impact on transport arrangements and the artificialisation of surrounding land. Changes need to be made to optimise their positioning, regulate out-of-town commercial zones and reinvigorate town centres, and plan for the redevelopment/reconversion of these peripheral areas.

2. Compromise, recommendations and development drivers

a) Promoting innovation in all its forms

- Promoting innovations which contribute to energy efficiency and self-sufficiency, be they technological or social: supporting bottom-up initiatives, city-specific transition plans, slow cities etc. (initiatives piloted by citizens, joint construction of public policy etc.).

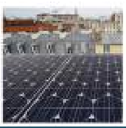
b) Improving urban performance in towns and metropolises

- Optimising the use of space and facilities: urban temporalities, occupancy rate of homes and public facilities, versatility and reversibility.
- Capitalising on flows and nurturing the circular economy: simplicity and efficacy of urban services, reuse of materials, urban recycling, urban renewal and reconversion of brownfield sites, waste reduction, energy recuperations, ecological engineering etc.
- Developing natural resources in the city with a view to protecting the ecosystem and encouraging the spread of urban agriculture; Defending peri-urban agriculture, protecting farmed land and nurturing short distribution circuits, without neglecting the importance of large agricultural and natural zones in rural environments;
- Making active mobility (walking and cycling) an attractive option for the able-bodied, and making intra-city transport accessible.

c) Fostering the development of innovative, energy-efficient rural regions, in synergy with our metropolises

As we seek, individually and collectively, to adopt a lifestyle which generates less CO_2 in more sparsely-populated areas, there are several recommendations we can make:

- Working to rethink the way we get around (ride-sharing zones, car-share programmes)







- Encouraging local living (cutting distances between home-work-other activities, expanding the option of remote working for compatible professions)
- Helping families and regions to take control of their consumption practices (self-sufficiency, understanding of energy usage etc.)
- Developing activities in complementarity and solidarity with metropolitan areas: food production, bio-resources, recreation, water management and purification.

d) Protecting natural spaces and agricultural land, taking their role as carbon sinks into account when developing future projects

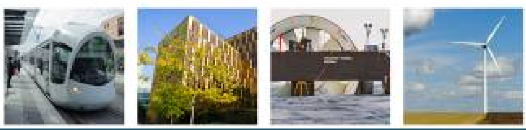
- Taking into account the environmental and climate-related benefits of agricultural land (farms, production chains etc.) and natural spaces in regional development plans.
- Strong action to preserve natural resources and their capacity to capture and store carbon

e) Preparing the governance and regulatory tools of tomorrow

- Giving local authorities the methodological tools they need to develop an integrated approach to urban development and transport, ensuring the coherency and complementarity of all official documents (Regional Development Plans, Territorial Cohesion Plans, PCAET, PLU, PLUI, PDU, PLH) which translate our objectives for the energy transition, climate change and the development of the green economy into practical terms;
- Supporting local authorities as they take the lead in developing territorial strategies (e.g. the role of mayors in granting planning permission and managing conflicts of interest with regard to urban sprawl which would generate new property taxes and create new homes (and often new jobs), while the corresponding investment required in networks is often largely subsidised by other levels of local government, particularly county councils).
- Boosting the legal capacities of local authorities (metropolitan areas and inter-municipal groupings) in order to keep a lid on property speculation, urban sprawl and functional and/or socio-cultural ghettoisation.
- Devoting particular attention to this issue during the first revision of this strategy.

f) Guiding and supporting decision-making with assessment and monitoring tools

- Encouraging the spread of simple tools for assessing the direct and indirect impact of projects in terms of greenhouse gas emissions (inspired by carbon budgets, NECATER, GES-URBA, the carbon barometer etc.) and highlighting, where possible, joint benefits or points of overlap with other ecological, social and economic issues;
- Developing tools to observe and analyse flows of energy and materials between regions, as well as evaluation methods capable of highlighting the cost-benefit performance of projects in the short, medium and long terms, adopting an approach which is cross-cutting and not sector-specific.



v. Financial priorities and guiding investment

1. Current state of affairs and carbon challenges

In terms of the financing of low-carbon trajectories, the issue of finding extra financial resources is not a major concern. In fact, the increased investment required to finance a trajectory which takes climate constraints into account is 5% compared with standard investments worldwide,[13] with a similar figure found at national level and incorporated into the reference scenario. Our ability to direct investment towards activities compatible with a 'decarbonised' economy is, however, the major financial challenge facing the transition to a low-carbon economy. This applies to both public and private financing. Given the scale of investment required, the latter will necessarily provide the lion's share of the financial resources dedicated to the low-carbon economy.[14]

Guiding these investment flows requires us to effectively manage the supply and demand of capital, as well as the instruments connecting the two:

- Capital demand includes all policies aimed at boosting the economic and financial attractiveness of "green" projects - improving the yield-to-risk ratio, making technology accessible etc.;
- Capital supply depends on the financial sector and its capacity to support change in an orderly manner;
- The aim of connecting instruments is to ensure that the financial channels flow smoothly from the sources of capital - savings, institutional investor etc. - to the areas where spending is required. They include instruments such as securitisation and green bonds.

Risks and opportunities: the carbon challenge and the financial sector

The challenges posed by climate change and the energy transition for players on the financial markets are two-fold, particularly for institutional investors and other players focused on the long term:[15]

- The energy transition requires us to target investments in a manner which is consistent with our emission reduction targets, committing substantial resources in the process. Financing the energy transition will thus open up significant opportunities.
- On the other hand, climate change and energy concerns also bring with them substantial risks for the majority of financial institutions. The general acknowledgement of the importance of integrating these concerns into operational decisions is a relatively recent development, but it received a spectacular boost at the UN climate summit in September 2014, with ambitious projects regarding the placement of assets by institutional managers and investors.

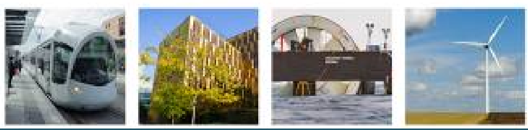
The carbon challenge will be a crucial priority for financial stakeholders in the medium term

For financial stakeholders, the challenges posed by climate change and the energy transition are

[13] New Climate Economy (2014). Better Growth, Better Climate.

[14] Tens of billions of euros in France, thousands of billions of euros all over the world. In France, climate-related investment was valued at between €20 and €25 billion in 2011 (CDC Climate Research 2014).

[15] Public or private organisations which manage savings and invest these funds on the financial markets. This term covers pension funds, insurers, reserve funds (or other public-sector institutional investors) as well as banks.



two-fold. On the one hand, they are exposed to the consequences of climate change (via the exposure of the counterparties which they finance). On the other hand, they are also exposed to the consequences of political efforts to reduce emissions, which will become more restrictive the later we leave it (risks associated with stranded assets and the possible formation of a 'carbon bubble', linked to the economic valuation of fossil fuel reserves which may have to be left in the ground). Several studies have demonstrated the need for the financial sector to align itself with a low-carbon trajectory, but for the time being it is still heavily invested in fossil fuels. This only serves to increase the costs associated with reducing greenhouse gas emissions over the course of the century, due to delays caused by technological and organisation lock-in and the impact of climate change[16] (cost of inaction).

Given the regulatory risks and the importance of planning ahead for the effects of climate change, it is in the best interests of institutional investors to take these considerations into account in the analysis and operational management of their investment portfolios, steering existing funds towards low-carbon investments. The interests of institutional investors should thus be aligned with the interests of society at large.

On the financial markets, a number of promising tools are under development…

These tools, designed to nurture the emergence of a 'decarbonised' economy, can be grouped into three broad categories:

- Instruments aimed at steering investment towards the green economy, with direct and more-or-less certified investments in low-carbon assets (e.g. green bonds, eco-labels for investment funds contributing to the energy and ecological transition etc.);
- "low-carbon" management initiatives, including signposting of the carbon footprint of assets, allowing investors to exclude or minimise carbon-intensive assets, which are generally over-represented in the available indices and thus attract substantial capital flows;
- shareholder action, exerting pressure - by means of direct dialogue or the use of voting rights - on companies to act in an environmentally-responsible manner

… but running up against the sticky issue of measuring climate performance

Financial analysts are heavily dependent on the information provided in advance by investment issuers, which goes some way to explaining the difficulties encountered in finding funding for energy efficiency and renewable energy projects. At the same time, in light of the substantial influence they exert, they have a responsibility to accelerate the development of 'carbon metrics' which will allow us to assess exposure and sensitivity to climate and energy developments.

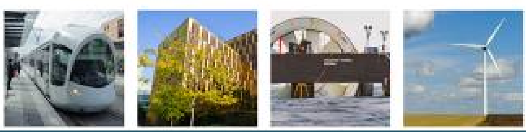
Efforts to quantify carbon risk are still in their infancy. Such analyses remain restricted to a handful of industries, which prevents us from achieving a comprehensive evaluation of total exposure to climate and carbon risk, and the scale of the consequences. However, new tools are currently in development - such as the Sustainable Energy Investment (SEI) Metrics promoted by the European Commission and the system of carbon stress-tests - which aim to analyse the impact of climate-energy scenarios on asset portfolios. Another initiative, the Beyond Ratings project,[17] aims to assign grades to sovereign bonds based on their climate credentials.

2. Strategy

Working hand in hand with other sources of financing, the financial sector has a central role to play and must step up to its responsibilities in terms of funding sustainable development and the

[16] In certain sectors, such as reinsurance, this risk has already materialised in the form of a substantial increase in costs. Further developments in climate conditions could aggravate these costs over the coming years (coastal flooding, heat waves etc.). Although the figure is well below the annual average for the past ten years ($188M/year), natural and man-made disasters cost the global economy $113M (approx. €90.5) in 2014, compared with $135M (approx. €108M) in 2013 [Argus de l'assurance, published 17 December 2014 at 15:09].

[17] Projects backed by the 2° Investing Initiative and the Riskergy consortium, respectively.



ecological transition. The mobilisation of the financial sector needs to be threefold: first and foremost in terms of risk management, then as a source of funding for the real economy and finally in terms of their own social and institutional responsibility.

In order to lead the way in changing investment practices, France is already equipped with a raft of forward-thinking regulatory tools, including Article 224 of Law 2010-788 (12 July 2010) on national environmental commitments, which obliges management firms to provide non-financial reports on the way they take social, environmental and governance quality criteria into consideration in their investment policies. France may shortly become the first country to demand that institutional investors submit non-financial reports providing information on the actions taken to further the energy and ecological transition and tackle the challenges of climate change (Article 173 of the Energy Transition and Green Growth Act).

Public policy-makers have a duty to reinforce these foundations, going beyond carbon pricing to effectively coordinate the various incentive schemes in six main ways:

2.1 Supporting the development of 'low-carbon' asset management

French institutional investors and fund managers are already committed to a strategy of promoting green investments to reduce our carbon footprint and ecological impact, while also reducing the exposure of their portfolio to carbon risk. This process should be supported and expanded with the creation of new labels and indices, more effective management of environmental risk factors and stricter environmental eligibility criteria for projects applying for export credits.

In the short term, priority should be afforded to developing a new incentive in the form of an "energy and ecological transition" label for investment funds.

2.2 Ensuring that financial stakeholders take carbon risk into account in their operational decisions

Faced with a potentially serious risk, financial stakeholders need to integrate environmental criteria into their operational decision-making processes. As well as promoting more comprehensive risk analysis, the goal for policy-makers is to ensure that carbon risk is taking into account on an operational level.

Furthermore - and with specific reference to long-term financial partners such as institutional investors, due to the fact that low-carbon investments are necessarily long-term commitments - the existing accounting framework (and, in some cases, its relationship to the prudential framework) is not suited to the business models of these stakeholders nor, by extension, to the analysis of low-carbon investment strategies.

As financial stakeholders are becoming increasingly aware of the importance of these issues, policy-makers need to continue systematically and regularly pushing for the adaptation of the IFRS accounting standards to better represent our long-term financing requirements, specifically for the ecological transition and including SMEs. The development of 'carbon stress-tests' is an interesting prospect.

2.3 Reinforcing the support available for operational research into the development of 'carbon metrics'

The current methods used to measure carbon emissions do not allow for a comprehensive overview of a portfolio's exposure to carbon risk (emissions financed), nor do they allow for a forward-looking approach enabling investors to ensure that they are in line with greenhouse gas reduction targets. The 'science' here is still young, and this is a pioneering initiative in need of consolidation. Public policy-makers have a key role to play in supporting R&D and innovation. Obviously, this support only makes sense if it contributes to the efforts going on at international level;[18] the aim here is to bolster national initiatives and help them to gain traction in a context which remains dominated by ideas from the English-speaking world.

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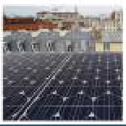
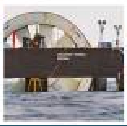
[18] Government support for the 2° Investing Initiative and the Riskergy consortium are examples of this approach in action.






2.4. Improving the non-financial reporting of institutional investors

Institutional investors handle substantial assets, with a responsibility to secure the enduring financial viability of their commitments to clients, subscribers, members and affiliates.

One form of action thus consists of increasing the information available to the clients, subscribers, members and affiliates of institutional investors, with regard to the ways in which the investment policies operated by the latter take environmental criteria into account, and the resources allocated to furthering the energy and ecological transition. This might take the form of a dedicated non-financial report, providing clients, subscribers, members and affiliates with the relevant information and helping them to choose those institutional investors who are most attuned to climate and energy concerns.

2.5 Creating a space for dialogue and exchange between policy-makers, private and public institutional investors and representatives of civil society

The purpose of such a space - whose form and rules will need to be defined in further detail, but which should certainly based on the principle of open discussion - would be to boost cohesiveness and encourage synergy between different initiatives (of which there are a multitude since COP21) which are not currently well co-ordinated, with each initiative developing on its own terms. The goal would be to encourage the creation of climate-compatible financial mechanisms, tools and instruments,[19] pushing investors to develop a genuine low-carbon strategy including firm targets and a detailed roadmap. In the long term, this system could help with the sector-by-sector implementation of the national low-carbon strategy. Further reflection is also needed on non-economic barriers such as lack of information and lack of sufficient training.

It seems clear that the scope of this reflection should not be limited to the national sphere, and that it should make full use of all available resources (feedback from the major carbon initiatives already up and running; national and international best practices which will, in the near future, feature in the COP21 Agenda of Solutions; major climate conferences aimed at investors; promoting national initiatives; proposals for 'carbon metrics' etc.).

2.6 Opening up access to financing for low-carbon projects, renewable energies, energy efficiency initiatives and the circular economy

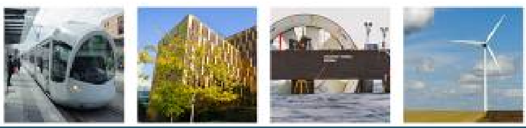
The first priority is to remove liquidity and access constraints for individuals, businesses and public bodies keen to launch projects to reduce greenhouse gas emissions, produce renewable energy, improve energy efficiency or boost the circular economy.

Various levers and mechanisms can be envisaged to help us achieve this goal: upgrading existing systems (for example increasing financial incentives for energy-efficient renovation work, and means-tested subsidies for households), developing a specialised intermediary service to facilitate funding of projects of all sizes (third-party financing, public participation in financing, companies set up to finance green energy etc.), government intervention in financing mechanisms (co-financing from borrowing and equity, green loans offered by BPI France, loans underwritten by the government, monetary mechanisms).[20] In order to boost their efficiency, these mechanisms may also be backed up with non-financial measures: boosting capacities, providing information (green loan brokers, for example) etc.

2.7 Systematically promoting low-carbon measures in the financial support provided to

[19] Cf. Measures 5.a & b of the Road Map drafted at the 2014 environment conference.

[20] Since the European Central Bank considers the low-carbon transition to be central to the resilience of the Eurozone's monetary and financial system, the bank should be entitled to intervene in various ways to facilitate the financing of this transition. The central bank could, for example, add carbon assets to its asset purchase programme. The value of these assets, generated by reductions in emissions, would be backed by a public guarantee corresponding to a reference price for carbon defined at national (or European) level.



public projects.

In application of Article L222-1B of the Environment Code, instated by the Energy Transition and Green Growth Act (ETGGA), financial support for public projects must systematically take the reduction of greenhouse gas emissions into consideration.

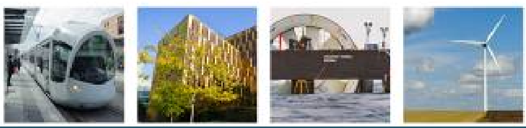
The principles and methods used to calculate greenhouse gas emissions from public projects will be determined by decree. In accordance with the present strategy, priority will be afforded to a life cycle approach wherever sufficient data is available, taking the reliability of this information into account. Evaluating the reduction of greenhouse gas emissions is also a pertinent way of assessing alternatives to these public projects.

2.8 Development aid and support for the international expansion of French businesses

Providing incentives in the form of development aid and support for the international expansion of French businesses is also a major priority.
Strategic initiatives have already been put in place to keep track of the investments made in this respect. The French Development Agency monitors the evolution of climate-related projects as a proportion of its total portfolio. This monitoring is based largely on the so-called 'Rio markers', identifying the major categories of anti-climate change actions, or initiatives with other objectives but which also offer significant ecological benefits.[21]

The qualifying criteria for export credits were reviewed in September in 2015, and are consistent with the priorities of domestic energy policy in that they demand the immediate removal of export credits for all new coal-fired power stations without carbon capture technology.
From a quantitative perspective, the target announced by France at the United Nations General Assembly in September 2015 is to increase funding for climate projects by €2 billion by 2020, increasing the annual pot from €3 to €5 billion.

[21]The same logic can be applied to other objectives such as protecting biodiversity, allowing us to promote options which contribute to several components of the ecological transition simultaneously.



vi. Education, awareness, appropriation of challenges and solutions by citizens

Bearing in mind the ambitions set out in the National Strategy for the Ecological Transition and Sustainable Development (NSETSD 2015-2020) and the various roadmaps for the ecological transition, our recommendations for education and awareness-raising correspond to the objective of giving citizens the means and resources to understand global developments and the challenges of the energy transition, enabling them to make an active contribution to the national low-carbon strategy.

Complementing and co-existing with the recommendations set out in Part vii. regarding professional training, these proposals require us to deploy a diverse array of techniques to educate and stimulate awareness, involvement and participation among citizens of all ages.

1. Schools and higher education

Our priorities must be to:

- Take full account of the stakes, practices and key skills associated with climate challenges, reducing greenhouse gas emissions, energy self-sufficiency and efficiency and renewable energies when updating the curriculum for primary and secondary schools, guiding young people towards professions which will be essential for the energy transition.
- Make higher education a leading force in the energy transition, boosting the skill level of public and private sector employees and managers as we move towards a low-carbon economy. Updating courses to reflect the latest advances in research and the need for professionals to keep pace with these changes.
- Organise, reinforce and develop the training provided to trainers, teachers and other educators regarding the stakes of the energy transition and climate change.
- Complete our analysis of the general key skills required by the industrialisation of new energy technologies (*intelligent systems and vectors, renewable and decarbonised energy, managing demand* etc.), and maintaining high levels of these skills.
- Support the development of engineering activities related to new energy technologies, derived from advances in research.
- **Facilitate and support the involvement of educational institutions and extra-curricular organisations in the deployment of grass-roots actions from the regional energy transition plans and strategies, fostering green growth locally** (*the Climate-Air-Energy Plan (PCAET); Regional Climate-Air-Energy Strategies (SRCAE); Territories for Energy Transition and Green Growth (TEPCV) and "Zero waste"; Regional Strategies for the Circular Economy, etc.*).

Coordinate these actions with:

- - projects led by agricultural schools and colleges, developing a 360° approach to sustainable development,
  - extra-curricular schemes,
- and approved projects run by institutions such as holiday centres, leisure centres, scout troops etc.
- Accelerate the process of making schools and universities sustainable, helping educational institutions to lead the way in matters of energy performance and, more broadly, social responsibility.
- Recruit energy/flow efficiency managers in all educational institutions by 2020, in accordance with the objectives of strategic plans such as the 'Campus d'@venir' programme. Promote and facilitate the involvement of students with these strategic plans, and in the energy transition charters drawn up by higher education associations.







- Develop experiments with new energy management practices at test facilities in higher education institutions (e.g. thermal insulation, energy recovery and storage, geothermal energy, managing energy demand).

2. Raising awareness and boosting participation

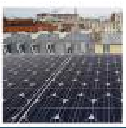
Our priorities must be to:

- Promote and develop experimentation and grass-roots innovation at local level, helping to change habits and ease the transition to a low-carbon economy.
- Mobilise and support young people as they come to terms with the stakes of the ecological transition.
- Deploy and develop a wide-ranging programme of civic service initiatives for the energy transition, the climate and biodiversity. For example, youth organisations were actively involved in preparations for COP21 via the COY initiative and numerous educational projects.
- Develop and reinforce multi-party partnerships for shared, concerted educational initiatives focusing on the environment, as well as local actions to raise awareness and involvement (e.g. energy-positive families, open workshops, artistic, sporting and cultural projects etc.)
- Consolidate and develop public participation in the implementation of regional projects and action strategies focused on creating a low-carbon economy
- Open up participative tools at local level (public debates, environmental consultations, local correspondents, mediators, participative charters, local policies etc.)
- Experiment with local shared responsibility schemes
- Promote the dissemination and sharing of information on the national low-carbon strategy (SNBC), with a strong emphasis on digital communication tools.

3. Consumer information and responsibility

Our priorities must be to:

- Promote and facilitate the development of collaborative consumption practices *(energy efficiency and self-sufficiency, reducing our consumption of new materials and resources).*
- Support the development of the functional economy and the sharing of goods and services in the market and non-market sectors (e.g. Community-supported agriculture, equipment sharing, remote working), with the help of new digital technologies.
- Implement and expand the voluntary system of environmental declarations for consumer products and services, increasing the profile of existing schemes (energy labels, European ecolabels etc.) to help consumers make low-carbon purchasing decisions.
- Inform and education individuals about the 'new generation' of practices and technologies for saving energy at home *(home automation, new lighting and heating technologies etc.).*
- Encourage the installation of customised energy systems, intelligent energy control technologies and automated services (businesses, local authorities, schools, individual homes).
- Continue to develop and expand the network of Renovation Information Points, particularly at inter-municipal level. Inform and educate users about dynamic management of smart transport services.
- Encourage the use of new transport solutions (car-sharing, easy cycle hire schemes etc.).
- Step up research into incentive schemes to influence consumption and usage habits, taking their results into account in campaigns to spread information and raise awareness of the ecological transition.







vii. Jobs, skills, qualifications and professional training

1. The energy transition, trades and skills

A. Knowledge

Our first priority must be to analyse our future requirements in terms of the sectors of activity, professions and skills featuring in the national low-carbon strategy. This will require enhanced cooperation between the national centre for professional development in the green economy (piloted by the CGDD) and the Skills and Employment Network (REC, piloted by France Stratégie).

B. Professional Transitions

Our priorities must be to:

1. Create a new action strategy for employment, training and professional transitions linked to the energy transition and green growth. This strategy will build upon the National Action Plan for Employment and Careers in the Green Economy, the national debate on the energy transition and the measures agreed upon at the environmental conferences in 2013 and 2014, as well as the Multi-Annual Energy Plan and its assessment of our skill requirements and the way they are met (or not) by existing training resources.

2. Encourage the introduction of regional management strategies for jobs and skills (GTEC), with particular reference to the report 'Proposals for national training priorities in connection with the ecological transition, and recommendations for future CPRDFOP plans' (regional strategies for the development of training and professional orientation) published by the National Council for Life-Long Learning (CNFPTLV):

- Identifying key skills allowing for career changes
- Supporting the grass-roots appropriation of methodological tools designed to facilitate professional transition in areas affected by the ecological transition and energy efficiency measures.

3. Improve the system of interprofessional qualification certificates (CQPI) for employees, in order to facilitate professional mobility.

4. Improve orientation advice and training available to job-seekers, preparing them for the jobs created by the ecological transition (with the support of the Pôle Emploi 2020 strategy).

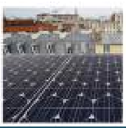
2. Energy transition, full-time and life-long professional training

We will encourage the inclusion of environment and climate modules in the school curriculum and further training courses, tailoring our educational actions to the demands of the ecological and energy transition:

Our priorities must be to:

- Ensure that the stakes of climate change and the energy transition feature more prominently in technological and professional training courses in schools and universities, in particular:
    - continuing to incorporate the key techniques and skills of the energy and ecological transition into the curriculum guidelines applied in our schools and universities
    - continuing to update the curriculum and degree system operated by the ministry for agriculture, in line with the "new approach to food production" action plan for education which forms part of France's agro-ecological strategy. The purpose of this update is to integrate agro-environmental practices which will help to reduce emissions from the agricultural sector (maximising the use of organic fertilisers and additives, agro-forestry,

prioritising grazing, increasing production of legumes and protein-rich plants etc.);
    - adapting the initial and further training provided to architects, equipping them for the changes induced by the energy transition and the return of natural resources to urban areas.
- Rely on innovation to facilitate access to training:
    - with innovative tools and methods (e-learning, MOOCs etc.)
    - providing tools for craftspeople, micro-businesses and small companies (SMEs), taking their specific requirements into account (e.g. the replacement system introduced in the agricultural sector)
- Improve knowledge transfer involving professionals:
    - training the trainers
    - creating spaces where stakeholders from the real economy, research and education can meet, such as clusters and competitiveness centres (sharing methods and profession/skill analyses) for all sectors of the economy (particularly industry, construction, transport and agriculture)
- Develop targeted actions with the voluntary sector, in particular:
    - Sector-specific action plans, with particular emphasis on support for professional conversion.
    - This is particularly important in jobs related to transport and mobility, where we must work to integrate new 'green' skills and update the findings of the Transport committee.
    - Boost the professional skills and reputation of the energy audit sector.
    - Support technology transfer initiatives in the wood-forestry sector.
    - Promote, on a broader level, awareness, information and training for employers and employees, particularly in small businesses, including actions to boost employability and the range of professional training on offer. This will include educating entrepreneurs about the high stakes of the energy transition, and encouraging them to adopt consulting, support and training services designed to boost eco-compatible skills in small businesses.
    - Create the conditions required to nurture the development of a new range of engineering, consultancy and educational services accessible throughout the nation (including in overseas territories), focusing on boosting employment, developing skills and increasing awareness of the stakes at hand and the actions to be taken to construct a low-carbon economy.
    - Look closely at the connection between digital skills and the jobs created by the energy transition, in order to plan ahead for training requirements.
    - Assigning a clear status to professional qualifications (degrees, diplomas etc.) in sectors impacted by the energy transition and the green economy in general.







viii. Territorial implementation

1. Current state of affairs and carbon challenges

France already has considerable experience of climate action at local level, with Regional Air-Climate-Energy Strategies and Local Energy-Climate Plans. Our regions and local authorities have demonstrated considerable ambition, working in synergy with France's objectives and obligations at the European and international levels. They are involved with countless concrete projects, while also overseeing the cross-cutting implementation of the different sector-specific measures (town planning and energy, town planning and transport) and providing the connection between the different stakeholders involved (other local authorities, businesses, households etc.).

They have made a significant contribution to the national debate on the energy transition, identifying areas for improvement and highlighting the importance of reforming the scope of regional climate-energy plans to ensure that all areas of the country are covered by one plan and one plan only. Discussions have also focused on the need to provide local authorities with greater access to energy data, enabling them to construct energy policies consistent with the challenges facing their territory.

2. Strategy (2030, 2050 and beyond)

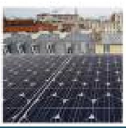
2.1 Continuing to devolve power to the regions, clarifying responsibilities at every level. :

- The Law Introducing France's New Regional System (NOTRe) hands more power to the regions in matters of climate change, air quality and energy.
- The Energy Transition and Green Growth Act requires all inter-municipal authorities representing over 20,000 residents to produce Local Climate-Air-Energy Strategies (PCAET), which must include air quality measures where relevant, particularly in areas covered by atmospheric protection plans.
- In calls for tender, financial incentives should be used to support the most ambitious regions (e.g. 'positive-energy territories for green growth' and 'zero-waste, zero-refuse territories').
- Regional and local stakeholders have a decisive role to play in implementing this strategy. They should be heavily involved with its next update, due for publication in June 2019.

In the long term, the majority of the country should be covered by PCAET strategies. Above and beyond immediate local concerns, these PCAET plans must include a short, medium and long-term vision for the territory, consistent with national and regional strategies.

Effective implementation of these PCAET plans will require us to:

- improve the governance of inter-municipal authorities and encourage the development of 'greenhouse-gas neutral territories' and other such programmes;
- work to create more **energy-positive territories (TEPCV)**, producing more energy than they consume;
- expand local authorities' access to energy data (particularly relating to gas, electricity, heat and oil products), allowing the regional observatories to produce more effective regional greenhouse gas emission accounts and break them down at inter-municipal level, making it easier to draft and implement PCAET plans;
- increase the capacity of local bodies to take 'Scope 3' criteria (i.e. indirect or induced emissions and not just direct emissions) into account in their greenhouse gas emission accounts (BEGES). In rural areas, the reductions in emissions made possible by the production of bio-based resources could thus be taken into account.







Further regulatory tools will allow local authorities to refine their GHG emission reduction policies. All towns with over 50,000 residents must produce three-yearly reports showing the GHG emissions falling within the scope of their responsibility. These accounts should be accompanied by action plans setting out the measures the local authority plans to take to reduce these emissions.

2.2 **Harmonising, in a progressive and iterative manner, the consistency of the quantitative objectives set at different scales**

- Regional Development, Sustainable Governance and Territorial Equality Schemes (SRADDET, superseding the current Regional Climate-Air-Energy Strategies) will be drawn up by the Regions in cooperation with the local authorities falling within their remit. The purpose of these plans is to define the region's strategic orientations and medium-to-long-term objectives with regard to climate change and related issues, in accordance with the national objectives.
- Territorial Air-Energy-Climate Plans (PCAET) and local planning regulations must take these principles and objectives into account, and remain consistent with the regional implementation measures involved.
- For PCAET published before the SRADDET, this harmonisation will occur during the first revision process following approval of the SRADDET. All PCAET plans must be made compatible with corresponding SRADDET measures within a maximum of three years following their approval. It is worth noting that the SRADDET strategies include a 'biomass' section designed to help regions effectively manage their bio-based resources, and to use them in a way which optimises emissions.

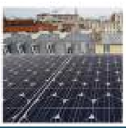
2.3 **Providing effective management tools at every level. In addition to the regulatory obligations it entails**, the Energy Transition and Green Growth Act provides local authorities with a number of tools and opportunities to implement consistent territorial policies to reduce emissions:

- In the construction sector, the creation of energy renovation platforms and third-party financing schemes should serve to greatly increase the number of energy-efficiency renovation projects.
- In the transport sector, the obligation for public bodies to replace old vehicles with new, greener alternatives, the development of a charging infrastructure for electric cars and the option given to mayors of restricting traffic or limiting speeds are all examples of concrete actions which will yield results in the short term.
- In the renewable energy sector, inviting local authorities and residents to invest in energy production companies should help to accelerate the transition towards less carbonised forms of energy.

3. Coordinating the national low-carbon strategy with other plans and programmes

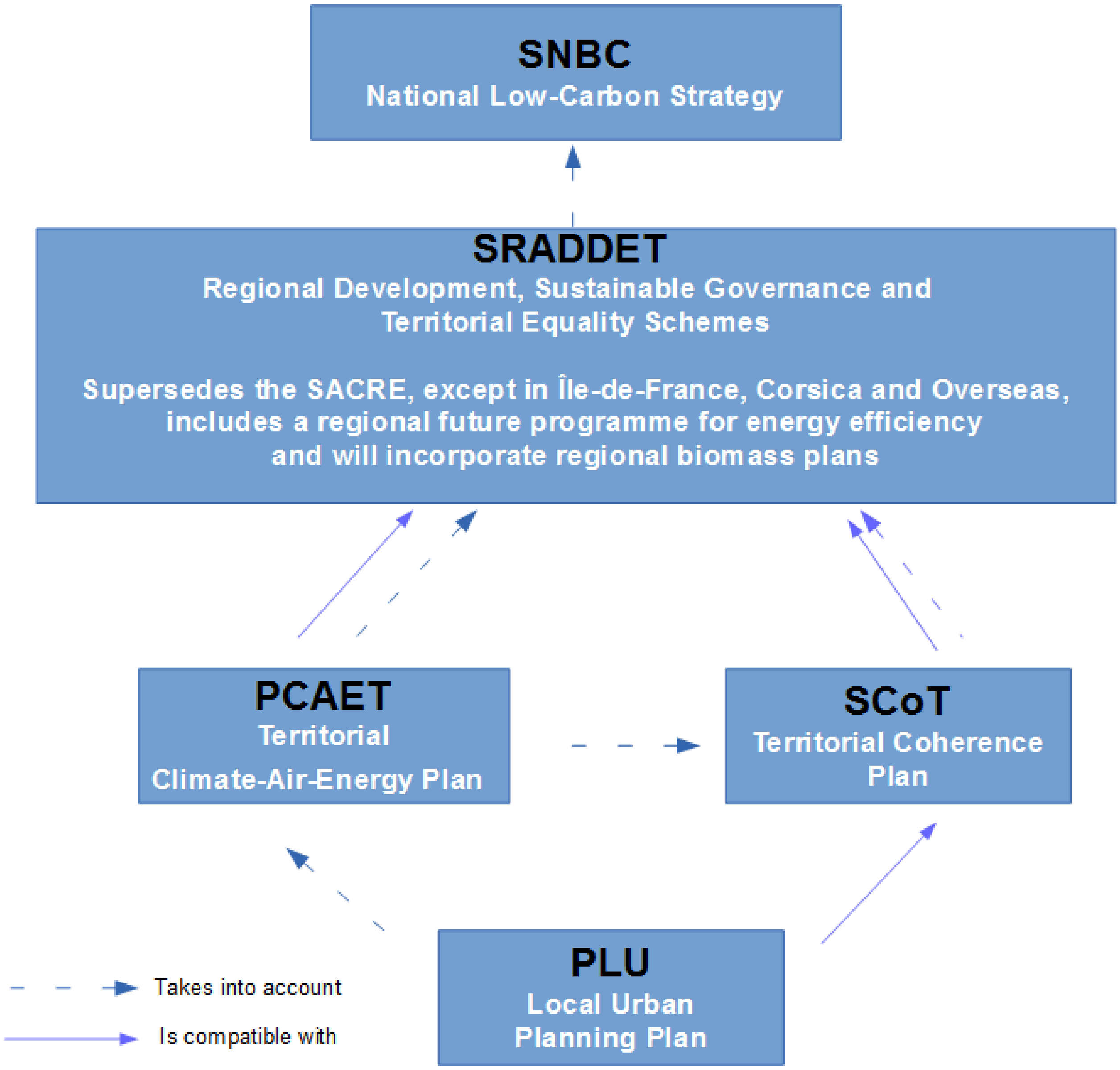
The strategy will be coordinated with:

- **Regional Development, Sustainable Governance and Territorial Equality Schemes (SRADDET, superseding the Current Regional Climate-Air-Energy Strategies)** are necessarily closely linked to the
- existing Territorial Climate-Air-Energy Plans (PCAET). This link may be indirect, if the SRADDET already incorporates the provisions of the national strategy.
- Other planning and scheduling documents produced by local authorities and their agencies which also have a significant impact on greenhouse gas emissions. This link may also be indirect if the SRADDET or PCAET already incorporate the provisions of the national strategy.









4. Special circumstances in the Overseas Departments, Corsica and the Ile-de-France region

In the Overseas Departments, the Regional Climate-Air-Energy Plan will be incorporated into the regional development strategy drawn up by the Region.
In Corsica and Île-de-France, the Regional Climate-Air-Energy Plan will be drawn up under the same conditions as the PADDUC and SDRIF strategies.

5. Monitoring-evaluation and indicators

Indicators for this plan:

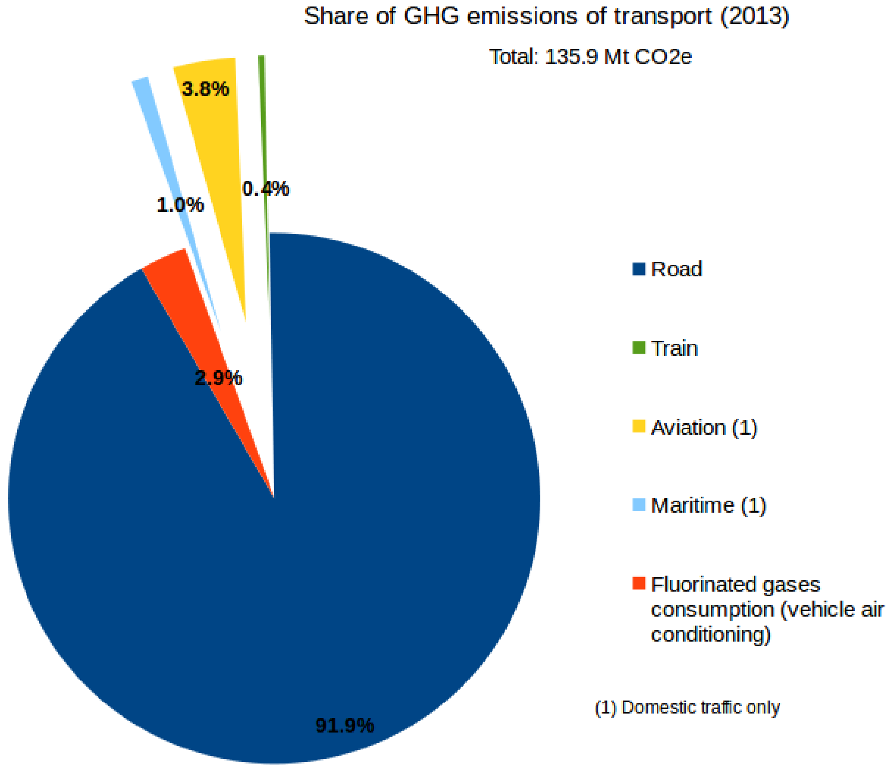
- percentage of towns with over 50,000 residents who have finalised their climate-air-energy plan by 31 December 2016,
- percentage of towns with over 20,000 residents following suit by 31 December 2018.

3.3. Sectoral recommendations

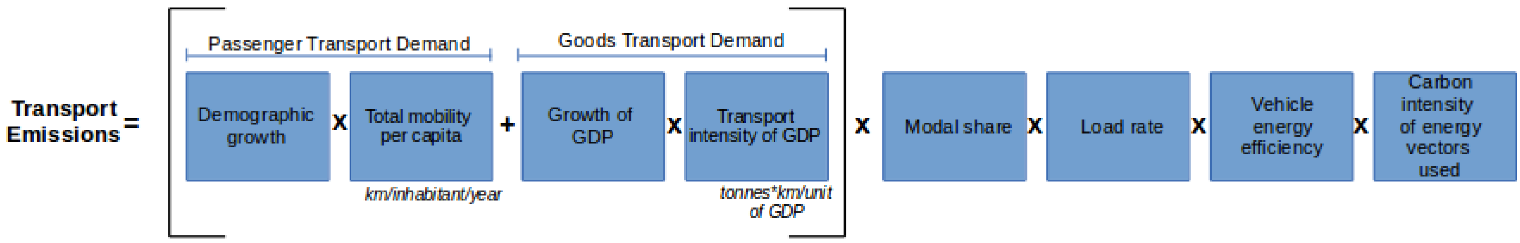
i Transport

1. Carbon challenges and the current state of affairs

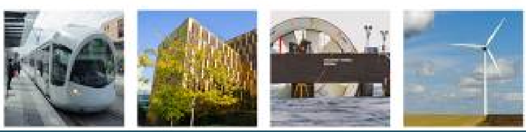
Greenhouse gas emissions from domestic transport (127 Mt, 27% of France's total emissions) increased by 20% between 1990 and 2004, falling between 2004 and 2013 to reach a total figure 12% greater than the 1990 level.



Key factors determining emissions from the transport sector:



- Two exogenous factors contributed to the increase in demand for transport: population (and its structure), and the growth of Gross Domestic Product.
- In order to reduce emissions from transport, modal transfer in favour of less carbon-heavy forms of transport (primarily rail) and a higher rate of occupancy are two key measures which can help to drive down GHG emissions from our roads. However, these actions alone will only be enough to stabilise emissions from the transport sector.



- Greater energy efficiency and reductions in the carbon intensity of energy sources used for transportation will account for the majority of GHG reductions. By 2050, a combination of highly-effective technological solutions should be widely available and utilised. They will include vehicles capable of travelling 100km on 2 litres of fuel, electric vehicles running on virtually carbon-free electricity, low-carbon fuels (liquid or gas, including third-generation biofuels and methanation systems) etc.
- The current inertia of the transport sector means that we are obliged to plan ahead for the 2050 time-frame, including measures which will not have a significant impact on emissions until after 2030, even if it is still a little premature to attempt to predict their market share. Take for example the advent of vehicles doing 100km to 2 litres of fuel: for this technology to be widespread by 2050 it will need to be included in the majority of vehicles sold from 2030 onwards. As for electric vehicles and new fuel sources, the creation of new recharging and refuelling infrastructure networks will be essential. The challenge we face in the present is to facilitate and prepare for these future developments.

Key messages:
At national level (including Overseas Departments):

- The 'Trajectory Committee' (2012),[22] estimates that the contribution of the transport sector to the national Factor 4 targets will need to be equivalent to a 65% reduction in greenhouse gas emissions between 1990 and 2050.
- Within the time-frame of the 2023-2028 carbon budget, the guideline reduction target of 22% on 1990 levels is consistent with the aforementioned 2050 objective, in that it takes into account the significant effort which will be required to diversify the energy mix in the transport sector (still dominated by liquid fuels). We will need to develop alternative power sources and charging infrastructure (electricity points, gas stations etc.) to make a much bigger impact by 2050 than that which we expect to see in the next few carbon budgets.
- This target is based on a certain number of hypotheses regarding mobility, occupancy rate and load rate of vehicles, energy efficiency, carbon intensity of fuels and the development of modal transfers. These hypotheses are designed to represent the expected impact of government policy. The main hypotheses, covering the period to 2030, correspond to the five major action priorities detailed in the reference scenario in Chapter 2.2. The details given in the paragraph 'Scope of the Reference Scenario' are of particular relevance to transport.

Internationally:

- Emissions from air and maritime transport should not be neglected, especially as they are likely to increase.

2. Strategy (2030 and 2050)

At the domestic level, the policy for reducing the climate impact of the transport sector will require **coordinated action on the following five fronts**:

A. Controlling or reducing demand for transport (per capita and per unit of GDP) diminution

- The continuation of past trends would lead to a further increase in demand. Increasing income would thus outstrip the impact of population ageing (with regard to individual mobility), and the increase observed in the average distance travelled per unit of GDP could be bolstered by the stabilisation or even growth of industry as a proportion of GDP, contributing to the dynamic development of

[22] **Centre for Strategic Analysis, Trajectory Committee** (2012). Trajectories for 2020-2050: towards a low-carbon economy. Report of the Committee chaired by C. Perthuis. Available at: http://archives.strategie.gouv.fr/cas/content/trajectoires-2020-2050-vers-une-economie-sobre-en-carbone-rapport.html

freight transportation included in the forecast scenarios.

- In order to achieve our long-term goal of stabilising mobility demand and transport intensity at their current level, town planning and the development of the circular economy and local distribution circuits (reducing the distance between the place of production and place of consumption) will play a crucial role.
- The development of remote working (and other concrete measures, particularly via companies' transport strategies and collective agreements) and remote services could also help stabilise per capita travel in the short term.

B. Load/occupancy rate of vehicles, and generally more efficient use of existing vehicles and networks:

- there is great potential for improvement simply by making better use of the free space in the vehicles currently on our roads. The rise of car-sharing and other alternative mobility services will be of great importance for passenger vehicles. Haulage firms can also do much to improve the load factor of freight cargoes. The reference scenario predicts an increase of approximately 10% in the load rate of HGVs and passenger vehicles between 2013 and the conclusion of the third carbon budget. Furthermore, reducing maximum speeds on intercity roads and motorways can also have a positive impact on reducing greenhouse gas emissions.

C. Energy efficiency of vehicles

- The target of 100km to 2 litres of fuel should be a general standard for all cars by 2050, and for all new vehicles by 2030 at the latest. An intermediary objective still needs to be set for the second carbon budget. This applies to individual vehicles, with respect for the environmental relevance (including grey energy from vehicles via life cycle analyses) and economic viability of each type of technology. It should also be possible to improve the energy efficiency of HGVs, and objectives will need to be set. The European scale appears to be the appropriate level for managing these developments. In terms of the overall energy efficiency of vehicles, the reference scenario predicts an improvement of around 20% for the unitary consumption of freight transport, and almost 30% for passenger transport between 2013 and the conclusion of the third carbon budget.

D. Carbon intensity of fuels

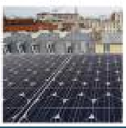
- **research and development** into decarbonised energy sources should open up new solutions not currently advanced enough to be featured on a significant scale in the carbon budgets (including but not limited to: 3rd-generation biofuels, increasing the autonomy and charging speed of car batteries, hydrogen power, bio-gas or methanation of hydrogen during the peak production periods of intermittent renewable energy sources etc.).
- in the short-to-medium term, the government will support the diversification of the energy mix in the transport sector, across all modes of transportation. This will mean promoting electric vehicles, biofuels (particularly 2nd-generation options, stabilising the proportion of conventional biofuels used for transport and not food at the current level), natural gas (as a stepping stone to bio-gas) and bio-gas. The reference scenario is based on a 6% improvement in the carbon intensity of the energy sources used between 2013 and the conclusion of the third carbon budget.

E. Modal transfer

- The aim here is to develop the transport modes and solutions which are most suited to the environmental, climatic and economic conditions of each territory. In dense urban areas, 'soft' transportation (walking, cycling) and collective public transport should take priority. For long-distance freight transportation (over 500km or so), as well as for other consignments whose size and flow characteristics make it possible to use bulk transportation methods, priority should be afforded to rail and river transport. River transport may also be useful for journeys of under 500km, connecting industrial sites or cities. The development of these bulk transport options should provide the industrial sector with a more competitive range of potential transport solutions. Stronger inter-modal connections represent a key strategic priority in this respect. We need to improve the services on offer, and this may require increased investment in infrastructure offering an alternative to road transportation. The reference scenario predicts that road and domestic air travel will fall by 2% as a proportion of all motorised transport for passengers, and 7% for freight transportation. The difference will be made up by other modes, particularly rail, between 2013 and the conclusion of the third carbon budget.
- Fiscal tools, guided by the price signal, allow us to influence the behaviour of individuals. The Domestic Tax on Energy Products (TICPE) includes a component based on the carbon content of fuels. This charge is set to grow over time. This cross-cutting instrument has the advantage of affecting all of the areas listed above. The current, legally-defined trajectory of €22 in 2016, €56 in 2020 and €100 in 2030 (2015 euros) gives people time to plan ahead and adjust their investment decisions accordingly (particularly when buying vehicles).
- Internationally, one priority is to establish globally-applicable rules via the IMO or ICAO, to effectively implement these rules in all Member States and ensure fair competition at the international level. It may be necessary to supplement these measures with specific regional initiatives, in spite of the difficulties involved (e.g. including the aviation sector in Europe's carbon market, promoting the use of alternative fuels for maritime transport etc.). This is especially true since initiatives taken by France or the European Union in this sector can serve to catalyse action at international level. However, our work must remain consistent with the global dynamic in order to avoid distorting competition in a manner which would put European operators (some of whose business is 90% international) at unfair risk.

Points to be watched closely:

- Bringing forward the development of refuelling infrastructure (electric vehicle charge points, gas stations) and coordination of all parties involved in their deployment (government, local authorities, public agencies, businesses, households etc.).
- Coordinating the development of different sectors in order to optimise their economic and environmental performance (joint benefits in terms of reducing atmospheric pollution), incorporating medium and long-term considerations and identifying the most effective means of pursuing our five priorities.
- Calibrating bio-based production chains and coordinating their connections with resources and capacities from partner chains. Sustainability of these chains.
- Ensuring that companies get on board with these objectives and seize the opportunities offered by the development of new industrial chains and service activities, creating new jobs.
- Special attention should be paid to the road freight sector, where margins are already tight and the market is shared between many small operators.







- Fighting to reduce energy poverty and combat the isolation of rural areas, particularly when new fiscal measures are introduced.
- Supporting rural territories - which could be fertile ground for new, alternative mobility services - in order to make the energy transition a positive, galvanising force in these areas.
- increasing the use of life-cycle analysis for transport projects.
- Regular evaluation of the measures taken to implement these principles in the transport sector.

3. Coordinating the national low-carbon strategy with the plans and programmes developed for the transport sector

At the national level, the following objectives will be taken into account:

- in the Multi-Annual Energy Plans (compatibility stipulated in the Energy Transition and Green Growth Act [LTECV])
- in the national strategy for the development of green mobility. This strategy sets out the national action plan for developing the alternative fuel market and creating the necessary infrastructure for these solutions to grow and thrive (Directive 2014/94 on refuelling infrastructure).
- in the investment programmes for transport infrastructure.

At territorial level, these objectives will be taken into account in:

- regulatory planning documents such as: Territorial Cohesion Plans (SCOT), Urban Transport Plans (PDU), Inter-Municipal Local Development Plans Incorporating Transportation (PLUi-D), Territorial Climate-Air-Energy Plans (PCAET);
- other planning documents: agreements made between competent authorities (e.g. guideline agreements), company travel strategies, inter-company agreements, administrative strategies etc.
- Regional Inter-Modal Development Plans, introduced by the Law on the Modernisation of Local Government and the Creation of Metropolitan Areas, which may be coordinated with the Rural Mobility Plans mentioned in the LTECV.
- The development of car-sharing facilities, as mentioned in the LTECV.

4. Special circumstances in the Overseas Departments

In terms of transporting goods, the development of the circular economy and short distribution circuits (for example bringing companies closer to the businesses whose products or waste they use) is a priority for cutting transport distances. The development of short circuits and local production to meet local consumer demand is of particular importance in France's overseas territories.

5. Monitoring-evaluation and indicators

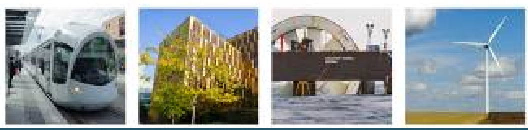
Managing the movement of people and goods:

- average daily distance travelled per person
- transportation of goods compared to GDP (t.km/€).

Source: transport accounts

Improving the energy efficiency of vehicles

- improving the energy consumption per km travelled for existing (overall average) and new vehicles and means of transportation.
- Government agencies using fleets of clean vehicles.



<u>Promoting alternative fuels and energy sources with low CO_2 contents (biogas, biofuels, electricity etc.)</u>

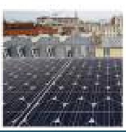
- Proportion of different fuel types, and CO_2 emissions per unit of energy. Life-cycle 'well-to-wheel' analysis.

<u>Modal transfer: using the form of transportation most suited to the environmental, climatic and economic conditions.</u>

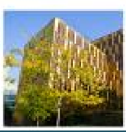
- shares of different forms in the transportation of goods and persons, long and short distances. Source: ENTD, EMD, SITRAM.

<u>Making better use of existing infrastructure and vehicles</u>

- average occupancy rate of private vehicles (ENTD household travel survey) and HGVs (ECHO study).







ii. Residential / Tertiary

1. Current state of affairs and carbon challenges

Direct emissions from the residential-tertiary sector account for around **20%** of France's total greenhouse gas emissions (cf. diagram below, Scope 1 emissions – in blue).[23] Since the turn of the millennium, in spite of an increase in the total population and heated surface area, emissions from fuel combustion have decreased slightly. If energy efficiency measures had not been introduced in the construction sector, these emissions would have increased sharply.

Overall emissions from this sector remain generally stable, given the increase in emissions derived from the use of fluorinated gases (for air conditioning). The latter should be brought under control by the European F-Gas regulations.

As well as direct emissions from buildings, there are also indirect emissions from energy production (energy and heat) (cf. Scope 2 emissions, in green on the diagram).[24] Taking these indirect emissions into consideration, the sector accounts for around a quarter of all French emissions. This total includes specific electricity consumption,[25] which represents only 18% of energy consumption in this sector, and less than 10% of greenhouse gas emissions, but has nonetheless increased by 150% in 20 years.

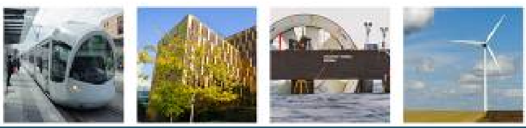
These emissions need to be set against those connected with the construction (and destruction) of buildings (cf. diagram, Scope 3 emissions shown in pink). While the latter account for just 10Mt of CO_2^e (equivalent to 2 - 3% of total French emissions), in the future they will represent a growing proportion of emissions from construction compared to emissions from the usage phase, across a building's whole life cycle. The steady increase in the proportion of GHG emissions from construction as compared to the usage phase (c. 50% for buildings built to RT2012 standards) requires us to adopt a whole life cycle approach to new buildings because, in 2050, buildings built after 2013 will account for almost 40% of total structures. This means that controlling the energy and environmental performance of new buildings is crucial to reducing our long-term impact on the climate.

Given that heating still accounts for a major share of energy consumption in this sector, and that energy performance requirements for new buildings have been greatly increased, energy used to heat existing buildings offers the most promising opportunity to further reduce greenhouse gas emissions from this sector (a big rise in serious renovation work is a key priority).

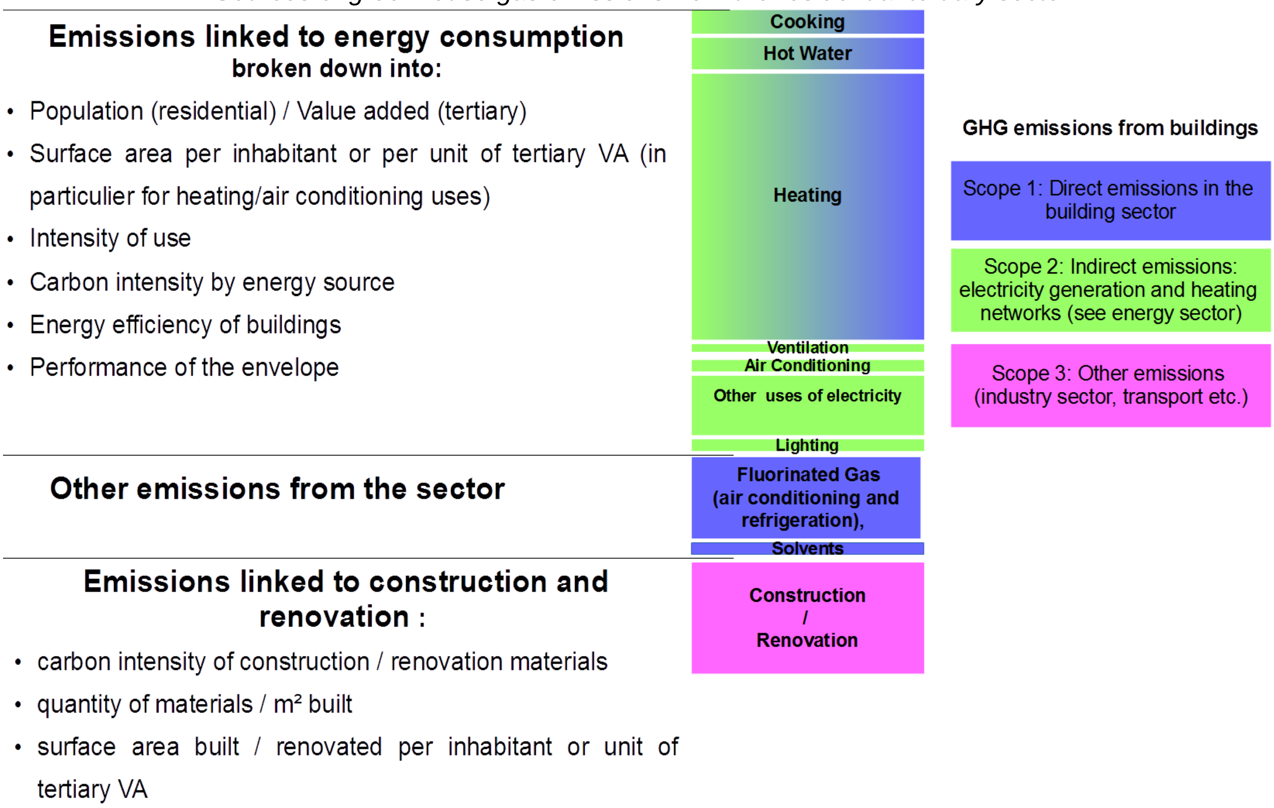
[23] Direct (or 'Scope 1' emissions): emissions linked to combustion for energy purposes in buildings (natural gas, oil, liquefied petroleum gas and coal), use of fluorinated gases and solvents

[24] These indirect (or Scope 2) emissions linked to energy production are, however, included in the sector's carbon budgets for 'energy production'.

[25] Specific electricity: the electricity required for services which can only be delivered by electrical energy (e.g. lighting and electrical appliances).



Sources of greenhouse gas emissions from the residential-tertiary sector



2. Strategy (2030 and 2050)

The Trajectory Committee (2012) calculated that reducing emissions from all sectors to a quarter of their 1990 levels by 2050 would require an 85% reduction in direct emissions from the residential-tertiary sector. The target of cutting direct emissions from the residential-tertiary sector in half within the time-frame of the third carbon budget is consistent with reaching this long-term objective.

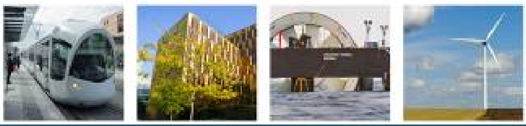
2.1. Reducing energy demand from the construction sector (Scopes 1 and 2)

The goal is for all existing buildings to be renovated to 'low-consumption building' standard by 2050. The reference scenario also requires renovation of the most energy-inefficient private homes (energy class F or worse) by the end of the third carbon budget.

a. For all buildings:

- Cutting down consumption by changing user habits and minimising specific electricity usage, with information and communication campaigns on energy-saving techniques as well as the use of price signals (individual heating bills in buildings where this is not already the norm, carbon tax added to energy prices etc.); The reference scenario forecasts a 4% reduction in specific electricity consumption within the time-frame of the 3rd carbon budget, based on the AMS2 projection.

b. For existing buildings:
We will need to take action on the following issues:



- Large-scale energy renovation of existing residential and tertiary buildings, focusing on thermal insulation, systems efficiency (heating, cooling, hot water, ventilation etc.). Reducing energy consumption in the residential-tertiary sector by 28% by 2030 (with reference to 2010 levels - this is the reduction forecast by the reference scenario) will require major renovations to 500,000 homes per year from 2017 onwards, with a target of reducing the energy used to heat buildings built before 2010 by more than 40% by the end of the period covered by the 3rd carbon budget.

- When replacing old heating systems, we need to encourage homeowners to avoid the most carbon-heavy solutions, i.e. those with average annual emissions of over 300gCO_2/kWh[26] of usable energy. This corresponds to the current average emissions from coal-only or oil-only heating. Users will be encouraged to switch to options which generate less GHG, particularly renewable energy sources. The reference scenario forecasts that heating systems with emissions greater than 300gCO_2/kWh will fall to below 4% as a proportion of total energy consumption in the residential-tertiary sector by the end of the third carbon budget.

c. For new buildings:
- New buildings must be designed to reduce GHG emissions, with life cycle analysis, enhanced energy performance targets (BEPOS) and widespread use of renewables. Effective implementation of these measures should allow us to meet our energy objectives.

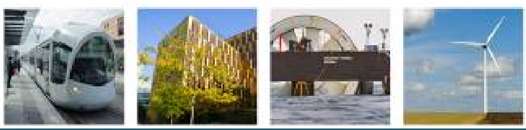
2.2 Reducing "grey"/Scope 3 emissions from buildings
This is a major priority both for renovation work and new-builds. We will need to:
- implement standards which take environmental impact into account, particularly greenhouse gas emissions, with life cycle analysis. The next update to thermal regulations for construction will include greenhouse gas emissions requirements, covering both the usage and building phases. Using bio-based materials is one example of a pertinent solution which can help reduce emissions and waste from construction and renovation. Bio-materials allow us to increase the amount of atmospheric carbon captured and stored by plants, and replace materials whose manufacturing processes generate GHG emissions. The can also be developed locally. (cf. § 3.3.iv forestry-biomass).

2.3 Implementing these objectives
These action priorities can be broken down into measures applying to new buildings and existing structures:

a. Helping project developers to improve their energy efficiency and reduce emissions from their buildings
- Promoting simple actions to reduce consumption and emissions (including pro-active management of consumption), supporting initiatives which encourage citizens to adopt green practices via information and communication campaigns.
- Incentivising households to perform environmentally-friendly energy renovations, developing public services in favour of energy performance via territorial platforms for energy renovation and the roll-out of the Energy Renovation Passport.
- Incentivising the owners of tertiary-sector facilities, particularly smaller businesses, to adopt an investment strategy based on improving energy performance and reducing emissions

b. Removing barriers to investment

[26] This figure for combustion emissions per unit of energy used in domestic heating will be revised downwards over time. It depends not only the carbon component of the energy sources used, but also the performance of heating systems.



- Supporting energy renovation for low-income households, a major priority in the fight against energy poverty
- Creating an array of additional incentives which are simple, coherent and stable in the long term
- Motivating the financial sector to come up with dedicated instruments (such as third-party financing solutions)
- Creating and deploying a guarantee fund for the energy transition
- Establishing long-term incentives for the social housing sector
- Making use of price signals (individual heating bills, carbon taxes incorporated into energy prices etc.).

c. Tightening the regulatory requirements for the energy performance of buildings, based on their technical and financial capacities:

- Planning ahead and publicising future regulatory requirements, with the use of quality labels and voluntary schemes
- Making the reduction of GHG emissions a key component of future regulations for new buildings, with life cycle analysis, enhanced energy performance targets (BEPOS) and widespread use of renewable energies at the appropriate scale.
- For new buildings, analysing all forms of environmental impact by making life cycle analysis a requirement for the design phase
- Revising the thermal regulations for existing buildings, increasing the performance requirements and taking recent innovations into account
- Expanding the scope of application of these regulations, with an obligation to include energy performance at every stage of a building's life cycle, along with compulsory renovations for tertiary-sector facilities

d. Professional skills for a low-carbon economy

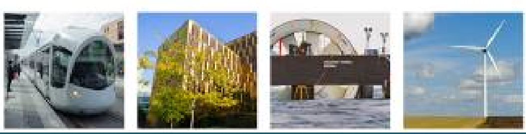
- Developing local chains devoted to the production and installation of low-carbon construction and renovation materials, particularly bio-based materials such as wood.
- Developing recycling activities for the materials and waste generated by construction, in line with life cycle analyses and in coordination with the national waste strategies.
- Encouraging professional training bodies to take a leading role in order to win the trust of commissioning clients and ensure the quality of the work done.
- Supporting training initiatives and labels, ensuring the consistency of the various actions conducted at national and local level
- Developing comprehensive renovation packages covering all technical, legal and financial aspects of projects for greater pertinence, quality and cost-efficiency.
- Ensuring that public-sector projects are exemplary, leading the way and helping to develop skills levels in the sector

e. Getting specific electricity consumption under control

- European directives on specific electricity consumption (ecodesign and labelling) allow consumers to rapidly identify the least efficient products
- We need to further increase the information available to consumers, with campaigns focusing on hidden consumption, websites highlighting inefficient devices, connected electricity meters (Linky) etc.
- In the tertiary sector, we need to promote active energy efficiency and minimise the use of air conditioning.

f. Expanding knowledge and supporting research and innovation (cf. support for research and development, Chap. 3.2.iii)

- Identifying different forms of energy usage and the reasons they change, in order to better



appreciate the gap between theoretical and observed consumption

- Supporting the deployment of new innovations, with ambitious initiatives such as the **PREBAT** scheme (life-size experiments) and the Future Investment programme.
- Rolling out a new asbestos treatment strategy - currently an obstacle to energy renovations - and a new plan on the digital transition for the construction sector.

Points to be watched closely:

- The massification of major renovation work will need to be monitored carefully. The availability of funding and the publication calendar for the government decree on tertiary renovation will require particular attention. We must also ensure that the support systems in place effectively reach their targets (financial instruments and advice/information services).
- While tightening up standards may be a structurally effective way of reaching our objectives, these standards must be backed up by additional instruments (technical efficiency checks, information, education, steering tools, pricing systems, obligations etc.) to reduce real consumption and minimise the rebound effect (heating temperatures, air conditioning, specific electricity use).
- The use of life cycle analysis is a key strategic measure which must be introduced in an educational, informative manner.

3. Coordinating the national low-carbon strategy with the plans and programmes developed for this sector

The priorities listed above must be taken into account in the following documents:

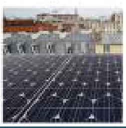
- **The National Investment Strategy** (designed to reduce energy consumption in private and public office buildings and homes, stretching until 2050 with revisions every 5 years): this strategy will include an action plan for targeted investments, based on technical and economic analyses of renovation opportunities and techniques.
- The list of research programmes to be developed under the PREBAT scheme.
- The National Biomass Strategy
- The Action Plan for Building Quality and the Energy Transition (PACTE)
- The digital transition strategy for the construction sector
- The R&D strategy for asbestos removal techniques, removing obstacles to major energy renovations

4. Special circumstances in Overseas Departments and regions

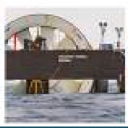
In France's five Overseas Departments and Territories, the residential-tertiary sector has an even more central role to play in reducing greenhouse gas emissions than it does on the mainland, on account of the heavy carbon dependency of the energy and electricity supplies. Electricity consumption is growing much more rapidly than it is in France (3 - 4% annually), with the bulk of production comprised of fossil fuels and other carbon-rich energy sources.
The actions to be taken will focus on reducing indirect emissions by cutting down on electricity consumption, specifically by limiting the use of air conditioning, since emissions from heating are virtually nil. Work is needed to protect buildings from sunlight, but also to increase the use of renewable energy sources in buildings and city blocks (solar heating for hot water, geothermal energy, heating and cooling networks etc.).

The recommendations listed above may be applied in the overseas territories, but some of them will need to be tailored and adapted to the local economic circumstances and climate.

1. To begin with, we will need a more detailed overview of the state of existing buildings and the potential energy saving opportunities they offer. In this way, we can develop initiatives tailored to the situation on the ground;





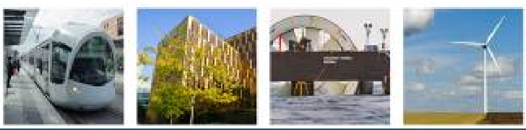

2. The thermal, acoustic and ventilation regulations applicable to new homes since 1st May 2010 (RTAA DOM) were designed to bring energy consumption under control, making buildings more comfortable in warm weather in order to reduce the need for air conditioning. We must look at the possibility of expanding the RTAA to create more comprehensive performance regulations, with more room for innovation and actions which apply to the tertiary sector and existing buildings. Voluntary environmental schemes are also to be encouraged;
3. In terms of energy renovations, financial incentives must take into account the specific climate conditions of the Overseas Departments from the outset. Energy renovations for social housing will be a major step towards the widespread improvement of heat management in homes.
4. Energy-efficiency training allowing professionals to obtain the RGE certificate will need to be adapted to the conditions of the Overseas Departments.
5. As in Metropolitan France, the development of bio-based materials is a major priority. Special attention should be paid to developing local production chains, creating permanent jobs and reducing reliance on imports.

5. Monitoring-evaluation and indicators

- Result indicators:
  - Energy consumption and greenhouse gas emissions associated with the residential-tertiary sector, by energy type, use and building type (residential/tertiary) (source CEREN, ADEME)
  - Energy consumption and greenhouse gas emissions from the construction sector (generated by construction and demolition) (indicator not currently available)
- Evaluation:

Monitoring renovation work - volume, type, efficiency - and the energy consumption of new buildings are the major priorities, as energy-efficiency measures represent a sizeable and structurally important component of the present strategy. Attentive monitoring of government policies will allow us to adjust them in response to developments observed during their deployment.

While energy renovation requires substantial public and private investment, it has so far proved impossible to effectively monitor the results generated by these investments because the process is deemed to be too complex and costly. This is largely a result of the huge variety of circumstances involved and the way data about private projects is scattered across numerous sources. Using the technical data supplied under the Tax Credit for the Energy Transition scheme could be one way of remedying this lack of visibility.



iii. Agriculture

1. Current state of affairs and carbon challenges

- **The global context: tensions, weaknesses, opportunities**

Despite the numerous sources of uncertainty at the European and international levels, we can identify several clear trends which will need to be taken into consideration in the future development of the SNBC. As well as the challenge of reducing greenhouse gas emissions, the potential for capturing carbon in agricultural land and the task of adapting to climate change and its effects, we must also take into consideration the question of food security and the specific requirements of agriculture in the face of climate change.

A strong increase in demand for food and non-food products
The global context will open up major opportunities for agricultural operations, with a sharp increase in demand for food and non-food products.
For example, combined analysis of the current estimates for demographic growth, economic growth and the nutritional transition leads the FAO to predict a 60% increase in global agricultural output by 2050. An even greater increase is predicted in livestock farming and plant oil production. This increase in demand for food should be echoed by an increase in demand for non-food products. These general trends conceal some genuine opportunities (rise of middle classes with a greater interest in the quality of products) as well as areas of fragility (stubbornly high levels of poverty which suggest that food security will not be an absolute certainty in 2050).

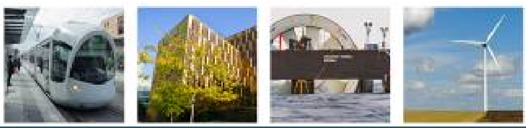
Vulnerability and tensions affecting resources
This necessary increase in agricultural output will come in a context of growing tensions over land and water resources, as well as other strategic resources which are often unevenly distributed. These multiple tensions will exacerbate existing weaknesses in the world's food systems, at a time when environmental pressures (biodiversity, pollution of soils and water) are also increasingly troublesome. Climate change will further aggravate these vulnerabilities, exacerbating tensions in countries already struggling with problems of food security.

Impact of international trade on food system, and growing interdependence
Last but by no means least, the planet's food systems are becoming increasingly interdependent, particularly via international trade and the liberalisation of markets for foodstuffs and non-edible agricultural goods produced from agricultural raw materials. Moreover, many emerging nations will soon come to play a more and more prominent role in a global market less and less dominated by Europe and North America.

More than ever before, we will need to design our national agricultural strategy in this global context. Carbon footprint and environmental impact are particularly pertinent indicators in this sector, which need to be incorporated into a multi-criteria approach in order to offer a comprehensive response to the many challenges facing the agricultural sector. At a more general level, in order to adequately respond to the global array of challenges and interactions listed above, carbon intensity is another key indicator.

- **The national context**

Current state of affairs
French agricultural production (excluding forestry and the food industry) accounted for 3.9% of



GDP in 2013, and around 730,000 jobs.[27] In 2013, total usable agricultural space covered 28.8 million hectares, or 52.5% of the total surface area of Metropolitan France (45.4% including Overseas Departments). This land is planted primarily with arable crops and oil protein crops (45.4%) and forage (49.6%), the latter accounting for 89% of grassland. France had the largest number of cattle of any EU country in 2013, with 19.1 million head of cattle of which 3.7 million were dairy cows and 4.1 sucklers.[28]

In France, the demographic forecasts drawn up by INSEE predict that the population will grow to 70 million by 2050, which may lead to an increase in demand for food. However, eating habits are changing and per capita meat consumption has declined in recent years.
In the meantime, the sector will also have to deal with growing demand for non-food products for use in energy production, green chemistry or bio-based materials.
But the primary obligation of the agricultural sector is to provide healthy food of good nutritional quality. Bearing in mind that, generally speaking, people have high expectations with regard to the quality of the food they eat as well as its origins, local production circuits, animal welfare, issues of food security and the positive external effects of agriculture (environment, landscape etc.).

Breakdown of greenhouse gas emissions from the agricultural sector

In 2013, greenhouse gas emissions from France's agricultural sector accounted for 21% of the country's total man-made emissions, some 92.1 Mt of CO_2 (Kyoto format, CITEPA 2015). These emissions fell by 6.2% between 1990 and 2013. 43% of these emissions are nitrous oxide (N_2O) derived from nitrogen-based fertilisers and animal waste, along with 42% methane (CH_4) produced by enteric fermentation in grazing animals, the decomposition of animal excrement in anaerobic conditions or the incomplete combustion of organic matter.[29] Energy consumption on farms also accounts for 12.6 $MtCO_2$ (CITEPA 2015).
Agricultural land also gives off CO_2 on account of the way it is used. These emissions were estimated at 10 $MtCO_2$ for the year 2013 (CITEPA 2015, UNFCCC inventory).

Greenhouse gas emissions from this sector are, by definition, diffuse: they are the product of 500,000 farms covering some 29 million hectares. They are the by-products of biological processes which still require further research, with very high levels of uncertainty (as much as 200% regarding nitrous oxide emissions at national level) which cannot be entirely brought under control. Furthermore, the mechanisms at play act in sometimes contradictory fashion when we take into consideration the induced effects on direct emissions, yields, available produce, indirect emissions, the environment etc.
These mechanisms, and indeed agriculture itself, are closely connected to the climate.
Finally, consumption connected to agricultural land leads indirectly to greater pressure on remaining land, leading to the release of carbon, particularly when artificialisation is involved.

- **Challenges facing the agricultural sector**

High stakes for the agricultural sector, closely linked to the general context

Decisions taken in the agricultural sector must be coherent with the national effort to reduce GHG emissions, while also satisfying a number of other criteria:

- guaranteeing food security;
- protecting public health, in terms of food quality and in terms of the effects of agricultural practices on farmers;

[27] In 2012. Source: Agreste France, Mémento 2014

[28] Source: Agreste France, Mémento 2014

[29] Cattle accounted for 82% of total methane emissions from French farms in 2012

- protecting the environment and natural resources, water, soils, air, biodiversity, preserving the landscape and guaranteeing animal well-being on farms;
- protecting jobs and competitiveness (in the EU and internationally) for agricultural businesses, which are often small, at a time of liberalisation in agricultural markets;
- helping these businesses to adapt to climate change;
- harmonious development of rural areas, protecting our gastronomic heritage;
- supporting the bioeconomy and maintaining the supply of non-food products (energy and materials);
- fighting against the reduction of agricultural land.

Five major factors which shape these challenges

- farming systems and practices, which can vary greatly in terms of the GHG emissions generated to produce a given quantity of agricultural goods;
- rural development and land use;
- the overall efficiency of the whole chain which delivers food to final consumers, with countless opportunities to reduce waste and indirect emissions;
- dietary habits, which determine the nature of the demand placed on agriculture;
- techniques for adapting to climate change, allowing us to maintain or improve production systems.

The importance of taking the risk of 'carbon leakage' into account
Fluctuations in final internal demand for food products need not necessarily lead to changes in greenhouse gas emissions from the French agricultural sector. For example, we may instead see outsourcing of production systems or an increase in exports (or a reduction of imports), both of which will have knock-on effects on emissions outside the country. We must therefore take emissions outside France into account when drawing up our carbon accounts.
All the more so since the risk of carbon leakage is very high in this competitive sector: if GHG reduction measures were to reduce the competitive capacities of farms, the risk of production going offshore is significant. The actual effect may thus be the opposite of that intended, as producing food overseas can generate even more greenhouse gas emissions.

Synergy and opportunities from green growth The low-carbon economy and the efforts required to implement this strategy must also aim to boost growth and employment in all sectors, including agriculture. Above and beyond the general boost to GDP, agriculture occupies a special place in the green growth process and will be instrumental to the success of the SNBC. The sector presents numerous opportunities in this respect: steering domestic demand towards local supply chains with greater added value, nurturing demand for bio-based products for bio-materials, green chemistry and energy products. The obstacles involved (economic, social and environmental) are complex, but French agriculture is well-placed to overcome them in terms of the human, technological and natural resources at its disposal. Maintaining and expanding the diversity of the production system will help to foster the emergence of effective activities in all areas, including initiatives to reduce carbon intensity.

1. **Strategy: Reducing greenhouse gas emissions and increasing carbon capture with the development of an environmentally-sustainable agricultural sector**

The general direction outlined in Chapter 2 should be interpreted pragmatically and adapted to the

circumstances of different economic sectors and, where applicable, regions.
It is on this scale that detailed assessment is required of the various joint benefits and impacts, adopting a multi-functional approach. In this respect the national objectives are merely advisory.
Evaluation and analysis of the potential for progress at this level, part of the process of producing action strategies for the agricultural sector, will allow us to more effectively measure the impact of the SNBC ahead of its next revision (to come into force on 1st July 2019).

b. Steering agricultural production towards agro-ecology

Our primary objectives are to reduce N_2O emissions by reducing the use of nitrogen-based fertilisers, to reduce CH_4 emissions by using animal effluents to produce energy and adapting the feed given to grazing animals, to capture carbon in soils and biomass, and to replace fossil fuel emissions with energy from biomass.

Enhanced implementation of the agro-ecology project
Meeting these objectives while also handling the challenges described above will require us to take the predicted effects of current policies into consideration: CAP (greening and second pillar), the end of milk quotas, more support for livestock farmers, the Organic Ambition strategy, the protein strategy and the enhanced implementation of the **agro-ecology project**:

- optimisation of the nitrogen cycle, increase in low-input circuits and replacement of mineral fertilisers with organic alternatives; *reduction of the nitrogen surplus, particularly via the development of low-input circuits and the optimisation of dosing and substitute treatments*. *Average guideline target: -30UN mineral/ha (units of mineral nitrogen) in 2035 compared to 2010*, for equivalent yield;
- increasing the duration of crop rotation periods, diversifying crops and planting more legumes;
  - *Guideline target: more than 2M ha of legumes by 2035, of which 900,000 ha of large protein-crop farms*
- protecting permanent grassland;
  - *Guideline target: restricting the reduction in permanent grassland to 490,000 ha between 2010 and 2035*
- developing agro-forestry, hedgerows and other agro-ecological infrastructures;
  - *Guideline targets: 700,000 ha of hedgerows and 120,000 ha of agro-forests by 2035*
- developing forms of arable and livestock farming with higher added value: organic agriculture, quality labels, environmental certifications, other forms of accreditation, new sales and distribution techniques etc.;
  - *Guideline target: 15% of arable UAA (25% of total UAA) to be converted to organic agriculture by 2035.*
- soil coverage and increasing the proportion of organic matter in our soils;
  - *Guideline target: catch crops accounting for 80% of spring crops by 2035*
- moving towards protein autonomy and adjusting animal feed to more closely reflect their protein requirements;
  - *Guideline targets: developing legume crops (see above) and reducing the protein rations provided to over 50% of dairy cattle by 2035*
- deployment of agricultural methanisation;
  - *Guideline target: 40% of usable excrement to be methanised;*
- boosting farms' energy performance by making them more efficient (buildings, materials and equipment) and replacing fossil fuels with renewable energy sources.
  - *Guideline target: 35% reduction in energy consumption by 2035, compared with 2010 levels*

Better tracking and valuation of the work done
We must improve our tracking of the GHG impact of agricultural practices, to ensure that it is accurately reflected in the national emissions inventories. We also need to closely monitor the economic impact of the changes we are promoting. We must also continue to recognise the value of the work done in agriculture in terms of quality of produce and carbon storage.

Developing our bio-economy strategy
The measures included in the agro-ecology project aim to establish conditions conducive to the development of the bioeconomy. The diversity of agricultural production and the promotion of agro-forestry can help us to boost the economic performance of farms while also replacing fossil fuels with more widespread use of biomass for energy and materials. The agricultural sector can also help to supply the energy, materials and chemical sectors with biomass materials. This contribution must not come at the expense of other purposes (particularly food production, which remains the primary purpose of agriculture), nor upset the equilibrium of production systems. We must therefore foster the development of efficient (economically and environmentally) supply systems which allow us to make the best possible use of bio-resources. We thus need to encourage the planting of intermediary crops, effective use of excess crops not required to maintain the agronomic quality of the soil or for animal feed, as well as low-carbon crops and crops requiring few inputs.

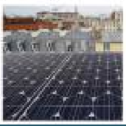
A guarantee of sustainable land management
The shrinkage of agricultural land must be stopped in the long term, and heavily reduced by 2035, in line with the development recommendations for our regions and urban areas (cf. §2.3).
For agricultural land which has been temporarily abandoned, we will need to find innovative solutions to ensure the **sustainable management** of resources and make use of their productive potential in various ways (food, materials, energy, chemicals etc.).
Appendix 7 on land usage and the categorisation of land and forest resources (UTCATF) provides further detail of their potential for carbon mitigation. This appendix also includes details of current and planned policies and measures for the management of pastures and cultivated land, and their impact.

a. Taking food production into consideration

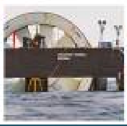
Stepping up the fight against food waste
The fight against food waste is an important aspect of reducing greenhouse gas emissions and our carbon footprint. Reducing food waste must be a top priority for public and private initiatives.

Developing local, seasonal distribution circuits
The development of local, seasonal distribution circuits will help us to reduce the environmental impact of transporting food, promoting local agriculture and protecting jobs. We need to adopt a comprehensive approach to analysing the benefits of such circuits. With regard to greenhouse gas emissions from the transport sector, we must take care to include the impact of the final few kilometres in the chain, which can be considerable. Information and education campaigns will be required to convince consumers of the benefits of eating a diverse array of locally-sourced, seasonal, high-quality foods (PDO, PGI).

Influence of eating habits on food production
Actions will be taken to promote a balanced, diverse diet. These actions may focus on the food products supplied to collective canteens (in the public and private sectors), promoting seasonal, local produce of certified quality and, where possible, organic status. This could have clear benefits for agricultural producers. Promoting the nutritional values of legumes could also have a positive impact. If livestock farming were to suffer as a result (which is not necessarily inevitable, given the






potential for exports), the preferable solution would be to compensate for the lost volume with an increase in quality. It is highly important that we protect the equilibrium and specific character of our agricultural land by maintaining livestock farms which make effective use of pastures that also act as carbon stores, while also reducing the need for mineral fertilisers thanks to the availability of manure.

b. Planning ahead for combined effects with other sectors

Environmental issues in synergy with the climate challenges
Agro-ecological systems offer various shared benefits: protecting water quality, preserving biodiversity, improving soil quality etc.
These factors help to increase the resilience of agricultural systems to climate change, which is another important factor in protecting farms, employment and output.
In order to consolidate these gains, we will need to develop initiatives to better appreciate and promote the environmental benefits of agriculture.

Land use
Fighting to stop the loss of farmland will necessarily have knock-on effects for urban development and infrastructures, as well as forestry stocks. Stemming the artificialisation of land is a major priority for the medium-to-long term, requiring strong leadership tools which must be developed in greater detail when the present strategy is revised (cf. §3.2.iv).

The availability and many uses of biomass
The growing diversity of uses for agricultural products, from food to energy production via materials of all sorts, makes it more important than ever to establish a firm understanding of the available resources and the interactions between the various production chains. We therefore need observational tools which cover all forms of biomass resources (agricultural resources as well as forestry, industrial and urban resources). In addition to soil fertilisation and animal feed, as much as 8 MtDM,[30] of leftover agricultural produce could be available each year[31] for non-food-related purposes Special attention should be devoted to preserving and increasing the amount of carbon stored in the soil.

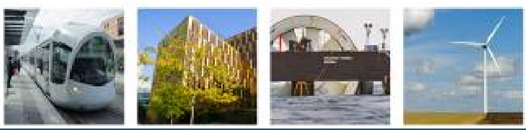
Contributing to the reduction of greenhouse gas emissions from other sectors
Reducing the use of nitrogen-based fertilisers will help to reduce the carbon footprint from food production. In 2012, 50% of simple nitrogen-based fertilisers used in France were imported.
The use of combustibles from renewable sources instead of fossil fuels, and the use of bio-based materials in lieu of more energy-intensive materials, can help to reduce greenhouse gas emissions from other sectors (transport, housing, industry etc.). This contribution will be monitored, in order to provide information on the contribution made by agriculture, in addition to reducing its greenhouse gas emissions.
Boosting protein autonomy and protecting permanent grassland will also have an impact on the production of livestock feed, in France and overseas.

c. Points to be watched closely

- When breaking this strategy down into sector-specific policies and plans (see next section), we must be sure to take into consideration the constraints and opportunities connected with reforms to the common agricultural policy.
- The concrete measures introduced to minimise land artificialisation will need to be monitored closely, as this is a major concern for the sector.
- Special attention should also be devoted to analysing the results of multifunctional

30 : MtDM = Millions of tonnes of dry matter

31 : according to the National Agency for Biomass Resources (ONRB)



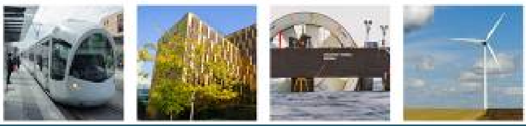
assessments (economic, social, environmental) of the development strategies implemented in each sector, focusing specifically on their efficiency in terms of emissions per unit of value added.

- When analysing the feasibility of new measures, we will also need to bear in mind the structure of farms (small businesses), as well as the investment capacity of agricultural firms and the prevailing economic conditions in the different production chains.
- Finally, and even more so here than in other sectors, the two major components of climate policy must be developed simultaneously in order to incorporate the challenges of adapting to climate change into the measures adopted for each production chain.

1. Coordination with sectoral policies and plans

The existing framework of sectoral policies and plans provides scope for action
Implementing the agro-ecological project and its sub-strategies already allows for numerous forms of action to reduce greenhouse gas emissions.
The 2014-2020 CAP reform paved the way for more effective consideration of climate change and greenhouse gas emissions, with both the 'greening' of the first pillar and the reinforcement of the second pillar. The regionalisation of the second pillar has also opened up more room for manoeuvre at territorial level, allowing us to tailor our actions to local requirements.
Last but not least, all sectoral plans for agriculture and food must incorporate targets for reducing greenhouse gas emissions during their next update (Regional Rural Development Rural Programme, Regional Climate-Air-Energy Plans, National Food Programme, regional food projects, national health and nutrition programmes etc.).
See Appendix 7 for more details on current policies

The need to step up our efforts in order to meet our targets
These recent policies focus on the period up to 2020, and we will need to go much further in order to hit our targets for 2050 by pushing for stricter requirements (in negotiations on the future of the CAP, in order to avoid distorting competition at the European level), investing more in innovation, training and information, exploiting opportunities for synergy between public policies and encouraging experimentation by all stakeholders (government, local authorities, professional bodies, NGOs etc.).
The government must promote technical innovation (in equipment and in terms of the precision of agricultural practices) as well as institutional and organisational innovation, with new instruments born of ground-level experiments and sharing of best practices.
Scientific research is expected to yield strategic breakthroughs, allowing us to develop economic tools which recognise and promote the environmental and social contributions of agriculture. We must aim to take the carbon content of agricultural produce into account (via life cycle analysis), master the complex task of measuring emissions (in light of the numerous biological and cultural phenomena involved) and produce suitable inventories and monitoring systems. Special attention should be devoted to preserving and increasing the carbon content of our soils, supporting the new initiative launched by the Minister for Agriculture ahead of the COP21 conference in December 2015: "4 for 1000: soils for food security and the climate." This initiative involves two major actions: an international programme of scientific research and cooperation, and a coalition of stakeholders committed to soil preservation.
A considerable amount of training and technical advice will be required to encourage the identification, optimisation, deployment and spread of innovative agricultural techniques and practices. Agricultural training must integrate these issues into its programmes from the outset, as must farmers when planning for their future.
Finally, reorganising the chains upstream and downstream of farms could help with cost abatement.



2. Monitoring-evaluation and indicators

The following indicators will be monitored,[32] though some of them require further fine-tuning.

Dealing with nitrogen

- Existing indicators:
  - use of nitrogen-based mineral fertilisers (compared with national nitrogen surplus);
  - sales of mineral fertilisers, proportion of imports.
  - legume cultivation;
- Indicators to be implemented or fine-tuned
  - Factors determining emissions from the fertiliser industry, not necessarily the same in France and elsewhere;
  - Real N_2O emissions from nitrogen-based fertilisers in mineral and organic form, and methanisation products

Reducing methane emissions

- Existing indicators:
  - nutritional breakdown of animal feed
- Indicators to be implemented or fine-tuned
  - quantities of animal effluent methanised;

Carbon capture in soils and biomass

- Existing indicators:
  - surface area of permanent meadow land;
  - surface area planted with catch crops;
- Indicators to be implemented or fine-tuned
  - carbon capture in farm soils
  - surface area devoted to agroforestry;

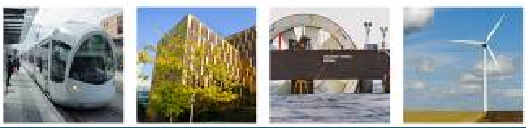
Reducing direct and indirect CO_2 emissions

- Existing indicators:
  - energy consumption by agricultural operations;
- Indicators to be implemented or fine-tuned
  - flows of non-forest biomass to materials and energy uses (MtDM/year) [broken down to show major sources and outlets];
  - rate of recycling in bio-based activities;

Cross-cutting indicators

- territorial emissions;
- indicator for the carbon intensity of agricultural production by unit of value added;
- surface area of artificialised land;
- national consumption of animal protein, plant protein and calories;
- measurements of food waste;
- surface area devoted to organic agriculture;
- assessment of the cross-cutting contribution of agriculture to attenuating climate change (including substitution effects from bio-based activities - bioeconomy and bio-energies).

[32] As agricultural activity is highly sensitive to variations in the climate and the economy, these indicators need to be analysed in their proper context.



1. Special circumstances in the Overseas Departments

On a general level, the major priorities set out above will also apply in the Overseas Departments. The transition to agro-ecological practices will be of particular importance in these territories.

One of the specific challenges facing France's overseas territories is their exposure to extreme climate phenomena. We therefore need to develop our understanding of the predictable consequences for agriculture. Protecting the soil is especially important, in light of the impact of intense rain and the risk of erosion. In this respect, the preservation and planting of plant coverage or agro-forests will allow us to protect soils and preserve or increase carbon stocks. Improving the fertility of our soils will also allow us to reduce the pressure on wooded areas and reduce artificialisation.

Food production is particularly important, especially on the islands (but also in Guiana), as strengthening local agricultural circuits could lead to a huge decrease in reliance on imports. To achieve this goal, we must strengthen collective organisation and activities in order to nurture the development of local production.
Agriculture also makes a major contribution to the diversity of the energy mix, as sugar cane by-products are used to power generators in some regions. Projects are also in place to increase the methanisation of agro-industrial by-products (from rum distilleries and abattoirs).

These initiatives need to be supported, in order to develop a better understanding of the emissions mechanisms at work in the major crops (research into banana cultivation is in progress, and a similar project is scheduled for sugar cane). Little information is available for Mayotte and Guiana, and strengthening local observatories would help us to better understand the phenomena at work in these regions.

iv. Forests - wood - biomass

1. Current state of affairs and carbon challenges

- **The total surface area covered by forests in Metropolitan France** has grown sharply since the mid-19th century to stand at 16 Mha in 2014. The figure is believed to have been approximately 9Mha in 1830. Wooded areas have expanded by 7Mha since 1900. Between 1980 and 2000, for example, the average annual increase was around 68,000 ha. This expansion has been caused primarily by the natural colonisation of land no longer used for agricultural purposes.

- France has the largest forestry resources in Western Europe in terms of its potential as a 'carbon pump',[33] with gross annual biological growth of around 120 Mm$_3$ (total above-ground wood volume). Meanwhile, current **annual usage is only about 60 Mm^3**, more than a third of which is firewood burned in private homes. Private forests are widely scattered and widely underused. They account for 76% of the total surface area of forests in Metropolitan France.

- Non-forest sources of biomass (other trees, by-products from the timber industry, short rotation coppice, agricultural biomass, methanisable substrates, green waste etc.) represent another major opportunity.

- In the long term, our focus will be on the following four areas:
  1. substituting bio-based products for more energy-intensive materials,[34]
  2. unlocking the energy potential of bio-based products and waste products, which can replace fossil fuels;[35]
  3. carbon storage in wood and wood-based products;[36]
  4. carbon capture by the forest ecosystem;[37]

  When combined, these measures should allow us to compensate for between 15 and 20% of national emissions.

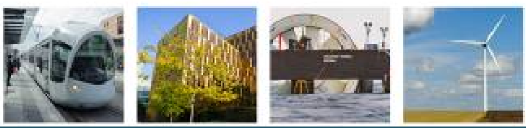
2. Strategy (2030, 2050 and beyond)

- We need to promote a multifunctional approach to forestry management, covering economic aspects among other things. In the long term, we should aim to **greatly increase the amount of wood used annually** and **maximise the value added** and efficiency of its uses, particularly by using by-products and waste from bio-based activities to boost recycling and energy production.

- Abandoned agricultural land needs to be **sustainably managed**, maximising its productive potential with high-added-value activities.

- Management of other biomass resources needs to be strengthened and optimised.

[33]Biological expansion, minus natural mortality.
[34]This allows us to cut down emissions from fossil fuels, and also opens up opportunities to reuse, recycle and optimise waste.
[35]In the long term this allows us to avoid burning fossil fuels, although in the short term the emissions from burning wood are greater than those released by fossil alternatives. This phenomenon is known as 'carbon debt' (delayed positive effect for the climate) or 'carbon investment' (immediate deduction), cf.
http://www.ademe.fr/sites/default/files/assets/documents/avis_ademe_foret-mitigation-cght-clim_vdef.pdf.
[36]This allows us to increase temporary stocks of artificial carbon, and thus to delay emissions.
[37]These stocks naturally fluctuate (but the volumes involved are substantial: biomass from plants and soils)



In order to capitalise on all forms of biomass,[38] while prioritising those uses which generate the most value added, we will need to encourage the use of timber (and other bio-based products) on a large scale in the construction sector, while developing the corresponding commercial and industrial chains. Developing these chains is our first priority - the work must begin now, but their development will necessarily be a long-term process. This ties in with our objective of exploiting the energy potential of under-used resources from the timber industry (this objective itself must be particularly sensitive to the needs of other sectors using biomass), in order to **limit our use of fossil fuels.**

Achieving these two objectives will require:

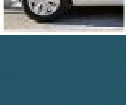
- a five-fold increase in demand for bio-based products (particularly wood-based products) and a production chain capable of meeting this demand. This is all part of a long-term and highly promising project to increase the use of alternative materials, already under way but in need of substantial reinforcement and support from public authorities and professional organisations (investors, developers, project owners, contractors, R&D, regulations, environmental performance labels etc.).
- more dynamic forestry management and regular renewal of forestry resources: managing uncultivated land, converting coppice land (particularly low-quality areas, with replanting where necessary),
- unification of small forest parcels (or at least their management),
- fiscal incentives for dynamic, sustainable resource management,
- efficient use of bio-based resources in industry, construction, interior design, packaging, energy etc.
- close monitoring of the sustainability of the activities involved, particularly their impact on biodiversity, soils, air, water and the landscape. All projects to develop the use of these resources should meet superior environmental performance criteria.
- enhanced and shared monitoring of the flows of materials and economic data,
- a deeper understanding of the potential uses of biomass, including for energy purposes, and the impacts on climate change of the development of energy optimisation efforts in the short, medium and long term, in the context of French forestry resources.

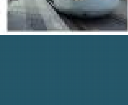
3. Coordinating the national low-carbon strategy with the plans and programmes developed for the forestry and biomass sector

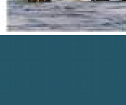
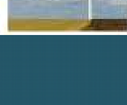
The long-term stakes and objectives identified above must be taken into account when drafting or revising the following documents:

- the **National Biomass Strategy and Regional Biomass Plans.** Beyond the major strategic orientations set out above, the level of mobilisation to be used as a medium-term objective is yet to be determined. It should be defined in this strategy and its accompanying regional plans, taking into account the requirements of the Multiannual Energy Plan for the period to 2023. The biomass strategy should specify the measures required to guarantee the sustainability of the resources involved - including imports, where applicable - and ensure the superior environmental quality of all activities involved, particularly in terms of biodiversity.
- the **National Bioeconomy Strategy**
- the **National Programme for Wood and Forestry** (PNFB), broken down into regional forest and wood programmes;
- the **'Wood Industries' strategy** drawn up by Nouvelle France Industrielle;
- the **Wood Construction Techniques Action Plan,** including measures to promote professional training, the rehabilitation of existing buildings (thermal insulation and

[38] Biomass from forests, farmland and trees outside of forests (roadsides, urban trees etc.), by-products of the wood industry (HHV chips, black liquor etc.), short rotation coppice, agricultural biomass (straw, other by-products or residues, energy crops etc.), green waste etc.



expansion) and the use of hardwood timber in construction.

- the **National Plan for Bio-Based Construction Materials,** designed to support other forms of construction with bio-based materials (excluding timber) .
- The **National Climate Change Adaptation Strategy** (PNACC), taking into account the close synergy between adaptation and mitigation, particularly for our forests;
- the **Strategic Contract for the Wood Sector**, spelling out the measures included in the National Action Plan for the future of wood-based industries.

It will also be useful to take these factors into consideration in future budgets, since the fiscal context is of great importance to the forestry sector and can provide the owners of forestry resources with incentives to sustainably and actively manage this natural heritage. These include tools such as the tax incentive for forestry investments (DEFI); the forestry investment and insurance account (CIFA); the degressive rate of amortization for saws, production equipment and treatment systems used by the wood industry; conditions attached to tax relief for forestry assets or income; levying of the tax on unoccupied land and potential changes to the system; terms applying to Forestry Economic and Environmental Interest Groups (GIEEF).
These considerations should also be taken into account when deciding how best to use the **Renewable Heat Fund** managed by the ADEME.

4. Special circumstances in the Overseas Departments

The challenge of limiting deforestation while developing the wood industry

Production is thoroughly underdeveloped in the Overseas Departments (70,000 m^3/year in Guiana – equivalent to the output of a 10-15,000ha forest in Metropolitan France, 10,000 m^3/year in Reunion, a few m^3/year in other departments), but the local timber industry provides jobs (3rd largest sector of the economy in Guiana). The development potential of this sector is huge, in terms of self-sufficiency in timber, construction materials and biomass as well as job creation, while also preserving the environmental, social and protective/regulatory functions of forestry resources.

The scientific data currently available does not allow us to estimate the carbon sink potential of forests in the Overseas Departments, so a conservative hypothesis of a neutral impact has been used. However, figures are available for afforestation/deforestation, and Guiana and the Antilles are net emitters. Proportionally to the surface area of their forestry resources, they are France's most heavily-emitting regions. The inventory submitted to the UNFCCC under the terms of the Kyoto Protocol shows that deforestation in Guiana accounts for 15% of total deforestation (approx. 5000 ha/year), but over 45% of GHG emissions.

The main action priority in the Overseas Departments is afforestation/deforestation. Limiting deforestation is a matter of more effectively managing authorised land clearing and strictly policing illegal clearing (clandestine gold prospecting, agriculture and construction). We also need to consider increasing reforestation efforts, including new planting programmes. This will depend on the development of the local wood sector, both to provide wood products (particularly for construction) and also to replace fossil fuels with forestry biomass.

5. Monitoring-evaluation and indicators

We will need to establish a system to monitor the implementation of the major strategic actions in this sector, making use of the indicators supplied by the National Wood and Forestry Programme as well as the work of the ONRB's Wood & Forestry Module and the Joint Economic Monitoring initiative created by the wood sector (these resources are currently in the launch phase).
This could involve scheduling regular studies (frequency to be determined) focusing on a number

of subjects. We will also need to define new indicators, in order to keep track of:

- the optimisation of the 'carbon pump' effect (the phenomenon whereby carbon from the atmosphere is captured by ecosystems);
- the efficacy, in terms of climate change mitigation, of making use of the biomass generated by this 'carbon pump' (and particularly a macro indicator for the wood-forestry sector)

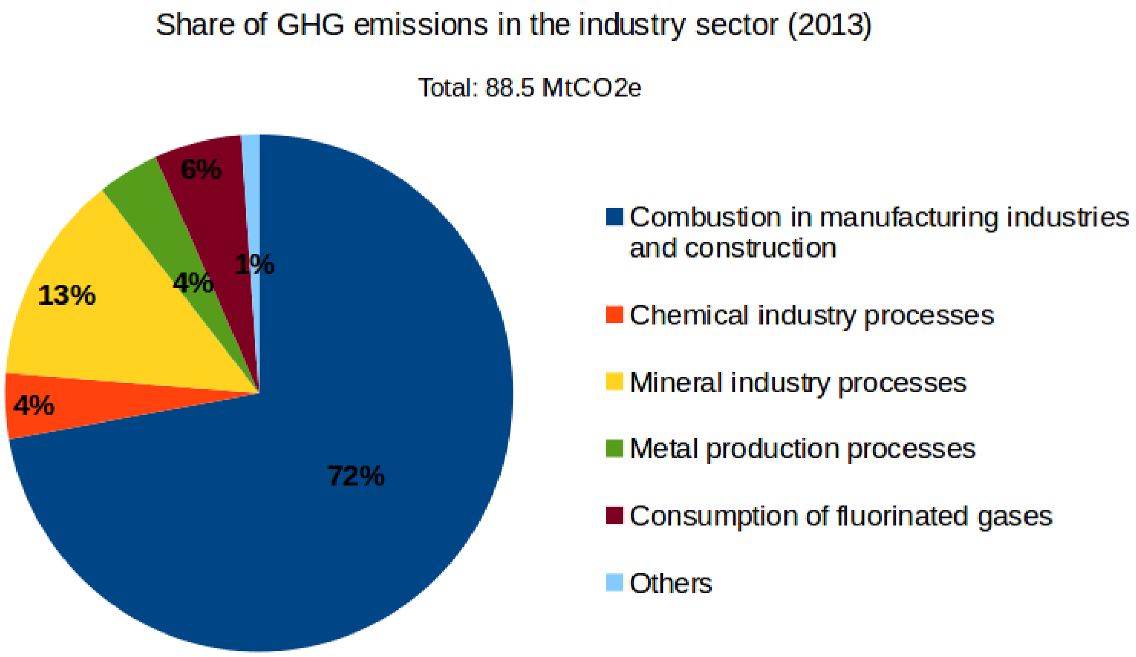
Pertinent indicators for these criteria, as well as the time-frames involved, are the subject of their own detailed chapter, as well as the UTCATF appendix.

Furthermore, the sustainability of the resources used and the environmental quality of the sector as a whole must also be monitored closely. Sustainable forestry management indicators could be useful in this respect. France also supports the creation of a European scheme to monitor the sustainability of solid biomass, with procedures and criteria which would allow us to guarantee the sustainability of all biomass used within our country (even if it is imported).

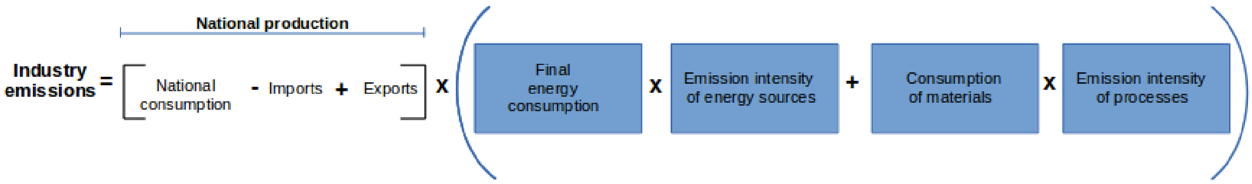
v. Industry

1. Current state of affairs and carbon challenges

Emissions from industry account for 18% of France's total greenhouse gas emissions. These emissions have dropped by 27% since 1990 (see Section 1.1 for an explanation of the reasons for this fall). 75% of these emissions are covered by the European Emissions Trading Scheme (EU ETS).



Factors which determine the level of industrial emissions:

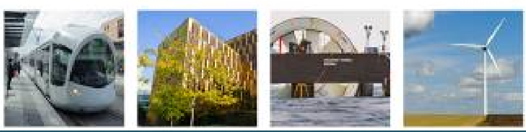


Key messages:

The Trajectory Committee (2012) calculated that reducing emissions from all sectors to a quarter of their 1990 levels by 2050 would require an 85% reduction in direct emissions from the industrial sector. The target set in the third carbon budget is consistent with reaching this long-term objective.

The transition to a low-carbon industrial sector by 2050 will involve (in decreasing order of priority or chronologically):

- energy efficiency to drive down the energy and materials consumed to make products;
- recycling, reuse and energy recuperation to minimise consumption of energy and materials;
- energy substitution in order to reduce the prominence of high-emission energy sources as a proportion of overall industrial consumption;
- the development and deployment of carbon capture and storage (CCS) in the long term, in order to reduce the GHG intensity of energy generation and industrial processes.



2. Strategy (2030 and 2050)

Emissions reductions will be driven by the following actions:

European and international level

- The European Union Emissions Trading Scheme (ETS): The 'cap and trade' programme introduced by the ETS is based on setting an ambitious emissions target for the European Union (-1.74%/year between 2012 and 2020, then -2.2%/year between 2020 and 2030), allowing us to achieve a 43% reduction on 2005 levels by 2030. With reference to this maximum value for emissions permitted across Europe as a whole, a carbon price will be introduced allowing all parties to optimise their investment strategy in line with their emission reduction capacities, easing time pressures. Emission reduction efforts can then be traded on the European market, which will determine the most economically beneficial actions for industrial stakeholders. While carbon prices are only one factor in the investment decisions of industrial stakeholders (who must take all costs into account, including raw materials and energy and their future predictability, with reference to the timescale of their investments), they at least permit us to set ambitious objectives and spur all parties into action with a clear price signal. Our governments will be responsible for ensuring that these investments create an environment conducive to the continued international competitiveness of our industries.
- In this respect, the creation of a carbon price system in the major economies outside the European Union is the best guarantee of fair incentives on a global level, in support of the green economy and the long-term competitiveness of European industry. During the interim period where equivalent measures have not yet been implemented in other major economies, measures must be introduced to protect against the risk of 'carbon leakage' (shifting production offshore to countries with less stringent environmental regulations, which is damaging to our economy as well as to the environment). This might include the granting of quotas to those sectors most at risk of carbon leakage, equivalent to 100% of their benchmark level (carbon intensity reference figures for products and sectors, as defined by the European Commission). This method has already proved to be efficient in limiting carbon leakage.[39] The current system will be improved when the EU ETS scheme is revised for 2020 onwards, and quota allocations should be introduced on the basis of each sector's actual exposure, particularly in terms of international trade and the impact of quota prices on value added.

At national level

The reference scenario expects the industrial sector to improve its energy efficiency performance to the tune of 20% by 2030 (energy used per tonne produced, compared with 2010 levels). The potential improvements for each sector are estimated at: 8% for steel, 13% for primary metals, 18% for chemicals, 19% for non-metal minerals, 29% for food and agriculture, 28% for machinery and 25% for other sectors. These figures are based on data from ADEME and CEREN;

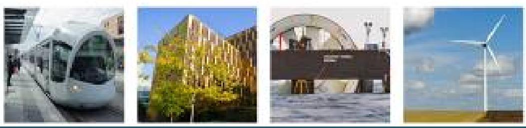
A. Taking action to reduce emissions from burning fuel for energy

- **Bringing energy demand under control by improving energy efficiency:**
    - from combustion
    - by product (Kwh/product)

thanks in particular to GHG accounts and energy audits, allowing us to define and quantify the available options and facilitate optimised decision-making.

Investment in energy efficiency may also be catalysed by an influx of third-party financing and guaranteed return on investment, thanks to energy efficiency services of proven quality.

[39] The absence of carbon leakage prior to 2013 is corroborated by various econometric studies. cf. in particular the 'Carbon Leakage Evidence Project', Ecorys 2013.



- **Reducing the greenhouse gas intensity of energy production:**
    - reducing fossil fuels with fuels that release less CO_2, such as gas (which can be renewable in the form of biomethane and power-to-gas systems), sustainable biomass or waste burning (especially with the development of refuse-derived fuels [RDF]), with respect for waste processing priorities. These sources can be used to produce heat for industrial processes. Alternatively, clean electricity may be used. The reference scenario predicts that the decarbonisation of the electricity mix could lead industrial stakeholders to use more electric power (to reduce CO_2 emissions). This would help us to achieve our target of a 30% reduction in final fossil energy consumption by 2030 (compared to 2012).
    - recuperating fatal heat for reuse in industrial facilities and via heat networks (cf. 3.vi Energy Production). By 2030, the reference scenario expects to see the reuse of 10TWh of heat annually, recovered from sources of waste heat over 100°C.
    - developing and deploying carbon capture and storage (CCS) and carbon capture and use (CCU) technologies suitable for use in the chemical industry, hitting our target of an 85% reduction by 2050.

B. Limiting the greenhouse gas intensity of products used:

- **Replacing high-emission materials with low-emission alternatives, such as bio-based materials**

- **Optimising the use of raw materials** (more efficient use of resources, less waste), **increasing recycling and reuse of materials.** The reference scenario for 2030 forecasts a 90% recycling rate for steel, 80% for aluminium, 80-85% for glass and 90% for paper.[40] This increase in recycling will contribute to the overall improvement in the energy efficiency of the sector (cf. infra).

- **Promoting the eco-design of products** in order to improve their durability, modularity, repairability and recyclability.

- **Replacing fluorinated gases (which have a high radiative forcing potential) with less harmful alternatives, increasing the recuperation of fluids from machines at the end of their life cycle, developing processes which require less fluid.** The reference scenario predicts a 55% reduction in emissions between 1990 and 2030.

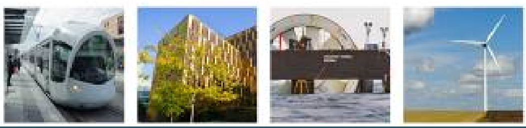
- **Improving manufacturing processes to reduce emissions at the source**: in the chemical sector for example, with processes which cut emissions at the source and avoid the need for further emissions (cf. the example of N_2O emissions in the fabrication of adipic acid (E355).

- **Developing CCS for industrial processes in sectors such as steel and cement.** The development of CCS could be galvanised by an increase in CO2 usage in chemistry or food production.

C. Cross-cutting factors:

- **Developing the circular economy:** In order to increase reuse and recycling and reduce the overall quantity of waste, it is vital that the industrial sector should promote eco-design and the reuse of its products. More generally, businesses have a crucial role to play in

[40] The potential sources of efficiency gains have been evaluated by the DGPR.



reducing consumption emissions (cf. 3.2.i) by manufacturing and selling products which perform better and emit less throughout their life cycle (products which are energy-efficiency, recyclable or reusable, services which replace products in the new functional economy etc.). The government can support this dynamic by creating labels which help consumers to identify high-quality products which will last for a long time and can be easily repaired. This will help to boost the already highly-active market for second-hand goods, and make repairs an important and well-structured sector of the modern economy, requiring considerable digital and logistical skills: a new industrial revolution.

- Extending and amplifying support for innovation: our goal must be to reduce the cost of decarbonising industrial processes and make technological options such as electrification and carbon capture economically viable (cf. 3.2. iii research, innovation and deployment).
    - In the medium term, the competitive capacities of industry will be heavily dependent on the ability of governments to implement innovative systems to support R&D, finance the development of businesses, define the structure of new chains, provide training etc.
    - At the European level, efforts to structure and support R&D - particularly the Strategic Energy Technology Plan (SET-PLAN) and the HORIZON 2020 research and innovation framework strategy - must be extended and amplified. Training programmes and their funding must be recognised as urgent priorities of the energy transition. The EU must nurture the emergence of new chains of excellence in renewable energies and low-carbon technologies, as well as energy efficiency. It is essential that the EU should assume a leading role in the development of industrial technologies to limit consumption, minimise emissions and phase out fossil fuels. In doing so we can stake out a prime position in the global market for low-carbon energy technology.

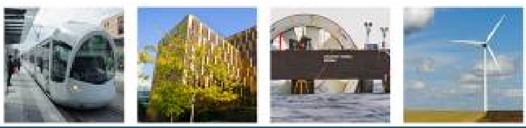
D. Implementation challenges:

- **Developing bio-chemistry and green production chains at local level**: this will help us to reduce emissions, thanks to the use of bio-based products, while also developing a stable industrial network and ensuring that it remains competitive in the long term. With this goal in mind, a certain number of organisational, regulatory and technical obstacles will need to be overcome by 2030.
- **Boosting the profile of the carbon price signal and ensuring that its future trajectory is clear:** Increasing the visibility and predictability of the carbon price signal will allow us to reassure industrial stakeholders of the profitability of their investments, making the carbon price a vital decision-making tool consistent with our environmental ambitions. Some industrial stakeholders are keen to see credible constraints introduced by 2030, backed up with immediate tightening of the regulations which govern the carbon market.
- In order to protect the competitiveness of those sectors which are most exposed to the risks of carbon leakage, the use of free quota allocations based on an ambitious benchmarking system is a satisfactory method whose implementation leaves room for further improvement. The current system of free quota allocations needs to be revised in order to:

    More effectively target those sectors which are most at risk, given that the total volume of available quotas for industry is decreasing;

    Establish a more dynamic allocation system which offers incentives for keeping production in Europe without penalising companies' growth, while also limiting windfall effects.

    Reform the system for compensating indirect costs, which is currently wracked with distortions, to make it harmonised, transparent and systematic. The goal is to compensate those sectors which are generally exposed to the risk of carbon leakage in terms of CO_2 costs being passed on via electricity prices.

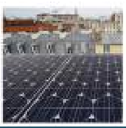


E. Points to be watched closely:

- **Investment 'lock-in' effects:** The life expectancy of industrial facilities is counted in decades, and technological choices will have long-term repercussions for emissions. In order to avoid harmful 'lock-in' effects, long-term visibility regarding environmental policies is essential.
- **Industrial competitiveness:** Some sectors are exposed to international competition, and we need to ensure that the instruments we use to drive down emissions do not also lead to deindustrialisation. Targeted, effective protective measures will be required, within the framework described in this strategy.
- **Efficient inter-sectoral mobilisation and use of biomass** (cf. 3.3. iv Forestry and Biomass)
- Boosting recognition of GHG accounts with recognisable labels.

3. Coordinating the national low-carbon strategy with other plans and programmes

- This coordination will be particularly important in the field of R&D (see Chapter 3.2.iii Research & Innovation Policy) and, more broadly, in the implementation of plans devoted to the modernisation of France's industrial capacities, such as the 'Future of Industry' strategy.
- The future development of measures to promote renewable energies and energy efficiency, such as the heat fund (inc. BCIAT) and energy certification schemes, must also take account of targets for the industrial sector and potential energy savings to be found in SMEs.
- The SNBC must be effectively coordinated with regional industrial policies and the new Regional Economic Development Plans introduced by the NOTRe Act.



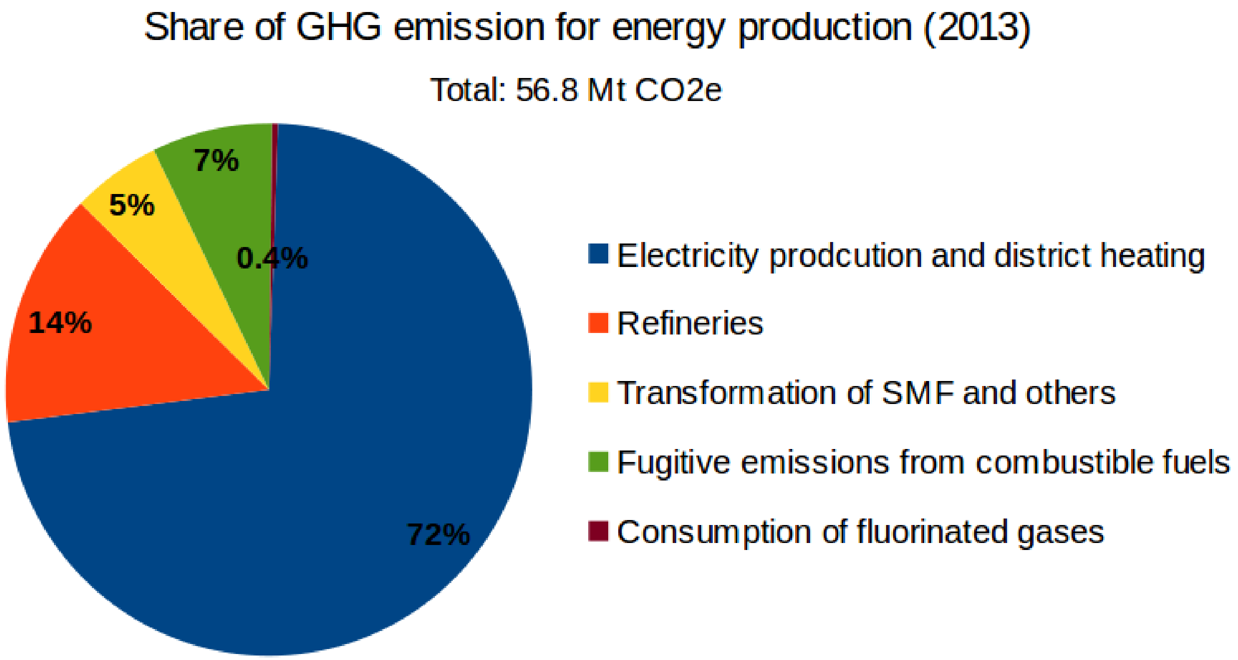




vi. Energy production

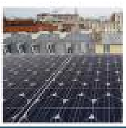
1. Current state of affairs and carbon challenges

Emissions from energy production currently account for 12% of France's greenhouse gas emissions, and 85% of these emissions are covered by the EU emissions trading scheme (EU ETS). These emissions fell by 27% between 1990 and 2013 (just over 30% when corrected for climate conditions).



Emissions linked to electricity production

- In light of the structure of France's power mix, electricity production has historically been low-carbon. In 2013, the mix was: nuclear 74% (77% in 2014), hydroelectric 13%, fossil fuels (coal, gas, oil) 9% (5% in 2014) and solar, wind and renewable thermal energies 4% (5% in 2014). Greenhouse gas emissions from electricity production thus originate from a small sub-section of the sector.
- **Structural phenomena** have propelled recent reductions in these emissions, and this dynamic should continue: a sharp decline in the number of coal-fired power stations in favour of renewable energies and stations which also run on gas, with much lower GHG emissions, as well as the rise of renewable energies and the success of energy efficiency measures.
- Annual GHG emissions are subject to sizeable fluctuations, which become proportionally more significant as the overall level of emissions declines. **Circumstantial phenomena** (mild or harsh winters influencing demand for heating, rainfall levels determining the level of hydroelectric energy available) thus determine the demand placed upon back-up energy sources.
- Finally, it is important to bear in mind that the operational viability of production facilities running on fossil fuels is also largely dependent on the interconnected European market, with complex border effects caused by a mixture of short-term (power station shut-downs, as seen in Belgium in late 2014) and structural factors (changes in the energy mix of our neighbours).







Emissions from district heating:[41]

- Emissions from this sector depend primarily on the sources of its energy. Fossil fuels accounted for 57% (42% natural gas, 9% coal and 4% heating oil) of the total output of France's 518 heating and cooling networks in 2013. The two major action priorities must therefore be to make the shift towards more renewable resources, and to improve energy efficiency.

Emissions from refineries:

- Since 1990, France's direct emissions have fallen by 32%. But this fall can be attributed to the closure of four refineries in France and the decline in our net output of refined products (-30% since 2007). This decrease is therefore not significant in terms of climate change mitigation. The decline of French production has been offset by an increase in imported products, which are refined (and thus generate emissions) in Asia or the Middle East. At France's remaining refineries, it is important to highlight the steady process of optimisation which has been underway since the 1970s, allowing us to achieve a CO2 intensity score which was close to the EU average in 2012. It receives very little attention, but this hard work illustrates the benefits of preserving French industry: tackling climate change is not just a matter of reducing our national emissions, we need to take the overall carbon footprint into account.

Other emissions from this sector:

- Fugitive emissions from combustible fuels, particularly methane, have been cut in half since 1990.[42] This can be attributed to the closure of several coal mines and processing plants. Emissions generated by the transformation of solid mineral fuels (SMF) and other fuel sources have fallen by 35% since 1990, as coke production has declined.

2. Strategy (2050 and beyond, 2030)

By 2050, our target is to reduce the emissions from energy production by 96% compared to their 1990 levels (Trajectory Committee, 2012), a 'Factor 20' improvement. This will mean:

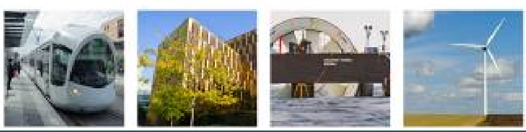
- **accelerating increases in energy efficiency** (Factor 2): reducing the overall energy intensity of GDP and getting a handle on total energy demand (priority will go to reducing the consumption of carbonised energy and switching to clean electricity).
- **radical decarbonisation of the energy mix by 2050 (Factor 10):** (reducing the gCO2/kWh ratio of electricity and heat networks). We must not forget that the ambitious targets set out in our reference scenarios are based on the assumption that there will be a widespread roll-out of carbon capture and storage (CCS) technologies by 2050. If this proves not to be the case, the decarbonisation of energy production will have to come from other sources, including other sectors of the economy.

<u>A. Managing and regulating demand:</u>

- Boosting **energy efficiency**, **focusing our efforts on carbonised energy sources**.
- Electrification
- Smoothing out **seasonal and daily consumption peaks**, in order to reduce the use of back-up (carbonised) energy sources to meet demand:
  - Developing **load management and offsetting capacities** (the MEP contains targets for the development of load management measures, making use of the opportunities offered by the installation of new 'Linky' connected meters)
  - **Coordinating these efforts with other public policies** when it comes to making decisions regarding different energy vectors, and particularly with regard to incentives

[41] District heating: Centralised heat production, for distribution to third parties via the grid.

[42] Fugitive emissions from the extraction, processing and distribution of solid, liquid and gaseous fuels.



for switching to electric power sources, in order to protect and even increase our capacity to control demand for electricity (e.g. the deployment of electric vehicles, guiding users to charging stations which are not powered by carbon-intensive energy, reducing the sensitivity of electricity consumption to temperature variations by reducing the proportion of electrical heating in homes etc.)

Target for **total** reduction in the consumption of energy from fossil fuels: -30% reduction by 2030 (from 2012)

B. Decarbonisation and flexibility of the energy mix:

B.1 Electricity production

- Keeping a handle on investments in fossil-fuel-fired power stations, given the life expectancy of these facilities and the ambitious nature of our emissions objectives:
    - Precautions must be taken to ensure that back-up power stations intended to help meet demand in peak periods do not end up supplying 'semi-basic' energy needs in certain years (the Energy Transition and Green Growth Act imposes a cap on their operating hours in order to ensure that our legally-declared greenhouse gas emissions targets are respected).
    - In order to meet our 'semi-basic' energy requirements, we must avoid investing in new power generation facilities running on fossil fuels. These will be of no use to us in the medium term, in light of the growth of renewable energy sources; in fact they could turn out to be an obstacle to the development of renewables.
    - With regard to combined plants running partly on natural gas, priority should be afforded to facilities which are sufficiently flexible to allow for a subsequent transition to combined production with renewable sources.
    - We need to plan ahead for the deployment of carbon capture and storage systems at any fossil fuel-fired power stations which may still be in operation by 2050 (retrofitting where necessary), taking storage considerations into account when selecting the location of new facilities.

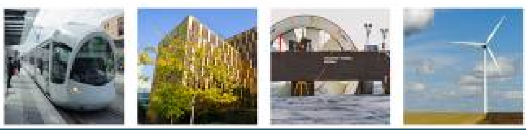
    ➔ Requirements in terms of new thermal resources will be covered in detail in the MEPs, in accordance with the **strategic orientations adopted in other sectors**, **supply security targets** (to which the capacity market also contributes) and the need for **flexibility in the electricity system**, within the limits imposed by the carbon budgets.

- Improving the flexibility of the system without increasing emissions:

In the long term, integrating renewable energies will require greater flexibility; in order to meet this requirement and guarantee the security of the energy supply, we will need to harmonise and optimise coverage for peak periods, demand management, storage and interconnections.

- ◦ We will also need to increase the flexibility of the hydroelectric energy sector, which can produce a substantial amount of energy at peak periods;
- ◦ We will develop intelligent storage networks, deploying reserves as and when required: week-by-week to compensate for intermittent wind energy production between now and 2030, day-by-day storage when solar power production reaches significant levels after 2030; transfers between energy systems (power-to-gas, power-to-heat);
- ◦ Another priority will be to develop interconnections with neighbouring countries in order to feed the renewable energy boom, in synergy with the EU energy strategy.

- In zones which are not connected to this network: developing non-intermittent renewable energy production



In non-interconnected zones (ZNI), specific solutions will be required in order to capitalise on the rise of renewable energies. On account of their limited size, these ZNIs do not benefit from the combined effects of geographical and temporal overlap we see on Metropolitan France, making intermittent supply a more serious problem. Non-intermittent renewable energies such as biomass and geothermal power are particularly well-suited to the demands of ZNIs, and should be encouraged.

The development of storage and demand management - rendered essential by the intermittent supply from wind and solar power facilities - will be particularly important to the success of the energy transition in the islands, helping us to reach our goal of full energy autonomy for the overseas territories by 2030.

<u>B.2 Heat networks</u>

- Steering production towards renewable heat sources and heat recovery: thermal renewables (biomass, geothermal etc.) and recovery of fatal heat (heat given off by industrial processes or thermal inertia in buildings)
- Developing district heating networks, allowing for greater use of renewable energy sources and more heat recovery

Our objective is for 38% of total heat consumption to be supplied by renewable sources by 2030, while also multiplying 5-fold the proportion of renewable and recovered energy in the heating and cooling networks by 2030 (from 2012 levels).

<u>B.3. European and international level</u>

- **<u>The European Union Emissions Trading Scheme (ETS)</u>**

The management of emissions from energy production will be primarily handled by the EU emissions trading scheme. As this is a Europe-wide programme, it requires no specific recommendations in this national low-carbon strategy.

The management of emission reductions in this sector will depend primarily on the evolution of the targets set by the ETS, and as such can only be envisaged on a European scale. National policies nonetheless have a vital role to play, facilitating the planned evolution of the French energy mix, in cooperation with our neighbours.

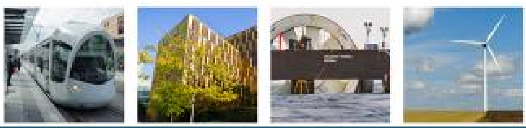
- **<u>Refineries</u>**

Above and beyond driving down demand for oil products (cf. section on transport, industry and construction), reducing the greenhouse gas emissions from refineries will require increased international cooperation. This sector is subject to intense international competition: the Nelson complexity index (the higher the score, the more competitive the refinery) and the reduction of sulphur content in fuels have both contributed to making refining activities more energy-intensive. Furthermore, the increase in the amount of "poor quality" crude oil on the market could lead to a further increase in emissions per litre processed.
In light of these factors, we need to make sure that the measures taken to reduce emissions in this sector do not simply lead to oil refinery operations being shifted offshore to other countries. This requires a comprehensive approach, above and beyond the national level.

3. Coordinating the national low-carbon strategy with the plans and programmes developed for the energy sector

- The Energy Transition and Green Growth Act (LTECV) stipulates that the Multiannual Energy Plan for mainland France must be compatible with the national low-carbon strategy (SNBC).

- This will be taken into account for:



- the specific Multiannual Energy Plans for non-interconnected zones
- the Regional Development, Sustainable Governance and Territorial Equality Schemes (SRADDET, superseding the current regional climate-air-energy strategies)
- the Territorial Climate-Air-Energy Plans (PCAET). This link may be indirect, if the SRADDET already incorporates the provisions of the national strategy.

4. Special circumstances in overseas territories

While emissions from electricity production in the overseas territories are relatively low in volume compared to those from Metropolitan France, the energy mix remains highly carbon-dependent (78% from classic thermal energy sources). The goal is for France's overseas territories to achieve energy independence by 2030. Our ambitious objective of achieving energy independence for these territories will require a thorough decarbonisation of electricity production, before we can think about usage transfers. The ZNI recommendations also apply in the overseas territories.

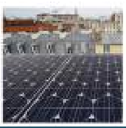
5. Monitoring-evaluation and indicators

As this sector is covered almost in its entirety by the ETS scheme, the strategic management of emissions will take place primarily at European level.

At the national level, the Multiannual Energy Plans will be the most strategically-important tools.

Most strategically significant indicators:

- greenhouse gas emissions from the electricity sector
- proportion of electricity production derived from the combustion of fossil fuels



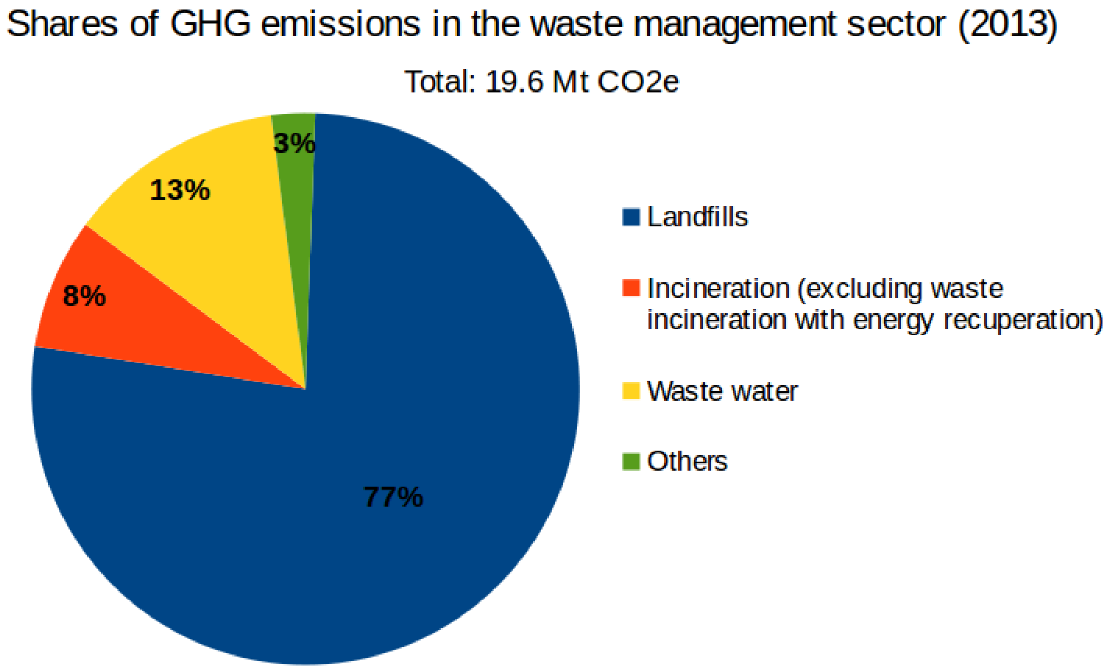




vii. Waste management

1. Current state of affairs and carbon challenges

The waste management sector accounted for 4% of France's total greenhouse gas emissions in 2013. Since 1990, these emissions have increased by 13%. Methane from waste storage sites accounts for the majority of these emissions (75%).



2. Strategy (2030 and 2050)

As per the recommendations of the 'Trajectory Committee' (2012), the objective for the waste management sector is a -75% reduction by 2050.

With this goal in mind, our long-term action priorities (in decreasing order of precedence) will be as follows:

1. Reducing the volume of waste produced by preventive measures (ecodesign, extending the lifespan of products, repairs, minimising food waste) and reuse (the circular economy),
2. Making better use of waste material which cannot be avoided (recycling),
3. Using unavoidable waste which cannot be reused in material form for energy purposes,
4. Reducing methane emissions from landfills and treatment plants, particularly non-recoverable gas,
5. Stop incineration unless the energy is captured and used.

These five actions will be undertaken simultaneously. At stake here is the transition towards a more circular economic model, a paradigm shift from our current model of production and consumption (efficient use of materials, resources and energy; long-term value, more jobs).

Widespread sorting of organic waste by 2025 (Art. 70 of the LTECV) will be particularly important in reducing our greenhouse gas emissions. Special care must be taken over the technical and financial conditions of its implementation.

In the immediate short term, two actions derived from point 4 should also be highlighted:

- capture and flaring of gas emissions from landfills, for immediate use. The reference scenario predicts that the rate of biogas capture from landfills will increase from 38% in 2010 to 70% in 2030, and the rate of usage of this biogas will increase from 59% to 80%: these are strategically-significant measures for reducing greenhouse gas emissions from the sector.
- optimising the energy and climate performance of waste water treatment facilities, with strategic investments (production, collection and use of methane; recovering heat from waste water).
-

Points to be watched closely:

- The massive wave of home renovations will generate huge volumes of waste, including mineral materials (which can be reused in building and public works) and combustibles (which can be used for energy purposes).

3. Coordinating the national low-carbon strategy with the plans and programmes developed for the waste management sector

- Waste Management Plans (the Waste Plan for 2014-2020 should allow us to reduce GHG emissions by 2.8 Mt CO2 equivalent per year between now and 2025),
- National Waste Prevention Programme,
- the EMAA Plan (energy, methanisation, nitrogen independence)
- regulations for listed installations and instructions for their implementation (collection and treatment of methane from landfills),
- Master Plans for the Development and Management of Water, and national sanitation regulations, which will designate the treatment plants concerned and the resources to be put in place.

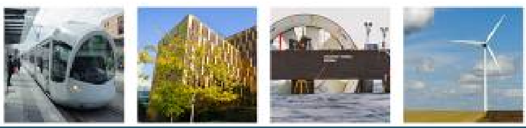
4. *Special circumstances in the Overseas Departments*

The most significant waste-related constraint in the Overseas Territories, as far as carbon emissions are concerned, is the high cost of transporting waste for treatment on the mainland and the impossibility of processing it on site, in light of the regulatory constraints imposed by the Basel convention. Further work is required to identify opportunities for pooling facilities with neighbouring countries, and questions arising from the Basel convention.

5. *Monitoring-evaluation and indicators*

Indicators included in the National Waste Management Plan

- monitoring methane collection from landfills
- To be determined, in the sanitation sector
- indicators from the EMAA strategy



Chapter 4: Monitoring the implementation of this strategy

4.1. Carbon budgets

i. The first three budgets

The first carbon budget will allow us to respect our commitments up to the year 2020.

The levels of the second and third carbon budgets take into account our objective for 2030, and are consistent with Europe's promised contribution to the international climate agreement of 2015, i.e. reducing greenhouse gas emissions by at least 40% (from their 1990 levels) by 2030.

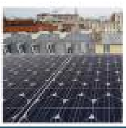
The reduction of emissions from those facilities which generate the most greenhouse gases will be managed at European level (via the EU Emissions Trading Scheme), with a separate target of a 43% reduction on 2005 levels by 2030.

In other sectors (transport, construction etc.), the target is to reduce European emissions by 30% from their 2005 levels by 2030. The manner in which these reduction efforts will be split between the different EU members will be finalised in 2017. This distribution will be based on the GDP per capita of each Member State, with adjustments allowing us to exploit the most cost-effective sources of potential reductions among countries whose GDP is above the European average. For the time being, the distribution of carbon budgets between the ETS and non-ETS sectors for the periods 2019-2023 and 2024-2028 has not yet been finalised. This distribution may be finalised when the EU Effort Sharing Decision has been agreed, or at the latest when the carbon budgets are updated in mid-2019.

The first three carbon budgets are as follows:

Period	**Carbon budget** (annual average, without net account of land usage at this time)*	sectors for which emissions are managed primarily at European level (**ETS**, excluding international aviation)	other sectors, for which France is bound by European and international commitments. (sectors covered by the EU effort sharing decision 406/2009/EC)
2015-2018	442 Mt CO_2eq	110 Mt CO_2eq	332 Mt CO_2eq
2019-2023	399 Mt CO_2eq		
2024-2028	358 Mt CO_2eq		

The greenhouse gas emissions accounted for above correspond to the totals reported by the French government to the European Commission as per our European and international commitments under the aegis of the United Nations Framework Convention on Climate Change, particularly in application of Article 7 of Regulation 525/2013. 525/2013. The geographical scope applied here corresponds to France's commitments under the second phase of the Kyoto protocol, i.e. emissions from the mainland, Corsica and Guadeloupe, Guiana, Martinique, Reunion, Saint-



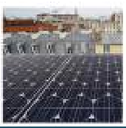




Martin and Mayotte as well as emissions from transport between these territories. Emissions from other countries and overseas territories are excluded, as are emissions from international aviation and maritime transport.

The position of agriculture and land usage in this schema requires further clarification. When determining the carbon budgets for the periods 2015-2018, 2019-2023 and 2024-2028, the emissions associated with land usage and changes (i.e. variations in the volume of carbon stored in the soil) and forestry activities will not be included, on account of the fact that the method to be used to quantify these emissions with regard to France's European engagements for 2030 have not yet been determined. Organic carbon capture associated with land use will be incorporated into the carbon budget for 2029-2033, scheduled for mid-2019. The accounting methods used in the implementation of the Energy and Climate Plan for 2030 will be applied here. The carbon budgets for 2019-2023 and 2024-2028 will also be revised to incorporate these emissions, without significant alterations to the efforts demanded of other sectors of the economy.

The distribution of the emissions reduction burden between those sectors primarily governed at EU level (the ETS and, depending on the outcome of future negotiations, some emissions from agriculture and/or land usage) and other sectors (for which France will be bound by commitments made to the EU) will also be clarified at this juncture.







ii. Guideline breakdown by sector and by type of gas

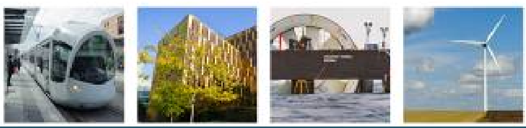
The burden of reducing emissions can be broken down broadly between different sectors of activity, and different types of gas:

Emissions (annual average) (in Mt CO_2eq)	1990	2013	1st carbon budget 2015-2018	2nd carbon budget 2019-2023	3rd carbon budget 2024-2028
Transport	121	136	127	110	96
Residential / Tertiary	90	99	76	61	46
Manufacturing Industry	148	88	80	75	68
Energy industry	78	57	55	55	55
Agriculture	98	92	86	83	80
of which N_2O	*44*	*40*	*37*	*35*	*34*
of which CH_4	*42*	*39*	*38*	*38*	*37*
Waste management	17	20	18	15	13
of which CH_4	*14*	*17*	*16*	*12*	*11*
Total annual average emissions	552	492	442	399	358
of which CO_2	400	367	323	288	257
of which N_2O	69	60	57	54	51
of which CH_4	71	44	42	41	40
of which fluorinated gases	12	21	20	16	10

This breakdown is given for guideline purposes only.

It is derived from the forward studies (cf. Section 1.2) conducted by a panel of stakeholders, experts and modelling specialists, particularly the Trajectory Committee (France Stratégie, 2012), as well as the hypotheses and results from the reference scenario, directly inspired by the AMS2 scenario derived from the climate-air-energy studies conducted by the Ministry for Ecology and ADEME in 2015.

It represents a fairly-balanced distribution of emissions reduction efforts, based on the political decisions described above (cf. Part 2.1). For each of these sectors, this breakdown also takes account of economical, technical and practical considerations such as the cost of mitigation, the inertia induced by previous or forthcoming investments, the level of organisation or federation of



the stakeholders involved, the potential difficulty of mobilising the necessary resources or changing behaviours etc.

As such, the carbon budgets presented here do not represent a rigid compartmentalisation of objectives for different sectors. They offer an initial sector-by-sector distribution intended to steer overall progress, with adjustments between sectors made wherever necessary. When reductions look likely to be smaller than expected in certain sectors, we will need to take measures allowing us to make more substantial reductions in other sectors. This breakdown is an essential component of the low-carbon strategy's arsenal of indicators, providing signals regarding the risk of not meeting our overall targets, and highlighting areas in need of corrective measures.

iii. Breaking down the carbon budgets into components reflecting annual emissions

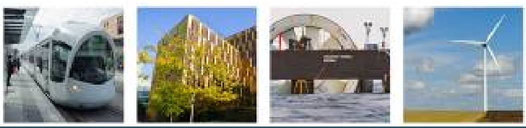
The emissions trajectory used as a point of reference for the carbon budgets can be broken down into annual targets:

Years	Indicative annual components (Mt CO_2eq)
2015	457
2016	447
2017	437
2018	427
2019	417
2020	407
2021	399
2022	391
2023	383
2024	374
2025	366
2026	358
2027	351
2028	343

Numerous circumstantial factors can justify year-to-year variations which stray from this guideline breakdown (climate conditions, economic outlook, fluctuations in the prices of different fuels on the international market etc.). As cold winters can lead to significant increases in heating demand, it is advisable to correct for these effects to ensure that the comparison between annual emissions results remains pertinent. Over the time-frame covered by the carbon budgets (four to five years), the effect of these circumstantial factors is less significant.

iv. Evaluating the implementation of carbon budgets

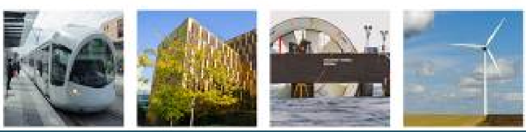
At the conclusion of each carbon budget period, the extent to which the budget has been respected will be assessed with reference to the most recent annual inventories submitted to the European Commission or the UN Framework Convention, with the exception of the last year in the budget period, for which we will use the provisional inventories submitted to the European



Commission.

If the greenhouse gas accounting system should change in a manner which requires previous emissions to be corrected by more than one percent, the balance of the carbon budget will be adjusted accordingly in order to ensure that the calculation methodology employed is consistent with the methodology which will be used to evaluate the results.

Analysis of the implementation of the low-carbon strategy and our adherence to carbon budgets must take the political context into account, as well as the actual capacity of the actions put in place to deliver the results expected of each sector. Managing the impact of these measures on the public finances is a key priority. A posteriori analysis should allow us to identify cost-efficiency and acceptability issues which were not accurately quantified when drawing up the original strategy.



4.2. Monitoring indicators

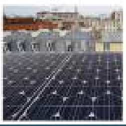
These indicators must be monitored annually or twice annually. They will be more effective within the framework of a cross-cutting analysis, taking the general and sector-specific context into account. It may also be useful to look at the European context and establish comparisons with other Member States. Guideline trajectories (with a few years' perspective, and as far as 2028) may also be of use. This is a draft version, which may be reorganised and restructured with the help of the committee of experts for the energy transition.

These indicators will be made public. They will be aimed primarily at the stakeholders involved in drawing up this strategy, who will also be involved in monitoring its progress. They will also be designed to reinforce cooperation with partners and regional and territorial level. The committee of experts for the energy transition will be involved with the annual implementation review, and bi-annual updates will be provided to the CNTE, at which point the monitoring indicators will be published.

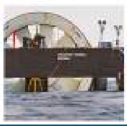
In addition to these indicators, monitoring must also take into account the issues flagged up in the 'Points to be watched closely' section of Chapter 3.

4.2.i Summary Indicators

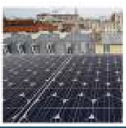
	Monitoring indicators	**Reference scenario**	**Unit**	**Measurement frequency**
Overall indicators	Carbon footprint of France and French citizens.		$MtCO_2eq$ & $MtCO_2eq/h$	Annual (TBC)
	Total greenhouse gas emissions from France	carbon budgets	$MtCO_2eq$	annual
	Carbon capture by forests (Biological growth net of mortality, or the "carbon pump" effect)	A reference scenario may be established later on, based on the PNFB-MEP-SNMB figures and CSF projections.	$MtCO_2eq$, based on Mm3 (IGN volume, and total air volume)	annual
	Annual variation in carbon stored in soil		$MtCO_2$	annual
	Greenhouse gas emissions by sector and category	see §4.1 (trajectory forecast)	$MtCO_2eq$	annual
	Sectoral "Scope 2" emissions (dividing the emissions from the "energy production" sectors between those sectors which consume the energy		$MtCO_2eq$	annual
	(estimated overall contribution of the) agricultural sector	including agricultural activities and those sectors upstream (agricultural supplies) and downstream (the food industry), for a better estimate of the substitution effects made possible by the bio-economy.	$MtCO_2eq$	annual





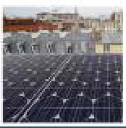

	Monitoring indicators	Reference scenario	Unit	Measurement frequency
	(estimated overall contribution of the) forestry-wood sector	variation in forestry stock and wood products + weighted sum of material (incorporating substitution effects) and energy (idem) uses. Coefficient and reference year to be determined. A reference scenario may be established on the basis of the PNFB-MEP-SNMB	$MtCO_2eq$	annual
	Population	2015: 66.17M – 2035: 71.68M	pop.	annual
	GDP/capita	Hypotheses from reference scenario	€2010/hab	annual
	Final energy consumption per unit of GDP	AMS2 results	Toe/person	annual
	Average GHG emissions per unit of energy	AMS2 results	TCO_2eq/Toe	annual
	Surface area of home / resident	Hypotheses from reference scenario	m²	frequency to be confirmed
	public investment (government) in creating a low-carbon society	N/A	M€	annual
	Estimate of total investment (private and public, including local authorities) in creating a low-carbon society	N/A	M€	annual
Competitiveness and cost	Household transport budget	Assessment of redistributive impact: compared with the trend-based scenario for all households, fuel savings of €215/year 2015-2028.	%	every 5 years
	Household energy budget	Assessment of redistributive impact: compared with the trend-based scenario for all households, heating savings of €100/year for families in existing homes in the period 2015-2028 (improvement made possible by renovation work, see details infra).	%	every 5 years
	Cost of energy for companies (industry, with estimations for tertiary sector and agriculture based on their consumption trends)	to be compared with European benchmark	% value added	every 5 years
Employment	Job offers and demand for green and green-related posts	N/A	index Base 100 in 2010	annual







	Monitoring indicators	Reference scenario	Unit	Measurement frequency
Energy poverty	People at risk of energy poverty	N/A	%	every 3 years
Air	Evolution of the air pollution index in urban environments	N/A	index Base 100 in 2000	annual
Resources	Domestic consumption of materials and intensity	N/A	index Base 100 in 1990	annual







4.2.ii Indicators for the implementation of cross-cutting recommendations

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario / Reference based on past level
1	Carbon footprint	Encouraging the inclusion of "Scope 3" elements in the greenhouse gas emission accounts (BEGES), when corresponding actions may be taken, while also supporting action plans to reduce these emissions.	- Number of BEGES which incorporate Scope 3 emissions - Number of voluntary commitments involving these emissions	N/A
2	Reorienting investments	Increasing the price of carbon in domestic energy consumption taxes from €22/tCO2 in 2016 to €56 in 2020 and €100 in 2030 (in € at 2015 value). This increase will be offset by a tax break on other products, activities or forms of revenue.	Price levels indexed against carbon prices (min, max, weighted average)	Price of CO_2 under the ETS (excluding electricity): €7/tCO_2eq (2015), €10/tCO_2eq (2020), €14/tCO_2eq (2025), €35/tCO_2eq (2030) Price of CO_2 outside ETS: carbon component of the TICPE (€22/tCO2 in 2016, 56 in 2020, 100 in 2030 - in € at 2010 value)
3		Creating and deploying a guarantee fund for the energy transition	private investment in the energy transition	Results of the reference scenario
4		Making these fiscal advantages conditional upon the use of the money for green purposes (e.g. sustainable development accounts)		
5		Promoting initiatives which further our ambition of establishing a carbon pricing system which covers the majority of the world's greenhouse gas emissions.	Percentage of global emissions subject to carbon taxes	Emissions covered in 2015 (see figure in section 3.2.ii)
6		Improving analysis of the carbon footprint and green footprint of assets held by institutional stakeholders (e.g. BPI France), improving non-financial reporting to provide clear information and ultimately implement compulsory greening of these investments.		
7		Ensuring that financial stakeholders take carbon risk into account in their operational decisions		
8	Sustainable land management	For agricultural land which has been temporarily abandoned or is no longer used for food production, we need to find innovative solutions to ensure that land resources are managed sustainably, capitalising on their productive potential for high-value-added food and non-food-related purposes and/or uses which can directly or indirectly replace fossil fuels		

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario / Reference based on past level
9		Substantially reducing artificialisation by 2030 and stopping it entirely thereafter, while ensuring that we are still able to meet the requirements of our growing population, particularly in terms of housing	Artificialisation of land (5-year development) in %	80% reduction in artificialisation by 2035, stopped on long term
10		Bringing residential areas closer to business and leisure zones, reducing the land taken up by transport infrastructure. This priority will be integrated into local development plans.	Percentage of French land covered by territorial cohesion plans (SCOT) incorporating criteria to reduce land consumption	2014 level: 11.2%
11	Supporting local project implementation	Harmonising, in a progressive and iterative manner, the consistency of the quantitative objectives set at different levels	Emissions by region	N/A
12		Multiplying local projects, supporting their work and promoting their contribution (labels and certificates such as "positive-energy territories for green growth" and (TEPCV) "zero-waste, zero-refuse territories" (ZGZD)), while also making it easier to experiment	Number of project zones (TEPCV, ZGZD)	N/A
13		Getting all inter-municipal authorities involved with territorial Air-Energy-Climate Plans (PCAET) or similar, facilitating access to the data required to produce local carbon accounts and action strategies.	Number of PCAET put in place (proportion of eligible local authorities who have adopted a PCAET, within the post-LTECV context and calendar)	Majority of France covered in the long term
14	Research and innovation	Nurturing the development and rapid spread of future technologies, moving towards a low-carbon planet	Percentage (or volume) of investments in energy R&D devoted to low-carbon technologies, distinguishing between energy efficiency schemes and low-carbon energies (renewables and nuclear)	2013 results : 167 M€ in energy efficiency and 787 M€ in low carbon energy production
15		Forming clusters of excellence in renewable energies, low-carbon technologies and energy efficiency, becoming industrial leaders in the field of low-carbon systems.	Public spending on R&D covered by the DPT Climate policy document (including the 'Future Investment' scheme)	
16	Education	Involving schools in the implementation of the actions contained in the regional energy transition and green growth plans and programmes.	Number of sustainable development education projects launched in primary, middle and high schools.	N/A
17		Accelerating the transition to "sustainable" campuses, ensuring		

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario / Reference based on past level
		that schools and universities lead the way in terms of energy and ecological performance.		
18	Training	Supporting the regional management strategies for jobs and skills (GTEC), with special focus on facilitating career changes linked to the ecological transition		
19		Boosting the professional skills and reputation of the energy audit sector		

4.2.iii Indicators for the implementation of sectoral recommendations

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario
20	Transport	Improving the energy efficiency of vehicles: achieving an average of 2L/100 km for all vehicles sold in 2030	Unitary consumption (fuel/km) of new and old cars	Fall in unitary consumption (average of 2l/100km for new vehicles by around 2030).
21		Developing the essential refuelling infrastructure (electric vehicle charge points, gas stations) required to make low-carbon transport alternatives viable.	Proportion of low-carbon energy sources per unit of energy. Life-cycle, "well-to-wheel" analysis.	-6% GHG emissions/per unit of energy used between 2013 and the conclusion of the 3rd carbon budget (or +5% increase in the proportion of electricity in transport by 2030), -37% GHG/unit of energy by 2050.
22		Introducing quotas for low-emission vehicles in public sector fleets (including buses)		
23		Deployment [coordinating the deployment] of low-carbon transport solutions [by all stakeholders]		
24		Encouraging modal transfers by: Promoting clean, green mobility (walking and cycling, e.g. with tax incentives for cycling) Massification of rail and river transport	Public transport and active mobility as a proportion of total passenger transport Percentage of freight transport by road/rail	Between 2013 and the conclusion of the 3rd carbon budget: 2% reduction in road and domestic air travel as a proportion of all motorised passenger transport, -7% for freight transportation
25		Keeping the demand for transport under control, particularly by: reducing the distance between the place of production and place of consumption by nurturing the circular economy and short circuits, and encouraging the inclusion of remote working in companies' transport strategies and collective	km travelled per person and transportation of goods per unit of GDP (t.km/€)	+2% km travelled/person by the end of the 3rd carbon budget (compared with 2013), stabilising the number of tonnes x km/unit of GDP by 2050 (at 2013 level)

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario
		agreements		
26		Supporting the development of car-sharing and mobility services allowing us to increase the rate of occupancy of vehicles	average rate of occupancy of private vehicles	+8% rate of occupancy for passenger transport by the end of the 3rd carbon budget (compared with 2013)
27		Improving the load factor of freight containers, supporting voluntary schemes such as the "Transporters' Programme" and "FRET21"	Average load factor for HGVs	+10% increase in the average load factor of HGVs by the end of the 3rd carbon budget (compared with 2013)
28	Residential / Tertiary	Reinforcing the use of life cycle analysis to assess the environmental impact of new buildings under future thermal regulations. Preparing for these regulatory changes with new quality labels etc.	GHG emissions from construction (life-cycle analysis)	N/A
29		Massification of energy renovations, focusing both on thermal insulation and the energy efficiency and environmental performance of systems (heating, hot water, cooking)	private investment in the energy transition (Construction)	Assumptions of the reference scenario
30		Removing barriers to investment, supporting energy renovation for low-income households and urging the financial sector to come up with dedicated instruments (such as third-party financing solutions)		
31		Cutting down consumption by changing habits and minimising specific electricity usage, with information and communication campaigns aimed at consumers (focusing on hidden consumption and energy-saving techniques) as well as the use of price signals and regulations.	Energy consumption by source and by use (12 lines)	Assumptions of the reference scenario
32		Encouraging the replacement of the most carbon-intensive heating systems (emissions of over 300gCO_2/kWh of usable energy) with other, less GHG-intensive heating systems - particularly renewable sources.		Assumptions of the reference scenario
33		Developing local chains devoted to the production and installation of low-carbon construction and renovation materials, (particularly bio-based materials such as wood), while also supporting the recycling of construction materials and waste which can be	Volume of wood consumed by the construction sector; volume of wood used in buildings	N/A

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario
		included in a buildings' life cycle analysis		
34			Percentage of construction waste reused/recycled	N/A
35	Agriculture	Optimising the nitrogen cycle, supporting low-input farming practices and replacing mineral fertilisers with organic alternatives	Sales of nitrogen-based fertilisers (in tonnes of nitrogen per year)	average decrease of 30 units of mineral nitrogen per hectare by 2035 (from 2010 level, including the development of low-input practices, dosage optimisation and use of alternative fertilisers)
36			efficiency of nitrogen fertilisers (sales of fertilisers / average yield of cereal crops)	
37		Developing legume crops, increasing the duration of crop rotation periods and diversifying the crop mix	Surface area planted with legumes	more than 2M ha of legumes by 2035, of which 900,000ha of large protein-crop farms
38		Optimising animal feed rations and working towards protein autonomy		developing legume crops and reducing the protein rations provided to over 50% of dairy cattle by 2035
39		Protecting permanent grassland, developing agroforestry, hedgerows and other agro-ecological resources	Surface area of permanent grassland and length/surface area of hedgerows	restricting the reduction in permanent grassland to 490,000 ha between 2010 and 2035
40		Developing soil coverage and increasing the proportion of organic matter in our soils		catch crops accounting for 80% of spring crops by 2035
41		Developing agricultural methanisation	Number of methanisation units on farms and volume of biogas produced	40% of usable excrement to be methanised
42	Forests - wood - biomass	Improving the management of small forest parcels to ensure that their rate of renewal is sufficient, for example by encouraging unification of separate parcels	surface area of private forestry resources (under X ha) (10, 20, 25?)	
43			Number and total surface area of GIEEF forestry groups	cf. PNFB and the Strategic Contract for this sector
44		Introducing fiscal incentives for dynamic, sustainable resource management	Minimum bar for effective property tax on small forestry parcels Monitoring the implementation of management strategies, supporting forestry	

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario
			investments.	
45		Encouraging the efficient use of bio-based resources in industry, construction, interior design, packaging, energy etc.	1 - Volume of French wood used in the French construction, furniture, packaging, panel and paste-making sectors; volume exported for material uses. 2 - Volume of French wood used for energy purposes in France; average energy efficiency; volume of wood exported for energy use.	
46		Attentively monitoring sustainability, particularly the impact on soils and biodiversity	to be specified in the PNFB and/or SNMB (national biomass strategy)	
47		Enhanced and shared monitoring of the flows of materials and economic data,	(setting up the wood and forestry module and establishing joint economic monitoring)	N/A
48	Industry	Improving energy efficiency to reduce the amount of energy and materials required to deliver a given output, with the help of GHG accounts and energy audits	Energy intensity of industrial production (particularly the 7 most energy-intensive activities)	Results of the reference scenario
49		Developing high-quality, universally-recognised energy efficiency services, and making us of third-party financing	Share of investments devoted to energy saving measures in industry	Results of the reference scenario
50		Promoting fatal heat recycling in industrial facilities and via heat networks	MWh reused	10 TWh of fatal heat recovered in 2030
51		Developing the circular economy and increasing the rate of reuse and recycling, reducing the total quantity of waste in order to deliver products to market with low-emission, high-efficiency life cycle credentials.	Material productivity and domestic consumption of materials, per capita	N/A
52		Reducing the prevalence of high-GHG emission energy sources as a proportion of total energy supply	Different sources as a proportion of total energy used by industry	Results of the reference scenario
53	Energy production	Accelerating increases in energy efficiency, focusing our efforts on the most carbon-intensive energy sources	Primary energy intensity of GDP	Results of the reference scenario

Number	Chapter	Recommendation	Monitoring indicator	Reference scenario
54		Smoothing out seasonal and daily consumption peaks, in order to reduce the use of carbonised energy sources	Average power requirement and peak consumption times	N/A
55		Radical decarbonisation of the energy mix and centralised energy production by 2050 (Factor 10)	gCO_2/kWh ratio of electricity and heat networks	N/A
56		Avoiding investing in new power stations running on fossil fuels. These will become useless in the medium term, as renewable energy sources continue their rise	Authorised power from fossil fuels to meet basic or semi-basic energy requirements, since publication of the SNBC	N/A
57		Increasing the flexibility of the system without increasing emissions, integrating renewable energies while also increasing the flexibility of the hydroelectric energy sector, intelligent networks and storage capacities. We must also take care to maintain and develop interconnections with neighbouring countries.	Share of renewable energies in gross electricity production	respecting our legal objectives (Art. L-100-4)
58		Developing district heating networks and steering production towards renewable heat and recovery of fatal heat	Share of renewable and recovered heat used in heat networks	respecting our legal objectives (Art. L-100-4)
59	Waste manageme nt	Reducing the volume of waste produced (ecodesign, extending the lifespan of products, repairs, minimising food waste etc.) and promoting reuse	Household waste	Waste by sector (Base 100): In 2010 / 2030: Storage ISDND :100 / 43 Incineration UIDND: 75 / 64 Material reuse :44/ 62 Composting :33 / 57 Methanisation: 3 / 14
60		Making better use of waste material which cannot be avoided (recycling)	Flow of waste to storage ISDND	
61		Using unavoidable waste which cannot be reused in material form for energy purposes		
62		Reducing methane emissions from landfills and treatment plants, particularly non-recoverable gas	Volume of methane captured and number of facilities connected for biomethane injection	ISDND storage 2010/2030: rate of capture (%): 38%/70% Reuse of captured biogas (%): 59%/80%
63		Stop incineration unless the energy is captured and used.		

CHAPTER 5: ACCOMPANYING REPORT

5.1. Making sure that we meet the objectives set out by law, and respect France's European and international commitments with carbon budgets and an effective low-carbon strategy

Article 173 of the Energy Transition and Green Growth act stipulates that, no later than four months before the publication deadline, the government must draw up and publish a report which explains how the carbon budgets and low-carbon strategy will be reconciled with the objectives stipulated in Article L. 100-4 of the Energy Code, as well as France's European and international commitments. The extent to which we are on track to hit these objectives is analysed here.

A. Objectives of the Energy Transition and Green Growth Act (Art. L.100-4 of the Energy Code)

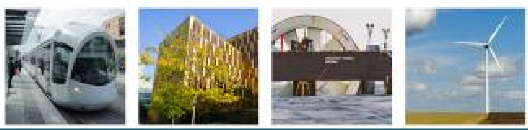
Art. L. 100-4. – I. – Objectives of the national energy policy:

1. To reduce greenhouse gas emissions by 40% between 1990 and 2030, and reduce them to a quarter of 1990 levels by 2050. The corresponding trajectory is set out in detail in the carbon budgets mentioned in Article L.222-1 A of the Environment Code;

The National Low-Carbon Strategy (SNBC) sets out a roadmap and includes sector-specific recommendations, with a view to reaching our target of a 40% reduction between 1990 and 2030 and maintaining a trajectory consistent with slashing emissions to a quarter of their 1990 levels by 2050. The trajectory mapped out in the carbon budgets should allow us to achieve a 42% reduction in emissions by 2030 (from 1990 levels). This intermediate target is consistent with a 75% reduction by 2050. According to the calculations of the Trajectory Committee (2012), who considered several reduction trajectories ranging from 33% to 41% in 2030, a trajectory close to the top end of this spectrum (-41%) is the best way to respect the principles of intergenerational fairness.

2. To cut final energy consumption to 50% of its 2012 level by 2050, with an intermediate target of 20% by 2030. This dynamic will support the development of an energy-efficient economy, particularly in the construction and transport sectors and the circular economy, while also protecting the competitiveness and development of the industrial sector;

The trajectory set out in the carbon budgets will allow us to achieve a 22% reduction in final energy consumption between 2012 and 2030. By extending the rate of reduction for the period 2025-2030 (-1.43%/year) after 2030, we will succeed in cutting consumption in half between 2012 and 2050. The SNBC sets out energy efficiency actions to be taken in the different sectors: renovation of old buildings, improving the energy performance of vehicles (average fuel consumption of 2l per 100km for all cars sold in 2030), developing the circular economy (reuse and recycling) etc. This dynamic will allow us to protect the competitiveness and continued development of the industrial sector (cf. the evaluation of the macro-economic effects of this strategy in Chapter 5). The objectives set out here for the industrial sector have been calculated on the basis of an annual growth rate of industrial value added estimated at 1.6% for the period 2016-2020, 2.0% for 2021-2025, 1.5% for 2026-2030 and 1.3% for 2031-2035.



Nevertheless, it is worth bearing in mind that it falls to the Multiannual Energy Plans (MEP) to provide detailed targets for energy efficiency.

3. To reduce primary energy consumption from fossil fuels by 30% by 2030 (from the reference year 2012), adapting this target to each category of fossil fuel on the basis of their greenhouse gas emission factors;

The trajectory set out in the carbon budgets will allow us to reach this objective. The reference scenario on which this trajectory is based predicts reductions in primary energy consumption from fossil fuels by 2030 which exceed this objective.

The SNBC will, however, propose modulations to these targets based on GHG emission factors, with two clear examples (in addition to the gradual increase in the weight of the carbon component in domestic taxes on energy consumption):

- in the residential-tertiary sector, when renewing systems which have reached the end of their life cycle, we will encourage home-owners to avoid the most carbon-intensive heating systems (those with emissions of more than 300g CO_2/kWh)
- diversifying the energy mix in the transport sector, in order to reduce the carbon intensity of the energy sources used by 6% between 2013 and the conclusion of the 3rd carbon budget.

4. To increase renewable energy usage to 23% of gross final energy consumption by 2020 and 32% by 2030; at this date, in order to satisfy this objective, renewable energy sources will need to account for 40% of electricity production, 38% of final heat consumption, 15% of final fuel consumption and 10% of gas consumption;

The SNBC supports the development of renewable energies, and the carbon budgets are compatible with these objectives.

Nonetheless, it is worth bearing in mind that it falls to the Multiannual Energy Plans (MEP) to provide detailed targets for the development of renewable energies.

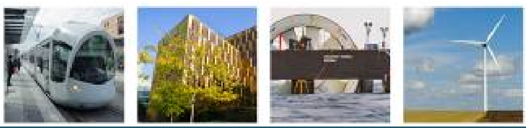
5. To reduce the share of nuclear power in total energy production to 50% by 2025;

It does not fall within the remit of the SNBC to provide a precise breakdown of the electricity mix, as long as this mix meets the emissions reduction targets contained in the carbon budgets and follows the recommendations of this strategy. The MEP, which is compatible with the SNBC, will determine the share of nuclear power in the energy mix.
However, the SNBC is compatible with the objective of reducing our reliance on nuclear power, with recommendations focusing on the development of renewable alternatives.

6. To help meet the objectives on reducing atmospheric pollution found in the national strategy for the reduction of atmospheric pollutants, set out in Article L. 222-9 of the Environment Code;

These legally-defined objectives and measures make a strong contribution to reducing emissions which cause atmospheric pollution (cf. Part 4.3). The PREPA document will explore these objectives in greater detail.

7. Manage housing stock so that all buildings are renovated to "low-consumption building" standard by 2050, with a programme of thermal renovation subsidies aimed primarily at low-



income households;

The strategy expects all existing buildings to be renovated to "low-consumption building" standard by 2050. The trajectory on which the carbon budgets are based also requires renovation of the most energy-inefficient private homes (energy class F or worse) by the end of the third carbon budget.

8. To achieve energy independence for the Overseas Departments by 2030, with an intermediate target of 50% renewable energies by 2020;

Meeting this objective will requires additional, locally-specific measures, to be defined in the MEPs.

9. To multiply by five the quantity of renewable and recovered heating and cooling provided by heating and cooling networks by 2030.

The SNBC and the carbon budgets include this objective of multiplying by five the quantity of renewable and recovered heating and cooling provided by heating and cooling networks by 2030.

VIII – The Government's objective for the carbon component - incorporated into domestic taxes on the consumption of energy products as per Table B, Paragraph 1 of Article 265 of the Customs Code - is to reach a carbon price of €56 by 2020 and €100 by 2030.

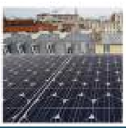
This increase is written into the strategy, and is one of the instruments which will allow us to stick to our carbon budgets.
This target for the carbon component of energy taxes is naturally included in the reference scenario, replacing or complementing the measures initially contained therein. This target makes carbon pricing more explicit and less implicit (the implicit carbon price is the valuation used by economists to express the combined effect of all non-fiscal constraints and incentives aiming to limit carbon emissions).

B. European and international commitments

European target of -14% greenhouse gas emissions (exc. ETS) between 2005 and 2020:
This objective will be easily met by sticking to the terms of our first two carbon budgets.

France's international engagements regarding greenhouse gas emissions (Kyoto protocol) are closely connected with our European commitments, which are virtually equivalent in their scope. They therefore do not require any further, specific analysis: adhering to these targets is largely a matter of respecting the first two carbon budgets.

Energy efficiency target for 2020:
In order to meet the target of a 20% improvement in energy efficiency, in 2012 the European Union adopted an ambitious legislative framework in the form of EU Directive 2012/27 on energy efficiency.
In order to transpose Article 3 of EU Directive 2012/27 on energy efficiency into national legislation, France has set itself a target of capping final energy consumption at 131.4 Mtoe by 2020 (excluding international aviation), with a cap of 219.9 Mtoe for primary energy consumption. Analysis of the different scenarios reveals that these two objectives can be met by a trajectory at the lower end of the forecast range, based on the twin hypotheses of an ambitious energy efficiency programme and a gradual improvement of economic conditions.
In the context of the present strategy, we must therefore emphasise the importance of remaining highly ambitious when determining the concrete measures required to meet our objectives. The







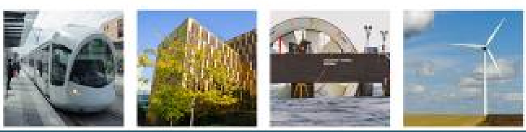
gradual increase in the carbon component of energy prices will play a key role here.

Targets for renewable energy development by 2020:

EC Directive 2009/28 on renewable energies in the Climate and Energy Package sets a target of 20% renewable energy in total energy consumption by 2020, across the European Union as a whole. Within this framework, France is committed to increasing the share of renewable energies in final energy consumption from barely 10% in 2005 to 23% by 2020. This will mean producing an extra 20Mtoe of renewable energy, more than doubling the previous level, which was already substantial thanks to wood energy and hydroelectricity. France has thus adapted an ambitious stance on this issue, an ambition reinforced by the objectives contained in the Energy Transition and Green Growth Act, which sets a target for 32% of final energy consumption to come from renewable sources by 2030 (cf. infra).

Respecting this objective will require the implementation of dynamic measures within the framework of the present strategy and the MEPS;

It is worth noting that this objective is closely linked to the energy efficiency objective examined above, as the target is based on renewable energy as a proportion of total energy consumed.



5.2. Studying the impact of the decisions made thus far

i. Analysing the economic impact

1. Macro-economic effects

Our evaluation of the macro-economic impact of the decisions taken in the SNBC is based on two scenarios: a trend-based scenario (the AME scenario, based on existing measures) and a reference scenario (the AMS2 scenario, with additional measures), as described in Part 2 of the strategy. The macro-economic impact of the reference scenario is analysed on the basis of its deviation from the trend-based scenario. This corresponds to the difference in employment figures and GDP, for a given year or as an average over the period 2014-2035, between the reference scenario and the trend-based scenario. This difference reflects the impact of the SNBC measures under consideration here.

Two different models were used for this evaluation: the NEMESIS model developed by SEURECO-ERASME, and the THREEME model developed by the ADEME and the CGDD. Combining these two models allows us to adopt a more nuanced approach to the combination of effects we can expect to see.

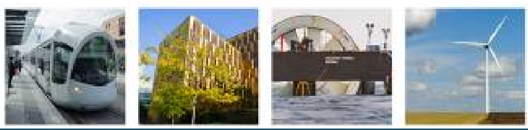
Principal conclusions of the macro-economic evaluation

Calculating the macro-economic impact of the reference scenario (AMS2), in relation to the trend-based scenario, reveals positive results for both GDP and employment. Above and beyond fluctuations linked to waves of investment, this positive effect can be seen in the boost to average annual GDP over the period and the average number of extra jobs created each year.
The NEMESIS model predicts that the reference scenario will boost GDP by an average of €25 billion per year over the period 2014-2035, while creating an extra 108,000 jobs per year over these 22 years.[43]

The macro-economic evaluation performed by the ADEME using the THREEME model predicts an annual average GDP boost equivalent to that forecast by the NEMESIS model, with an extra 350,000 jobs created each year over the period 2014-2035.

The detailed results yielded by each of these models are presented below.
The THREEME analysis integrates the gradual increase in the carbon component of domestic energy consumption taxes from €22 in 2016 to €56/tCO2 in 2020 and €100/tCO2 by 2030 (2015 euros). It is presented in greater detail in the methodological appendix. This integration was not taken into account in the analysis of the NEMESIS model.

[43]Calculating the average annual GDP increase and number of new jobs over this 22-year period (2014-2035) without the additional effort of 170,000 new buildings/year between 2017 and 2021 leaves us with a GDP boost of 23 billion and 87,000 new jobs/year.



2. Further analysis of the macro-economic impact of the AMS2 scenario as predicted by the NEMESIS model

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The GDP gap between the reference scenario and the trend-based scenario (black line on figure 5.1 below) is positive throughout the period, which shows that the measures included in the SNBC will cause economic activity to grow more rapidly than it would in the trend-based scenario for 2014-2035.

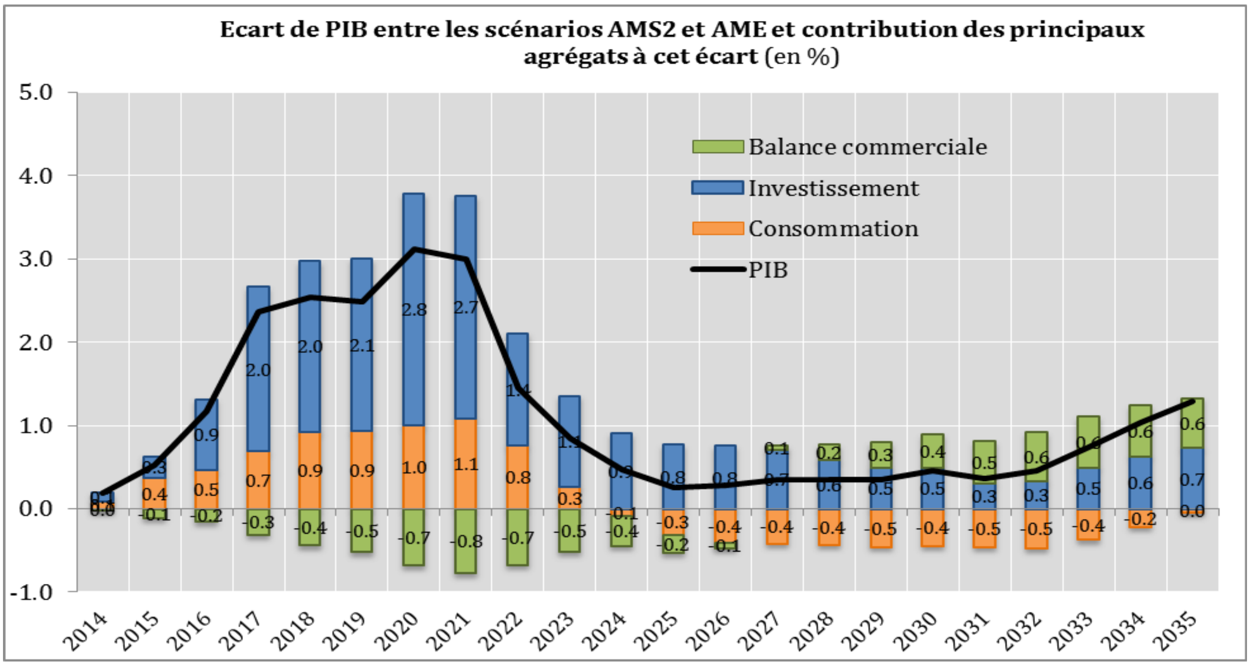


Figure 5.1: Evolution of the GDP gap and contribution of GDP aggregates (NEMESIS model)

The additional investment included in the reference scenario compared to the trend-based scenario (blue bars), particularly in construction (renovation and new-builds), is the main factor behind the additional growth seen in AMS2.[44] This GDP boost peaks in 2020 (GDP in the reference scenario is 3.1% above the trend-based scenario). On account of the lending required to finance these investments, the level of investment effort far outstrips financial provisions until 2022. The multiplier effect of investment (a boost in growth generates more income, and thus more consumption) will be in full swing in this period.

An increase in investment will naturally lead to an increase in the demand placed on those sectors supplying capital assets. In turn, the demand for production inputs (including labour) will increase in these sectors, in order to meet the increase in demand from clients. New jobs will therefore be created. These knock-on effects create a virtuous circle, with the multiplier effects of additional investment generating a spike in activity which exceeds the initial investment: these effects are referred to as 'Keynesian'.

Once additional investment in new construction comes to an end in 2022 (the hypothesis included in the reference scenario), the GDP boost drops off to stabilise somewhere between 0.3% and 0.5% between 2014 and 2031. Loan repayments become substantial at this point, and the ebbing away of the investment surplus (and the corresponding bounce in employment) sees consumption begin to lose steam. The contribution made by consumption to the GDP gap between AMS2 and

[44] It should be noted that the additional investment scheduled for other sectors often pales in comparison with the sums earmarked for the construction sector (although they are nonetheless significant to the stakeholders and activities concerned). By way of an example, the development of methanisation is expected to generate a significant amount of additional investment for the agricultural sector; but the sums involved will not far exceed €100 million per annum, which seems inconsequential compared with the sums shown in figure 5.2 below.

AME becomes negative from 2024 onwards.

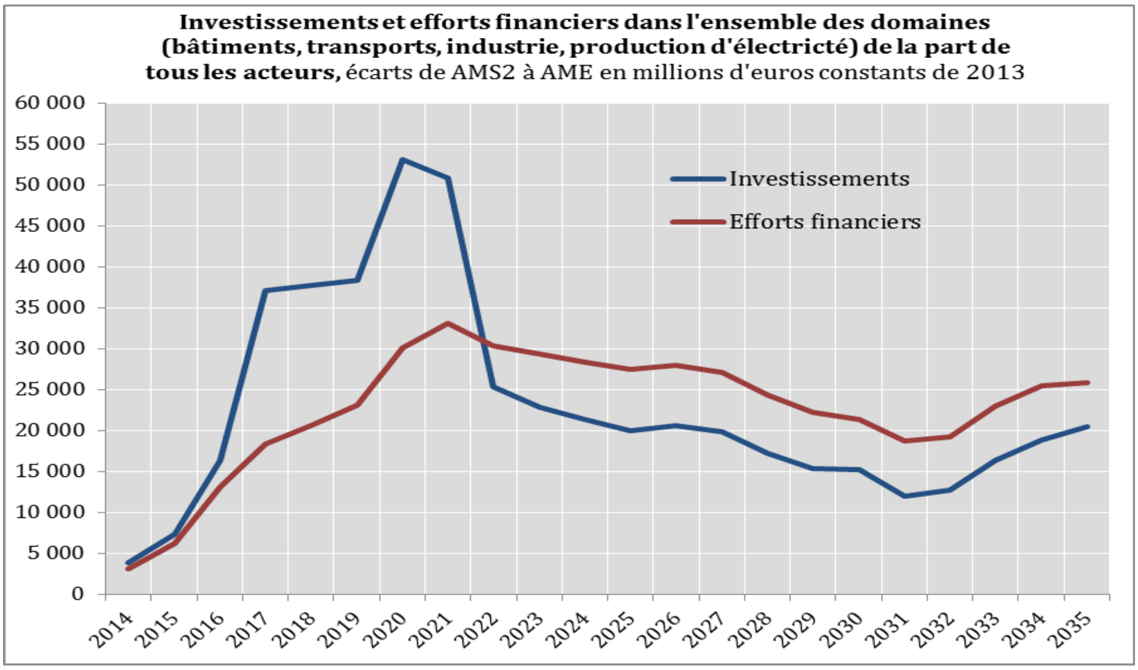


Figure 5.2: investments and financial provisions in the NEMESIS model

Between 2023 and 2035, total financial provisions for investment exceed total investment (cf. figure 5.2). The overall economic situation is expected to deteriorate slightly during this period (investment slows, household purchasing power is reduced by the repayment burden, competitiveness suffers from the price increases induced by strong economic activity and the cost of the investments made in the period 2017-2021, although these costs are offset by lending, which spreads the costs and charges over a longer period).

Nonetheless, the final years of the scenario do see a further increase in the GDP gap (reaching 1.3% in 2035). This is partly a result of investment in new electricity production facilities, causing a new spike in total investment. It is also related to the cumulative effects, from the mid-2020s onwards, of **energy savings** (made possible by previous investments), gradually freeing up more purchasing power and allowing consumption to pick up (and hence reducing the negative contribution of consumption to the GDP surplus, cf. figure 5.1). Energy efficiency savings have several consequences for the economy: increased productivity and lower costs for businesses, increased purchasing power for households and, from a macro-economic perspective, a reduction in the national energy bill.

Job creation is relatively substantial in the first period of growth (as many as 413,000 extra jobs in 2021, comparing the AMS2 scenario to the AME scenario): households will see their situation in the labour market improve, with an increase in their income. This upturn in wealth creation will allow households to increase their consumption in comparison with the trend-based scenario, particularly since lending helps to spread the cost of investment.

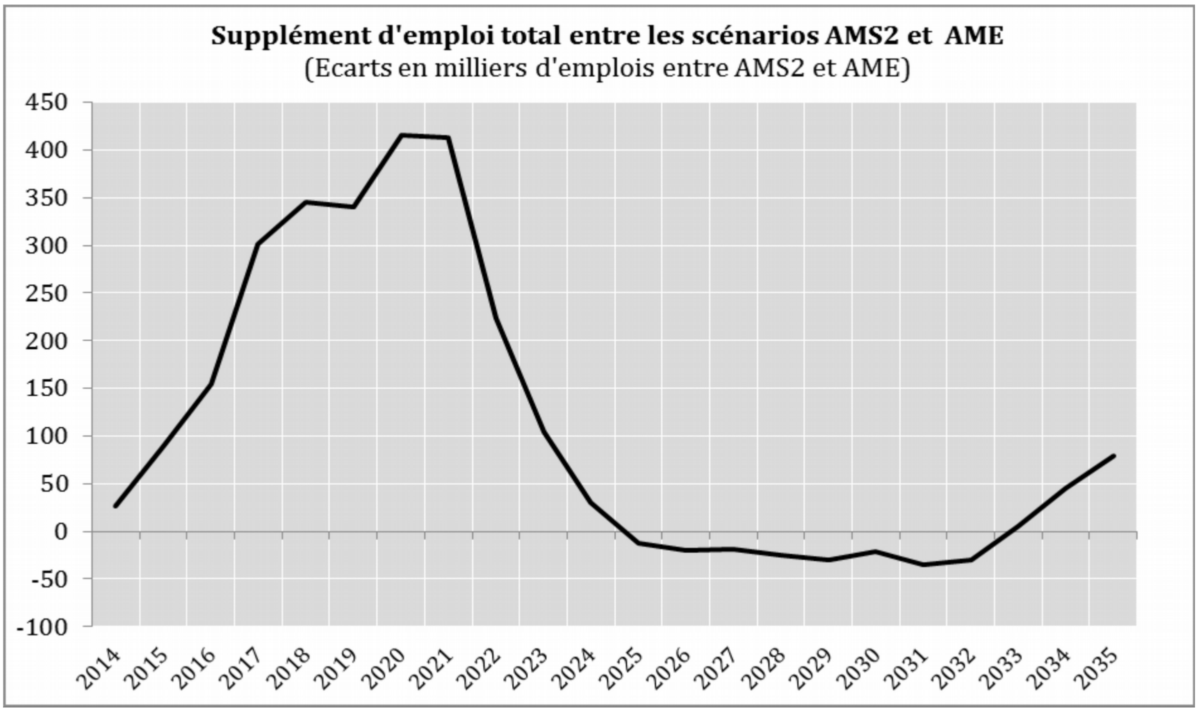


Figure 5.3: boost to employment predicted by NEMESIS

The contribution of foreign trade to the GDP gap between AMS2 and AME (negative until 2026 then increasingly positive thereafter, cf. figure 5.1 above) can be attributed to two phenomena:

- on the one hand, developments in competitiveness. The accelerated growth of the price index, resulting from the significant, rapid upturn in economic activity between 2015 and 2020 (the price index stands 4.2% above its reference account benchmark in 2022), initially leads to a deterioration in price competitiveness. The level of exports thus falls in relation to the level predicted in the AME scenario (AMS2 exports are 1.8% below the level of exports in the AME scenario for the year 2022). Thereafter the surplus in the price index subsides, because the activity surplus falls away and because energy savings come into play. Exports thus come to stand at just 0.9% below the level seen in the trend-based scenario in 2035.
- on the other hand, fluctuating imports. The significant increase in consumption early on in this period leads to an increase in imports, aggravating the external trade deficit. In the second period (from 2022 onwards), the surplus in domestic demand compared to the trend-based scenario melts away (fewer imports of goods and services from overseas) and energy savings drive down fossil fuel imports (particularly oil). The level of imports falls back to 2.6% below the level seen in the trend-based scenario by the end of this period. The decline of imports and rebound in competitiveness make foreign trade a decisive factor in the overall macro-economic dynamic at the end of this period (contributing 0.6 points to the GDP surplus of 1.3% in 2035).

Major investments in the AMS2 scenario compared with the AME scenario, in the building, transport, energy and industrial sectors

In terms of total investment in **construction**, the deviation from the trend-based scenario is considerable: over €30 billion each year from 2017 to 2019, €40 to 45 billion in 2020 and 2021, and €13-14 billion per annum throughout the rest of the period (2022-2035). The cumulative gap in investment in construction between the reference scenario and the trend-based scenario is thus equivalent to €390 billion for the period 2014-2035. If we were to remove the "500,000 new homes between 2017 and 2021" target from the reference scenario, investment in construction would fall by €17 billion between 2017 and 2019, €26 billion in 2020 and €22 billion in 2021.

Investment in construction will be funded as follows:

Type of operation	Stakeholder	Nature of loans	Level of borrowing
Renovation of buildings and heating systems	Households	Average duration of loan: 10 years Real interest rate 3%	33% from borrowing, remainder from available funds
Renovation of buildings and heating systems	Private tertiary sector	Average duration of loan: 10 years Real interest rate 3%	67% from borrowing, the remainder passed on directly to production costs
New homes	Households	Average duration of loan: 18 years Real interest rate 3%	85% from borrowing, remainder from available funds
New tertiary-sector buildings	Private tertiary sector	Average duration of loan: 18 years Real interest rate 3%	85% from borrowing, the remainder passed on directly to production costs
Renovation of buildings and heating systems	Social housing	Average duration of loan: 10 years Real interest rate 1%	50% from borrowing

This additional investment (in the reference scenario, compared with the trend-based scenario) is funded to the tune of 62% by households (€242 billion over the whole period 2014-2035), 20% by tertiary sector businesses (€78 billion), 9.5% by the public tertiary sector (€37 billion) and 8.5% by social housing authorities (€33 billion).

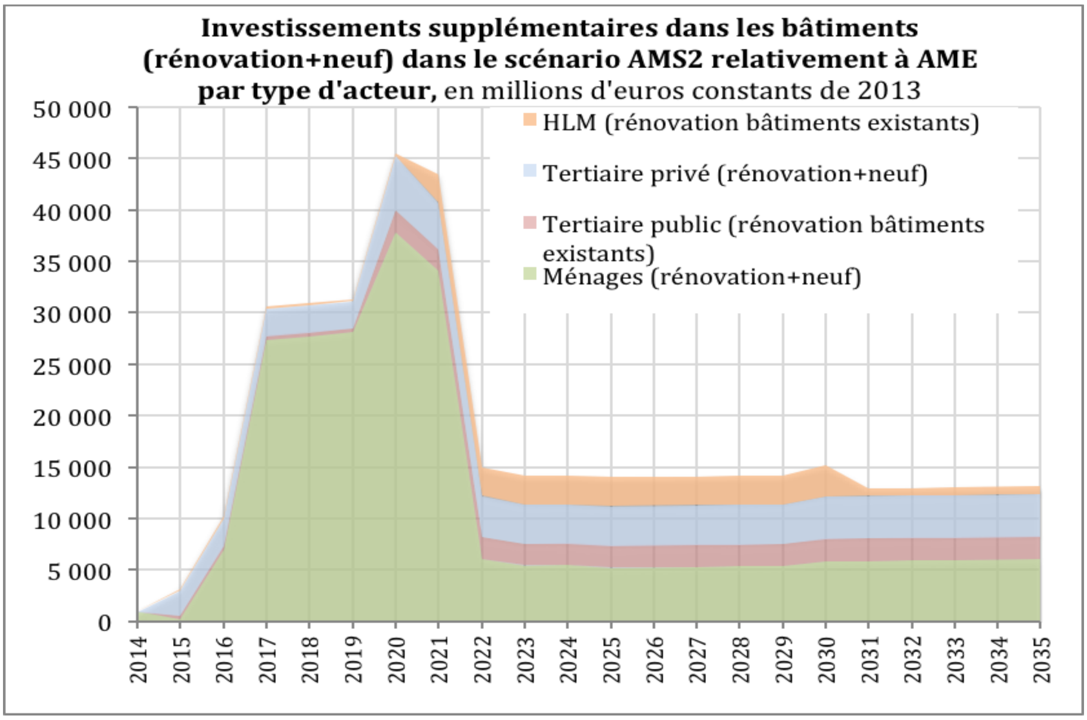


Figure 5.4: additional investment in construction (exogenous for NEMESIS)

Total surplus spending and investment in **transport** (investment in charging stations for electric vehicles, high-speed train lines and urban public transport, investment by car manufacturers and the surplus cost of buying electric vehicles), fluctuates around €3 billion per annum in the AME scenario (giving a cumulative total for surplus spending and investment of €63.9 billion over the period 2014-2035), and between €4 and €6 billion per annum in AMS2 (cumulative total of €109.5 billion). For the period 2014-2035 as a whole, the total boost in surplus spending and investment on transport is €46 billion (reference scenario compared with the trend-based scenario). The annual gap between AMS2 and the trend-based scenario oscillates between €2.2 and €2.5 billion in the period 2020-2030.

As for the industrial sectors,[45] the reference scenario allows for additional investment of €1.9 billion per annum (compared to the trend-based scenario) thanks to energy savings, spread across all sectors of industry between 2015 and 2035 (€39.6 billion of cumulative investment across the period). This investment will be concentrated primarily in the chemical (20%), food (23%) and capital goods sectors.

To sum up, investment in buildings (renovation and construction) is the largest category of investment, and thus has the greatest resonance in macro-economic terms. These are structurally-significant investments and will have the greatest impact on the overall economic dynamic seen in the reference scenario, compared with the trend-based scenario.

[45] In the service sector, energy-saving investments are the fruit of investments made in tertiary buildings and not the result of direct investments, as is the case in the industrial sector.

3. Further analysis of the macro-economic impact of the AMS2 scenario as predicted by the THREEME model

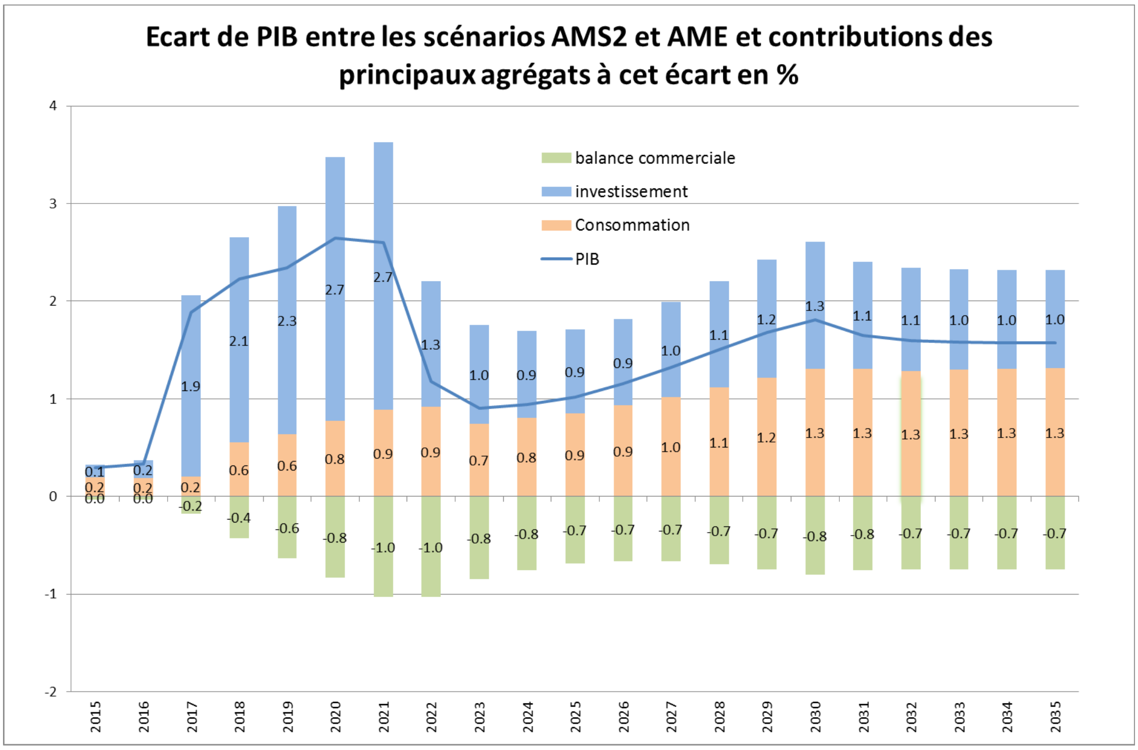


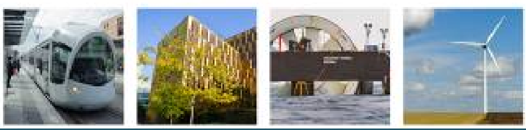
Figure 5.5: Evolution of the GDP gap and contribution of GDP aggregates (THREEME model)

In the forecast produced by the ADEME using the THREEME model, choosing the reference scenario (AMS2) over the trend-based scenario (AME) leads to surplus investment equivalent to +2.1 GDP points in 2021 (its peak), and a +1.6 point GDP boost in 2035.

Early on in this period, growth is primarily driven by investment. This leads to new jobs and an increase in consumption, with a positive impact on activity. Job creation is robust in the early years of this period. The increase in monthly repayment instalments induced by new construction projects, and the crowding-out effect on consumption, is largely offset by the increase in total earned income. Household consumption increases from 2015 onwards, making a vigorous, positive contribution to growth.

The balance of trade is worse in AMS2 than in AME at the start of the period, as a result of imported consumer goods. The gap between the trade balance forecasts in AMS2 and AME narrows thereafter, but the contribution of foreign trade to the growth gap remains negative in both scenarios. The rebound in imports of consumer goods and the reduction in companies' competitiveness, resulting from the increase in energy prices, will cancel out the effects of the fall in energy bills. Nonetheless, the balance of trade as a proportion of GDP will drop by 0.8 points in 2035.

Ultimately, it is job creation which will have the biggest effect on demand, and thus on GDP.



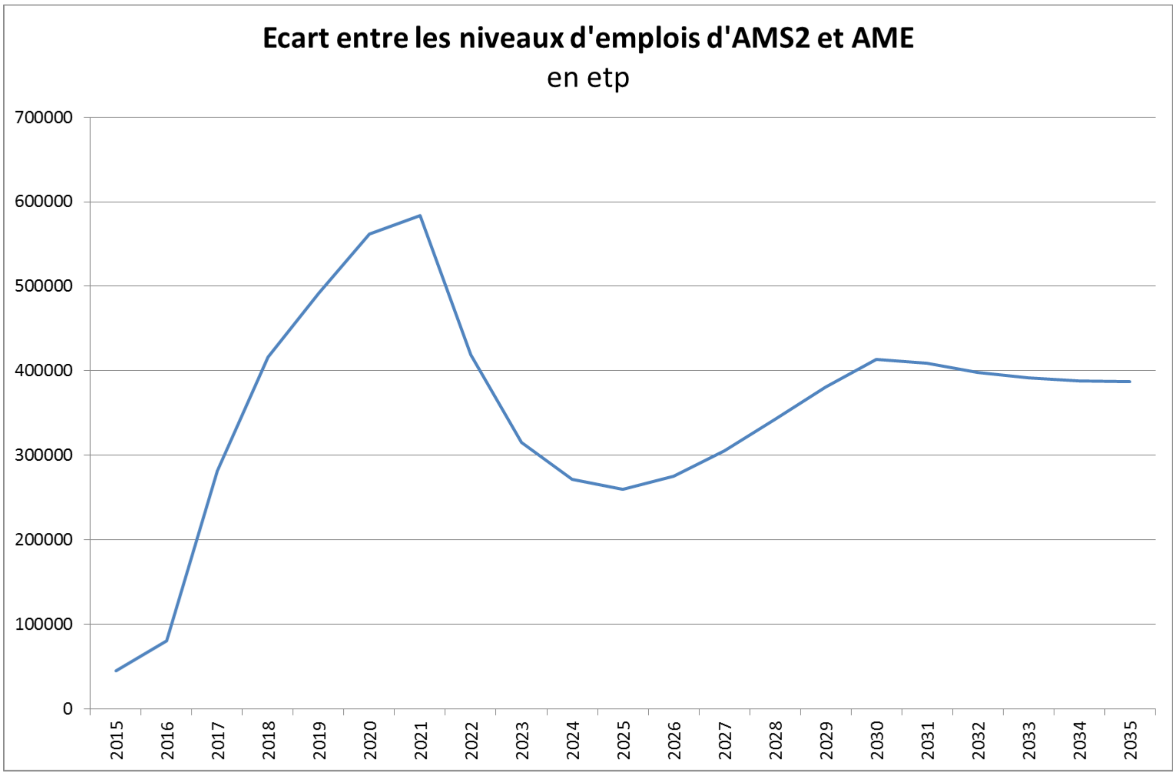
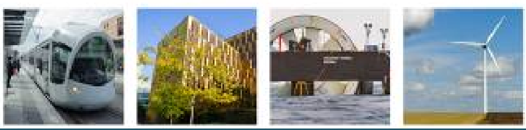


Figure 5.6: boost to employment predicted by THREEME

The number of jobs created in new green sectors is greater than the number of jobs lost in the fossil fuel sector and energy-intensive industries. In 2035, AMS2 sees the creation of almost 390 000 extra jobs compared to AME, with an annual average of 350,000 over the period 2015-2035



3. Impact on competitiveness

The gaps between these two models, and the array of concrete measures which could potentially be taken to implement the SNBC strategy, do not allow us to make precise, sector-by-sector forecasts for competitiveness.

The strategy will have certain negative effects on competitiveness, described and quantified in the models detailed above (an increase in energy prices, a general price increase caused by the spike in economic activity and the temporary postponement of the costs associated with the investments required in each of the sectors concerned).

Measures will be taken to attenuate these negative effects. One notable measure is that the carbon component of energy prices, set at €56/tCO_2 for 2020 and €100/tCO_2 for 2030, will not apply to the sectors covered by the emissions trading scheme (ETS). Carbon pricing will therefore not have a direct impact on the main industrial sectors which are most exposed to international competition and most sensitive to energy prices.

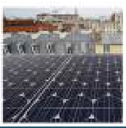
Furthermore, the models detailed above look only at the effects of the French energy transition. The relative decline in French competitiveness needs to be reframed in the European and international context, as our economic partners will need to implement similar policies. The introduction of a carbon guide price in the main non-European economies would allow for a fair system of incentives at international level, and France would benefit from the surplus demand coming from international clients.

Positive effects on competitiveness can also be detected in the macro-economic analyses.

On the one hand, energy savings will drive down production costs in the long term. On the other hand, the investments required by the energy transition will encourage companies to truly get to grips with technologies allowing them to reduce their consumption and emissions, as well as finding alternatives to fossil fuels. This will give French businesses a head start in tomorrow's global market for low-carbon energy technology.

In order to foster this dynamic, support for innovation will be one of the key priorities of the ecological transition. France's goal - which is also the EU's objective - is to create new clusters of excellence in energy efficiency, renewable energies and low-carbon technologies.

Ultimately, the macro-economic analyses which have been conducted thus far agree on the fact that the overall economic impact of the AMS2 reference scenario (compared with the AME scenario), although difficult to quantify exactly, is positive for both growth and employment.







4. Abatement cost curve

An abatement cost curve (ACC) is a planning tool designed to compare different potential ways of reducing greenhouse gas (GHG) emissions, identifying the methods which will allow us to achieve our stated reduction target by a given deadline and in the most cost-efficient manner. The construction of these curves, on a sectoral or aggregated scale, is based on estimating costs in comparison to a reference scenario predicting the evolution of greenhouse gas emissions.

Each of the potential mitigation technologies/measures is then judged on its: (i) speed of deployment, (ii) potential to reduce emissions, (iii) the time-frame of the stated objective and (iv) cost in relation to an average comparable technology as modelled in the reference scenario.

The quality of the database used to create an ACC is crucial. This database should be the fruit of transparent, open discussions between stakeholders to ensure that the resulting ACC is pertinent. The idea is to allow for useful comparison between different options.

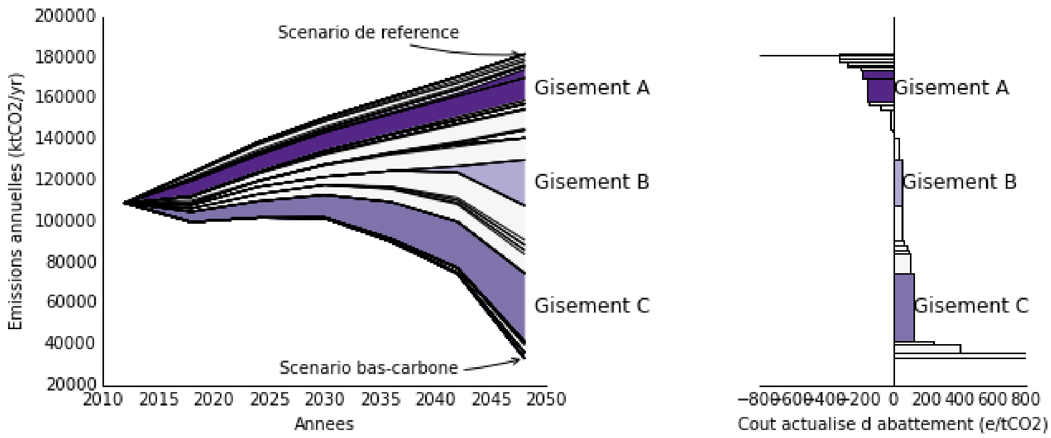
The key messages delivered by assessment and guidance tools such as the ACC are as follows:

- They allow us to represent, on a single graph and for a given period of time (see below), the uptake scenarios for different potential methods of reducing emissions, along with their cost. Analysing these curves allows us to evaluate all the technological solutions modelled and the extent to which they contribute to the achievement of our mitigation objectives.

- They allow us to identify actions which would be directly profitable (i.e. have negative costs), which are not always immediately obvious (lack of information, changing costs, discount rate differences in the private and public sectors) and which should be deployed as soon as possible (e.g. Option A in Fig. x)

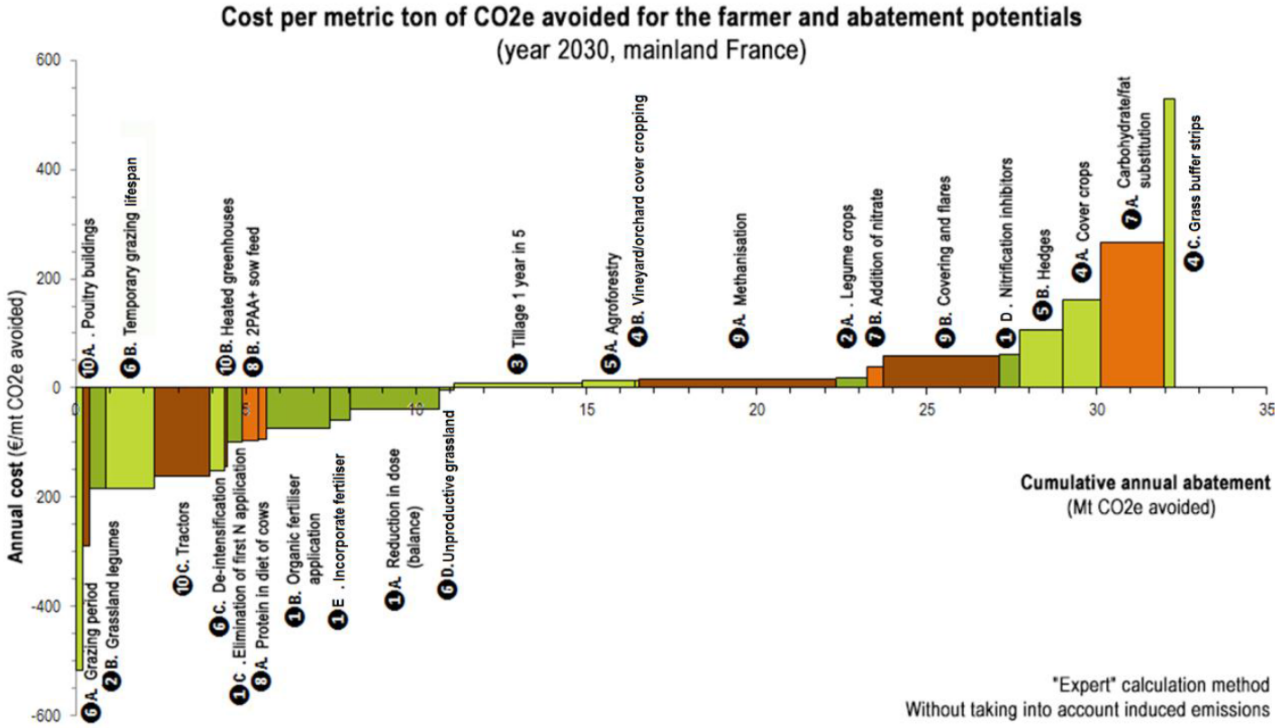
- We must take care to ensure that the emission reduction measures implemented with a view to achieving intermediate targets do not induce a form of technological lock-in which will be harmful in the long term. Options selected in the short term should help us to prepare for the next steps, reducing costs and maximising joint benefits.

- The ACC allows us to distinguish between costly technologies with slow uptake (Option C) which will need to be implemented at the same time as technologies with low (or even negative) abatement costs (Option A) and before options with lower costs but quicker uptake (Option B), in order to meet our long-term objective. The ACC allow us to put the different emissions reduction options into perspective.



These curves may also be usefully applied to different sectors of activity. For example, an ACC was drawn up for the agricultural sector by the INRA, for the purposes of the study 'What contribution can French agriculture make to the reduction of greenhouse gas emissions?' published in 2013.[46] This curve contains a forecast for mitigation potential up until 2030, as well as the estimated mitigation cost of each of the sub-measures identified. The curve does not specify the speed with which these sub-measures will be implemented, but the momentum predicted for the period 2010-2030 is the fruit of systematic analysis.

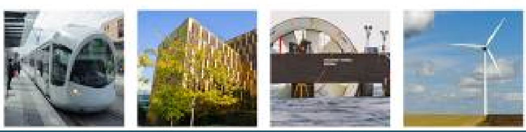
This curve demonstrates that many of the actions envisaged by the SNBC correspond to measures with low or even negative costs: reducing doses of mineral inputs, improving energy efficiency, developing legume crops, adjusting animal feed portions etc. We must also bear in mind that some of the sub-measures with the highest mitigation costs are already actively encouraged by the CAP (particularly the goal of protecting ecological resources such as hedgerows and grassy areas); these actions have joint benefits which must also be taken into account when assessing their pertinence.



Source : INRA

Finally, although the ACC is a powerful analytical tool (as well as being much more pertinent than simply looking at the static marginal abatement cost, an indicator which is often cited), when choosing between different options we also need to take into account some elements which the curve does not cover: joint benefits or clashes between these measures and other policy objectives (secondary environmental impact, economic development, usage value of different assets, acceptability etc.). The ACC alone does not allow us to accurately prioritise the measures to be taken.

[46] http://institut.inra.fr/Missions/Eclairer-les-decisions/Etudes/Toutes-les-actualites/Etude-Reduction-des-GES-en-agriculture



ii. Analysis of the social impact in terms of equitable redistribution

In the long term, investment in renovation will be compensated by savings on household energy bills

The reference scenario for the energy transition (known as AMS2) involves more renovation work than the trend-based scenario (AME) (a total of 29.8 million renovation operations on existing buildings in the period 2015-2028, compared to 19.1 million in the trend-based scenario). The nature of this renovation work is also more ambitious in the reference scenario (in which 45% of projects involve at least two forms of renovation, which is only the case for 20% of projects in the trend-based scenario). Last but not least, the reference scenario includes a carbon price signal which makes fossil fuels more expensive than they would be in the trend-based scenario.

For the period 2015-2028, investments in renovation should reach €24 billion in the reference scenario, compared with €16 billion in the trend-based scenario. These investments will be spread out somewhat unevenly: in the reference scenario, renovation investment is predicted to be €23 billion per year for 2015-2018, then €25 billion per year for 2019-2023 and €24 billion per year for 2024-2028, whereas the trend-based scenario forecasts a decline in renovation investment from €16 billion per year in the period 2015-2023 to €15 billion per year in 2024-2028.

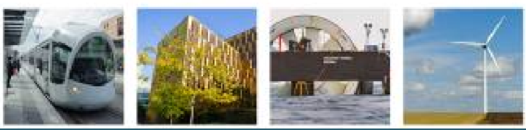
The average spend on renovation work in existing homes is estimated at around €955 per year in the reference scenario, which is **almost €345 per year more than the figure predicted by the trend-based scenario**. This investment surplus in comparison to the trend-based scenario will fluctuate over time, in line with the rate of renovation and the level of income of residents:

- in 2015-2018, the reference scenario expects renovation work to generate an average investment of around €275 per year, diverging from the trend-based scenario. The majority of these investments are likely to involve homes occupied by families in the upper deciles of the "standard of living" scale (5th decile and above).[47] The renovation surplus predicted by the reference scenario, is derived primarily from individual homes, which are generally occupied by households in the upper income brackets. In the homes occupied by the most well-off households (top three deciles), annual investment should average €320 more than the trend-based scenario. Surplus investment by lower-income households (bottom three deciles) is expected to be around €225 per annum.

- in the period 2019-2023, the increase in renovation work in all categories of home is expected to generate surplus investment of around €390 per year, compared with the trend-based scenario. This surplus investment will be slightly lower in homes occupied by lower-income households (an average of €375 per year for households in the first three deciles). The level of investment will depend on the size of the home involved, which naturally means that lower-income households spend less, as they have smaller homes. For homes occupied by households in the top three deciles, surplus investment should be around €420 per year;

- in 2024-2028 the average investment surplus should be less substantial, at €355 per year above the trend-based scenario, being concentrated primarily on homes occupied by lower-income households (an average of €380 per year for the bottom three deciles) and less on

[47] The deciles referred to here are measurements of standard of living. A household's standard of living is defined as its total disposable income divided by the number of consumption units in the household. All members of the same household are thus considered to have the same standard of living.



homes occupied by the wealthiest households (average of €345 per year for the top three deciles). This difference can be partly ascribed to the differing rates renovation for different types of home: renovation on apartment blocks and social housing are more concentrated in this period, compared to work on individual homes.

In total, for all renovation work and as compared with the trend-based scenario the average investment surplus of €345 per year across the period as a whole should actually correspond to lower spending on homes occupied by low and middle-income families, spread relatively evenly across the scale (averaging €335 for the bottom seven deciles). Spending by higher-income households will be greater, given the size of the homes to be renovated (average of €365 per year).

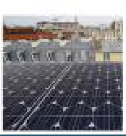
As the purpose of these renovations is to make homes more energy-efficient, all other factors being equal they should help to reduce heat consumption, and thus drive down energy bills. At the same time, carbon signal-prices will make carbonised energy sources more expensive, nudging heating bills upwards. The actual impact on energy bills will thus depend on the scale of the renovation work, the initial condition of the home (energy performance, size), the type of heating system installed and the level of carbon pricing.

As the energy efficiency savings made possible by renovation work are greater than the increase in energy bills caused by rising carbon prices, **as an average over the period and, in comparison with the trend-based scenario, the savings made on heating bills should be around €130 per year for households in existing homes.** In the period 2015-2018, these savings should be no more than €30 per year compared with the trend-based scenario, as energy consumption reductions from renovation just about manage to offset the increase in the cost of carbonised energies caused by carbon signal prices. In 2019-2023, however, the dynamism of energy renovations should see a clear reduction in bills. Household should save an average of €140 per year, rising to €200 in 2024-2028. Over the period 2015-2028, the average saving of €130 per year and per household should be less substantial for lower-income households (an average of €90 per year) because they have smaller homes. As a proportion of annual heating bills, these savings will be relatively evenly spread across the deciles, equivalent to an average reduction of 10% on the heating bill predicted by the trend-based scenario 15% for the three lowest deciles).

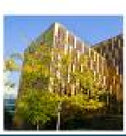
In the reference scenario - taking into account the fact that the energy savings made possible by renovations outlast the duration of the work, and that the rise of carbon prices will increase the sums saved - investment in renovation is eventually compensated by the savings made on heating bills. Specifically, the **surplus of €345 in renovation investment predicted by the reference scenario for the period 2015-2028 should be fully offset by savings on heating bills by 2033-2034, compared with the cost of heating without renovations.** This abatement time is identical for all homes, regardless of the standard of living of the household.

It should be noted that the investments considered here are connected directly to the homes receiving the renovation work, regardless of who actually pays for the work (the occupant or, in other cases, the landlord, or even the taxpayer via public subsidies). In practice, home-owners with lower incomes will be less likely to undertake renovation work as they have less access to credit, due to the fact that the investment involved represents a greater share of their income than it does for other households. The 'Habiter Mieux' (Better Living) programme launched by the Agence Nationale de l'Habitat, combined with the third-party financing system, should nonetheless help to remove these obstacles. There is also a high proportion of renters among these households[48]

[48] The impact this will have on individual decision-making is hard to determine with any certainty: a programme of energy renovation for a large social housing complex involves a relatively small number of decision-makers, but convincing small landlords is, at least in theory, a harder task. Hence the option included in the Energy Transition and Green Growth







Finally, potential rebound effects linked with improved energy efficiency have not been taken into account, particularly the potential for substitution effects between spending on heating and other forms of energy.

Fuel spending should fall because there will be fewer vehicles on the road, travelling shorter distances and running more efficiently.

The total number of vehicles on the road in the reference scenario is slightly lower than the figure given in the trend-based scenario (300,000 fewer vehicles in 2035 in the reference scenario, with 2.7 million fewer petrol and diesel vehicles and 2.4 million more electric cars and hybrids). Furthermore, the vehicles included in the reference scenario are more efficient (in the reference scenario, a petrol-fuelled vehicle uses 3.8 litres of fuel per 100 km in 2035, compared with 5.9 litres in the trend-based scenario) and travel shorter distances (average distance travelled annually by a petrol vehicle = 8,600 km in 2035 in the reference scenario, compared with 10,900 km in the trend-based scenario).

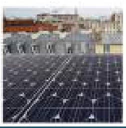
This has an impact on household spending on fuel, and the conditions sketched out in the reference scenario with regard to the evolution of automobile performance and usage are factors liable to drive down fuel consumption, compared with the trend-based scenario. The increase in fossil fuel prices, caused by the introduction of carbon pricing, will be offset by the fall in consumption. In 2015-2018, annual household spending on fuel should be €125 less than in the trend-based scenario. This fall in fuel spending should pick up pace thereafter, as the characteristics of vehicles on our roads change: €165 per year in the period 2019-2023, then €330 each year from 2024 to 2028.

Over the period 2015-2028, and for all households, average fuel savings should be equivalent to €215 per year, an 11% saving compared to the trend-based scenario.

The impact of the reference scenario on investment in individual transport equipment has not been estimated precisely with reference to levels of living standards.[49] As a result, the evolution of transport habits (number of vehicles per household, fuel efficiency, distance travelled) has been uniformly applied to all households while retaining the relative distribution between deciles, which are held to be stable over time. As such, savings on fuel spending are almost uniformly spread across the deciles (an 11% saving across the period 2015-2028 compared with the trend-based scenario, regardless of living standards). In absolute terms, the savings made on fuel spending are much less substantial for lower-income households (€145 per year for the lowest three deciles in 2015-2028) and much higher for the richest households (€290 per year for the top three deciles over the period 2015-2028). Compared with other households, lower-income households have fewer vehicles and travel shorter distances.

Act of introducing a bonus-malus scheme (Art. 14 VIII).

[49] It should be noted that the macro-economic forecasts used to construct these scenarios are based on the assumption that options inducing spending increases and decreases will offset one another: stricter performance criteria for manufacturers may drive car prices up, but the increase in fuel prices (coupled with the rise of biofuels) may prompt households to opt for smaller vehicles. Furthermore, the development of lift sharing and car sharing may serve to reduce the total number of vehicles on the road. The combined result of these different phenomena is hard to evaluate with reference to household living standards.







Investment in renovation: total spending per year and per household on existing housing stock

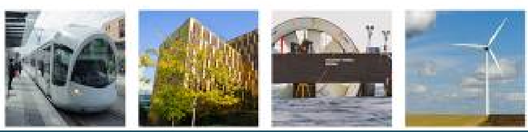
	investment in renovation (in € billion)			annual investment in renovation (in € billion)			spending on existing housing stock, per annum and per household		
	Reference	Trend-based	*Surplus*	Reference	Trend-based	*Surplus*	Referenc e	Trend-based	*Surplus*
2015-2018	92.9	64.5	*28.4*	23.2	16.1	*7.1*	880	607	*273*
2019-2023	125.5	78.2	*47.3*	25.1	15.6	*9.5*	995	607	*388*
2024-2028	118.2	77.0	*41.2*	23.6	15.4	*8.2*	971	614	*357*
Total 2015-2028	**336.6**	**219.7**	***116.9***	**24.0**	**15.7**	***8.4***	**953**	**609**	***344***

Average investment in renovation and energy bills in the reference scenario*, <u>difference with the trend-based scenario</u> in € per annum, broken down by decile of household living standards

2015-2018	**D1**	**D2**
Investissements de rénovation	**187**	**236**
Facture logement (1)	-13	-25
Facture de carburants (2)	-65	-84
Facture totale (1) + (2)	**-78**	**-109**

2019-2023	**D1**	**D2**
Investissements de rénovation	**361**	**378**
Facture logement (1)	-118	-135
Facture de carburants (2)	-85	-112
Facture totale (1) + (2)	**-202**	**-247**

Note: in 2015-2018, the reference scenario expects households in the bottom living standard decile to invest an average of €187 more per year in renovation work than they would in the trend-based scenario.



Average renovation investment and energy bill in the reference scenario*, in € per year, by decile of standard of living

2015-2018	D1	D2
Investissements de rénovation	**611**	**745**
Facture logement (1)	842	884
Facture de carburants (2)	1043	1343
Facture totale (1) + (2)	**1885**	**2227**

2019-2023	D1	D2
Investissements de rénovation	**747**	**828**
Facture logement (1)	723	758
Facture de carburants (2)	968	1247
Facture totale (1) + (2)	**1691**	**2005**

2024-2028	D1	D2

Note: in 2015-2018, the reference scenario expects households in the bottom living standard decile to invest an average of €611 per year in renovation work.

** These tables do not incorporate tax cuts introduced to offset the increase in carbon signal prices.*

iii. Environmental challenges and public health issues

Combined benefits and points to be watched closely

This is a qualitative approach.

We have methodically reviewed the main ways in which the first three carbon budgets (and, more generally, the implementation of the low-carbon strategy) are liable to raise environmental issues other than the central question of attenuating the effects of climate change. The definition of environmental issues applied here is broad, and extends to questions of public health.

In this section, we explore the main joint benefits (other than climate change mitigation) and points to be watched, with a view to ensuring that they are taken into consideration in the sectoral plans and programmes, with further reflection where required.

1. Energy efficiency and renewable energies: reducing the use of fossil fuels

The joint benefits of this action are significant: reducing the consumption of fossil fuels would help to reduce the environmental and health-related consequences of their usage, but also their extraction, transportation, transformation and distribution. The impact and damage done by fossil and fissile fuel extraction could thus be reduced in France and internationally.

Nor should we forget the reduced risk of accidental pollution linked to fossil fuel extraction (oil contamination, polluted soils), transportation (oil spills, illegal gas purging) and transformation (air and water pollution).

- **Insulation of buildings**

This measure will have beneficial health effects in summer and winter, for example by ensuring that vulnerable people are better protected during heat waves.

Insulation can lead to a deterioration of interior air quality if the accompanying ventilation system is poorly-designed or defective. This risk should be minimised by the fact that, in order to qualify for the sustainable development tax credit, the work must be performed by an RGE-certified professional (an environmental quality label). Renovating old buildings may in fact provide an opportunity to improve interior air quality. It is important that health concerns should be at the heart of our renovation policy, along with energy efficiency and climate change mitigation.

The campaign to renovate heat insulation in French homes will lead to an increase in waste from the construction sector and an increase in the demand for insulation materials.

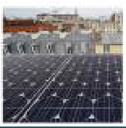
2. Transport

- **Managing demand, shifting to other modes of transport and optimising logistics**

These measures will allow us to minimise the negative side-effects of transport (noise, atmospheric pollution, health problems), infrastructure and parking problems (freeing up space).

They will also help to reduce energy consumption, and particularly consumption of fossil fuels (cf. energy efficiency section above).

- **Electric vehicles**



Electrification has significant joint benefits in terms of reducing noise and atmospheric pollution, which is a real boon for urban areas.

Nonetheless, one aspect of this development will need to be monitored closely. Increasing consumption, mining and transformation of mineral resources may have serious environmental consequences (lithium, cobalt etc.). In some cases, there may be conflicts over land use for agriculture or mining. Nevertheless, we can reduce these impacts by developing more efficient systems for collecting and recycling used materials, optimising the design of equipment and products and ensuring that the raw materials we use are sourced from mining operations using the best available technology.

- **Gas-powered vehicles**

Replacing traditional fuels with gas can have significant benefits in terms of respiratory health and atmospheric pollution.

We nevertheless need to be careful with regard to the sources of biogas, as their chemical composition will vary depending on the source material used. They may require preliminary analyses or treatments, or at least regular checks.

- **Active mobility**

As well as helping us to limit demand for motorised transport (cf. above), active mobility brings obvious health benefits, as physical exercise can reduce the risk of numerous health problems.

3. The circular economy and bio-sourcing, agriculture, forestry

- **The circular economy and recycling: cutting down on our use of mineral resources.**

In the long term, limiting our use of the planet's mineral resources will be a necessary priority. Our strategy is constructed accordingly, with its focus on energy efficiency, the bio-based economy, the circular economy and the systematic promotion of reuse and recycling. This is one of the clear joint benefits of our policy. (The development of some renewable energy sources will nonetheless require additional resources, which will need to be optimised, cf. hereunder)

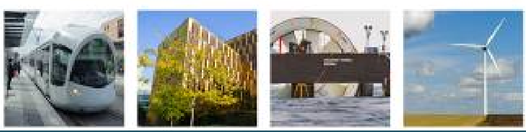
- **Greater use of biomass and the circular economy**

The SNBC promotes the development of bio-based materials and more widespread use of biomass for energy purposes (biogas and solid biomass, particularly for heating, as well as second-generation biofuels) and for material purposes (e.g. in manufacturing to create wholly or partially bio-based products).

Changing the way we use biomass and agricultural materials will naturally have consequences for the corresponding ecosystems. In accordance with Objective 12 of the National Biodiversity Strategy, ensuring the sustainable use of biological resources is an essential priority. Securing this sustainability will require us to find a coherent way to juggle the challenges listed in the following paragraphs.

- Use of biomass for non-alimentary purposes: agricultural impact

This strategy does not include a huge increase the amount of agricultural land dedicated to non-food uses, and recommends the use of catch crops wherever possible. First-generation biofuels and other fuels which represent competition for food should be subject to restrictions (both



nationally and at EU level). This will allow us to manage competition for agricultural land and minimise the potential direct and indirect impact of changing land uses on an international scale.

Promoting the methanisation of manure, leftover crops, catch crops and bio-waste will also help minimise competition between 'methanisation' as a revenue source and other agricultural uses.

However, phytosanitary products are sometimes required to destroy catch crops: keeping these products under strict control is a key priority, in accordance with the 'Ecophyto' strategy.

- Development of legume crops

Use of legumes in crop rotation can help to reduce the need for mineral fertilisers, and thus reduce the pollution - and energy consumption - connected with their production, transport and spreading. By regulating the level of nitrogen present in the soil, legumes help to improve soil quality and reduce the leakage of nitrogen into the water table.

Moreover, their melliferous properties attract pollinating insects, and thus help to ensure the pollination of other crops.

Development of hedgerows

The guideline target is to hit 700,000 ha of hedgerows by 2035, up from the current figure of 500,000.

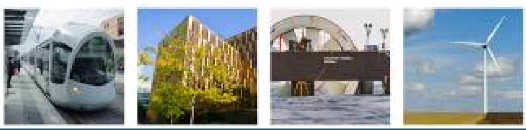
Hedgerows help to protect the soil (reducing erosion by wind and water). They are an essential element of our landscape. They also represent an irreplaceable habitat and source of biodiversity.

Sustainable forestry management

This means making sure that forestry resources are renewed effectively, and planning ahead to deal with increased pressure on natural resources (soils, water, biodiversity). Regular, increased demand for forestry biomass should not lead to a drop in soil fertility. Forestry management methods must limit the impact on the soil (with particular attention paid to the risk of subsidence). Certain soil additives may be useful of even necessary (ash, for example), as long as they are non-toxic and used in such a manner as to avoid leakage into the water table.
If forest residues are to be used for other purposes, we must still take care to leave a sufficient quantity of dead wood in situ for the sake of biodiversity (habitat and food, particularly when reducing the quantity of forest residues) (Bio2, 2009). Certain practices can help us to reduce the negative impact of removing dead wood, such as delayed collection in order to reduce the loss of food sources (Bio2, 2009).
Changes in the structure and composition of forestry resources can represent both an opportunity and a challenge, and we must ensure that forestry management is sensitive to the need to preserve biodiversity (particularly the diversity of habitats) and the landscape.
In this respect, it is important to distinguish between domestic and international effects. For the time being, pressure on forestry resources is under control in France thanks to a long-standing legal framework. But we must remain vigilant, especially since use of these resources is expected to increase significantly. At the international level, and since there is no system in place to monitor the sustainability of global forestry management practices, the indirect impact of imports can be significant, depending on the origin of the wood in question. With some developed economies forecasting rapid growth in their imports, this issue will require particular attention.
It should also be noted that importing wood increases the risk of spreading diseases and pathogens (risk level depends on the quality of the wood).

Highly-intensive forestry practices - a special case

High-intensity forestry operations (short or very short rotation coppice) require detailed preliminary



studies to avoid the use of phytosanitary products or fertilisers. These studies must also take into account the possible effects on water resources (interception, transpiration) and drainage basins (maintaining minimum flow rates).

The use of invasive plant species requires specific advance studies and reinforced monitoring.

- **The carbon impact of using forestry biomass - carbon debt or investment**

Using timber from the forest leads to a temporary decrease in the carbon stored by the living trees. In the short term, this carbon release is greater than the reduction in emissions made possible by avoiding fossil fuels. We thus end up with an excess of carbon in the atmosphere, compared with an alternative scenario in which the wood is left where it is and we burn fossil fuels instead. This excess is known as a carbon investment or debt. If forestry management respects the principles of sustainability and ensures that resources are protected and renewed, this carbon debt is only temporary - generally in the order of several decades - and will be more than compensated by a positive long-term climate impact. Furthermore, this positive impact can be repeated in the next forestry cycle. Carbon debt is therefore not a major concern from a climate perspective, as long as forestry resources are managed sustainably. Moreover, effective forestry management allows us to support the adaptation of ecosystems and stave off certain natural risks, including risks aggravated by climate change (drought and forest fires, for example, or parasite infestations). Finally, when forestry by-products are used correctly the carbon debt is substantially reduced and its "repayment" time becomes extremely short.

4. Development of renewable energies

- **Energy from wood**

When not burned fully, using wood as a source of heating represents a risk for respiratory health and air quality, emitting harmful atmospheric pollutants.

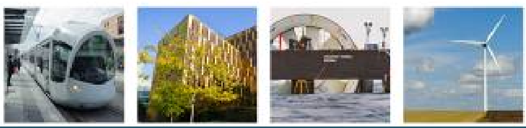
The widespread installation of modern heating equipment to replace old boilers (and especially open fireplaces) has allowed us to drastically reduce these emissions, representing one of the major secondary benefits of improvements in heating technology (and sometimes the main objective).

The use of wood for heating also creates large quantities of ash, which is rich in nutrients but can present certain risks when not effectively managed. We need to take these risks into consideration in order to make wood a sustainable energy source.

- **Methanisation**

Methanisation is a process allowing us to recover the biogas naturally emitted by farm waste, using some of this biowaste to produce energy and also fertilise soils. Methanisation does not reduce the raw quantity of nitrogen contained in animal effluents, but it converts this nitrogen into a digestate form which is more easily absorbed by plants. Spreading these digestates can limit the need for mineral fertilisers.

However, the nitrogen contained in these digestates is also more volatile, and methanisation can thus lead to an increase in gaseous ammonia emissions (and nitrous oxide, a powerful greenhouse gas of which ammonia can be a precursor) as a result of raw effluents being replaced with digestate fertilisers. Further research is needed into the potential impact of this process, and to identify potential technological solutions.



- **Wind power**

The development of onshore wind farms may place pressure on biodiversity (birds, bats etc.). The noise generated can disturb ecosystems. Turbines also change the landscape.

Developing wind power also requires us to increase our consumption of certain minerals needed to construct the corresponding infrastructure. Some of these mineral resources (rare earth elements) carry supply risks (particularly for offshore facilities), and their production (including mining) induces serious environmental damage (emissions of pollutants into the air, water and soils, significant quantities of waste etc.). These effects may be attenuated by using raw materials from mines using the best technologies on the market, but particularly by developing effective networks for the collection and recycling of materials from obsolete products.

Wind farms can also have beneficial effects on local biodiversity. For example, offshore wind farms can create habitats for some species of marine life. Furthermore, it is worth putting the environmental impact of wind turbines into some perspective. For example, the number of birds killed in collisions with wind turbines is tiny compared to the number of birds (from the same species) killed every year by pet cats, windows or power lines.

- **Solar power**

Photovoltaic power cells are relatively intensive in terms of the materials required for their manufacture, in comparison to other forms of energy generation.

The mining and preparation of the raw materials required to produce this equipment (particularly photovoltaic cells) have an impact on terrestrial and aquatic ecosystems (releasing toxic substances). Solar panels also take up space, and may induce the artificialisation of soils or modifications to habitats and biodiversity. Using spaces which are already developed (e.g. the roofs of buildings) or restricted (industrial risks) can substantially reduce this impact.

- **Transport networks and the electrical grid**

The development of intermittent renewable energy sources in France and across Europe as a whole, particularly wind and solar power, will require significant modifications to the existing electricity distribution networks. Depending on their specific properties, these technologies are subject to environmental impact assessments to help limit any damage done.

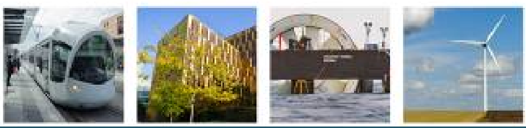
- **Hydroelectric power**

The production of hydroelectricity, even on a small scale, has an impact on the hydrological and sedimentary functions of watercourses (disturbing natural flow, reducing morphogenetic factors, sedimentary deficits etc.) as well as biological functions (aquatic milieus and habitats) in immediate proximity to the power facility, and also further up and down the ecological chain (disrupting the movements of invertebrates and fish, shifting sediment deposits etc.).

In watercourses frequented by highly migratory species (salmon, sea trout, shad, eels etc.) the impact of these different obstacles is cumulative (D4E, 2002). The installation of small hydro facilities therefore does have an impact, even when measures are taken to provide safe passage.

The operation and maintenance of dams also has certain effects.

The development of hydro power must be managed with reference to the framework directive on water resources.



5.3. Evolutions in greenhouse gas emissions, 1990-2013

A study commissioned by the Ministry for Ecology in 2015 and conducted by CITEPA/CEREN provides an analysis of national greenhouse gas emissions in Metropolitan France between 1990 and 2013 (for all sectors), and since 1960 for sectors connected to energy by a certain number of determining factors. A more detailed summary is given as an appendix. The main findings of the study are presented here.
This study allowed us to:

1. identify the main parameters influencing the developments observed in each sector;
2. better comprehend the relationship between the evolution of these parameters and variations in emissions.

Between 1990 and 2013, total GHG emissions (exc. changes to land usage and forestry) fell by 12.3% in Metropolitan France as a result of:

1. on the one hand, an 11.7% increase in emissions from the transport sector, 5.9% in the residential-tertiary sector and 11.1% in the waste management sector;
2. on the other hand, emissions fell by 39.8% in the manufacturing sector, 30.9% in the industrial energy sector, and 6.1% in agriculture/forestry.

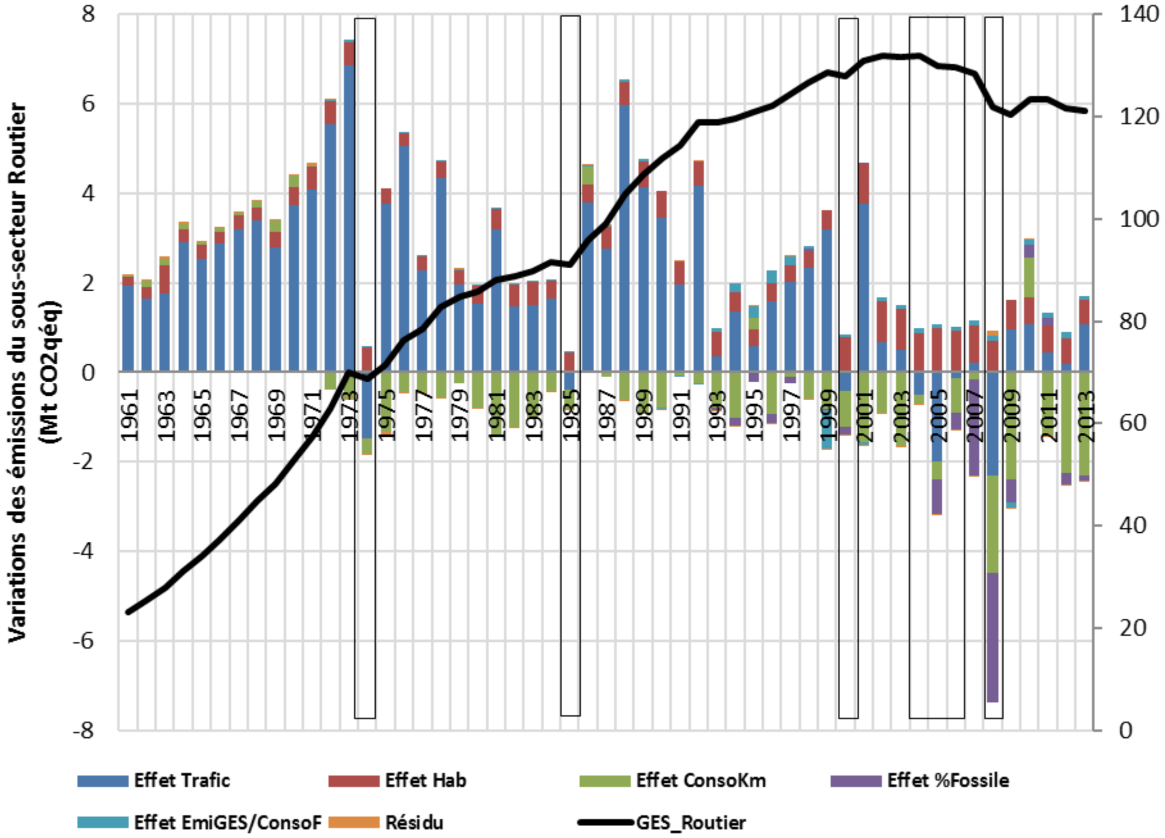
These sectoral developments need to be weighted to take into account the contribution of each sector to overall greenhouse gas emissions. Fluctuations bucking the general trend were observed during this period, particularly under the impact of certain government policies.

The sector-by-sector results are as follows:

- **Transport sector**

Since 1990, emissions from the transport sector have increased by 11.1% (from 118.3 $MtCO_2eq$ in 1990) to reach 131.4 $MtCO_2eq$ in 2013. Road transport made the biggest contribution (92% of greenhouse gas emissions), followed by air travel (3% of greenhouse gas emissions) and maritime transport (1% of greenhouse gas emissions).

On the roads, the development of biofuels served to reduce emissions, along with a decrease in per-vehicle fuel consumption and the reduction of average speeds. However, increases in distances travelled, population growth, number of vehicles per capita and road freight combined to push emissions upwards. Nevertheless, it is not easy to clearly determine the influence of other factors such as average fuel prices, the distribution of passengers between private vehicles, buses and trains, the extension of urbanised areas and the average age of vehicles on the road.

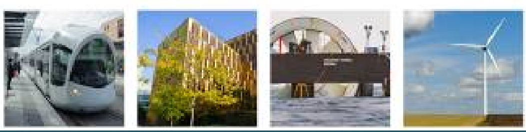


Between 1960 and 1990, greenhouse gas emissions grew steadily along with the volume of traffic per capita (traffic effect), with the exception of periods of economic crisis such as 1974 and 2008. Meanwhile, the fall in the average unitary consumption of vehicles on the road (the miles-to-the-gallon effect), which has improved over the years, partly as a result of European and national policies (bonus-malus schemes, European regulations limiting CO_2 emissions for new cars etc.), has helped to limit greenhouse gas emissions. The gradual introduction of biofuels (% fossil sources) has contributed to the decrease in greenhouse gas emissions since 2005. Sustained population growth between 1960 and 1990 (the population effect) pushed greenhouse gas emissions upwards, but not as significantly as traffic. The emissions factor (GHG Emi / Cons) caused emissions to increase slightly.

Greenhouse gas emissions from the aviation sector have increased since 1990, peaking at 4.7 $MtCO_2eq$ in 2000. They then declined steadily until 2010, stabilising at just under 4$MtCO_2eq$. The first period (1990-2000), marked by favourable economic conditions, saw an increase in tourism and commercial passenger numbers, leading to an increase in emissions. Air traffic slowed in the second period (2001-2013), and so did emissions, as passengers turned to alternative means of transportation, in a context rendered less favourable by increasing oil prices. The opening of new high-speed rail lines (the Mediterranean LGV) may have encouraged passengers to take the train instead of the plane.

- **The agricultural sector**

Between 1990 and 2013, emissions from arable crops fell by 8.4%. This was primarily a result of changes in nitrogen use and the economic circumstances affecting the sector. Some public policies may also have contributed to the fall in emissions, such as the nitrates directive and certain



subsidies offered by the second pillar of the CAP. Since 2000, increases in fertiliser prices may also have contributed to the decline in emissions. The decline in cultivated surface areas and a tricky economic context can partly explain the downturn in farm emissions in this period, even as crop output continued to increase.

Over the period 1990-2013, emissions from farming fell by 6.5%. These emissions come primarily from cattle. Over the period in question, the total number of cattle in France fell while dairy yields increased. These developments should be seen in the context of the restructuring of the dairy sector (milk quotas introduced in 1984), the dairy premium and CAP reform. As for the management of cattle effluents, we have moved from a system dominated by manure use to a more even balance of manure and slurry, reflecting the structural evolution of cattle farms and the gradual disappearance of small herds. Although slurry systems generate more emissions, overall emissions from animal waste have remained relatively stable as changing uses have been balanced out by the general decline in cattle numbers. Meanwhile, the development of methanisation techniques has contributed to a reduction in emissions from the sector.

The current economic state of the sector (which has shrunk over the course of this period) and the rising prices of production inputs have also contributed to this fall in emissions. This is borne out by the IPAMPA animal feed indicator (index for the average purchase price of agricultural inputs), which has increased over the period in question.

- **The waste management sector**

Emissions from waste management increased by nearly 10% over the period 1990-2013 (16.8. $MtCO_2eq$ in 1990, 18.4 $MtCO_2eq$ in 2013) to represent 4% of total greenhouse gas emissions in 2013. The increase in the quantity of waste generated per capita initially had an inflationary effect on greenhouse gas emissions (between 1991 and 2000), and then a deflationary effect (between 2001 and 2013) as per capita waste began to decline. Greenhouse gas emissions per unit of waste produced increased until 1995, and have fallen since. This may reflect the increase in the rate of emissions captured since the late 1990s.

- **The residential-tertiary sector**

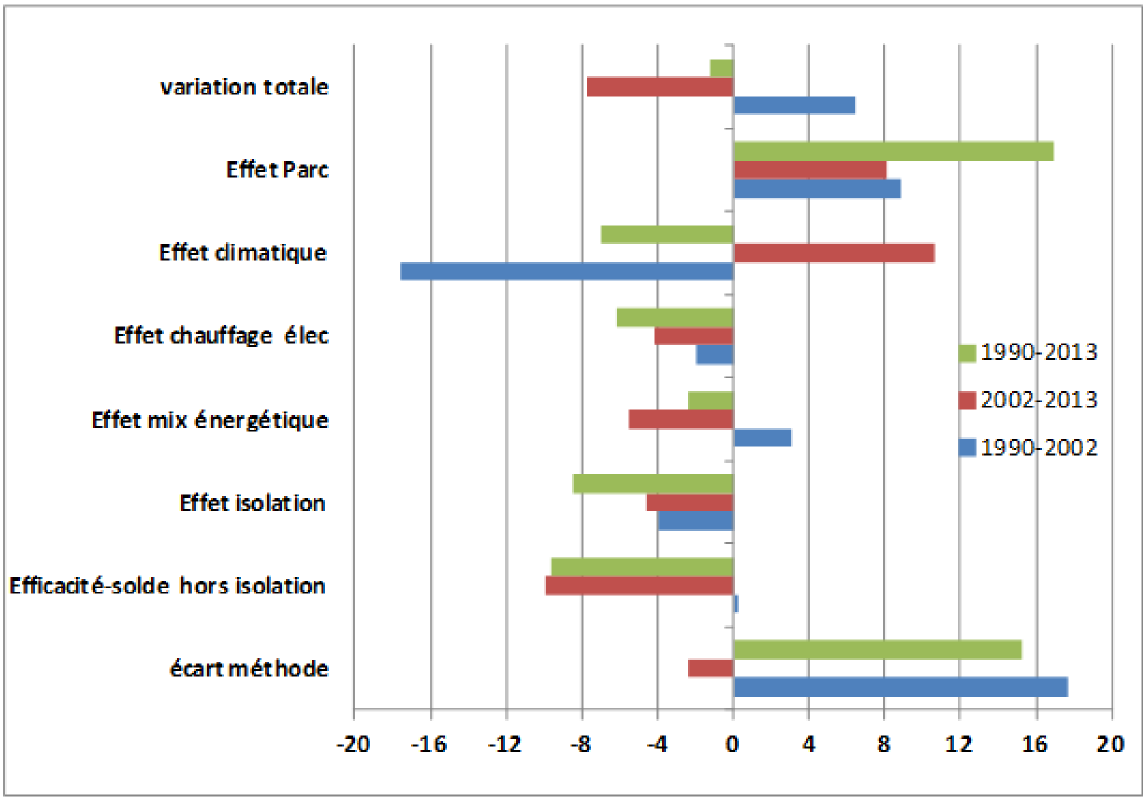
Between 1960 and 2013, direct GHG emissions from energy consumption in the residential and tertiary buildings increased by 77%, from 49 million tonnes to 86.6 million tonnes. The evolution of these emissions has involved several distinct phases. Demographic developments, economic activity, changes in heating habits, energy prices, environmental issues and the government policies which take them into account, thermal regulations and household reactions, as well as the evolution of the energy mix and varying GHG emission from different energy sources have all had an impact on the overall level of emissions.

With the exception of demographic factors, which have had a steady impact on the level of GHG emissions, all of the other factors listed above have influenced fluctuations in emissions to varying extents at different periods.

The sub-period 1960-1975 saw strong economic growth (an average of 5.2% per annum) and low energy prices. The sub-period 1975-1990 was marked by the effects of the 1973 oil crisis, at a time when economic growth was strong but not as strong as it had been in the preceding period (average annual growth of 2.7% between 1975 and 1990). The sub-period 1990-2002 saw prices fall in constant currency, as growth remained strong (average 2% p.a.). The sub-period 2002-2013 saw a sharp increase in energy prices, and a slowdown in economic growth (average 1.1% p.a., with recession in 2008-2009). This sub-period also saw the gradual introduction of new thermal regulations for housing, with notable reforms in 2000 and 2005.

- **The residential sector**

We analysed emissions from the energy consumption in the residential sector by breaking down their effects. The results (in $MtCO_2eq$) are presented in the graph below.



Between 1990 and 2013, direct GHG emissions induced by the consumption of energy were virtually stable ('total variation'). "Stock" and "energy efficiency" effects (*"efficiency_balance"*[50]) were dominant and cancelled one another out (an average annual increase of +1.1% greenhouse gas emissions as a result of the former, and a -1.5% decrease attributable to the latter).

The "energy efficiency" effect saw a strong increase between 2002 and 2013, and thus had a positive influence on the reduction of greenhouse gas emissions (annual average of -2.5%; compared with -0.5% in the period 1990-2002). In the first period, fuel prices were relatively stable in constant currency. They increased sharply in the second period. The combination of these circumstances and successive waves of thermal regulations provided an incentive for energy efficiency efforts in the second period. Over the period 1990-2013 as a whole, better insulation of buildings accounted for around half of the improvement in energy efficiency, though this figure fluctuated over time: it accounted for all of the progress made in the period 1990-2002, and around a third of efficiency gains made in 2002-2013.

Over the period as a whole, the climate effect served to limit greenhouse gas emissions (-0.5% per year on average). The first few years were milder than the years toward the end of the period (only two years were recorded as being cooler than average), leading to a 2.8% annual decrease in greenhouse gas emissions between 1990 and 2002. Between 2002 and 2013, climate effects saw

[50] The "efficiency balance" effect in the residential sector is the difference between the total variation in emissions as calculated by CEREN and the sum total of effects such as housing stock, climate conditions, electric heating, energy mix and insulation. The discrepancy here is the result of differences in the calculation methods used by CITEPA and CEREN.

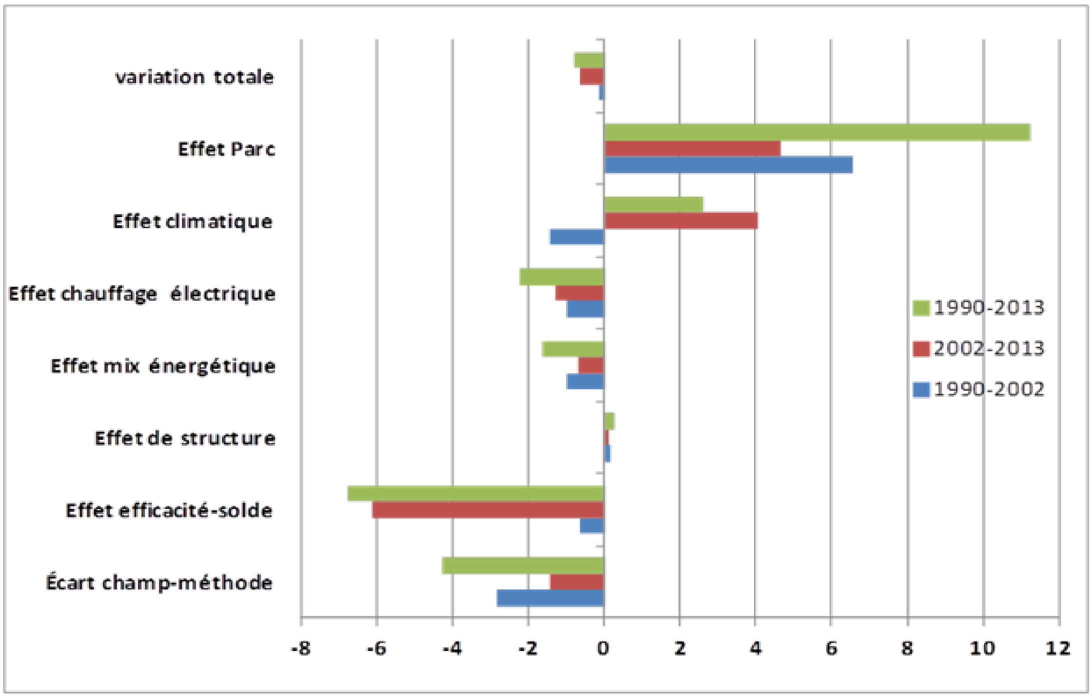
emissions increase by 1.5% each year. Four of those years saw cold winters, including 2010 which was particularly harsh. Unlike the tertiary sector, the overall impact of climate effects in the period 1990-2013 was to drive emissions down.

The contribution of changes in the energy mix to the reduction of GHG emissions is estimated at -0.2% p.a. over the period 1990-2013. This contribution fluctuated over the course of the period: the decline in wood burning between 1990 and 2002 more than balanced out the gains made possible by increased use of gas. The energy mix effect actually increased emissions by an average of 0.4% each year between 1990 and 2002, after which the gains made possible by the rise of wood and gas led to a significant reduction in overall emissions (-0.9% p.a. between 2002 and 2013).

The effect of replacing combustible fuel-powered heating with electric alternatives helped to reduce greenhouse gas emissions by an average of -0.5% per year between 1990 and 2013, under the combined effect of a decline in unitary consumption and a reduced average GHG content. This reduction was more substantial in the latter period as a result of the accelerated uptake of electric heating (34% market share in 2013, up from 28% in 2002 and 26% in 1990). This acceleration has been driven largely by the installation of heat pumps in private homes since the mid-2000s.

- **The tertiary sector**

As with the residential sector, we analysed emissions from energy consumption in the tertiary sector by breaking down their effects. The results (in $MtCO_2eq$) are presented in the graph below.



Direct GHG emissions were relatively stable between 1990 and 2013. "Stock" and "energy efficiency" effects ("efficiency_balance"[51]) had a major impact on the evolution of emissions. The impact of the energy efficiency effect was amplified between 2002 and 2013 (annual average -2.2%) compared to the preceding period (-0.1% p.a. between 1990 and 2002).

The stock effect was a dominant force, though it fell from an annual average of 1.7% in 1990-2002 to 1.4% in 2002-2013. Over the period 1990-2013 as a whole, the climate effect led to an increase in greenhouse gas emissions: +0.3% per year on average, with variations over the course of this period (-0.5% per year between 1990 and 2002 then +1.2% per year between 2002 and 2012).

[51]This effect is calculated as the difference between the total variation in emissions and the sum total of effects such as building stock, climate conditions, electric heating, structure etc. The "methodology deviation" effect accounts for discrepancies arising from differences in the calculation methods used by CITEPA and CEREN, and differences in the scope of studies focusing on the tertiary sector.

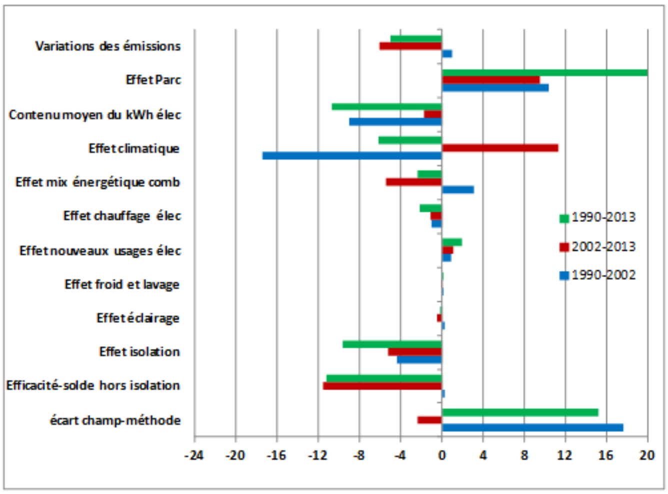
The evolution of the energy mix was favourable to natural gas, at the expense of domestic heating oil. This helped to reduce greenhouse gas emissions by an average of 0.3% per annum between 1990 and 2013. The impact of increased use of electric heating is estimated at -0.4% p.a. in the period 1990-2013. Replacing combustible fuel-powered heating with electric alternatives helps to reduce greenhouse gas emissions thanks to the combined effect of a decline in unitary consumption and a reduced average GHG content. Over the period 1990-2013 as a whole, the effects of energy efficiency measures had a positive impact on reducing greenhouse gas emissions estimated at -1.1% per year on average. This impact varied over time: -0.1% per year between 1990 and 2002, then -2.2% per year between 2002 and 2013. It is worth noting that fuel prices fell during the first period (in constant currency), before increasing substantially in the second period, a development which undoubtedly provided extra impetus for energy efficiency efforts. Furthermore, since the turn of the millennium thermal regulations have been extended to the tertiary sector, increasing overall energy efficiency in this sector with new buildings and thermal renovation of existing stock.

- **Factors explaining the evolution of direct and indirect GHG emissions from energy consumption in the residential-tertiary sector**

Analysing indirect emissions allows us to take into account the effects of electricity consumption, particularly the impact of average GHG emissions per kWh of electricity, the impact of air conditioning and the impact of other specific uses.

The following section looks at total (direct and indirect) emissions from the energy consumption in the residential and tertiary sectors over the period 1990-2013.

Residential buildings



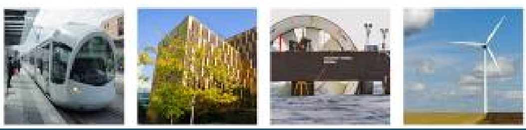
The evolution of "average GHG emissions per kWh of electricity" led to a significant fall in emissions:

-10.7 Mt CO_2eq between 1990 and 2013.

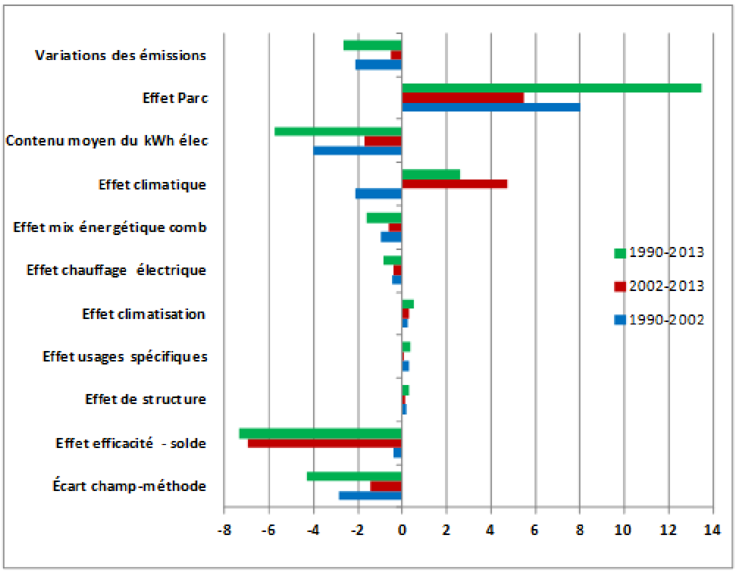
This reduction was concentrated in the first sub-period:

-9.0 Mt between 1990 and 2002, due to the milder climate conditions.

The effects of specific electricity consumption were limited, as a result of the low GHG content of this consumption.



Tertiary buildings



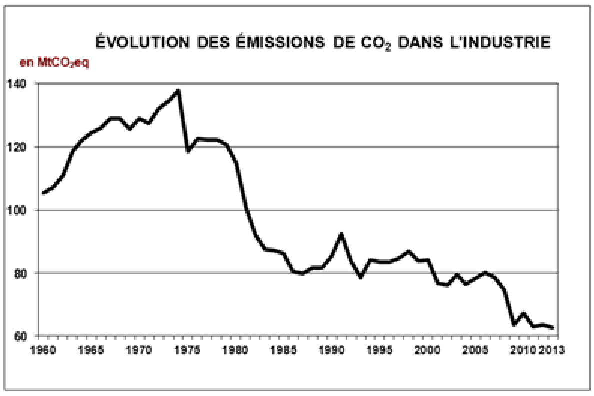
The reduction in average GHG emissions per kWh of electricity helped drive down emissions by 5.7 $MtCO_2eq$ between 1990 and 2013.

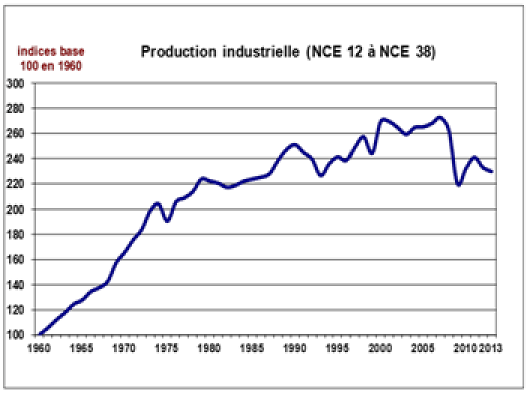
The spread of air conditioning had a limited impact on emissions due to its low GHG content.

The effect of specific uses was almost nil between 2002 and 2013, as a result of improved energy efficiency in lighting and office equipment.

- **The industrial sector**

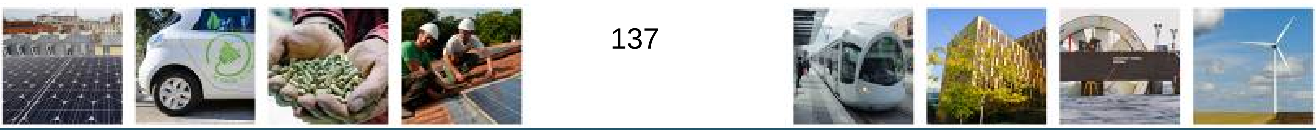
Between 1960 and 2013, direct GHG emissions from energy use in industry were virtually halved, shrinking from 105.2 million tonnes to 62.7 million tonnes, after peaking at 137.9 million tonnes in the mid-1970s.





Meanwhile, output was multiplied by 2.3 across the period as a whole, with an average annual increase of 5.2% between 1960 and 1974, +1.3% between 1974 and 1990 and -0.4% between 1990 and 2013, the latter figure reflecting the scale of the recession of 2008-2009.

Between 1990 and 2013, greenhouse gas emissions from industry fell substantially (-22.7 Mt). All of the effects studied contributed to the fall in emissions over the period, with the exception of the climate effect. The technical effect accounts for around half of this reduction. Over the period 1990-2013 as a whole, the technical effect (i.e. the difference between the total variation in emissions and the combined impact of other effects such as output, climate, structure and energy mix) made a positive contribution to the reduction of emissions, equivalent to a total of 11.6$MtCO_2eq$ or 0.5Mt per annum. This improvement is the result of greater energy efficiency and the development of new anti-pollution technologies. During the 1990s, fuel prices dropped (in constant currency). They then increased sharply in the 2000s, providing further impetus to energy efficiency. Since 2006, the energy efficiency certificate scheme has helped to increase energy efficiency in the industrial



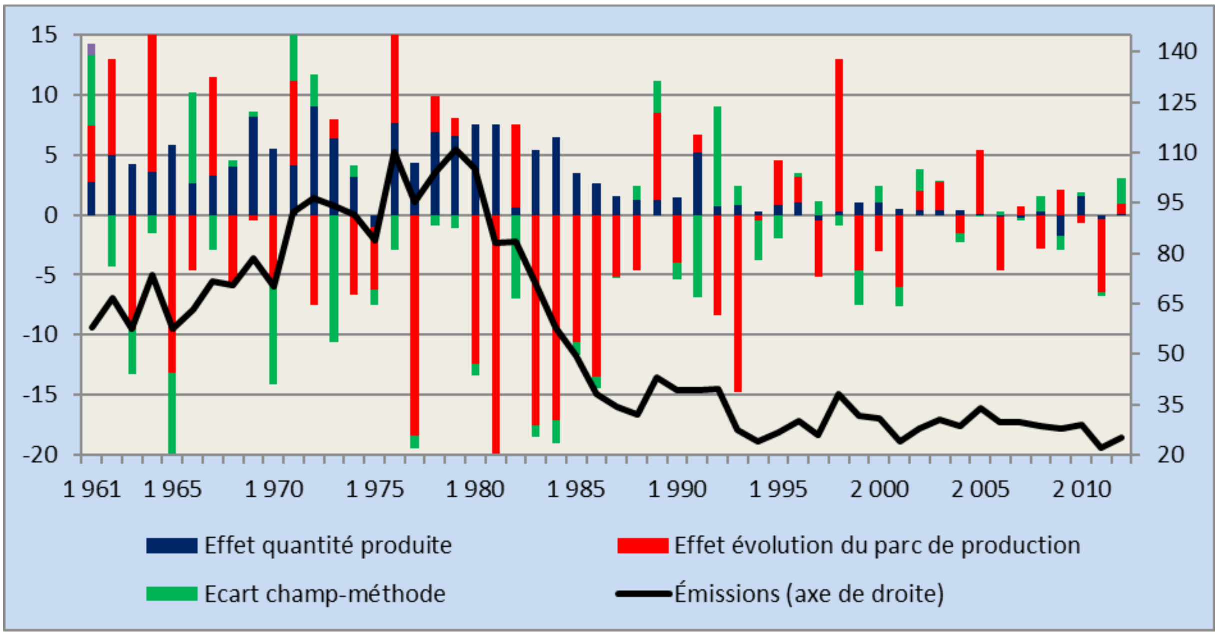
sector.

The output effect was virtually nil across the whole period (-0.5 $MtCO_2$eq.), but this quasi-stability masks conflicting dynamics in the two sub-periods (+6.6$MtCO_2$eq between 1990 and 2002, and -7Mt between 2002 and 2013).

With regard to combustible fuels, the evolution of the energy mix has favoured natural gas over oil products, while biomass has also seen its market share virtually double in recent decades (from 5% to nearly 10%). Emissions therefore fell by a third as a result of changes in the energy mix.

- **Electricity production**

The evolution of greenhouse gas emissions linked to electricity production saw three distinct phases in the years 1960-2013. Between 1960 and 1979, emissions increased sharply by 79 $MtCO_2$eq, driven by the increase in electricity production (+92 $MtCO_2$eq), as the effect of changes in the energy mix was virtually nil. Between 1980 and 1988, emissions fell (-79 $MtCO_2$eq) due to major changes in the energy mix (-101Mt) as the nuclear programme hit its stride, despite a big increase induced by the output effect (+39 $MtCO_2$eq). CO2). Between 1989 and 2013 emissions stabilised, with the effect of increasing output (+15 $MtCO_2$eq) offset by changes in the mix of energy sources.



CHAPTER 6: METHODOLOGICAL APPENDIX

i. Economic impacts: a detailed report on the analysis of the ThreeME model

Context

The ADEME and CGDD were asked to use ThreeME[52] (Multi-sector Macroeconomic Model for the Evaluation of Environmental and Energy policy) to simulate the macroeconomic effects of the roll-out of energy transition scenarios generated by the DGEC following the application of the Law on energy transition and green growth.

ThreeME is a multi-sector Neo-Keynesian macroeconomic model first co-developed by ADEME and the OFCE (French Observatory for Economic Contexts) in 2008.

The result of the simulation will be presented after a brief description of the key characteristics of macroeconomic modelling.

The ThreeME model

The model developed jointly with the OFCE is a Neo-Keynesian "Aggregate Demand-Aggregate Supply" model which is similar to those commonly used by economic forecasting organisations, such as EMOD by the OFCE[53] or MESANGE by INSEE,[54] with the difference that it is multi-sector.

A Neo-Keynesian multi-sector model

ThreeME is broken down into 24 production sectors and 17 energy sub-sectors and allows us to highlight the effects of activity transfer from one sector to another:

- on employment, because production sectors are not all equally labour intensive;
- on energy consumption, because they are not all equally energy intensive;
- on net exports, because they do not all have the same propensity for import and export.

For example, an increase in renewable energy in preference to combustion thermal power stations leads to an increase in employment – the former being more labour intensive than the latter – and a drop in fossil fuel imports.

Changes in job intensity in the economy has a direct influence on consumption and ultimately on GDP, as do changes in external deficit, since this aggregate is equal to the sum of consumption C, investment I, stock variation ΔS and net exports (X-M).

$GDP = C+I+\Delta S+(X-M)$

Given that demand has an influence on production (see infra), it is vital to carefully model the effect of sectoral transfers on employment and net export, without which the model-maker runs the risk of major forecasting bias.

Possible energy trade-offs

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[52] G. Callonnec, G. Landa, P. Malliet, F. Reynès, Y. Yeddir Tamsamani. *A full description of the Three-ME model: Multi-sector Macroeconomic Model for the Evaluation of Environmental and Energy policy*, OFCE, 2013.

[53] V. Chauvin, G. Dupont, E. heyer, M. Plane and Xavier Timbeau, "Le modèle France de l'OFCE, la nouvelle version : e-mod.fr", Revue de l'OFCE 81, April 2002, 300 p. http://www.ofce.sciences-po.fr/pdf/revue/6-81.pdf

[54] C. Klein, O. Simon, "Le modèle MESANGE nouvelle version réestimée en base 2000", Working paper by the DGTPE, number 2010/02, March 2010, 105 p. http://www.tresor.economie.gouv.fr/file/326046

17 energy sub-sectors have been identified (see the list of sectors on page 7) to model the energy decisions of actors.

Enterprises making energy trade-offs:

- Substitute energy with capital when its relative price increases.
- May substitute energy sources with other energy sources.

Households choose between investments allowing them to make energy savings or not, notably between three types of housing and vehicle.

- The market share of each type varies depending on the evolution of costs of use (amortisation of the purchase price, net subsidies and energy consumption).
- The penetration rate of electric vehicles is assumed to be exogenous.

ThreeME also takes into account the effect of restraint incurred by variation in prices: households reduce their heating and fuel consumption when prices increase and vice versa.

ThreeME also has the specific characteristic of being a hybrid model, in that it combines macroeconomic and technical modelling of energy consumption. Actors' investments (flow) lead to changes in vehicle and housing stock (stock), and the structure of these stocks determines energy consumption. This is an important difference against most general equilibrium models, in which energy consumption is directly dependent on household income. Such models tend to generate a forecasting bias because the relationship between energy consumption and income is not usually linear.

Contrary to supply-only models (of Neoclassical design) Neokeynesian models like ThreeME take into account the retroactive effect of variations in demand (consumption, investment and net export) on supply (the sum of value added) and vice versa. A multi-sector Neokeynesian model can therefore show the impact of energy transition on demand with less forecasting bias, and in turn evaluate its effect on economic activity.

Crowding out due to money creation

One of the big differences between models of supply and demand (Neokeynesian, in dynamic equilibrium) and models of supply (Walrasian, in static equilibrium) concerns the crowding out effect between investments.

In ThreeME, investments are financed by through bank loans, which is a form of money creation, and not only savings. The model presupposes a limited crowding out effect between investments.

For example, an increase in households' investments in energy renovation does not lead to an equivalent decrease in their expenditure. This decreases by an amount equal to the increase in debt annuities as a result of the works minus the reduction in energy bills.

In Neokeynesian models such as ThreeME, increase in investment can offset the "deadweight loss" entailed by instituting a tax. In supply-only models, an increase in taxes leads to an automatic increase in the price of goods or factors subjected to them. It incites actors to make certain investments in the place of others. These do not lead to an overall increase in demand because the crowding out effect is a complete one. These investments are less profitable that those they replace, because a tax is required to make them profitable. The tax therefore reduces profit and investment, which negatively affects demand and growth, unless the tax leads to a reduction in import either because it mainly concerns imported products such as fossil fuels, or because the recycling of revenue enables the State to reduce another tax which is even more distortive, such as employer contributions. In these cases, however, the cost of the tax is partially borne by everybody else.

In the ThreeME model, energy efficiency investments resulting from corporate or household environmental taxes are mainly financed on credit, and do not fully substitute others. Capital-energy substitution leads to an overall increase in investments in general because the crowding out effect is only partial. Demand increases and companies' outlets grow: demand influences supply.

This leads to an increase in production (influenced by the increase in the amount of productive capital and the increase in sales by capital goods suppliers) and a reduction in energy imports, generating an increase in employment and therefore consumption; supply influences demand.

A spiral effect is sparked off in the short term but, in the long term, reimbursing the debt incurred by financing the investment has a recessive effect on the economy (the money supply contracts).

In this theoretical context, in the short term, the introduction of an energy tax is offset by the improvement in net exports and an overall increase in investment.

In the long term, if the sum of the direct revenue generated by the investment, the indirect revenue resulting from the multiplying effect on employment, and changes in net exports cover the cost of the debt, there will be a durable rise in GDP. On the other hand, if the investments are not profitable (the NPVs are negative) and their losses are not made up for by the positive knock-on effect they have on the rest of the economy, there will be a durable drop in GDP.

For example, the introduction of a carbon tax encourages consumers to favour less carbon-heavy modes of transport, like for example shifting from road transport to rail. The use of cars decreases, but public transport consumption increases. On the other hand, railways have a higher job content than roads, leading to a reduction in unemployment which also positively and retroactively influences demand. In a supply model, this effect would have been at least partially offset by a downward trend in the level of profit, which would have reduced the amount of savings and therefore investments, so that demand would have remained stable. In the case of a supply–demand model in which savings do not finance investment, the creation of employment linked to the transfer of activity from very energy-consuming sectors towards less energy-consuming sectors has a positive multiplying effect on the economy, at least in the short term.

In theory, at full-employment equilibrium, Neokeynesian models also have Neoclassical properties. The growth trajectory becomes perfectly stable. The growth rate of the GDP returns to the level it was at before State intervention, but the level of GDP can differ in the long term from the level it would have been at in the trend-based scenario.

It can therefore be shown that the introduction of an energy transition policy generates a dual ecological and energy dividend.

The case of energy transition

Energy transition implies making energy efficiency investments and modifying the energy mix.

We have just explained why, in ThreeME, energy efficiency investments do not necessarily substitute investments in other sectors. This argument is not valid for investments linked to changes to the mix. For given demand at a moment T, the increase in the installed capacity of renewable energy will be at least partially offset by a reduction in the installed capacity of non-renewable energy. The increase in investments in green sectors should occur alongside a reduction in investment in other sectors, notably carbon-heavy energy (this argument is also valid for the different modes of transport). A significant substitution effect therefore exists independently of financing method for these installations. The rise in investment in renewable energies should not have a big knock-on effect in the short and medium term, unless the propensity to import capital goods in renewable energy production sectors is lower than the propensity to import capital goods in non-renewable energy production sectors, something which is not the case today.

On the other hand, replacing non-renewable energies with renewable energies will increase the employment content of the sector and lead to a noticeable decrease in import figures for fossil fuels. This should have an expansionary effect.

However, the increase in energy prices which may occur as a result of this could, at least in the short and medium term, have a recessive effect on activity, mainly through a decrease in domestic and international competitiveness because companies will have to reflect this increase in their sales prices. This could at least in part offset the expansionary effect linked to changes in employment and importation of fossil fuels.

This said, on a macroeconomic level the costs of some are the gains of others. All revenue linked to renewable energy production will be redistributed among actors (and ultimately to households) through expenditure in the sector (salaries, intermediate consumption, investment, dividends), with the exception of revenue that will be used to pay for imported goods and part of the debt burden (used for bank repayments to the Central Bank). The rise in renewable energy production and energy prices should therefore not negatively affect the average household disposable income net of their energy bill, unless the propensity to import and the cost of capital in green sectors are greater than in non-renewable energy sectors.

If the expansionary effects outweigh the recessive effects, and if the cumulative sum of increases in GDP covers payment of the loan annuities, then the level of GDP will, in the long term, remain greater than what it would have been if no transition had taken place. On the other hand, if the recessive effects outweigh the expansionary effects, companies will have to raise prices and the State will have to increase taxes in order to repay their respective debts. This will have a lasting negative effect on demand.

Ultimately, the macroeconomic effects of the energy transition will depend:

- on the impact of the decrease in energy demand on net export
- on the reduction in energy production;
- on the influence of energy prices on energy efficiency investments and their profitability;
- on changes in the different sectors' propensity for import/export;
- on the impact of the increase in companies' production unit costs on prices and domestic and international demand;
- on the modalities of redistribution of environmental tax revenue;
- on changes in employment.

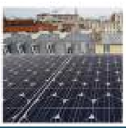
Calibration of the model

In order to correctly differentiate between the recessive and expansive effects at play, is vital to carefully calibrate the model.

The ThreeME model has been calibrated using several data bases, firstly on national account tables (input-output and the overall economic picture) by the INSEE for the base year (2006)[55], as well as on sectoral bases for housing (CEREN), vehicles (Car labelling by ADEME) and energy consumption for the different sectors (CEREN). Fluctuations in the economic context observed between 2006 and 2015 have been reproduced through the introduction of tax and budgetary reforms and imbalances in net export observed for the period.

Close attention has been paid to production unit costs, since these greatly influence the results. The energy production unit costs have been calibrated using the report on electricity production cost by the DGEMP (2003).[56] The other costs have been calibrated using the In Numeri report

[55] http://www.insee.fr/fr/themes/comptes-nationaux/default.asp?page=archives/archives_cnat_annu.htm
[56] DGEMP, DIDEME, "Coûts de référence de la production électrique", Report, December 2003. 79 p.







(2008).[57] The cost of nuclear energy estimated by the DGEMP in 2003 has been corrected using the report on the cost of nuclear energy (2012)[58] by the Court of Auditors and Senate report written on the subject (2012).[59] The cost per MWh (excluding cost of conveyance) is set at €50/MWh for existing stations (including extension costs). The EPR production cost has been set at €70/MWh based on the report. This figure corresponds to the lower range of the estimation, going from €70 to €90/MWh.

It has been supposed that renewable energy industries' propensity to import capital goods will converge towards that of industrial branches between now and 2030-2040. This implicitly means that the State will encourage the growth of sectors in the country through its policy for invitation to tender.

		Coût de production et de distribution
Carburants	Pétrole	49.8
	Biocarburants et biogaz	60.8
Electricité	Nucléaire	71.1
	Fioul	211.1
	Combiné gaz	77.6
	Charbon	74.0
	Eolien, hydrolien	105.3
	Solaire	203.9
	Hydraulique et step	53.8
	Cogénération, méthanation	107.1
Chaleur et vapeur	Gaz naturel	56.5
	Bois	62.3
	Biogaz	90.3
	Incinération (UIOM)	26.6
	Géothermie, pompe à chaleur	53.8
	Cogénération, autres	60.0

Average production prices in 2006, Source ThreeME 2014 according to the CGDD

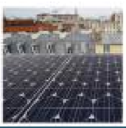
The parameters of the behavioural equations are estimated on the basis of econometric studies by the CEREN and INSEE for actors' energy trade-offs. For households' energy consumption, ThreeME distinguishes short-term price elasticity (effect of restraint or limitation due to the increase in energy prices) and decisions between inefficient investments (such as purchasing a vehicle high in energy consumption, renovation work without insulation) and efficient investments (purchasing an economical vehicle, efficient renovation work). The decision is made by the household with consideration for the cost of use of the vehicle and housing, which depends on the cost of investment, cost of credit and anticipated energy prices. For energy substitutions, elasticities from publications have been used for housing (of the order of 0.8), whereas the penetration rate of electric vehicles is exogenous because it is not possible to aptly model actors' choices due to a lack of data over a longer period.

In industry, energy and inter-energy capital elasticities of substitution have been set at 0.5 and 0.4 respectively for fuels used for heat production.

[57] I NUMERI, "Marchés, emplois et enjeu énergétique des activités liées à l'amélioration de l'efficacité énergétique et aux énergies renouvelables : situation 2008-2009_ perspectives 2010". ADEME Report, October 2010, 379 p.

[58] Court of Auditors, "les coûts de la filière electronucléaire", Themed report, January 2012, 430 p. http://www.ccomptes.fr/Publications/Publications/Les-couts-de-la-filiere-electro-nucleaire

[59] Senate, "Le coût réel de l'électricité afin d'en déterminer l'imputation aux différents agents économiques", Senate report n°667, chaired by L. Poniatowski, rap. J. Desessard, 11 July 2012, http://www.senat.fr/rap/r11-667-1/r11-667-11.pdf.







Outside of the energy sector, behavioural equations have been configured based on econometric studies by the OFCE including wage setting (Wage Setting WS Curve), price setting (markup rule) and elasticity of substitution between production factors (CES function). In this exercise, it is assumed that real interest rates remain fixed. The dynamic properties of the model are consequently comparable to those of the economic forecast used by INSEE and the Directorate General of the Treasury in Bercy, MESANGE. If public investment increases by 1 GDP point, economic activity will increase in the short term by 1.3%.

Results of the macroeconomic modelling

To understand the macroeconomic effects of energy transition, we will compare the economic aggregates of a trend-based scenario called AME ("With Existing Measures") with those of the reference scenario for energy transition called AMS2 ("With Additional Measures").

Calibration of the business-as-usual scenario (AME) and the reference scenario used to establish the sectoral distribution of transition (AMS2 in the rest of this section)

The calibration of the model was modified in accordance with hypotheses on changes in:

- demographic growth
- increase in productivity
- price of fossil fuels
- new registration numbers and the penetration rate of electric vehicles
- construction of new housing
- the share of the different means of energy production in each carrier (fuel, electricity, heat and steam), which has been exogenously set in accordance with hypotheses of the scenario
- environmental tax measures (CIDD and EcoPtz)
- price of the CO_2 quotas in the European market

To model the effects of the AMS2 scenario, the following modifications have been made to the AME trend-based scenario:

1. The share of the different energy production modes in each carrier (fuel, electricity, heat and steam) has been exogenously set in accordance with the hypotheses of the scenario.

2. Regulations measures and additional investments have been introduced according to different modelling techniques:

a. Simulation of the measure as such:

- Increase in the number of zero interest loans released;
- Changes in the CITE (energy transition tax credit) level;
- Investments in railways and public transport;
- Rise in the penetration of electric vehicles (EV);
- Improvement in the performance of personal vehicles, light commercial vehicles and heavy goods vehicles;
- Change in vehicle occupancy rates;
- Modal shift among travellers between road and rail;
- and the rise of soft mobility;
- Road traffic speed reduction;
- Increasing the number of new constructions;
- Improving the energy performance of domestic hot water production and cooking;

b. “Fictional” increase of energy prices in behavioural equations for economic actors, allowing the desired target of consumption to be reached (see details below):

- Requirement for renovation in the tertiary sector and strengthening of the EEC;
- Improvement of thermal standards in the construction industry;
- Rise of energy efficiency investment in industry.

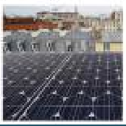
3. Increase of carbon tax

Carbon tax will increase from €22 in 2016 to €56/tCO_2 in 2020 and €100/tCO_2 in 2030 (at constant Euro exchange rate for 2015). It will remain at €100/tCO_2 after that (constant 2015 euros).

Concerning energy demand, signal prices have been introduced to encourage actors to reach end consumption targets in the scenarios. They reflect the implicit cost of strengthening standards and improving yield. The advantage of this method is that the investment mechanisms are endogenous. Only investments linked to new housing and new vehicle registration are exogenous.

	sorties ThreeME				Cibles DGEC			
	2010	2020	2030	2035	2010	2020	2030	2035
	threeME				Cible DGEC			
transport	44	38	32	31	44	37	32	30
résidentiel	44	41	34	32	45	41	33	32
tertiaire	22	21	18	18	22	22	19	18
industrie	36	33	30	29	34	33	29	29
Agriculture	4	4	4	4	4	4	3	3
total en Mtep finales	**151**	**136**	**118**	**115**	**150**	**136**	**116**	**112**

Source ADEME/SEP 2015





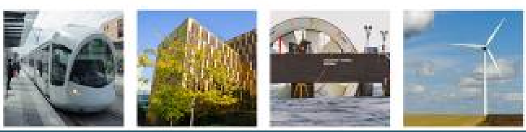


This is why the sum of investments does not correspond exactly to the estimation, all other things being equal, for the macroeconomic analysis of scenarios by the Seureco-Enerdata-Energies Demain-CITEPA consortium.

For that matter, 45% of renovation investments in housing are financed by loan, compared to 33% in NEMESIS. The other types of investments are financed exclusively by loan (also including purchase of a new-build, whereas according to NEMESIS, households borrow 85% of the sum when purchasing new housing).

Modelling the measures listed above allows end consumption targets given in AMS2 for each sector to be reached (115 Mtoe vs 112).

The version of the model used is the one with little delay in adjustment in the quantity of production factors used (estimations by macro-econometric models usually consider that the quantity of production factors used - capital, labour and intermediate consumption – is adjusted to its “desired level” with a delay).



Expansionist effects

Energy transition has a positive knock-on effect on economic activity.

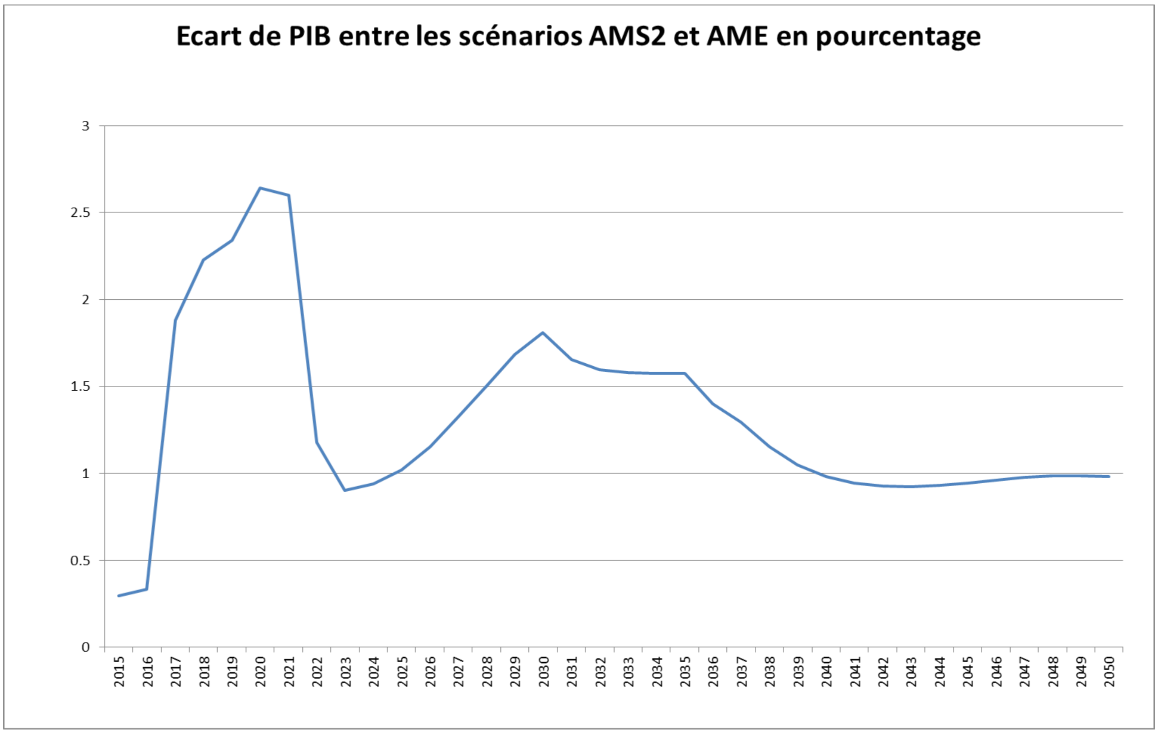


Figure 6.1 : Difference of GDP between the reference scenario (AMS2) and a business as usual scenario. Source ThreeME 2015 ADEME/SEP

Applying AMS2 produces an increase in GDP by 1.6 points in 2035 compared to its level in AME. Most of the growth is driven by investments at the start of the period, which lead to the creation of new jobs and an increase in consumption, which retroactively and positively influences activity.

The difference then gradually disappears as actors pay off their debts and as a result of a reduction in the net export deficit. The decrease in energy consumption is offset by the drop in exports caused by the rise in inflationary pressure, and the increase in import linked to a rise in consumption. Nevertheless, the trade deficit to GDP ratio decreases, but the external deficit to GDP ratio decreases by 0.8 points in 2035.

Over time, the difference in GDP remains positive, since in 2050 the difference between the level of GDP in AMS2 and GDP in AME remains close to 1 point.

This policy leads to a decrease in the public deficit to GDP ratio from 2020 as a result of (see table below):

- a decrease in State social spending (drop in unemployment),
- additional tax income (due to an increase in activity),
- and a rise in GDP.

		2014	2015	2020	2025	2030	2035	2040	2050
PIB en volume	(a)	0.0	0.3	2.6	1.2	1.9	1.6	0.8	0.9
Consommation des ménages	(a)	0.0	0.4	1.4	1.8	2.6	2.7	1.2	0.6
Investissement	(a)	0.0	0.6	12.6	4.5	6.6	5.2	3.7	4.7
dont investissement privé	(a)	-0.1	0.0	7.7	5.2	8.2	5.7	2.7	4.5
Dépenses publiques	(a)	0.0	0.3	1.1	-0.5	-0.8	-1.8	-3.0	-3.2
Exportations	(a)	0.0	0.0	-1.5	-2.9	-3.3	-3.8	-3.5	-2.5
Importation	(a)	0.0	0.1	1.6	0.0	0.2	-0.4	-1.3	-1.2
Taux de chômage	(b)	0.0	-0.2	-1.9	-1.0	-1.5	-1.3	-0.8	-0.9
Population employée	(a)	0.0	0.2	2.2	1.1	1.7	1.5	0.9	1.0
Salaire brut	(a)	0.0	0.2	5.5	7.8	9.2	10.2	8.8	6.4
Prix (déflateur du PIB)	(a)	0.0	0.1	3.5	6.5	7.6	8.9	8.2	5.8
Taux d'intérêt nominal	(b)	0.0	0.0	0.9	0.1	0.2	0.0	-0.2	-0.1
Déficit public/PIB	(c)	0.0	0.0	-0.8	-0.7	-1.3	-1.5	-1.8	-2.1
Dette publique/PIB	(c)	0.1	-0.2	-6.7	-9.2	-13.9	-18.8	-23.1	-31.9
Déficit commercial/PIB	(c)	0.0	0.0	0.2	-0.4	-0.6	-0.8	-1.0	-1.0
PIB (indice)	(d)	108	111	125	134	146	157	168	197
Emissions de CO2	(d)	87	83	72	68	57	49	51	57

SourceThreeME 2015 ADEME/SEP Légende: écart par rapport au scénario de référence sauf pour (d);
écart en pourcentage entre le niveau de l'agrégat d'AMS2 et celui d'AME pour l'année considérée (a)
différence entre le taux d'AMS2 et le taux d'AME pour l'année considérée en points de pourcentage (b);
différence entre le ratio d'AMS2 et le ratio d'AME pour l'année considérée en points de pourcentage (c);
indice base 100 en 2006 (d)

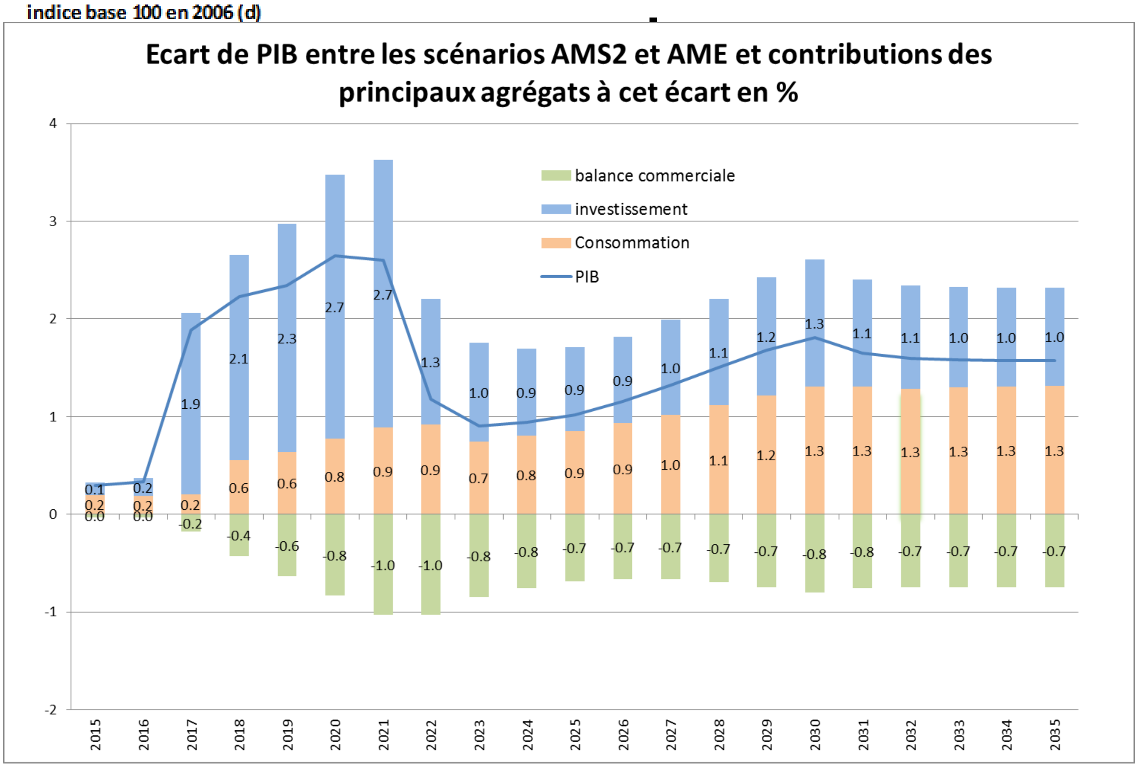


Figure 6.2 : contribution of the main agregates to the differences of GDP between the reference scenario (AMS2) and a business as usual scenario (AME). Source ThreeME 2015 ADEME/SEP

Household consumption increases as a result of energy savings and job creation, generated both by a high level of activity in the civil engineering sector between 2017 and 2021 and the energy

transition. It initially increases at a moderate rate due to the increase in household loan repayments. The latter is attributable to an increase in energy renovation works and a near doubling of new constructions. There is a crowding out effect. It later increases at a sharper rate then stabilises at 1.5 GDP points.

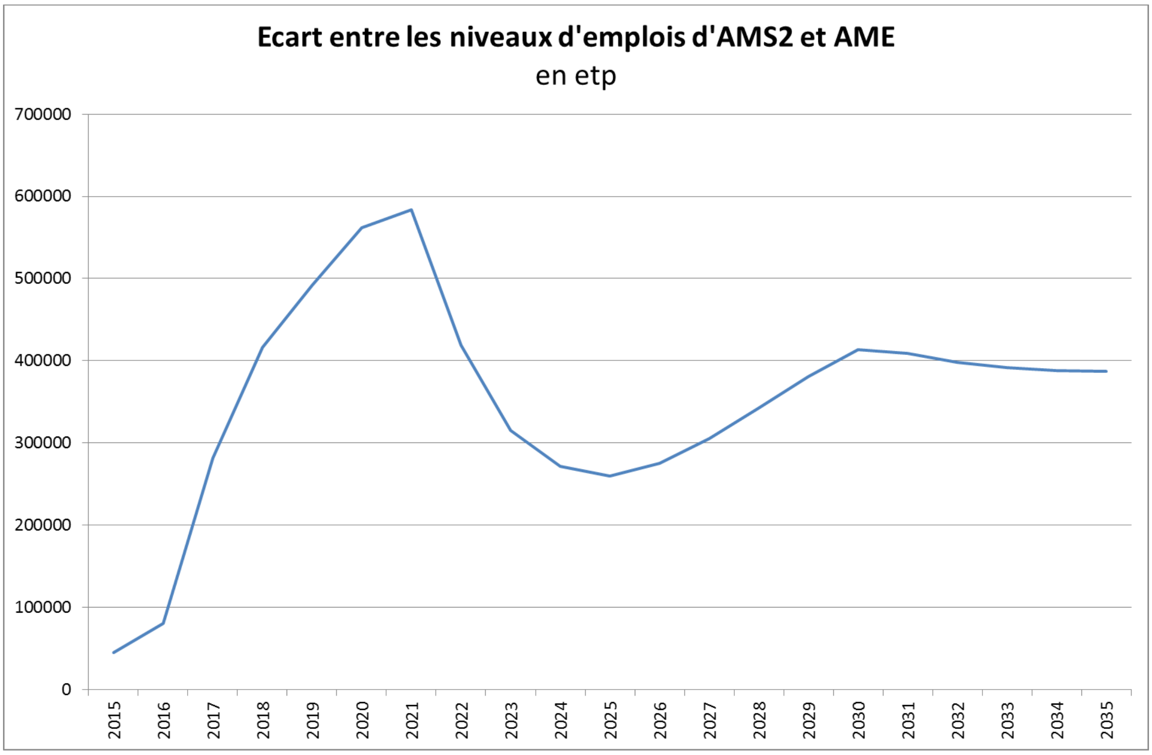
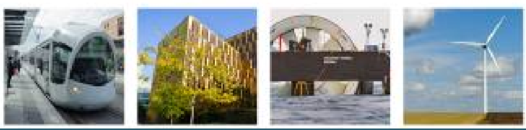


Figure 6.3 : difference of employment between the reference scenario (AMS2) and a business as usual scenario (AME). Source ThreeME 2015 ADEME/SEP

The implementation of measures planned in the AMS2 scenario would allow the creation of 390,000 additional jobs in 2035 compared with AME and 350,000 jobs on average between 2015 and 2035. The percentage of the working population in employment out of the overall population would increase by 1.5% in 2035. The percentage of the working population in unemployment would decrease by 1.3% in 2035.



Conclusion

According to our simulations, the measures represented in AMS2 would lead to a rise in investment and the creation of jobs in green industries, which outweighs the loss of employment in fossil fuel energy and high-energy-consumption sectors, as well as a decrease in the net export deficit to GDP ratio. In the short and medium term and in spite of the rise in prices, the measures lead to an increase in demand which positively and retroactively influences supply, so that the level of GDP is greater than what it would have been without the additional measures. All things considered, the energy transition leads to a profit equal to the revenue that would be generated by an additional year of growth during the period in question, i.e. 1.6 GDP points in 2035 compared with its level in AME. The percentage of working population in employment would increase by 1.5%.

Over time, the cumulated sum of energy savings and additional revenue generated (notably through expansion of the wage bill) would cover most of the debt and costs of interest linked to financing the transition. We also see value creation because the rise in GDP continues long after 2035 and rises again to 1 GDP point in 2050.

This modelling work supports the point of view that the energy transition will not inevitably be costly as a result of the rise in energy prices in the short and medium term. In addition, it would not necessarily be detrimental to household purchasing power and industrial activity, although compensation measures targeting the most vulnerable sectors of the population could be envisaged.

Reduction of the ecological footprint and greenhouse gases does not imply a decrease in economic activity. It seems possible to separate GDP and CO_2 emissions.

ii. Method of analysis of the social impacts in terms of equitable redistribution

Generally speaking, the method used for this analysis was based on external data produced during the elaboration of the SNBC. This data was input into adapted tools by the ERNR3 (Prométhéus microsimulation model, National Transport and Travel Survey), allowing it notably to be broken down according to different socio-economic characteristics. This allows us to analyse the impact of the SNBC in terms of renovation investments made in occupied housing and according to standards of living, or in terms of savings in heating or fuel bills, also according to standards of living.

1. Renovation investments and energy consumption in housing

1.1 Analysis of renovation investments per decile of standard of living

1.1.1 Transition matrix for each housing type

The analysis of renovation investments borne by households was based on one hand on the dynamics of flow of renovation for each housing type, and on the other hand on the distribution of households among housing types.

The external data produced during the elaboration of the SNBC[60] provided the dynamics of the existing housing stock in the business-as-usual scenario (or the trend-based scenario, called AME) and in the energy transition reference scenario (called AMS2), for each housing type (detached house, multi-unit housing, social housing) and energy class (from "0", for housing that has undergone no renovation since 2010, to "+++", in cases where the housing has undergone thermal renovation affecting all areas of consumption reduction: facade, roof, openings).

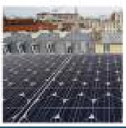
As a reminder, the typical works envisaged behind these actions are the following:

Renovation work	"Reference" works	
Moderate 0->+	Windows	Double glazing 4-16 (argon)-4 low-E – Wood or PVC frame - Uw[61]=1.4
Intermediate 0-> ++	Windows	Double glazing 4-16 (argon)-4 low-E – Wood or PVC frame – Uw=1.4
	Walls	Internal insulation - 15 cm - R = 4.7
Strong 0-> +++	Windows	Double glazing 4-16 (argon)-4 low-E – Wood or PVC frame – Uw=1.4
	Walls	External insulation - 20 cm - R[62] = 5.5
	Roof	Insulated loft renovation - 20 cm - R = 6
	Ventilation	Type B hygro-adjustable mechanical ventilation

Source: Énergie Demain.

For each period and housing type we have the housing stock in the starting year, the number of

[60] Cf. SNBC.
[61] Thermal transfer coefficient.
[62] Thermal resistance coefficient.







demolitions and the renovation flows taking a residential building from one energy class to a higher energy class (for example, see table below for 2019-2023 for detached houses built after 1975).

Detached houses built after 1975, per energy class and in 2019-2023, in the reference scenario

In millions of dwellings		Energy class at the start of 2019				
		0	**+**	**++**	**+++**	**Stock at the end of 2023**
Stock at the start of 2019		**3.16**	**2.43**	**1.30**	**0.37**	
Demolitions		0.04	0.05	0.03	0.01	
Energy class at the end of 2023	**0**	0.00				**0.00**
	+	1.81	1.97			**3.78**
	++	0.95	0.32	1.27		**2.53**
	+++	0.35	0.09	0.00	0,36	**0.80**

Note: in the reference scenario, in 2019 2.60 million dwellings out of the detached houses built after 1975 are in class "0". 0.04 million are demolished between 2020 and 2023 and 1.81 million are renovated and enter class "+". Source: Énergie Demain, CGDD calculations.

1.1.2. Determining the costs associated with renovation works

The external data produced during the elaboration of the SNBC has provided the sums invested during each period and for each scenario.

Renovation investments in € billion, in the reference scenario and business-as-usual scenario

	Reference	Business-as-usual
2015-2018	92.9	64.5
2019-2023	125.5	78.2
2024-2028	118.2	77.0
Total 2015-2028	**336.6**	**219.7**

Source: Énergie Demain.

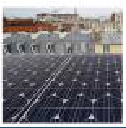
The external data produced from the elaboration of the SNBC has also provided the costs associated with renovation works for each dwelling and type of work undertaken, with a distinction between detached houses and multi-unit housing.

Relative prices associated with renovation works (in € per dwelling and according to the type of work)

Renovation work	Relative price of renovation between detached houses and multi-unit housing
0_+	1.8
0_++	2.0
0_+++	2.1
+_++	2.4
+_+++	1.9
++_+++	2.4

Source: Énergie Demain.

These prices are likely to change over time and are not dependant on the surface area of the dwelling, though it may seem logical to think that the bigger the dwelling to be renovated, the greater the renovation investment. Given the lack of additional information on changes in the renovation cost per dwelling over time, and to what extent these changes are affected by the





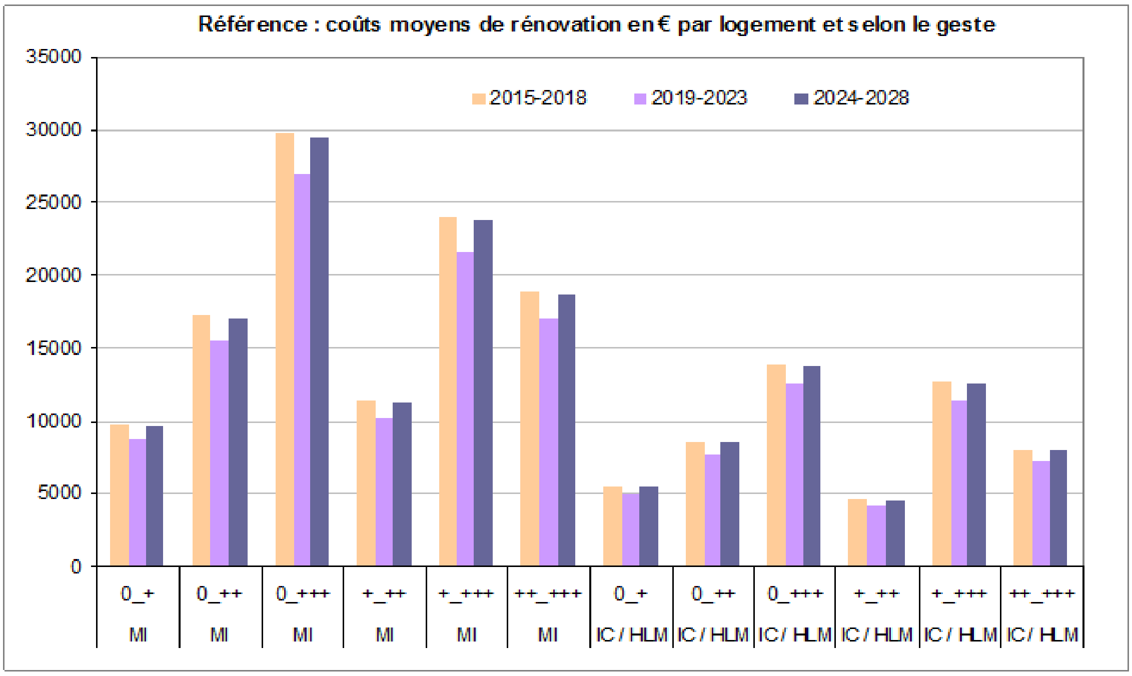


surface area of the dwelling, the following hypotheses have been adopted:

- for each period, we have a created a homothetic increase in renovation costs per work, so that the total amounts invested coincide with the amounts in the external data. This hypothesis allows us to maintain the hierarchy of costs according to the work and the differential cost between types of housing. For each period, we can therefore obtain the average renovation cost per dwelling according to the work and housing type. We check that the profile of the changes in costs obtained is not too irregular over time (cf. figure 6.4);
- we also assumed that the renovation costs were proportional to the surface area of dwellings. Alternative hypotheses consist in considering that a given part of these costs does not change, but due to the lack of information on the subject, the hypothesis of pure linearity was preferred. For each period, we therefore obtain the renovation costs per m² according to the work and housing type. We see that the costs thus obtained within the same type of renovation work for all types of housing have a relatively stable profile over time (although they could be higher for detached houses), and that the hierarchy between the different works is generally respected (cf. figure 6.5).

It is worth noting that in the reference scenario, average renovation costs are lower in the 2019-2023 period than in the 2015-2018 or 2024-2028 periods. In this scenario, the share of inexpensive renovation works is greater in 2019-2023 (from 0 to + or from + to ++) than during the other periods. In the business-as-usual scenario, works are more costly during the 2019-2023 period (although essentially fewer in number).

Figure 6.4: average costs associated with renovation works, in € per dwelling and according to the work and housing type Source: CGDD calculations



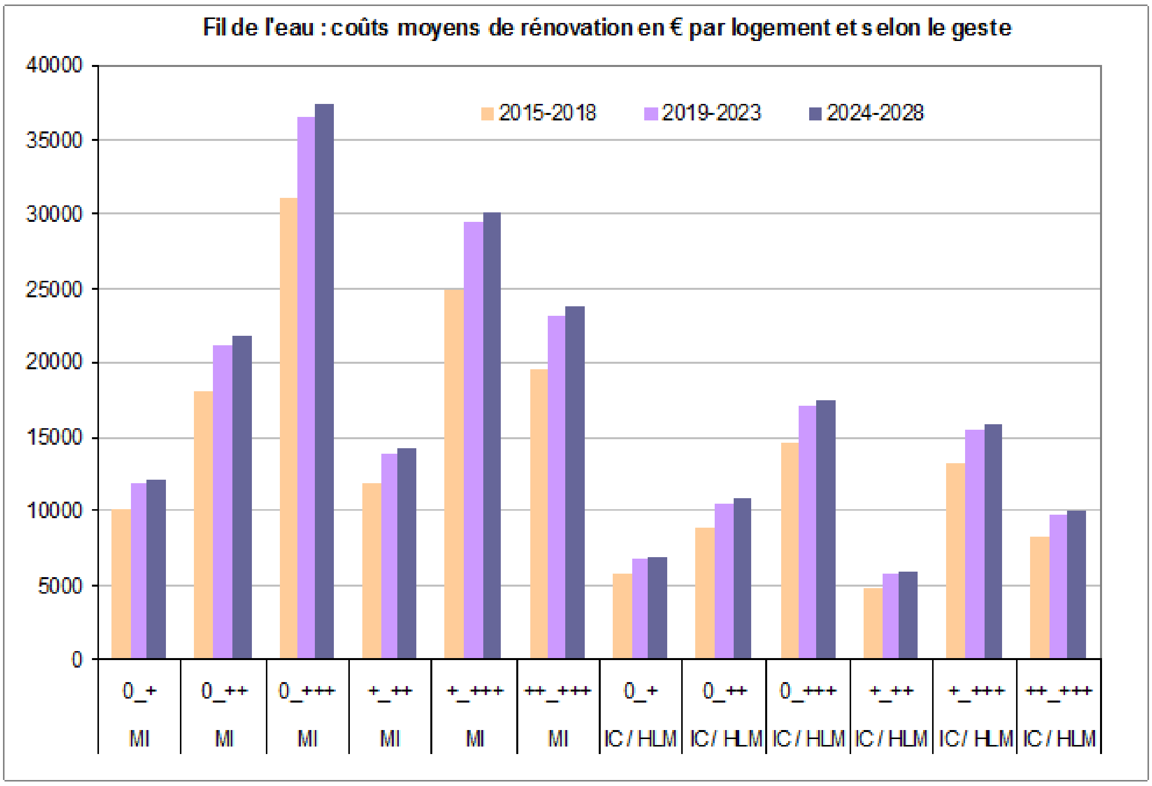
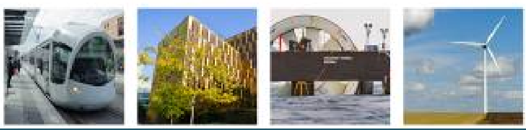


Figure 6.5 : costs per m² associated with renovation works, in € per dwelling and according to the work and housing type Source: CGDD calculations.



1.1.3. Break-down of renovation investments in dwellings according to the standard of living of the occupant household

Average investments in relation to the surface area are broken down per decile of standard of living, based on the distribution of households within each housing type. This distribution was provided by the Prométhéus model by the CGDD, which simulates households' energy consumptions in their dwellings on a microeconomic level for the year 2006 (for example, see table below for detached houses built after 1975).

Distribution of households within detached houses built after 1975 for 2006

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Proportion of households	4%	6%	7%	8%	10%	12%	14%	13%	13%	14%	**100%**

Note: 4% of households living in a detached house built after 1975 belong to the first decile of standard of living.
Source: Prométhéus (version produced from the French national housing survey in 2006), CGDD calculations.

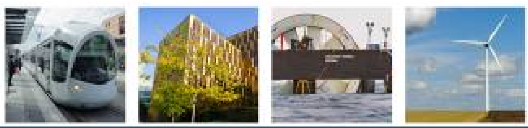
Using the surface area of the dwelling produced by Prométhéus for 2006 (cf. below), we can deduce the investments per decile, according to the renovation work and housing type. The surface area of the dwelling is assumed to remain constant over time.

Surface area of the dwelling in detached houses built after 1975, for 2006

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Surface area of the dwelling in m²	110	106	103	105	107	108	114	118	125	141	**116**

Note: the average surface area of dwellings of households in the first decile is 110m² for detached houses built after 1975.
Source: Prométhéus (version produced from the French national housing survey in 2006), CGDD calculations.

We can also determine the distribution of households between the different types of housing and energy classes, which follows the development of renovation flows from one class to another (for example, see below). Within each energy class, it is assumed that the distribution per decile follows the one given by Prométhéus for 2006.



Distribution of households among types of housing and energy classes, in 2019 in the reference scenario

2019		distribution	2019		distribution
Detached houses built before 1975	0	0%	Detached houses built after 1975	0	12%
	+	15%		+	9%
	++	9%		++	5%
	+++	3%		+++	1%
Multi-unit housing built before 1975	0	9%	Multi-unit housing built after 1975	0	8%
	+	5%		+	3%
	++	3%		++	2%
	+++	1%		+++	1%
Social housing built before 1975	0	7%	Social Housing built after 1975	0	7%
	+	0%		+	0%
	++	0%		++	0%
	+++	1%		+++	1%

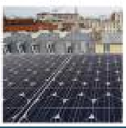
Note: in 2019 in the reference scenario, 12% of households live in a detached house built after 1975 in class "0". Source: CGDD calculations.

By aggregating renovation investments per housing type, energy class and decile, we can obtain the investments made in housing in the existing stock distributed per decile of standard of living in the business-as-usual scenario and the reference scenario.

Annual renovation investments per decile of standard of living for 2019-2023, in the reference scenario (in €)

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Annual investment in €	747	828	870	919	936	966	1043	1081	1154	1338	**995**

Note: renovation investments made in housing lived in by households in the first decile of standard of living is €747 per year in the reference scenario for the 2019-2023 period.







1.2. Analysis of energy consumption per decile of standard of living

The external data produced during the elaboration of the SNBC has provided the unit energy consumption (per unit of surface area) for heating according to the date of construction of the dwelling and for the year 2010.

Unit consumption for heating the dwelling, for 2010

Date of construction	kWh/m²
Housing built before 1975	147
Housing built between 1975 and 2000	117
Housing built after 2000	96
All	**130**

Source: Énergie Demain.

The Prométhéus model allows us to separate these external figures to obtain an estimation of unit consumption for heating according to the housing type considered in this analysis (see below).

Unit consumption for heating, per housing type for 2010

Housing type	kWh/m²
Detached house built before 1975	152
Detached house built after 1975	116
Multi-unit housing built before 1975	142
Multi-unit housing built after 1975	106
Social housing built before 1975	140
Social housing built after 1975	110
All	**130**

Note: Énergie Demain, Prométhéus (version produced from the French national housing survey in 2006), CGDD calculations.

The renovation works also lead to savings in unit consumption for heating, depending on the housing type and scope of the works[63]. Assuming that the existing housing stock in 2010 is entirely composed of housing in class "0[64]", the unit consumptions above correspond to housing in this class. From this, we can deduce the unit consumption for heating in each housing type according to the energy class (for example, see below). It is assumed that these unit consumptions remain unchanged so long as the housing remains in the same energy class. They are the same in both the business-as-usual and the reference scenarios.

Unit consumption of heating in detached houses built after 1975, according to energy class

	Detached house built after 1975	Energy savings in relation to "0"	kWh/m² of heating
Energy class	0	0%	116
	+	9%	103
	++	39%	75
	+++	74%	45

Source: Energie Demain, CGDD calculations.

[63] These savings, produced by works carried out in the framework of the SNBC, depend on the energy class the housing belongs to as well as the housing type, and are analysed in reference to class "0" for this housing type. For detached houses built after 1975, for example, unit energy consumption savings are at 9% for class "+" in relation to class "0", 39% for class "++" and 74% for class "+++" (source: Energie Demain).

[64] In the simulations by Énergie Demain, renovation works carried out before 2010 and allowing class "+" or higher to be reached are in the minority. Therefore, the hypothesis made in the framework of our analysis is almost confirmed.

The next step is to break down unit consumption for heating into the different heating types for each housing type and energy class. This break-down depends on both the distribution of housing with regards types of heating and the unit consumption associated with each one. To simplify things, we have assumed that the unit consumption for each type of heating only depends on the type of housing. In other words, for example, the unit consumption for heating in detached houses built after 1975 and in class "0" is 155 kWh/m², regardless of the type of heating. In reality, however, this is not the case, since for example the unit consumption of housing with electric heating is much lower than that of housing with gas heating. If these inequalities reflect differences in energy efficiency between housing with electric heating and housing with gas heating (linked to geographic or socio-economic factors), it would not seem relevant to keep them unchanged throughout the reference scenario. On the other hand, if these inequalities reflect intangible factors (for example, gas heating in regions with a harsher climate), they should be taken into account. Given the uncertainty and lack of structuring and explanatory factors, it would seem better to keep to the simplified hypothesis given above.

Consequently, the break-down of unit consumption for heating into the different heating types depends only on the distribution of housing with regards types of heating. This distribution has been provided by the external data produced during the elaboration of the SNBC:

Distribution of housing (primary residence) with regards types of heating

Principal heating type	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Electric	32%	35%	38%	37%	36%	34%
Gas	42%	41%	42%	44%	46%	47%
Fuel oil	16%	10%	4%	2%	0%	0%
Wood	10%	13%	16%	17%	18%	19%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Energie Demain.

From this, we have deduced the unit consumption for heating per housing type and energy class, broken down according to types of heating (see below, for example).

Break-down of the unit consumption for heating in detached houses built after 1975, according to energy class

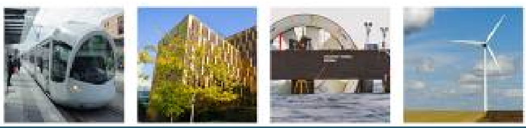
	Electric	**Gas**	**Fuel oil**	**Wood**	**Total**
0	38	49	19	11	**116**
+	39	45	3	17	**103**
++	28	33	3	12	**75**
+++	17	20	2	7	**45**

Note: for detached houses built after 1975, the unit consumption for heating is at 103 kWh/m² on average for housing in class "+", of which 39 kWh for electric, 45 kWh for gas, 3 kWh for fuel oil and 17 kWh for wood.

For 2006, Prométhéus also provides the distribution of unit consumption per housing type (see below) as well as the floor area of housing, as seen above. From this, we can deduce the energy consumption for heating per housing type, energy class, energy type and decile of standard of living for both the reference and business-as-usual scenarios.

Unit energy consumption for households in detached houses built after 1975, for 2006

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**



Unit consumption in kWh/m²	171	165	186	181	181	175	172	169	172	178	**175**

Note: households in the first decile consumed 171 kWh/m² in 2006 for detached houses built after 1975.
Source: Prométhéus (version produced by the French national housing survey in 2006), CGDD calculations.

Lastly, the external data produced by the elaboration of the SNBC have provided the energy prices in both scenarios:

Energy prices in the reference scenario, on average during the 2019-2023 period

In €/kWh	2019-2023
Electricity	0.16
Gas	0.11
Fuel oil	0.11
Wood	0.03

Source: Energie Demain.

The figures for energy prices in both scenarios allows us to determine the energy consumption for heating for each housing type, energy class, type of energy and decile of standard of living. Considering the distribution of households across the different housing types and energy classes, we have deduced the heating bill for each decile of standard of living.

Heating bill per decile of standard of living for 2019-2023 in the reference scenario (in €)

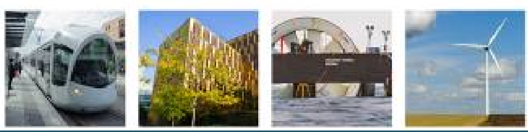
Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Energy consumptio n in €	723	758	820	849	842	841	912	930	976	1112	**882**

Note: in the reference scenario for the 2019-2023 period, the heating bill is at €723 per year for households in the first decile.

1.3. Implicit hypotheses in the analysis of housing renovation costs and energy consumption

It should be noted that the above analysis has been conducted based on the following hypotheses:

- by investments per decile, it should be understood investments made to renovate housing lived in by households in this decile, regardless of who bears the cost, whether it is the household itself or, if the case may be, the owner of the dwelling. In reality, it can be expected that renovation works are most often carried out by owner-occupiers, who consequently belong to higher deciles of standard of living. It should not be excluded that in the case of renovation work carried out on housing lived in by tenants, the cost of the investment may be subsequently passed on through the rent paid by the tenant;
- the probabilities of renovation, the costs associated with the different works and the associated energy savings are assumed to be independent of the deciles of standard of living;
- the distribution of housing per heating type is assumed to be independent of the deciles, and identical whatever the housing type (type and energy class, excluding class “0” for which the distribution remains unchanged in comparison to the initial date);
- consequently, inter-decile variation concerns the distribution of households among types of housing (less well-off households are more often in multi-unit and social housing), the distribution of unit consumption among deciles (inverse U-shaped curve, with less well-off households having higher unit consumption than medium-level households, which in turn



have a lower consumption than that of well-off households), and finally the floor area of housing (with less well-off households having less floor area). These different distributions are assumed to remain stable over time. These hypotheses are based on the assumption that households do not move during the period of study and that the structure of households living in the existing stock is constant;

- for all households, the unit consumption of each housing type is considered constant, whatever the heating type;
- new housing built during the 2010-2028 period have not been included in the analysis, and the amounts calculated (housing renovation and energy consumption costs) concern households in the existing housing stock.

2. Analysis of the energy consumption of fuel

The external data produced during the elaboration of the SNBC has allowed us to identify the evolution of the number of vehicles in the vehicle stock per fuel type, the fuel efficiency and average distances travelled each year (for example, see below).

Characteristics of petrol-engine vehicles in the reference scenario, for 2019-2023

Petrol-engine vehicles	2019-2023
Number (in millions)	14.2
Fuel efficiency (in L/100km)	6.4
Distance travelled each year (in km)	9,276

Note: Énergie demain, CGDD calculations.

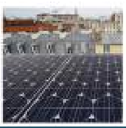
The National Transport and Travel Survey (ENTD) also provided the distribution of the vehicle stock per decile of standard of living for 2007-2008, as well as fuel efficiency and distances travelled (see below for example).

Distribution of petrol-engine vehicles per decile, for 2007-2008, as well as the fuel efficiency and distances travelled

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Proportion of vehicles	6%	7%	9%	9%	10%	11%	11%	11%	12%	14%	**100%**
Fuel efficiency (L/100km)	7.2	7.1	7.1	7.1	7.2	7.3	7.2	7.2	7.2	7.5	**7.2**
Distance travelled (km per year)	7293	7597	7738	7777	8221	7910	8664	9285	8976	8395	**8285**

Note: according to the National Transport and Travel Survey in 2007-2008, households in the first decile possess 6% of petrol-engine vehicles, which consume 7.2 L/100km and travel 7293 km per year.

We can use these distributions to determine, in each scenario, the distribution of households per type of vehicle, their energy efficiency and the distances travelled. By taking into account fuel prices, we can deduce the fuel consumption for each type of vehicle, broken down per decile, since the aggregation of consumption gives the average fuel consumption for each decile.







Annual fuel consumption per decile in 2019-2023, in the reference scenario

Decile of standard of living	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	**All**
Fuel consumption in €	968	1247	1619	1927	2155	2424	2599	2578	2458	2403	**1881**

Note: in the reference scenario and for 2020-2023, fuel consumption is at €865 per year for households in the first decile.

It should be noted that the analysis of households' fuel consumption has been conducted based on the following hypotheses:

- the relative distribution of households per type of vehicle, the fuel efficiency and distances travelled are assumed to remain unchanged over time;
- concerning electric vehicles and hybrid vehicles, the ENTD does not provide sufficient data. For electric vehicles, we assumed there was an even distribution of households, energy efficiency and distances travelled; for the fossil fuel share of hybrid vehicles, we assumed the distribution was identical to that of petrol-engine vehicles;
- The analysis does not take into account the costs associated with replacing the vehicle stock.

iii. Analysis of changes in national greenhouse gas emissions from 1960 to 2013

A study commissioned by the Ministry for Ecology in 2015 and conducted by the CITEPA/CEREN provides an analysis of changes in national greenhouse gas emissions from 1990 to 2013 for all sectors, and an extended analysis for 1960-1990 for sectors connected to energy. This study allowed us to:

1. identify the main parameters influencing developments in greenhouse gas emissions observed in France;
2. better comprehend the relationship between the evolution in these parameters and variations in emissions.

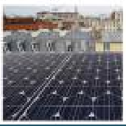
Emissions were analysed in Metropolitan France.

Different methods have been used, including analysis of raw data on changes in potential explanatory factors in changes in greenhouse gas emissions, principal component analysis or other analysis methods such as cointegration and decomposition of effects, when possible in terms of data available and convincing results.
A sectoral approach has also been adopted. Changes in greenhouse gas emissions were analysed for each sector in the inventory, and in some cases the analysis was broken down into sub-sectors.

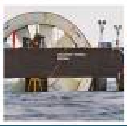
Sectors	> [Sub-sectors]	>> (Categories)
Transports	> [Road]	>> (Private vehicles)
		>> (Heavy goods vehicles)
		>> (Light commercial vehicles)
	> [Aviation]	
	> [Maritime]	
Agriculture	> [Livestock]	
	> [Crops]	
Residential-tertiary	> [Residential]	
	> [Tertiary]	
Industry		
Waste management		

1. Evolution in greenhouse gas emissions per sector in Metropolitan France

Between 1990 and 2013, total greenhouse gas emissions (excluding changes to land usage and forestry) fell by 12.3%. This overall reduction in emissions is the result of an 11.7% increase in emissions in the transport sector, a 5.9% increase in emissions in the residential-tertiary sector, an 11.1% increase in emissions in the waste management sector, and a 39.8% reduction in emissions in the manufacturing sector a 30.9% reduction in emissions in the industrial energy sector, and a 6.1% reduction in emissions in the farming/forestry sector.
These sectoral changes need to be weighted to take into account the contribution of each sector to overall greenhouse gas emissions. Fluctuations bucking the general trend were observed during this period, particularly under the impact of certain government policies.
Descriptions of policies and measures implemented since 1960 are available in the national communications submitted to the United Nations Framework Convention (UNFCCC) every 4 years, which can be downloaded at the following address: http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php.






2. The transport sector

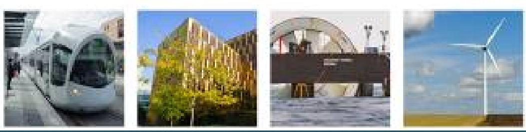
Since 1990, emissions from this sector have increased by 11.1% (from 118.3 MtCO$_2$eq in 1990) to reach 131.4 MtCO$_2$eq in 2013. Within the sector, road transport made the biggest contribution (92% of greenhouse gas emissions), followed by air travel (3% of greenhouse gas emissions) and maritime transport (1% of greenhouse gas emissions).

2.1 Changes in the road sector between 1990 and 2013

In 2013, Private Vehicles (PV) were the cause of 56% of greenhouse gas emissions, Heavy Goods Vehicles (HGV) 23% and Light Commercial Vehicles (LCV), 20%.
The three vehicle categories were analysed separately. Cointegration models were tested to find the relationship between certain factors and changes in greenhouse gas emissions.
We define a:

- “Certain” effect of a parameter as its direct or indirect physical contribution to the increase or decrease in emissions.
- “Probable” effect of a parameter as its direct or indirect physical contribution to the increase or decrease in emissions, while considering it weak and/or offset by a significant rebound effect.
- “Ambiguous” effect of a parameter as a contribution that varies according to the analyses conducted in this study (positive, negative or neutral), or that could not be defined in this study.

	PV	HGV	LCV
biofuels	Certain contribution to decrease Change from 0% to nearly 6% in fuel between 1990 and 2013	Certain contribution to decrease Change from 0% to nearly 6% in fuel between 1990 and 2013	Certain contribution to decrease Change from 0% to nearly 6% in fuel between 1990 and 2013
miles-to-the-gallon	Certain contribution to reduction Decrease by 20% between 1990 and 2013	Certain contribution to reduction Decrease by 4.3% between 1990 and 2013	Certain contribution to reduction Decrease by 6% between 1990 and 2013
Average speed of vehicles	Probable contribution to reduction Decrease by 15.7% between 1996 and 2013	Probable contribution to reduction Decrease by 16.3% between 1996 and 2013	Probable contribution to reduction Decrease by 15.7% between 1996 and 2013
Kilometres travelled in vehicles	Certain contribution to increase Increase by 15% in kilometres travelled per inhabitant, between 1990 and 2013	Certain contribution to increase Increase by 12% in kilometres travelled by HGV, between 1990 and 2013	Certain contribution to increase Increase by 30% in kilometres travelled per inhabitant, between 1990 and 2013
Number of vehicles per inhabitant	Probable contribution to increase Increase by 21% between 1990 and 2013*		
Distribution of goods transport between road and rail		Certain contribution to increase Goods transport went	



	PV	HGV	LCV
		from 4 to 7.5 times that of rail transport.	
Average fuel prices	Ambiguous parameter Increase by more than 100% between 1990 and 2013, but with variable impacts on traffic between the short and long term	Ambiguous parameter Increase by nearly 100% in the price of diesel between 1990 and 2013	Ambiguous parameter Increase by nearly 100% in the price of diesel between 1990 and 2013
Increase in the share of the motorway network in heavy goods vehicle traffic		Probable contribution to increase Change from 32% to 43% of HGV traffic between 1990 and 2013	
Distribution of travellers between PV and road and rail public transport	Ambiguous parameter		
Extension of urban areas	Ambiguous parameter Increase by 40% between 1990 and 2013		
Average age of PV	Ambiguous parameter Increase by nearly 30% between 1990 and 2013		
Growth of the French population	Contribution to increase	Contribution to increase	Contribution to increase
Women entering the labour market	Contribution to increase		
Economic context		Contribution to increase or decrease depending on the year	Contribution to increase or decrease depending on the year

* The upward trend in the average age of vehicles has slowed, in particular as a result of environmental policies.

2.2 Changes in the road sector between 1960 and 2013

The method used to break down effects for the period of 1960 to 2013 allowed the following principal parameters to be identified:

- Traffic effect: between 1960 and 1990, greenhouse gas emissions were systematically pushed upwards by the volume of traffic per inhabitant, except in economic crisis years such as 1974 or 2008.
- Miles-to-the-gallon effect: conversely, the reduction in average unitary consumption of road vehicle stock (miles-to-the-gallon) which has improved over the years, thanks in particular to the application of European or national policies (bonus-malus schemes, European regulations limiting CO2 emissions for new vehicles), has helped limit greenhouse gas emissions.
- Share of fossil fuels (% fossil sources) effect: gradual introduction of biofuels contributed to

decreasing greenhouse gas emissions from 2005.

- Population effect: constant growth of the population between 1960 and 1990 contributed to increasing greenhouse gas emissions, but to a lesser extent than traffic.
- Greenhouse gas emissions per fossil fuel energy consumption effect: the emissions factor (GHGEmi/FConso) led to a slight increase in emissions.
- Non-Integrated effects: these effects are very limited and thus validate the method.

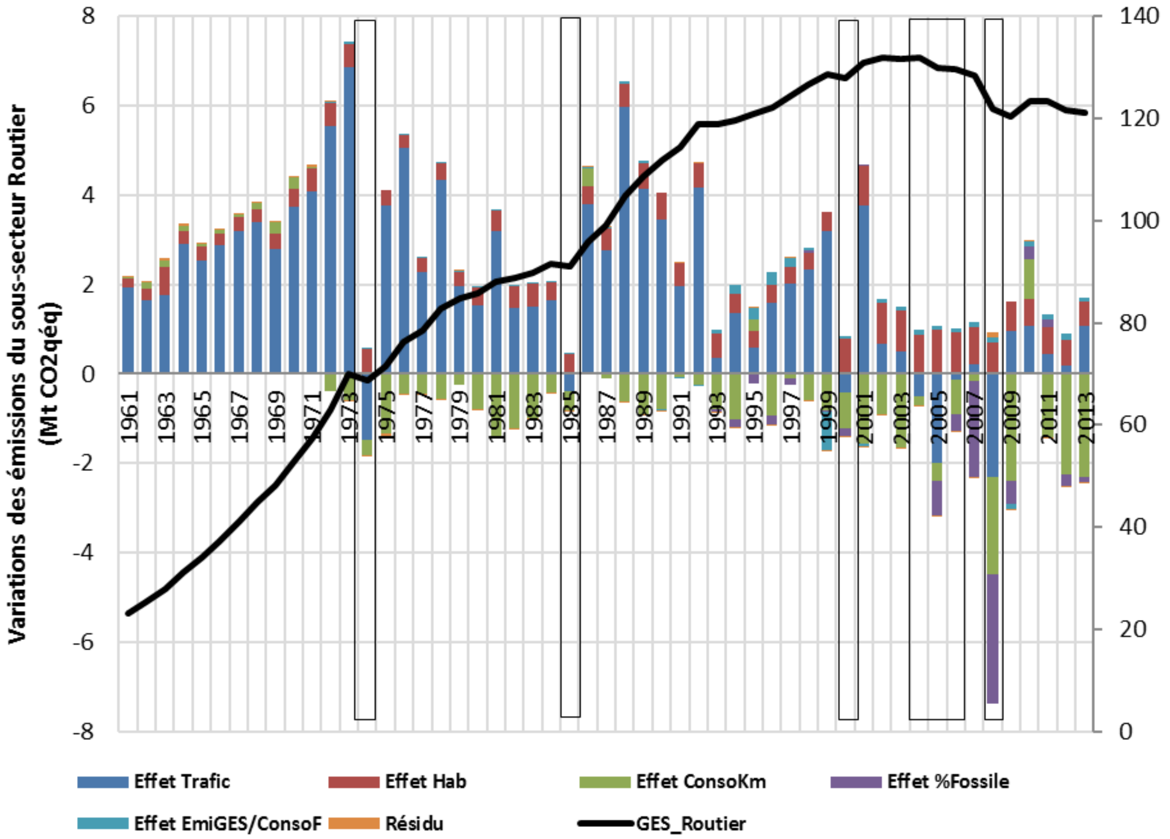


Figure 6.6 : decomposition of the contributions to the interannual variations of evolution of the road transport sub-sector

- Changes in the aviation sector between 1990 and 2013

Greenhouse gas emissions from the aviation sub-sector have been on the rise since 1990, peaking at 4.7 MtCO2eq in 2000. They then gradually declined until 2010, stabilising at just under 4 MtCO2eq.

The principal parameters affecting emissions are: passenger.kilometres (PKT: the product of the number of passengers transported and kilometres travelled); average capacity (number of passengers divided by the number of journeys containing passengers only, excludes cargo flights); cargo; number of passengers for all speeds; GDP per inhabitant.

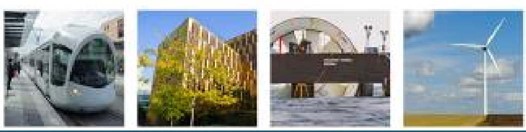
Two periods have been distinguished for the aviation sector from the principal component analysis:

- The first period (1990-2000) was characterised by a rise in tourist and commercial passenger numbers, leading to an increase in emissions. This period was favourable from an economic point of view.
- The second period (2001-2013) was characterised by a decrease in traffic as passengers turned to alternative means of transport, in a context rendered less favourable by increasing Brent fuel prices, leading to a decrease in emissions.

These evolutions should be considered in parallel with two events separating these periods:

11 September 2001: terrorist attack in the USA leading to a change in behaviour among users.

In France: the opening of the high-speed train line (LGV Méditerranée), leading to a transfer from



air to rail transport among passengers.

4. The agricultural sector

4.1. Field crops

Emissions from arable crops fell slightly between 1990 and 1994. This was followed by a period in which emissions increased until 2000, when the downward trend was restored, despite a few sporadic instances which went against the general trend. Overall, between 1990 and 2013, emissions from the sector dropped by 8.4%.
The principal parameters analysed owing to their impact on emissions for the sector were: nitrogen spread (mineral, organic and pasture); farmland; the price of Brent fuel; the price of natural gas; the price index of straight fertilisers (IPAMPA); support provided (direct support from the first pillar of the CAP); GDP from Agriculture.

Emissions connected to crop farming have been mainly affected by use of nitrogen on farmland and the economic circumstances affecting the sector. Certain public policies may also contribute to the fall in emissions, such as the nitrates directive or subsidies from the second pillar of the CAP. From 2000, the increases in fertilizer prices may also have contributed to reducing emissions.
The decline in the amount of agricultural land and a tricky economic context can partly explain the downturn in farm emissions in this period, even as crop production continued to increase.

4.2. Livestock

Emissions from livestock followed a slight downward trend in 1990-1998 before rising in 1999. This was followed by a downward period until 2004, when emissions stabilised. In 1990-2013 livestock emissions decreased by 6.5%.
Two main areas have been considered in the analysis of these emissions: enteric fermentation and management of animal excretion.
General parameters have also been taken into consideration: methanisation; the price index of animal feed (IPAMPA); subsidies provided (direct support from the first pillar of the CAP and the dairy premium); GDP from Agriculture. Additional parameters were taken into account for beef cattle herds; milk yield; excretion management methods (manure or slurry).

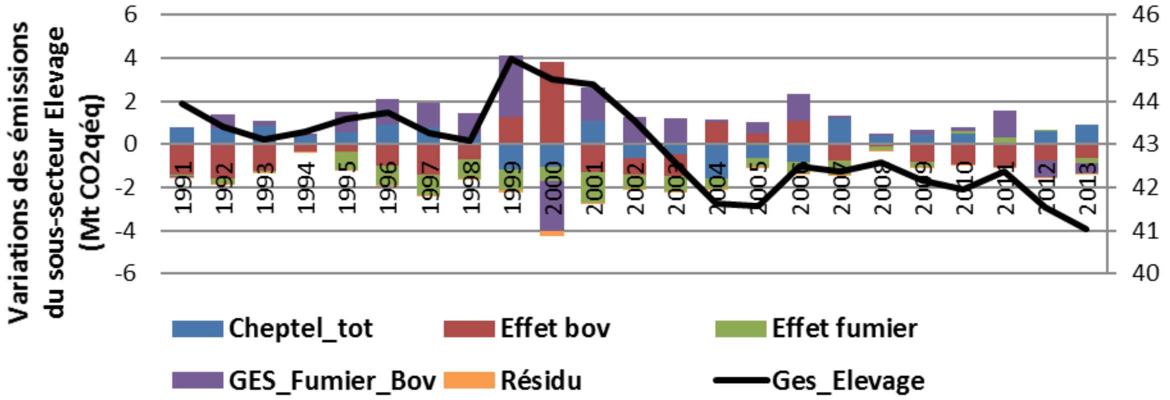
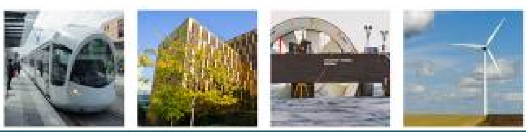


Figure 6.7 : decomposition of the components contributing to te variation of emissions from animal husbandry

Beef cattle herds have the strongest influence on livestock emissions. During the period in question, the total number of cattle in France decreased while the dairy yields increased. These developments should be seen in the context of the restructuring of the dairy sector (milk quotas introduced in 1984), the dairy premium and CAP reform. As for the management of cattle effluent,



we have moved from a system dominated by manure use to a more even balance of manure and slurry, reflecting the structural evolution of cattle farms and the gradual disappearance of small herds. Although slurry systems generate more emissions, overall emissions from animal waste have remained relatively stable as changing uses have been balanced out by the general decline in cattle numbers.
Meanwhile, the development of methanisation techniques has contributed to a reduction in emissions from the sector.
Lastly, the economic state of the sector, represented by GDP from Agriculture in our analysis, showed a drop in activity over the period which was accompanied by a decrease in emissions. Likewise, the changing prices of production inputs also had an impact on emissions from the sector. This is borne out by the IPAMPA of animal feed (index for the average purchase price of agricultural inputs) which has increased over the period in question. This change may indirectly explain certain reductions observed in emissions.

4. The waste management sector

Emissions linked to waste management increased by nearly 10% in 1990-2013 (16.8MtCO_2eq in 1990, 18.4MtCO_2eq in 2013) to represent 4% of total greenhouse gas emissions in 2013. The breakdown of effects method was used for this sector.

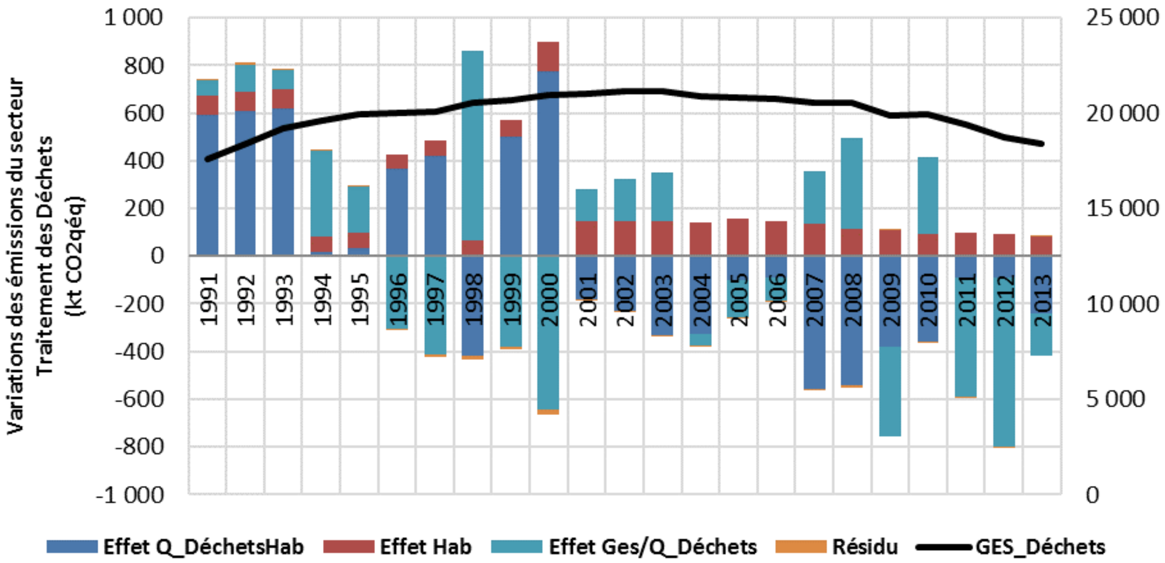


Figure 6.8 : decomposition of the contributions to the interannual variations in the emissions of the west sector

It gave the following results:

- "Quantity of waste produced per inhabitant" effect: this parameter first had an upward influence on greenhouse gas emissions (from 1991 to 2000), followed by a downward trend (from 2001 to 2013) as a result of a decrease in the production of waste for the number of inhabitants.
- "Inhabitants" effect: the increase in the number of inhabitants led to a slight increase in waste.
- "Greenhouse gas emissions for the quantity of waste produced" effect: this factor tended to increase greenhouse gas emissions until 1995. The effect then followed an overall downward trend during the following period. This may result from higher collection rates at the end of the 1990s.

5. The residential – tertiary sector

Between 1960 and 2013, direct greenhouse gas emissions from energy consumption in the residential and tertiary buildings increased by 77%, going from 49 million tonnes to 86.6 million tonnes. The evolution of these emissions has involved several distinct phases. Demographic developments, economic activity, changes in heating habits, energy prices, environmental issues and the government policies which take them into account, thermal regulations and household reactions, as well as the evolution of the energy mix which emits more or less greenhouse gases, have all had an impact on the overall level of emissions.

With the exception of demographic factors, which have had a steady impact on the level of greenhouse gas emissions, all of the other factors listed above have influenced fluctuations in emissions to varying extents at difference periods.

The sub-period 1960-1975 saw strong economic growth (an average of 5.2% per annum) and low energy prices.

The sub-period 1975-1990 was marked by the effects of the first oil crises in 1973, at a time when economic growth was strong but not as strong as it had been in the preceding period (average annual growth of 2.7% between 1975 and 1990).

The sub-period 1990-2002 saw prices fall in real terms, as growth remained strong (average 2% p.a.)

The sub-period 2002-2013 saw a sharp increase in energy prices, and a slowdown in economic growth (average 1.1% p.a, with recession in 2008-2009). This sub-period also saw the gradual introduction of new thermal regulations for housing, with notable reforms in 2000 and 2005.

5.1. Analysis of direct emissions linked to the consumption of fuel in residential and tertiary buildings

Between 1960 and 1990, direct greenhouse gas emissions from energy consumption in residential and tertiary buildings increased by 37.6 million tonnes, which is an increase of 77% in relative value.

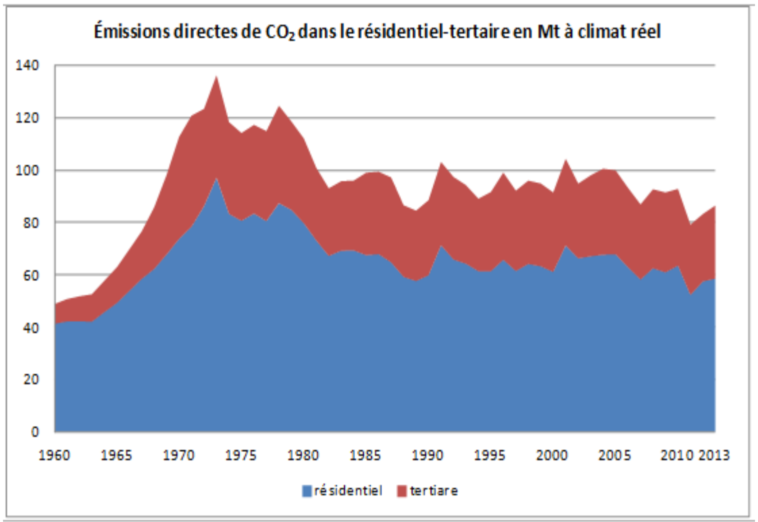
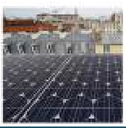


Figure 6.9 : direct emissions of CO2 in the residential-tertiary sector (after correction for climate anomalies)

Emissions in the tertiary sector multiplied by 3.7 during this period, and those in the residential sector increased by 42%. The overall evolution for both is therefore similar throughout the period, with a peak in both sectors in the mid-1970s, followed by a decrease until the early 1990s and a period of relative stability between 1990 and 2013.

5.2. Factors explaining the changes in greenhouse gas emissions from 1960 to 2013 in the residential sector







a. The residential sector, 1960-2013 (in MtCO2eq.)

We used the breakdown of effects method. The results are presented in the graph below in $MtCO_2eq$.

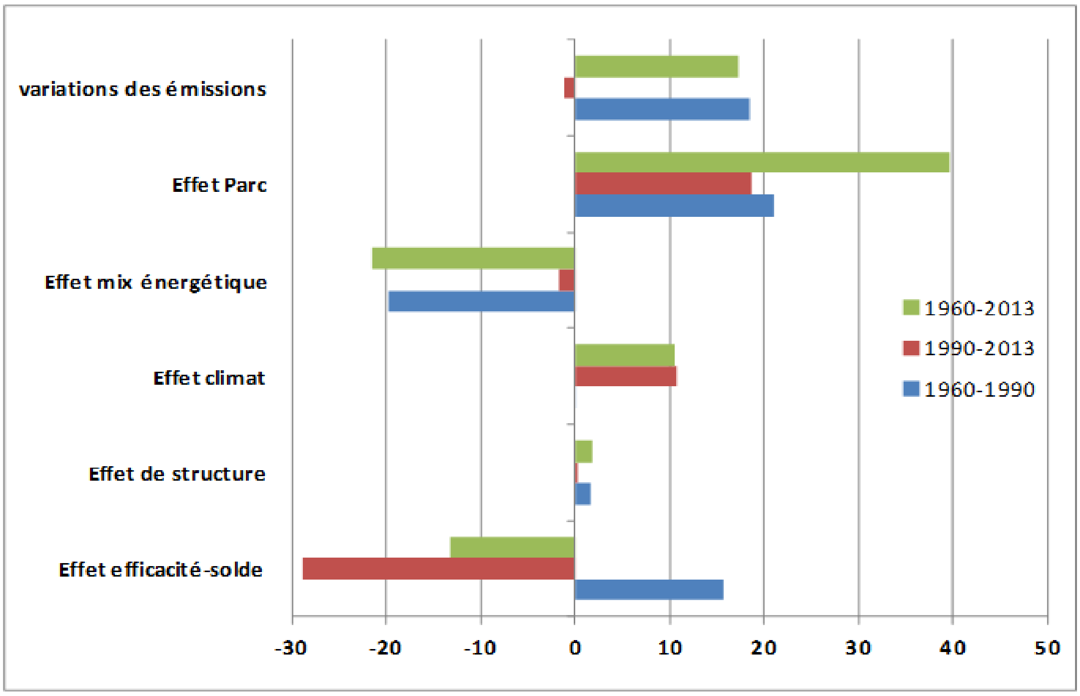
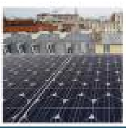


Figure 6.10 : decomposition of the factors of variation of the GHG emissions induced by energy consumption in the building sector between 1960 and 2013

Greenhouse gas emissions increased by 18.5 Mt during the period. The Energy Mix effect, concentrated in the first sub-period (-19.7 Mt) mostly offset the significant Stock effect (+21 Mt).
It is worth noting that the “energy efficiency” effect is far from being dominant in each sub-period. It was mainly negative between 1960 and 1975 (+38.3 Mt), due in particular to the large-scale penetration of central heating in residences, with 53% of households fitted with it in 1975 compared to just 20% in 1962. This phenomenon continued between 1975 and 1990 with another rise in central heating fitting by nearly 30 points in the period (82% in 1992 compared to 53% in 1975). However, it later had a strong positive impact on greenhouse gas emissions after the first oil crisis (-22.7 Mt between 1975 and 1990) and in connection with the rise in the nuclear power programme linked to the spread of electric heating.

b. The residential sector, 1990-2013:

The analysis of the 1990-2013 period of the above graph was carried out using limited and partial data available for the 1960-1990 period and extended to the 1990-2013 period. These results were refined by carrying out an analysis specific to the latter period, using the CEREN statistics IT system, which notably allowed analysis of the impact of the spread of electric heating and insulation works in homes.
Greenhouse gas emissions associated with energy consumption were virtually stable (“total variation”). The “Stock” and “Energy efficiency” effects (“efficiency_balance”) were dominant and cancelled one another out (1.1% increase in greenhouse gas emissions per year on average for the first, and a 1.5% decrease per year for the second).







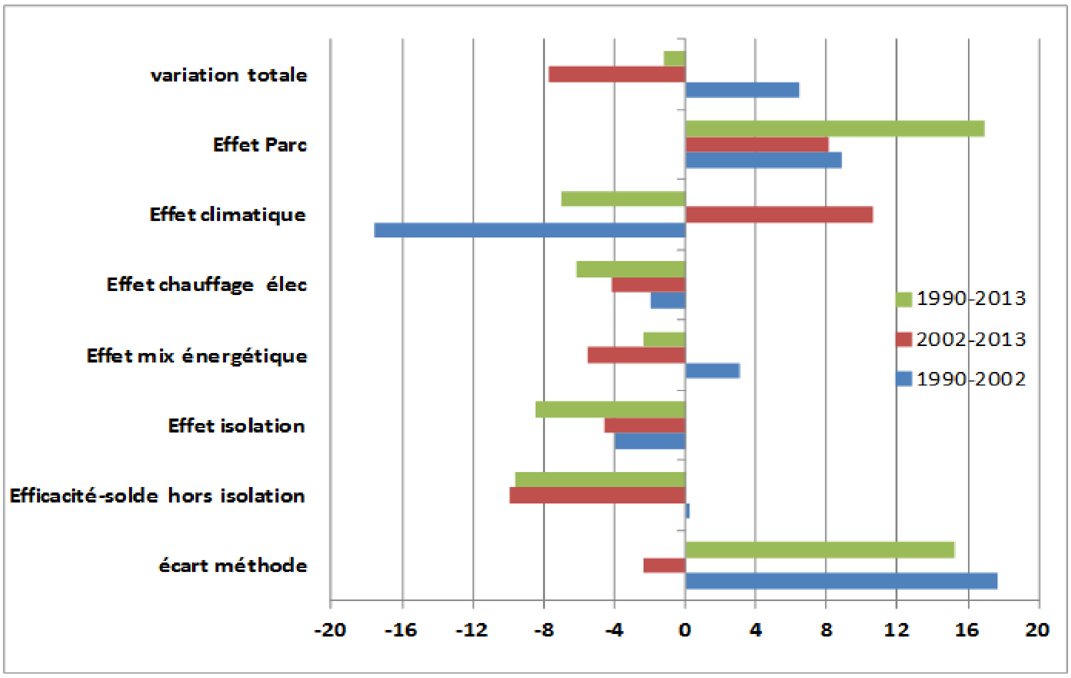


Figure 6.11 : decomposition of the factors of variation of the GHG emissions associated with energy consumption in the building sector between 1990 and 2013

The effects in $MtCO_2eq$ are described in greater detail.

- Stock effect: this led to an average increase of 1.1% in emissions per year between 1990 and 2013.
- Climate effect: throughout the 1990-2013 period, the climate effect reduced overall greenhouse emissions (-0.5% per year on average). The earlier years were milder than at the end of the period (only two years were colder than the “normal” year). This led to a corresponding decrease of 2.8% in greenhouse gas emissions per year between 1990 and 2002. From 2002 to 2013, the climate effect led to an increase of 1.5% in emissions per year. Four years were colder, including 2010 which was a particularly cold year, explaining a negative impact by the climate on emissions in this period. Unlike in the tertiary sector, the overall climate effect in 1990-2013 helped reduce emissions.
- Structure effect (residence type: house/unit): this effect is negligible here, residence types not having significantly changed between 1990 and 2013.
- Fuel mix effect: regarding fuel, changes in the energy mix show a trend in favour of natural gas to the detriment of domestic fuel. This change helped decrease greenhouse gas emissions, but the relative drop in wood burning contributed to increasing emissions. All things considered the share of reduction of emissions linked to the change in the energy mix was estimated at -0.2% on average per year between 1990 and 2013. There results differ according to the period in question: the drop in wood burning between 1990 and 2002 more than attenuated the savings generated by the penetration of gas. The effect of the energy mix therefore increased emissions by 0.4% per year on average over the period. The relative savings from gas and wood burning in the energy mix later led to a significant decrease in the level of emissions (-0.9% per year on average between 2002 and 2013).
- Electric heating effect: the impact of this effect on greenhouse gas emissions was estimated at -0.5% per year on average between 1990 and 2013. The electric heating effect reflects the substitution of fuel heating with electric heating, leading to a decrease in emissions thanks to the combined effect of a decline in unitary consumption and reduced average greenhouse gas content. This effect was greater in the second period due to an acceleration in the penetration of electric heating (34% of market share in 2013 compared to 28% in 2002 and 26% in 1990). This acceleration was notably boosted by the spread of heat pumps in households from the

mid-2000s.

- Energy efficiency effect (“energy_balance” in the graph): this effect, calculated as the difference between the total variation in emissions and the overall impact of all the above effects in the 1990-2013 period, contributed to decreasing greenhouse gas emissions, its effect being estimated at -1.5% per year on average. However, it had a varying impact according to the sub-period in question: -0.5% per year between 1990 and 2002, then -2.5% per year between 2002 and 2013. It is worth noting that fuel prices were relatively stable in constant currency during the first period, whereas they rose significantly during the second period. The combination of the economic context and the successive waves of thermal regulations encouraged energy efficiency actions during the second period. Overall in 1990-2013, the Building insulation effect accounted for approximately half of energy efficiency savings to varying extents according to the sub-period, equating to the overall savings in the 1990-2002 period, and approximately half of overall efficiency savings in the 2002-2013 period.

c. The tertiary sector, 1960-2013 (effects in MtCO2eq):

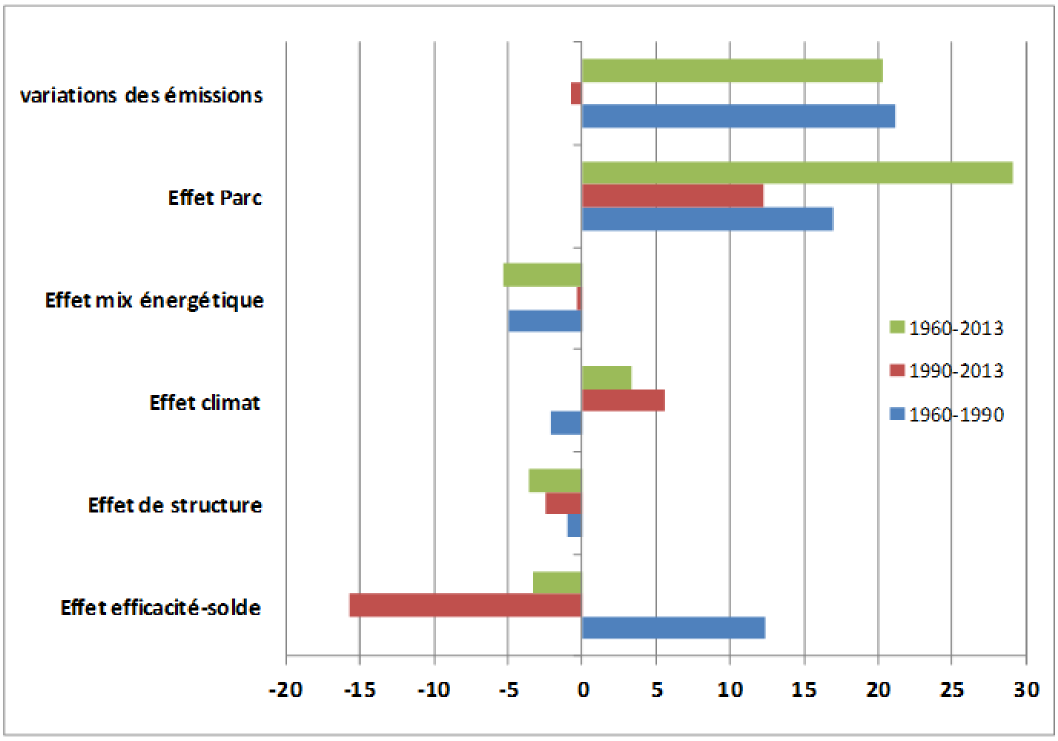


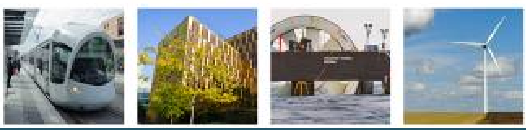
Figure 6.12 : decomposition of the factor of variation of GHG emissions induced by energy consumption in the tertiary sector between 1960 and 2013

Greenhouse gas emissions associated to energy consumption in the tertiary sector increased by 21.1 Mt between 1960 and 1990. The stock effect (+16.9 Mt) and low energy efficiency (+12.4 Mt) had the greatest impact by far. This is partially offset by the other effects which contribute to decreasing emissions, particularly the energy mix (-5.0 Mt). It is worth noting the impact of poor energy efficiency between 1960 and 1975 (+18.2 Mt) and, conversely, the positive impact from energy efficiency actions during the second sub-period (-5.8 Mt between 1975 and 1990).

d. The tertiary sector, 1990-2013:

The analysis presented in the figure 6.12 for the 1960-2013 period was carried out using limited and partial data available for the 1960-1990 period and extended to the 1990-2013 period. The results for the 1990-2013 period have been refined by performing a new, specific analysis using the CEREN statistics IT system, which has notably allowed analysis of the impact of the spread of electric heating.

Greenhouse gas emissions from energy consumption were relatively stable (“total variation” bar).



The stock and energy efficiency ("efficiency-balance"[65]) effects heavily impacted changes in emissions. It is worth noting the heightened energy efficiency effect between 2002 and 2013 (-2.2% per year on average) compared with the previous period (-0.1% per year in average between 1990 and 2002).

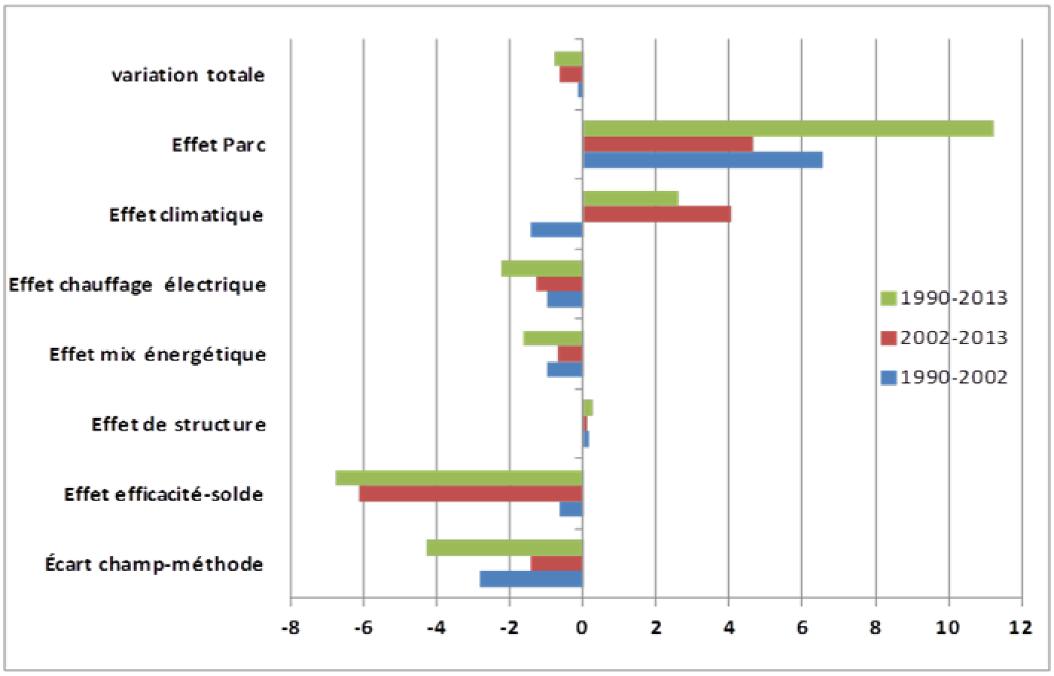
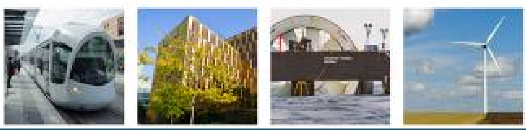


Figure 6.13 : decomposition of the factor of variation of GHG emissions induced by energy consumption in the tertiary sector between 1990 and 2013

- Stock effect: this was the dominant force, leading to an average increase in emissions by 1.4% per year between 1990 and 2013. Growth slowed slightly in the second period, going from an average of 1.7% per year between 1990 and 2002 to 1.4% per year between 2002 and 2013.
- Climate effect: the reference degree-days and observed degree-days which allow us to analyse the climate effect in the tertiary sector are calculated per tertiary branch while taking into account sectoral specificities. In the 1990-2013 period, the climate effect contributed to an increase in greenhouse gas emissions, with the yearly average at +0.3% with variations within the period (-0.5% per year between 1990 and 2002, then +1.2% per year between 2002 and 2012). During the first period, the weather was fairly mild. There were only two years which were colder than "normal". During the second period, there were four years which were colder than "normal", including 2010 which was particularly cold.
- Structure effect (building type): this has been a very marginal effect (0.04% increase in greenhouse gas emissions per year linked to this effect), with the rise in heated surfaces remaining relatively stable in each of the eight tertiary branches evaluated (catering, community living, health, education, sport/leisure/culture, offices, businesses, transport).
- Fuel mix effect: regarding fuel, changes in the energy mix show a trend in favour of natural gas to the detriment of domestic fuel. This change fostered a decrease in greenhouse gas emissions of -0.3% per year on average in 1990-2013. This downward impact was slightly less pronounced in the first period (1990-2002) due to a slowing of work to substitute fuel with gas in the mid-1990s.

[65] The "efficiency-balance" effect in the residential sector is the difference between the total variation in emissions calculated by the CEREN and the sum of stock, climate, electric heating, energy mix and insulation effects.
The difference method is linked to the methodological differences in calculating emissions between the CITEPA and the CEREN.

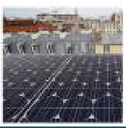


- Electric heating effect: the impact of this effect was estimated at -0.4% on average per year between 1990 and 2013. It reflects the replacement of fuel heating with electric heating, leading to a decrease in emissions due to the combined effect of a decline in unitary consumption and lower average greenhouse gas content.
- Energy efficiency effect[66] ("efficiency-balance" on the graph): this effect reflects the variation in energy consumption in the tertiary sector in relation to the heated area and excluding the effects already mentioned. This balance includes "behaviour/investments" effects by users/managers influenced by changing energy prices or government policies. For the 1990-2013 period, the technical effect, which is the difference between the overall change in emissions and the total impact of all the above effects, contributed to reducing emissions and was estimated at 1.1% on average per year. This can be assimilated to energy efficiency improvements. The level varied over time, going from -0.1% per year between 1990 and 2002 to -2.2% per year between 2002 and 2013. It is worth noting that fuel prices dropped in constant currency in the first period, whereas they rose significantly in the second period, a factor which doubtlessly spurred on energy efficiency actions. Thermal regulations also affected the tertiary sector from the 2000s, improving overall energy efficiency through new buildings and thermal renovation.

5.3. Factors explaining the evolution of direct and indirect greenhouse gas emissions from the residential-tertiary sector

The above analysis concerned direct emissions linked to fuel consumption in residential and tertiary buildings.
Analysing indirect emissions allows us to take into account the specific effects of electricity consumption, and more particularly the impact of average greenhouse gas content per kWh of electricity, the impact of air conditioning and the impact of other specific uses.
Total emissions from energy consumption in the residential and tertiary sectors (direct and indirect) are presented below for 1990-2013, as the 1960-1990 period has not been the subject of a sectoral breakdown for indirect emissions due to a lack of studies allowing us to do so.

[66]This effect is calculated as the difference between the total variation in emissions and the sum or stock, weather, electric heating, energy mix and structure effects. The effect of the "scope-method difference" incorporates the methodological differences linked to the different approaches by CITEPA and CEREN and the differences in scope of surveys linked to the tertiary sector.







Residential buildings (effects in $MtCO_2eq.$)

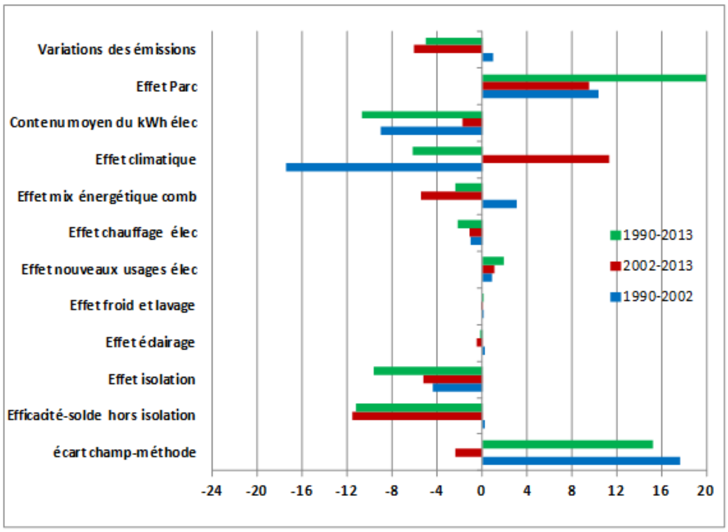


Figure 6.14 : decomposition of the factor of variation of GHG emissions induced by energy consumption in the residential sector (including indirect emissions associated with the production of electricity) between 1990 and 2013

The “average greenhouse gas content per kWh of electricity” effect led to a significant drop in emissions:
-10.7 $MtCO_2eq$ between 1990 and 2013.
This reduction was concentrated in the first sub-period.
-9,0 Mt between 1990 and 2002 due to milder climate conditions.
The effects of specific electricity consumption were limited, as a result of the low greenhouse gas content of this consumption.

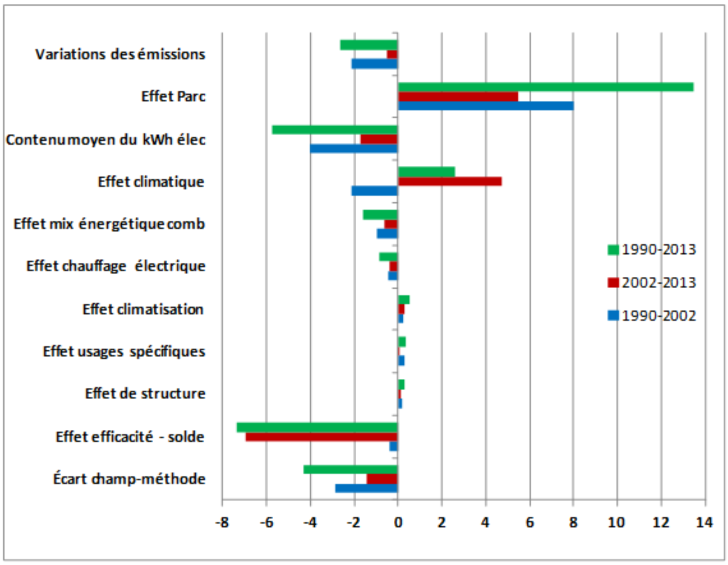


Figure 6.15 : decomposition of the factor of variation of GHG emissions induced by energy consumption in the tertiary sector (including indirect emissions assoiated with the production of electricity between 1990 and 2013

The evolution in average greenhouse gas content per kWh of electricity helped drive down emissions by 5.7 MtCO2eq between 1990 and 2013.
The spread of air conditioning had a limited impact on emissions due to its low greenhouse gas content.
The same is true of the effect of specific uses, which was almost nil between 2002 and 2013, as a result of improved energy efficiency in lighting and office equipment.

6. The industrial sector

Between 1960 and 2013, direct greenhouse gas emissions from energy consumption in the industry were virtually halved, shrinking from 105.2 million tonnes to 62.7 million tonnes, after peaking at 137.9 million tonnes in the mid-1970s.
Meanwhile, output was multiplied by 2.3 throughout the period, with an average annual increase of 5.2% between 1960 and 1974, +1.3% between 1974 and 1990 and -0.4% between 1990 and 2013, the latter figure reflecting the scale of the recession of 2008 and 2009.

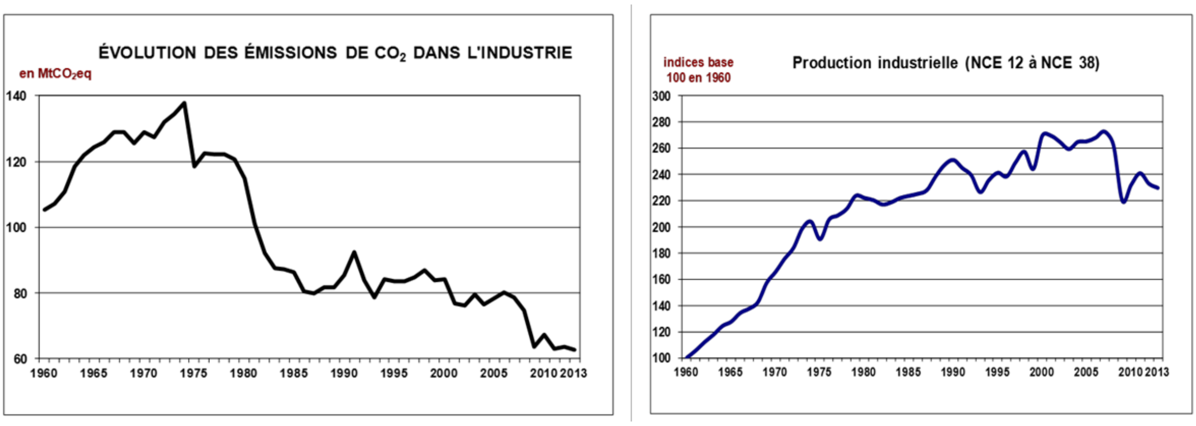


Figure 6.16 : decomposition of the factor of variation of GHG emissions induced by energy consumption in the industry (in Mt CO2 eq.) between 1960 and 2013 and evolution of the industrial production over the same period (indexed as 100 in 1960)

The graph below breaks down changes in direct greenhouse gas emissions in $MtCO_2eq$ induced by energy consumption into four effects (production, energy mix, structure and technical-substitution) and evolution of the industrial production between 1960 and 2013.

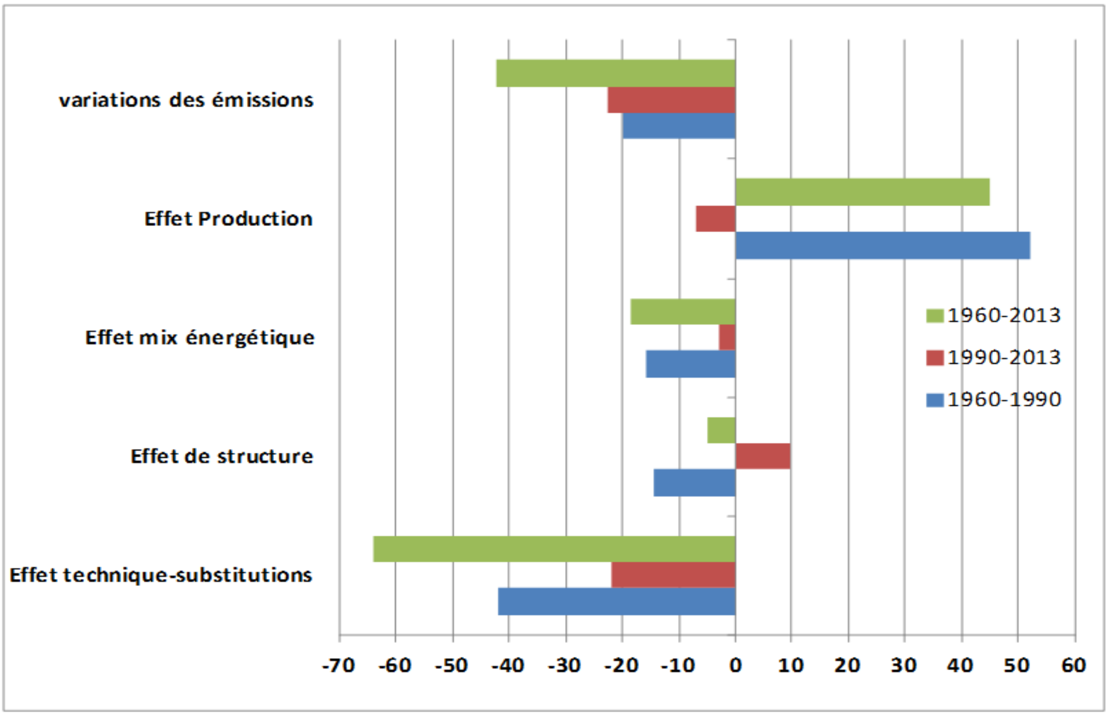
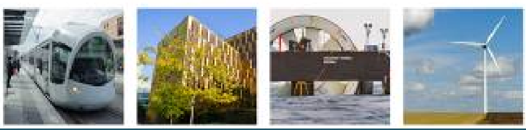


Figure 6.17 : decomposition of the contribution of different factors to the variations of the GHG emissions associated with the consumption of energy in the industry sector between 1960 and 2013 (in Mt CO2 eq.)

Direct greenhouse gas emissions from energy consumption in industry decreased by 42.5 Mt between 1960 and 2013. A number of effects contributed to this drop in emissions, with the “technical-substitution” effect being the main one by far (-63.9 Mt). The energy mix effect pulled down greenhouse gas emissions by 18.6 Mt, mostly between 1960 and 1990, in particular thanks to large-scale move away from carbon between 1960 and 1975. Conversely, the increase in industrial output drove up greenhouse gas emissions, with the effect concentrated in 1960-1990. Overall in 1960-2013, the output effect led to an increase in emissions of 45 Mt.

- The 1990-2013 period



The results presented in the above graph for the 1960-2013 period have been produced using limited and partial data available for the 1960-1990 period and extended to 1990-2013. The results have been refined by carrying out a new analysis specific to this period using the CEREN statistics IT system, which notably allowed us to replace the analysis in 15 branches in 1960-2013 with an analysis in 250 industrial products.
This analysis shows that greenhouse gas emissions from energy consumption in industry have noticeably decreased (-22.7 Mt). All the effects had a downward influence on emissions throughout the period, with the exception of the climate effect. The technical-substitution effect accounts for approximately half of the decrease in emissions, while the effect of energy mix accounts for approximately one third.

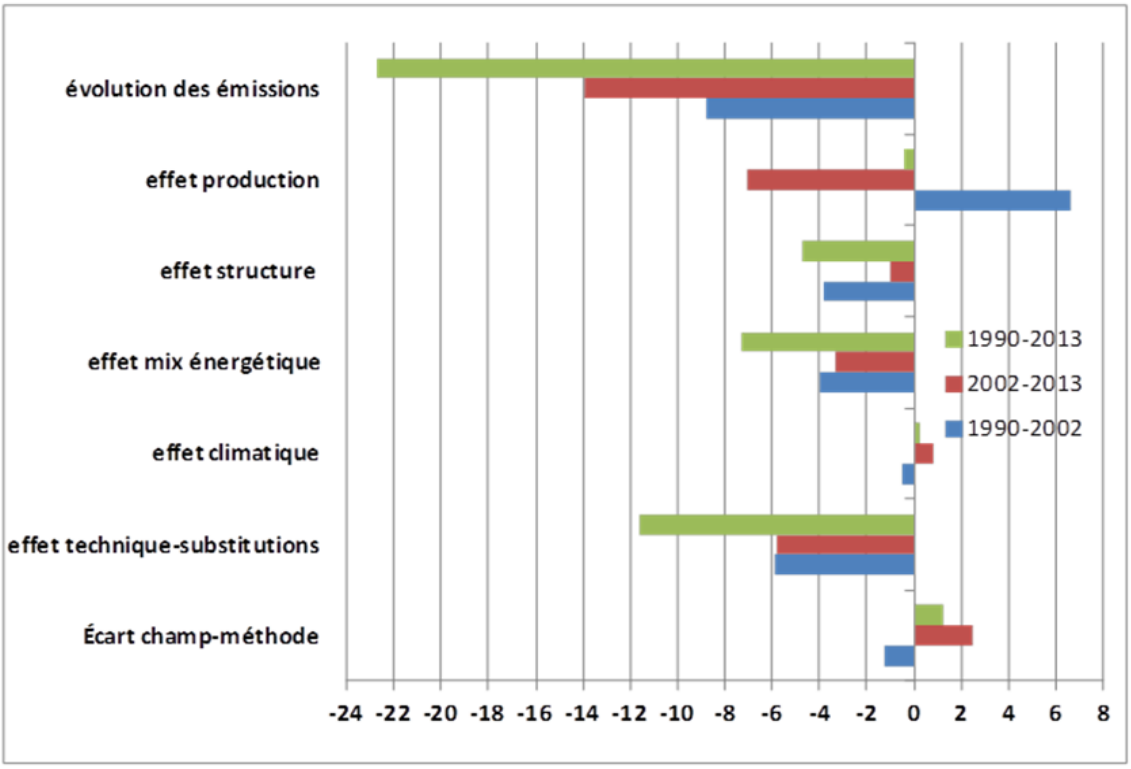


Figure 6.18 : decomposition of the contribution of different factors to the variations of the GHG emissions from energy consumption in the industry sector between 1990 and 2013 (in Mt CO2 eq.)

- Output effect: the overall output effect was virtually nil throughout the period (-0.5 Mt), although this near-stability is the result of two contrasting sub-periods (+6.6 Mt between 1990 and 2002 and -7 Mt between 2002 and 2013).
- Structure effect: this helped reduce greenhouse gas emissions (-4.8 Mt) in the first sub-period.
- Fuel mix effect: regarding fuel, changes in the energy mix show a trend away from oil products and towards natural gas and biomass, the latter seeing its market share nearly double over the period (from 5% to nearly 10%). Emissions went down as a result of changes in the energy mix.
- Technical-substitution effect: throughout the 1990-2013 period, the technical effect, calculated as the difference between the total variation in emissions and the overall impact of all the above effects, had a positive impact in reducing emissions, estimated at nearly 11.6 MtCO2eq, i.e. 0.5 Mt on average per year. These savings can be assimilated with energy efficiency improvements and environmental remediation schemes. During the 1990s fuel prices dropped in constant currency, whereas they rose sharply during the 2000s, a

factor that tended to encourage energy efficiency actions. The energy savings certificates scheme launched in 2006 also contributed to energy efficiency in industry.

7. Electricity production from 1960 to 2013

The explanatory variables used included the amount of electricity produced and evolutions in the production stock (distribution between sectors (heat, nuclear, renewable energy) and energy efficiency).
The graph below summarises the results.

Determining factors in the annual evolution of emissions from electricity production in MtCO2eq (between 1960 and 2013)

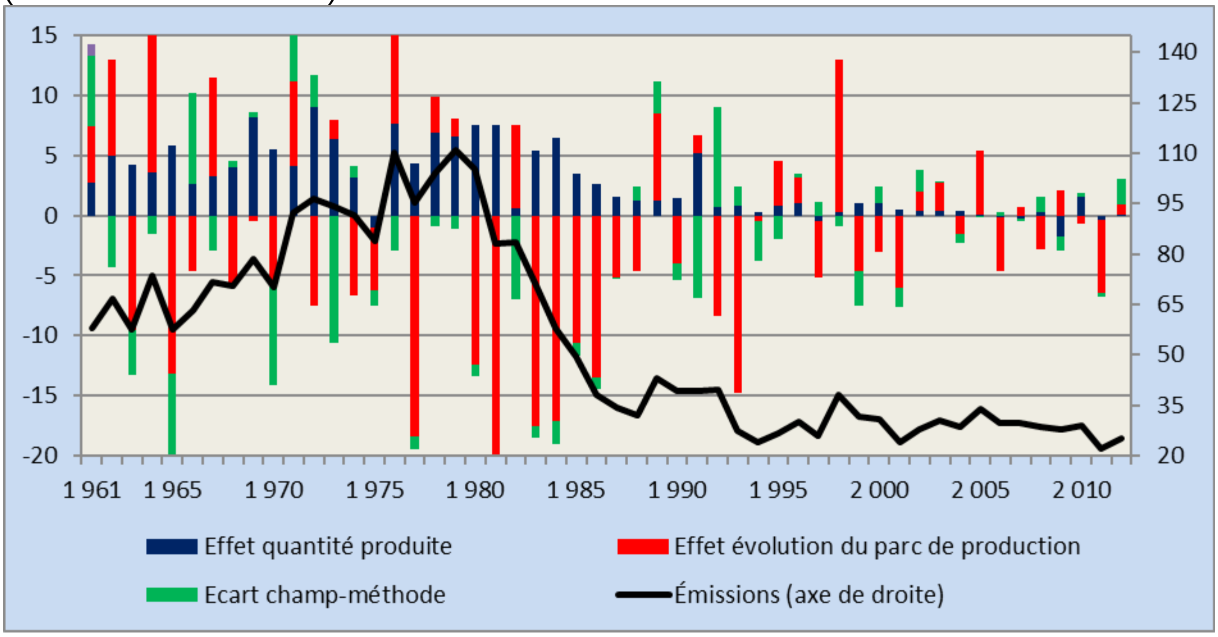


Figure 6.19 : decomposition of the contribution of different factors to the inter-annual variations of the GHG emissions for the production of electricity between 1960 and 2013 (in Mt CO2 eq.)

The evolution of greenhouse gas emissions linked to electricity production between 1960 and 2013 saw three clearly distinct phases:

- From 1960 to 1979: emissions increased sharply by 79 Mt, driven by the increase in electricity production (92 Mt), as the effect of changes in the energy mix were virtually nil.
- From 1980 to 1988: drop in emissions (- 79 Mt) due to a significant effect from the mix and changes in production stock (- 101 Mt), as the nuclear programme hits its stride, despite a big increase induced by the output effect (+ 37 Mt).
- From 1989 to 2013: emissions stabilised, with the production effect (+ 15 Mt) being offset by the effect of changes in the production stock.

Chapter 7: Appendix on Land use, Land-Use Change and Forestry (LULUCF)

Introduction

This appendix constitutes a clearly identifiable part of the SNBC and responds to the obligation of France under Article 10 of Decision no. 529/2013/EU of the European Parliament and Council of 23 May 2013 on accounting rules on greenhouse gas emissions and sequestration resulting from activities relating to land use, land-use change and forestry and on information relating to those activities

It describes the current context in France in the LULUCF sector (Part 1), presents data from the National Greenhouse Gas Inventory submitted to the United Nations Framework on Climate Change (UNFCCC) under the terms of the Kyoto protocol (Part 2), presents the results of projections (Part 3), and lastly presents information on levers for reducing emissions (Part 4) and current and prospective policies and measures in the framework of the SNBC (Part 5).

The Low-Carbon Strategy is designed to describe the main aims, but it does not replace sectoral plans. The reference scenario (AMS2 run 2 later on in this appendix) may therefore be revised according to targets adopted in the framework of the National Biomass Strategy.

1. The situation in France

The surface area of Metropolitan France (550,000 km^2) is the largest of all the countries in the European Union (approximately 13% of the area covered by the European Union). Situated between the Atlantic Ocean and the Mediterranean Sea between latitudes 41°N and 51°N, France has around 3,200km of coastline. The country's altitude is average, with plains and mountains covering two thirds of the territory, and it has two mountain ranges on its east and south borders: the Alps and the Pyrenees. The highest point in France is the summit of Mont Blanc, at 4,810m, which is in the Alps and on the border with Italy. The Massif Central, in the centre of the country, distributes water to the four main basins via the Seine in the north, the Loire in the north-west, the Rhône in the east and the Garonne in the south-west.

Farmland (cultivated and permanent grassland) occupies 51% of the surface area of Metropolitan France. Zones considered natural areas (woodland, moor, open land, wetland and areas covered by water) account for 40% and artificialised land for 9% (built-up areas, covered or stabilised land, other artificialised land).

1. 1 Agriculture

The farming and agrifood industry generated approximately 3.2% of national GDP (1.6% and 1.6% respectively) in 2011 and accounted for 5.6% of total employment in 2011 (3.3% and 2.3% respectively). France is the leading agricultural producer in Europe and is in second position in terms of revenue from agrifood industries on a European level.[67]

In 2010, farming activity covered 29.2 million hectares out of the 55 million that make up Metropolitan France. 131,800 hectares out of the 8.5 million hectares in Overseas Departments are agricultural land. There are approximately 515,000 farms across the territory.

Utilised agricultural area (UAA) has shrunk steadily since 1950. This reduction has benefited wooded areas and non-agricultural land which have increased by 75,000 and 51,000 hectares respectively on average per year since 1950. For example, between 1990 and 2010 UAA decreased by 75,000 hectares on average per annum (Cf. Table 1, below).

The breakdown of the territory between arable land (63%), permanent grassland (33%) and permanent crops (4%) has remained relatively consistent, but it is important to note that areas of permanent grassland have nevertheless followed a downward trend, accounting for 37.3% of UAA in 1990 compared with just 33.3% in 2010.

	1990	2010
Utilised agricultural area	30.6	29.1
- arable land	17.8	18.3
- permanent grassland	11.4	9.7
- vines, orchards, others	1.4	1.1
Non-cultivated agricultural land	2.8	2.6
Poplar groves, woods and forests	15.0	15.6
Other (non-agricultural) land	6.5	7.6
Area of Metropolitan France	54.9	54.9

Table 7.1: changes in utilised agricultural area (in millions of hectares) - Source: Agreste France – 2012 memo

[67] Agreste farming statistics memo, December 2012

Like its European neighbours, French farming saw unprecedented modernisation and rises in productivity over the course of 50 years. The farming sector must now meet new challenges concerning the protection of the environment and natural resources and the fight against climate change. France’s agro-ecological project and the rolling out of the Common Agricultural Policy contribute to promoting more sustainable farming that reconciles economic and ecological efficiency.

1. 2 Forestry

France has the second largest forested area out of the 28 countries in the European Union (Sweden has 28 million hectares (Mha) and Finland has 23Mha), representing 10% of the EU’s forests.[68] Forests cover nearly 24.3 Mha, with 16 Mha in Metropolitan France, i.e. 27% of the metropolitan territory, and 8.3 million hectares in Overseas Departments (Guadeloupe, French Guiana, Martinique and Reunion, Mayotte). French Guiana is a mainly wooded department with forest covering 95% of the territory and contains almost all the forested area in the overseas departments.

Broad-leafed woodland covers 62% of the forested area in Metropolitan France, resinous trees cover 21% and the remaining 17% is composed of mixed woodland. The forestry sector employs approximately 400,000 people directly and indirectly, most often in rural areas.

The surface area of French forests has grown sharply since the late 19th century. It is estimated that wooded area in France covered between 8.9 and 9.5 million hectares in 1830, and approximately 10 Mha in 1900 before reaching 16 Mha in 2014.[69] Wooded area (forests and other woodland, the latter currently covering about 2 Mha) has increased by approximately 7 million hectares since 1900, rising by around 68,000 hectares per year between 1980 and 2000. This expansion mainly took place through the natural colonisation of land not used for farming.

Private forest in Metropolitan France accounts for 75% and is very broken up. The remaining 25% is composed of national forest owned by the State (10%), and forest belonging to regional government (15%). In the Overseas Departments, forests are mainly national forests.

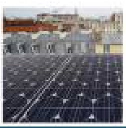
The standing timber volume of French forests is growing at a fast rate, with a gross annual increase of approximately 120 Mm3 (total above-ground wood volume) in 2004-2012, whereas average annual felling is estimated at around 60 Mm^3 in total above-ground volume, which is a fell rate of approximately 50%.[70]. This felling includes commercial and own-consumption harvesting including from forests, losses and smallwood.[1]

The French forest carbon sink is one of the largest in the European Union.

According to an approach based on the **report written by France for the UNFCCC,** in 2013[71] there was:

- a forest carbon sink of around 65.5 $MtCO_2eq$ (of which 58 $MtCO_2eq$ for forests remaining so, and 7.5 $MtCO_2eq$ for land being turned into forest)
- a carbon sink of around 11 $MtCO_2eq$ for pastureland
- a carbon sink of around 2 $MtCO_2eq$ for wetland
- a source of around 21 $MtCO_2eq$ for cultivated land,
- a source of around 12.5 $MtCO_2eq$ for urbanised areas

68 Agreste-2012
69 Agreste 2013, “La Forêt et les Industries du Bois”
70 IGN 2014
71 CITEPA v2015 inventory for 2013







Altogether, for all land uses (forestry or not), this corresponds to a **LULUCF balance for the sector of a carbon sink of approximately 45 $MtCO_2eq$** (not including carbon stored in wood products).

In the **accounting format for the Kyoto protocol**, in 2013 for forest land alone, the **carbon sink** (again excluding carbon stored in wood products) was **in the order of 52 $MtCO_2eq$**[72] and was composed of a sink of nearly 54 $MtCO_2eq$ by way of forestry management, a sink of 10 $MtCO_2eq$ relating to wooded areas since 1990 and a source of 12 $MtCO_2eq$ corresponding to already-cleared woodland. The carbon sink in harvested wood products was estimated at 3.8 $MtCO_2eq$ in 2013.

These figures can be viewed against the **reference level set for France for its "Forestry Management" activity, in the framework of the 2nd period of the Kyoto Protocol (2013-2020)**, since carbon footprint of Forestry Management is indeed compared with this **projected reference level.** The difference between the emissions recorded for this activity in the inventories each year and the reference emissions gives the overall balance of emissions (or carbon sink, if the emissions are negative) recorded for the activity. The projected reference level is estimated by modelling the trend of carbon emissions and sequestration from "Forestry Management", taking into account the impact of the policies in effect until mid-2009.

The projected reference level for France in 2011 was 63 $MtCO_2eq$ on average per year for 2013-2020 (67.4 $MtCO_2eq$ including harvested wood products), but this was calculated **based on past French data which has since been significantly revised** (following a technical correction by our national forestry inventory in 2011, leading to a significant decrease in the estimations of the forest carbon sink). In order to take these new results into account, a technical correction of the reference level is currently in process.

[72]CITEPA v2015 inventory for 2013

2. Trends of past emissions and absorption

The figures in the Kyoto format are given for the whole of France, including Metropolitan France and overseas territories included in the EU (Overseas Departments[73], and Overseas Authorities[74]). The figures in the UNFCCC format are given for the whole of France within the Kyoto scope plus the overseas countries and territories not included in the EU.[75]

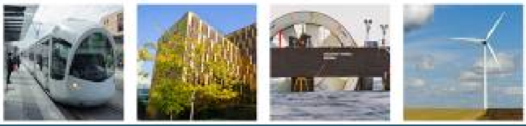
2.1 KYOTO Format

Physical balance of GHG emissions in $MtCO_2eq$					
Year	3.3 Total	3.3 Afforestation and reforestation	3.3 Deforestation	3.4 Forestry management	HWP
2008	8,401.65	-8,011.09	16,412.74	-65,530.38	11,283.40
2009	6,418.32	-8,590.56	15,008.89	-57,595.75	11,127.21
2010	4,115.97	-8,654.66	12,770.63	-48,389.93	10,956.24
2011	2,778.89	-9,095.03	11,873.91	-51,217.15	10,602.05
2012	2,319.78	-9,554.64	11,874.42	-57,767.75	10,047.56
2013	1,849.95	-10,032.31	11,882.26	-53,621.52	-3,843.21

Table 7.2: Balance of GHG emissions and absorption for the LULUCF sector in the Kyoto format according to the different activities recorded (v2015 inventory for 2013)

Comments:
- Due to a change of method, only 2013 shows a representative result for the balance of emissions connected to the evolution of the wood products category. Emissions only linked to the degradation of wood products are presented for 2008-2012, and not the sink corresponding to the production of new products, where the "instantaneous oxidation" accounting rule has been used for this period.
- "Pasture management" and "Crop management" are not included for this period.

[73]Guadeloupe, Guiana, Martinique, Reunion
[74]Saint Barthélémy and Saint Martin
[75]Saint-Pierre and Miquelon, Wallis and Futuna, French Polynesia, New Caledonia, French Southern and Antarctic Lands and Clipperton Island + Mayotte on 1 January 2014



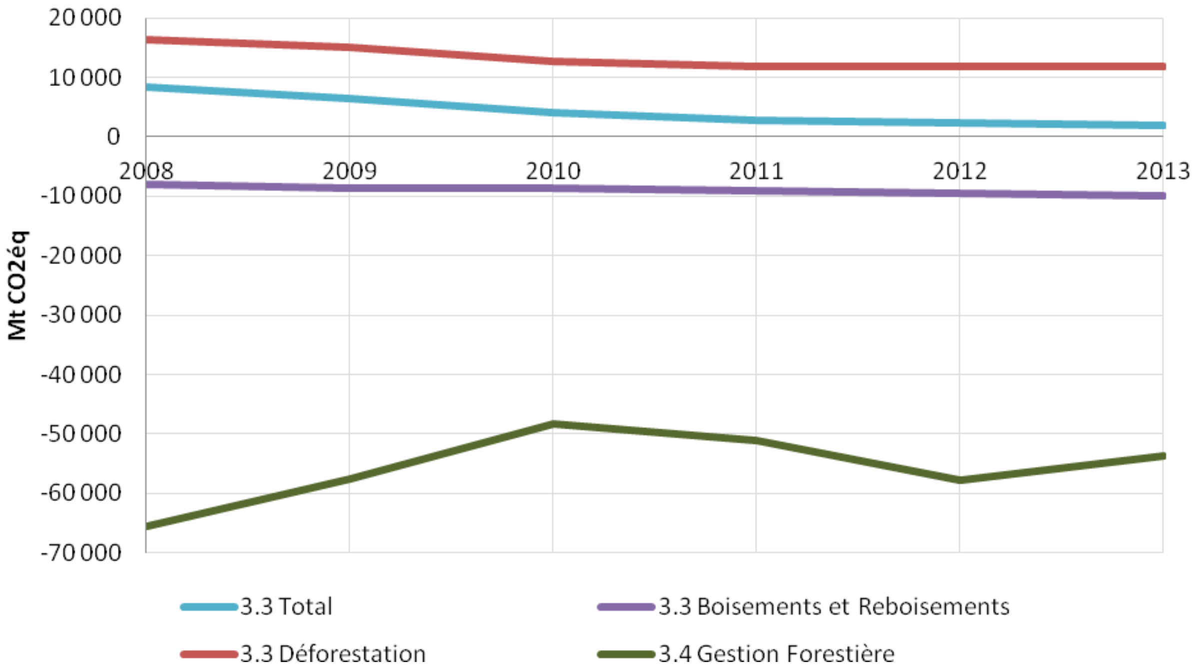
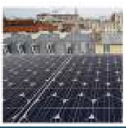


Figure 7.1: Evolution of GHG emissions / absorption from activities in the LULUCF sector (Kyoto format, v2015 inventory for 2013)

2.2 UNFCCC format

LULUCF sector									
Year	**Forest-land**	**Cropland**	**Grass-land**	**Wetlands**	**Settle-ments**	**Other lands**	**Wood products**	**Other (Petit-Saut Dam)**	**Total**
1990	-40,785.11	13,481.45	-8,649.23	-923.59	7,162.67	0.16	-7,810.20		-37,523.85
1991	-39,683.94	14,384.92	-9,807.46	-1,084.62	7,515.20	0.16	-7,457.45		-36,133.18
1992	-38,795.73	15,339.16	-10,906.03	-1,253.51	7,886.43	0.16	-4,534.52		-32,264.04
1993	-45,309.86	16,339.40	-11,956.89	-1,430.28	8,276.41	0.16	-3,233.03		-37,314.10
1994	-46,558.92	17,112.58	-12,528.27	-1,534.15	9,127.60	0.16	-3,912.82	3,473.67	-34,820.14
1995	-47,110.76	17,687.64	-14,093.89	-1,779.59	9,326.12	0.16	-4,200.73	3,915.03	-36,256.03
1996	-50,992.95	18,909.58	-14,367.85	-1,697.48	9,499.57	0.16	-3,754.53	3,056.94	-39,346.55
1997	-50,720.82	19,491.18	-15,063.85	-1,859.98	10,519.95	0.16	-4,317.91	2,417.72	-39,533.55
1998	-53,005.01	20,493.27	-16,001.72	-2,073.73	10,725.95	0.16	-4,892.23	1,938.46	-42,814.85
1999	-56,732.65	21,443.20	-15,660.53	-2,076.50	12,328.51	0.16	-4,982.07	1,576.53	-44,103.35
2000	-41,807.21	20,215.96	-16,622.92	-2,154.39	10,747.80	0.16	-5,216.07	1,301.07	-33,535.59
2001	-50,219.14	20,443.37	-15,713.70	-2,005.51	11,107.76	0.16	-5,083.04	1,089.63	-40,380.47
2002	-54,345.19	19,851.52	-15,061.00	-2,166.03	11,461.00	0.16	-3,853.29	925.90	-43,186.92
2003	-58,466.96	19,337.26	-14,790.22	-2,185.78	11,210.46	0.16	-3,664.06	797.85	-47,761.28
2004	-60,222.97	19,296.82	-13,303.44	-2,006.01	11,827.57	0.16	-4,047.16	696.82	-47,758.20
2005	-63,037.27	19,534.45	-12,202.69	-1,890.31	12,525.76	0.16	-4,579.33	616.31	-49,032.92
2006	-68,939.99	19,977.82	-11,176.76	-1,818.76	13,123.54	0.16	-4,618.70	551.54	-52,901.13
2007	-70,323.17	20,536.58	-10,277.50	-1,808.35	13,524.11	0.16	-5,026.53	498.94	-52,875.76
2008	-71,658.52	21,951.35	-10,704.11	-2,302.16	14,195.22	0.16	-3,658.45	455.90	-51,720.61
2009	-66,123.36	21,511.36	-10,943.68	-2,282.32	13,958.51	0.16	-2,515.48	420.34	-45,974.47
2010	-57,246.79	21,597.59	-11,268.44	-2,390.76	12,789.33	0.16	-3,254.41	390.78	-39,382.55
2011	-60,500.57	21,033.73	-11,632.95	-2,244.71	12,990.92	0.16	-3,368.83	366.01	-43,356.23
2012	-67,493.22	21,020.43	-11,312.24	-2,218.74	12,815.94	0.16	-1,937.86	345.17	-48,780.34
2013	-65,596.10	20,961.38	-11,040.29	-2,185.17	12,618.84	0.16	-1,652.60	327.53	-46,566.24

Table 7.3: Balance of GHG emissions and absorption for the LULUCF sector in the UNFCCC format according to the different types of land covered in the report (v2015 inventory for 2013)







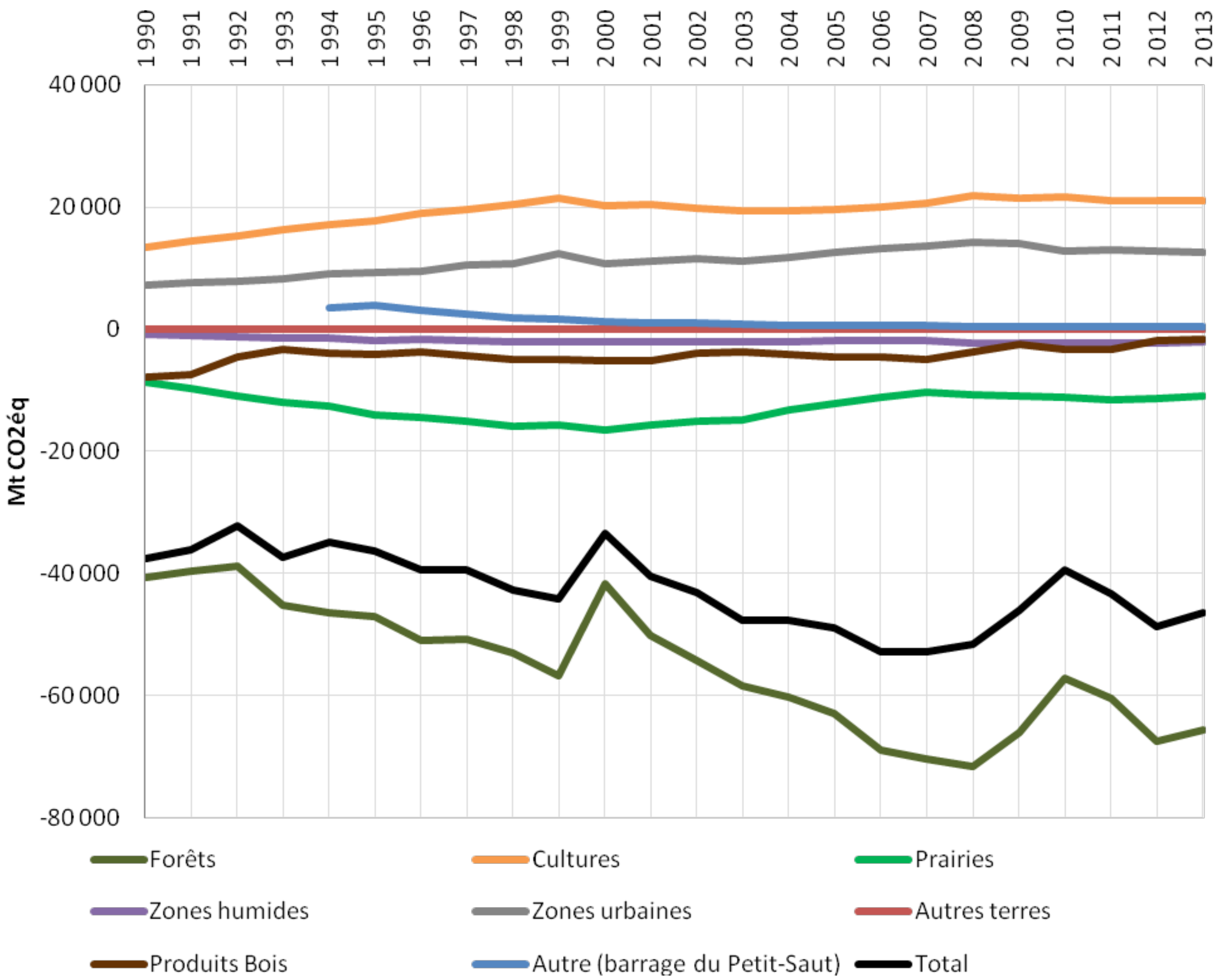


Figure 7.2: Evolution of GHG emissions / absorption from different types of land and wood products from 1990 to 2013 (UNFCCC format, v2015 inventory for 2013)

3. Projections of emissions and absorption for the accounting period 2013-2020 and until 2035.

This section presents the results of perspective scenarios for 2035 created in the framework of the elaboration of the present national low-carbon strategy.
The AME scenario "with existing measures" is based on all measures effectively introduced or executed before 1 January 2014, and assumes a slight increase in felling in forests. The AMS2 scenario "with additional measures 2" (corresponding to the reference scenario described in chapter 2 of the SNBC) includes all the measures allowing us to meet the objectives of the law on energy transition and green growth (LTECV). It assumes a greater increase in wood harvested from forests.

In both scenarios, the level of felling in forests only constitutes a provisional hypothesis, which will be revised later. Felling targets will be established in the National Strategy for the Mobilisation of Biomass provided for in the Law on Energy Transition and Green Growth. New projections will be able to be made for the LULUCF sector based on these objectives – in the knowledge that they will not affect the carbon budgets set for sectors that are sources of emissions, but excluding LULUCF.

Whatever the case, reaching national targets for the development of renewable energy will imply a substantial increase in felling in woods, if we consider that net imports of biomass cannot be excessively increased. An ambitious revival of the use of wood as a material (timber, and in construction in particular), of which firewood is mainly a coproduct, may be necessary.

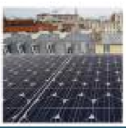
Concerning DOM, COM and PTOM,[76] the trends have been extended to produce the projections presented.

3.1 KYOTO format

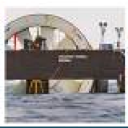
	AME Kyoto				AMS2_RUN2 Kyoto			
Year	3.3 Total	3.3 Afforestation and reforesta-tion	3.3 Deforest-ation	3.4 Forest Management	3.3 Total	3.3 Afforestation and reforesta-tion	3.3 Deforesta-tion	3.4 Forest Man-agement
2014	731.88	-8,426.04	9,157.92	-64,806.32	750.67	-8,407.25	9,157.92	-63,913.73
2015	743.39	-8,585.56	9,328.95	-66,119.68	790.46	-8,538.49	9,328.95	-64,402.28
2016	662.95	-8,821.69	9,484.64	-67,528.11	748.65	-8,735.99	9,484.64	-64,890.80
2017	577.43	-9,056.26	9,633.69	-68,803.56	709.84	-8,923.85	9,633.69	-65,182.12
2018	505.29	-9,309.57	9,814.86	-70,018.73	693.39	-9,121.47	9,814.86	-65,369.28
2019	284.59	-9,588.41	9,873.00	-71,232.92	538.20	-9,334.79	9,873.00	-65,507.94
2020	**226.28**	**-9,928.64**	**10,154.92**	**-73,178.97**	**548.06**	**-9,606.86**	**10,154.92**	**-66,323.01**
2021	36.80	-10,296.30	10,333.10	-74,874.30	442.17	-9,890.93	10,333.10	-66,865.81
2022	-108.42	-10,618.56	10,510.14	-75,818.14	386.51	-10,123.63	10,510.14	-66,619.13
2023	-200.64	-10,964.29	10,763.65	-76,770.24	382.49	-10,381.16	10,763.65	-66,351.87
2024	-444.89	-11,330.88	10,885.99	-77,725.67	248.08	-10,637.90	10,885.99	-66,077.81
2025	-784.66	-11,671.15	10,886.49	-78,603.91	44.00	-10,842.49	10,886.49	-65,737.40
2026	-1,303.43	-12,088.88	10,785.45	-79,471.26	-309.48	-11,094.93	10,785.45	-65,418.80
2027	-1,872.35	-12,479.11	10,606.76	-80,304.59	-681.03	-11,287.80	10,606.76	-65,062.36
2028	-2,494.23	-12,906.27	10,412.05	-81,123.99	-1,142.86	-11,554.91	10,412.05	-64,685.97
2029	-3,057.25	-13,364.78	10,307.53	-82,007.25	-1,539.46	-11,846.99	10,307.53	-64,346.82
2030	-3,433.91	-13,818.68	10,384.77	-82,844.31	-1,761.06	-12,145.82	10,384.77	-63,972.74
2031	-3,904.23	-14,289.69	10,385.46	-83,643.55	-1,406.08	-11,791.54	10,385.46	-59,144.77
2032	-4,385.09	-14,770.54	10,385.46	-84,428.67	-1,607.61	-11,993.07	10,385.46	-58,258.24
2033	-4,873.82	-15,259.27	10,385.46	-85,199.08	-1,801.95	-12,187.40	10,385.46	-57,354.67
2034	-5,225.32	-15,610.78	10,385.46	-84,587.66	-1,862.34	-12,247.80	10,385.46	-55,255.94
2035	-5,725.10	-16,110.55	10,385.46	-85,337.66	-2,054.93	-12,440.39	10,385.46	-54,496.98

Table 7.4: Balance of projected GHG emissions and absorption for the LULUCF sector in the Kyoto format according to the different activities recorded (Prospective scenarios for 2035 CITEPA)

[76] Overseas Departments, Overseas Authorities and Overseas Countries and Territories





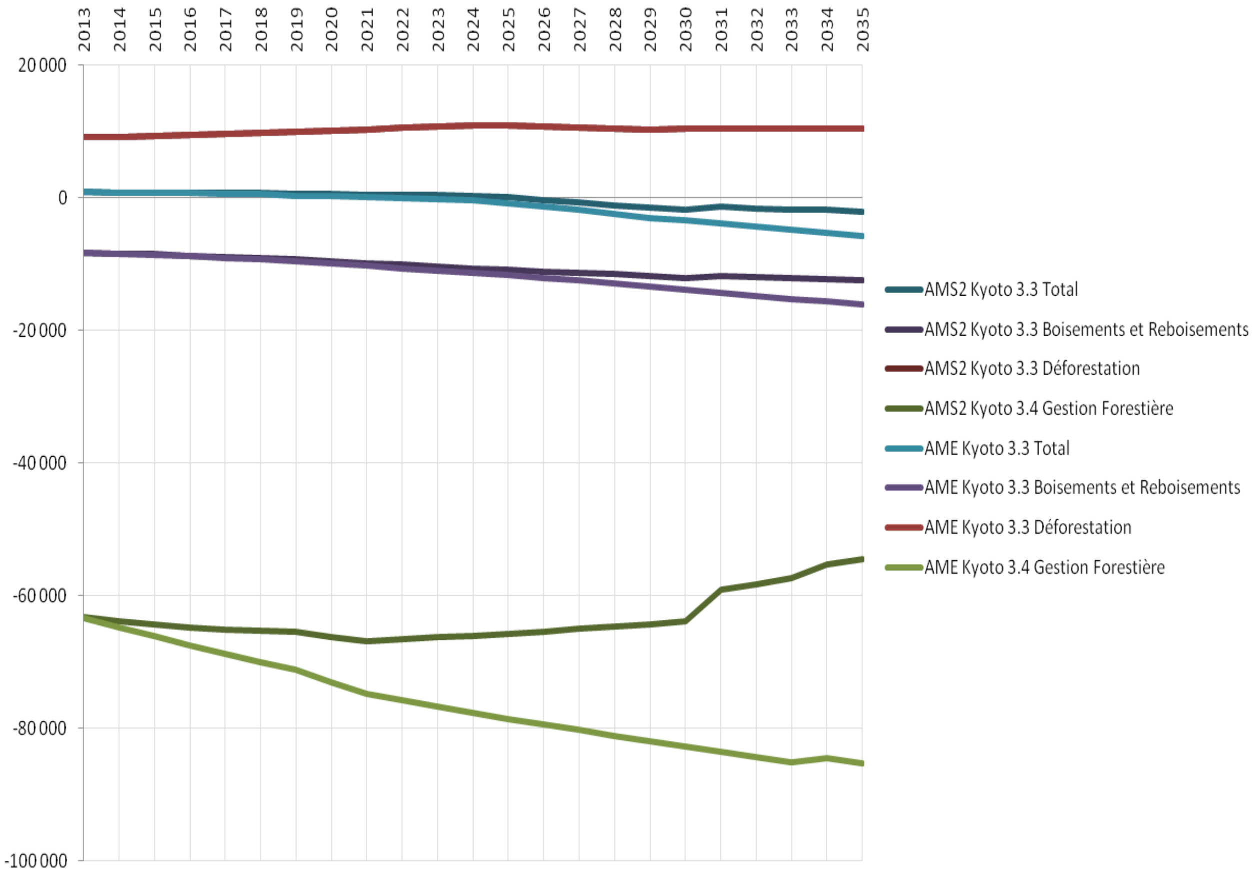



Figure 7.3: Evolution of projected GHG emissions / absorption for activities in the LULUCF sector (Kyoto format, Prospective scenarios for 2035 - Citepa) version 1

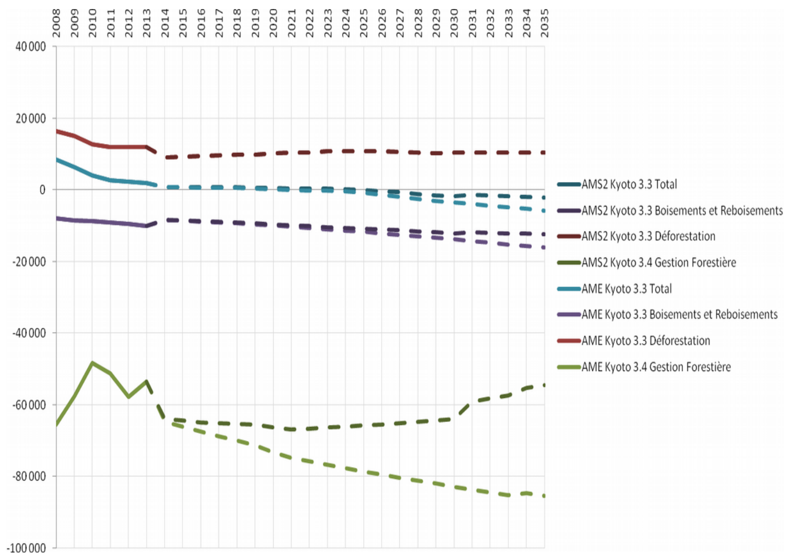


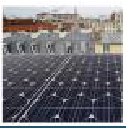
Figure 7.4: Evolution of projected GHG emissions / absorption for activities in the LULUCF sector (Kyoto format, Prospective scenarios for 2035 - Citepa) version 2 (unbroken lines: 2013 inventory v2015, Kyoto format; dotted lines: projection)

3.2 UNFCCC format

AME UNFCCC									
	Forest Land	Cropland	Grassland	Wetlands	Settle-ments	Other lands	HWP[77]	Other	Total
2014	-72,429.90	19,675.01	-10,479.58	-2,588.82	11,207.73	0.00	-1,598.39	0.00	-56,213.95
2015	-73,902.78	19,673.39	-10,245.45	-2,588.82	11,329.88	0.00	-1,673.22	0.00	-57,407.00
2016	-75,547.34	19,633.70	-10,043.30	-2,588.82	11,458.17	0.00	-1,699.80	0.00	-58,787.39
2017	-77,057.35	19,675.45	-9,913.16	-2,588.82	11,556.54	0.00	-1,739.74	0.00	-60,067.07
2018	-78,525.83	19,703.18	-9,804.03	-2,588.82	11,715.33	0.00	-1,775.94	0.00	-61,276.11
2019	-80,018.87	20,013.15	-9,857.47	-2,588.82	11,729.68	0.00	-1,798.32	0.00	-62,520.65
2020	**-82,305.14**	**20,238.50**	**-9,979.60**	**-2,588.82**	**11,967.88**	**0.00**	**-1,809.36**	**0.00**	**-64,476.54**
2021	-84,368.13	20,874.92	-9,956.36	-2,588.82	12,120.38	0.00	-1,819.19	0.00	-65,737.21
2022	-85,634.23	21,397.24	-9,989.16	-2,588.82	12,288.36	0.00	-1,824.60	0.00	-66,351.21
2023	-86,932.07	22,078.37	-9,967.62	-2,588.82	12,326.97	0.00	-1,829.61	0.00	-66,912.78
2024	-88,254.09	22,572.49	-9,861.42	-2,588.82	12,312.98	0.00	-1,830.61	0.00	-67,649.46
2025	-89,472.60	22,934.19	-9,665.58	-2,588.82	12,254.97	0.00	-1,831.12	0.00	-68,368.96
2026	-90,757.68	22,960.87	-9,422.83	-2,588.82	12,173.18	0.00	-1,834.90	0.00	-69,470.17
2027	-91,981.24	22,592.56	-9,154.32	-2,588.82	12,082.98	0.00	-1,827.35	0.00	-70,876.19
2028	-93,227.80	21,903.68	-9,154.00	-2,588.82	11,983.27	0.00	-1,828.31	0.00	-72,911.97
2029	-94,569.57	21,808.60	-9,222.51	-2,588.82	12,006.71	0.00	-1,815.65	0.00	-74,381.25
2030	-95,860.53	21,825.27	-9,363.03	-2,588.82	12,157.62	0.00	-1,805.53	0.00	-75,635.02
2031	-97,130.77	21,617.40	-9,368.56	-2,588.82	12,288.00	0.00	-1,790.66	0.00	-76,973.41
2032	-98,396.76	21,270.59	-9,387.50	-2,588.82	12,418.69	0.00	-1,773.38	0.00	-78,457.18
2033	-99,655.89	21,112.83	-9,376.42	-2,588.82	12,549.67	0.00	-1,753.88	0.00	-79,712.50
2034	-99,395.98	21,315.27	-9,386.79	-2,588.82	12,549.67	0.00	-1,732.52	0.00	-79,239.17
2035	-100,645.75	21,516.98	-9,397.40	-2,588.82	12,549.67	0.00	-1,709.65	0.00	-80,274.97

Table 7.5: Balance of projected GHG emissions and absorption for the LULUCF sector in the UNFCCC format according to the different types of land recorded (Prospective scenarios for 2035 CITEPA - AME)

[77] Harvested Wood Product





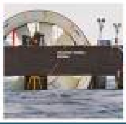


AMS2_run2 UNFCCC									
	Forest Land	Cropland	Grassland	Wetlands	Settle-ments	Other lands	Harvested Wood Products	Other	Total
2014	-71,518.51	18,646.50	-10,489.77	-2,588.82	11,129.54	0.00	-1,699.40	0.00	-56.520.46
2015	-72,138.30	18,067.34	-10,264.74	-2,588.82	11,173.49	0.00	-1,866.52	0.00	-57,617.55
2016	-72,824.33	17,788.48	-10,365.88	-2,588.82	11,204.82	0.00	-1,993.39	0.00	-58,779.12
2017	-73,303.51	17,585.78	-10,539.22	-2,588.82	11,187.47	0.00	-2,134.46	0.00	-59,792.75
2018	-73,688.29	17,363.68	-10,733.86	-2,588.82	11,211.76	0.00	-2,267.15	0.00	-60,702.68
2019	-74,040.27	17,418.03	-11,091.13	-2,588.82	11,072.85	0.00	-2,382.24	0.00	-61,611.58
2020	**-75,127.41**	**17,383.50**	**-11,517.55**	**-2,588.82**	**11,139.02**	**0.00**	**-2,484.70**	**0.00**	**-63,195.95**
2021	-75,954.27	17,802.94	-11,798.33	-2,588.82	11,091.35	0.00	-2,585.62	0.00	-64,032.75
2022	-75,940.30	18,101.15	-12,135.43	-2,588.82	11,030.99	0.00	-2,682.26	0.00	-64,214.66
2023	-75,930.57	18,548.77	-12,418.23	-2,588.82	10,813.12	0.00	-2,778.34	0.00	-64,354.06
2024	-75,913.25	18,801.62	-12,616.35	-2,588.82	10,514.50	0.00	-2,869.79	0.00	-64,672.09
2025	-75,777.43	18,913.23	-12,724.72	-2,588.82	10,143.72	0.00	-2,959.93	0.00	-64,993.95
2026	-75,711.26	18,735.43	-12,786.37	-2,588.82	9,736.64	0.00	-3,052.80	0.00	-65,667.18
2027	-75,547.69	18,163.31	-12,823.34	-2,588.82	9,308.64	0.00	-3,131.81	0.00	-66,619.71
2028	-75,438.42	17,269.80	-13,129.23	-2,588.82	8,858.62	0.00	-3,219.34	0.00	-68,247.39
2029	-75,391.34	16,961.58	-13,504.00	-2,588.82	8,519.24	0.00	-3,289.25	0.00	-69,292.60
2030	-75,316.11	16,763.99	-13,951.41	-2,588.82	8,294.81	0.00	-3,360.41	0.00	-70,157.94
2031	-70,133.85	16,370.89	-14,263.98	-2,588.82	8,046.74	0.00	-3,285.57	0.00	-65,854.60
2032	-69,448.84	16,070.19	-14,551.82	-2,588.82	7,795.83	0.00	-3,337.24	0.00	-66,060.70
2033	-68,739.61	15,873.14	-14,822.63	-2,588.82	7,542.10	0.00	-3,385.24	0.00	-66,121.06
2034	-66,701.27	16,427.22	-15,103.42	-2,588.82	7,232.45	0.00	-3,405.21	0.00	-64,139.05
2035	-66,134.90	16,981.17	-15,383.85	-2,588.82	6,919.67	0.00	-3,431.88	0.00	-63,638.61

Table 7.6: Balance of projected GHG emissions and absorption for the LULUCF sector in the UNFCCC format according to the different types of land recorded (Prospective scenarios 2035 CITEPA – AMS2_run2)





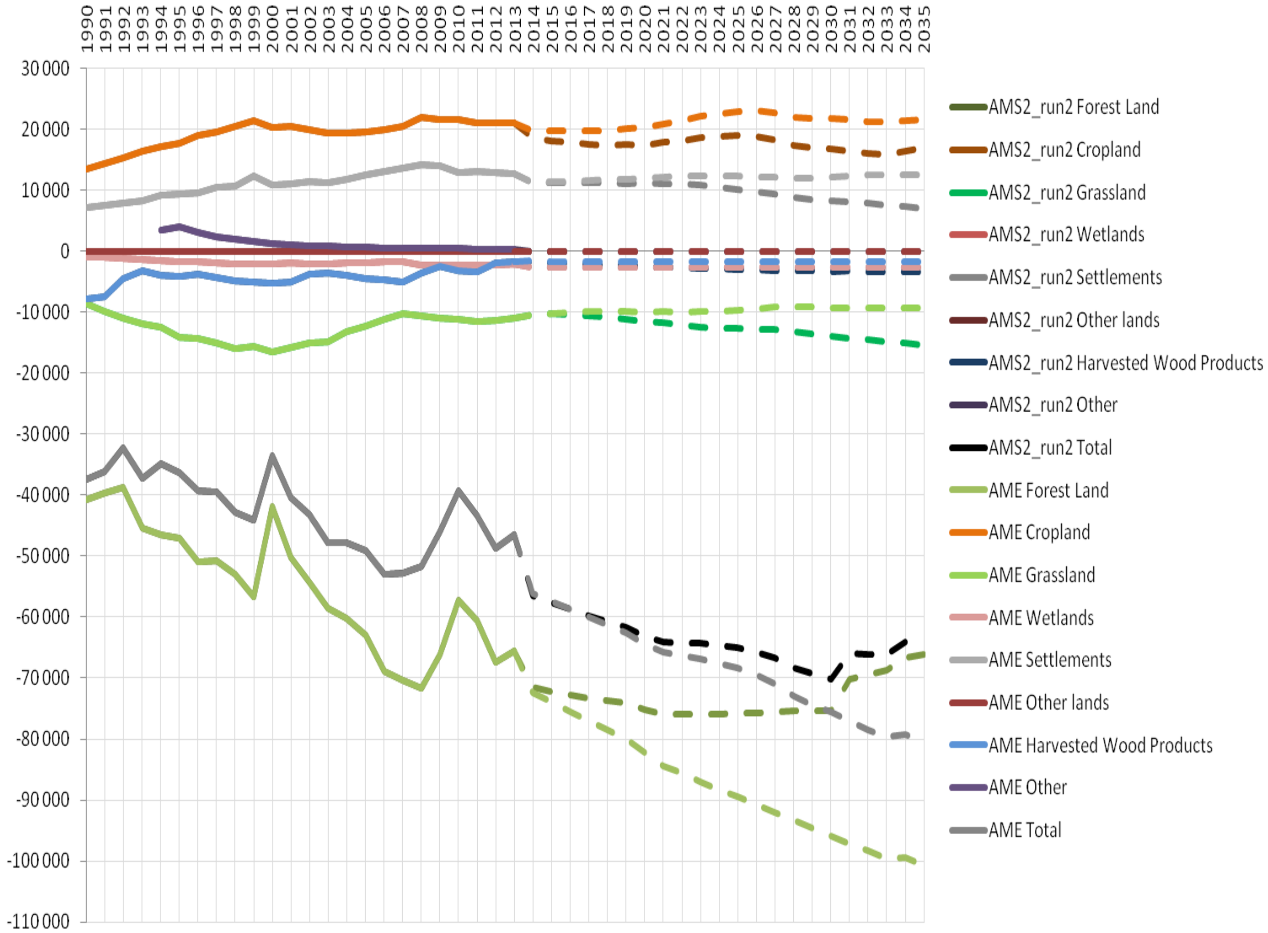
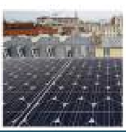
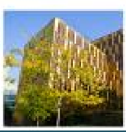



Figure 7.5: Evolution of projected GHG emissions / absorption for activities in the LULUCF sector (UNFCCC format, Prospective scenarios 2035 - Citepa) version 2 (continuous lines: 2013 inventory v2015, Kyoto format; dotted lines: projections)







4. Analysis of the potential for emissions limitation or reduction, and maintaining and reinforcing absorption and adequate measures.

4.I. Agricultural land

The existing scientific literature highlights numerous techniques for boosting carbon capture in soils and biomass:

- optimising grassland management to encourage carbon capture (maintaining permanent grassland and improving the productivity of the least productive land)
- slowing down the artificialisation of land
- developing agro-forestry systems (tree planting in forest parcels, hedgerows and tree cover on the boundaries of agricultural plots);
- promoting agro-ecological production systems based on: soil coverage (catch crops; intercropping and grass patches), simplified tilling, longer rotation periods.
- continuing efforts to promote the value of grass and grazing
- developing the production of materials and energy from bio-based resources, replacing energies and materials which generate substantial amounts of greenhouse gases.

Scheduling implementation of the AMS2 measures, with an enhanced agro-ecology programme founded upon a number of action priorities for 2035:

- protecting permanent grassland;
  - Guideline target: restricting the reduction in permanent grassland to 490,000 ha between 2010 and 2035
- developing agro-forestry, hedgerows and other agro-ecological infrastructure;
  - Guideline targets: 700,000 ha of hedgerows and 120,000 ha of closely-managed agro-forestry by 2035
- soil coverage and increasing the proportion of organic matter in our soils;
  - Guideline target: Catch crops (CIPAN nitrate traps) accounting for 80% of spring crops by 2035
- slowing down the artificialisation of land;

The cumulative effects of a territorially-coherent effort to implement these actions and halt the artificialisation of land (as per the model used to create the AMS2 scenario) will allow us to invert the trend for CO_2 emissions from agricultural land, slashing these emissions from 9.9 to 3.6 $MtCO_2$ between 2013 and 2035 (UNFCCC measurements)

Last but not least, the production of extra biomass will create substitution effects for materials and energy.

4.2. Forests-wood

The French wood and forestry sector can make a major contribution to reducing GHG emissions, capturing carbon and respecting our international commitments, with a number of key priorities:

1) using wood instead of energy-intensive materials such as aluminium, steel, cement and petrochemical plastics;
2) using forestry biomass and the by-products of the timber industry for energy purposes, as well as wood products reaching the end of their life cycle, replacing fossil fuels;
3) carbon storage in wood and wood-based products;
4) carbon capture by the forestry ecosystem thanks to photosynthesis (soils, forest litter, biomass above and below ground).

It is important to adopt the broadest possible approach to the mitigation potential offered by this sector, including **all GHG sources** over the long term.

The CGAAER report of October 2014 on the contribution of agriculture and forestry to the fight against climate change insists upon the importance of these 4 action priorities, and particularly the 2 substitution measures.

The effects of carbon capture also need to be taken into account - in biomass, above ground and below ground, as well as the substantial quantities captured in the soil. We must also remain attuned to the potential risks of carbon release. France's forests currently act as a major "carbon sink," especially since the volume of standing timber is growing rapidly (wood felling corresponds to just half of annual biological growth less natural mortality, and the existing forestry stock is relatively young on account of planting campaigns by the National Forestry Fund (FFN). Forests also continue to expand and occupy former farmland).

But for a truly long-term approach, substitution effects (energy and materials) also need to be further developed. The corresponding reduction in emissions will be crucial in the medium and long term, facilitating the transition to a low-carbon (and bio-based) economy. The volume of carbon stored in biomass and the soil cannot continue to grow indefinitely (indeed it is already stabilising in a number of EU nations); furthermore, increasing these carbon stocks also increases the risk of subsequent release, particularly as climate change may have a significant destabilising effect on ecosystems (insect attacks, trees blown down by storms, forest fires etc.). It is therefore crucial that we boost the potential for substitution effects.

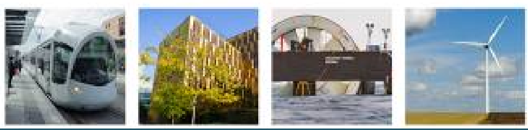
Moreover, in order to reduce the risk of carbon release from forestry ecosystems, we need to find a more dynamic way of managing forests which are currently under-managed or not managed at all. This is particularly important for medium-density coppice, land left wild after being abandoned by farmers, forestry areas in decline and other areas which are too densely planted. Where the potential of the ecosystem allows it, converting coppice to forest-standard coppice or even full timber forest will allow us to increase the proportion of quality timber produced, as well as increasing overall forest productivity and thus boosting the rate of GHG retention. The same goes for former agricultural land, which can be replanted with higher-yield species which are better equipped to resist climate change.

Substitution effects should be prioritised, primarily those offered by expanding the use of wood as a building material

i) this approach will allow us to make optimal use of wood resources - in terms of value added, jobs created and greenhouse gas emissions avoided (substitution effects from material uses are more significant than those made possible by energy uses);

ii) sales of quality timber will be the primary economic driver behind the development of forestry management;

iii) developing timber operations will require an increase in tree selection and thinning activities, separating the best quality timber from lower-quality wood which can be used in



other areas of the wood industry (panel boards, paste, wood fibre etc.) and for energy purposes; low-quality wood (branchwood) can also be harvested along with stems from timber-quality trees;

iv) timber processing will generate by-products which can be used for material or energy purposes; at the end of their life cycle, after reuse and/or recycling, wood products can also be used for energy generation (this is the "cascade" system of wood use, with a clear hierarchical chain).

The development of timber will thus act as a catalyst for the whole forestry-wood sector.

5. Policies and measures (in place and forthcoming) and their impact

5.1. Agricultural land

5.1.1. Policies and measures in place and scheduled for launch

The implementation of the agro-ecological plan and its sub-strategies will incorporate numerous actions to reduce greenhouse gas emissions and promote carbon capture in agricultural soils.

The 2014-2020 CAP reform paved the way for more effective consideration of climate change and greenhouse gas emissions, with both the 'greening' of the first pillar and the reinforcement of the second pillar. The regionalisation of the second pillar has also opened up more room for manoeuvre at territorial level, allowing us to tailor our actions to local requirements.

a) National application of the CAP

- The conditional aspects of the CAP and the implementation of good agricultural and environmental conditions (GAEC) apply to all of the direct support available to rural development:
  - GAEC I buffer strips
  - GAEC IV minimum soil cover
  - GAEC VI ban on burning arable stubbles
  - GAEC VII retention of landscape features (hedgerows etc.)

- Greening the CAP
  - maintaining permanent grassland;
  - diversification of crop rotation;
  - protected ecological areas.

- Rural development:
  - Agri-environmental and climate measures (AECMs)
    - AECM Systems: AECM maintenance of extensive grasslands and grazing / limiting intensification and returning organic material to the soil; AECM maintaining and changing practices in mixed farming systems / limiting inputs; AECM changing practices in large arable farming / improving the carbon capture capacity of soils.
  - Agro-forestry measures;
  - A plan to boost competitiveness and help farms to adapt by investing in new equipment, for example simplified crop cultivation techniques.

b) National strategies implemented within the framework of the agro-ecological project

The national strategies described above are based primarily on the European funding provided under the 1st and 2nd pillars of the CAP.

- The agro-ecological project (diversifying crop rotation, agro-forestry, soil tillage, reducing mineral fertilisers etc.)

- The Organic Ambition programme, supporting organic agriculture (limiting direct impact of LULUCF, reducing total emissions from the agricultural sector)

- The plant protein plan, developing the cultivation of protein-rich plants (limiting direct impact of LULUCF, reducing total emissions from the agricultural sector)

c) Other regulations and legislation

- Measures to halt the artificialisation of land (ALUR and LAAF acts): protecting agricultural land and their carbon capture potential

- Agroforestry development plan

<u>5.1.2. Policies to be developed/reinforced</u>

These recent policies focus on the period up to 2020, and we will need to go much further in order to hit our targets for 2050 by pushing for stricter requirements (in negotiations on the future of the CAP, in order to avoid distorting competition at the European level), investing more in innovation, training and information, exploiting opportunities for synergy between public policies and encouraging experimentation by all stakeholders (government, local authorities, professional bodies, NGOs etc.).

We must promote technical innovation (in equipment and in terms of the precision of agricultural practices) as well as institutional and organisational innovation, with new instruments born of ground-level experiments and sharing of best practices.

Scientific research is expected to yield strategic breakthroughs, allowing us to develop economic tools which will:
- recognise and promote the environmental and social contributions of agriculture
- take the carbon content of agricultural produce into account (via life cycle analysis, in particular),
master the complex task of measuring emissions (in light of the numerous biological and cultural phenomena involved),
produce suitable inventories and monitoring systems.
Special attention should be devoted to preserving and increasing the carbon content of our soils, supporting the new initiative launched by the Minister for Agriculture ahead of the COP21 conference in December 2015: "4 for 1000: soils for food security and the climate." This initiative involves two major actions: an international programme of scientific research and cooperation, and a coalition of stakeholders committed to soil preservation.

A considerable amount of training and technical advice will be required to encourage the identification, optimisation, deployment and spread of innovative agricultural techniques and practices. Agricultural training must integrate these issues into its programmes from the outset, as must farmers when planning for their future.

Finally, reorganising the chains upstream and downstream of farms could help with cost abatement.

5.2 Forestry - Wood

The mitigation actions to be prioritised in the land and forestry sector, described in detail in Section 4 above, are as follows:
Action 1: using wood instead of energy-intensive materials such as aluminium, steel, cement and petrochemical plastics;
Action 2: using forestry biomass and the by-products of the timber industry for energy purposes, as

well as wood products reaching the end of their life cycle, replacing fossil fuels;
Action 3: carbon storage in the form of wood products;
Action 4: carbon capture by the forestry ecosystem thanks to photosynthesis (soils, forest litter, biomass above and below ground).

5.2.1. Policies and measures in place and scheduled for launch

The majority of the policies and measures implemented or scheduled for the wood and forestry sector will have combined effects on several of these actions.

- **Amended budget (LFR) for 2013:**
    - the extension and renovation of the fiscal incentive for forestry investment (DEFI), encouraging forestry owners to manage their resources sustainably, and to join forces in producers' organisations in order to receive more tax credits. Improving forestry management will yield multiple benefits, including reducing overcrowding in some forests, making forests more resistant to storm winds and making better use of wood.
    - the creation of the forestry investment and insurance account (CIFA), giving forestry owners an incentive to take out insurance against storm damage, start saving to fund preventive work and, where relevant, to clean up and replant damaged zones. The goal is to make forests more resistant to climate change, and thus capable of capturing more carbon;
    - the introduction of a new, higher rate of degressive amortization for production, sawing and processing equipment acquired or constructed by companies in the wood sector between 13th November 2013 and 31st December 2016. The aim of this measure is to develop transformation activities all over the country, encouraging wood as an alternative material and energy source, including its by-products and waste products.

- **Law on the Future of Agriculture, Food and Forestry (LAAAF), published 14th October 2014:**
    - recognition that CO_2 capture by forests and wood products is a matter of public interest;
    - creation of the Strategic Fund for Wood and Forests (FSFB) to provide financial backing for the forestry policy. This initiative covers all of the action priorities, in that the fund can be used to support all manner of actions relating to forestry resources and their multifunctional management;
    - creating Forestry Economic and Environmental Interest Groups (GIEEF) to promote the sustainable management of private forestry resources at the appropriate territorial level, bringing forestry owners together to develop wood operations;
    - the National Programme for Wood and Forestry (PNFB), broken down into regional forest and wood programmes; These programmes set out the broad lines of national forestry policy and its regional variations for the next 10 years; they cover all of the key mitigation action priorities.

- The **National Action Strategy for the Future of the Wood Industries (PNAA),** paired with the Strategic Contract for the Wood Sector (cf. infra) which aims to secure the future of companies involved in the business of transforming wood. This strategy sets out four strategic priorities:
    - redynamising the sector,
    - taking into account the need for more funding to develop competitiveness,
    - immediate, structurally-significant actions,
    - the rapid introduction of structural changes designed to make the sector more competitive,







- **The 'Wood Industries' strategy, one of the 34 plans included in the Nouvelle France Industrielle programme launched by the President in September 2014 and officially integrated in May 2015 by Economy Minister E. MACRON into the "Sustainable Cities" section of the FUTURE INDUSTRY strategy.** This plan aims to promote the use of wood in construction and for interior design purposes, including tall buildings;

- the new **Wood Construction Techniques Action Plan,** including measures to promote professional training, the rehabilitation of existing buildings (thermal insulation and expansion) and the use of hardwood timber in construction;
-
- the **National Plan for Bio-Based Construction Materials,** designed to support other forms of construction with bio-based materials (excluding timber);
-
- the **Heat Fund:** expanded, with more resources allocated to promoting the use of wood (€30M). In addition to this raft of tax credits aimed at the forestry sector, the heat fund offers financial incentives for biomass burners. This should also serve to bolster demand for wood, increase energy substitution effects and helping to galvanise the whole sector;
-
- The **National Climate Change Adaptation Plan (PNACC)**: although focused on adaptation, this plan includes measures with direct consequences for climate change mitigation, including measures in line with Action 3: "Promoting the adaptive capacities of forestry resources and preparing the wood industry for climate change" (measures 3.1, 3.2 & 3.3);

- **The Strategic Contract for the Wood Sector (CSF Bois) signed 16 December 2014,** which builds upon the measures included in the National Action Strategy for the future of the wood industries (PNAA) and aims to contribute to the industrial development of the wood sector. These measures should allow us to promote the use of wood for construction, establishing clear quality categories for French wood (particularly hardwood), removing regulatory obstacles to the use of wood and developing promotional strategies focusing on architecture and interior design.

- **The National Biomass Strategy and Regional Biomass Plans** will identify different potential sources of useful biomass, the corresponding volumes and, where relevant, the measures to be taken to ensure that these resources are used effectively. These plans will also include objectives for the development of biomass for energy purposes.

5.2.2. Policies to be developed/reinforced

5.2.2.1. intensifying felling in forests:

- speeding up development of forestry infrastructure (paths and cables);
- improving cooperation with local authorities and, above all, private forestry owners;
- supporting the creation of GIEEF Forestry Interest Groups;
- ensuring that firms in the forestry sector are well-equipped;
- boosting the incentive offered by these fiscal measures in favour of sustainable management, increase wood use and combined forestry management;
- supervising the sustainable development guarantee, ensuring that the applicable rules are respected.

5.2.2.2. increasing the productive capacity of forests and their role as "carbon pumps":

- improving forestry quality and promoting timber-quality wood, introducing more productive species and/or species better adapted to climate change and the local conditions,
- speeding up forestry renewal

5.2.2.3. speeding up the replacement of energy-intensive products with wood or wood-based products:

- increasing consumer awareness of the advantages of low-carbon products;
- supporting the increased use of wood-cellulose fibres in construction (new criteria in public contract documents, including these materials in the rules for calculating the energy consumption and substitution effects of buildings etc.), furnishing, packaging etc.

5.2.2.4. promoting carbon storage in wood products, and encouraging their reuse:

- promoting eco-design and the development of a circular economy;
- stepping up efforts to collect, sort and recycle low-carbon products;
- making it easier to recycle wood products, providing a boost to the circular economy.

5.2.2.5. accelerating the substitution of wood for fossil fuels by:

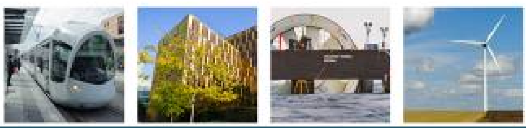
- creating 'Energy-Positive Territories for Green Growth', striking a balance between investment which consumes wood and the use of forestry resources, adapting the network of biomass burners to the wood resources available locally, adopting sustainable management practices;
- providing incentives for industrial operators to use high-efficiency wood burners to fuel their heat networks;
- updating regulations so that wood or wood-based products can be used for heating purposes when they reach the end of their life cycle

5.2.2.6. supporting and expanding intangible investment (studies, research).

- improving our understanding of the sector, its material flows, its economic consequences etc.;
- improving our understanding of GHG flows: continuing the work started by the ADEME "REACCTIF" scheme (BicaFF, GesFor, Evafora projects etc.);
- further research to understand the temporal dimension of GHG flows: major research projects are already under way at EU level (the UK Forestry Commission is a close partner) and in France (methodological work with the ADEME, review of the existing literature on carbon debt etc.);
- launching new research intended to reduce the level of uncertainty in our models and measurements.
- developing a forestry equivalent to the Clim'Agri local decision-making tool produced by the ADEME (providing an estimate of GHG emissions and sequestration, based on a certain number of variables). This will provide local authorities with a better idea of their GHG flows in the Agricultural and Forestry sectors, helping them to target policy initiatives more effectively.
- improving our understanding of the connection between agricultural and forestry management practices and the amount of carbon stored in the soil (cf. the '4 for 1000' project for agricultural land).

5.2.3. Monitoring indicators to put in place

No new indicators have been created specifically for the SNBC, existing indicators will be used.

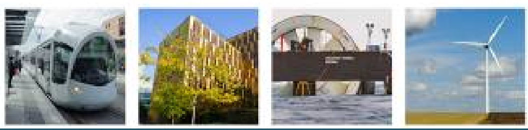


5.2.3.1. With regard to the "carbon pump" effect:

- Biological growth minus mortality (annual measurement; IGN volumes of solid timber and total volume, distinguishing between hardwood and resinous trees).
- Number of GIEEFs set up, and total surface area covered by these GIEEFs (annual measurement)

5.2.3.2. Monitoring the efficiency, from a climate perspective, of the way wood resources are used:

- Wood harvested (felling minus operational waste). Annual measurement in Mm^3; distinguishing between hardwood and resinous trees (Sources: EAB - annual branch surveys - conducted by the MAAF for wood brought to market, IGN for total harvested volume);
- Operational waste. Annual measurement, in Mm3 (Source: IGN)
- Volume of sawed lumber produced in France (annual measurement); distinguishing between hardwood and resinous trees (Source: EAB)
- Volume of wood used for energy purposes (annual measure) (sources: EAB for wood sold for energy; SOeS; ADEME)
- Volume of wood used by the construction/renovation sector (Source: DHUP)



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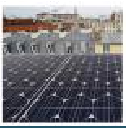





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