Directorate of Housing, Urban Development and Landscapes (*Direction de l'Habitat de l'urbanisme et des paysages*)

d

Transposition of Article 4 of Directive 2012/27/EU

Long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private

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1 Preamble

France's actions during its presidency of COP 21 led to the birth of a new awareness in the global mobilisation for the fight against climate change.

The French presidency was an opportunity to advance an unprecedented environmental ambition to use the response to the challenge of climate change as a way to reduce inequality, protect the environment and even support innovation in relation to low-carbon development for the benefit of a planet that will be preserved for future generations.

The Paris Agreement, brought about by the committed support of France, marks an unprecedented ambition in support of the climate and drives forward a new environmental impetus in the fight against climate change. This Agreement, which entered into force less than one year after it was concluded, has today been ratified by 143 countries representing over 80% of global greenhouse gas emissions. It made the Habitat III conference, which was held in Quito in October 2016 and which set a new global urban agenda for the next 20 years, yet more pressing.

France, with its environmental ambitions and desire to be exemplary, paved the way for the application of the Paris Agreement by adopting the Energy Transition for Green Growth Law of 17 August 2015, which affirms and realises the government's commitment to making France a low-carbon economy and society.

The building sector, which consumes the largest amount of energy and emits significant quantities of greenhouse gasses, is a priority for making energy savings. This scale is justification for offering incentives and support to households and professionals. This is why the Energy Transition for Green Growth Law provides the opportunity to develop energy and environmental excellence in the building sector, an area where innovation flourishes and sustainable and highly qualified jobs can be created in the regions. The law thus sets the goal of reducing greenhouse gas emissions by 40% between 1990 and 2030, and by three quarters between 1990 and 2050. It anticipates a 50% reduction in final energy consumption in 2050 in comparison with 2012.

The number of existing buildings far outweighs new constructions. Renovating them is therefore the major challenge the policy to reduce energy consumption and greenhouse gas emissions faces. In fact, out of 33.5 million dwellings, 27.8 million are primary residences, and a third of them consume the most energy, with an F or G energy performance analysis label, which represents energy consumption of above 330 kWh(primary energy)/m^2/year.

The Energy Transition for Green Growth Law therefore makes renovating buildings to improve energy efficiency a high national priority in order to involve the whole country in the energy transition by setting long-term and priority-based objectives:

- By 2025, all private residential buildings whose primary energy consumption is above 330 kilowatt hours of primary energy per square metre per year must be renovated to improve energy efficiency;
- From 2017, 500,000 homes must be renovated to improve energy efficiency each year, at least half of which must be occupied by low-income households;
- By 2050, France must have building stocks that have been entirely renovated in line with the 'low-consumption building' standards or equivalent.

In order to speed up and greatly extend the implementation of these large-scale renovation works, the Energy Transition for Green Growth Law provides legal and financial means to take action and support to jointly stimulate supply and demand aimed at households and local authorities, companies and building professionals.

These drivers include:

- The obligation to perform energy efficiency works when deep renovations are carried out;
- Rolling out the individualisation of heating costs;
- The obligation to take steps to reduce energy consumption in the tertiary sector and strengthen the objectives every 10 years to achieve a 60% reduction in energy consumption by 2050;
- The integration of energy efficiency into the decency criteria for rental accommodation;
- A ban on selling energy intensive social housing without renovations being carried out.

To support these measures, the Energy Transition for Green Growth Law provides for new types of support:

- The creation of a new energy-saving obligation for households in fuel poverty: fuel poverty energy savings certificates;
- Support for low-income households in paying their energy bills with the creation of the 'energy check';
- The operational implementation of third-party financing activities;
- The creation of an energy renovation guarantee fund to facilitate the financing of renovation works by guaranteeing dedicated loans;
- The creation of the 'Positive-Energy Regions for Green Growth' certification enabling volunteer regions to receive financial support from an energy transition financing fund that has mobilised EUR 750 million over three years;
- The creation of the Public Department for the Energy Efficiency of Housing (*service public de la performance énergétique de l'habitat*), organised by the regional platforms for energy renovation to support households during their renovation works.

Going forward, France is therefore on the right track in terms of factor 4 and the 2050 deadline. The Energy Transition for Green Growth Law includes all the operational measures that currently need to be implemented without delay to speed up the changes to lay the best conditions to combat fuel poverty, reduce energy bills and develop the green economy.

The European Union is a leading stakeholder in climate action. Energy efficiency is central to the European Union's energy policy.

In 2016, the Commission's evaluation indicated that the European Union was well placed to achieve its 2020 strategy, under the terms of which Member States must reduce their greenhouse gas emissions by 20% by 2020 in comparison with 1990 levels. Nevertheless, efforts must be stepped up to meet commitments, and Member States are encouraged to prioritise the renovation of existing buildings.

On 30 November 2016, the European Commission presented a package of measures for the Energy Union ("Clean Energy for All Europeans") lasting until 2030.

The 2030 climate and energy framework sets three main objectives for 2030:

- To reduce greenhouse gas emissions by at least 40% (compared to 1990 levels);
- To increase the share of renewable energy to at least 27%;
- To improve energy efficiency by at least 27%, on the agreement that this objective will be re-examined by 2020, with the aim of reaching 30%.

The basis for the announcement of the long-term national strategy for mobilising investment in the renovation of residential and commercial buildings, both public and private, in order to improve the energy performance of the housing stock is found in article 4 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012. It forms part of a process to evaluate and compare the mobilisation procedures implemented by Member States. It was created to ensure that, beyond the announcement of the objectives, stakeholders do not lack the actual means for mobilising investment and dynamism. This is why it dedicates a large section to the means put in place, and in particular to the tools for mobilisation on the ground. To enable comparisons between Member States and real-time monitoring, it includes the plan introduced in the article of the Directive.

To meet the long-term renovation cap set at 2050, it will be necessary to carry out these works, which will then lead to a report being drawn up at the French Parliament, pursuant to article 4 of the Energy Transition for Green Growth Law.

Pursuant to article 4 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012, this report constitutes an update to France's strategy, submitted in April 2014 to mobilise investment in renovation of the national building stock in order to seize growth and employment opportunities in all sectors connected with construction. This report, a brief summary of which is presented below, includes a reminder of the inventory of the residential and tertiary stock, then an evaluation of the most opportune options to speed up a set of guidelines and mobilise drivers to instil in public and private stakeholders a low-carbon ambition for the 2050 deadline in the building field followed thirdly by a large section dedicated to the policies and means put in place.

A general presentation of the national building stock will highlight, out of the 33.5 million dwellings in France, the significant share of owner-occupants and also individual homes, as well as the impact of rental stock comprising mainly apartment blocks and a share of social housing of around 40%. An analysis of the large periods of construction, compared with identification of the housing that consumes the most energy, confirms that housing constructed before 1974 should be a priority for renovations. As for the tertiary sector, here too renovation work is also targeted at buildings dating from before 1975.

The cases studied have enabled cost-effective approaches to renovation to be identified by proving that clusters of works are indeed the most viable renovations in terms of the overall cost. The cost of investment is indeed much higher in the case of deep renovations, but these scenarios are the most cost-efficient for the lifespan of the buildings. Installing very efficient equipment and insulating walls properly markedly reduces energy bills, and therefore makes long-term savings despite a high cost of investment. These clusters see works carried out both on the energy systems (heating, domestic hot water, ventilation and lighting) and on the construction itself (walls and roof). For housing, the works were selected in line with the most common choices made by households (source: the OPEN survey, 2015 campaign). The sample group of buildings studied show that clusters of works are effective at significantly reducing energy consumption. However, in some cases we found it difficult to reach very high efficiency levels at a managed cost depending on the types of construction and the current state of the technical solutions and incentives on offer. Achieving France's strategic objectives will therefore rely on mobilising innovation to find efficient and affordable solutions quickly.

The main part of the report deals with the policies, measures and direction adopted to give individuals, industry, all construction professionals and financial institutions the clear understanding they need to make investment decisions that are often medium- or long-term in scope. The Energy Transition for Green Growth Law has innovated or strengthened certain structuring measures that will act as a policy framework:

- strengthening the regulatory component by revising the thermal regulation for buildings that sets the averages that enable more and more efficient buildings to be achieved on a stage-by-stage basis. The extended ban on selling energy-intensive social housing should be noted, as should the framework obligation to carry out energy renovations on residential stock, when significant works are planned, or on the tertiary stock with a strengthening of energy saving requirements by 2050.

- promoting the financial drivers, with firstly a simplification and streamlining of state aid that provides an incentive to carry out renovation, and secondly a strengthening of state actions to drastically reduce fuel poverty. In addition, the emphasis should be placed on mobilising regional intelligence and the network of economic stakeholders to create the competition and synergies required to develop new types of financing for energy renovations, mobilising in particular private financing.

- increasing and modernising the professional offering will be one of the key solutions for success and should promote the creation of all-encompassing offers that include multiple works within regions, in support of a mindset that sees services focus on comfort and wellbeing in the dwelling. On this point, it is important to favour the creation of local, physical or dematerialised platforms that connect the different parties (companies, financing, legal, real estate, etc.) to bring about dynamic progress on the initiative of the regions and support a new section of the local economy. Developing a veritable public energy efficiency service throughout the whole country will be a pledge of support for households and create consistency among the different regional approaches.

Finally, it is important to remember that success will come from the momentum of local initiatives to create innovation, raise awareness and consolidate the network of stakeholders who are collectively involved in making energy renovation part of a regional approach. To do so, the focus will be on capitalising on and developing best practices in their diversity and richness.

In order to estimate the expected energy savings, the report finally recounts that the national low-carbon strategy established by the Energy Transition for Green Growth Law requires the building sector to reduce CO_2 emissions by 54% by the third carbon budget (2024–2028) and at least 87% by 2050. In 2013, direct emissions from the residential and non-residential sector accounted for 20% of greenhouse gas emissions (almost one quarter if indirect emissions linked to producing electricity and heat for the buildings are taken into account). Projections show that energy renovations on buildings, taking into account a new regulation, improvements to heating systems and energy substitutions will significantly improve the energy efficiency of the building stock by 2035.

This strategy sets a cap, a direction and an unprecedented policy framework.

It demonstrates France's commitment to a bolstered ambition for the building sector, which is a force for innovation and highly qualified jobs.

It embodies France's responsibility to make the energy transition a reality following the success of the Paris Agreement.

2 Presentation of the national building stock

This section provides an analysis of the residential and tertiary building stock. For the residential sector, statistics are used for five main construction periods. These statistics enable separate estimates to be made for one-dwelling homes and apartment blocks of:

- the share of main residences and the nature of their occupants (owner or tenant)
- the most common energy systems
- the energy performance recorded (energy performance analysis labels and level of consumption).

For the tertiary sector, a detailed analysis provides:

- details on the broad categories of buildings (schools, offices, etc.)
- estimated energy performance and renovation requirements
- a presentation of the databases used to produce these statistics is provided in annex.

2.1 Detailed analysis of the national building stock for residential use

In 2013, the French building stock included around 33.5 million homes[1], 27.8 million of which were main residences. The data presented below come from two main sources:

- The PHEBUS survey (Performance Survey of Housing, Needs and Usages, see annex) carried out by the Observation, Studies and Statistics Department of the Ministry of the Environment on a representative statistical sample of the state of the stock of main residences in 2013. This database, qualified thanks to the data from the National Housing Survey (French National Institute of Statistics and Economic Studies, INSEE), enables us to obtain precise information on the characteristics of residential stock up to 2013;
- the database of the Standardised Summaries of the Thermal Study (RSET, see annex) completes the PHEBUS data by providing precise information on new buildings built between 2013 and 2017.

[1] Source: National housing survey 2013, INSEE

2.1.1 *Classification of the national housing stock using their occupation status*

The housing stock (metropolitan France) is distributed as follows:

Number of homes (thousands)		**One-dwelling buildings** *Source PHEBUS*	**Share of stock of main residences (%)** *Source PHEBUS*	**Apartments** *Source PHEBUS*	**Share of stock of main residences (%)** *Source PHEBUS*	**Total stock** *Source PHEBUS*
Primary residences		15,553	*58.6%*	10,977	*41.4%*	26,531
Of whom	**Owner occupants**	12,334	*46.5%*	3,373	*12.7%*	15,707 *59%*
	Tenants in private stock	2,311	*8.7%*	4,109	*15.5%*	6,420 *24%*
	Tenants in social stock	908	*3.4%*	3,496	*13.2%*	4,404 *17%*
Second residences, occasional housing or vacant housing		Source ENL 2013: 4,633		Source ENL 2013: 1,796		Source ENL 2013: 18.6%

Distribution of main residences by type of occupation- Source: PHEBUS 2013 survey

More than four homes out of five are main residences, 59% of which are occupied by their owners. In almost four fifths of cases (78.5%), these owner occupants live in a one-dwelling building. The remaining 41% of the stock of main residences is occupied by tenants, 40% of whom live in social stock. Rental stock, both private and public, is mainly made up of apartment blocks: on average more than three quarters of rented dwellings are apartments.

The following analysis concentrates on main residences.

2.1.2 *Classification of the national stock of main residences by construction period*

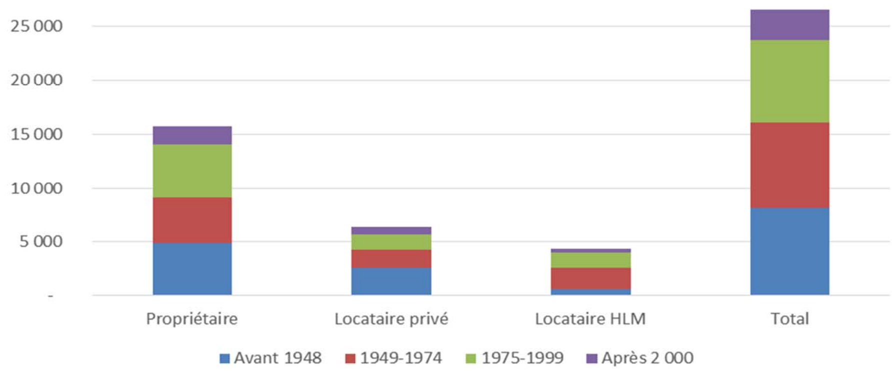
We have defined five broad periods of construction, with the first three each representing around 30% of main residences:

			Before 1948	**From 1949 to 1974**	**From 1975 to 2000**	**From 2001 to 2012**	**After 2013**	**Total**
Primary residences		Thousands	8,139	7,933	7,669	2,790	*not accounted for*	26,531
		%	*30.7%*	*29.9%*	*28.9%*	*10.5%*	-	*100%*
Of which	**Owner occupants**	Thousands	4,896	4,247	4,882	1,682	*not accounted for*	15,707
		%	*18.5%*	*16.0%*	*18.4%*	*6.3%*	-	*59.2%*
	Tenants in	Thousands	2,624	1,683	1,382	732	*not accounted for*	6,420

	private stock	%	*9.9%*	*6.3%*	*5.2%*	*2.8%*	-	*24.2%*
	Tenants in social stock	Thousands	620	2,003	1,405	376	*not accounted for*	4,404
		%	*2.3%*	*7.5%*	*5.3%*	*1.4%*	-	*16.6%*

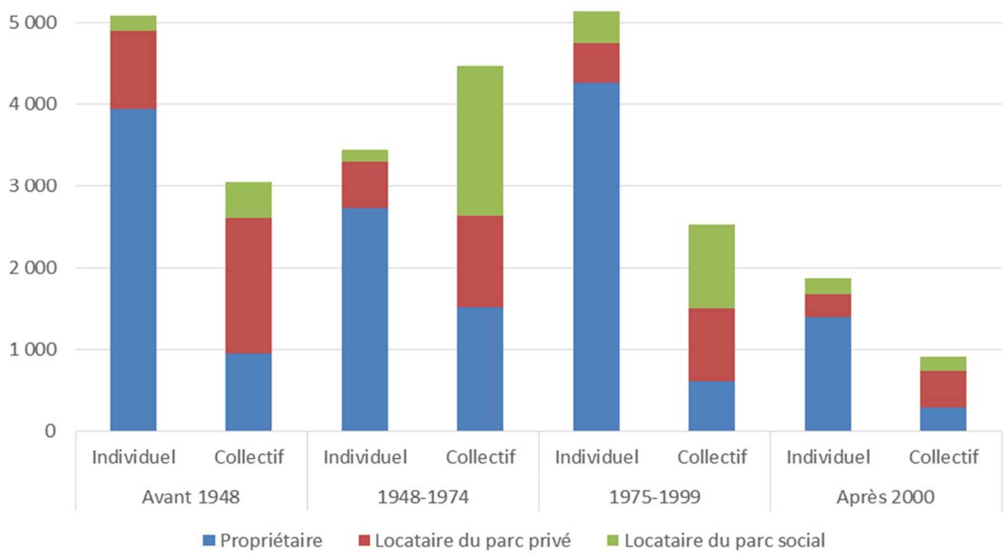
Distribution of main residences by construction period - Source: PHEBUS 2013 survey

**share of stock of main residences*



Distribution of main residences by occupation status following construction period (in thousands) - Source: PHEBUS 2013 survey

Propriétaire	Owner
Locataire privé	Private tenant
Locataire HLM	Social housing tenant
Total	Total
Avant	Before
Après	After



Distribution of main residences by construction period and type of housing (in thousands) - Source: PHEBUS 2013 survey

Individuel	One-dwelling building

Collectif	Apartment
Avant	Before
Après	After
Propriétaire	Owner
Locataire du parc privé	Tenant in private stock
Locataire du parc social	Tenant in social stock

Before 1948: housing built before 1948 makes up around 30% of main housing stock

These are homes built before the wave of reconstruction following the Second World War. They were built using local techniques and materials that can be energy efficient. In addition, old buildings in this category were often designed with climate conditions in mind, thus making them not energy intensive in comparison with the rest of the park. Finally, certain materials that were used, in particular on the facade or roof, are sometimes not well suited for the addition of insulation (issues with condensation, etc.) thus requiring special attention to be paid to the energy renovation techniques used on these old buildings.

Between 1949 and 1975: Housing constructed in this period makes up around 30% of the stock of main residences.

Almost half of social housing (45%) was built in this period, which is known as the *Trente Glorieuses* (the thirty years following the end of the Second World War). Conversely, private rental stock is older than the average for main residences in relative terms, with two thirds of housing built before 1975, and 40% before 1949. It was built using the first industrial techniques, before the first thermal regulation was put in place. The design of the buildings and the materials used in this period make this category of buildings one of the most energy intensive of the stock.

Between 1975 and 2000: Housing built between 1975 and 2000 makes up 29% of the stock of main residences.

From 1975 to 1989, housing was constructed following the first thermal regulation (RT) established after the first oil crisis. The aim of this first regulation was to reduce the heating consumption of housing by around 25% by insulating the outside walls and making use of a better understanding of air exchange.

Then from 1989 to 2000, two thermal regulations strengthened the requirements for reducing the energy consumption of buildings. These new regulations aimed to manage heating and domestic hot water requirements. They set an efficiency objective, leaving a choice between good insulation or more efficient heating and domestic hot water equipment.

The proportion of housing with a G label has reduced considerably (around 9% in place of 20–25% over the two previous periods). Two thirds of housing constructed in this period has a D or E label.

Between 2001 and 2012: Housing constructed in this period makes up around 10% of the stock of main residences.

The RT2000 regulation and then the new RT2005 thermal regulation were in force in this period. A building's overall energy consumption for heating, domestic hot water, cooling, backups and lighting in the case of a tertiary building must be lower than the building's reference consumption. The reference consumption corresponds to the consumption that the same building should have for the performance requirements as defined by the works and equipment that comprise it. On average, housing constructed in this period must consume less than 150 kWh(primary energy)/m^2/year.

As for the previous period, around two thirds of housing constructed in this period has a D or E energy performance analysis label. However, the amount of housing with an F or G label reduced significantly (around 5% of the stock).

From 1 January 2013:

The new thermal regulation (RT2012) entered into force for all new buildings. This regulation considerably increases the level of energy efficiency required from new buildings by imposing upon them primary energy consumption lower than an average threshold of 50 kWh(primary energy)/m^2/year. This requirement is based on a conventional calculation of the energy consumption of heating, cooling, lighting, domestic hot water production and backup (pumps and ventilators). This threshold is adjusted depending on geographical location, altitude, type of usage of the building, the average surface area of housing and greenhouse gas emissions. This new regulation put in place by France should therefore guarantee a future housing stock that consumes little energy and emits little greenhouse gas.

Towards a future environmental regulation:

In order to prepare the future environmental regulation for new construction in the best conditions, a national experiment has been launched to test ambitious performance levels on the energy and carbon aspects of real-life projects. The first stage of this process is to get stakeholders to construct more efficient buildings than current regulations provide for, then to get feedback on the experience. The experiment is based on a frame of reference and plans to make use of the details of the technical (energy and carbon) and economic (detailed costs) characteristics of the projects through a national observatory. It will also analyse these data to get the best picture of the future requirements of the next regulation. The E+C label was created to support this process and denote very specific performance levels.

2.1.3 *Classification of the national stock of main residences by energy and heating methods*

2.1.3.1 Comparison of the main types of energy used for heating by type of housing

	Apartments		**One-dwelling buildings**		**All main residences**	
	Number (thousands of dwellings)	*Share of apartments*	Number (thousands of dwellings)	*Share of one-dwelling buildings*	Number (thousands of dwellings)	*Share of main residences*
Gas	4,922	*42.4%*	4,855	*32.2%*	9,777	*36.6%*
Electricity (joule heating and heat pump)	3,934	*33.9%*	4,630	*30.7%*	8,564	*32.1%*
Heating oil	741	*6.4%*	3,104	*20.6%*	3,845	*14.4%*
Wood	58	*0.5%*	1,125	*7.5%*	1,183	*4.4%*
Coal	*in 'other types of energy'*	*0.0%*				
Thermal Network	1,235	*10.6%*	1,379	*9.1%*	3,340	*12.5%*
Other	727	*6.3%*				
TOTAL	**11,617**	***100.0%***	**15,093**	***100.0%***	**26,710**	***100.0%***

Distribution of main types of energy used for heating main residences - Source: PHEBUS 2013 survey

Gas (37% of housing) then electricity (32%) are the main forms of energy used for heating over the entire residential stock, and particularly so in apartment blocks, where three quarters of dwellings are heated using gas or electricity.

In one-dwelling buildings, fuel oil comes in third, with these three types of energy having an almost equal share of 80% of the market. Wood is almost only used in one-dwelling homes (there is no or little wood use in apartment blocks) and district heating is normally found in almost all apartments.

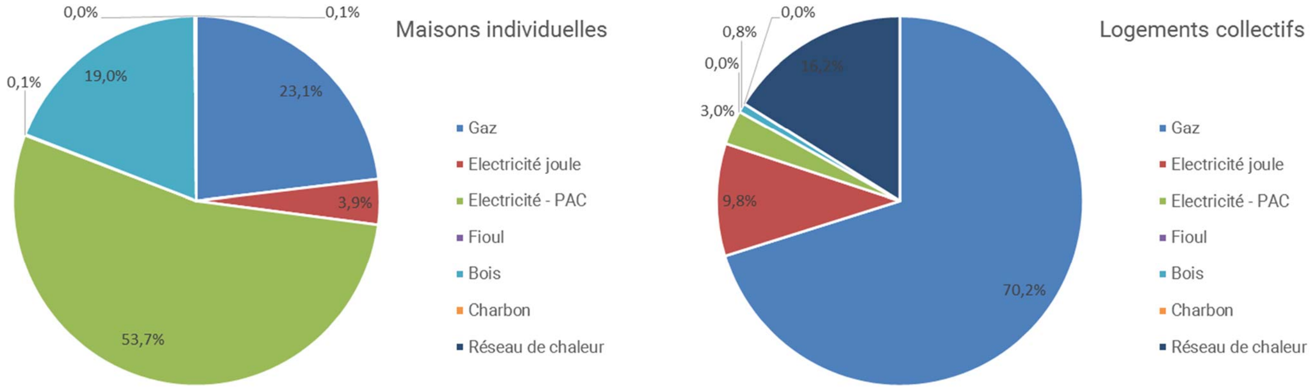
The type of housing (one-dwelling building or apartment) seems to determine the market share of the energy types used for heating, in particular because of the level of urbanisation affecting the presence of grid-bound energy. The availability of energy is of course one of the determining factors in these market shares: the lack of a gas network leads to other kinds of energy being used such as fuel oil and wood, the latter being easier to access in rural environments.

Perspectives for housing built in line with RT2012:

Using the RSET database, it is possible to evaluate the changes to the market share of the types of energy used for heating in new buildings in comparison with existing stock. In March 2016, this was composed of 39,767 single-dwelling buildings and 29,578 apartments.

The analysis carried out by the Scientific and Technical Building Centre (*Centre scientifique et technique du bâtiment*, CSTB)[2] in June 2016 of the Standardised Summaries of the Thermal Study database that was provided after completion of the construction work on new buildings subject to RT2012provides the changes to the market shares of the different types of energy used for heating:

[2] Analysis of the impact of the thermal regulations on energy solutions in single-dwelling buildings, CSTB study, June 2016



Distribution of the main types of energy used for heating in new housing built in line with RT2012 - Source: RSET database

Maisons individuelles	One-dwelling buildings
Gaz	Gases
Electricité joule	Electricity - joule heating
Electricité – PAC	Electricity - heat pump
Fioul	Fuel oil
Bois	Wood
Charbon	Coal
Réseau de chaleur	Thermal Network
Logements collectifs	Apartments

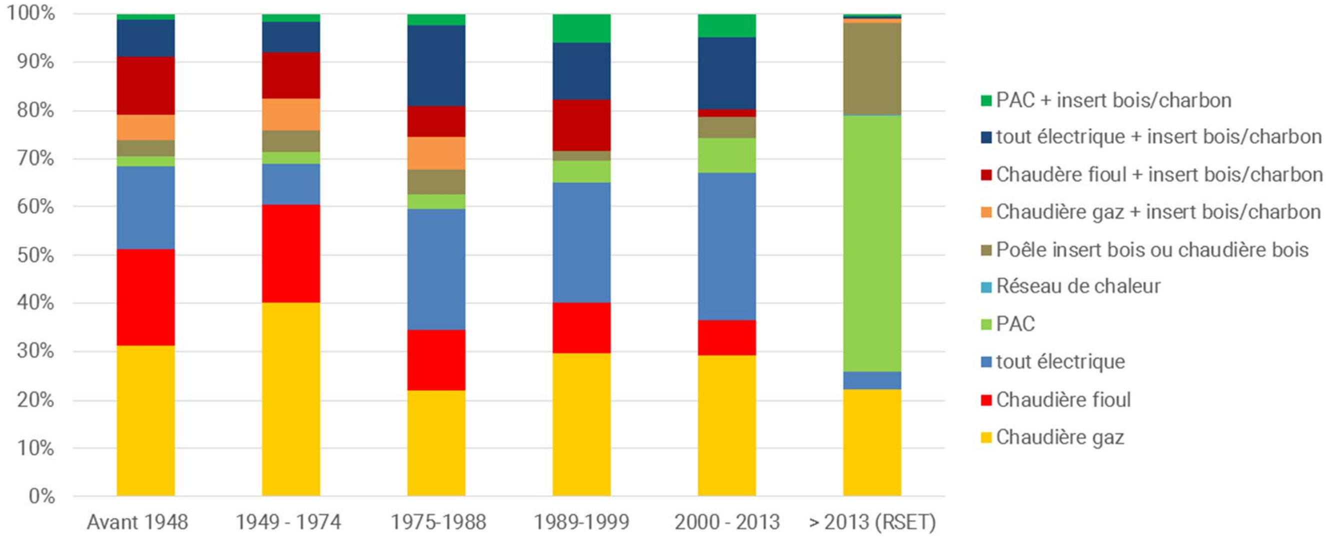
For one-dwelling buildings, analysis of the RSET database shows that gas has remained the main type of energy used for heating new buildings in a relatively stabile manner, but that there has been a big increase in the use of thermodynamic electricity (heat pumps) and wood/biomass.

As regards apartment blocks, the use of gas and district heating has increased significantly for new buildings: these two types of energy represent around 85% of newly constructed apartments.

2.1.3.2 Comparison of the main heating systems by year of construction, by type of housing

	Apartments		**One-dwelling buildings**		**All main residences**	
	Number (thousands of dwellings)	*Share of apartments*	Number (thousands of dwellings)	*Share of one-dwelling buildings*	Number (thousands of dwellings)	*Share of main residences*
Gas boiler	5,754	*51.2%*	4,855	*32.2%*	13,714	*52.1%*
Fuel oil boiler			3,104	*20.6%*		
All electricity (joules)	3,954	*35.2%*	3,850	*25.5%*	7,804	*29.6%*
Heat pump	155	*1.4%*	780	*5.2%*	935	*3.6%*
Wood boiler	76	*0.7%*	227	*1.5%*	1,201	*4.6%*
Wood-burning stove or wood/coal insert stove			898	*5.9%*		
Thermal Network	1,235	*11.0%*	1,379	*9.1%*	2,672	*10.1%*
Other	58	*0.5%*				
TOTAL	**11,231**	***100.0%***	**15,093**	***100.0%***	**26,325**	***100.0%***

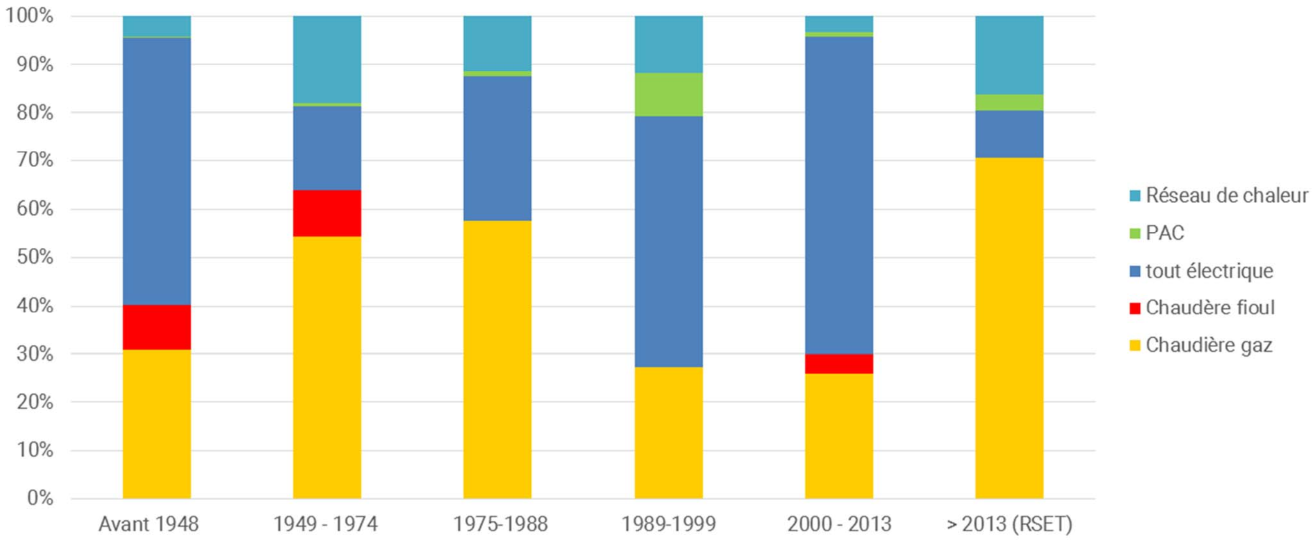
Distribution of main heating systems of main residences (system/energy pairs) - Source: PHEBUS 2013 survey



Distribution of main heating systems in one-dwelling buildings (main residences) - Source: PHEBUS survey 2013 and RSET database

Avant	Before
(RSET)	(RSET)
PAC + insert bois/charbon	Heat pump + wood/coal insert stove
tout électrique + insert bois/charbon	All electricity + wood/coal insert stove
Chaudière fioul + insert bois/charbon	Fuel oil boiler + wood/coal insert stove
Chaudière gaz + insert bois/charbon	Gas boiler + wood/coal insert stove
Poêle insert bois ou chaudière bois	Wood insert stove or wood boiler
Réseau de chaleur	Thermal Network
PAC	Heat pump
tout électrique	All electricity
Chaudière fioul	Fuel oil boiler
Chaudière gaz	Gas boiler

It should be noted that around 1.3 million one-dwelling buildings of the housing constructed before 2013 could not be classed in one of the categories above because the PHEBUS survey data do not provide sufficiently reliable information to identify the heating system.



Distribution of main heating systems in apartments (main residences) - Source: PHEBUS 2013 survey

Avant	Before
(RSET)	(RSET)
Réseau de chaleur	Thermal Network

PAC	Heat pump
tout électrique	All electricity
Chaudière fioul	Fuel oil boiler
Chaudière gaz	Gas boiler

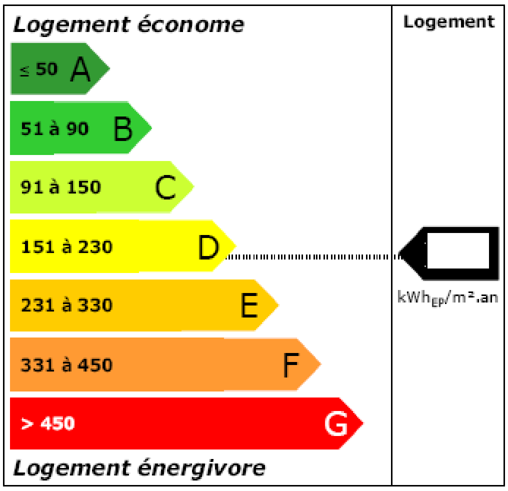
It should be noted that around 700,000 apartments of the housing constructed before 2013 could not be classed in one of the categories below because the PHEBUS survey data do not provide sufficiently reliable information to identify the heating system.

The age of the housing is another determining factor in the choice of heating system. For example, electricity is very commonly used in one-dwelling buildings built before 1948 as a replacement for the original systems (wood, fuel oil, etc.) as it is easy and less expensive to put in place than central heating. The period of mass construction after the Second World War, mostly of apartment blocks (construction of large complexes), saw a huge increase in central, shared (including district heating) and individual heating that used fossil fuels (gas and fuel oil), which were much more common than electricity. In housing built after 1975, there is a marked return to electricity, which was preferred to fossil fuels after the oil crisis of 1973 and then became the main type of energy.

2.1.4 *The theoretical energy performance (energy performance analysis 'energy' label) of the national stock of main residences*

2.1.4.1 Energy performance analysis

The energy performance analysis provides information on the energy efficiency of a dwelling or a building by evaluating its theoretical energy consumption and its impact in terms of greenhouse gas emissions on the basis of occupation scenarios established by convention. The energy performance analysis describes the house and its heating, domestic hot water, cooling and ventilation equipment.



Logement économe	Economical housing
Logement	Accommodation
51 à 90	51–90
91 à 150	91–150
151 à 230	151–230
231 à 330	231–330
331 à 450	331–450
Logement énergivore	Energy intensive housing
kWhEP/m_2.an	kWh(primary energy)/m^2/year

There are two methods for estimating the energy performance analysis label of a dwelling:

> **The 'conventional' method**: theoretical consumption is estimated using a description of the construction and the energy generation systems and a simplified thermal simulation is performed (energy performance analysis

3-CL method for example). This estimate is based on calculations of the consumption of four uses: heating, domestic hot water production, cooling and ventilation.

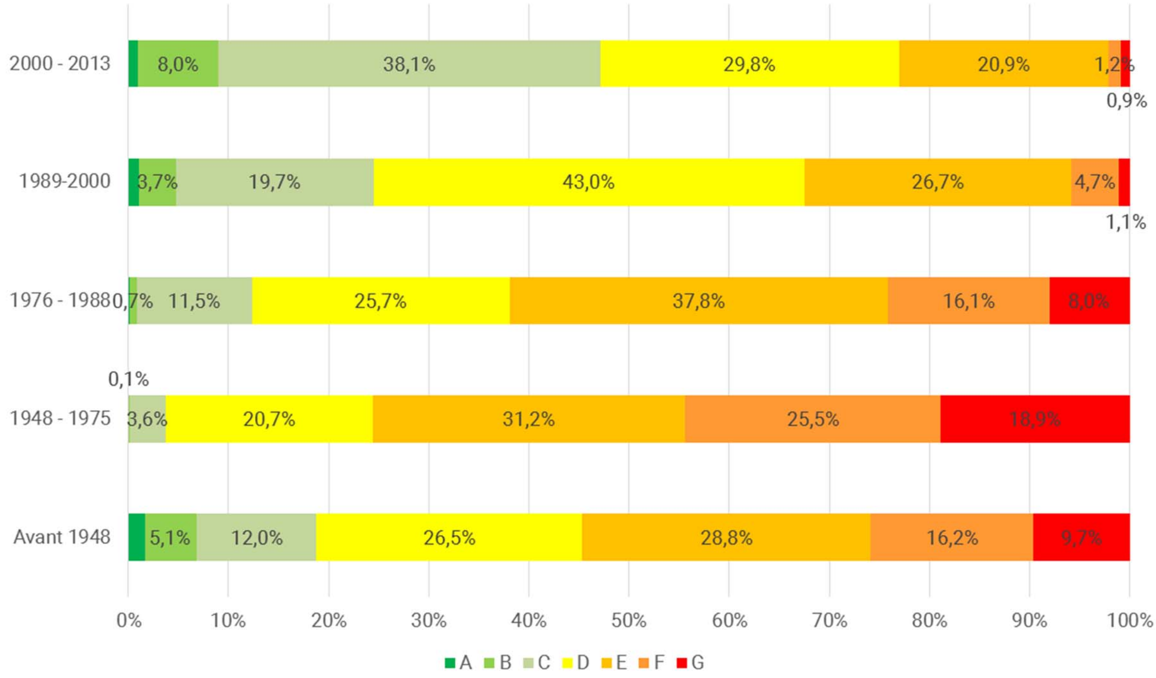
> **The bill method**, which consists of working out energy consumption from bills (for example, electricity or gas): this estimate is based on the consumption stated on the bill and therefore linked to the occupants' behaviours, in contrast to the conventional method which comes to a theoretical estimate. This method is used for housing constructed before 1948 and for apartments with collective heating that do not have individual energy metering systems.

In the following estimates, the PHEBIS survey provides the energy performance analysis label calculated using the 3-CL method for housing constructed after 1949. For housing constructed before 1948, the energy performance analysis label is deduced from energy bills, in accordance with the regulatory energy performance analysis.

	One-dwelling buildings		**Apartments**		**Entire stock of main residences**	
	In thousands of dwellings	*Share of the stock (%)*	*In thousands of dwellings*	*Share of the stock (%)*	*In thousands of dwellings*	*Share of the stock (%)*
A ≤50 kWh(primary energy)/m²/year	129	0.8%	145	1.3%	274	1.0%
B 51≤ ≤90 kWh(primary energy)/m²/year	506	3.3%	315	2.9%	821	3.1%
C 91≤ ≤150 kWh(primary energy)/m²/year	2,195	14.1%	1,541	14.3%	3,736	14.2%
D 151≤ ≤230 kWh(primary energy)/m²/year	4,268	27.5%	2,967	27.5%	7,235	27.5%
E 231≤ ≤330 kWh(primary energy)/m²/year	4,664	30.0%	2,918	27.1%	7,583	28.8%
F 331≤ ≤450 kWh(primary energy)/m²/year	2,334	15.0%	1,370	12.7%	3,705	14.1%
G 451 kWh(primary energy)/m²/year ≤	1,442	9.3%	1,517	14.1%	2,959	11.2%

Distribution of energy performance analysis labels by type of housing (main residences) - Source: PHEBUS 2013 survey

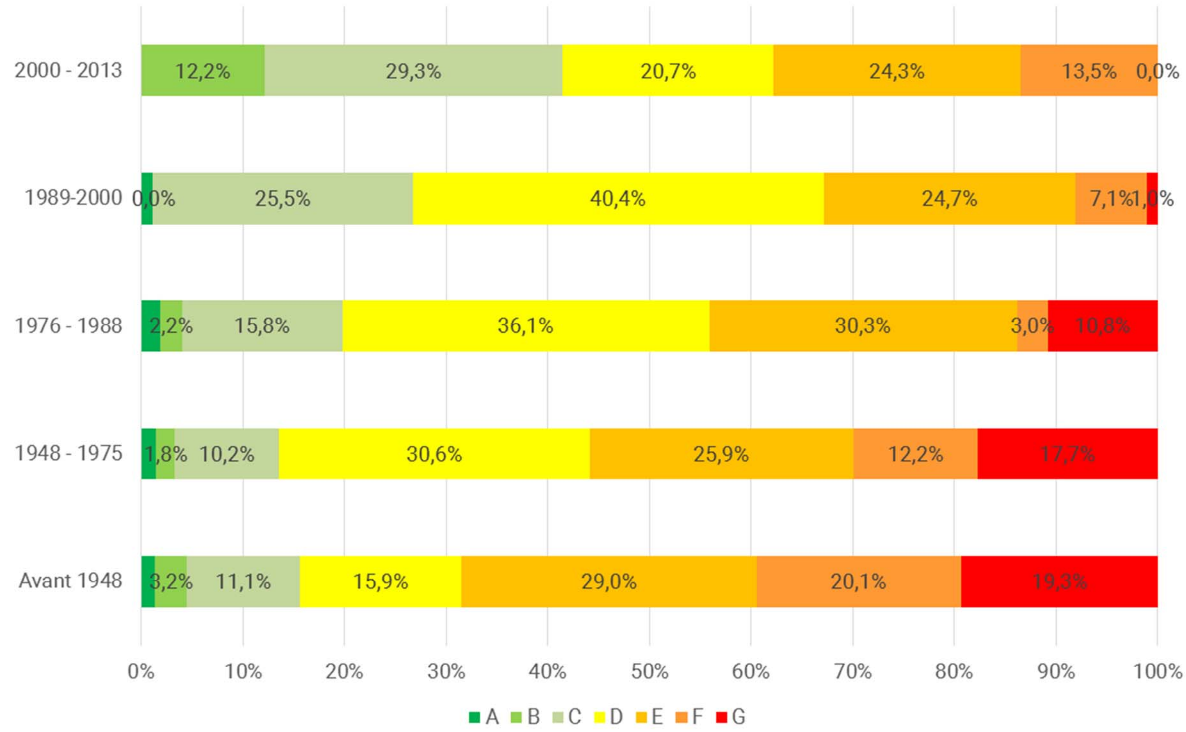
It can be noted that almost a third of main residences are among the most energy intensive with a theoretical energy performance analysis label of F or G, which represents an energy consumption over the five thermal uses (heating, domestic hot water, cooling, lighting and backups) that exceeds 330 kWh(primary energy)/m^2/year.



Distribution of energy performance analysis labels in one-dwelling buildings (main residences) by construction period - Source: PHEBUS 2013 survey

Avant 1948	Before 1948

This analysis can be deepened using construction period:



Distribution of energy performance analysis labels in apartment blocks (main residences) by construction period - Source: PHEBUS 2013 survey

Avant 1948	Before 1948

By way of comparison, this information can be compared with the data provided in the renovation strategy in 2014:

	Renovation strategy issued in 2014 *Share of the* ***<u>total housing stock</u>***	*PHEBUS survey data* *Share of* ***<u>stock of main residences</u>***
A	0 %	1.0%
B	3%	3.1%
C	15%	14.2%
D	26%	27.5%
E	25%	28.8%
F	17%	14.1%
G	14%	11.2%

Comparison of the distribution of energy performance analysis labels in relation to the 2014 renovation strategy

Comparing the data shows an overall improvement in the energy performance of the housing stock. Nevertheless, this result should be qualified because:

- firstly, the scope of the analysis used to calculate the relative share of each energy performance analysis label in the housing stock is not the same: in 2014, the data concern the entire housing stock while this report concentrates on the stock of main residences;

- secondly, the methods for calculating the energy performance analysis label differ. In the 2014 report, the energy performance analysis label was calculated using data from the National Housing Survey on the dwelling's equipment, its construction method etc., while the energy performance analysis labels for this report correspond to an energy performance analysis calculation that applies the method from the regulation in the framework of a statistical survey.

2.1.5 *The real energy consumption of the national stock of main residences*

2.1.5.1 Distribution of energy consumption by type of housing

The table below indicates the distribution of energy consumption in the residential sector by type of energy, according to the construction period of the housing. The data come from the CEREN survey (Centre for Economic Studies and Research on Energy) carried out in 2013 and published in 2015. The CEREN data do not enable us to distinguish buildings constructed before 1948 from buildings constructed between 1949 and 1975.

	Construction period	**number of homes (thousands)**	**surface area (million m²)**	**Energy consumption for all uses (TWh, final energy)**				
				Total	*of which gas*	*of which electricity*	*of which fuel oil*	*Of which: Other*
Apartments	< 1975	7,035	466	**90.8**	47.2	24.2	6	13.4
	1975–1998	3,263	213	**34.1**	12.4	15.5	1.5	4.7
	> 1999	1,864	124	**17.6**	6.4	9.2	0.2	1.8
	Total	**12,162**	**803**	**142.5**	**66**	**48.9**	**7.7**	**19.9**
One-dwelling buildings	< 1975	8,098	869	**171.1**	51.1	45.1	34.5	40.4
	1975–1998	5,014	578	**96.3**	18	37.8	11.2	29.3
	> 1999	2,785	324	**51.2**	11.1	22.5	2.5	15.1
	Total	**15,897**	**1,771**	**318.6**	**80.2**	**105.4**	**48.2**	**84.8**

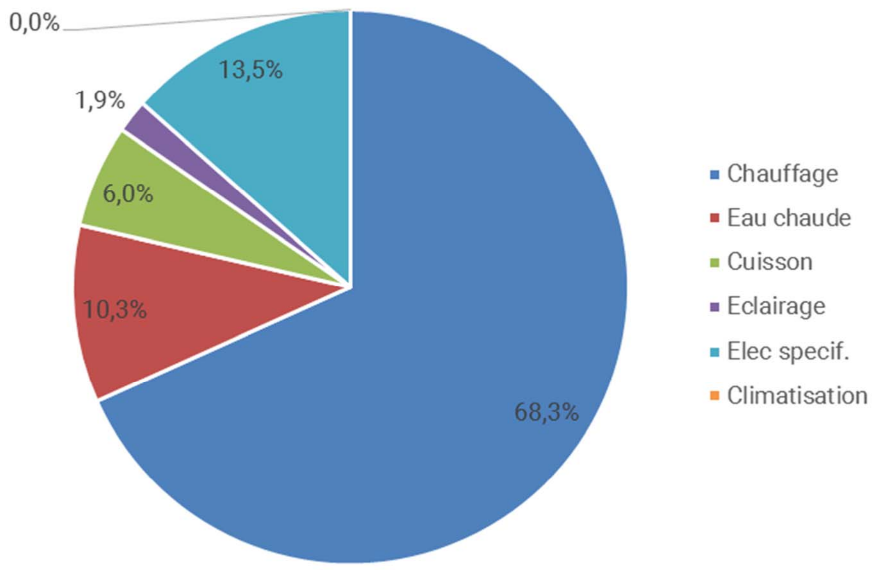
Table of energy consumption by usage (source: CEREN)

These figures enable us to deduce

- that housing constructed before 1975, both apartments and one-dwelling buildings, which make up half of the housing stock, represent more than two thirds of gas consumption, an over-representation that is essentially due to apartment blocks. This is confirmed in the graphs on page 25 that show that gas is the main form of energy used to heat buildings constructed before 1945;
- 85% of the consumption of fuel oil is linked to one-dwelling buildings, essentially those built before 1975, namely before the first thermal regulation.

2.1.5.2 Distribution of energy consumption by usage

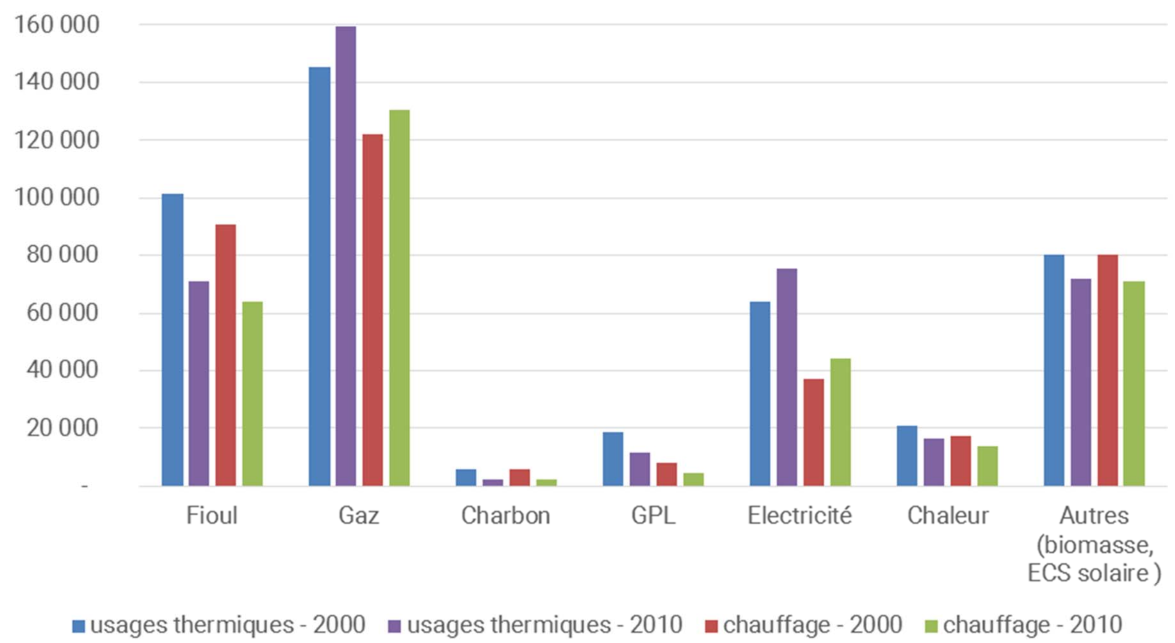
The consumption of the housing stock may be distinguished according to usage. The graph below indicates the distribution of energy consumption in the residential sector (AME 2016 scenario, Directorate General for Energy and the Climate) between the different thermal uses: heating, hot water, cooking, lighting and specific electricity use. Heating represents over two thirds of energy consumption in the residential sector, even though this share is decreasing (73% in 2010).



Distribution of energy consumption in the residential sector in 2010 by usage - in GWh - Source: AME 2016 scenario, Directorate General for Energy and the Climate (final energy)

Chauffage	Heating
Eau chaude	Hot water
Cuisson	Baking
Eclairage	Lighting
Elec specif.	Specific electricity
Climatisation	Air-conditioning

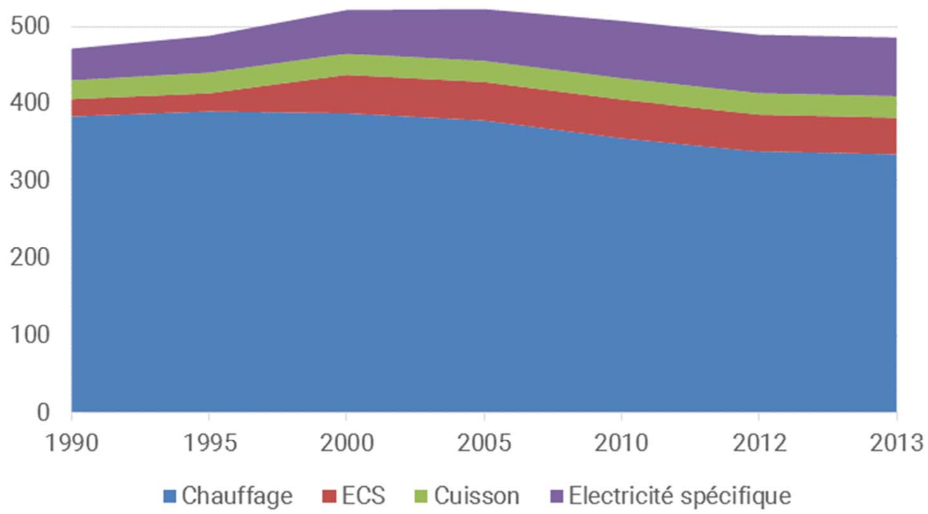
The graph below indicates the distribution of energy consumption for housing by type of energy, according to which the energy is used for heating, domestic hot water, cooking or other electric devices (specific electricity). The following graph represents the change in energy consumption between 2000 and 2010 for each usage in the residential sector. Although energy consumption for heating had dropped by 10% in 2010 in comparison with 2000, electricity use for electric devices (specific electricity) increased by a quarter over the same period. The 'hot water' and 'cooking' uses have remained relatively stable. These trends have been confirmed by CEREN's longer series studies.



Comparison of the distribution of energy consumption in the residential sector by usage and by type of energy in 2000 and 2010 - in GWh - Source: AME 2016 scenario, Directorate General for Energy and the Climate (final energy)

Fioul	Heating oil
Gaz	Gases
Charbon	Coal
GPL	LPG
Electricité	Electricity
Chaleur	Heat energy
Autres (biomasse, ECS solaire)	Other (biomass, solar domestic hot water)
usages thermiques – 2000	thermal uses - 2000
usages thermiques – 2010	thermal uses - 2010
chauffage – 2000	heating - 2000
chauffage - 2010	heating - 2010

Heating is by far the highest consumer for each type of energy.



Changes to the energy consumption of the residential sector by usage since 1990 - in TWh (final energy) - Source: CEREN 2013

Chauffage	Heating
ECS	Domestic hot water
Cuisson	Baking
Electricité spécifique	Specific electricity

2.2 Detailed analysis of the national building stock for tertiary use

2.2.1 *Scope of buildings for tertiary use*

The main source of detailed information on the types of tertiary buildings (uses, surface area, numbers, energy consumption, etc.) is the BASIC/CODA database created by BASIC Consultants and CODA Stratégies, which contains data that were updated in 2012. The data come from an information collection, survey and modelling project and they provide information, by sector of activity, on the types of occupation, occupation status, construction periods, surface areas, types of energy used by usage, energy consumption and the technical characteristics of the buildings.

The database is segmented into 11 sectors of activity: agricultural buildings, cultural buildings, healthcare buildings, transport buildings, education and research buildings, industrial buildings, offices, cafes/hotels/restaurants, shops, community housing and sports buildings. The stock of tertiary buildings is very heterogeneous due to the differences in surface area, construction types, types of occupation and energy consumption, depending on usage.

The CEREN data provide information on the overall energy consumption of the tertiary building stock. The sectors examined by CEREN are based on 'branches' using the APE (main activity performed) codage for establishments (source: SIRENE). This specific definition of the different branches is available on request from CEREN. The difference in the way sectors are characterised is due to the differences between the CODE and CEREN data on the workforce of certain tertiary sub-sectors.

2.2.2 *Distribution of the national building stock for tertiary use by usage - in number and surface area*

2.2.2.1 Distribution of usages of the tertiary stock

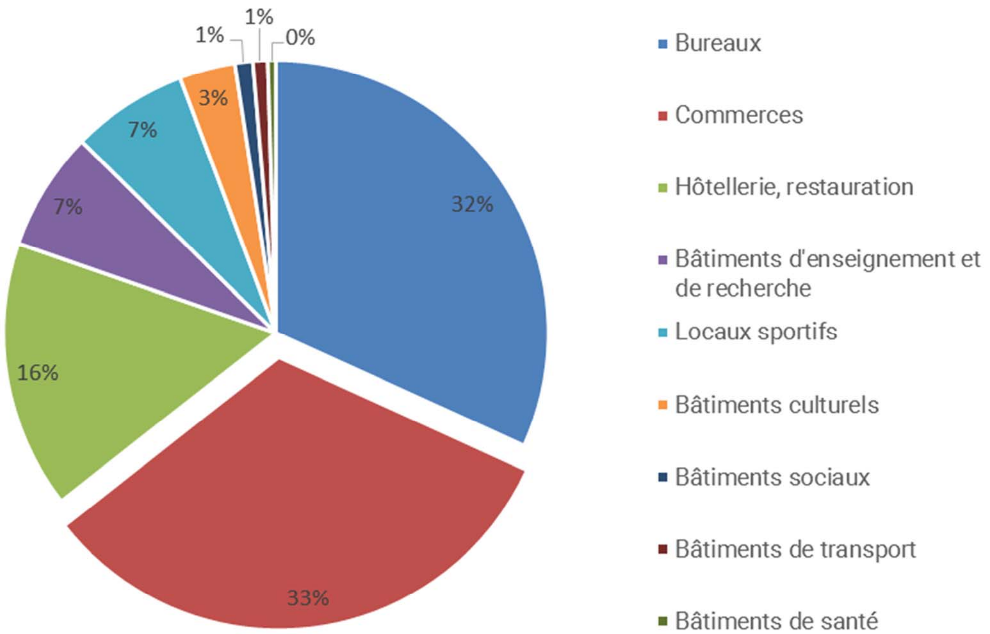
Tertiary real estate stock can be divided into the following categories:

- Offices;
- Shops;
- Education and research buildings;
- Hotel trade (including community housing), the restaurant business;
- Sports premises;
- Cultural buildings - these can be grouped with sporting buildings under 'leisure buildings';
- Healthcare buildings;
- Transport buildings;
- Social buildings.

These categories will be used herein.

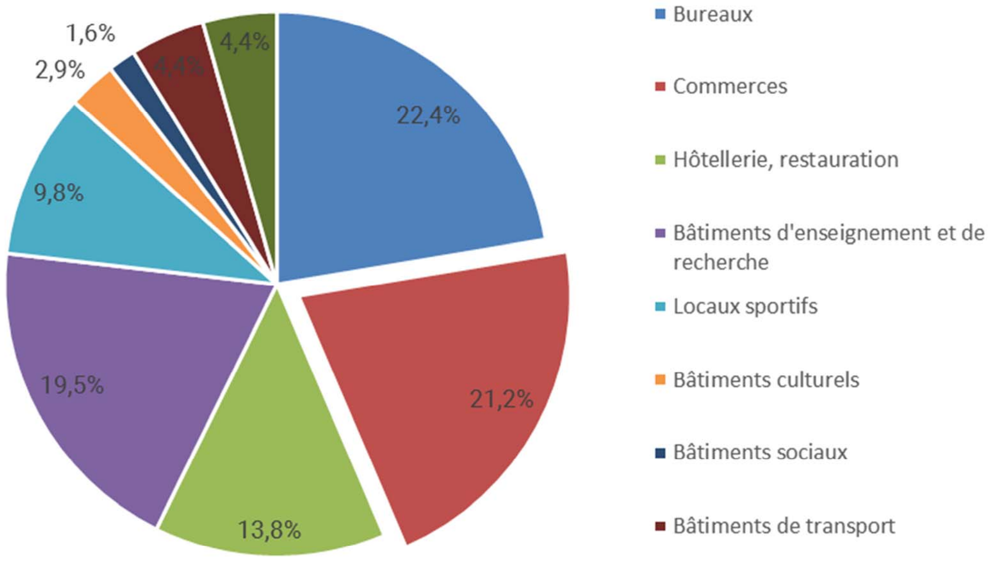
Sector	Number of buildings	Distribution by sector (%)	Total surface area of the buildings (thousands of m^2)	Distribution by sector (%)
Offices	463,797	31.8%	192,908	22.4%
Shops	476,546	32.7%	182,540	21.2%
Education and research buildings	103,170	7.1%	168,251	19.5%
Hotel or restaurant business	231,668	15.9%	118,744	13.8%
Sports premises	100,673	6.9%	84,656	9.8%
Cultural buildings	48,386	3.3%	24,838	2.9%
Healthcare buildings	6,965	0.5%	37,944	4.4%
Transport buildings	12,788	0.9%	38,297	4.4%
Social buildings	15,440	1.1%	14,087	1.6%
Total	**1,459,433**	**100%**	**862,263,687 m²**	**100%**

Distribution of tertiary buildings by sector, in surface area and number of buildings - Source: BASIC/CODA study 2012



Distribution of tertiary buildings by sector, in NUMBER of buildings - Source: BASIC/CODA study 2012

Bureaux	Offices
Commerces	Shops
Hôtellerie, restauration	Hotel or restaurant business
Bâtiments d'enseignement et de recherche	Education and research buildings
Locaux sportifs	Sports premises
Bâtiments culturels	Cultural buildings
Bâtiments sociaux	Social buildings
Bâtiments de transport	Transport buildings
Bâtiments de santé	Healthcare buildings



Distribution of tertiary buildings by sector, in FLOOR AREA - Source: BASIC/CODA study 2012

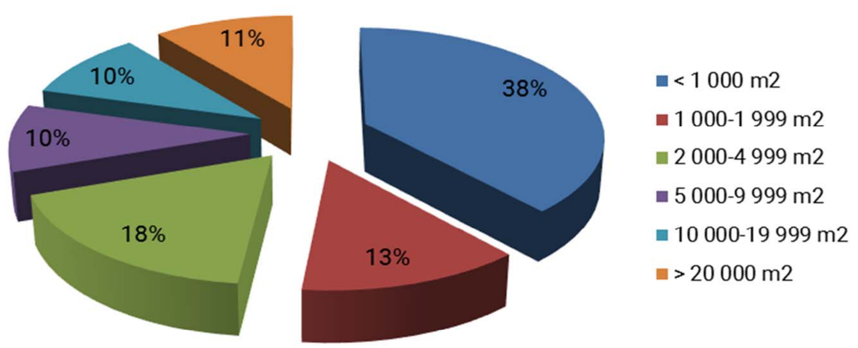
Bureaux	Offices
Commerces	Shops
Hôtellerie, restauration	Hotel or restaurant business
Bâtiments d'enseignement et de recherche	Education and research buildings
Locaux sportifs	Sports premises
Bâtiments sociaux	Social buildings
Bâtiments de transport	Transport buildings

2.2.2.2 Detailed presentation of office buildings

Types of office buildings

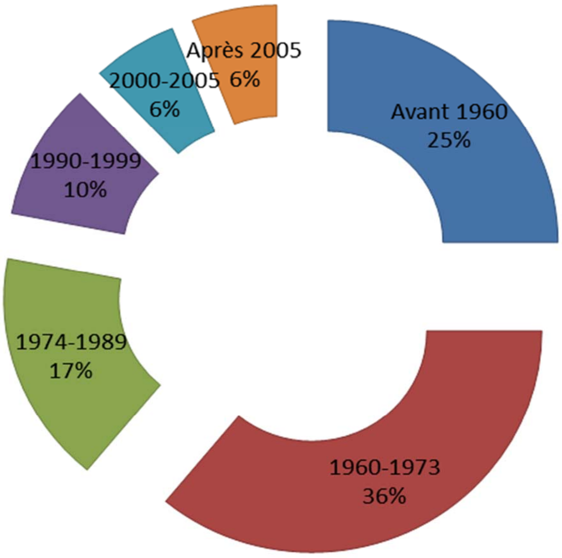
Office buildings are mainly part of the private sector.

The stock of office buildings represents over 190 million m^2 spread over buildings of all sizes, a quarter of which are smaller than 500 m^2.



Distribution of office surface area by surface area tranche - Source: BASIC/CODA study 2012

< 1 000 m2	< 1,000 m^2
1 000-1 1 999 m2	1,000–1,999 m^2
2 000-4 999 m2	2,000–4,999 m^2
5 000-9 999 m2	5,000–9,999 m^2
10 000-19 999 m2	10,000–19,999 m^2
> 20 000 m2	> 20,000 m^2

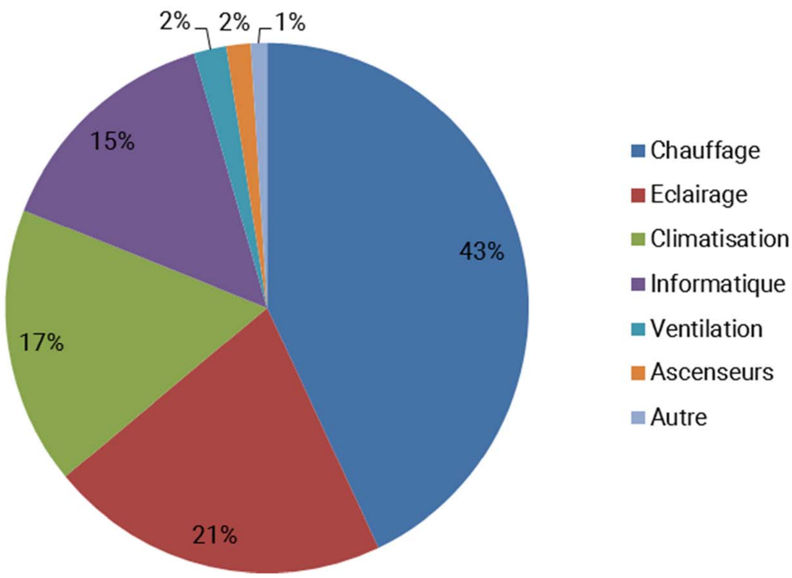


Distribution of offices by construction period - Source: BASIC/CODA study 2012

Avant 1960	Before 1960
Après 2005	After 2005

Analysis of the energy consumption of office buildings

The graphs below provide the evaluation of the energy consumption of office buildings in 2012 by usage and type of energy. In 2011, office buildings represented a total energy consumption of 47 TWh (final energy), which is distributed between the main usages in the following manner:

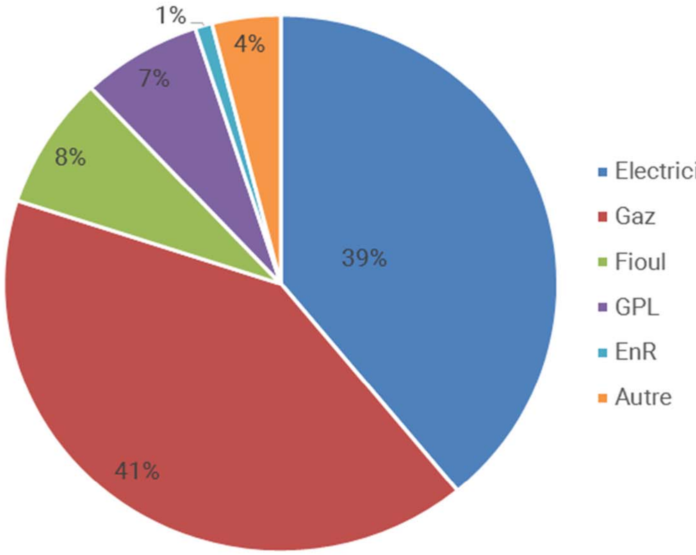


Distribution of the energy consumption of office buildings by usage - Source: BASIC/CODA study 2012

Chauffage	Heating
Eclairage	Lighting
Climatisation	Air-conditioning
Informatique	IT

Ventilation	Ventilation
Ascenseurs	Lifts
Autre	Other

The types of energy used in this sector are distributed in the following way:



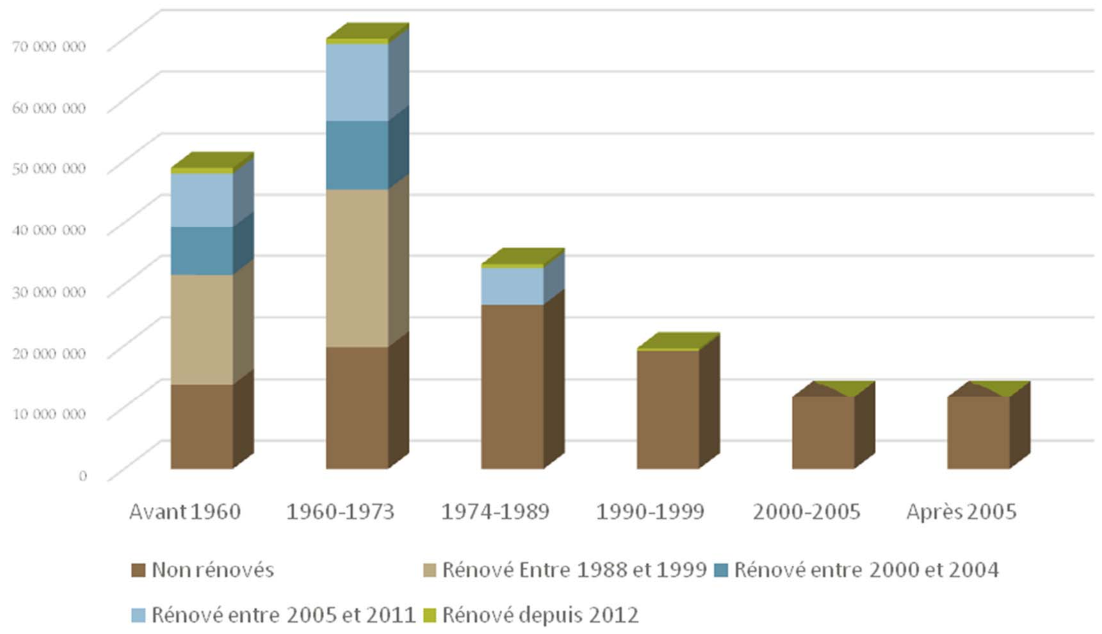
Distribution of types of energy used in office buildings - Source: BASIC/CODA study 2012

Electricité	Electricity
Gaz	Gases
Fioul	Heating oil
GPL	LPG
EnR	Renewable energies
Autre	Other

The main type of energy used in office buildings is gas, followed by electricity. These two types of energy represent 80% of energy supplies. This is in particular explained by the preponderance of the 'heating' item in the distribution of usages, as well as by the scale of IT and lighting, which represent 37% of usages, or almost all the consumption supplied by electricity.

Heating represents the main source of energy consumption in office buildings (almost half of consumption). It is followed by lighting and air conditioning. The share of electricity of the energy consumption of office buildings is constantly increasing due to the spread and increased use of office equipment and other electronic equipment to the detriment of fossil fuels such as fuel oil and gas. Almost two thirds of office buildings were constructed before 1973 in a period when, as with housing, there were no thermal regulations, making the stock particularly energy intensive.

Tertiary buildings are nevertheless being renovated as the graph below shows, which represents the distribution of the surface area of renovated office buildings according to the construction period of the building and its renovation period:



Distribution of surface area of renovated office buildings - Source: BASIC/CODA study 2012

Avant 1960	Before 1960
Après 2005	After 2005
Non rénovés	Not renovated
Rénové Entre 1988 et 1999	Renovated between 1988–1999
Rénové Entre 2000 et 2004	Renovated between 2000–2004
Rénové Entre 2005 et 2011	Renovated between 2005–2011
Rénové depuis 2012	Renovated since 2012

2.2.2.3 Detailed presentation of commercial buildings

Types of commercial buildings

The purpose of shop buildings is to house sales and services activities that can be grouped into three types:

- city-centre or town-centre shops (small stores);
- shopping centres, which are groups of at least twenty shops and services with a useable commercial surface area of at least 5,000 m^2 that are designed, put in place and managed as an entity;
- retail parks that group large-scale retailers in separate buildings and form a unit.

In 2011, there were 476,546 commercial buildings with a surface area of 183 million m^2. The stock is dominated by the category 'other specialist shops' with 175,835 buildings. This represents 37% of the total stock in number and 32% in surface area. Shopping centres and hypermarkets are the least represented categories in number (3%) but are in an expansion phase with a surface area of 6% of the stock. As for small non-specialist food shops, which represent 6% of the stock, they are on the wane due to the high levels of competition from supermarkets and hypermarkets.

	2011	%
Other specialist shops	175,835	36.90%
shopping malls.	643	0.13%
Wholesale trade	68,160	14.30%
Specialist food shops	74,366	15.61%

Specialist luxury goods shops	15,348	3.22%
Car dealerships	31,145	6.54%
Hypermarkets and large shops	1,461	0.31%
Small non-specialist shops	29,214	6.13%
Car repairs	69,670	14.62%
Supermarkets	10,704	2.25%
Total	**476,546**	**100%**

Distribution of the commercial building stock by usage, in number - Source: BASIC/CODA study 2012

	2011 (m²)	**%**
Other specialist shops	57,920,879	31.73%
shopping malls.	3,255,538	1.78%
Wholesale trade	50,764,546	27.81%
Specialist food shops	5,879,667	3.22%
Specialist luxury goods shops	3,372,403	1.85%
Car dealerships	14,806,601	8.11%
Hypermarkets and large shops	11,526,131	6.31%
Small non-specialist shops	2,904,978	1.59%
Car repairs	15,678,400	8.59%
Supermarkets	16,430,781	9.00%
Total	**182,539,924**	**100.00%**

Distribution of the commercial building stock by usage, in surface area - Source: BASIC/CODA study 2012

Almost 90% of shops are stores with a surface area of less than 1000 m^2. This category represents half of the commercial stock in terms of surface area. The remaining 10% of shops alone represent the other half of the stock, 8% of which is made up of shops of between 1,000–2,000 m^2 with 20% of the surface area. There are 321 shops of over 20,000 m^2 representing a surface area of 5,048,339 m^2 (3% of the total surface area). Despite the growing number of large shops, small shops dominate the market.

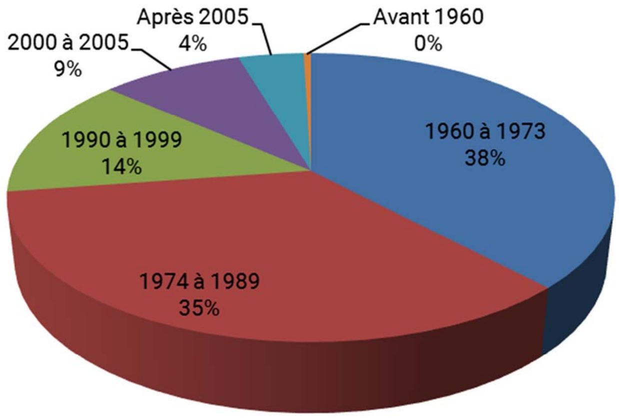
	Number	**%**	**Surface area (m^2)**	**%**
<1000 m²	417,976	88%	88,613,123	49%
1,000–1,999 m²	37,890	8%	36,982 720	20%
2,000–4,999 m²	17,124	4%	33,533,923	18%
5,000–9,999 m²	2,161	0%	12,970 865	7%
10,000–19,999 m²	1,074	0%	5,390,955	3%
>20,000 m²	321	0%	5,048,339	3%
Total	**476,546**	**100%**	**182,539,924**	**100%**

Distribution of the commercial building stock by tranche of surface area - Source: BASIC/CODA study 2012

Commercial buildings are very heterogeneous in surface area as the stock is made up on the one hand of specialist food shops and small non-specialist shops, small local shops with an average surface area that is much smaller than 1,000 m^2 and on the other hand of hypermarkets and shopping centres with surface areas that can exceed 20,000 m^2.

Large-scale construction of commercial buildings began in the 1960s. Over 70% of the stock was built between 1960 and 1989. This was the period in which the concept of large shops took hold in France. It also corresponds to the period of the *Trente Glorieuses* during which increasing purchasing power lead to the development of retail trade. Buildings constructed before 1960 represent barely 1% of the commercial building stock.

Recent buildings are often supermarkets or hypermarkets, but also shopping centres, which represent the majority of commercial buildings being constructed today.

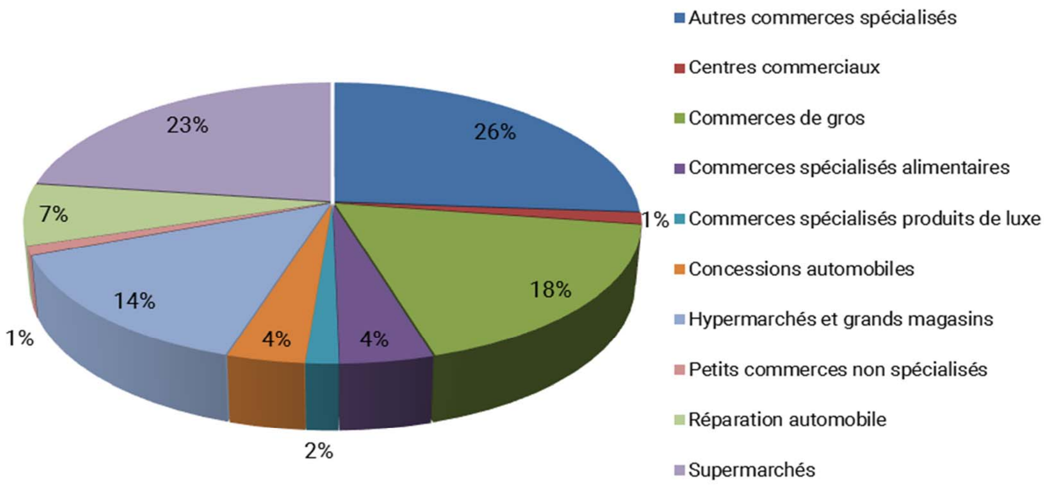


Distribution of the commercial building stock by construction period - Source: BASIC/CODA study 2012

Avant 1960	Before 1960
1960 à 1973	1960–1973
1974 à 1989	1974–1989
1990 à 1999	1990–1999
2000 à 2005	2000–2005
Après 2005	After 2005

Energy consumption of commercial buildings

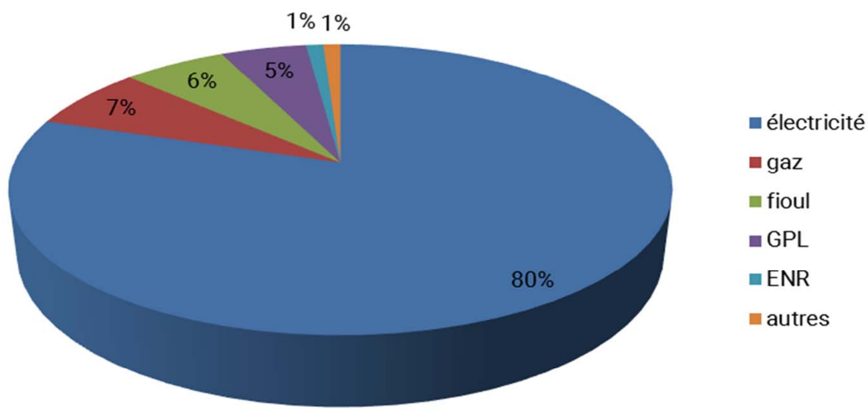
In 2011, France's commercial stock consumed 49,663 GWh of final energy. The energy consumption of the commercial stock is very heterogeneous. The largest consumers of energy are hypermarkets and bakeries with 600 kWh(final)/m^2/year. The smallest consumers of energy are fishmongers and car repair garages, which consume around 110 kWh(final)/m^2/year.



Distribution of the energy consumption of the commercial building stock by usage - Source: BASIC/CODA study 2012

Autres commerces spécialisés	Other specialist shops
Centres commerciaux	shopping malls.
Commerces de gros	Wholesale trade
Commerces spécialisés alimentaires	Specialist food shops
Commerces spécialisés produits de luxe	Specialist luxury goods shops
Concessions automobiles	Car dealerships
Hypermarchés et grands magasins	Hypermarkets and large shops
Petits commerces non spécialisés	Small non-specialist shops
Réparation automobile	Car repairs
Supermarchés	Supermarkets

In addition, the most commonly used form of energy is electricity, which represents over 80% of total consumption due to the large amount of equipment used that runs on electricity. Gas is mainly used for heating.



Distribution of the energy consumption of the commercial building stock by type of energy - Source: BASIC/CODA study 2012

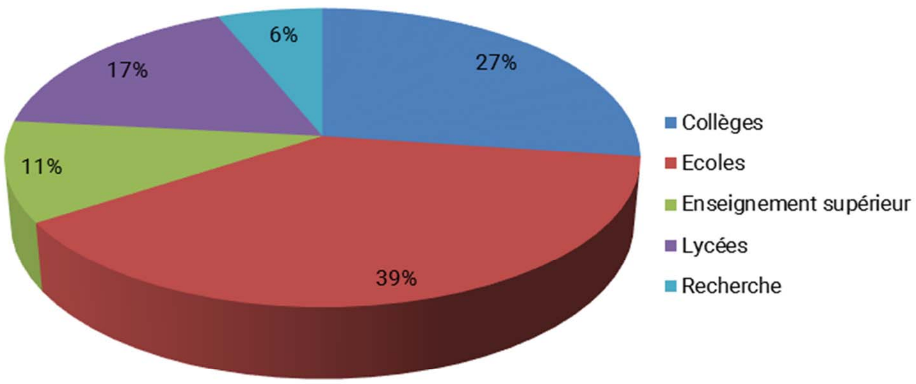
électricité	electricity
gaz	gas
fioul	Fuel oil
GPL	LPG
ENR	renewable energies
autres	other

2.2.2.4 Education and research buildings

Types of buildings

The stock of education buildings is one of the biggest sectors in terms of surface area (BASIC CODA 2012). The surface area of education buildings stands at 168,250,965 m^2. This surface area is dominated by primary schools (*écoles*) and secondary schools (*collèges*) which alone occupy 110,641,994 m^2, or 66% of the total surface area of the stock of education buildings. The remaining surface area is split between:

- sixth-forms (*lycées*): 17% of the total surface area of the stock;
- further education: 11% of the total surface area of the stock;
- research: 6% of the total surface area of the stock.



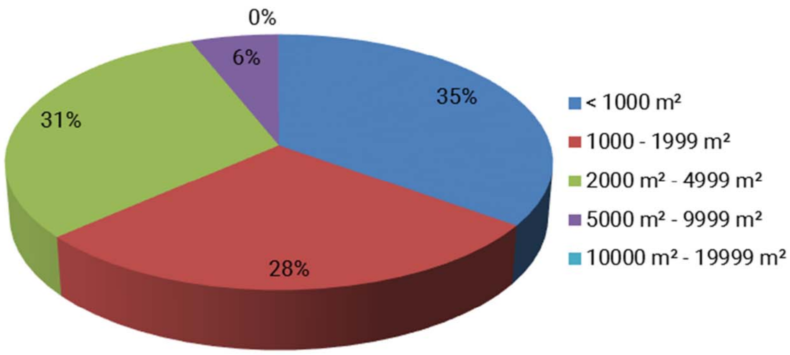
Distribution of the education and research building stock by surface area - Source: BASIC/CODA study 2012

Collèges	Secondary schools
Ecoles	Primary schools
Enseignement supérieur	Further education
Lycées	Sixth forms
Recherche	Research

The education stock is dominated by medium-sized buildings. There are only 16 buildings with a surface area between 10,000 and 20,000 m^2. Buildings of less than 1,000 m^2 are the most common with a 35% share (in number of buildings) while second place is occupied by buildings from 2,000–4,999 m^2 that represent 31% of education and research buildings.

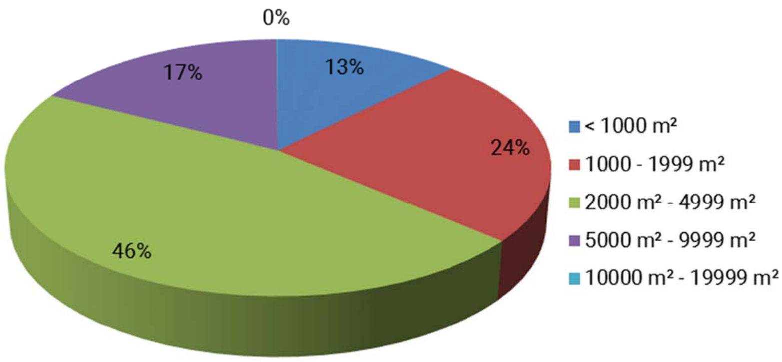
Buildings from 2,000–5,000 m^2 represent almost half of the surface are of the education stock. The remaining surface area of education buildings is distributed as follows:

- Buildings from 1,000–2,000 m^2: 24% of the stock;
- Buildings from 5,000–10,000 m^2: 17% of the stock;
- Buildings of less than 1,000 m^2: 13% of the stock.



Distribution of the education and research building stock by tranches of surface area - in NUMBER of buildings Source: BASIC/CODA study 2012

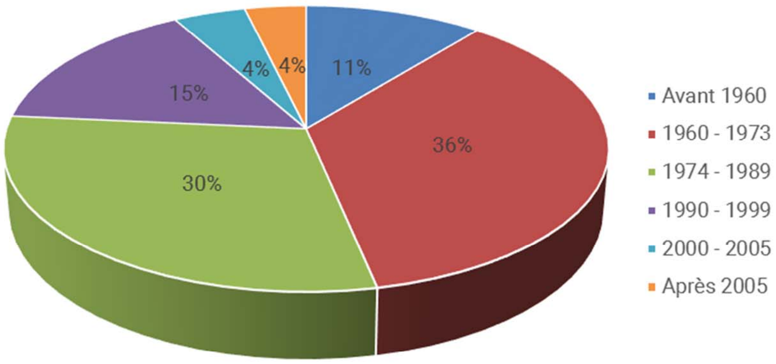
< 1000 m2	< 1,000 m^2
1000 – 1999 m2	1,000–1,999 m^2
2000 m2 – 4999 m2	2,000–4,999 m^2
5000 m2 – 9999 m2	5,000–9,999 m^2
10000 m2 – 19999 m2	10,000–19,999 m^2



Distribution of the education and research building stock by tranches of surface area - in building SURFACE AREA - Source: BASIC/CODA study 2012

< 1000 m2	< 1,000 m^2
1000 – 1999 m2	1,000–1,999 m^2
2000 m2 – 4999 m2	2,000–4,999 m^2
5000 m2 – 9999 m2	5,000–9,999 m^2
10000 m2 – 19999 m2	10,000–19,999 m^2

The period 1960–1989 saw a boom in the construction of education buildings with two thirds of the stock built during this period. This corresponds to a period of huge commitment from the state to the construction of school and university buildings.



Distribution of the education and research building stock by construction period - in NUMBER of buildings - Source: BASIC/CODA study 2012

Avant 1960	Before 1960
Après 2005	After 2005

2.2.2.5 Hotel and catering industry buildings

The data from the BASIC/CODA database is based on INSEE data and shows that the number of hotels has been constantly decreasing for the last 20 years, which translates into an increase in the average size of establishments. The number of cafes has also dropped, while the number of restaurants has increased.

In this sector, restaurant buildings are highest in number. Around of quarter of buildings in the hotel and catering industry were built in the period 1974–1989. Restaurants consume the most energy given their high proportion in the sector, but also given the consumption associated with cooking. Electricity remains the most used type of energy for most usages, and heating consumes the most energy.

2.2.2.6 Buildings dedicated to leisure

Buildings dedicated to leisure are very heterogeneous as they include cultural buildings and sports buildings. According to the 2012 CODA database, they represent 10% of the number of tertiary buildings (7% for sports premises and 3% for cultural buildings) and 13% of the surface area of tertiary buildings (10% for sports premises and 3% cultural buildings).

These buildings are mainly held by local authorities.

The 'culture' sector includes cinemas, museums, theatres, libraries, youth and cultural centres, performance and festival halls. The rate of construction has fluctuated greatly over recent decades. Nevertheless, the economic crisis of 2008 and the decrease in state and local authority investment have significantly reduced investment in this sector.

The total energy consumption of cultural buildings is 3,913 GWh (final energy) with an average consumption of 155 kWh/m^2. They generally do not use much energy as they have low occupation rates. The most used type of energy is electricity, which represents 58% of total consumption. Gas accounts for 29% of consumption, almost exclusively for heating purposes.

Sports buildings include ice rinks, swimming pools, sports halls and stadiums that were mainly constructed during the period 1974–1989, an era in which their construction was initiated by the ministry in charge of sport.

They represent an energy consumption of around 15 TWh of final energy, 78% of which is due to sports halls. Skating rinks however consume large amounts of energy, on average 400 kWh/m^2. Given the different usages, the distribution of items of consumption is very heterogeneous between the different types of sports buildings:

- Mainly electricity to provide the cold required for skating rinks;
- Mainly gas for heating and sanitary hot water in swimming pools, sports halls and stadiums.

2.2.2.7 Buildings for transport

The sector includes airports and aerodromes, railway stations, bus terminals, private garages and shopping centre car parks. Private garages and shopping centre car parks are not *a priori* included in this sector by the CEREN terminology which explains the differences, in number and in surface area, between the CODA and CEREN data.

These buildings only represent 1% of tertiary buildings and 4% of surface area.

Given the heterogeneity of the ways these buildings are used, their energy consumption structures vary greatly. The items that consume the most energy are:

- lighting, IT and displays for railway stations, old buildings;
- air-conditioning for airports;
- lighting and ventilation for car parks.

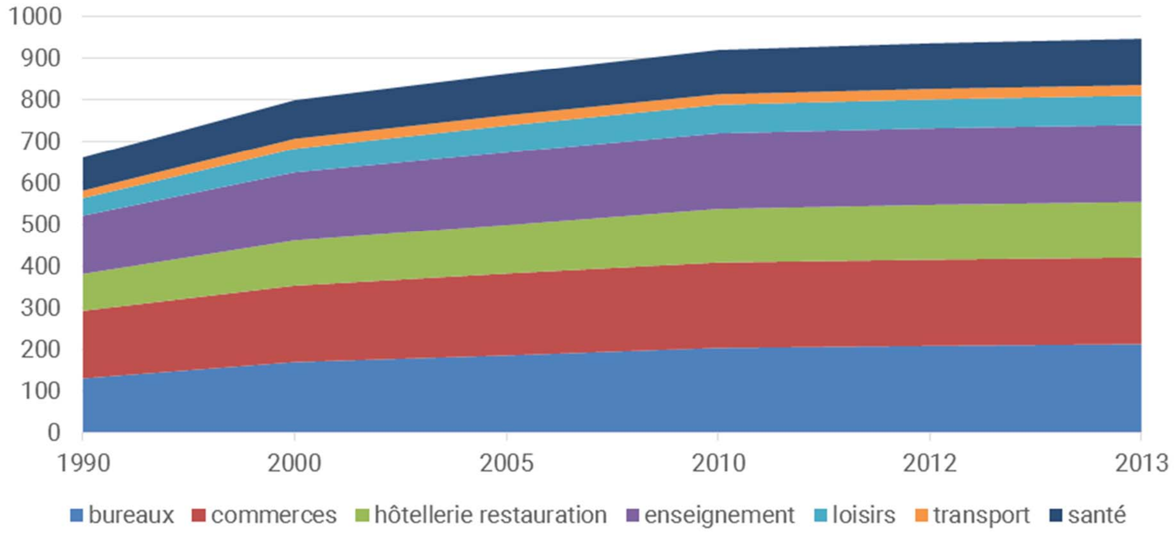
2.2.2.8 Healthcare buildings

Healthcare buildings include both public and private hospitals. Their total energy consumption is estimated at around 12,582 GWh, or 340 kWh/m^2. They consume a lot of energy because of the large number of energy-intensive devices used and their heating conditions (an average temperature of 23°C). Consequently, electricity is the most used type of energy.

2.2.3 *Analysis of the overall energy consumption of the national building stock for tertiary use*

The CEREN 2015 statistical data do not provide information on all the uses of tertiary buildings. The CEREN surveys target tertiary establishments with energy consumption that stems mainly from a 'building' issue, namely heating, air conditioning and lighting. Therefore, data related to specific electricity consumption, in particular IT, are not covered in the CEREN surveys, although they represent more than 15% of the total energy consumption of office buildings (see paragraph 2.2.2.2).

Nevertheless, the CEREN data does illustrate a constant increase since the middle of the 1980s in heated surface area in the tertiary sector, and for all kinds of usage, with a growth rate that has started to slow since 2012:

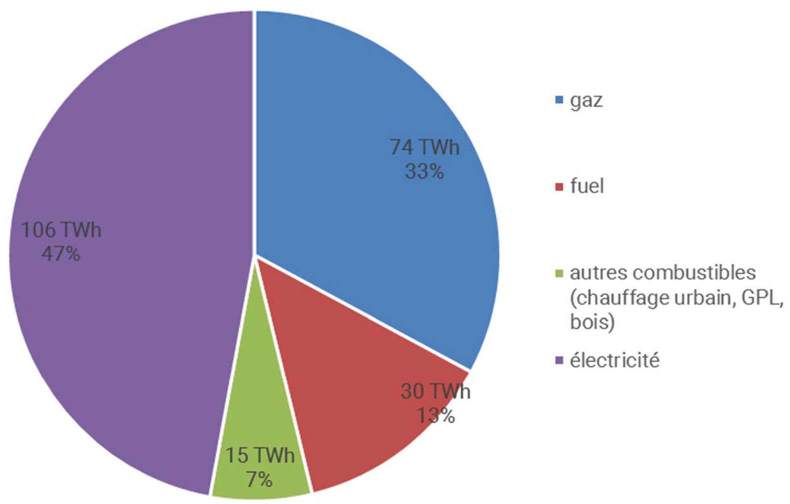


Changes to heated surface area by tertiary branch - Source: 2013 CEREN data

bureaux	offices
commerces	shops
hôtellerie restauration	hotel or catering industry
enseignement	education
loisirs	leisure
transport	transporting
santé	health

Heating remains the main item of energy consumption in the sector, although its share has started to decrease each year (47% in 2013, according to the 2013 CEREN data). Electricity is the only type of energy for which consumption increased in 2013, given the growth in specific electricity consumption and ever more widespread IT equipment.

Therefore, energy consumption is distributed as follows, by type of energy, in the tertiary sector:



Distribution of energy consumption in the tertiary sector (final energy) by type of energy - Source: 2013 CEREN data

gaz	gas
fuel	fuel
autres combustibles (chauffage urbain, GPL, bois)	other fuels (urban heating, LPG, wood)
électricité	electricity

2.3 Overview

The table above contains the statistics presented in this section. It displays the number and share of the most energy-intensive housing (energy performance analysis labels F and G) by period of construction. It can therefore be concluded that, for apartment blocks and one-dwelling buildings, renovation work should target buildings constructed before 1974 as a priority. Over 5 million dwellings from this period that are main residences have an energy performance analysis label of F or G.

	Before 1948	1949-1974	1975-1999	After 2000
one-dwelling buildings	5,086,471 *33%*	3,448,285 *22%*	5,142,240 *33%*	1,876,328 *12%*
apartments	3,053,002 *28%*	4,484,396 *41%*	2,526,730 *23%*	913,174 *8%*
one-dwelling buildings F and G	1,309,042 *26%*	1,537,370 *44%*	893,556 *17%*	39,736 *2%*
apartments F and G	1,155,664 *38%*	1,327,716 *30%*	283,706 *11%*	120,576 *13%*

Number of dwellings by year of construction and energy class

The following section will aim to define renovation strategies for examples of buildings that are representative of this period, namely clusters of work that will maximise energy gains while guaranteeing financial profit over the long term for the household or the manager of the property.

This approach to finding profitable renovation strategies will also be followed for the tertiary sector, for which renovation is of great value, in particular for buildings constructed before 1975.

3 Identification of profitable approaches to renovation

The aim of this chapter is to determine efficient approaches to renovation that maximise energy gains while also representing financial profit over 30 years[3] for households or property managers. The method used to define profitable approaches to renovation is made up of six successive stages:

1. Identification of example buildings that are representative of the construction periods;
2. Identification of works solutions that can be performed on each of these buildings;
3. Definition of clusters of works in the form of renovation scenarios with progressive levels of efficiency: renovations that are not very ambitious, efficient and very efficient;
4. Thermal simulation and economic costing of multiple variants: cost of investment and overall cost over 30 years;
5. Identification of the most economically and technically pertinent solutions;
6. Conclusion on the profitable approaches to renovation.

Example buildings were identified using the information gathered in the previous section. For the residential sector, it was judged pertinent to focus on the period before 1975 and 1975–1988, as these buildings constitute the priority target for renovation works. The following table was used to identify four reference buildings:

- for one-dwelling buildings (59% of the stock), it is important to analyse constructions over these two periods and test renovations on gas and electricity;
- for apartment blocks (41% of the stock), the accent was placed on gas by choosing two buildings with very different construction systems: a classic building with shuttered concrete walls and a building with a large amount of glass.

	construction period	share of the number of dwellings	Energy consumption including all uses (TWh, final energy)	main heating carriers	reference buildings
Apartments 41%	< 1975	69%	64%	electricity and gas (alternatively)	Apartments gas 1960
	1975–1998	23%	24%		Apartments gas 1970
One-dwelling buildings 59%	< 1975	55%	54%	gas/fuel oil/electricity	One-dwelling buildings 1955 gas
	1975–1998	33%	30%	electricity/gas/fuel oil	One-dwelling building 75–85 joule heating

In addition, the description of the buildings in the tertiary stock show a very heterogeneous stock that is difficult to model. Office buildings represent the largest surface area in terms of total m² of the tertiary stock, and consumption for heating, ventilation and air conditioning counts for 60% of their energy consumption. The

[3] Delegated regulation (EU) No 244/2012 of the Commission of 16 January 2012, completing directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings advises a calculation period of 30 years for residential buildings.

types of offices are relatively homogeneous (in comparison with the stock of commercial premises). The building studied that was chosen is a large office that was constructed in 1976.

Therefore, from these five reference buildings, it is possible to create a large number of simulations to trace renovation trajectories that translate the variety of choices that could be made by households or property managers.

3.1 Detailed methodology

3.1.1 *Description of the scenarios*

In order to define profitable approaches to renovation, several energy renovation scenarios have been studied for five example buildings (as a reminder: one-dwelling building with gas, one-dwelling building with joule heating, apartment with gas, apartment with gas and lots of glass and a large office). This section will aim to perform works simulations on these five buildings using current financing conditions (in particular, the criteria and amount of incentives) to determine profitable approaches to renovation

For each of these example buildings, three renovation scenarios have been simulated:

- scenario 1: this scenario corresponds to **renovation that is not very ambitious** that rests on one or two works actions (equipment and/or envelope) at a regulatory level (thermal regulation that applies to the existing building);
- scenario 2: this scenario is associated with **efficient renovation** work that rests on at least two actions, one of which being very energy efficient (the performance criteria defined in article 18a of annex IV of the General Tax Code for obtaining renovation assistance);
- scenario 3: this scenario corresponds to **very efficient renovation** work that rests on at least three actions that comply with the criteria from article 18a of annex IV of the General Tax Code.

The technical solutions used in the scenarios are some of the most commonly chosen equipment used in energy renovation works today[4].

The resulting works on the interior construction have not been included in the calculation as the balance in terms of the overall cost of the study only relates to actions with an impact on energy efficiency.

The scenarios were determined using several stages:

- The first consisted of determining which of the works most commonly performed by households were suitable for the building (whether it is technically possible to carry out this type of intervention);
- These works were then costed, and thermal and economic simulations were carried out for the different possible combinations of works;
- From the different combinations obtained above, we have chosen those that enabled us to define the three scenarios presented above by trying to find as far as possible a very efficient type of renovation for each building that enables very high efficiency to be achieved at a managed cost.

The five buildings that will be analysed later in this document are considered representative of the period of construction to which they belong. The choice was made to carry out extensive work to create and analyse renovation scenarios on a limited number of buildings in order to present profitable approaches to renovation.

The 'element by element' thermal regulation sets minimum requirements that must be followed if an element of a building is replaced that has an impact on its energy efficiency. This regulation was revised in 2016 (this point will be discussed in detail later in the document), so we are referring to the new requirements when

[4] Sources: the OPEN survey 2015 campaign and the database of equipment installed in connection with the sustainable development tax credit in 2014.

defining the minimum performance of equipment for each action put in place enabling compliance with this regulation. This is the level that was defined above as the "regulatory level".

3.1.2 *Defining the overall cost*

The profitability of the scenarios was studied using an overall cost approach that considers all the costs associated with the operation. The method used complies with the recommendations of delegated regulation (EU) No 244/2012 of 16/01/12 completing directive 2010/31/EU on the energy performance of buildings.

According to Article 5 of regulation No 244/2012, deferred costs must be updated.

The overall cost includes:

- the investment cost: all costs borne up to delivery of the building or the element of the building to the client (supply and installation, excluding the cost of studies);
- the updated energy consumption cost: the annual costs linked with the energy consumed to run the building or part of the building, updated each year;
- the updated replacement costs: the investments intended to replace one element of the building, according to the estimated lifecycle over the calculation period;
- the updated maintenance costs: the costs required to maintain and look after the building over time;
- the updated residual value: the sum of the residual values of the elements of the building at the end of the calculation period. The residual value shall be determined by a straight-line depreciation of the initial investment or replacement cost of a given building element until the end of the calculation period discounted to the beginning of the calculation period.

The overall cost shall be calculated using the following formula:

$C_g(\tau) = C_I + \sum_{t=1}^{T} \frac{C_t}{(1+a)^t} + \frac{V_t}{(1+a)^T}$	Where C_g: overall cost C_I: investment cost C_t: all annual costs a: discount rate in % V_t: residual value

The energy efficiency of buildings is defined by calculating the conventional annual consumption of the building using the Th-C-E Ex regulatory calculation engine.

3.1.3 *Calculation assumptions*

The assumptions used to calculate the overall cost are as follows:

- calculation duration: 15 and 30 years;
- discount rate: 4%[5];
- price of energy: obtained using the Pégase database (Oil, Electricity, Gas and Other Energy Statistics) (average 2016 data);

[5] The Commission's guidelines on impact analysis suggest a social discount rate of 4%.

- electricity: EUR 0.2021 incl. taxes/kWh (final energy);
- gas: EUR 0.0639 incl. taxes/kWh (final energy);
- energy inflation rate: 4% (from the Pégase database, average energy growth rate for the period 2005–2015 after correction of general price inflation);
- investment costs: the costs of the works came from the database of construction prices (Batichiffrage, Batitel and Batiprix), value date: December 2016;
- maintenance costs: maintenance costs are calculated using a percentage of the investment cost from the NF EN 15459 standard on the energy efficiency of buildings;
- replacement costs: replacement costs correspond to the updated investment costs, considering that equipment or a part is replaced with an identical item at the end of its lifespan[6];
- VAT: 10% for housing according to the Tax Code article 278-0a;
- 20% for offices.

3.1.4 *Calculation of financial aid*

The profitability of the works scenarios was calculated taking into account the national public financial aid available during the initial investment. Local and national assistance specifically for low-income and very-low-income households (the Live Better programme of the National Housing Agency, ANAH) and European aid have not been included in the calculation.

Aid for housing	
Energy transition tax credit (CITE)	- single rate of 30% on eligible expenditure; - eligible works must meet the efficiency criteria defined in article 18a of annex IV of the General Tax Code; - eligible expenditure corresponds to the cost of equipment (except for thermal insulation works on opaque walls for which the cost of installation is included in eligible expenditure); - for our study, we have considered that the housing was occupied by a married or civilly partnered couple and that the limit of eligible expenditure is EUR 16,000.
Reduced rate VAT	- 5.5% applied to energy renovation works (supply and installation) performed in housing premises and completed over two years ago; - eligible works must meet the performance criteria defined in article 18a of annex IV of the General Tax Code.
Energy savings certificates	- calculated using the standardised sheets for the third period of the residential building sector.

Details of the aid for residential buildings

[6] The lifespans of equipment and parts are taken from the NF EN 15459 standard

Aid for tertiary buildings	
Energy savings certificates	- calculated using the standardised sheets for the third period of the tertiary building sector.

Details of the aid for tertiary buildings

3.2 Renovation of a one-dwelling building that uses gas

3.2.1 *Description*

The house studied is a one-dwelling building heated using gas with three bedrooms that was constructed in 1955. Its living surface area is 92 m^2 split over two levels plus a non-converted loft. The ceiling height of the ground floor is 2.60 m and that of the first floor is 2.52 m. The house was extended in 1980.

It is located in an H2b climate zone.

3.2.2 *Characteristics:*

- Walls from 1955: 25 cm hollow bricks without insulation
- Walls from 1980: 18 cm hollow bricks with 6 cm polystyrene insulation
- Roof: not insulated
- Floor of the loft: not insulated
- Lower floor (between the ground floor and the cellar): 4 cm glass wool insulation
- Windows: wooden frame, single glazed
- Heating: gas boiler from the 1980s, steel radiators from the 1980s
- Domestic hot water: provided by the boiler using a storage system
- Ventilation: natural.

As the part of the house that dates from 1955 is not insulated, it experiences significant thermal loss. In addition, the heating equipment is old and inefficient. This is why the house needs to be renovated to improve its energy efficiency and increase user comfort, reducing energy consumption and therefore the cost of bills.

Before the works, the conventional energy consumption of the dwelling was evaluated at 307.44 kWh(primary energy)/m^2/year, which is an annual energy bill of around EUR 2,692.

3.2.3 *Works:*

Scenario 1: installation of a ventilation system and roof insulation.

Ventilation: Single-flow humidity-sensitive mechanical extract ventilation B with low-consumption 11 W casing, air inlets installed in windows and extraction units in bathrooms equipped with humidity-sensitive parts.

Roof: insulation between rafters with 16 cm of glass wool (R = 4.55 m^2*K/W).

Scenario 1	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Breakdown	EUR 2,004	EUR 20
Roof	EUR 4,388	EUR 0

Details of the investment costs of scenario 1 (one-dwelling building from 1955)

Following the works from scenario 1, energy consumption stands at 267.34 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 2,344 all taxes included, which is a saving of 13% in relation to the initial situation.

Scenario 2: insulation in the roof and replacement of the boiler with a programming system.

Roof: insulation between rafters with 16 cm of glass wool (R = 4.55 m^2*K/W).

Heating: replacement of the old boiler with a condensing boiler and domestic hot water micro-storage.

Regulation: installation of a timer with temperature control.

Scenario 2	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Roof	EUR 4,388	EUR 0
Heating	EUR 2,115	EUR 85
Regulation	EUR 190	EUR 0

Details of the investment costs of scenario 2 (one-dwelling building from 1955)

Following the works of scenario 2, energy consumption stands at 170.94 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 1,499 all taxes included, which is a saving of 44 % in relation to the initial situation.

Scenario 3: wall and roof insulation, replacement of the boiler with a programming system, installation of a ventilation system.

Walls: external insulation with 14 cm of expanded polystyrene (R = 3.65 m^2*K/W).

Roof: insulation between rafters with 20 cm of glass wool (R = 5.7 m^2*K/W).

Heating: replacement of the old boiler with a condensing boiler and domestic hot water micro-storage.

Regulation: installation of a timer with temperature control.

Ventilation: Single-flow humidity-sensitive mechanical extract ventilation B with low-consumption 11 W casing, air inlets installed in windows and extraction units in bathrooms equipped with humidity-sensitive parts.

Scenario 3	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Walls	EUR 22,365	EUR 0
Roof	EUR 4,498	EUR 0
Heating	EUR 2,115	EUR 85
Regulation	EUR 190	EUR 0
Breakdown	EUR 2,004	EUR 20

Details of the investment costs of scenario 3 (one-dwelling building from 1955)

Following the works of scenario 3, energy consumption stands at 104.59 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 924 all taxes included, which is a saving of 67 % in relation to the initial situation.

3.2.4 *Results:*

The overall cost was calculated for a period of 30 years and a period of 15 years for each scenario, taking into account the aid described above.

The total updated overall cost of energy consumption for the house over 30 years is EUR 80,752 or EUR 878/m^2 of living surface area and over 15 years it is EUR 40,376 or EUR 439/m^2 of living surface area inclusive of tax.

	One-dwelling building using gas		
	Scenario 1	Scenario 2	Scenario 3
	Roof + ventilation	Roof + heating + regulation	Roof + walls + heating + regulation + ventilation
Energy performance analysis			
Primary energy coefficient (kWh$_{(primary\ energy)}$/m^2/year)	267.34	170.94	104.59
Profit on energy bill (in EUR)	EUR 347	EUR 1,193	EUR 1,768
Profit on energy bill (in %)	**13%**	**44%**	**67%**
Analysis of the investment cost			
Investment cost (EUR, all taxes included)	EUR 6,392	EUR 6,693	EUR 31,172
Amount of aid	EUR 112	EUR 908	EUR 7,928
Remainder to pay (investment cost - amount of aid) EUR/m^2 of living surface area	**EUR 68/m²**	**EUR 63/m²**	**EUR 253/m²**
Analysis of the overall cost over 30 years			
Overall cost (in EUR inclusive of tax)	EUR 76,578	EUR 54,177	EUR 53,508
Overall cost (in EUR inclusive of tax/m^2 of living surface area)	**EUR 832/m²**	**EUR 589/m²**	**EUR 582/m²**

Analysis of the overall cost over 15 years			
Overall cost (in EUR inclusive of tax)	EUR 40,042	EUR 27,084	EUR 28,403
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 435/m²**	**EUR 294/m²**	**EUR 309/m²**

Details of the results in the case of the one-dwelling building from 1955 using gas

It can be noted that the cost of investment is much higher in the case of deep renovations, but it is the most cost-efficient scenario over the lifespan of the building. Installing very efficient equipment and insulating walls properly significantly reduces energy bills, and therefore makes long-term savings despite the very high cost of investment.

Moreover, scenario 3 will also have a significant impact firstly on the comfort of the building's occupants and secondly on the market value of the property (change from energy label class E to C).

During the investment, the remainder to pay in scenario 3 is large despite the aid available (EUR 253/m² of living surface area). Nevertheless, the energy renovation work can be scheduled to take place during renovation work that would have been necessary in any case to ensure the longevity of the building (changing the boiler, restoration of the façade).

Let's look at the effect of carrying out energy efficiency works at the same time as major maintenance in the case of this one-dwelling building. For this, we will create a 'maintenance' scenario for which we will assume that the household needs to carry out restoration works on the facade and also change the boiler. In this scenario, a significant improvement to energy efficiency will not be taken into account (no insulation in the facade, and the boiler installed is low temperature and corresponds to the minimum of the current standard).

We will then compare this scenario with scenario 3 which integrates these works, but for which energy efficiency of the elements is markedly improved.

Refurbishment works	Details	Investment cost
Heating	Changing the existing boiler for a low-temperature boiler [7]	EUR 1,600 excluding taxes
Walls	Refurbishment of the facade	EUR 12,070 excluding taxes

	One-dwelling building using gas	
	Maintenance scenario	Scenario 3
	Low-temperature boiler + refurbishment of the facade	Roof + walls (refurbishment + external thermal insulation) + heating (condensing boiler) + regulation + ventilation
Energy performance analysis		
Primary energy coefficient ($kWh_{(primary\ energy)}/m^2/year$)	207.94	104.59
Profit on energy bill (in EUR)	EUR 870	EUR 1,768

[7] It impossible to replace the boiler with an identical one, as the technology used in the 1980s is no longer available on the market. Installing a new boiler then means that some improvement in energy efficiency 'obliged' by the products available is inevitable.

Profit on the energy bill (in %) in relation to the scenario without works	**32 %**	**67%**
Profit on the energy bill (in %) in relation to the maintenance scenario	*/*	***49 %***
Analysis of the investment cost		
Investment cost (EUR, all taxes included)	EUR 15,037	EUR 31,172
Amount of aid	EUR 0	EUR 7,928
Remainder to pay (investment cost - amount of aid) EUR/m² of living surface area	**EUR 163/m²**	**EUR 253/m²**
Overinvestment due to energy efficiency		**EUR 90/m²**

Details of the results in the case of the one-dwelling building from 1955 taking maintenance into account

In this configuration of carrying out energy efficiency works during major maintenance, for scenario 3 the overinvestment due to energy efficiency is EUR 90/m² of living surface area (EUR 8,207 all taxes included).

This reflection on improving the thermal efficiency of a building during maintenance works led to the measure on piggy-back works being put in place in the Energy Transition for Green Growth Law. Decree no 2016-711 of 30 May 2016 makes it mandatory from 1 January 2017 to carry out works to improve the thermal efficiency of buildings, under certain conditions, when carrying out deep refurbishment works (works to refurbish facades, repair roofs or change premises to make them habitable).

3.3 Renovation of a one-dwelling building with joule heating

3.3.1 *Description and characteristics*

Net surface area = 104 m² Living surface area = 95 m² Bungalow Year of construction: 1975-1985 Walls: concrete blocks fully insulated with 4 cm of mineral wool. Roof: non-convertible loft insulated with 8 cm of mineral wool. Lower flooring: laid over void insulated by 4 cm mineral wool. Windows: single glazing with wooden frame. Heating: electric (convectors) Domestic hot water: individual electric hot water heater. Ventilation: self-regulating mechanical extract ventilation. Initial primary energy coefficient =	

468.73 kWh(primary energy)/m²/year Energy bill before the works: EUR 3,819	

Recommended works	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Roof: insulation of the flooring of non-convertible lofts with 30 cm mineral wool (R = 7.5 m^2/K/W).	EUR 2,660	0
Heating: installation of an air-to-air heat pump with inverter technology + timer and temperature control.	EUR 13,608	EUR 537
Domestic hot water: installation of a thermodynamic water heater using energy extracted from the air.	EUR 4,116	EUR 165
Ventilation: installation of single-flow humidity-sensitive mechanical extract ventilation.	EUR 2,004	EUR 20

Details of the works for the one-dwelling home from 1975 with Joule heating

The total updated overall cost of energy consumption for the house over 30 years is EUR 114,557 or EUR 1,209/m^2 of living surface area and over 15 years it is EUR 57,279 or EUR 603/m^2 of living surface area inclusive of tax.

	One-dwelling buildings with joule heating		
	Scenario 1	Scenario 2	Scenario 3
	Heating + regulation	Heating + regulation + domestic hot water	Heating + regulation + domestic hot water + roof + ventilation
Energy performance analysis			
Primary energy coefficient (kWh(primary energy)/m²/year)	196.89	144.39	110.94
Profit on energy bill (in EUR)	EUR 2,215	EUR 2,643	EUR 2,915
Profit on energy bill (in %)	**58 %**	**69 %**	**76 %**
Analysis of the investment cost			
Investment cost (EUR, all taxes included)	EUR 14,969	EUR 19,496	EUR 24,627
Amount of aid	EUR 4,601	EUR 5,921	EUR 6,499
Remainder to pay (investment cost - amount of aid) EUR/m² of living surface area	**EUR 109/m²**	**EUR 143/m²**	**EUR 190/m²**
Analysis of the overall cost over 30 years			
Overall cost (in EUR inclusive of tax)	EUR 85,640	EUR 81,662	EUR 77,518

Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 901/m²**	**EUR 860/m²**	**EUR 816/m²**
Analysis of the overall cost over 15 years			
Overall cost (in EUR inclusive of tax)	EUR 46,948	EUR 43,240	EUR 42,324
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 494/m²**	**EUR 455/m²**	**EUR 446/m²**

Details of the results in the case of the one-dwelling building from 1975 with joule heating

The very efficient renovation included in scenario 3 (construction + system) leads to an energy profit of 76% for an investment cost of EUR 18,050 inclusive of tax.

The analysis of the overall costs shows us that scenario 3 is the most cost efficient over 15 and 30 years. Moreover, scenario 3 will also have a significant impact firstly on the comfort of the building's occupants, in particular due to the installation of ventilation, and secondly on the market value of the property (change from energy label class G to C).

3.4 Renovation of an apartment block from the 60s

3.4.1 *Description*

The apartment block studied is a building constructed in the 60s. It contains 81 dwellings. Its living surface area measures 4,035 m² spread over 10 floors. Its ceiling is 2.70 m high.

This building has gas-fired shared heating, single-glazed wooden windows and non-insulated opaque walls.

It is located in an H2b climate zone.

3.4.2 *Characteristics:*

- Net surface area = 4,560 m²
- Walls: non-insulated shuttered concrete walls
- Roof: non-insulated flat roof
- Lower flooring: over a cellar, not insulated
- Windows: single glazing with PVC frame
- Heating: gas boiler from the 1980s, water radiators, loop system for shared production
- Domestic hot water: supplied by the boiler
- Ventilation: natural.

Before the works, the conventional energy consumption of the dwelling was evaluated at 219.69 kWh(primary energy)/m²/year, which is an annual energy bill of around EUR 64,555.

3.4.3 *Works:*

Scenario 1: Replacement of the boiler

Heating: Replacement of the old installation with two 350 kW condensing boilers.

Scenario 1	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Heating	EUR 43,084	EUR 1,723

Details of the investment costs of scenario 1 (apartment block from the 1960s)

Following the works of scenario 1, energy consumption stands at 167.72 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 49,334 all taxes included, which is a saving of 24 % in relation to the initial situation.

Scenario 2: Replacement of the boiler and roof insulation

Heating: Replacement of the old installation with two 350 kW condensing boilers.

Walls: External insulation under a coating with 14 cm stone wool (R = 3.85 m².K/W).

Scenario 2	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Heating	EUR 43,084	EUR 1,723
Walls	EUR 612,535	0

Details of the investment costs of scenario 2 (apartment block from the 1960s)

Following the works of scenario 2, energy consumption stands at 100.59 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 29,731 all taxes included, which is a saving of 54 % in relation to the initial situation.

Scenario 3: Replacement of the boiler, roof insulation, wall insulation and refurbishment of the ventilation system.

Heating: Replacement of the old installation with two 350 kW condensing boilers.

Roof: External insulation with 16 cm of polystyrene (R = 6.95 m².K/W).

Walls: External insulation under a coating with 14 cm stone wool (R = 3.85 m².K/W).

Ventilation: Putting in place natural humidity-sensitive ventilation B

Scenario 3	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Heating	EUR 43,084	EUR 1,723
Roof	EUR 93,492	EUR 0
Walls	EUR 612,535	EUR 0
Breakdown	EUR 64,296	EUR 643

Details of the investment costs of scenario 3 (apartment block from the 1960s)

Following the works of scenario 3, energy consumption stands at 77.14 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 22,887 all taxes included, which is a saving of 65 % in relation to the initial situation.

3.4.4 *Results:*

The overall cost was calculated for a period of 30 years and a period of 15 years for each scenario, taking into account the aid described above.

The total updated overall cost of energy consumption for the block over 30 years is EUR 1,936,637 or EUR 480/m^2 of living surface area and over 15 years it is EUR 968,318 or EUR 240/m^2 of living surface area inclusive of tax.

	Apartment block from the 1960s		
	Scenario 1	Scenario 2	Scenario 3
	Heating	Heating + walls	Heating + roof + walls + ventilation
Energy performance analysis			
Primary energy coefficient ($kWh_{(primary\ energy)}/m^2/year$)	167.72	100.59	77.14
Profit on energy bill (in EUR)	EUR 15,221	EUR 34,824	EUR 41,668
Profit on energy bill (in %)	**24 %**	**54 %**	**65 %**
Analysis of the investment cost			
Investment cost (EUR, all taxes included)	EUR 47,392	EUR 721,181	EUR 894,748
Amount of aid	EUR 24,889	EUR 275,118	EUR 312,782
Remainder to pay (investment cost - amount of aid) EUR/m^2 of living surface area	**EUR 6/m^2**	**EUR 111/m^2**	**EUR 144/m^2**
Analysis of the overall cost over 30 years			
Overall cost (in EUR inclusive of tax)	EUR 1,561,616	EUR 1,314,005	EUR 1,227,073
Overall cost (in EUR inclusive of tax/m^2 of living surface area)	**EUR 387/m^2**	**EUR 326/m^2**	**EUR 304/m^2**
Analysis of the overall cost over 15 years			
Overall cost (in EUR inclusive of tax)	EUR 757,274	EUR 624,905	EUR 610,679
Overall cost (in EUR inclusive of tax/m^2 of living surface area)	**EUR 188/m^2**	**EUR 155/m^2**	**EUR 151/m^2**

Details of the results in the case of the apartment block from the 1960s

For this apartment block, it appears that scenario 3 that corresponds to very efficient renovation works proves the most cost efficient in terms of overall cost over 15 and 30 years. The savings generated thanks to the works from scenario 3 compensate for the investment, which is however significant (around EUR 11,000 per dwelling) at 18 times more costly than scenario 1 without the aid. This cost effectiveness is improved thanks to financial aid that represents a large part of the investment cost.

3.5 *Renovation of an apartment block with large amounts of glass*

3.5.1 *Description and characteristics*

- Net surface area = 786m²
- Living surface area = 700m²
- 7 floors
- Year of construction: 1970
- 14 apartments
- Walls: non-insulated full concrete
- Roof: non-insulated flat roof
- Windows: single glazing with aluminium frames
- Heating: shared gas boiler
- Domestic hot water: supplied by the boiler
- Ventilation: natural.

Initial primary energy coefficient = 291.16 kWh(primary energy)/m^2/year

Energy bill before the works: EUR 14,724

3.5.2 *Works*

Recommended works	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
<u>Walls</u>: external insulation with 14 cm of glass wool (R = 4 m².K/W).	EUR 76,990	0
Roof: external insulation with 12 cm of polyurethane (R = 5.2 m².K/W).	EUR 10,998	0
Windows: replacement of the windows with double-glazed windows with an aluminium frame, argon gas and thermal bridge prevention, 4/16/4 glazing with reinforced insulation - Uw = 1.7 W/m².K without shutters	EUR 145,982	EUR 1,460
Heating: installation of a condensing boiler	EUR 26,500	EUR 795

Details of works for the building with a large amount of glass

The total updated overall cost of energy consumption for the building over 30 years is EUR 441,722 or EUR 631/m^2 of living surface area and over 15 years it is EUR 220,861 or EUR 316/m^2 of living surface area inclusive of tax.

	Apartment block with a large amount of glass		
	Scenario 1	Scenario 2	Scenario 3
	Windows	Windows + heating	Windows + heating + roof + walls + ventilation
Energy performance analysis			
Primary energy coefficient (kWh$_{(primary\ energy)}$/m²/year)	251.13	162.96	68.48
Profit on energy bill (in EUR)	EUR 2,007	EUR 6,441	EUR 11,201
Profit on energy bill (in %)	**14 %**	**44 %**	**76 %**
Analysis of the investment cost			
Investment cost (EUR, all taxes included)	EUR 160,580	EUR 189,730	EUR 293,482
Amount of aid	EUR 29,573	EUR 40,355	EUR 77,486
Remainder to pay (investment cost - amount of aid) EUR/m^2 of living surface area	**EUR 187/m²**	**EUR 213/m²**	**EUR 308/m²**
Analysis of the overall cost over 30 years			
Overall cost (in EUR inclusive of tax)	EUR 560,901	EUR 477,569	EUR 389,069
Overall cost (in EUR inclusive of tax/m^2 of living surface area)	**EUR 801/m²**	**EUR 682/m²**	**EUR 555/m²**
Analysis of the overall cost over 15 years			
Overall cost (in EUR inclusive of tax)	EUR 303,944	EUR 249,345	EUR 206,291
Overall cost (in EUR inclusive of tax/m^2 of living surface area)	**EUR 434/m²**	**EUR 356/m²**	**EUR 295/m²**

Details of the results in the case of the apartment block with large amounts of glass

The renovation of the windows incurs a very high investment cost (over EUR 10,000 per dwelling despite public aid) for a profit of 14% on the energy bill. However, this renovation also has a very significant impact on the comfort of the occupants. Indeed, the old windows were not properly sealed, which lead to currents of air and cold walls, which were sources of discomfort. The refurbishment of the windows also increases the asset value of the property.

The analysis of the overall cost, notably taking into account the residual value, leads to the conclusion that scenario 3 (very efficient renovation works) appears the most cost effective over 15 and 30 years.

3.6 *Renovation of an office building*

3.6.1 *Details*

The building studied is a large office that was constructed in 1976. Its living surface area measures 5,0342 m^2 spread over five floors (ground floor + 4). Its ceiling is 3 m high. It is located in an H2b climate zone.	

3.6.2 *Characteristics:*

- Walls: prefabricated concrete 25 cm thick without insulation
- Flat roof: concrete slab 20 cm thick without insulation
- Lower flooring: concrete slab 20 cm thick without insulation
- Windows: single-glazed PVC
- Heating: two shared gas boilers from 1976, water radiators
- Ventilation: single-flow self-regulating mechanical extract ventilation
- Lighting: 18 W compact fluorescent tubes.

As the buildings dates from before the first thermal regulation that applies to tertiary buildings, its thermal properties are inefficient. In addition, the heating equipment is old and inefficient. This is why the building needs to be renovated to improve its energy efficiency and also increase user comfort, reducing energy consumption and therefore the cost of bills.

Before the works, the conventional energy consumption of the building was evaluated at 162.68 kWh(primary energy)/m^2/year, which is an annual energy bill of around EUR 57,466.

3.6.3 *Works:*

<u>Scenario 1</u>: replacement of the boilers with a programming system

<u>Heating</u>: replacement of the old boilers with two condensing boilers.

<u>Regulation</u>: installation of a timer with temperature control.

Scenario 1	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Heating (for the two boilers)	EUR 36,154	EUR 542
Regulation	EUR 190	EUR 0

Details of the investment costs of scenario 1 (office building)

Following the works of scenario 1, energy consumption stands at 136.12 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 48,740 all taxes included, which is a saving of 15 % in relation to the initial situation.

Scenario 2: insulation in the roof and replacement of the boiler with a programming system

Roof: inverted insulation with 14 cm of extruded polystyrene (R = 4.5 m^2.K/W).

Heating: replacement of the old boilers with two condensing boilers.

Regulation: installation of a timer with temperature control.

Scenario 2	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Roof	EUR 126,270	EUR 0
Heating	EUR 36,154	EUR 542
Regulation	EUR 190	EUR 0

Details of the investment costs of scenario 2 (office building)

Following the works of scenario 2, energy consumption stands at 122,46 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 44,321 all taxes included, which is a saving of 23 % in relation to the initial situation.

Scenario 3: wall insulation, replacing the boilers with a programmable system, replacing the lighting systems

Walls: internal insulation with 12 cm of mineral wool (R = 3.75 m^2.K/W).

Heating: replacement of the old boilers with two condensing boilers.

Regulation: installation of a timer with temperature control.

Lighting: putting in place T5 fluorescent tubes (8 W/m^2) with a motion detector.

Scenario 3	*Investment cost* (EUR excl. taxes)	*Annual maintenance cost* (EUR excl. taxes)
Walls	EUR 190,464	EUR 0
Heating	EUR 36,154	EUR 542
Regulation	EUR 190	EUR 0
Lighting	EUR 133,714	EUR 2,674

Details of the investment costs of scenario 3 (office building)

Following the works of scenario 3, energy consumption stands at 82.82 kWh(primary energy)/m^2/year and the energy bill amounts to EUR 28,809 all taxes included, which is a saving of 50 % in relation to the initial situation.

3.6.4 *Results:*

The overall cost was calculated for a period of 30 years and a period of 15 years for each scenario, taking into account the aid described above.

The total updated overall cost of energy consumption for the office building over 30 years is EUR 1,723,975 or EUR 342/m² of living surface area and over 15 years it is EUR 861,988 or EUR 171/m² of living surface area inclusive of tax.

	Shared office building		
	Scenario 1	Scenario 2	Scenario 3
	Heating + regulation	Roof + heating + regulation	Walls + heating + regulation + lighting
Energy performance analysis			
Primary energy coefficient ($kWh_{(primary\ energy)}/m^2/year$)	136.12	122.46	82.82
Profit on energy bill (in EUR)	EUR 8,726	EUR 13,145	EUR 28,657
Profit on energy bill (in %)	**15%**	**23%**	**50%**
Analysis of the investment cost			
Investment cost (EUR, all taxes included)	EUR 36,344	EUR 162,614	EUR 360,522
Amount of aid	EUR 6,993	EUR 13,996	EUR 24,294
Remainder to pay (investment cost - amount of aid) EUR/m² of living surface area	**EUR 6/m²**	**EUR 29/m²**	**EUR 67/m²**
Analysis of the overall cost over 30 years			
Overall cost (in EUR inclusive of tax)	EUR1,523,445	EUR 1,523,722	EUR 1,506,163
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 302/m²**	**EUR 302/m²**	**EUR 299/m²**
Analysis of the overall cost over 15 years			
Overall cost (in EUR inclusive of tax)	EUR 769,025	EUR 794,678	EUR 852,467
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 153/m²**	**EUR 158/m²**	**EUR 169/m²**

Details of the results in the case of the shared office building

The most profitable solution is indeed the most efficient renovation. Although the difference between the different scenarios in terms of overall cost over 30 years is slight, energy efficiency is improved markedly in scenario 3 as it enables 50% savings to be made on each year's energy bills, in comparison with the building in its current state.

3.7 Reaching the 'low-consumption building' level in stages

The Energy Transition for Green Growth Law sets the programmatic objective that by 2050, France must have building stocks that have been entirely renovated according to the 'low-consumption building' standards or equivalent. From the cases discussed above, only two buildings reached this level of efficiency: the two apartment blocks with consumption in scenario 3 of under 80 kWh(primary energy)/m^2/year.

In this section, for each of the three buildings that did not reach the low-consumption building level, we will look at the additional steps needed to reach it.

The following table presents the results for the two one-dwelling buildings:

	One-dwelling building using gas		One-dwelling buildings with joule heating	
	Scenario 3 *as a reminder*	'Low-consumption building' scenario	Scenario 3 *as a reminder*	'Low-consumption building' scenario
	Roof + walls + heating + regulation + ventilation	Roof + walls + heating + regulation + ventilation + lower flooring	Heating + regulation + domestic hot water + roof + ventilation	Heating + regulation + domestic hot water + roof + ventilation + walls + windows
Energy performance analysis				
Primary energy coefficient (kWh(primary energy)/m²/year)	104.59	79.7	110.94	79.4
Profit on energy bill (in EUR)	EUR 1,768	EUR 1,985	EUR 2,915	EUR 3,172
Profit on energy bill (in %)	**67%**	**74%**	**76%**	**83%**
Analysis of the investment cost				
Investment cost (EUR, all taxes included)	EUR 31,172	EUR 42,538	EUR 24,627	EUR 47,747
Amount of aid	EUR 7,928	EUR 8,946	EUR 6,499	EUR 8,004
Remainder to pay (investment cost - amount of aid) EUR/m² of living surface area	**EUR 253/m²**	**EUR 365/m²**	**EUR 190/m²**	**EUR 418/m²**
Analysis of the overall cost over 30 years				
Overall cost (in EUR inclusive of tax)	EUR 53,508	EUR 53,219	EUR 77,518	EUR 98,436
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 582/m²**	**EUR 579/m²**	**EUR 816/m²**	**EUR 1036/m²**
Analysis of the overall cost over 15 years				
Overall cost (in EUR inclusive of tax)	EUR 28,403	EUR 29,176	EUR 42,324	EUR 57,263

Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 309/m²**	**EUR 317/m²**	**EUR 446/m²**	**EUR 603/m²**

Details of the results of striving for the low-consumption building level in one-dwelling buildings

It can be noted in the case of the one-dwelling building with gas that the low-consumption building level could be reached by insulating the lower flooring of the dwelling (there is a cellar). The overall cost over 50 years would then be very close that scenario 3, but the remainder of the investment to be paid by the household is greatly increased by around EUR 10,000.

In the case of the house with Joule heating, the change in the overall cost is significant when attempting to reach the low-consumption building level, which involves putting in place insulation in the walls and replacing the woodwork.

The following table presents the results for the tertiary office building:

	Tertiary office building	
	Scenario 3 *as a reminder*	'Low-consumption building' scenario
	Walls + heating + regulation + lighting	Walls + heating + regulation + lighting+ roof +lower flooring + windows + ventilation
Energy performance analysis		
Primary energy coefficient (kWh(primary energy)/m²/year)	82.82	47.23
Profit on energy bill (in EUR)	EUR 28,657	EUR 39,323
Profit on energy bill (in %)	**50%**	**68%**
Analysis of the investment cost		
Investment cost (EUR, all taxes included)	EUR 360,522	EUR 1,770,041
Amount of aid	EUR 24,294	EUR 46,221
Remainder to pay (investment cost - amount of aid) EUR/m² of living surface area	**EUR 67/m²**	**EUR 342/m²**
Analysis of the overall cost over 30 years		
Overall cost (in EUR inclusive of tax)	EUR 1,506,163	EUR 2,392,771
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 299/m²**	**EUR 475/m²**
Analysis of the overall cost over 15 years		
Overall cost (in EUR inclusive of tax)	EUR 852,467	EUR 1,688,458
Overall cost (in EUR inclusive of tax/m² of living surface area)	**EUR 169/m²**	**EUR 335/m²**

Details of the results of trying to reach the low-consumption building level for the tertiary office building

This section consisted of outlining the profitable approaches to renovation in order to reach high levels of efficiency while representing a financial profit over 30 years for the household or property manager. Efficiency is therefore the watchword. However, it has not always been possible to achieve the low-consumption building level at a managed cost with the most common clusters of works on the buildings studied. This should nevertheless be qualified by taking into account the limits that are due on the one hand to the fact that the analysis was very limited in scope (only five buildings were chosen for this study) and on the other hand to the starting assumptions used. In fact, these calculations were made taking into account only the technologies and incentive measures that are currently available. This assessment leads us to imagine new modes of financing that take into account the levels reached after renovation works. Such is the framework of the report on article 14 of the Energy Transition for Green Growth Law which must study "the means for replacing all the fiscal aid linked with the installation of certain construction products with an overall form of aid, the granting of which would be subject to, for each building, the presentation of a completed project of renovation, if applicable organised in stages." New technology and renovation methods will appear over the next 30 years which will lead to all the scenarios above, and in particular the costs they represent, being reviewed.

It should nevertheless be highlighted that reaching the low-consumption building level is economically profitable for a part of the stock which may henceforth be brought to reach this level through general renovation works or renovation in stages. The rest of the stock may, through initial renovation work, be prepared to reach this level while awaiting technical evolutions and changes to incentives to come that will help bring it to fruition.

These assessments lead to the proposal to monitor the renovation works by analysing real projects. This monitoring should lead to a better understanding of the real costs of the different actions taken to improve the energy efficiency of the buildings, capitalising on feedback on the technical choices and the innovative procedures used, as well as a measurement of the learning effects and their impact on the total investment cost of renovation to bring a building to low-consumption building level. This monitoring requires that all the stakeholders in the sector mobilise to provide reliable information including project owners, consultancy firms, co-owner and owner syndics and co-ownership associations.

Consequently, profitability thresholds should also be monitored over the long term. Here, we evaluate this profitability in relative terms, in comparison with the costs incurred by the occupation of the building over 30 years in the absence of any renovation work. It is conceivable that this evaluation could go further still by identifying and diversifying the main determiners of costs (for example, energy prices, length of observation, discount rate), then by monitoring, over a large number of projects, the levels of profitability (expressed in EUR/m^2) to then observe and analyse the trends and the influence of progression parameters.

3.8 Balance sheet

The cases studied have enabled cost-effective approaches to renovation to be identified by proving that clusters of works are indeed the most viable renovations in terms of the overall cost. In fact, the cost of investment is much higher in the case of deep renovations, but these are the most cost-efficient scenarios over the period of analysis. Installing very efficient equipment and insulating walls properly significantly reduces energy bills, and therefore makes long-term savings despite a high cost of investment. These clusters see work carried out both on the energy systems (heating, domestic hot water, ventilation and lighting) and on the building itself (walls and roof). For housing, the works were selected in line with the most common choices made by households (source: the OPEN survey, 2015 campaign).

The results of the simulations show that:

- the most efficient renovations enable (clusters of works) to make very significant energy savings, with a reduction in the energy bill of between 50% and 76%;
- the difference in overall cost between scenarios 2 and 3 is sometimes low over 30 years, from 1 to 5% in most cases, while the difference in investment cost can be much bigger (for example, for one-dwelling buildings with gas, the difference between the overall cost over 30 years between scenario 2 and 3 is only EUR 669, which the investment cost is over three times greater);
- In the residential sector, financial assistance (CITE, CEE, VAT at 5.5%) has a significant impact on investment capacity, hence the importance of guiding and informing households. For private housing,

the costs to be borne can prove very high (EUR 20,000 to 25,000 for a single-family home), which points to the need to phase projects in order to reach the highest efficiency levels, similar to the step-by-step approach to achieving level BBC.

As regards the methodology applied, there are a number of reasons why this approach should be seen more as a form of guidance and decision-making aid than as a presentation of the best renovation strategies:

- The major influences affecting economic assumptions, in particular the discount rate and the energy inflation rate: as fluctuations in the price of energy are difficult to predict, this may affect the results.
- The use of conventional consumption rather than actual consumption, which does not necessarily correspond to user behaviour: the rebound effect, which involves users changing their behaviour following a renovation, is not taken into account in this study.
- The simulations carried out for five types of building make it difficult to generalise the findings to the entire building stock: the results are dependent on the geographic zone in which the building is located (climate zone) and all of the architectural and technical properties of the building. As such, the cases presented here, although they are representative of the French building stock, cannot be generalised to the entirety of the existing stock.

In order to gain a broader overview, the cost-effectiveness approach would have to be accompanied by consideration of the asset value of the property after renovation (green value), the environmental impact in monetary terms and perhaps even the benefits brought about for occupants. Several studies have demonstrated the benefits in terms of occupant satisfaction and asset value for buildings having undergone an energy efficiency upgrade:

- according to the OPEN 2015 study, the majority of people having carried out energy efficiency upgrading note an improvement in thermal comfort;
- the evaluation of energy efficiency upgrading projects in residential properties (ERDF funding) in the Nord-Pas-de-Calais region carried out by Cerema Nord-Picardie (2014–2017) resulted in the conclusion that renovated homes demonstrate good hydrothermal comfort conditions; a measurement campaign indicated that the temperature and relative humidity in such homes are in the optimal comfort region of the hydrothermal comfort diagram.

The Dinamic study from October 2015 demonstrates the impact of energy performance ratings on the selling price of homes (data obtained from the notarial databases BIEN and PERVAL): houses with a DPE A/B rating sell for 5% to 10% more than houses with a DPE D rating, depending on the region.

4 Policies and measures in support of building renovation

Law No 2015-992 of 17 August 2015 on the energy transition in support of green growth (LTECV) sets ambitious objectives for the building sector:

- Article 1: ensure that all buildings in the building stock are renovated in line with the 'low consumption building' standards or similar by 2050.
- Article 3: perform energy efficiency upgrading of 500,000 homes per year starting in 2017, at least half of which must be low-income households.
- Article 5: by 2025, all private residential buildings with primary energy consumption of more than 330 kWh of primary energy per square metre, per year must have undergone energy efficiency upgrading.
- Article 17: impose more stringent obligations regarding upgrading work in the non-residential sector every 10 years.

National and local authorities have a number of potential initiatives at their disposal in order to achieve these objectives. These are illustrated in the following figure:

Possible initiatives that could be triggered by decision-makers

PP de la rénovation	Public Renovation Policy
Rénovation	Renovation
Suivi	Monitoring
Lutte contre la précarité	Combating insecurity
Actions des territoires	Regional actions
Accompagnement des ménages	Guidance for households
Accompagnement des professionnels	Guidance for professionals
Interventions exemplaires sur les bâtiments publics	Exemplary projects on public buildings
Aides	Financial support

In order to be effective, therefore, public renovation policy must:

1. provide specific support for households suffering from energy insecurity;
2. put in place effective regulatory measures: the LTECV has consolidated the regulatory framework with flagship measures for new and existing buildings;
3. support households with their renovation plans by providing useful, neutral, free advice country-wide: this can be done via the Public Service for Energy Efficiency of the Living Environment;
4. put in place financial support programmes tailored to the target group: households, social housing providers, local authorities, owners and managers of non-residential buildings;
5. provide guidance to professionals by offering training and by certifying their skills (RGE quality label);
6. set up initiatives tailored to individual regions;
7. propose specific actions for publicly managed buildings;
8. establish monitoring tools that allow both successes and pitfalls to be observed and analysed in order to come up with new solutions.

The following section is divided up according to these eight action areas.

4.1 Stepping up the fight against energy insecurity

Energy insecurity is broadly regarded as a key objective of the LTECV. Specific measures are in place, and have been intensified over the past few years, that contribute to this policy of combating energy insecurity.

The Convention between the State and the National Living Environment Agency (Anah) of 14 July 2010 resulted in the creation of a financial support programme for thermal renovation of private housing, entitled 'Living Better'. It aims to solve the problem of energy insecurity, which is estimated to affect 3.8 million households today. It is financed through the budgetary resources of the Anah and the thermal renovation fund (FART), for which EUR 483 million has been initially earmarked for the 2010–2017 period under the Future Investment Programme (PIA). The 'Living Better' programme is implemented via three types of actions: identifying situations to be addressed, diagnostics and technical, social and financial support, and finally financing of the work to be done. In 2013, a ruling was issued which adjusted the income thresholds for eligible owner-occupiers, thereby granting 45% of home-owners across the country access to funding (almost 7 million households). The objective set in 2015 to upgrade 50,000 homes has been achieved, with 49 706 homes having received support under the 'Living Better' programme. The objective for 2016 has been increased to 70,000 homes, with a target of 100,000 for 2017, 30,000 of which must be in commonhold.

The creation of a 'Living Better' zero-interest eco-loan in 2016 was intended to enable households to pay their share of the costs for energy efficiency upgrading under the 'Living Better' programme. All households eligible for support under the 'Living Better' programme are entitled to a 'Living Better' eco-loan, with the same conditions applying as under the 'Living Better' programme. The maximum loan amount that can be granted is EUR 20,000, and the loan is calculated on the basis of the amounts due for the work eligible for support, after deduction of the amount of funding provided under the 'Living Better' programme.

The creation of the energy efficiency upgrading guarantee fund (FGRE), provided for in the LTECV, aims to help finance energy efficiency upgrading work and to counteract banks' reluctance to lend to certain groups by providing a guarantee for 75% of individual eco-loans in accordance with income thresholds, and by providing a counter-guarantee covering 50% of group loans. Negotiations on the source of the FGRE budget are still ongoing.

In mid-2015, the LTECV put in place a new energy savings obligation in connection with the energy savings certificate initiative, which aims to support households suffering from energy insecurity. The principle behind this new obligation is to impose upon those bound by it a requirement to obtain energy insecurity CEEs ('PE' CEEs) equivalent to the volume of their insecurity obligation. These must be obtained by the end of 2017. In order to do so, those subject to the obligation may buy CEEs emanating from energy efficiency projects carried out in order to help disadvantaged households, or may directly or indirectly carry out such work themselves.

In order to further encourage vulnerable commonholds to carry out work, the Anah has been offering a new form of financing for engineering and construction work since 1 January 2017. The objective set for the 2017 period is for project planning procedures to be launched for 30,000 homes in commonholds that are considered as vulnerable. This new financial support is subject to the Agency's general rules on subsidies.

Moreover, for low-income households, the State finances all or part of domestic energy costs via the 'energy cheque'; this is currently being piloted in several regions, and is set to be rolled out country-wide in 2018.

Finally, an energy savings bonus aimed at financing energy efficiency upgrading of the most vulnerable households was launched in 2017. This special bonus is part of the energy efficiency certification scheme. The operation, which is set to last one year, aims to step up the fight against energy insecurity. Five operations in particular will be encouraged, including loft insulation and boiler replacement. Those who are subject to this obligation and who participate in the scheme will be eligible for a cheaper, fixed price energy efficiency certificate.

4.2 *Bolstering regulation in order to meet the objectives of the LTECV*

4.2.1 *Measures under the LTECV for existing buildings*

In order to meet these objectives, the LTECV provides for key measures for both new and existing buildings. The main measures aimed at encouraging renovation are summarised in the table below:

Measure	**Article of the law** **Codification**	**contents**
Extension of the ban on sales of energy-intensive social housing to single-family homes	Article 13 LTECV Article L. 443-7 of the Construction and Living Environment Code (CCH)	With a view to combating energy insecurity of households and in line with public policies currently in place in the field of energy efficiency of homes (in particular the aim to eradicate the most energy-intensive homes), the measure aims to extend the prohibition on selling high-consumption homes imposed on social housing associations to single-family homes.
Application of the measure on individual metering of heating costs to all apartment buildings with shared heating systems, unless technically infeasible or excessively costly due to the need to modify the entire system	Article 26 LTECV Article L. 241-9 of the Energy Code	The measure on individual metering of heating costs aims to raise awareness and foster a sense of responsibility among apartment building occupants when it comes to their energy consumption by calculating their energy bills on the basis of their own consumption. This consumption is determined by measuring devices installed in each home. Article 26 LTECV sets out the level of ambition in line with the objectives for reducing energy consumption and greenhouse gas emissions in the building sector. Implementing provisions, set out by decree and by rulings, have translated this ambition into a number of requirements: ▪ The measure applies to all multi-dwelling buildings with a shared heating system, unless technically infeasible or if this would entail excessive costs due to the need to modify the entire heating system. ▪ It is essential for occupants to be able to adjust the internal temperature of their apartment: radiators will therefore be equipped with temperature regulators

Measure	Article of the law Codification	contents
		(thermostatic valves). ▪ An order of priority has been set out for installing measuring devices, so that the most energy-intensive apartment buildings are equipped first, followed at a later stage by more efficient buildings. The most energy-intensive buildings (over 150 kWh/m^2/year in heating consumption) will therefore be equipped with devices by 31 March 2017. Subsequently, more efficient buildings will be equipped in phases: 31 December 2017 and 31 December 2019. ▪ The heating bill sent to occupants will be established partly on the basis of measured consumption (individual costs, 70% of the bill) and partly on the basis of the total consumption of the building (shared costs, 30% of the bill).
Obligation to carry out energy efficiency upgrading during certain renovation projects (façade renovation, re-roofing, renovation of rooms to make them habitable)	Article 14 LTECV Article L. 111-10 of the Construction and Living Environment Code	This measure allows opportunities arising during voluntary major renovation work to be seized in order to save costs by carrying out energy efficiency upgrading work at the same time, thereby reducing the energy consumption of the building. This obligation is subject to the prior decision of the contracting individual to carry out substantial renovation. Cost-effectiveness conditions have been defined. This provision contributes to the reduction of energy consumption in France, of the resulting greenhouse gas emissions and of the use of imported fossil fuels. It provides greater comfort for the occupants and users of the buildings in question, and supports economic activity in the construction sector by way of the demand for labour that it entails.
Inclusion of an energy efficiency criteria as a condition for rental of a property by its owner	Article 12 Article R. 111-1-1, R. 111-2 and R 111-6 CCH	The inclusion of an energy efficiency criterion as one of the conditions to be respected by property-owners wishing to rent their property should bring about a reduction in energy insecurity in the living environment as a result of the intrinsic characteristics of such properties. In this way, a home can be deemed not to meet energy efficiency requirements on the basis of the property itself, regardless of its mode of occupation and the cost of energy. Decree No 2002-120 of 30 January 2002 on decent housing characteristics sets out a qualitative definition of 'decent’ for each of the areas covered. It is being suggested that this approach be retained, with a focus on the main factors behind energy insecurity, namely: - air-tightness of doors and windows, and of external walls of the property or walls facing onto a non-heated area; - humidity linked to the properties of the building that may lead to abnormal energy consumption levels. In order to gradually step-up the requirement without distorting the rental market, it is proposed that the provision be gradually made more stringent between January

Measure	**Article of the law** **Codification**	**contents**
		and July 2018.
Obligation to improve the energy efficiency of existing non-residential buildings	Article 17 Articles R. 131-38 to R. 131-50 CCH In application of L. 111-10-3	The measure imposes energy efficiency improvements on existing non-residential buildings, and is prolonged by ten year periods as of 2020, with an increased efficiency level to be attained every decade until 2050. This will bring about efforts to reduce final energy consumption across the entire stock of affected buildings by at least 60% in 2050 as compared to 2010, with the objective of achieving 'low-consumption building' (BBC) status. The measure applies to office buildings, retail buildings, educational institutions and administrative buildings measuring over 2000 m^2. Every building must undergo an energy efficiency assessment, followed by the drawing up of an action plan aimed at reducing total energy consumption by 25% by 2020 and 40% by 2030.
Extend provisions on dedicated infrastructure for recharging electric or rechargeable hybrid vehicles for existing non-residential buildings	Article 41 Articles R. 136-1 and R. 136-4 in application of Article L. 111-5 CCH	The measure extends provisions on dedicated infrastructure for recharging electric or rechargeable hybrid vehicles and bicycle parking, which are currently applicable to existing non-residential buildings primarily serving as a place of work and which have dedicated parking spaces for employees under the CHH: 1 - to all habitations with individual parking spaces; 2 - to all industrial or commercial buildings with dedicated employee parking spaces; 3 - to buildings housing a public service with dedicated parking spaces for officials or users of the public service; 4 - to buildings constituting a commercial unit or housing film showings equipped with dedicated customer parking spaces. The provisions apply when any work is carried out on the associated car parks.

4.2.2 *New heating regulations for existing buildings as of 2017*

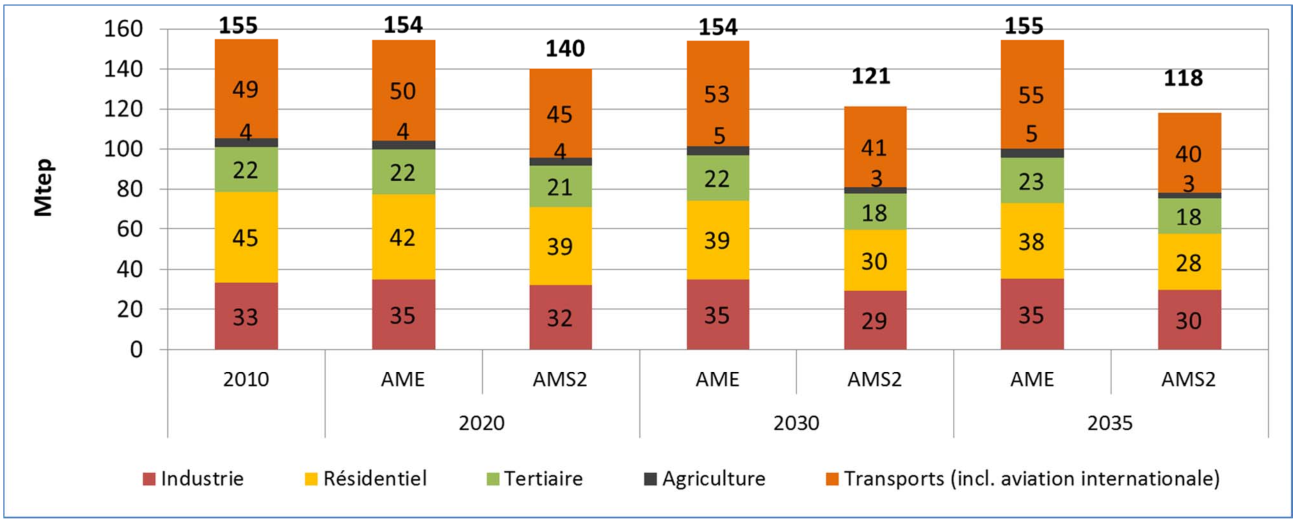
The Ruling of 3 May 2007 on the thermal characteristics and energy efficiency of existing buildings covers the minimum efficiency levels to be attained by each of the building components (insulation, windows, boilers, etc.) when they are put in place, installed or replaced.

In order to contribute to meeting the objectives of the LTECV and to accelerate the effects of renovation work, the level of ambition has been increased, and this ruling has undergone a revision. This revision introduced requirements that are stricter, in fact close to the most ambitious European levels, yet still feasible, in order to limit the financial impact on households and to allow professionals in the sector to grow their businesses.

4.2.3 *Regulatory aspects in need of improvement*

The measures taken by way of application of the LTECV will be monitored in order to evaluate their implementation. To this end, the monitoring tools presented in the sections below will constitute particularly rich sources of data. In addition, in the specific case of individual metering of heating costs, ex-post analyses will be performed with the support of the ADEME, in order to calculate the reduction in energy consumption. In the same area, surveys of commonhold managing agents and professionals will enable an analysis of take-up by property owners and the tangible effects of the measures.

Regarding the new measures to be implemented, the Energy – Climate – Air reference scenarios for France for the year 2035 allow an evaluation not of the nature, but of the effect of the measures to be taken in order for France to meet its commitments. The efforts to be made in terms of reducing energy demand in residential and non-residential buildings will also help work towards the objectives of the LTECV for the building sector:



Forecast final energy demand per sector and per scenario (source: summary of climate-air-energy scenarios)

Mtep	Mtep
AME	AME
AMS2	AMS2
Industrie	Industry
Résidentiel	Residential
Tertiaire	Tertiary
Agriculture	Agriculture
Transports (incl. aviation internationale)	Transport (incl. international aviation)

N.B.: the AMS2 scenario refers to hypotheses and modelling adopted during the drawing up of the National Low Carbon Strategy.

A regular evaluation of regulatory performance will be carried out in connection with market innovations and the resulting impact on the market and those affected in terms of environmental ambition when it comes to the living environment.

In connection with the transposition of Directive 2002/91/EC on the energy performance of buildings, France decided to draw up two pieces of legislation on heating in existing buildings, which represents a unique and ambitious step at European level: ‘element by element’ thermal regulations and global thermal regulations.

The revision of the global thermal regulations will be examined in order to further encourage the performance of simplified audits with a view to more systematic initiation of comprehensive renovations.

4.3 Better guidance for households carrying out renovation work

4.3.1 *Measures put in place*

Energy efficiency upgrading of existing residential properties is a primary concern, meaning that households must be encouraged to embark on renovation projects for their homes.

In order to inform private individuals about ways of reducing energy consumption by carrying out renovation work and about their daily consumption behaviour in their homes, a Public Service for Energy Efficiency Upgrading was set up, which provides information and neutral, free advice on legal, technical, regulatory and fiscal matters.

Since 2013, this consulting service for private individuals has been present across the country in the form of 450 Renovation Information Service Points, which together form the national one-stop-shop. They rely on local authority structures, Departmental Agencies for Information on Housing (ADIL) or Department Directorates for the Regions (and Maritime Affairs) (DDT/(M)) in the case of groups eligible for support under the 'Living Better' programme of the Anah, and on the Energy Info Spaces (EIE) set up by local authorities with the support of the Agency for the Environment and Energy Management (ADEME) in the case of other groups.

Since 2014, experiments have been conducted by the regions with the support of the ADEME, with the aim of providing increased support to households through greater involvement in their renovation projects. These structures, run by local authorities on a voluntary basis, also run campaigns in order to boost involvement of professional or banking networks.

In 2015, this Public Service for Energy Efficiency of the Living Environment and its advisory structures, referred to as 'regional energy efficiency platforms', was enshrined in the LTECV.

In order to inform the general public about this service:

- a dedicated national telephone number is available: 0808 800 700
- a national website, 'Renovation Info Service', helps private individuals locate their nearest advisor: http://renovation-info-service.gouv.fr/
- an extensive media campaign (TV, radio, internet) was run by the Ministers responsible for construction
- a guidebook on financial support is available online and has been widely circulated, and is updated every year (http://www.ademe.fr/sites/default/files/assets/documents/guide-pratique-aides-financieres-renovation-habitat-2017.pdf)
- Other subject-specific guidebooks in relation to renovation provide targeted information to households: http://www.ademe.fr/guides-fiches-pratiques

4.3.2 *Areas for improvement*

4.3.2.1 Development of regional energy efficiency upgrading platforms

The LTECV defines the Public Service for Energy Efficiency of the Living Environment as a structure that draws on the regional energy efficiency upgrading platforms. It aims to provide free, neutral and impartial information to households on the subject of technical solutions and financial feasibility in relation to their renovation projects. These platforms are intended to be established as long-term structures in each of the regions, and to establish synergies with private renovation services that will need to be developed in order for it to position itself with confidence in the field of household consulting.

In future, it will be possible to diversify the increased support provided to households depending on the structure of the private services offered by operators, project managers, engineering consultants, etc. in the region. In this way, via their integrated strategy, and depending on the structures already in place, the regions will establish the right ecosystem that is needed in order to develop energy renovation activities in connection with the various networks of stakeholders.

The development of virtual platforms providing personalised advice that are accessible to the general public 24/7 is one way in which services for private individuals could be improved. The use of virtual platforms would make it possible to reach out to those households less inclined to physically travel elsewhere in order to meet a renovation consultant, providing them with autonomy by way of online simulation or forecasting tools for renovation projects. As such, digital platforms could act as an interface to a network of diagnostic, construction, financing and maintenance services linked to renovation projects. Online rating of professionals within communities of experienced stakeholders could also contribute to increasing confidence, thereby speeding up the pace of renovation work.

Finally, the development of partnership activities with real estate professions, commonhold associations, notaries, etc. as new vectors for raising awareness about energy efficiency upgrading would represent alternative leverage for increasing the take-up of such upgrading work (green deal, charter, voluntary commitment, etc.).

4.3.2.2 Taking a global view of the approach to energy and improvement of living conditions

A discourse revolving around energy savings alone is not enough to trigger energy efficiency upgrading of the living environment. Although the fight against energy insecurity does depend to a great extent on tailored technical, social and financial support, getting households to put words into action seems to be determined by other factors.

It will therefore be necessary to improve communication on renovation on the basis of the following pillars:

- carrying out energy efficiency upgrading during other refurbishment work or at the point of changes in the lifestyle of households, thereby bringing added value to the investment in the property;
- benefiting from changes in the real estate market to increase awareness among private individuals of the advantages of renovation and ‘green’ value; this involves professional training for estate agents and dissemination of communication tools;
- stressing in a more systematic manner the link and complementarity between the installation of assisted living facilities and energy efficiency work, as both can contribute to allowing elderly and/or dependent individuals to continue living at home.

4.3.2.3 Providing guidance for comprehensive step-by-step projects

In order to increase the take-up of energy efficiency upgrading, there is another tool for households that is intended to encourage them to actually implement such a project by defining a step-by-step process tailored to their home and budget: the energy efficiency upgrading passport will, according to a preliminary evaluation, help prioritise the work to be done and make it easier for private individuals to carry projects through by better reconciling the renovation work and their financial resources.

A range of pilots are currently under development in the regions in order to test the concept of the energy efficiency upgrading passport (P2E pilot, Engie pilot, Direct Energie pilot, National Council of the Order of Architects (CNOA) and other pilots launched by local authorities in Alsace, Burgundy-Franche-Comté, etc.). Of these, two are the subject of a CEE programme, and are connected to the TEPCV regions (Positive Energy and Green Growth Regions): the ENGIE passport was enshrined in a convention with the Minister for the Environment signed on 10/11/15; the DIRECT ENERGIE passport was enshrined in a convention signed on 12/07/16.

In addition, Article 188 LTECV provides for full roll-out of the upgrading passport by the different regions via the regional energy efficiency programmes (PREE) currently being drawn up.

4.4 Financing refurbishment work: simplification, improved visibility and innovation

4.4.1.1 Measures in place

Since the establishment of the Energy Efficiency Upgrading Plan for the Living Environment (PREH) in September 2013, subsidies incentivising refurbishment have been stepped up. Efforts to harmonise and simplify measures have been redoubled over recent years.

The LTECV, which demonstrates an unprecedented level of ambition for the building sector, preserves and facilitates financial subsidies and brings about or further develops other measures, such as the mechanism for third-party financing or the creation of the FGRE.

Focus is increasingly being directed towards combating energy insecurity via the activities of the Anah and the ‘Living Better’ programme, whose annual objectives are being rendered more stringent each year, which will benefit of groups with low or very low incomes.

- For all households with privately owned homes: two key subsidies, the CITE and the zero-interest eco-loan, which have been in place since 2005 and 2009 respectively. The types of work eligible for support under these two measures have been aligned. Since its creation, the CITE tax credit has been further developed to make it more efficient and simpler. The CITE was consolidated on 1 September 2014 in order to speed up the pace of energy efficiency upgrading in stages, with the establishment of a single rate of 30% with no income threshold for renovation activities. The eco-loan also underwent a number of changes in order to improve the programme on 1 January 2015, in line with the further development of the CITE. In addition, since March 2016 it has been possible for all home-owners to use the two measures simultaneously, with no income threshold.
- For commonholds, a commonhold zero-rate eco-loan has been set up. This is a group loan granted to the commonhold association on behalf of the unit holders. As with the individual eco-loan, it can be used to finance energy efficiency upgrading work on buildings belonging to the commonhold and any charges incurred due to this work. This commonhold eco-loan can be used to finance the same categories of work as the individual eco-loan, and can be used to finance a single activity. A new engineering and execution subsidy was also set up by the Anah on 1 January 2017 in order to support vulnerable commonholds.
- For low-income households with privately owned homes: the ‘Living Better’ programme set up by the Anah is implemented via three types of actions: identifying situations in need of improvement, diagnostics and technical, social and financial support, and finally financing of the work to be done. This work must lead to an improvement of at least 25% in the energy efficiency of the property in the case of owner-occupiers, and of at least 35% in the case of properties rented out by landlords and vulnerable commonholds. The subsidies under the ‘Living Better’ programme comprise: an Anah subsidy for expenses (capped at EUR 20,000) linked to refurbishment, the amount of which depends on household income (35% for low-income households, 50% for very low-income households); a supplementary bonus under the thermal renovation fund equivalent to 10% of the cost of the work, capped and adjusted depending on household income (EUR 1600 for low-income households and EUR 2000 for very low-income households). The income thresholds for eligible owner-occupiers grant 45% of home-owners across the country access to funding (7 million households).
- For social housing: the eco-PLS loan issued by the Deposits and Consignments Fund (CDC) has been used to finance energy efficiency upgrading of energy-intensive social housing since 2009. The eligibility conditions for single-family houses were revised in 2015 in order to incentivise refurbishment in this segment. Furthermore, in order to speed up the pace of refurbishment, a new ‘asbestos eco-PLS’ was set up; this subsidised-rate loan is subject to the same financial conditions as the eco-PLS loan and is provided to landlords in order to finance the excess costs linked to refurbishment work carried out due to the presence of asbestos. In 2016, the government, together with the CDC, set up financing loans in order to support the refurbishment of social housing, with the objective of an additional 150,000 social housing units being refurbished by 2019.

- Since 2014, the reduced 5.5% VAT rate for high-quality energy efficiency upgrading eligible for the tax credit has been open to all. A 10% rate has been maintained for maintenance and improvement work. For social housing, a VAT rate of 5.5% is applied for energy efficiency upgrading work. Moreover, social housing associations who commission work aimed at contributing to energy and water savings that is eligible for the reduced 5.5% VAT rate can benefit from property tax relief on built properties, equivalent to one quarter of expenditure paid out in the previous year on which taxes are due.

- European Structural Funds: supporting the energy transition is a priority for the European Union. In France, almost EUR 2 billion from the European Structural and Investment Fund will be injected into projects in this area by 2020. Of this, EUR 750 million will be devoted to projects for improving the energy efficiency of public buildings and homes. In the current 2014–2020 period, all regions and management authorities have included energy efficiency upgrading as a priority action in their operational programmes. The ERDF can produce a favourable leverage effect when it comes to energy efficiency upgrading of social and private housing when used in conjunction with public financing already in place. In the 2014–2020 period, funding of upgrades to private housing is being permitted for the first time under certain conditions, as it has been demonstrated at national level that there is a real need to accelerate the refurbishment of private properties.

- Energy efficiency certificates, which were created in 2005 by the Energy Policy Programme Act (POPE law), are based on imposition of an energy savings obligation upon energy retailers by public authorities. These retailers must therefore actively promote energy efficiency among energy consumers, be they households, local authorities or professionals. This measure entered its third obligation period on 1 January 2015, for a period of three years. Standardised documents for recording operations, which are defined by way of rulings, are created in order to facilitate the planning of energy savings actions, including energy efficiency upgrading (insulation, boiler replacement, etc.). In practice, every energy provider must provide financial incentives to carry out energy efficiency upgrading.

  For the fourth CEE period (2018–2020), the energy savings target is set at 1600 TWh in discounted cumulated costs, of which 400 TWh is to be attributable to households suffering from energy insecurity (i.e. double the target for the current third period, which is 700 TWh and 150 TWh respectively for 2015–2017).

- Third-party financing makes it possible to incorporate all potential forms of leverage (technical support, financing, execution of work, etc.), with a view to increasing the take up and scope of energy efficiency upgrading operations. Following successive developments in the ALUR Law and the LTECV, the legal framework for third-party financing is now complete and operational. The LTECV supplemented previous provisions by regulating third-party financing activities, by specifying pre-conditions to be met and by allowing for an exemption to banking monopoly requirements for third-party financing undertakings in which the majority of shareholders are local authorities or which fall under the supervision of a local authority. Around half a dozen undertakings and public-private entities (semi-public companies, regulated) linked to particular regions are now operational or in the process of becoming operational. Provided that regional executive authorities do not oppose the creation or development of five third-party financing undertakings in the regions Hauts-de-France (SPEE and ORREL), Île-de-France (ENERGIES POSIT'IF), New Aquitaine (ARTEE) and Grand Est (OKTAVE), regional initiatives in 2017 are expected to lead to the conclusion of discussions on the creation of a regional energy efficiency operator in the regions Auvergne-Rhône-Alpes, Occitanie and Centre-Loire Valley. These initiatives will be monitored by a working group and in the context of exchanges that have been held since 2015 by the Plan Urbanisme Construction Architecture (PUCA) service and the initiating local authorities along with other local authorities who have set up a pilot programme on an integrated approach to renovation of private housing.

- Local authorities may offer supplementary subsidies to incentivise energy efficiency upgrading by focusing on the needs and priorities in their region. The National Agency for Housing Information (ANIL) has brought together these available forms of funding in an observatory in order to make it easier for households to find out more about them at local level. These subsidies are usually targeted at low-income and very-low-income individuals or aim to encourage extremely intensive energy efficiency upgrading.

- A large number of local initiatives have also emerged with a view to stimulating the provision of related banking services at regional or sub-regional level. These partnership activities take the form of calls for expression of interest by local banking networks, discussion meetings with all levels of local governance responsible for renovation and training activities for banking advisers.
- 554 regions carrying the label 'Positive Energy and Green Growth Regions' (TEPCV) have benefited from support via the energy transition financing fund for sums between EUR 500,000 and EUR 2 million per local authority volunteering to take part. Of the range of activities that are possible under this framework, speeding up the upgrading of housing and public buildings has been broadly encouraged and instigated. The TEPCVs should thus be able to record 5 000 cases of extensive renovation of housing (BBC level) and 1 500 cases of upgrading of public buildings.

4.4.2 *Areas for improvement*

- The incentive measures have been subject to successive revisions in order to make them more comprehensible to private individuals. The conclusion that can be drawn from the past few years is that stability, simplicity and comprehensibility of funding are primordial in order to ensure greater take-up: this means administrative simplification in obtaining the funding, a 'one-stop-shop' website for obtaining all the types of funding, stability in order to secure financing plans for households until the launch of the project. Future policies on promoting renovation should be focused on ensuring the comprehensibility of financial support, which provides substantial leverage.
- Improving the links between networks of stakeholders from the banking sector and representatives of construction and real estate professionals would enable, on the one hand, better promotion of the measures and, on the other, would make it possible to take advantage of key moments to launch energy efficiency upgrading projects (real estate transactions, modification of housing for elderly inhabitants, etc.).
- This also applies to links between regions engaged in renovation strategies in order to encourage complementarity between the measures by way of dialogue.

Other avenues for reflection are currently being examined. Of these, modulating subsidies according to the level of efficiency achieved thanks to the upgrading project would make it possible to incentivise more efficient renovations. Therefore, the creation of a specific subsidy for extensive, high-efficiency upgrading in one or several stages with a view to achieving the 2050 objective of the LTECV could be considered.

The fourth period of the CEE programme, which runs from 2018 to 2020, will increase the pace of renovation and will contribute, as it has during the third and current period, to increased take-up of upgrading projects and to the fight against energy insecurity.

The involvement of local authorities in financing is also a subject for future consideration: by way of financial incentives, support programmes to which they contribute, the creation of local funds dedicated to upgrading and programmes of renovation activities (PREE, etc.). Helping local authorities to build up networks of trust throughout the entire process, from the decision of a household to initiate an upgrade up until execution and monitoring of the renovation work, is necessary in order to achieve the objectives set out in the LTECV.

The emergence of private investment funds dedicated to the renovation of exemplary, highly efficient non-residential buildings is another way of providing momentum in order to speed up the pace of initiatives in this voluntary segment.

4.5 Turning the energy transition into an opportunity for the building sector

4.5.1 *Measures put in place*

Professionalisation of the sector involved in the plan for energy efficiency upgrading of the living environment is being undertaken nationwide via a combination of three actions:

- the establishment of environmental eligibility criteria for renovation subsidies by way of 'Recognised Environmental Protection' (RGE) quality labels;
- the setting up of the FEE BAT programme (energy efficiency training for the construction sector);
- the establishment of an action plan for construction quality and the energy transition (PACTE).

4.5.2 *Qualified professionals to ensure quality work*

The objectives specified in the field of energy efficiency upgrading of buildings necessarily require increased skills on the part of tradesmen and small businesses in the construction sector so that they can keep pace with new developing markets, in particular by way of public incentive measures and the environmental eligibility criteria for State aid in place since September 2014 for the eco-loan and January 2015 for the tax credit and energy efficiency certificates.

For example, in order to benefit from the zero-interest eco-loan, the energy transition tax credit or energy efficiency certificates, a private individual must call upon an 'RGE' company, i.e. a professional undertaking that meets the qualification criteria drawn largely from the requirements of the RGE Charter signed in 2011 and in 2013, to which professionals in the building sector made a substantial contribution. As such, the technical qualification criteria for professionals are inspired by those drawn up by the stakeholders themselves.

The criteria are demanding, so as to provide a guarantee for households that the work carried out will be of a high quality. They are centred around staff training requirements, evidence of technical resources and performance assessments. These requirements focus on proof of competency, and allow companies of all sizes to compete on an equal footing.

The technical criteria comprise two major 'families'; on the one hand, specific criteria for individual services mainly aimed at SMEs and micro-enterprises, and on the other requirements for all-in-one services for companies wishing to offer the full spectrum of services including thermal analysis.

Taking into account market needs and the necessity of propping up the emergence of a green economy in the construction sector, measures were taken in late 2014 in order to facilitate companies' access to the RGE label without downgrading the associated requirements. Simplification measures were continued in 2015: this programme of simplification, which was carried out together with construction professionals, will make it possible to reduce costs for companies, particularly micro-enterprises.

At present, around 65 000 companies hold an 'RGE' label nationwide, 85% of which count fewer than 10 employees. Companies with such quality labels are listed on the website www.renovation-infoservice.gouv.fr, under the 'Find a professional' tab.

4.5.3 *FEE BAT training for continuous professional development*

Training courses financed by EDF in connection with the CEE regime as well as by Accredited Fund Collection and Distribution Agencies (OPCA) and training insurance funds (FAF) in the building sector respond to the need to provide support for skill building on the part of construction professionals in order to achieve the ambitious energy efficiency objectives set out by the Plan for Energy Efficiency Upgrading of the Living Environment in 2013. An initial convention on energy efficiency training for construction companies and professionals was signed on 14 June 2010 by the State, EDF and the professional organisations that have been involved since the measure was launched, as well as the ADEME. The most recent convention, signed for the 2014–2017 period, signals a renewed commitment of the signatories to the FEE BAT programme.

As a response to the issues surrounding energy efficiency upgrading of buildings, the FEE BAT programme aims to help construction professionals build up skills in relation to work performed on the building envelope and building equipment as well as in relation to the corresponding project management.

The circumstances under which the environmental criteria for public State aid for energy efficiency upgrading of buildings were introduced meant that it was necessary to allow the greatest possible number of companies and tradespeople to receive training that would allow them to access the market for which the subsidies were being made available as well as the market affected by the CEE regime.

In order to achieve the energy efficiency upgrading objectives, construction professionals must understand the overarching concept of energy efficiency in buildings, as well as how to integrate the implications thereof into quality and control procedures.

Since 2014, 60,000 training sessions have resulted in an RGE label being awarded. At the current time, around 1 000 interns are being trained each month under the FEE BAT programme.

4.5.4 *The Action Plan for Construction Quality and the Energy Transition (PACTE)*

The PACTE programme aims to assist construction professionals in building their skills in the area of energy efficiency.

The objective is to improve the quality of construction and upgrading work, and ultimately to enable professionals to perform this work better, more quickly and more cost-effectively.

Since 2015, the PACTE has been focused on fostering knowledge acquisition, providing technical reference material and modern tools adapted to professional practices, and on supporting projects with these objectives in the different regions.

The programme is built upon three pillars:

- developing, capitalising on and enhancing in-house knowledge surrounding claims and actual energy efficiency of structures, and promoting the spread of highly efficiency technical solutions;
- continuing the modernisation of industry standards in light of energy efficiency requirements, and developing pedagogical tools for implementation and self-monitoring for all sizes of site;
- supporting local activities aimed at enhancing the skills of construction professionals together with regional stakeholders.

The activities supported include the design of digital site logs to be used by site personnel (tools presenting industry standards in an educational and illustrative manner), the development of tools for measuring energy efficiency during the building completion process, as well as around 40 projects across the whole of France aimed at enhancing the skills of construction professionals.

4.5.5 *Areas for improvement*

4.5.5.1 Encouraging the development of single-source provision and enhancing customer orientation

Measures aimed at forming groups of tradespeople with complementary skills, accessible via one contact point and able to offer high-quality energy efficiency upgrading at a reasonable price, will be encouraged. Such measures help to generate networks of construction professionals and companies with complementary skills in order to provide a group response to private projects, by providing a single contact point for households wishing to carry out energy efficiency upgrading on individual homes or small groups of homes.

In addition to this partnership-based approach, which is sought between all professionals involved throughout the duration of the upgrading project, from the initial survey to completion of the work, the successful take-up of energy efficiency upgrading is dependent on the involvement of construction industry stakeholders, traders in building products and even innovators in the construction sector.

It will be necessary to step up cooperation between the construction professions and better structure the industry's upgrading services.

Some regions have already started promoting this kind of approach, which will have to be evaluated in future.

4.5.5.2 Support for innovative SMEs in the area of the energy transition

Encouraging innovation will be a key factor in achieving the upgrading objectives of the LTECV. The government has commissioned the Scientific and Technical Centre for Construction (CSTB) to support innovative SMEs via a programme structured together with the various regions.

As a result, the CSTB has developed regional partnership platforms, and is working on setting up an innovation support network: the National Support Network (RNA). In 2015, it signed a partnership agreement with the French Public Investment Bank (BPI France) in order to provide local technical and financial support services in each of the regions. The objective is to facilitate the emergence and access to the market of innovative construction products and techniques in the area of the energy transition.

The Future Investment Programmes (PIA) run by the Commission-General for Investment (CGI) offer a range of service portals run by different operators into which innovative construction products can be incorporated. Some of the more interesting examples include the Industrial Methods call for proposals, Green Tech, the IPME (SME initiative) call for proposals for the ADEME, PSCP (structural research and development projects for competitiveness) aimed at structural competitiveness projects for BPI France as well as the fund for digital transition of the State and the modernisation of public action for the Deposits and Consignments Fund. This plethora of activities all aim to ensure that innovations in the field of energy efficiency upgrading receive support during selection processes, to offer a clear overview of the range of innovation subsidies available to companies, to direct innovation towards the right contact points and to bring about new service portal projects if necessary.

4.5.5.3 Enhancing the skills of professionals

In order to supplement the long-term objectives of the LTECV, the various training programmes, covering both theory and practice, should be continued, stepped up and updated in line with new demands and the changing skills of professionals across the sector.

The focus should be on using digital tools in aid of developing training and self-study courses and creating better interfaces with the professional training environment, which will continue to act as a springboard for attracting young people to the construction sector. Training in the field of the energy transition would be better received if it encouraged the use of digital technologies and the enhancement of existing knowledge.

Some initial projects have already been conducted to this end: on the initiative of the ADEME and the Sustainable Construction Plan, all of the major professional organisations and construction industry stakeholders came together to create a MOOC (massive open online course) platform solely dedicated to sustainable construction. Over 15 000 people have already signed up to this platform, and around a dozen MOOCs will be held during the year 2017.

4.5.5.4 Use of virtual platforms for supply and demand

The development of virtual platforms allowing professionals to link up with private individuals looking for experts and qualified, competent professionals is another new market for the sector. These virtual services could increase the take-up of energy efficiency upgrading and allow a new range of digital renovation services to emerge.

As a supplement to the traditional approach based on physical contact and information platforms, they could make it possible to reach out to and raise awareness among a different public, helping households to plan upgrading projects using online simulations for construction work, loans and foreseeable energy savings.

Capitalising on the feedback and testimonies of households having already carried out energy efficiency upgrading projects will lead to the formation of communities of stakeholders, which help to build confidence.

The development of applications creating an interface between these virtual tools and platforms and the housing monitoring and maintenance log stipulated by Article 11 of the LTECV represents a new field that could be explored.

4.6 Prioritising and enhancing regional initiatives

4.6.1 *Support and monitoring by the State of regional activities in support of energy efficiency upgrading of buildings*

4.6.1.1 Framework provided by the LTECV

The LTECV equips the regions with a strengthened role in implementing energy policy measures, with different responsibilities allocated to the various types of local authority:

- **Planning takes place at regional level. As such, it is** 'the primary level at which studies are coordinated, information is disseminated and energy efficiency initiatives are promoted' (LTECV, Article 188). In accordance with the Law on the Reorganisation of the Territory of the French Republic (NOTRe), each region must have adopted a Regional Programme for Sustainable Development and Equality Between Regions by 2019. A key component of this planning document, the Regional Energy Efficiency Programme, will establish a Public Service for Energy Efficiency of the Living Environment in line with the framework set out in Article 22 of the LTECV, and will make it possible to offer support to all households in the field of energy efficiency upgrading of buildings.
- **At sub-regional level**, Article 22 LTECV provides that the Public Service for Energy Efficiency of the Living Environment (SPPEH) shall be based on a network of regional energy efficiency upgrading platforms. These platforms shall perform basic but essential tasks, and may also voluntarily launch initiatives to garner support, encourage the involvement of professionals and provide guidance to consumers. The activities undertaken by the regional energy efficiency upgrading platforms defined by law therefore link in with the information provided by the public service, and these activities must remain neutral, impartial, objective and free of charge.
- **At a more detailed level**, the LTECV favours areas which carry out ambitious projects in support of the energy transition. For example, the TEPCV call for proposals enabled support to be provided for activities encouraging the renovation of buildings.

4.6.1.2 The National Workshop for Local Energy Efficiency Upgrading Initiatives

The National Workshop is a space in which all good practices demonstrated by local authorities and stakeholders on the ground can be capitalised upon and exploited. It allows the needs of the regions to be determined, legal and technical solutions to be provided, and solutions tailored to the problems raised to be developed.

The first session was held on 14 December 2016. It covered, in particular, the subject of local energy efficiency upgrading platforms, the energy efficiency upgrading passport, the third-party financing model and the consideration of listed buildings in energy efficiency upgrading over the course of four technical sessions.

This Workshop aims to provide momentum that will then filter down to regional level, encouraging full take-up of the solutions and their collaborative implementation in each of the regions. It will act as national a forum for capitalising on knowledge, but will also be a catalyst for success at local level.

4.6.1.3 Regional momentum pooled and supported by the Regional Sustainable Construction Plans

Since 2012, the momentum created at national level by the Sustainable Construction Plan has been rolled out in seven pilot regions. In these regions, specific involvement of the Regional Council in close collaboration with regional stakeholders truly enables activities to be scaled up, cooperation to be encouraged and innovative measures to be put in place, primarily in favour of energy efficiency upgrading of housing.

These initiatives are closely linked to the future regional energy efficiency programmes (PREE) stipulated by the LTECV.

4.6.1.4 Financing and enhancing projects piloted by local authorities

Positive Energy and Green Growth Regions (TEPCVs)

To date, 210 regions of the 554 TEPCVs having been granted the award are active in the field of building renovation. Their activities primarily concern the upgrading to BBC level of public buildings (schools, crèches, town halls, swimming pools, media libraries, etc.) and the upgrading to BBC level of housing belonging to local authorities. This has lead to the upgrading of 1 500 public buildings, equivalent to 1.1 million square metres. Of these, 240 have already been completed, with the remaining projects either under way or set to start soon. For housing, this has meant energy efficiency upgrading of 5 000 homes, equivalent to almost 420,000 m^2 of habitable surface area. Ultimately, these initiatives will result in over 300 GWh in final energy savings per year, 10% of which are already in effect today. In addition, they have prevented, or will prevent the emission of 61 000 tonnes of CO^2 into the atmosphere per year.

Ecocities

The Future Investment Programme ‘Cities of Tomorrow’ supports the Ecocities initiative with the objective of setting up ambitious, innovative projects tailored to certain regions. In this context, activities in support of the renovation of the public and private building stocks have been undertaken. It will now be possible to move into the capitalisation phase involving the identification of difficulties and criteria for success, thereby determining the necessary leverage for a transition from a pilot project approach to generalised take-up across the entire country. The network of Ecocities committed to energy efficiency upgrading will now start forming working groups that will provide feedback on their experiences, thereby feeding in to the deliberations of the National Workshop for Local Energy Efficiency Upgrading Initiatives when it comes to the upgrading of commonholds.

Loan provided by the Deposits and Consignments Fund (CDC)

The CDC is offering local authorities an envelope amounting to a total of EUR 20 billion for the period 2013–2017, part of which is earmarked for ‘green growth’ loans. The ‘green growth’ loan is a zero-interest loan destined to finance the upgrading of local-authority-owned public buildings, public health institutions and universities over the period 2016–2017.

4.6.2 *Areas for improvement: consolidating the national framework conditions and prioritising regional initiatives*

In the light of the aforementioned, and in line with the LTECV, which attaches increased importance to local authorities, the latter will play a key role in the upgrading of their residential and non-residential housing stock and in the creation of real momentum at local level around energy efficiency upgrading in the regions.

Given the number of upgrading projects evaluated under the National Low Carbon Strategy in order to achieve the objectives of the LTECV and taking account of the framework provided for by law in order to define a Public Service for Energy Efficiency of the Living Environment (SPPEH), the following points should be underlined and scrutinised:

- State monitoring of and support for regional strategies on drawing up a 'Regional Energy Efficiency Programme' (PREE) as defined by the LTECV;
- coordination of the various local networks in order to boost energy efficiency upgrading;
- support for regions at the necessary level for their local renovation strategy depending on their population and labour catchment areas. The intention behind these supporting initiatives is to incorporate energy efficiency upgrading into regional policy:
    - as part of city or town-centre renewal programmes;
    - as part of initiatives aimed at the preservation of heritage sites.

The National Workshop for Local Energy Efficiency Upgrading Initiatives will try and identify the relevance of these at local level, in order to stimulate initiatives and good practices and facilitate the sharing thereof.

4.7 Energy transition: the State as trailblazer

For the State and its officials, who occupy a building stock of almost 100 million m^2, equivalent to around 4% of all existing buildings, reducing the environmental impact of buildings constitutes a major focal point in the fight against climate change. In addition, the State must set an example by taking account of environmental and energy aspects, and by encouraging local authorities to adopt an exemplary system of management for their building stock.

At budgetary level, State real estate spending accounts for the second largest proportion of State expenditure after wages. Around one billion euros is spent on energy costs each year. It is therefore pertinent to develop a highly efficient environmental and energy management strategy for the publicly owned building stock in order to get a handle on this expenditure.

On the basis of this observation, the State is currently drawing up an overview of the operational hurdles and is identifying areas where progress can be made:

- definition of an action framework at national level
- better upstream knowledge of the building stock and its potential
- structuring of an inter-ministerial stakeholder network
- drawing up of an intervention strategy at building stock level by establishing a Regional Real Estate Director (SDIR) role rather than a sporadic, project-by-project approach
- prioritisation of activities to be undertaken, depending on the level of investment, in order to tap into various intervention scenarios.

4.7.1 *Definition of a roadmap to 2050*

On the basis of the stock-taking exercise illustrated above, the government has begun defining an 'Energy Transition for Public Buildings' roadmap, which will make it possible to gradually reduce the energy consumption of public buildings and their operators, and to monitor progress made.

This roadmap will be part of the process establishing the SDIRs.

4.7.2 *Undertaking exemplary projects in support of the energy transition – starting today*

The government was behind the 2015 launch of the CUBE 2020 project for public buildings (#CUBE2020). This competition, the third edition of which will be held in 2017, is an occasion for promoting initiatives undertaken by building occupants to better manage energy by way of adapting usage and aimed at optimal control of technical equipment, with no investment needed.

This competition will serve to test and to stimulate further roll-out of the observed best practices. Public buildings, comprising the 35 registered administrative State buildings as well as universities and public establishments (Natural History Museum, BNF, CSTB, ADEME), who have now become involved in the competition, represent over one hundred of the buildings entered in this third edition.

In a letter dated 3 February 2016, the Minister for the Environment, Energy and Maritime Affairs requested regional and departmental prefects to define regional action plans for implementing the energy transition in the construction sector. As such, 12 regional action plans have been drawn up by the Regional Directorates for the Environment, Planning and Housing (DREALs) and Department Directorates for the Regions (and Maritime Affairs) (DDT(M)s), with a specific section dedicated to public buildings.

As regards the CPEs, 7 service CPEs are currently in force in five regions within the remit of the regional prefects (office buildings occupied by the State) for the 2012–2017 period for the first CPEs signed, and until 2020 for the others.

As regards CEEs, agreements have been signed by the various ministers to promote the taking of energy efficiency measures in public buildings. The fusion of the regions has been successful in calling into question the scope of certain active agreements or agreements in the course of being drawn up. It is necessary to continue searching for new synergies to ensure broad, inter-ministerial roll-out.

4.8 Voluntary initiatives by the service sector

Since 2013, a voluntary scheme has been in place to encourage stakeholders to immediately start upgrading their properties, which has resulted in the creation of a charter. The objective of the charter is to stimulate a mass movement in support of energy efficiency, the well-being of the users of the buildings and economic activity in the construction and real estate sector. By signing the charter, stakeholders agree to commit to reducing the energy consumption of the commercial buildings they occupy, manage or own. As regards the ambition of the charter, signatories commit to regularly communicating the results they have achieved, but no numerical targets are set.

In April 2017, the Charter for Energy Efficiency of Public and Private Non-Residential Buildings counted 107 public and private signatories.

Regular monitoring of the commitments made by signatories will help to expand knowledge on upgrading strategies in this specific sector of the building stock, and will serve as a useful springboard for the roll-out of energy savings across the service sector, as stipulated by the LTECV.

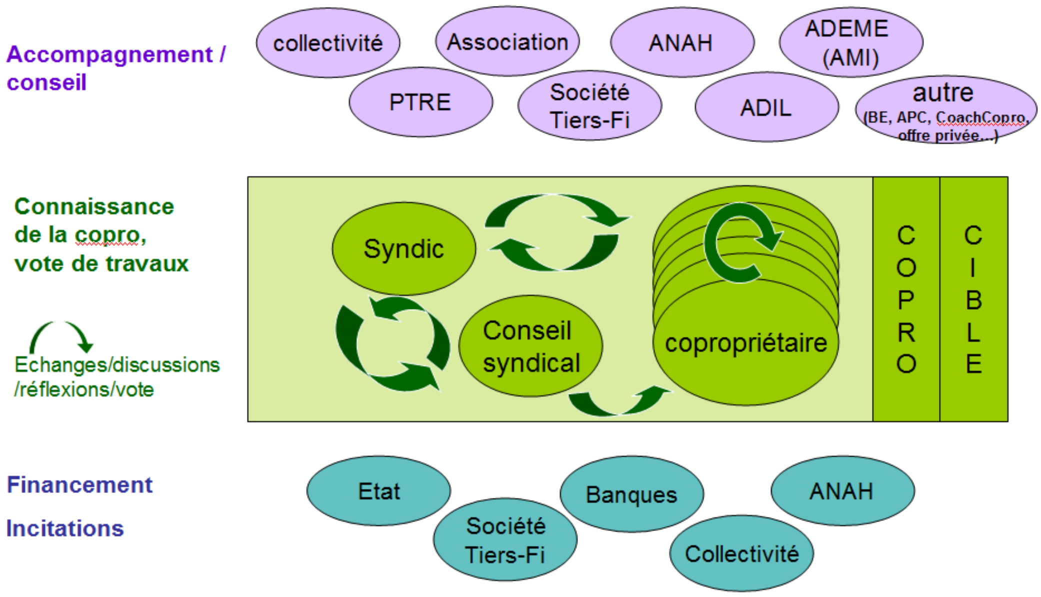
4.9 Upgrading commonholds: a priority

In 2006, 8.4 million homes were in commonhold (source: INSEE), equivalent to more than one quarter of the French building stock: upgrading these properties is therefore of crucial importance for the construction sector. Although commonholds thus represent a strategic target for the energy efficiency upgrading sector given their major potential for reductions in energy consumption, putting words into action is a complex affair due to:

- a lack of momentum in the decision-making process with regard to carrying out work; feedback provided indicates that it takes a minimum of three years and three General Assemblies for a project to be adopted;
- a complex ecosystem which requires interaction between a range of stakeholders throughout this decision-making process;
    - the influence exercised on decision-making by three types of stakeholders within the commonhold, both during and between each General Assembly: the commonhold association

for the building, the management council whose members are elected by the unit holders and the association of unit holders;

- the influence exercised by two types of stakeholders in connection with the commonhold: renovation consulting services and providers of dedicated financing.



Ecosystems of stakeholders in the energy efficiency upgrading of commonholds

Accompagnement / conseil	Support/advice
collectivité	Local authority
Association	Association
PTRE	PTRE
ANAH	Anah
Société Tiers-Fi	Third-party financing company
ADIL	ADIL
ADEME (AMI)	ADEME (AMI)
autre (BE, APC, CoachCopro, offre privée...)	Other (BE, APC, CoachCopro, private services, etc.)
Connaissance de la copro, vote de travaux	Knowledge of unit holders, vote on the work
Echanges/discussions/réflexions/vote	Exchanges/discussions/reflections/vote
Syndic	Commonhold association
Conseil syndical	Commonhold management council
Copropriétaire	Unit owner
COPRO	COMMONHOLD
CIBLE	TARGET
Financement	Financing
Incitations	Incentives
Etat	State
Société Tiers-Fi	Third-party financing company
Banques	Banks
Collectivité	Local authority
ANAH	Anah

Recurring difficulties can thus be observed when it comes to putting plans for the energy efficiency upgrading of commonholds into practice. The National Workshop for Local Energy Efficiency Upgrading Initiatives has made it possible to highlight the need for specific support in this area. In this vein, local authorities can act as a driving force by investing themselves, together with their fellow citizens, in energy efficiency upgrading projects, thereby fully respecting the approach set out in the LTECV of rendering local and regional authorities the catalyst for the energy transition. This role makes it possible to gradually remove the barriers to the actual implementation of commonhold upgrading projects by getting highly skilled professionals involved and by according one project management consultant privileged status in supporting the local authority, then by financing each stage of the project.

4.10 Reconciling energy efficiency upgrading and the preservation of listed buildings and architectural heritage

The objectives of the LTECV mean that it is necessary to reconcile preservation of architectural heritage on the one hand, and the efficiency and durability of upgrading projects on the other by limiting the risk of pathologies. As a result of their specific characteristics, listed buildings must therefore be paid special attention, and appropriate techniques must be applied that take into account the unique nature of the materials used.

Numerous regional programmes (at regional or local level) have been set up to raise awareness among project managers and professionals when it comes to the unique character of local heritage sites. They mostly revolve around one shared foundation based on:

- detailed knowledge of the housing stock in the region as a preliminary step;
- typologies allowing work programmes to be subsequently drawn up;
- upgrading projects that can be carried out whilst guaranteeing preservation of listed buildings and the durability of the renovation work.

In connection with the plan for energy efficiency upgrading of the living environment, certain DREALs and DDTs have called upon the expertise of CEREMA in collaboration with other stakeholders, including Councils for Architecture, Urban Planning and the Environment (CAUEs), in order to raise awareness among households and local stakeholders when it comes to the specific features of local architecture, in order to encourage further roll-out of upgrading projects. These initiatives primarily involve the production of documents setting out the different types of listed buildings, either directly targeted at the general public or at professionals tasked with providing advice on energy efficiency upgrading. They aim to explain what kind of work is compatible with the buildings in question.

These tools will enable the development of a balanced approach, shared between preservation of listed buildings and the objectives of the LTECV.

Related activities will focus on boosting the utilisation of this knowledge and on encouraging the development of specific expertise in the field of energy efficiency upgrading of listed buildings. Under this approach, particular attention will be paid to reconciling the future-oriented issue of energy efficiency upgrading and the huge importance of preserving historical heritage and listed buildings.

4.11 Observing and evaluating energy efficiency upgrading policy

4.11.1 *Varied tools providing detailed information*

On top of the fiscal and banking data available to the administration for the purpose of analysing developments in the renovation of private and social housing (see section on financial incentives), tools and observatories have been set up in order to share reliable information with all stakeholders, allowing joint diagnoses to be generated in relation to upgrading:

Tool	Target
OPEN Permanent Observatory for Improving the Energy Efficiency of Housing ADEME	Monitoring of upgrading activities and efficiency in the field of private housing (single-family homes and private areas of apartment buildings) in cities. The 2015 ADEME campaign focused on work carried out between 2012 and 2014 and completed in 2014: http://www.ademe.fr/sites/default/files/assets/documents/open_2015_8679.pdf . In particular, it has made it possible to evaluate the number of renovations performed to each level of efficiency: ▪ 1 776 000 moderate efficiency renovations at an average cost of EUR 5 455 179 000 efficient renovations at an average cost of EUR 11 146 ▪ 109 000 highly efficient renovations at an average cost of EUR 25 410. In this respect, OPEN constitutes the primary source of data when evaluating the extent to which the objectives set by law have been met. On this basis, it is possible to determine that 288 000 efficient or highly efficient renovations were carried out in private buildings in France in 2014, which can then be compared to the objective of 380,000 renovations of private buildings set out in Article 3 LTECV for the post-2017 period. The large number of average efficiency renovations, the majority of which under the CITE tax credit programme, demonstrates that there is real potential for achieving the objectives of the law.
ONPE National Observatory for Energy Insecurity Multi-stakeholder steering Coordination by ADEME	The work of the ONPE has made it possible to take true stock of the energy insecurity situation. According to the initial results of a study based on the most recent National Housing Census in 2013 (covering the period from 2007 to 2012), which was published in November 2016 during the second conference of the ONPE, 5.8 million households in France are suffering from energy insecurity according to at least one of the indicators defined by the ONPE. This is equivalent to 12.2 million people and over 20% of households.
Convention on monitoring the energy efficiency upgrading market following measures taken to accelerate the energy transition	The convention has made it possible to define and monitor indicators for the three action pillars, which are awareness raising and support for households, financing energy efficiency upgrading and encouraging the involvement of professionals in the sector. This monitoring involves: the State (Directorate for the Living Environment, Urban Development and Landscapes, [DHUP], Directorate General for Energy and Climate [DGEC]), the ADEME, the Anah, the National Agency for Information on Housing (ANIL) and the Network Group of Regional Economic Divisions for Construction (CERC). Since most of the data is collected at the level of the departments, detailed analyses can be carried out and sent to local authorities in order to help them come up with a diagnosis for the region.

Tool	Target
	Example of the Auvergne-Rhône-Alpes region: ▪ *statistics regarding State-supported measures demonstrate real momentum:* Living Better Programme (Anah) In 2014, 14% of homes upgraded thanks to the programme were located in the Rhône-Alpes and Auvergne regions, with the average subsidy amounting to EUR 21 000. This programme is flanked by financing from local authorities on the basis of the Anah criteria: this includes the Regional Council, municipal groupings and cities. The CITE, a programme which has been highly successful at national level, has also been confirmed a success at regional level. In 2013, almost 90,000 homes carried out work eligible for CITE tax credits in the Auvergne and Rhône-Alpes regions, equivalent to 15% of the national total. This corresponds to State subsidies for households amounting to over 80 million euros. Energy Savings Certificates In 2015, the Auvergne and Rhône-Alpes regions accumulated 16% of the CEEs granted for the residential sector nationwide. New ways of funding The Auvergne-Rhône-Alpes region is also looking into new forms of funding, in particular third-party funding. ▪ *Analysis of the activities of renovation companies shows that they are highly motivated:* The Auvergne-Rhône-Alpes region achieves an annual turnover of 5 300 million euros, which is 12% of the national total, making this region the second most dynamic in France (after Île-de-France). Rhône-Alpes had 6 600 companies with an RGE label in 2015 (the highest regional score), and Auvergne 2 000, making this new region the most dynamic in France.
Other sources	The DPE observatory, CEREN data, the Phébus survey and the National Housing Census all provide data which, when combined, make it possible to conduct targeted research (see part I of this report).

4.11.2 *Areas for improvement in the field of monitoring*

It is important to maintain the observatories referred to in the section 'Overview of policies – monitoring of upgrading' and to update figures in order to continue sharing reliable data that is of use to all construction stakeholders. The following have been identified as areas where progress is required:

1. Monitoring the upgrading of homes: continuation and consolidation of existing measures, in particular by way of an OPEN survey flanked by:
    - a study on commonholds, thereby covering all types of private housing;
    - regional evaluations;

- a performance appraisal after completion of the work.

2. Monitoring of information provided to households via regional energy efficiency upgrading platforms.
3. Establishment by ADEME of an observatory for calls for proposals launched by Regional Energy Efficiency Upgrading Platforms (PTREs), i.e. platforms offering households further support on top of what is provided by the regional upgrading platforms.
4. Moving towards more detailed, joint monitoring of upgrading activities: costs, number of renovations and distribution, with information broken down into the different types of operations, thereby making a valuable supplement to the OPEN survey and its upgrading cost estimates for different levels of efficiency.
5. For low-income households, the Anah's digitisation programme will also enable better monitoring of renovations with the support of Anah operators.
6. Working towards a scoreboard for construction activities. By summarising a consistent grouping of economic, technical and environmental indicators, the scoreboard will serve to analyse the climate in the construction sector, its past momentum and present situation, and to publish forecasts regarding the short and medium term developments in some of these indicators. The indicators presented will be grouped by topics, for example: construction, marketing, renovation, business and employment, financial situations of households, environment.

5 Estimating expected energy savings

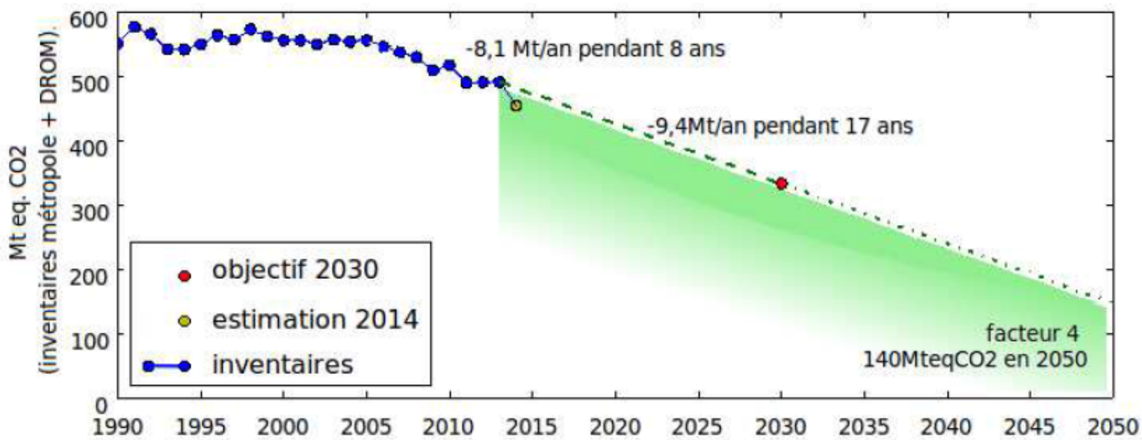
In 2014 the Ministry for Energy, the Environment and Maritime Affairs launched a forecasting exercise piloted by the Directorate General for Energy and the Climate (DGEC) in collaboration with the Commission-General for Sustainable Development (CGDD) and the Environment and Energy Management Agency (ADEME). The previous DGEC study, which was carried out in 2012–2013, involved drawing up prospective scenarios in relation to energy, the climate and air quality for the year 2020. This new exercise further builds upon those earlier forecasts, extending their scope to 2035 and incorporating analyses of energy consumption, greenhouse gas emissions and pollutant emissions.

This modelling exercise has allowed France to establish a 'National Low Carbon Strategy' (SNBC), which was enshrined in the LTECV and which sets out the general framework for and nature of the envisaged solutions for transitioning to a low carbon economy, in line with the target of reducing emissions by a factor of four by the year 2050. This strategy is broken down into sectoral measures and carbon budget requirements.

5.1 Overview of the SNBC

Beyond 2020, France has set itself highly ambitious objectives in terms of cutting greenhouse gas emissions, in particular via the LTECV:

- 40% reduction in total emissions by 2030 compared to 1990 levels;
- 75% reduction in total emissions by 2050 compared to 1990 levels (factor of four).



Detailed overview of French commitments (source: summary for SNBC decision-makers)

Mt eq. CO2	Mt eq. CO2
(inventaires métropole + DROM)	(inventories for mainland France + overseas department and regions)
-8,1 Mt/an pendant 8 ans	-8.1 Mt/year for 8 years
-9,4Mt/an pendant 17 ans	-9.4 Mt/year for 17 years
Objectif 2030	2030 objective
Estimation 2014	2014 estimate
inventaires	Inventories
facteur 4 140MteqCO2 en 2050	Factor of four 140 Mteq CO2 in 2050

Achieving these objectives will mean substantially reducing greenhouse gas emissions over the next 20 years at a faster rate than that achieved during the 2005–2013 period. This will require a major overhaul of the entire economy, as well as of modes of production and consumption. The transition towards a low carbon economy is dependent on a substantial increase in efforts to reduce energy consumption and on a reduction in the carbon intensity of the energy used. The residential and non-residential building sectors form an integral part of this strategy, and will make a significant difference when it comes to achieving the objectives.

In 2013, direct emissions from the residential and non-residential sector accounted for 20% of greenhouse gas emissions (almost one quarter if indirect emissions linked to producing electricity and heat for the buildings are taken into account). The objective is to reduce these emissions by 54% (compared to 2013 levels) by the time of the third carbon budget (2024–2028), and by at least 87% by 2050.

The national low carbon strategy thereby establishes the general foundations and sets out the type of solutions foreseen. It must now be supplemented by sectoral action plans, which will also present an opportunity to fine-tune the chosen solutions and optimise their implementation.

5.2 The residential and non-residential building sector

5.2.1 *Modelling*

Forecasting and modelling has been entrusted to a group of service providers, comprising:

- **Enerdata**: modelling, final energy demand forecasting with Med-Pro and POLES models, costing of measures for the purpose of the macro-economic evaluation carried out by Seureco.
- **Énergies Demain**: expertise and modelling for the construction sector, support and guidance, in particular for aligning the results with the data on the equipment inventories derived from the SceGES model used by the DGEC in its evaluation of climate policy.
- **CITEPA**: expertise on and modelling of greenhouse gas emissions, atmospheric pollutants and non-energy-related emissions (agriculture, waste and LULUCF).
- **ARMINES**: expertise on and modelling of fluorinated gas emissions.
- **SEURECO/ERASME**: support for macro-economic scoping and evaluation of the macro-economic impacts of the scenarios.

The French Petroleum Institute's New Energy Sources Centre (IFPEN) is also involved in the exercise: it is carrying out modelling for the refining industry. The **ADEME** has also been involved in macro-economic modelling. The energy demand forecasts produced during this study are primarily based on modelling work done using two models in parallel:

The Med-Pro model is a bottom-up, techno-economic model of energy demand. It can be used to closely scrutinise final energy demand on a sector-by-sector basis, the usage of the energy and its form, whilst explicitly taking account of policies and measures in relation to energy efficiency and in support of direct usage of renewable energies, i.e. standards and regulations.

The POLES model can be used to construct detailed, consistent energy assessments taking into account both the European and global context, and explicitly includes economic tools put in place via public policies as well as the behaviour of energy supply stakeholders.

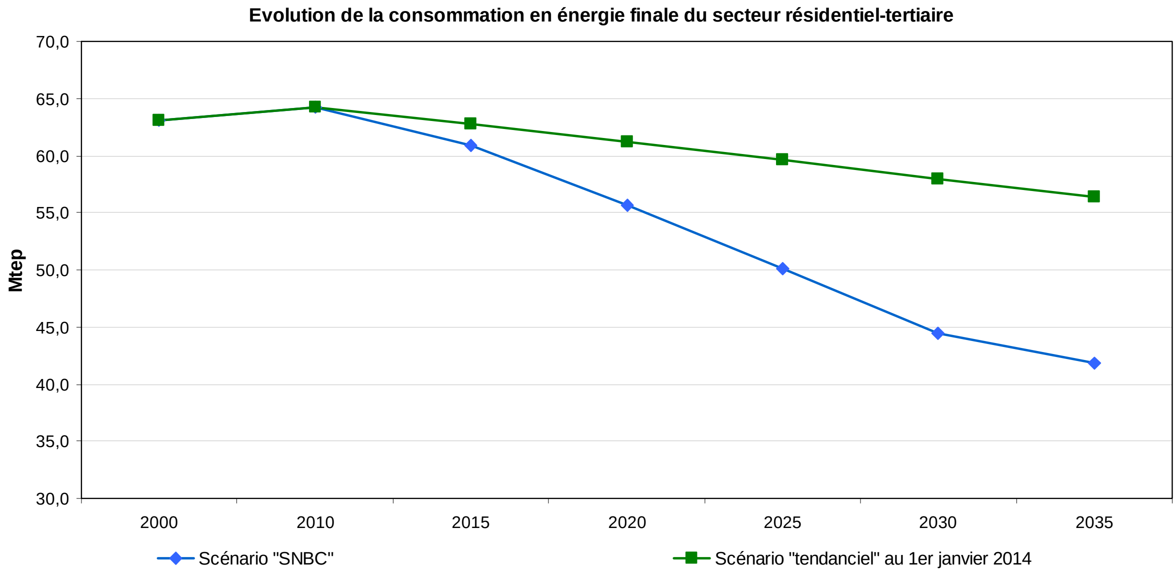
Forecasting in relation to energy, greenhouse gas emissions and atmospheric pollutants is carried out simultaneously on the basis of a holistic approach, in order to ensure the greatest possible methodological consistency. The proposed forecasts cover the period from 2015 to 2035, split into ‘phases’ of five years, and look at mainland France, overseas departments and regions (DROMs) and overseas territorial communities (COMs). Forecasts for overseas territories are, however, conducted separately, and in less detail than predictions for mainland France.

These different models have made it possible to forecast the impact of the various measures that make up the general framework of the SNBC, in terms of reducing both energy consumption and greenhouse gas emissions. The scenario hereby functions as a point of reference for analysing attainment of the objectives. It does not constitute an action plan, but serves as a potential roadmap for achieving the objectives set, whilst also defining short and medium-term recommendations for reaching those objectives.

5.2.2 *Modelling the objectives set by the SNBC for the construction sector*

The figure below illustrates the development in modelled consumption in the residential and non-residential sector between 2010 and 2035. It serves to highlight the ambitious objectives set for the construction sector by the SNBC, and thus by the LTECV, and to estimate the impact of efforts already undertaken.

- The 'SNBC' scenario corresponds to a situation in which the sector achieves the objectives of the LTECV, and therefore is a model including all of the measures contained in this strategy. Some of these measures were presented in Section 5 of this report. All of this information is available on the website of the ministry:
  SNBC: http://www.developpement-durable.gouv.fr/strategie-nationale-bas-carbone#e2
  Modelling: http://www.developpement-durable.gouv.fr/scenarios-prospectifs-energie-climat-air
- The scenario labelled 'trend' corresponds to the change in consumption in the sector if no measures to improve the energy efficiency of buildings were taken since 1 January 2014. It therefore only takes account of measures that had been effectively adopted before that date. The divergence between the curves for this scenario and the SNBC scenario therefore indicate the effort required by the sector between 2010 and 2035 in order to achieve the LTECV objectives. A comparison of the two curves enables the production of an estimate of efforts to be undertaken in order to achieve the objectives set by law.

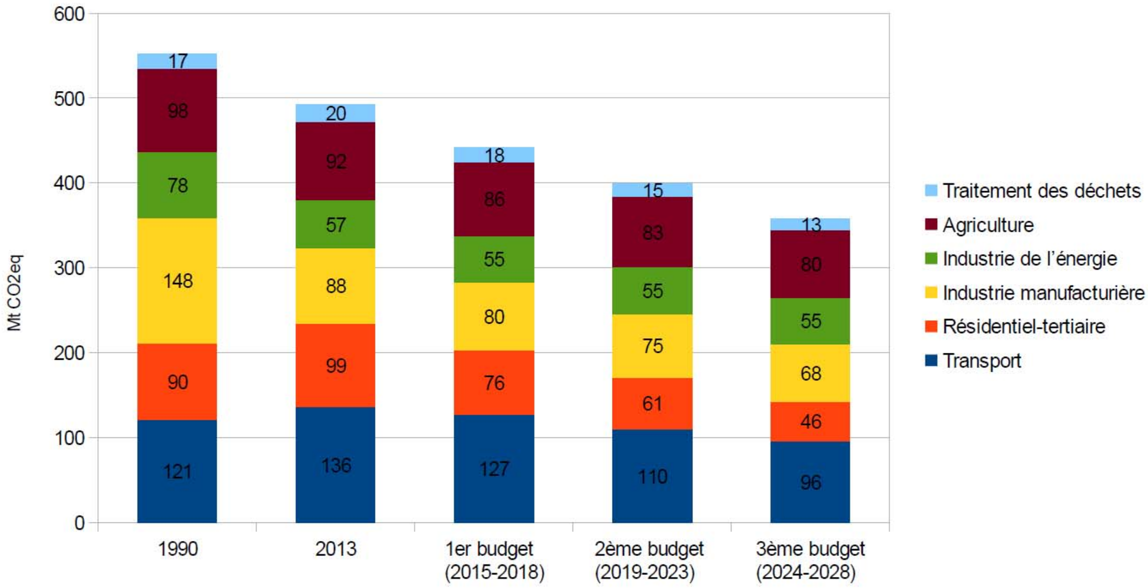


Changes in consumption in the residential and non-residential sector

Evolution de la consommation en énergie finale du secteur résidentiel-tertiaire	Changes in final energy consumption in the residential and non-residential sector
Mtep	Mtep
Scénario "SNBC"	'SNBC' scenario
Scénario "tendanciel" au 1er janvier 2014	'Trend' scenario on 1 January 2014

The graph above indicates the efforts that need to be made in order to achieve the objectives of the LTECV. It can therefore be regarded as a tool/indicator for monitoring consumption in the sector.

The objectives set out by the SNBC are not expressed in terms of energy consumption, but in terms of greenhouse gas emissions. These carbon budgets, which are allocated to each sector, are illustrated in the graph below:



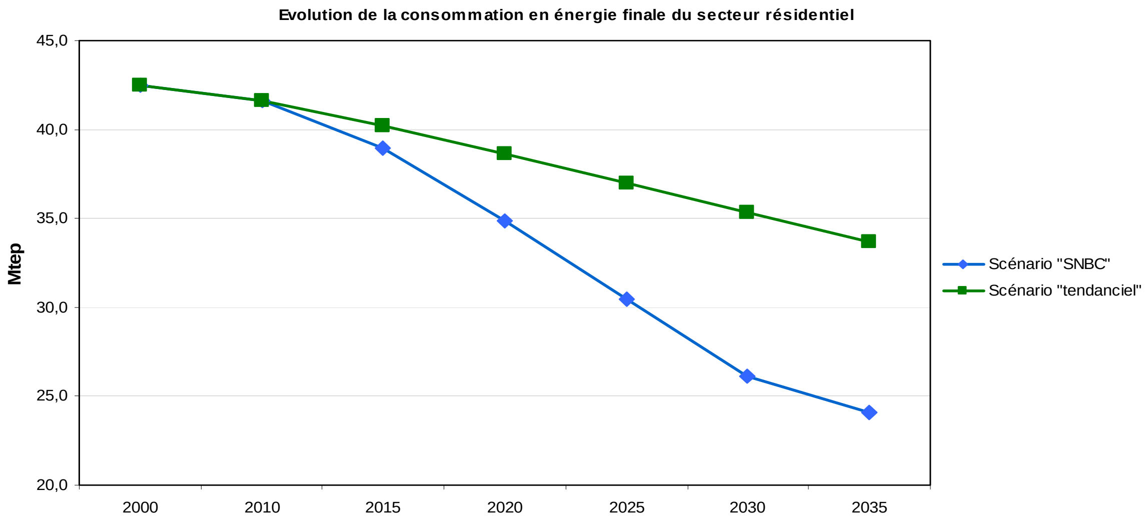
Sectoral allocation of carbon budgets (source: SNBC)

Mt CO2eq	Mt CO2eq
1er budget	1st budget
2ème budget	2nd budget
3ème budget	3rd budget
Traitement des déchets	Waste treatment
Agriculture	Agriculture
Industrie de l'énergie	Energy industry
Industrie manufacturière	Manufacturing industry
Résidentiel-tertiaire	Residential and non-residential sector
Transport	Transport

This allocation demonstrates the high level of ambition of the objective set for the construction sector, which represents a 54% reduction in emissions between 2013 and 2028.

5.2.3 *The results and key measures for the residential sector*

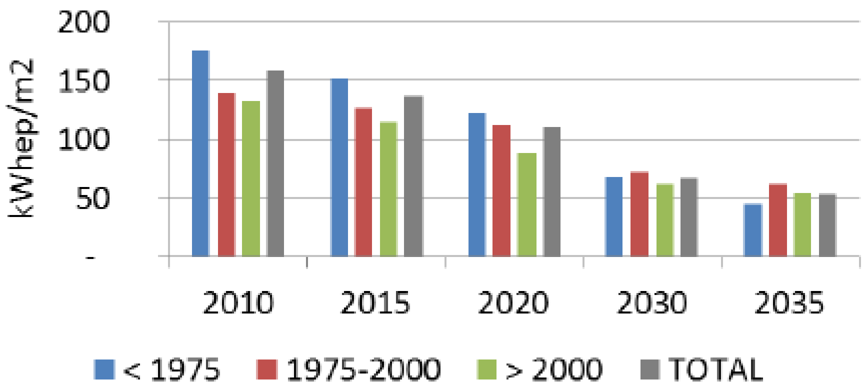
Using a similar approach to the one above, it is possible to hone in specifically on trends in the residential building sector alone. It should be noted that the SNBC encompasses the entire sector, which means that consumption by new constructions is also included in the scope of the analysis. A subsequent, more detailed analysis will allow the impacts on new and existing buildings to be separated.



Changes in consumption in the residential sector

Mtep	Mtep
Evolution de la consommation énergie finale du secteur résidentiel	Changes in final energy consumption in the residential sector
Scénario "SNBC"	'SNBC' scenario
Scénario "tendanciel"	'Trend' scenario

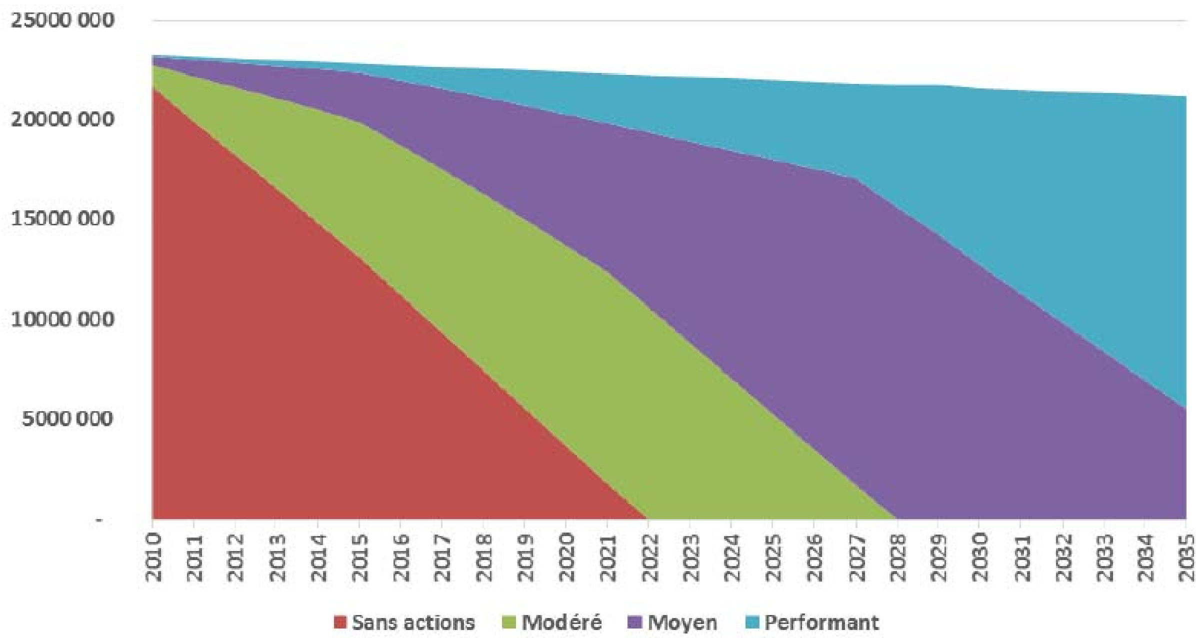
Energy efficiency upgrading of buildings, implementation of new regulations for new housing, improvement of heating systems and energy substitution will have a major influence on improving the energy efficiency of the building stock by 2035. The graph below illustrates this development for three sections of the building stock.



Average unit heating consumption expressed in terms of primary energy (source: reference scenario of the SNBC)

kWhep/m2	kWhep/m2
TOTAL	TOTAL

These levels of energy efficiency will primarily be achieved thanks to widespread take-up of upgrading and the high level of efficiency of the upgrading work itself (compatible with BBC level). The graph below presents a dynamic illustration of developments in the private housing stock according to their energy efficiency upgrading level. It is based on the hypothesis that by 2023, all houses will have carried out a moderate level of upgrading work (leading to a 13% reduction in energy consumption), with a robust increase in efficient upgrading projects as of 2027 (work that can bring about a 75% decrease in energy consumption).

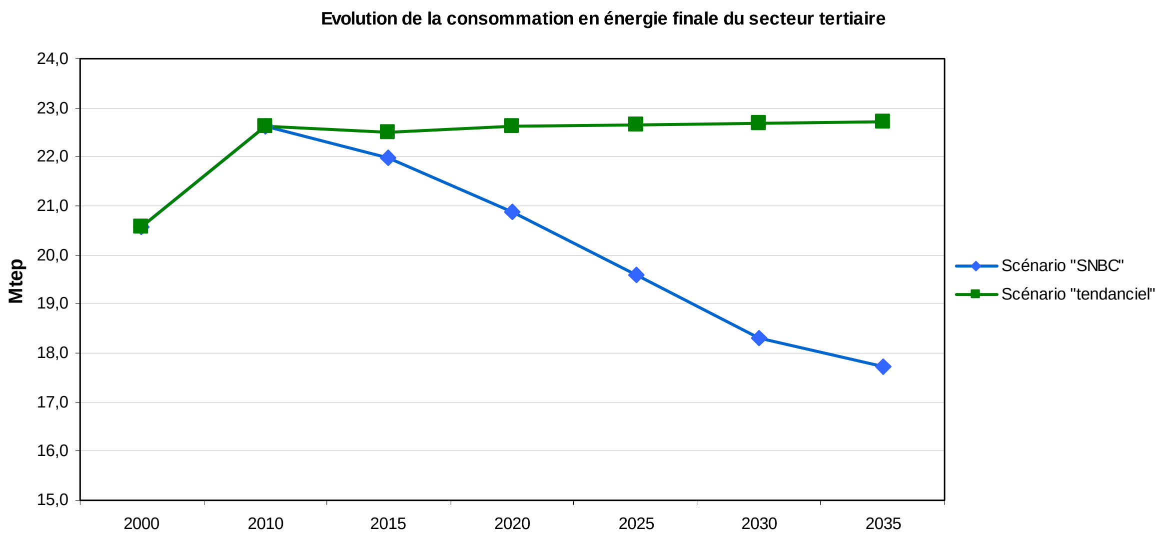


Development of the existing private housing stock according to the level of energy efficiency upgrading

Sans actions	No action
Modéré	Minor
Moyen	Medium
Performant	Efficient

5.2.4 *The results and key measures for the service sector*

The service sector is making a major contribution to achieving the objectives: by 2035, it is expected that the sector will consume 20% less than it did in 2010. These efforts are all the more impressive when one bears in mind that the current trend (measures taken before 01/01/2014) would only lead to a stabilisation in consumption, unlike in the residential sector.

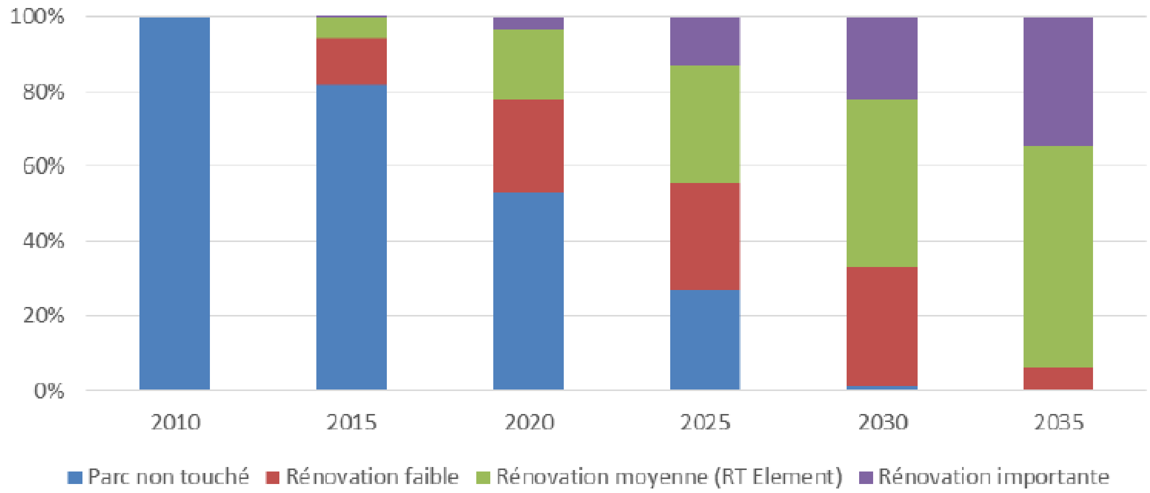


Changes in consumption in the non-residential sector

Mtep	Mtep
Evolution de la consommation en énergie finale du secteur tertiaire	Changes in final energy consumption in the non-residential sector

Scénario "SNBC"	'SNBC' scenario
Scénario "tendanciel"	'Trend' scenario

As in the residential sector, this reduction in consumption will necessitate widespread take-up of energy efficiency upgrading measures in non-residential buildings.



Changes in the proportion of upgraded buildings in the non-residential building stock

Parc non touché	Unaffected stock
Rénovation faible	Minor upgrading
Rénovation moyenne (RT Element)	Average upgrading (RT Element)
Rénovation importante	Major upgrading

5.2.5 *Monitoring the objectives set for the building sector*

The objectives set by the SNBC for the building sector are monitored by evaluating and updating sectoral indicators, including:

- energy consumption in the residential and non-residential sectors, with separate figures for heating consumption;
- public and private investment in favour of the energy transition ('building' component);
- number of private houses upgraded, broken down according to the level of efficiency;
- number of individuals having received advice after contacting a regional energy efficiency upgrading platform (PTRE);
- number of homes upgraded in connection with the Anah's 'Living Better' programme;
- energy consumption according to usage for the residential and non-residential sectors;
- life-cycle assessment of greenhouse gas emissions from construction activities.

A summary of these indicators will be drawn up and disseminated in connection with the updating of the national low carbon strategy, which is expected to be published in mid-2019.

ANNEX I: Databases used for studying the residential and non-residential building stock

The table below compares the available databases on energy efficiency of residential buildings, including an analysis of their pros and cons when it comes to attempting to perform a detailed analysis of building stock and providing evidence for drawing up scenarios for cost-effective upgrading strategies.

Database	Database producer	Coverage	Database content	**Statistical sampling** *Representativeness of the database*	Survey year
PHEBUS Energy Efficiency Survey of the Living Environment, Needs and Uses	Service for Observation and Statistics (SOeS) of the Ministry for the Environment, Energy and Maritime Affairs (MEEM)	Primary residences – mainland France Detailed data	- 'CLODE' phase of the survey (5 400 homes): *General characteristics of the home and its occupants, socio-demographic characteristics of the household, work carried out since 2008, type of heating and energy consuming devices, energy usage and habits, actual energy consumption* - 'DPE' phase of the survey (2 400 homes): *Carrying out of an energy efficiency diagnosis (DPE) using the 3CL calculation method on a sub-sample of 2 400 homes from the CLODE phase*	Sample drawn from the INSEE sample for the purposes of the 2013 annual census, representative of regions, climatic zones, living arrangements (individual or collective) and construction years. The sample is representative of the 27 million primary residences.	Data collected from April to October 2013.
ENL (2013) National Housing Census (ENL)	INSEE	Primary residences – mainland France and overseas departments Detailed data	Description of the housing stock and household occupation conditions, in particular the cost of the housing born by households	Large-scale sample, representative at national level (all primary residences), enabling detailed exploitation of the data. Around 36 000 respondents in 2013, 27 137 of which in mainland France.	Data collected from June 2013 to June 2014
DPE Observatory	ADEME – the data are	All buildings subject to a	The database contains	3.7 million DPEs in the	Continuous collection of data

	transmitted directly to ADEME by DPE diagnosticians	transaction (sale or letting): single-family homes, apartments, multiple-dwelling buildings Detailed data (few data fields) at data.gouv.fr Data aggregated by the observatory	information obtained from the DPE on the location of the building and estimated energy consumption	database, but the sample is not statistically representative (representative of flows and not of stock), nor does it provide statistical adjustment keys. In addition, the reliability of the data has not been verified	since 2013
Centre for Economic Studies and Research on Energy (CEREN) Statistical Observatory on Energy Demand – 2015 publication using data from 2013	CEREN	Primary residences Aggregated data	The CEREN data are based on the ENL and on data drawn from censuses, as well as on: - Sitadel (construction permits); - CONSUEL[8] publications; - SOeS data on heating consumption produced by urban heating networks. The data on energy consumption are updated each time a new ENL is carried out.	The data are representative at national, regional and department level. The CEREN carries out two surveys: - one of 250 heating installers across 3 500 homes regarding annual changes in energy consumption; - another of 3 500 households regarding their energy consumption.	Surveys conducted in 2013, based on the data from the 2013 ENL
Standardised Thermal Study Summaries (RSET) database	The data are transmitted by the project managers for new buildings. The database is managed by the CSTB	All types of housing – new housing only – mainland France Detailed data	Technical characteristics allowing calculation of the (theoretical) energy efficiency of buildings Does not provide actual consumption data	Most complete, non-exhaustive database on new buildings: *although the RSETs are systematically submitted before submission of the construction permit, when it comes to obtaining confirmation of completion, the RSET is not systematically submitted upon completion of the work. There is a substantial*	Continuous collection of data since 2013

[8] National Committee for the Safety of Electricity Users, which surveys homes having undergone work in order to ensure the conformity of electrical installations.

				difference in the number of RSETs submitted in these two phases, which cannot be justified by the construction deadline alone.	
Population Census	INSEE	Detailed data at municipal and IRIS (groupings of areas based on statistical information) level.	A wealth of data on inhabitants and their living conditions (type of housing, year of construction, heating, level of comfort, etc.)	Representative at municipal and IRIS level	Annual collection of data drawn from the concatenation and weighting of five annual surveys.
'Energy Management' survey	ADEME	Detailed data at national level. Annual summaries on the ADEME website.	A sample of 10,000 households aimed at qualifying and quantifying the energy efficiency work carried out. The objective is to establish a tool for raising awareness among households on questions relating to energy management. Example of information collected (reasons for carrying out work, use of subsidies, opinions of households on the thermal quality of their living environment, etc.)	National sample of 10,000 households	Annual survey, first launched in 1986.

Analysis of the characteristics of the available databases on the energy efficiency of housing

	Characteristics of the housing	Characteristics of the household	Equipment and energy types	Theoretical energy consumption (DPE)	Actual energy consumption	Detailed data available for use?
PHEBUS	Yes	Yes	Energy: yes Equipment: yes	Yes	Yes	Yes
ENL (2013)	Yes	Yes	Energy: yes Equipment: yes	No	Yes	Yes
DPE Observatory	Yes	No	Energy: yes Equipment: yes	Yes	No	No
CEREN	Yes	No	Energy: yes Equipment: no	No	Yes	No
RSET	Yes	No	Energy: yes Equipment: yes	Yes	No	Yes
Population Census	Yes	Yes	Yes	No	No	Yes
'Energy Management' survey	Yes	No	Yes	No	No	No

Comparison of the information typologies contained in the databases studied

As regards the non-residential building stock:

Database	**Database producer**	**Coverage**	**Database content**	**Statistical sampling** *Representativeness of the database*	**Survey year**
DPE Observatory	ADEME – the data are transmitted directly to ADEME by DPE diagnosticians	All buildings subject to a transaction (sale or letting): non-residential (not split into categories), retail parks	The database contains information obtained from the DPE on the location of the building and theoretical estimated energy consumption	200,000 DPEs for commercial buildings in the database, but the sample is not statistically representative (representative of flows and not of stock), nor does it provide statistical adjustment keys. In addition, the reliability of the data has not been verified	Continuous collection of data since 2013
Centre for Economic Studies and Research on Energy (CEREN) Statistical Observatory on Energy Demand – 2015 publication using data from 2013	CEREN	Commercial buildings in line with the principal activity (APE) codes from the SIRENE system The study covers almost 190 million m^2 of heated area Includes all office buildings, including public and municipal	Non-residential establishments whose consumption falls under building-related issues: heating, air conditioning and lighting. Does not cover general consumption of buildings (lifts, etc.) or consumption linked to an industrial type procedure	The surveys conducted by CEREN comprise: - 12 000 responses regarding existing establishments in the SIRENE system - 3 000 project manager responses on the basis of construction permits - 1 200 recently built establishments The definition of the sectors is based on the SIRENE database and the APE codes The total heated surface area is assessed on the basis of the number of employees in the sector. Statistical tests demonstrate the development	Surveys conducted in 2013

				in m^2/employee	
CODA database	CODA Strategies	Business real estate Estimated surface area of 190 million m^2, of which: - 115 million m^2 of private office buildings; - 59 million m^2 of public office buildings; - 16 million m^2 of municipal buildings.	Sectors of activity Type of occupation, occupation status, type of owner Type of energy by usage and energy consumption Technical characteristics, construction date, surface area	The 2012 survey is an update, and supplements the CODA 2007 study on the non-residential building stock in Europe. The primary data are collected by way of polls and surveys of professionals, building stock managers, property managers, facilities managers, real estate officers, etc.	2012
Survey on Energy Consumption in the Commercial Sector (ECET)	INSEE – SOeS	Commercial establishments, without any size restriction, whose principal activity is a primarily commercial service sector activity, including retail craft traders but excluding transport and warehousing. Does not cover the main non-commercial service sectors: education, health, etc.	- Contextual data on the establishment: surface area, type of heating system, air conditioning - Energy types used - Uses - Quantities of energy purchased, cost of that energy and distribution according to use (%)	Baseline survey established on the basis of the SIRENE directory, sample of 20,000 establishments stratified by activity sector	September 2012–January 2013
CSTB study on municipal building stock	CSTB – Directorate for Economic Studies and Analysis	- Utilisation of the municipal building stock segment of the CODA 2012 database. - Regional focus on five local authorities in order to add more detail to the national database.	Contextual data broken down by asset type, property type, number of buildings, etc.	Contextual data at national level drawn from the CODA database. Regional studies are not intended to be representative.	January to June 2013

Analysis of the characteristics of the available databases on the energy efficiency of the non-residential building stock

	Detailed information on commercial usage (shops, offices, etc.)	**Distribution of heated surface area**	**Equipment and energy types**	**Theoretical energy consumption (DPE)**	**Actual energy consumption**	**Detailed data available for use?**
DPE Observatory	No	No	Energy: yes Equipment: yes	Yes	Yes	No
CEREN	Yes	Yes	Energy: yes Equipment: no	No	Yes	No
CODA database	Yes	Yes	Energy: yes Equipment: yes	No	Yes	No
ECET	Yes	Yes	Energy: yes Equipment: no	No	Yes	Under certain conditions
CSTB study on municipal building stock	Yes	Yes	Energy: yes Equipment: no	No	Yes	No

Comparison of the information typologies contained in the databases studied