Climate-KIC

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Building Market Brief

France

Climate Innovation Experience

Edition

Building Market Brief
France

Prelude

In light of the necessary global transformation towards a low-carbon economy, the building sector is facing dramatic changes and dire need for disruptive innovations in the years to come. These changes come with risks as well as opportunities. A solid and regional specific understanding is needed to minimize the first and maximize the second when designing, investing in or implementing low-carbon solutions.

Global greenhouse gas emissions from the building sector have globally more than doubled since 1970. In Europe buildings are responsible for 40% of the energy consumption and 36% of the emissions. As such, a low-carbon transformation of the building sector, (deep) refurbishment of the existing building stock and a revitalization of the sector are key components of the EU Roadmap 2050.

With this European perspective in mind, one of the major barriers curtailing large scale investments into low-carbon technologies in the building sector is the lack of cross-country comparable market data. Such an overview would enable inventors, low-carbon technology suppliers and other key stakeholder to exchange know-how and transfer solutions across borders. As the building sector is commonly described as one of the most fractured and regionally colored industries - with very specific habits, traditions and stakeholder setups - this is often impossible.

It is exactly this gap of understanding and data availability that the Building Market Brief series addresses. On a limited number of pages, the condensed essence of a countries' building sector and its spirit is summed up and quantified with indicators aligned across countries. The series of reports provides a reliable basis for low-carbon innovation, investments and adoption, by offering a pan-European market understanding and providing comparable insights of the sector. It aims at documenting a holistic understanding, taken from multiple perspectives, market experts, models and statistical data. This information contributes to enable optimization, integration and scaling. We endeavor a sustained, collective effort to channel investments and behavior in a manner necessary to realize this low-carbon future of the building sector.

Therefore, we would like to address low-carbon innovation suppliers and entrepreneurs that look for suiting markets for their ideas or inspiration for their developments, but also investors and policy makers who would benefit from a better pan-EU overview, allowing for benchmarking and cross-country experience exchange.

I am confident that the information and insights provided by the Building Market Brief series contribute to the transformation into a low-carbon economy as one of the key challenges of this century.

York Ostermeyer
Editor in chief

Acronyms list:

2DS:	2-Degrees Scenario
ADEME:	Agency for Environment and Energy Management (Agence de l'Environnement et de la Maitrise de l'Énergie)
BBC:	Bâtiment basse consommation
BSM:	Building Stock Model
CITE:	Crédit d'impôt transition énergétique
DH:	District Heating
EMF:	European Mortgage Federation energy performance certificate (EPC)
EPBD:	Energy Performance Building Directive
EPC:	Energy Performance Certificate
EU(28):	European Union
EUROSTAT:	European Statistical Office
GDP:	Gross Domestic Product
GHG:	Greenhouse Gases
HDD:	Heating Degree Days
INDC:	Intended Nationally Defined Contribution(s)
INSEE:	The National Institute of Statistics and Economic Studies (Institut National de la Statistique et des Études Économiques)
kWh:	kilo Watt Hours
LCA:	Life Cycle Assessment
LEB:	Low Energy Buildings
MDB:	Multi-Dwelling Building(s)
MEPS:	Minimum Energy Performance Standard
NEEAP:	National Energy Efficiency Action Plan
nZEB:	nearly Zero Energy Building(s)
PREH:	Plan de rénovation énergétique de l'habitat
PTZ:	prêt à taux zero
R&D:	Research & Development
RES:	Renewable Energy Sources
RS:	Reference Scenario
RT:	Réglementation Thermique
SDB:	Single-Dwelling Building(s)
SME:	Small and medium-sized enterprises
t CO_2eq.:	Tonne CO_2 equivalent
TFPB:	Taxe foncière sur les propriétés bâties
TJ:	Terajoule
UN:	United Nation

How to use this report
How to read it and meta structure

This report is meant to provide an intuitive and reliable entry point for assessing the character of the construction sector in the addressed country. It is not necessarily meant to be read from the beginning to the end but rather to be used as an encyclopedia of facts and figures with links to complementary data sources if one wants to get more detailed information on a certain aspect. The structure of the report in independent subchapters enables the readers to start reading at any point depending on their needs and interests. Condensed information is provided from as many perspectives and sources as possible. This might lead to conflicting statements from different sources hopefully helping to communicate the complexity of the market rather than provide streamlined insights. This report is part of a series, one for each country. All reports follow a similar methodology, making all indicators listed comparable between countries. Even if not familiar with a certain indicator the knowledge on one market can therefore be used by the reader to put other markets into perspective. The structure of the reports also allows direct comparison. The readers will find the same indicator on the same page at roughly the same position in every report if it was available for the respective country.

This report is divided into three main chapters according to the methodology followed: **Chapter A**, a literature-based approach; **Chapter B**, a survey-based approach; and **Chapter C** a model-based approach. This structure is complemented by an executive summary and indicator factsheets in the beginning of each report.

Each of the chapters is divided into subsequent subchapters or sections addressing specific topic condensed in a 2-pager format. The main body of the text aims to highlight the most relevant information from the graphs and contextualize the data by explaining relevant frame conditions. For this purpose, the graphs and figure trends are listed side by side with absolute numbers in most cases. This aims to allow an easy perception of the development of a sector as well as to put trends into an absolute perspective, comparing relevance between countries. Specially highlighted numbers are also listed in the factsheet at the beginning of the report where they are sided with numbers form different fields to provide market characterization indicators.

The graphs in the report follow a color code. The color therefore indicates what kind of data is visualized in the graph, making the reading of the report as intuitive as possible.

The chapter's content is complemented by market expert comments and additional sources of information such as reports and data bases in the side bar of each page. The comments refer to opinions voiced by experts as a direct reaction to the report as well as in complementary workshops and interviews and are listed to provide a holistic view of the market as possible. Great care was taken to quote a wide array of opinions.

DOBLE PAGE COLOR SCHEME
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Content

Executive summary

Economic framework conditions

With a population of 66.5 million (2015), France is the second largest among the EU member states in terms of population (13% of EU) and it is the largest in terms of land area (633,000 km²). France's mixed economy system is one of the largest in the world, ranking in 2018 6th worldwide and 3rd in Europe. The country has seen its nominal GDP grow at an annual average rate of +2.18 % (2005-15), while the GDP per capita changed from 28,228 €/capita (2005) to 33,002 €/capita (2015). In the same period the French population grew at an annual average rate of +0.58% (Section A1).

The household disposable income is one of the highest in Europe (5th). The monthly household expenditure on housing and fuel has increased by +17% (2005-15), at an average annual rate of +1.6%, representing more than a quarter of the total expenditure (26%) in 2015. Another large share of the household expenditure is spent on transportation, followed by food & beverages, goods, among others (Section A1).

The construction sector accounts for over 5% of the French GDP. In 2015 roughly 2% of the French GDP, totalling €46 billion was spent on building construction expenditure. Since 2005 the total investments in building construction increased at an average annual rate of +2.5% (Section A5). At the same time, a gradual shift was witnessed in the family structure of the French society. The proportion of single households in the total, rose from 31.4% (2005) to 35.6% (2015). Both single and double family households constituted 68.8% in 2015 of the total households, up from 65.4% in 2005. The changing family structures will have a direct impact on the tenure mix of the building stock as well as the demand patterns for particular kind of houses (Section A6).

France is also a fertile land for innovation. The various incentives offered by the government in promoting R&D and innovation has led the country to be grouped among "strong innovators" in the EU 28 countries (European Innovation Scoreboard 2017). About 2.2% (2015) of the GDP of the country is spent on R&D, against the EU28 average of 2.0% (Section A1).

The structure of the building sector in France

French's metropolitan building stock is dominated by residential buildings, constituting about 76% of the total floor area, from which 68% is occupied by single-dwelling buildings (SDB). The non-residential floor area is 24% (948 million m²) of the total area. Roughly 45% of the total non-residential floor area is occupied by offices and wholesale & retail trade institutions combined.

The stock is predominately private and owner-occupied. About 79% of the residential dwellings are privately owned and 58 % of them are occupied by the owners. This is followed by private tenants who occupy about 21% of the residential dwellings and the remaining 16% are social housing units (Section A2).

The age distribution of the residential building stock still shows a large share of old buildings, with about 40% of the heated floor area built before 1970. During this period, the absence of building codes and the need for rapid reconstruction after the Second World War translated in a large share of very poorly insulated buildings. The effect of the first thermal regulation introduced in 1974, led to a substantial decrease in the GHG intensity of the new stock added during the period from 1970 to 1980, especially in multi-dwelling buildings (MDB). In recent years, especially after 2000, the percentage of buildings that are low-carbon intensive has increased significantly. Buildings with less than 10 $kgCO_2$-eq per m² (climate label 'B' in France) represent about 72% of the total floor area of MDB built after 2000. However, there still remains a significant number of buildings with high GHG emissions that needs to be addressed, as well as a share of buildings built in recent decades that do not meet the targets of a nearly Zero Energy Building (especially SDB) (Section C1).

The proportion of building investments in SDB and MDB has varied over the last decade. A gradual increase can be observed in the proportion of money invested in MDB, with an annual growth

rate of +3.7% from 2005-15. However, in 2015 the development of SDB still lead the investments with 55% of the construction expenditure in housing attributed to this typology (Section A5).

Policy framework and other demand side drivers

Since 2001 when climate change was declared as a "national priority", France has taken increasing commitments towards the reduction of its GHG emissions.

Built on the strategies and targets of the 2005 POPE Law and the 2007-10 Grenelle Environment Acts, France adopted the Energy Transition for Green Growth Act (2015), which targets to cut fossil fuel consumption by 30% compared with 2012, GHG emissions by 40% and to reduce nuclear energy's share in electricity production by 50% by 2025, compared with 1990 levels. It also intend, total energy consumption reduction by 50% by 2050 compared with 2012. Moreover, the Government also intends to price carbon at 56 €/tonne by 2020 and at 100 €/tonne by 2023, for the carbon component of the tax on energy products consumption.

These ambitious goals have translated into further plans and resolution for all sectors, including the building sector. For new buildings, the current RT2012 reflects the demands of the Energy Performance Building Directive (EPBD) recast, requiring 40% higher efficiency compared with the 2005 regulations and seeking to bring about zero-energy consumption in buildings by 2020. It also has provisions for labelling of low-energy buildings that can avail certain financial incentives. For existing buildings, The Energy Transition Act aims to increase the pace of energy renovation in the housing sector by targeting 500,000 major renovations per year by 2017, with the intention that the whole stock adheres to the low energy building (LEB or BBC in French) standard by 2050 (Section A4).

These policies are expected to be important drivers in an increasing demand for more efficient buildings and the shift from fossil fuels to renewable sources of energy. A relationship between house values and their Energy Performance Certificate (EPC) rating can already be observed. Prices can vary by 5% or even 10% when moving from one rating band to the next (Section A6).

Housing and derived energy demand and carbon emissions are also driven by the changing family and household structures, along with personal needs which together entail a demand for more dwellings and floor area (Section A1). Considering these trends, a net addition of 12% to the floor area by 2050 is expected (according to the modelling results). This increase is mainly driven by a growing population (+10% in 2050) and, to some extent, by an increase in the demand for floor area per person. Refurbishment of the existing stock is projected to be an on-going process up to 2050 (Section C4) when most buildings will be partially or comprehensively refurbished (section C4).

Demand side energy, carbon and market trends

Although population and floor area are expected to grow, final energy demand (including ambient heat and solar energy) for heating, hot water, and ventilation, is expected to be 4% lower than present values in 2030 and 20% lower in 2050 under current and decided policies (what is called in this report the Reference Scenario). With more stringent policies and regulations (the 2-Degrees Scenario), the reduction would reach more than 10% in 2030 and more than 31% by 2050 (Section C3). The main responsible for this reduction are the building codes requirements for new construction and the ambitious plans that France has set to comply with their climate goals, including an increase in the retrofit activity and a structural change towards renewable energy sources (RES).

At present, more than half of the total residential floor area in France emits more than 20 kg CO_2-eq/m²/year. A shift occurs until 2030 when for both scenarios is expected that the majority of the buildings emit less than 20 kg CO_2-eq per m² for the RS and less than 5 kg CO_2-eq per m² for the 2DS. This as a consequence of the renovation (at least partially) of more than 40% of the building stock at that point (Section C4). Retrofitting activity is fostered by higher

availability of subsidies and attractive loans, and an increasing CO_2 tax which translates in a higher energy price for fossil fuels Heat pumps and other renewable energy sources, e.g. district heating, are expected to compensate the demand for fossil fuels that will be no longer attractive when retrofitting or constructing new (Sections A4 and C3).

From the market perspective, this transformation will have an important impact on the market volumes for energy sales and low-carbon technologies.

According to calculations with the building stock model (BSM), the total market volume of the energy- and GHG-related building market amounts to €76.5 billion per year in 2018 (section C.5). More than half of this market volume comes from energy sales (€42.3 billion per year), even though electricity sales for household appliances are not included. This volume is expected to be more or less stable in the medium and long term despite growth in population and floor area as the increase in energy prices compensate the stagnation or reduction in energy demand (due to more efficient buildings). The price of electricity in France, today one of the cheapest in the Eurozone, is expected to strongly increase due to the high cost for dismantling nuclear power stations and investing in renewable energy sources. The building envelope market (€22.5 billion per year in 2018) and building technology market (€11.8 billion per year) are expected to strongly increase in the short term, (especially in the 2DS that better catches up neglected retrofit from the past (section C5).

In the long term, all volumes decrease compared with present values. For energy sales, a higher rate of refurbishment results in a lower energy demand that is not compensated for by the increase in the energy price. The reduction on the envelope market volumes is partially explained by the decrease on partial refurbishments (usually linked to replacement of old elements) but also by the reduction in new construction due to the expected stabilization of the floor area per person after 2030. Decreased construction activities also impact the market for building technologies, which suffer from further reductions due to decrease in installed capacities for heating systems and learning-related cost reductions, especially for heat pumps.

The supply side: construction sector and technology providers

The supply side in France, particularly architects, engineers, planners and other stakeholders, consider that the envelope elements present the biggest opportunities for improving the energy performance, followed by the penetration of RES, complemented by in-site production, particularly solar and heat-pumps. However, the use of RES still faces some barriers being considered an investment difficult to pay off with the present energy prices (Section B6 and B3).

There is an agreement that the renovation of the existing housing building stock is a priority with a big part built before the first oil shock of 1974. However, current renovation market struggles to meet the goals of 500,000 renovation per year, reaching only to 200,000 buildings/year. This is also negatively affected by the fragmented structure of the sector, where approximately 80% of the turnover is generated by craft companies with less than 10 employees (Section B1). Training remains organized by profession with little interdisciplinary interaction. Therefore, integrative approaches remain difficult.

On the roles in different projects, the evolution of technologies, and regulations heavily reliant on engineering, have favor more integrative and standard solutions, placing engineers and interdisciplinary networks as the main actors in building projects. The role of the architect rest as the main communication point for the planning process but not much for the execution particularly for SDB. On the other hand, in MDB, and large renovation projects, at a level of community or neighborhood their role is key (Section B4).

From the perspective of supply-side stakeholders, the most effective drivers for low-carbon technologies are regulatory pressure together with financial and fiscal incentives. Particularly successful has been the obligation of a DPE (Energy Performance Diagnostic) for every

transfer of owner or tenant, to show the Energy and GHG performance of the property. This has helped the owners to making renovations to increase the value of their property, overcome some important barriers like the mistrust in low-carbon technologies and the long payback periods of investment (Section B7).

Conclusion and outlook

The climate goals adopted by the latest French government have translated into stringent building codes and ambitious plans to retrofit the existing building stock, accompanied by financial instruments that together intend to drive a deep transformation of the built environment from here to 2050. However, the results from the modelled scenarios suggest that France needs even more stringent policies and financial instruments (such as those outlined in the 2DS) to meet the commitments adopted on the Paris Agreement.

According to experts, the transformation is facing some important barriers like the mistrust of customers in low-carbon technologies and the long pay-back period of investment. On the other hand, according to these experts, regulatory pressure together with financial and fiscal incentives are the most effective drivers to overcome them.

This demands a building sector prepared to provide the necessary expertise and technologies to deliver a more energy-efficient and low-emission building sector, that can also ensure the comfort and health of its habitants. The related reduction in the demand of fossil fuels suggests that the energy and technology providers should be prepared to diversify its activities and to carefully manage its infrastructure assets. Renewable gas or developing heat pump-related energy services might be elements of new business strategies (Section C3)

These conditions along with France robust mixed economy and long tradition of innovation, make it a fertile land for new business opportunities in these times of change.

A

Market overview

A

Aim

Chapter A intends to provide an overview of the country's building market, its frame conditions, trends and market mechanisms for the demand of low carbon products and solutions. It does this by providing a brief introduction of the country´s economy and society as well as a characterization of the building stock and influencing climate factors. Energy and climate goals of the country are also synthesized, which include grid mix, emission factors and implication of climate goals. This is followed by an overview of the current framework of standards and support measures. Investments and employment in the construction sector are finally depicted.

This chapter is based on an extensive literature study. The sources cover a wide range including European statistical data, the respective countries own statistical office, national and international public reports, scientific publications and market information such as prices and sales volumes. The main contribution is, therefore, collecting and summarizing this information, though readily available present in a fragmented manner. All data sources are clearly marked to allow the reader accessing more detailed information as needed. The complete list of sources can be found in the annex of the report.

A1 Introduction
France's economy and society

USEFUL READING:

BNP Paribas 2017. Overview of the French Economy. BNP Paribas.
www.economic-research.bnpparibas.com

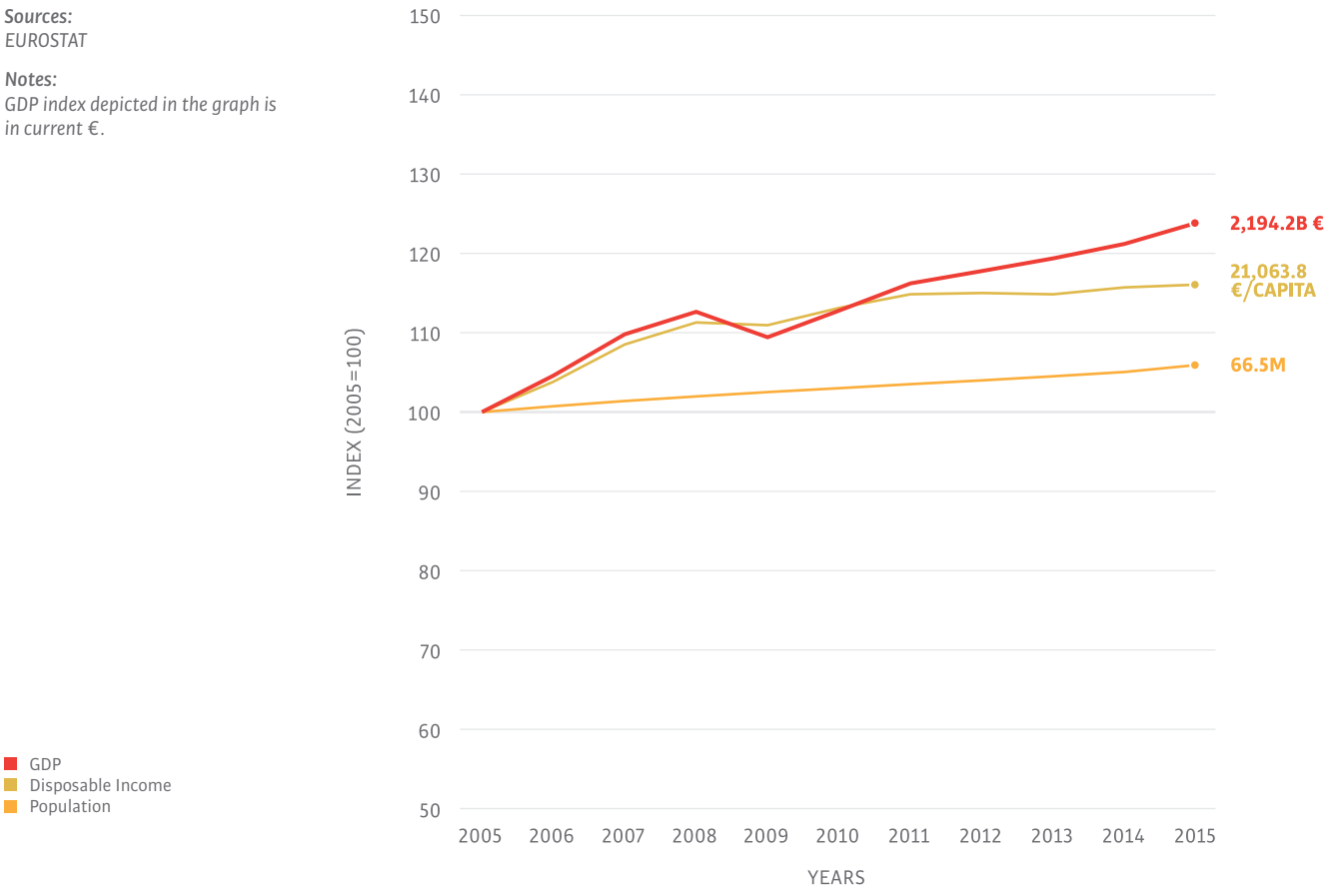
OECD 2017. OECD Economic Surveys: France. OECD.
www.oecd.org

With a population of 66.48 million (2015), France is the second largest of the 28 European Union member states (EU28) in terms of population (containing 13% of the EU population). It is the largest in terms of land area (at 633,187 km²).[1] The country has seen its nominal GDP grow at an annual average rate of 2.18% (2005-15), whilst the GDP per capita changed from 28,228 €/capita in 2005 to 33,002 €/capita by 2015. During the same period, the French population grew by an annual average rate of 0.58%.[2]

A1.1 – *Trends in France's GDP, disposable incomes and population.*
French GDP is expected to expand due to increasing private investments and public spending. The French government spending as a % of GDP is one of the highest in Europe i.e. 56.6%[3].

Sources:
EUROSTAT

Notes:
GDP index depicted in the graph is in current €.



The services sector adds major value to the French economy, with its value added contribution standing at 78.5% of total in 2015, industry (14%), manufacturing (11.6%) and agriculture at 1.8%.[3] In the first half of 2016, France had a 3.3% global market share in goods exports, with SMEs contributing 14% of the export value.[4] These SMEs account for 99.8% of French businesses and employ 50% of the workforce.[5] In addition, France has some of the largest companies globally, with 29 French companies listed in the Fortune 500.[6] The various incentives offered by the government in promoting R&D and innovation has led the country to be grouped amongst 'strong innovators' in the EU28 (European Innovation Scoreboard 2017).[7] About 2.23% (2015) of the French GDP is spent on R&D, compared to the EU28 average of 2.03%.[8]

In the cleantech sphere, France was ranked 13th in a group of 40 countries in the Global

Cleantech Innovation Index 2017,[9] a two-point jump in rank from 2014. France demonstrated strong indications of emerging cleantech activity, as evident in the high amount of early-stage venture capital investment in domestic companies. Some 2.6% of total private equity investments (€ 312.52 million) in the year 2016 were made in energy and environment companies.[10] The country also issued a record € 7.5 billion in green bonds with a 22-year maturity.[11]

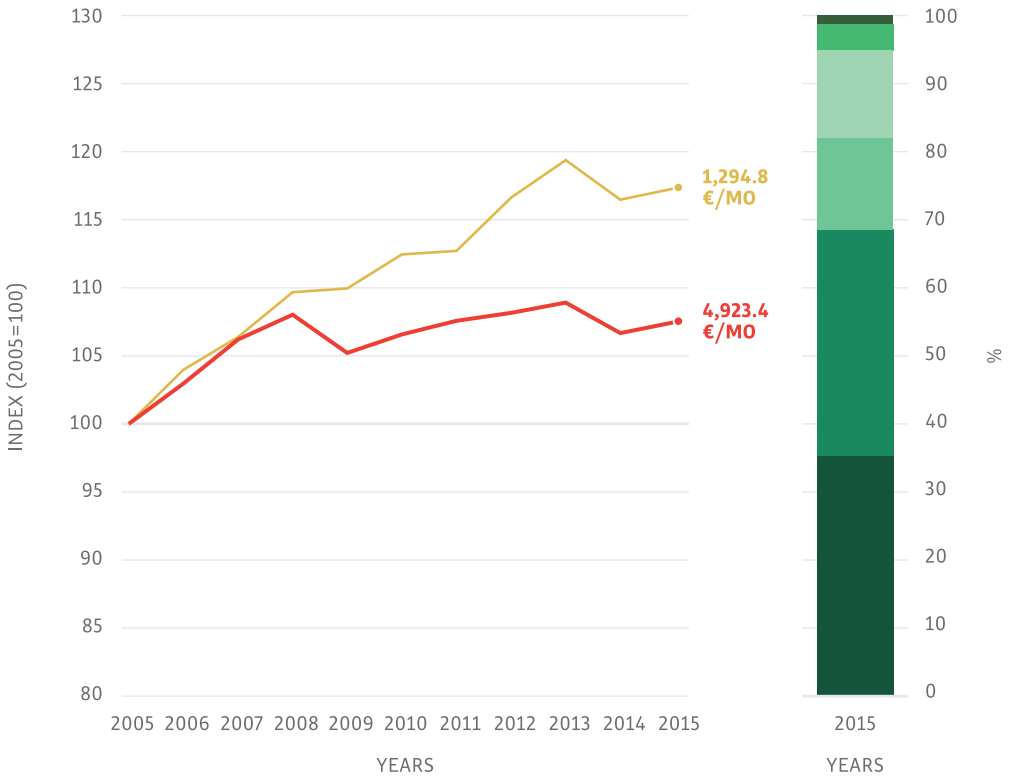
USEFUL READING:

EUROSTAT 2016. Expenditure of households by consumption purpose: News Release.
www.ec.europa.eu/eurostat

Monthly household expenditure on housing and fuel has increased by 17.32% from 2005 to 2015 at an average annual rate of 1.63%. By contrast, total household national consumption expenditure (monthly) increased by some 7.49% during the same period at an average growth rate of 0.74%. Expenditure on housing and fuels is more than a quarter of total expenditure and stands at 26.3% in 2015, up from 24% in 2005.[12] A large share of household expenditure is spent on transportation, followed by food and beverages, goods, and others.

A1.2 – ***French has witnessed a gradual increase in the number of one-person households. In 2015, 68.8% of households were one- and two-person households.***

The total household expenditure is roughly 53.1% of the GDP, while that on housing and fuel a 13.98% of the GDP. The slow growth in population and increase in single person households will lead to shift in consumption patterns and preferences overtime.



Sources:
EUROSTAT

Simultaneously, a gradual shift has been witnessed in the family structure of French society. The proportion of single households rose from 31.4% in 2005 to 35.6% in 2015. Both single- and double-family households comprised 68.8% of total households in 2015, up from 65.4% in 2005. Changing family structures will have a direct impact on the tenure mix of the building stock as well as the demand patterns for particular kinds of houses.

USEFUL READING:

McKinsey 2010. Meeting the 2030 French consumer. How European-wide trends will shape the consumer landscape. McKinsey & Company.
www.mckinsey.com

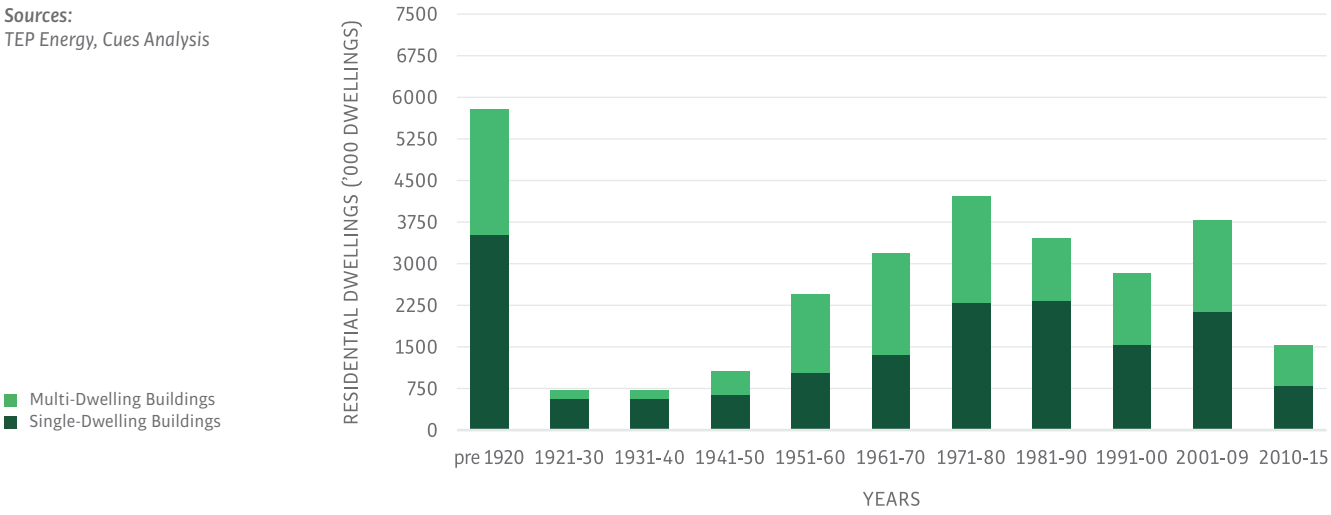
A2

Building stock
Building characteristics and influencing climate factors

Over half of the total housing stock in France (19 million dwellings) was built prior to 1975,[13] and the growth in the number of dwellings has been waning since 1980, with a trend of inadequate growth in housing supply relative to the growth in the number of households. The housing stock in metropolitan France is over 28 million main residences (2017),[14] and the average surface area per capita has increased by 15 m² in the last thirty years. The average living area stabilised to 40 m²/capita by 2013.[15] Since 2007, the supply as well as the demand for housing has dropped in response to the economic recession. In the past few years, however, the pace of housing has increased due to support measures by the government as well as low lending rates.[16]

A2.1 – *Residential building space trends.*
Growth in number of households outpaces growth in population, leading to demand for residential dwellings.

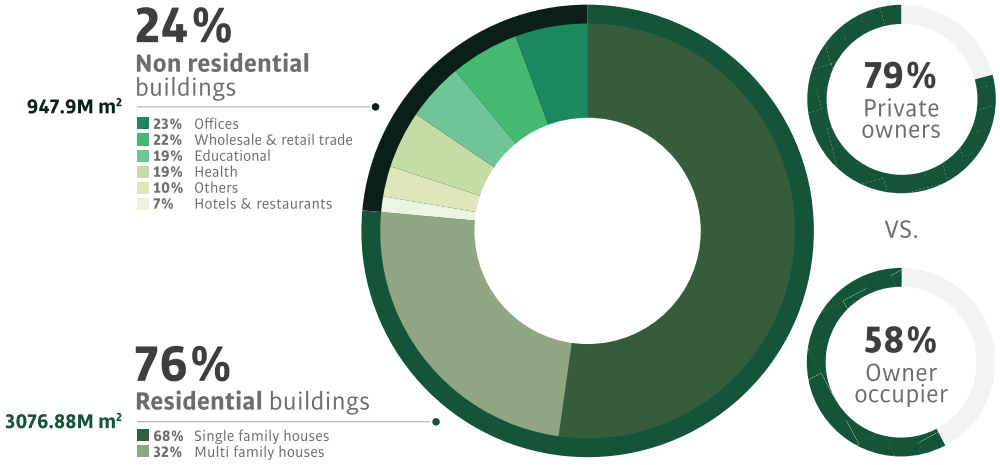
Sources:
TEP Energy, Cues Analysis



In France, 76% of total building floor area is occupied by residential dwellings (totalling some 3076.88 million m²). Of this, 68% of the floor area is occupied single-dwelling buildings, followed by multi-dwelling buildings at 32%. The non-residential floor area is 24% of total area (948 million m²), of which roughly 45% is occupied by either offices or wholesale and retail trade institutions.[17]

A2.2 – *Breakdown of the building stock.*

Sources:
EU Building Stock Observatory



Some 79% of the residential dwellings are privately owned and **58 % of them are occupied by the owners in France**. This is followed by private tenants, who occupy some 21% of the residential dwellings, with the remaining 16% being social housing units. The desire to own one's own home, as well as a dominant owner-occupied market combined with fiscal incentives, has positively affected the demand for new homes.[18]

The medium- and long-term repercussions of climate change related phenomena cannot be ignored, as they could well shape how the French building stock evolves. Whilst demographic and socio-economic factors will play a role in building stock development, changes in weather will require efforts to make buildings more environmentally resilient. For example, it is estimated that due to a recurrence of natural hazards, annual damage of more than € 1 billion can be incurred to residential dwellings due to clay shrinkage and swelling. The gradual rise in temperature, as evident in the reduction of the number of Heating Degree Days (HDD), calls for the development of more energy-efficient planning, especially in terms of cooling.[18][19] Between 1980 and 2009, HDD's decreased by 17%. The variation in temperatures over time will affect future energy demand as well as building design load.

NOTE

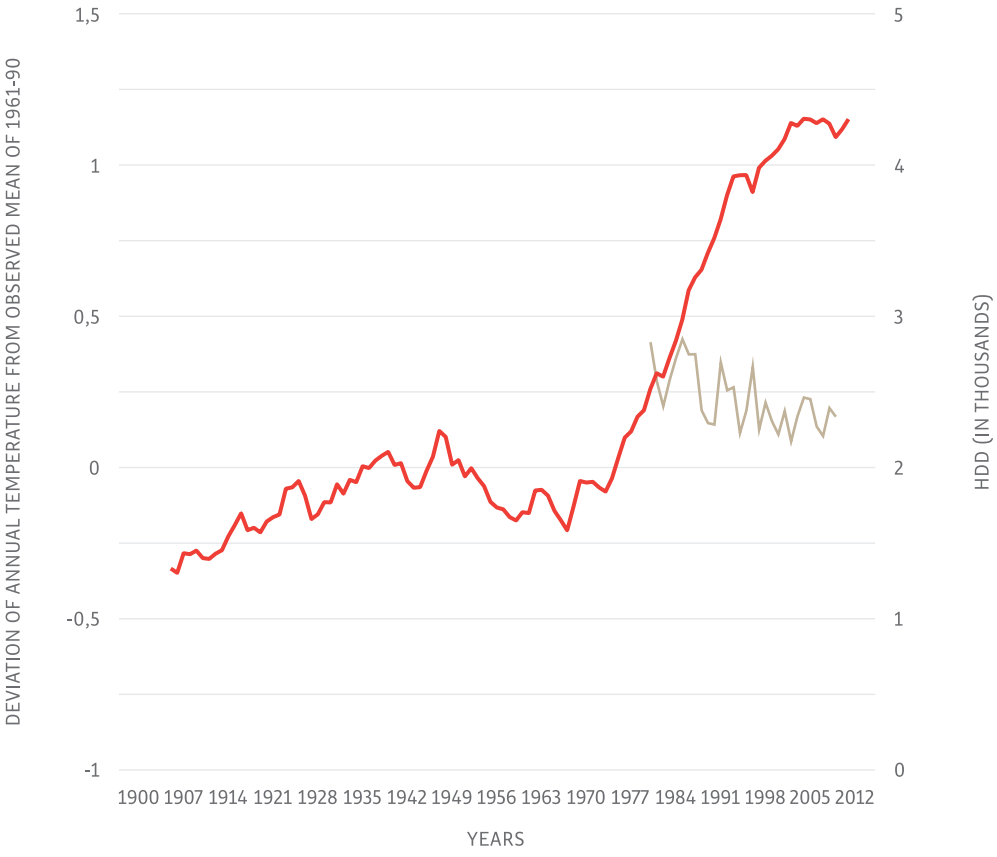
(HDD) is an indicators to quantify the heat energy demand for a building. It is the number of degrees that a day's average temperature is below a base temperature, below which buildings need to be heated.

USEFUL READING:

BPIE 2014. Renovation strategies of selected EU countries. Buildings Performance Institute Europe, Brussels.
www.bpie.eu

BPIE 2011. Europe's buildings under the microscope. Buildings Performance Institute Europe, Brussels.
www.bpie.eu

A2.3– *A period of constant warming.*
Substantially reduced heating demands due to increasingly warmer mean temperatures.



Sources:
EUROSTAT, Statistiques Developpement-durable

Concerted action is required to reduce the energy consumed by the building sector as a result of increasing cooling demands over time. Simultaneously, buildings must be adapted to limit health vulnerability and increase the comfort of the occupants. A general effort is required to address issues that will arise due to climate change, and such risks must be included in the development of policies, measures, and standards so as to optimise the demand for energy.[21]

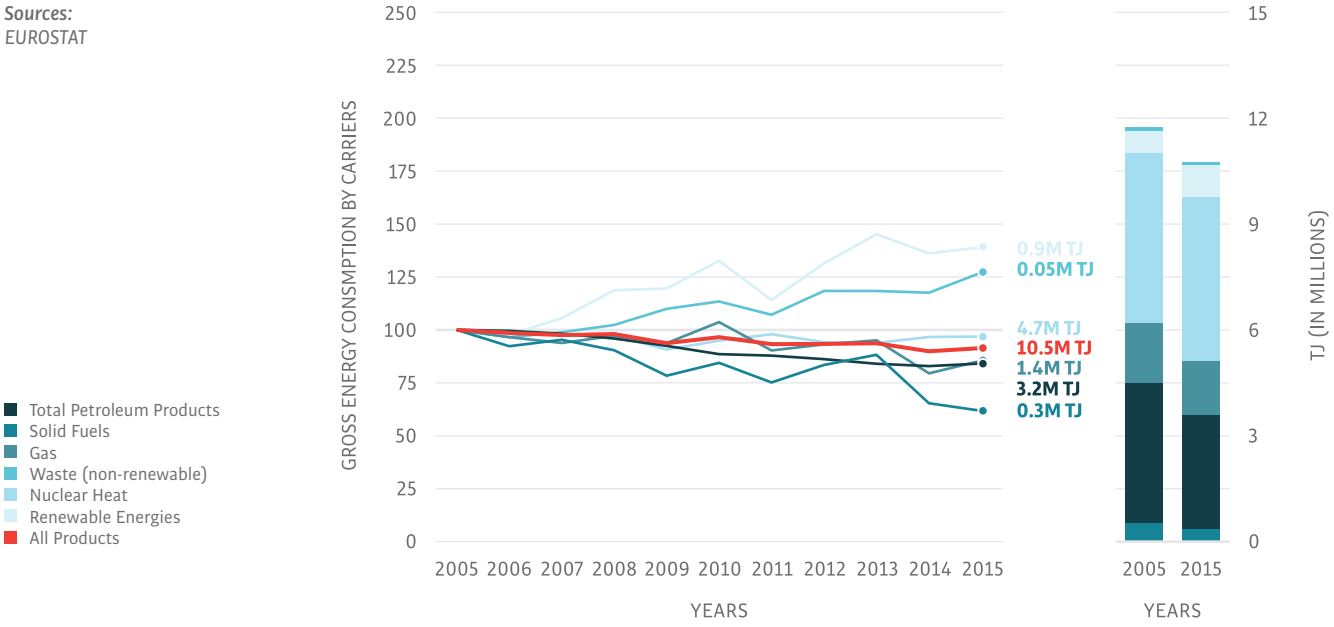
A3

Energy, emissions, and climate goals
Introduction to the energy mix, emissions profiles, and the implications of climate goals

French gross energy consumption declined at an average annual rate of 0.87% from 2005 to 2015. Meanwhile, the renewable energy share of gross final energy consumption rose from 9.5% in 2005 to 15.2% by 2015.[22] Nuclear energy occupies the largest share (44.66% in 2015), followed by petroleum products (30.97%).[23] France enacted the Energy Transition Act for Green Growth in 2015, paving the way for the transformation of its energy system with the aim of reducing nuclear energy's share in electricity production to 50% by 2025.[24]

A3.1 – *In the decade since 2005, French total gross inland energy consumption decreased by 8.6%.*
The Energy Transition Act 2015, intends to cut France's consumption of fossil fuels by 30% by 2030.

Sources:
EUROSTAT



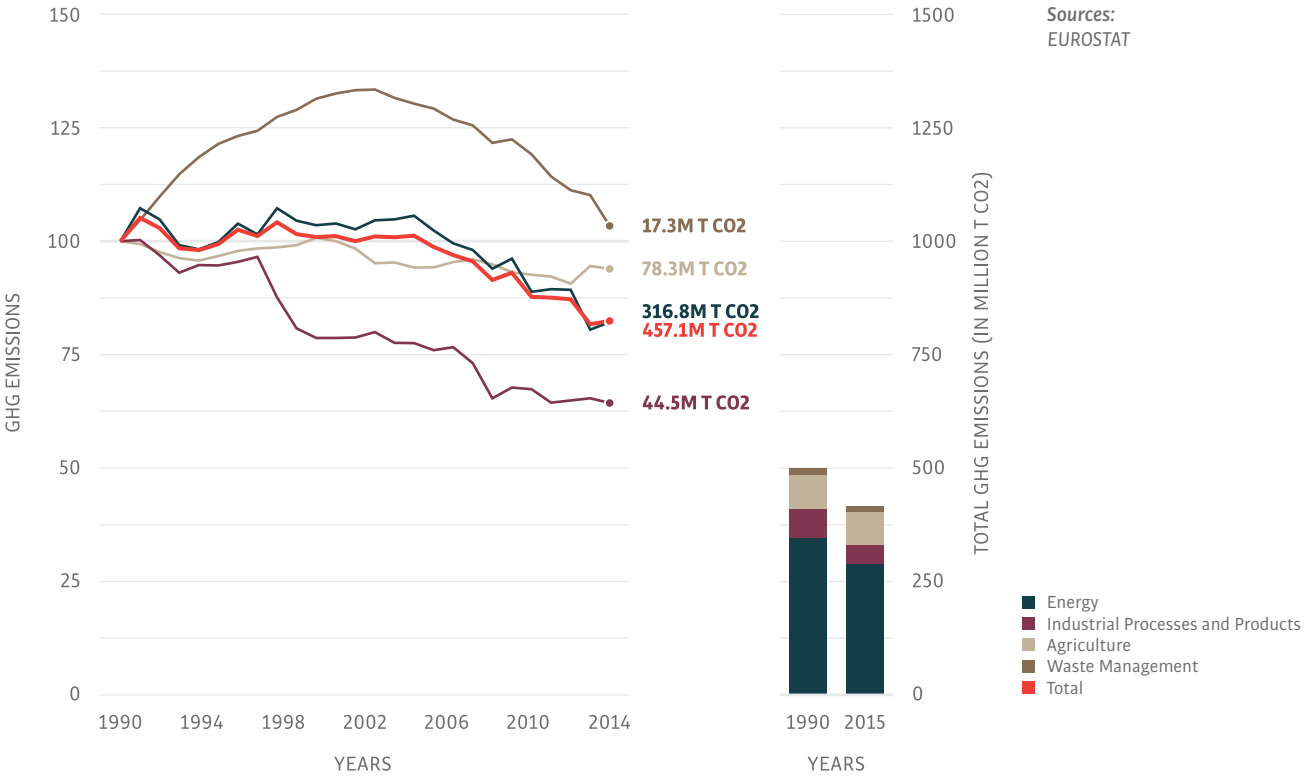
In 2015, some 424,919 GWh of electrical energy was consumed (compared to 422,771 GWh in 2005), with the share of electricity in the final energy consumption of households at 34.8%.[25] The high nuclear energy proportion (76.22% in 2015) of consumed electricity leads to better-than-average emissions factors of 0.056 kg CO_2eq./kWh, or 0.146 kg CO_2eq./kWh using an LCA approach.[26] The average price of electricity for medium size households was 0.17 €/kWh$_{electr}$ with 0.077 €/kWh$_{electr}$ the average price for a mid-sized industry.[27]

French residential energy consumption was around 1.57 million TJ in 2015,[28] dominated by space heating (64.7% of usage). Space heating fuels are pre-dominantly gas (34.7%), renewables and waste (26.6%), and petroleum products (21.7%). In water heating, electricity is the dominant energy source (51.8%), followed by gas (25.9%).[29]The renewable energy share in heating and cooling was 19.8% in 2015, up from 12.2% in 2005[30] and resulting in an emissions factor of 0.124 kg CO_2eq/kWh$_{heat}$.[31] Heat energy prices including taxes averaged to 0.0825 €/kWh$_{heat}$ in 2014.[32]

The energy consumed by households and commercial institutions translates to building related emissions, which were 75.46 million t CO_2 eq. in 2015, or 16.5% of total emissions. Since 1990, building sector emissions fell by 14.65% at an average annual rate of -0.30%.[33]

A3.2 – *Since 1990, French total direct CO_2 emissions decreased by 16.44% while building sector emissions reduced by 14.65%*

France accounts for 1.2% of global emissions. French total emissions remained stable in the range of 453-573 Mt, from 1990 to 2015. The emissions per capita in 2015 was 7.14 t CO_2eq/capita and has been gradually reducing since 1990.



Sources:
EUROSTAT

Since 1990, whilst the amount of residential building space needing to be heated increased by 31% (from 1,982 to 2597 million m² in 2014),[34] and the population by 13.8% (from 58 to 66 million), emissions were nevertheless reduced. Efforts in the direction of energy efficiency, higher renewable (and nuclear) penetration helped in achieving the same effect.

France met its Kyoto Protocol Phase I target of stabilising 2008–12 emissions at approximately the 1990 levels (reduced by 11.6% in 2012) by adopting national and EU plans that focussed on reducing emissions and energy usage whilst increasing renewable energy.[35] The climate policy in France since 2004 is presented in the Climate Plan, which is actualised every two years. The Grenelle de l´environment in 2007 aimed to reinforce climate policy in France and enacted multiple initiatives.[36] The Energy Transition for the Green Growth Act of 2015 has set a target of a 40% reduction in emissions by 2030 and 75% by 2050 in comparison to the 1990 levels. This is to be accomplished by increasing the share of renewable energy and decreasing energy consumption. Under the National Low-Carbon Strategy, a transition to a low-carbon economy is envisioned from 2015 to 2028.[37] In September 2015, France eliminated export credits for all new coal-fired power stations not fitted with a CO_2 capture and storage system. With the adoption of the EU's 2030 Climate and Energy Framework, the climate commitments have gone a notch further,[38] as highlighted in the EU's and member states' INDCs in accord with the UN Paris Conference of the UN.[39]

NOTE

EU targets to reduce GHG emissions by 40% by 2030, from 1990 levels; 80 to 95% by 2050; and in a long-term zero net emissions by 2100

A4

Policy framework
Building sector norms and a legal framework

USEFUL READING:

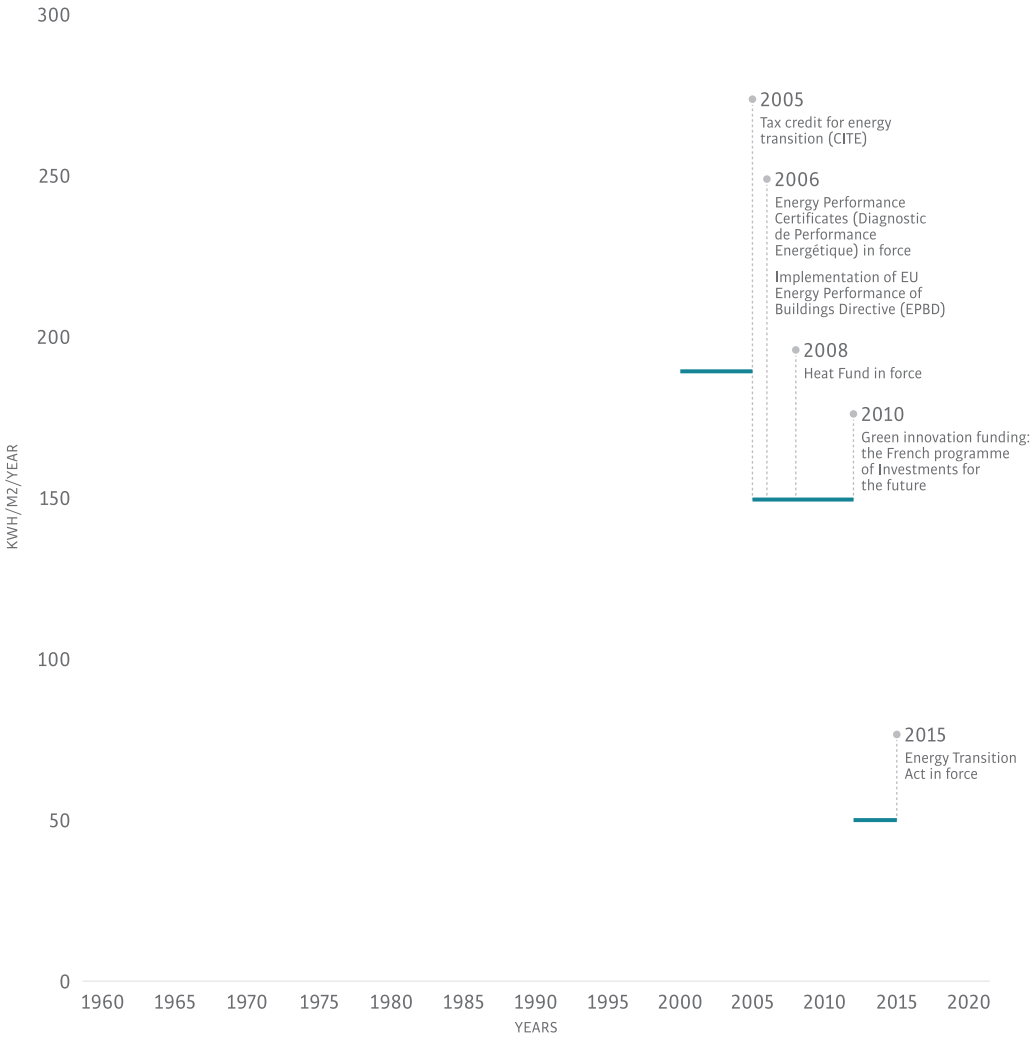
Videau et. al, 2013. An Introduction to the Development of the French Energy Regulation Indicators and Their Calculation Methods. Centre Scientifique et Technique du Bâtiment (CSTB), France.
www.cometh-cstb.fr

In 2015, France adopted the Energy Transition for Green Growth Act to build on the strategies and targets of the 2005 POPE Law and the 2007–10 Grenelle Environment Acts.[40] The new act set a target of cutting fossil fuel consumption by 30% and greenhouse gas (GHG) emissions by 40% and increasing renewable energy penetration to 32% of final energy consumption and 40% of electricity production by 2030, all compared to 1990 levels. The act intends to reduce the share of nuclear energy in electricity production by 50% by 2025 compared to its 1990 share, as well as reducing total energy consumption by 50% by 2050 compared to the 2025 level. In addition, the French Government also intends to price carbon at 56 € per tonne by 2020 and 100 € per tonne by 2023 for the carbon component of the tax on energy product consumption.[41]

The Energy Transition Act aims to increase the pace of energy renovation in the housing sector according to the 2013 Plan de *rénovation énergétique de l'habitat* (PREH) by setting a target of 500,000 major renovations per year by 2017 and requiring all newly constructed buildings to adhere to the low energy building (LEB) standard by 2050.[42]

A4.1 – *Evolution of French building standards.*
Building standards have been increasingly getting stringent for space heating.

Sources:
TEP Energy, CUES Analysis



Building Standards

France's Heating Regulation, the *Réglementation Thermique* (RT), was introduced in 1974 to offset the increases in energy prices by improving the insulation of new residential buildings. Subsequently, the government adopted a five-year revision process which continued until 2005, at which point the first performance-based standard was implemented. The *Grenelle de l'environnement* laid the foundation of the current RT2012, which seeks to bring about zero-energy consumption in buildings by 2020. The RT2012 reflects the recast demands of the European Energy Performance of Buildings Directive (EPBD) and requires 40% higher efficiency compared to the 2005 regulations.[43] [44] The heating regulation also has provisions for designating buildings as low-energy so that they can avail themselves of certain financial incentives.

NOTE

As per the existing regulations all new buildings must have energy consumption of maximum 50 KWh/m²/pa, while for residential retrofit the requirement is of 80 KWH/m²/pa and for commercial it is in between 80 - 195 kWhep/ m² /year

An energy performance certificate (EPC) has since 2006 been mandatory for building transactions, as have building labels. The latter include the 'high energy performance renovation, HEP 2009' label for buildings whose primary energy consumption is less than 150 kWhep/ m² per year and a 'low-energy consumption building renovation, LEB 2009' for those consuming less than 80 kWhep/m² per year.[45] The 'Effinergie+' label is applied to buildings with a consumption level of 20% below the RT2012.[46]

Financial Support Measures

Multiple financial incentives exist to promote building energy efficiency. An energy transition tax credit, the *Crédit d'impôt transition énergétique* (CITE) is applicable for up to 30% of energy renovation work costs, with a limit of € 8,000 for a single person and € 16,000 for two.[47] An interest-free loan, the *prêt à taux zero* (PTZ), of up to € 30,000 is available for property owners to finance energy refurbishment. The *Habiter Mieux* (better housing) programme has provided subsidies and advice to support 140,000 households from 2010 to 2015, with a 2010–17 target of 3 million.[48] The *Chèque énergie* scheme, under the Transition Act of 2015, is intended to provide vouchers to help low-income households pay energy bills or renovation works.[49]

The purchase of LEBs which perform better than the RT2012 can lead to better interest rates and a 50%–100% property tax exemption (the *Taxe foncière sur les propriétés bâties*, TFPB) for new buildings completed before 1 Jan 2009. In addition, an individual investor who wishes to purchase a new building built in between 1 Jan 2013 and 31 Dec 2016 can see an income tax reduction of up to 18% of the purchase price spread over nine years. Since 1 January 2014, energy renovation works on dwellings over 2 years in age can benefit from a reduced VAT rate of 5.5% (compared to the usual 20%).[51] Otherwise, the funds provided by the *Caisse des dépôts* (the French state-controlled financial institution) are used to contribute to the financing of initiatives concerning renovation and positive-energy buildings.[52] [53]

A5

Investment and employment
Construction costs and jobs in the building sector

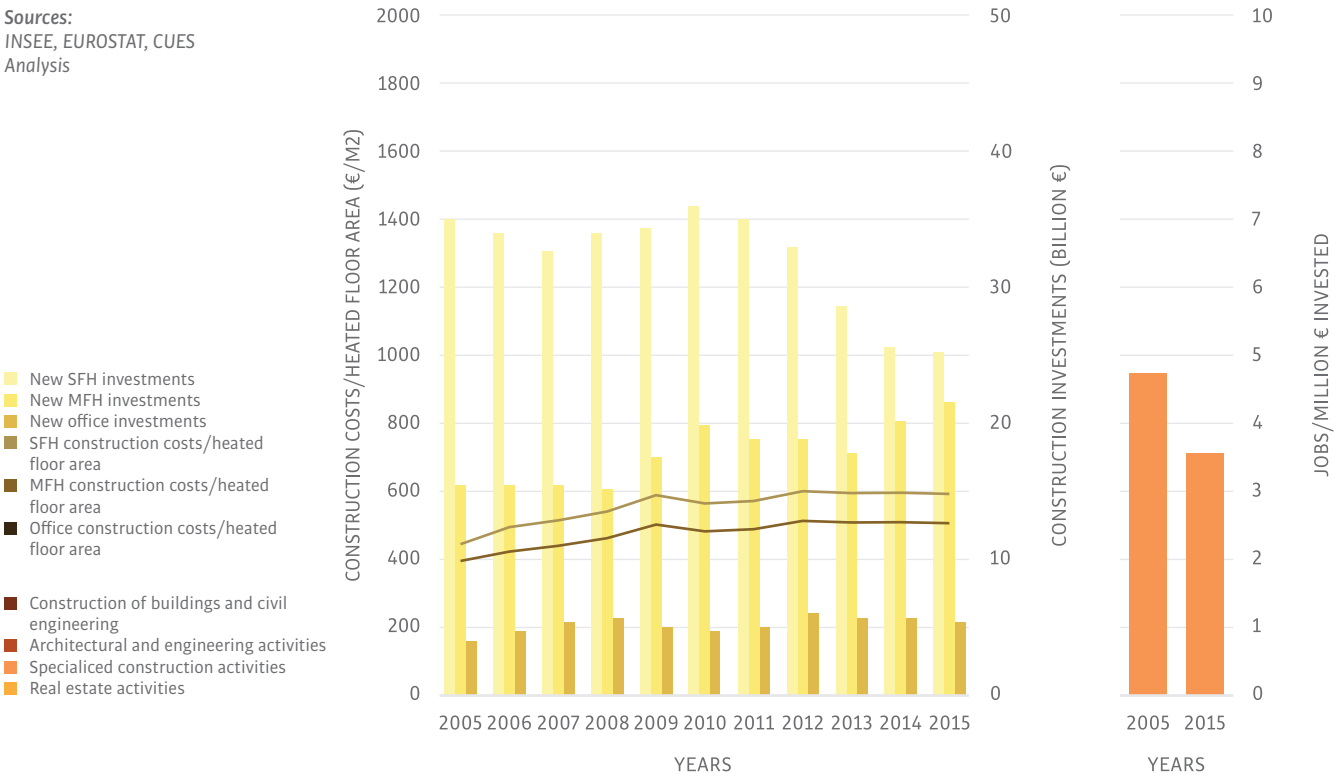
USEFUL READING:

Crédit Agricole S.A , 2016. FRANCE – Housing Market. Recent developments and outlook for 2016-2017. Credit Agricole S. A. www.economic-research.credit-agricole.com

The construction sector accounts for over 5% of the French GDP, and in 2015, roughly 2.09% of the French GDP, totalling € 46 billion, was spent on building construction. Since 2005, total investments in building construction have increased at an average annual rate of 2.49%. Beside its apparent economic significance, the building construction sector of the economy impacts employment as well. In 2015, for every million € that was thus invested, around 3.6 jobs were created that could be directly linked to construction of buildings.[54]

A5.1 – *Total construction investments by type of development (in € billion), along with jobs attributed to construction related investment.*
The total employment contribution by construction and ancillary sectors linked to it was 7.5% in 2015.

Sources:
INSEE, EUROSTAT, CUES Analysis



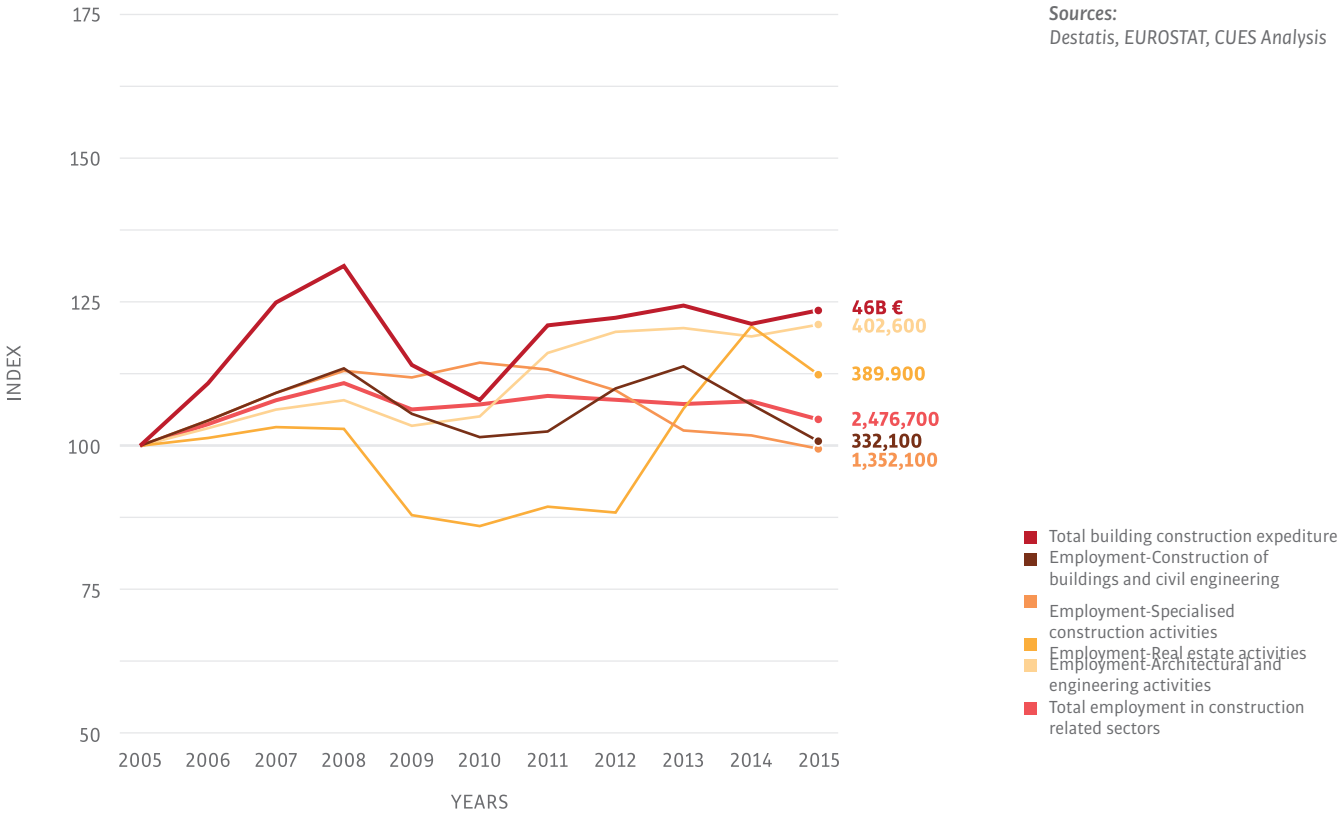
Investment into building construction is driven by an increase in population and average net floor area per person. This is in parallel to a trend toward smaller households and a general demand for a greater amount of personal space. Since 2005, the proportion of building investment in single- and multi-dwelling building has varied, but a gradual increase can be observed in the proportion of money invested in multi- dwelling buildings. In 2015, 55% of construction expenditure in housing could be attributed to the development of single-dwelling housing, with the remaining to multi-dwelling. Investment increased at an average annual growth rate of 3.68% in multi-dwelling buildings from 2005 to 2015.

Metropolitan France has 28.9 million residential dwellings, many of which require refurbishment for France to meet its energy efficiency targets. The current rates of deep renovation are too low for the goals to be met.

Of the 26.11 million total employed individuals in France in 2015, roughly 9.5% were part of the construction sector (including building construction) or sectors which are linked to

the main construction activity; for example, professional services such as architecture or building engineering, and specialised construction activities such as refurbishment. In 2015, the hourly labour costs for enterprises of all sizes were € 33.2 for construction, € 37 for real estate activities, and € 45.6 for professional, scientific, and technical activities (including architecture and engineering services).

A5.2 – *Index of employment and investment (2005=100)*
The increase in total construction investment is paralleled by a similar trend in total construction-related employment.



Sources:
Destatis, EUROSTAT, CUES Analysis

In 2015, 62% of the French population was of working age (15–64).[55] Gradual growth was witnessed in employment in the construction and the ancillary sectors which depend directly or indirectly on the construction activity, such as architectural and engineering services and real estate activities. Whilst total construction expenditure jumped by 24% between 2005 and 2015, total employment in the construction and ancillary sectors increased by 4% during this period. Of this increase, employment in architectural and engineering activities witnessed the most pronounced change, with a 21.4% increase since 2005.

Building construction is thus an important economic sector of France, and the changing trends in business, lifestyle, and demographics, along with the development of the building stock, should be closely monitored. To transition the existing stock toward a low-carbon path would require not just specialised skills but also targeted investments.

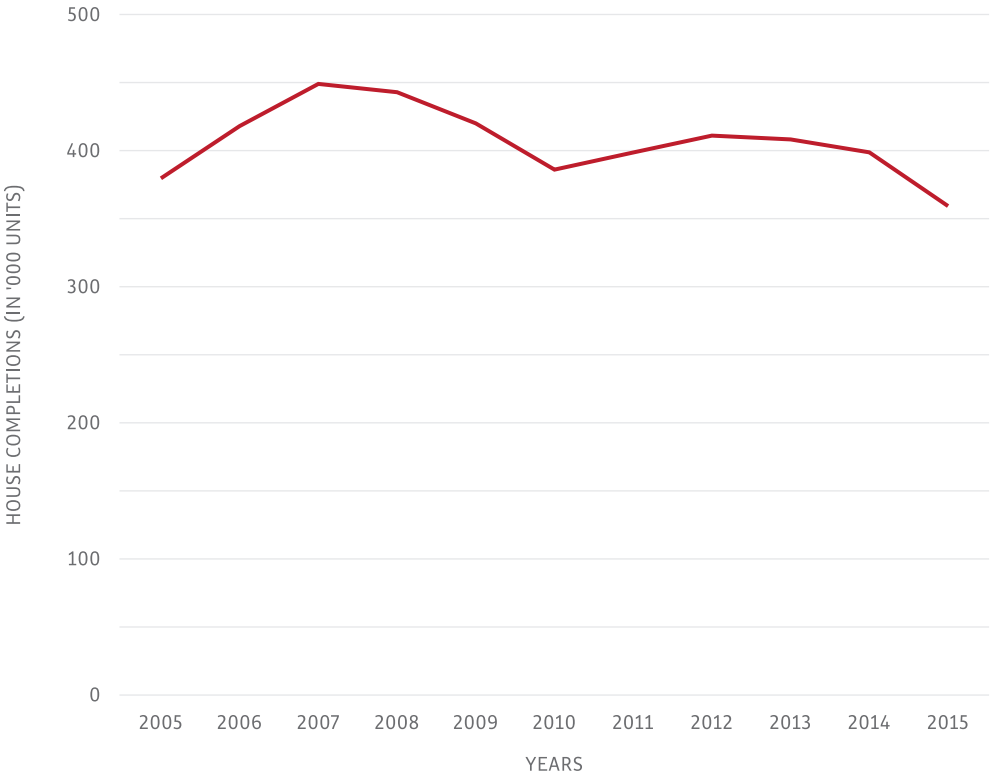
A6 Demand, supply, and affordability
Housing market conditions

Almost 58% of the 35 million housing units in France are privately owned, 3.3 million of which are used as secondary (holiday) homes. A further 2.8 million houses and apartments are vacant, an increase of nearly 1 million from ten years earlier. These empty homes are primarily in rural areas, and many have little prospect of improvement due to high renovation costs. Most of the housing in France (56%) consists of single-dwelling buildings, whilst apartments make up 44% of the housing stock; around 54% of the housing stock was built prior to 1975.

There has been a considerable need for new housing in France in recent years, and in 2012, the newly-elected president François Hollande set an objective of building 500,000 new homes a year by 2017. However, each year, the production of houses has fallen significantly below what is required to respond to the increasing numbers of households,[56] which has resulted in a shortage of supply. Prices are kept high for households, whilst housing exclusion and homelessness continue to grow.

A6.1 – *Net supply of housing and completions*

Sources:
European Central Bank

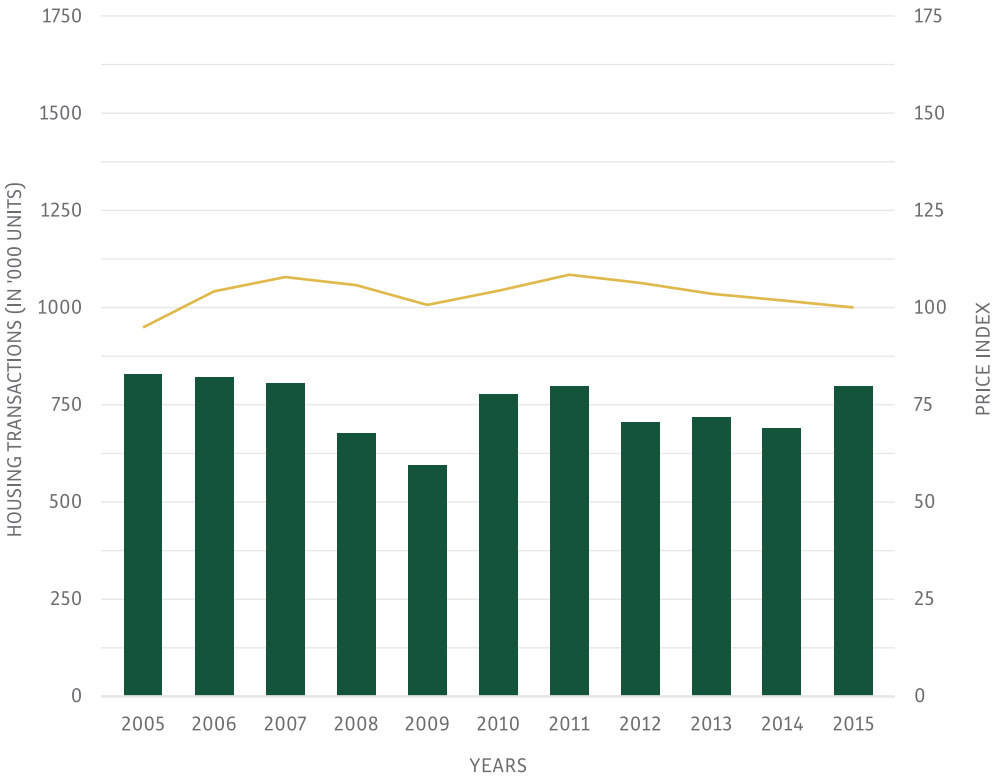


House construction, which had been falling since 2012, stabilised in 2015, and in 2016, construction on new housing rose to 351,800 units, representing a 0.4% increase over 12 months. Building permits, meanwhile, rose by 1.8% to 383,100 units. In October 2016, new housing projects reached 377,000 (12-month cumulative), up 10.4% over 12 months, whilst permits were up 16.5% over 12 months at 431,000.

The period between 1997 and 2007 saw one of the largest housing booms in French history, when property prices rose by an astonishing 150% (112.5% inflation-adjusted). After the ban-

king crash of 2007, the housing market began to weaken in 2008, but price falls have been moderate. Prices rebounded from 2009, rising by 7.57% in 2010 and 3.66% in 2011 despite austerity measures, the capital restructuring of banks, and the Eurozone debt crisis.

A6.2 – *Number of transactions and house prices*



Sources:
EUROSTAT; European Central Bank

Prices dipped again from 2012 to 2014 but started to recover in 2015 thanks to an increase in the volume of transactions. The increase in prices is still fairly modest, however, compared to the average of 12% a year seen from 2004 to 2007. The ongoing recovery is primarily linked to very low lending rates as well as to the new-build stimulus plan, with the Pinel buy-to-let scheme and the broadening of the PTZ interest-free loan.

NOTE

Uncertainties about the general condition of the property and the sometimes small size of the samples, however, call for caution.

The recovery in transactions began in 2015, when it reached 797,000 units, an increase of 15.7% over 12 months. The transactions thus returned to a level close to that during the housing boom of 2000–07 after staying relatively modest for three years (2012–2014) at around 700,000 units a year. Considering 2016 as a whole, sales are expected to be more or less at the level of 845,000 units, a 5% increase over the year. Sales are thus forecast to exceed the highs of the previous cycle (827,000 per year on average from 2004 to 2007). Over the past 15 years, the French mortgage market has expanded tremendously, from 20.6% of GDP in 2000 to 44.8% of GDP in 2016. Due to the dominance of fixed rate mortgages, France's housing market is likely to be much less prone to sharp upturns and downturns than housing markets in other countries, wherein floating rate housing loans are a major source of instability. According to a recent report by *Notaires de France*, a relationship exists between house values and their EPC rating.[57]. The report found that prices can vary by 5% or even 10% when moving from one rating to the next. The effect linked to a bad rating (F and G) is greater than that to a good rating (A and B), but the discount (from -6% to -17% depending on the region) has slightly decreased, whilst the surplus value (+6% to +13% depending on the region) has increased.

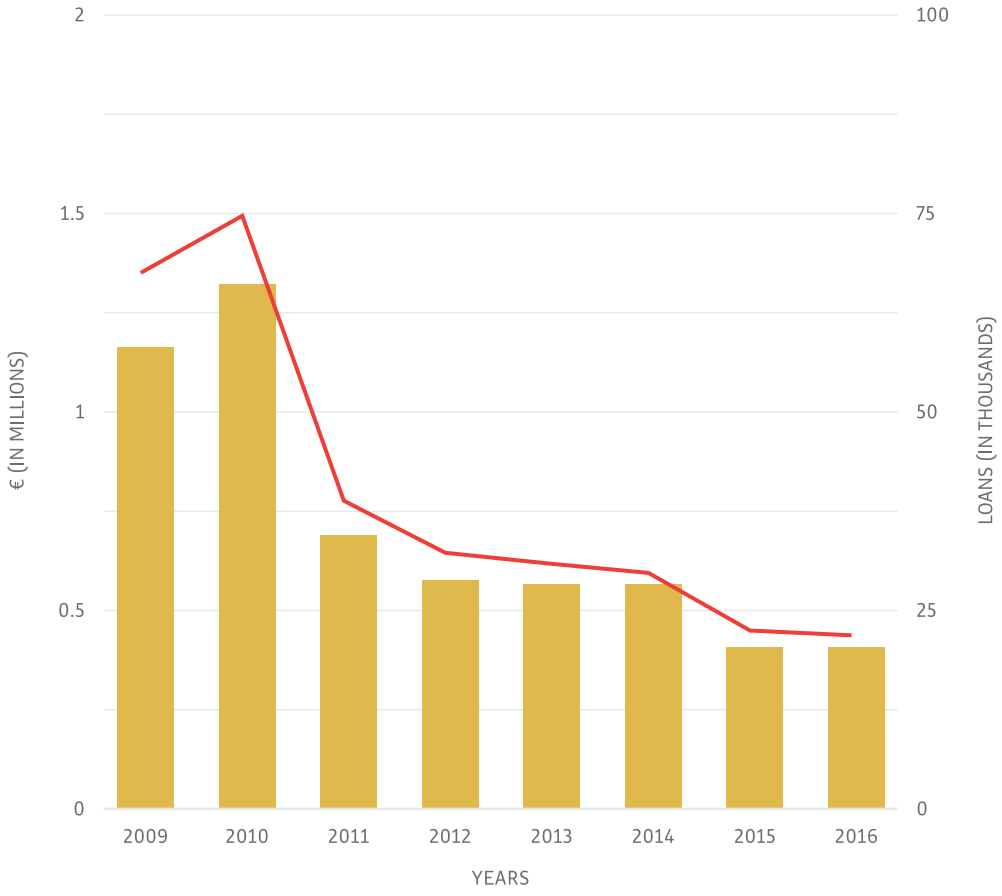
A7 The retrofit challenge
Status of building refurbishment

Metropolitan France has approximately 35 million residential dwellings (main, secondary, and empty residences),[58] accounting for approximately 28% of the country's final energy consumption.[59] Furthermore, about 19 million of these dwellings (54% of total housing stock) were built before the first thermal regulations were introduced in 1975 and are highly energy-inefficient.[60]

In 2005, the French Government introduced tax credits to incentivise homeowners to upgrade their properties, and the 2013 PREH[61] set ambitious retrofitting targets. In addition, France is gradually tightening its thermal regulations for new buildings. This comprehensive package of programmes, funds, and regulations has already delivered significant financial and emissions savings and has led to the creation of a € 7.2 billion energy efficiency industry. As part of the *Grenelle de l'environnement* Acts (2009–10),[62] France set a goal of reducing primary energy consumption in existing buildings by 38% by 2020. To achieve this, PREH plans to achieve 500,000 retrofits per year by 2017, which would be split into 380,000 private homes and 120,000 social housing units. In addition, the Energy Transition Act[63] states that by 2025 all 'poorly insulated buildings' consuming more than 330 kWh/m² per year (F and G ratings) must be retrofitted. However, according to government figures,[64] 7 million poorly insulated dwellings exist in France, which means that the PREH targets may fall significantly short of the actual retrofitting need. The PREH also aims to retrofit the entire French housing stock to the Low-Energy Building level, or Bâtiment basse consummation (BBC) by 2050, which sets the maximum primary energy consumption to 80 kWh/m² per year (adjusted to climatic zone and altitude).

A7.1 – *Number of Eco-PTZ loans and total loan volumes*

Sources:
Société de Gestion des Financements et de la Garantie de l'Accession Social à la Propriété (SGFGAS)



Financial assistance to households for energy-efficient refurbishment works comes in forms which include interest-free loans, VAT rebates, tax credits, and free support and advice for landlords and home owners. Tax credits the CITE for homeowners who upgrade their properties have been available since 2005. Currently, they can cover 15% or 25% of the overall retrofit budget depending on the number of actions achieved and the performance level (up to a maximum of € 16,000). Property owners can also benefit from a reduced rate of VAT (5.5% instead of 10%).

However, the central financial measure to incentivise retrofits is the Eco prêt à taux zéro (Eco-PTZ), an interest-free loan available for both owners and tenants since 2009 (extended until 31 Dec 2018). The loan is granted to cover retrofit projects including equipment, material, and engineering, with a maximum of € 30,000 to be repaid over a maximum of 10 years. Landlords can ask tenants for a contribution toward up to half of the costs of improvements, but only if they reach a minimum standard of energy performance. Costs are normally recouped from tenants by rent increases over a set period of time. During the period from 2009 to 2010, an average of 75,000 dwellings per year have benefited from this soft loan at an average of € 16,500 each. The number of Eco-PTZ loans granted sharply declined to an average of 34,500 per year during the period from 2011 to 2014, and in 2016, only 22,931 eco-loans were issued.[65]

Energy retrofit in France must conform to the government's thermal regulations for existing buildings.[66] The applicable measures vary according to the extent of the work undertaken and the building's date of construction. For extensive work on buildings larger than 1,000 m² and constructed after 1948, the RT set the maximum energy consumption between 80 and 195 kWhep/m² per year, depending on the type of heating and climate. For buildings smaller than 1,000 m², undergoing minor renovation work, or constructed before 1948, the item-by-item RT set a minimum performance for those items replaced or installed. So far, the ambitions set by the PREH and the Energy Transition Act are not being met in practice. According to the Ademe OPEN survey,[67] out of a total of 3.5 million projects completed in 2014, only 288,000 were classed as 'highly energy efficient' retrofits.

B

Market mechanisms, barriers and drivers

Aim

The chapter 'Market Mechanisms, Barriers and Drivers' provides stakeholders' perspective on residential building projects in France. The aim of this chapter is to support the conception of business strategies and policy measures to foster energy efficiency and low carbon solutions.

Based on a survey covering the whole value chain and a series of experts' interviews, this chapter aims to capture the stakeholders' perspective on low carbon building concepts and solutions, covering both the construction of new buildings and the retrofit of existing ones. Special attention is put on those aspects considered as most critical for in the uptake of respective technologies, particularly the decision-making process.

B

Methodology

The data gathered in this chapter was obtained via an online survey and in-depth market expert interviews.

The data from the online survey were collected from June 2018 to September 2018 and covered stakeholders along the complete value chain of the building. Stakeholders from a stratified sample of a total of 21 groups were approached, providing a differentiated view of the market. The study is centred around concrete past projects of the respondents. The survey results are used to quantify findings when a statistically relevant response rate is available.

The content and topic of the survey is based on exploratory interviews and findings from a literature review study. Sources used are listed in the reference section of this report. Questions and answer options were tested in a pilot phase. Every survey question offered a pre-selection of choices as well as 'other' and 'I don't know / can't judge' options.

The in-depth experts' interviews to market experts were conducted between August and September 2018. The experts were selected to cover the complete value chain of the construction sector in the respective country (i.e. planning, technology and material suppliers, construction and installation, use, end of life and overarching), as well as projects types (new built and refurbishment) and project scales (small and large typologies of buildings), where applicable. The results from these interviews are presented and clearly marked after the survey results, to complement this information. These statements may, in rare occasions, conflict the results from the survey.

The level of agreement among the interviewees on the statements in the main text is ranked in the following stages:

- **Very high**: virtually all experts that feel confident to comment on the statement agree.
- **High**: nearly all experts agree at least to a certain degree.
- **Medium**: there is a trend among the experts to back up the statement, but a notable number are not convinced, though they don't disagree.
- **Low**: some experts emphasize the statement but there is no consensus among the experts, some experts might even disagree

B1 Value chain & life cycle of the building
Defining the scope and rationale

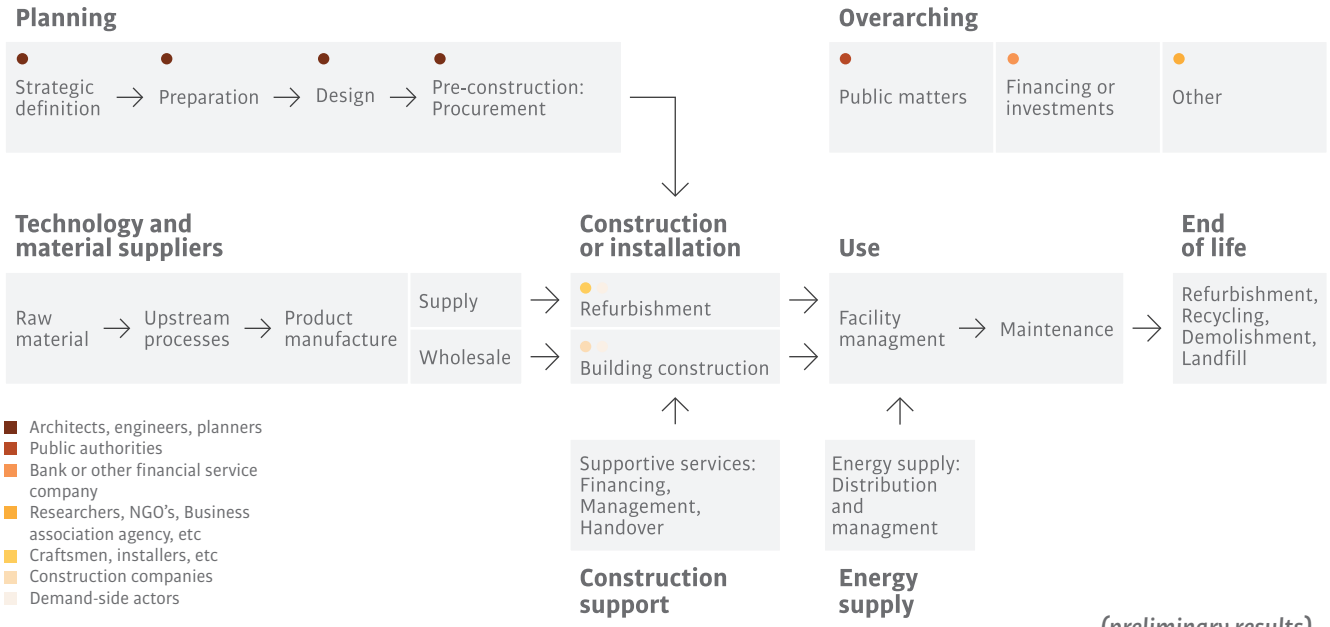
USEFUL LINKS:

www.ec.europa.eu

The value chain refers to all stakeholders from the raw material, material and technology production, installation usage and deconstruction professions. To provide a comprehensive understanding of stakeholders' view, this study covers groups along the whole building value chain in France, entailing more than 20 stakeholder groups. To properly contextualize the market structure the exact number and size of enterprises is listed below for the main stakeholder groups.

Figure B1.1.1 visualizes the structure and main phases in the building value chain that were used as basis for the survey and structure of the following subchapters. From the table B1.1.2 below it becomes apparent the majority of companies and also of the professionals of the main sectors of the building value chain in France are small and medium sized companies up to 50 employees. Only in the main sector of (new) building construction larger companies prevail.

*B1.1.1 – Characterization of the residential building value chain in the **France** (the "universe" of the survey) (preliminary results)*



(preliminary results)

Sources:
NACE Rev. 2, Eurostat

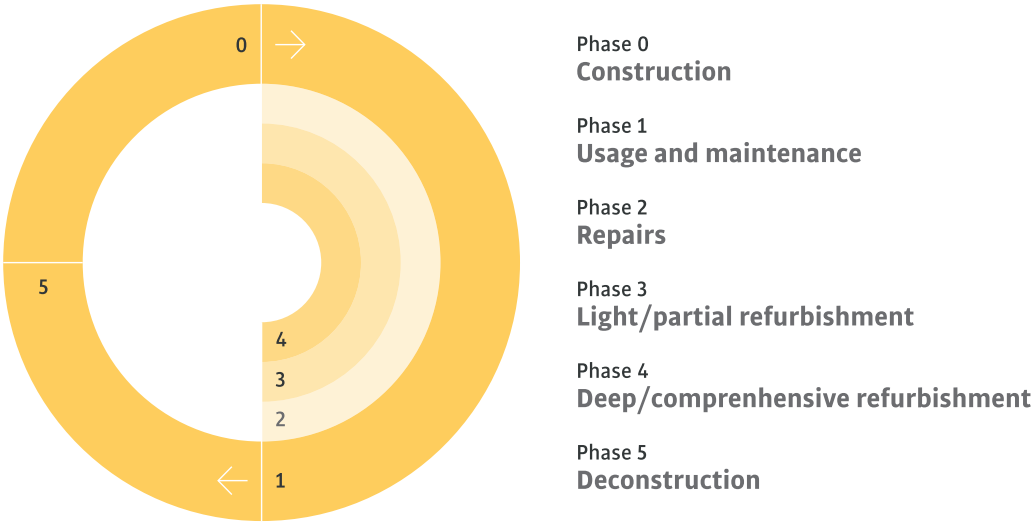
B1.1.2 – *Number of enterprises and employees for planning and construction activities in the **France**.*

		Total	0 to 9	10 to 19	20 to 49	50 to 249	250 or +
Number of enterprises	**Construction of buildings**	**59,727**	**58,059**	**940**	**526**	**165**	**36**
	Development of building projects	38,195	37,886	153	116	34	5
	Construction of residential and non-residential buildings	21,533	20,173	787	411	131	31
	Specialised construction activities	**428,695**	**410,002**	**12,102**	**5,490**	**974**	**128**
	Demolition and site preparation	20,006	18,401	978	516	101	10
	Electrical, plumbing and other construction installation activities	123,862	118,680	3,206	1,535	355	86
	Building completion and finishing	167,953	161,957	4,058	1,708	218	11
	Other specialised construction activities	116,875	110,963	3,860	1,731	300	21
Number of employees	**Construction of buildings**	**167,074**	**36,590**	**15,516**	**18,836**	**20,275**	**75,857**
	Development of building projects	22,918	7,364	2,733	4,320	4,333	4,168
	Construction of residential and non-residential buildings	144,156	29,266	12,782	14,516	15,942	71,689
	Specialised construction activities	**966,343**	**380,150**	**174,843**	**173,439**	**94,585**	**143,326**
	Demolition and site preparation	67,688	21,870	14,330	16,432	9,691	5,365
	Electrical, plumbing and other construction installation activities	352,104	100,370	45,825	47,952	36,435	121,522
	Building completion and finishing	274,738	133,041	60,091	55,314	20,819	5,474
	Other specialised construction activities	271,812	124,869	54,598	53,740	27,640	10,965

The building life cycle refers to the prospect of a building over the course of its entire life - encompassing the design, construction, operation, maintenance, modification and eventual demolition and waste treatment. To characterize what measures have taken place during the complete building's cycle in France, the building typologies are differentiated between small (one family home, row houses, small multi-dwelling building, etc.) and large projects (large multi-dwelling buildings) and types of projects are differentiated between new building activities, light modification of an existing building (overhaul, partial retrofit, refurbishment) and in-depth modifications of an existing building (deep comprehensive retrofit).

Figure B1.2 depicts the buildings life cycle, starting with planning/ construction phase (0), followed by a usage/ maintenance phase (1), continued by repair (2), interrupted by different intensities of light (3) and deep refurbishment (4), and eventually ending with deconstruction (5).

***B1.2** – Type of projects over the life cycle of the building. **(France)** (preliminary results)*



The statements and findings of this chapter are accordingly aggregated into the following project types a) to f):

	SMALL BUILDING	LARGE BUILDING
Construction of a new building	a)	b)
Overhaul or partial retrofit or refurbishment project	c)	d)
Comprehensive retrofit project	e)	f)

All questions in the survey are related to a concrete project that the respondent or interviewee worked on. This is to ensure receive concrete and specific answers.

That new construction is the main responsible for most of the market volumes in the building sector is shared by almost all interviewees (high agreement). They also highly agree that renovation should be the main priority from the climate perspective, as a big part of the building stock was built before the first oil crisis in 1974. Unfortunately, the renovation market is struggling to engage, renovating approximately 200'000 buildings per year while the goal is set to more than 400'000 buildings/year to reduce GHG emission by 4.

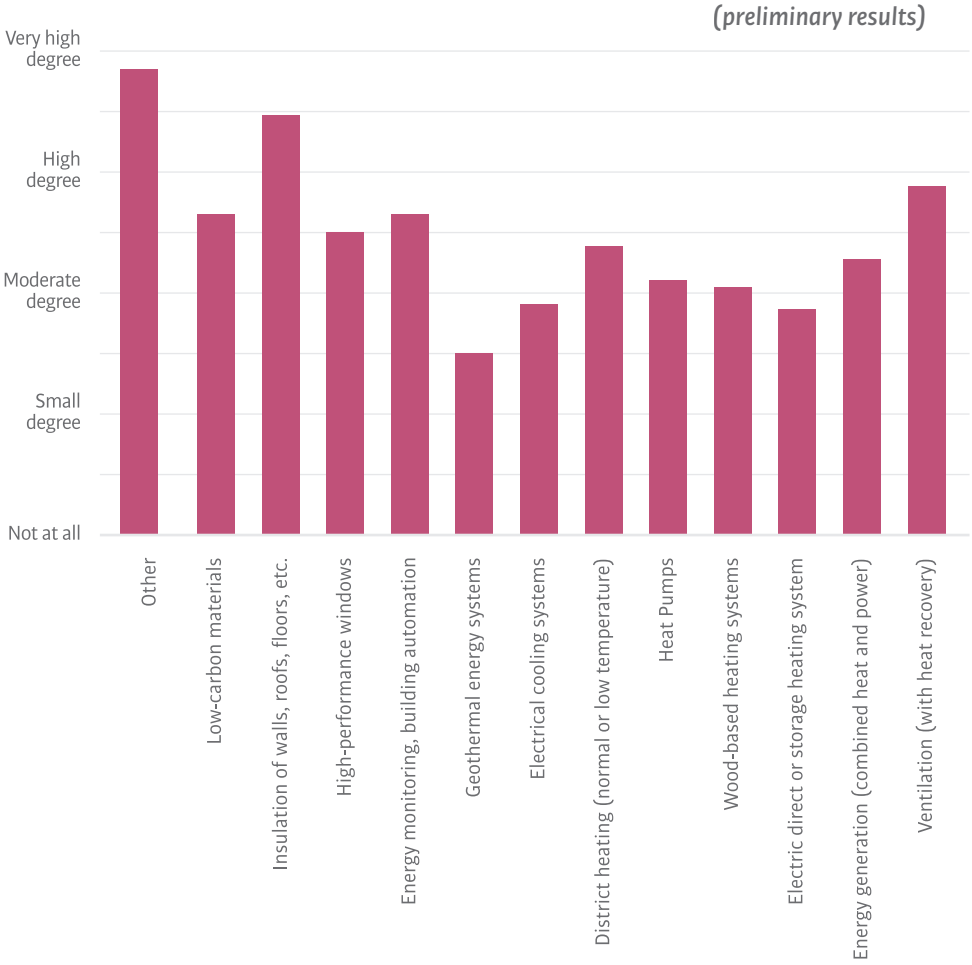
B2 Technology competences
Familiarity with technology groups

Competences related to implementation of technologies differ significantly in different markets. It is important to identify the level of knowledge towards different solutions a market has in order to design education programs when necessary. Hence, the following section assesses the level of competence and familiarity of stakeholders involved in planning and construction projects to different energy efficiency and low carbon technology groups.

Survey respondents from the groups of planners, constructors and facility managers/maintenance were asked ***'How familiar are you with the following technologies?'*** They were then provided with a pre-selected list of technologies and the options ***"worked with it once; worked with it several times, part of day to day business, no experience"*** on all technologies. Answering was not mandatory. The respondents could also add technologies they felt highly relevant in a free entry field. The final responses are listed in table B2.1, indicating the average familiarity of respondents with the listed technologies. Interviewees were asked the same question and given the opportunity to contextualize and comment.

'Insulation of walls, roofs, floors, etc.'' has the highest level of familiarity among the respondents in France (Figure B2.1). The technology with the least level of familiarity among the respondents is 'Geothermal energy systems'. Respondents are similarly lower familiarized with other heating technologies such as 'Electric direct or storage heating system' and 'Heat pumps", and 'Wood-based systems".

B2.1 – *Familiarity level with low carbon and energy efficiency technologies in* **France**. *(preliminary results)*



The interviewees **very highly** agree that there is a high level of familiarity with low-carbon technologies. However, because of the fragmentation of the profession, the familiarity remains restraint to their particular expertise. The training remains in a very vertical way between the different stakeholders of the value chain with little interaction. However, there is a high agreement that non-qualities are mostly found in business with interdisciplinary approaches.

The interviewees **highly** agree that craftsmen and planers are highly familiar with envelope technologies, heat pumps, and renewable energy sources (RES). Yet there is only a **medium** agreement that the use of tools for 3D design and digital mock-ups is quite delayed in the building sector compared with others (goods and services) and other countries (the UK or Nordic countries).

In order to improve this, it is necessary to develop collaboration and exchange platforms between technical bodies of state and groups of companies, as the interviewees highly agree.

Due to the environmental constraints and the increasing complexity of customer demands, the project design and execution are moving towards an integrated global engineering approach (**very high** agreement among the interviewees). However, the chain of actors is currently still very sequential and fragmented, and the business interfaces are very poorly managed.

B3

State of play
Measures implemented in the building stock

USEFUL READING:

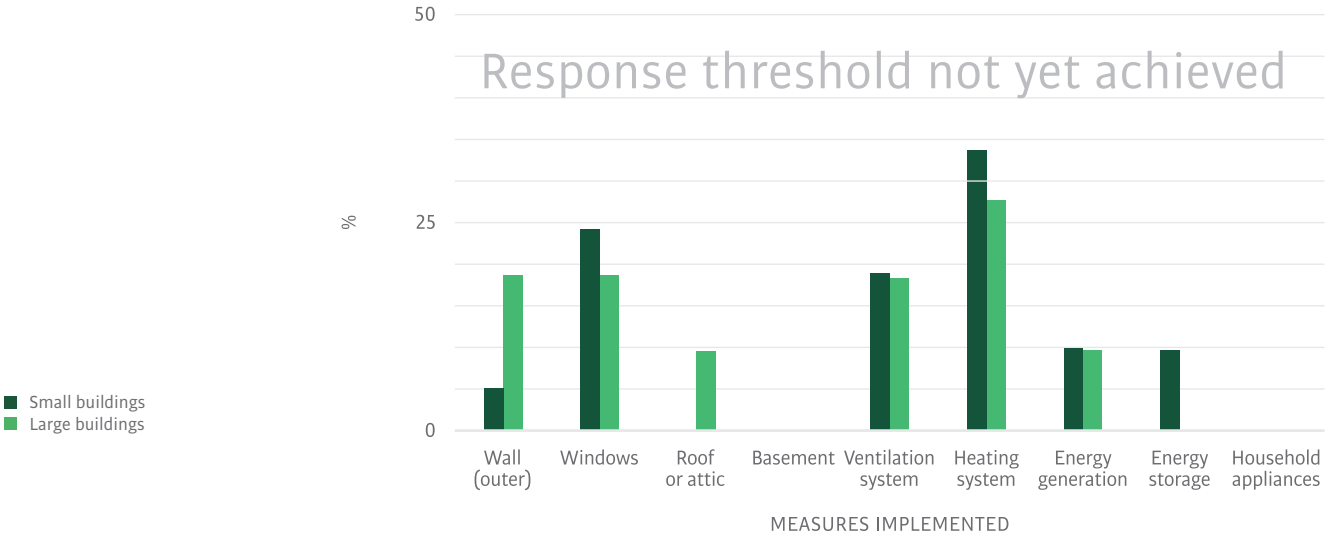
Campagne 2015 OPEN. Travaux achevés en 2014. ADEME.

In most European countries, the state of the building stock is mostly unknown due to limited monitoring of past and present retrofit measures. This section characterizes the measures that have been implemented in the residential buildings in France for the different project types. The results in B3.1 and B3.2 are based on the survey results. These have been complimented by insights from in-depth stakeholder interviews.

To gather this information, survey respondents were asked ***'What measures were implemented in your latest project?*** The respondent was provided with a table with 9 different elements covering all building components which they had to choose from. Then had to indicate what was the type of measure. The answer options were: 'Maintenance (including repair)', 'Upgrade of existing elements or systems (incl. insulation and control)' and 'New element or systems'. Additionally, to these answer options, they were provided the option of ***'I don't know'*** and ***'Other'***. Interviewees were asked the same question and given the opportunity to contextualize and comment.

The survey shows that, in many cases, the type of measure does not vary substantially between small and large buildings in France. As can be depicted in B3.1, for 'overhaul, partial retrofit or refurbishment projects', 'Heating systems' are the most often implemented measures both in small and large buildings (in about 30% of the cases). Also, window replacement and measures at the ventilation system are quite common in France. When it comes to the least frequent implemented measures, it is 'Household appliances' and 'Basement / crawl space', again for small and for large buildings.

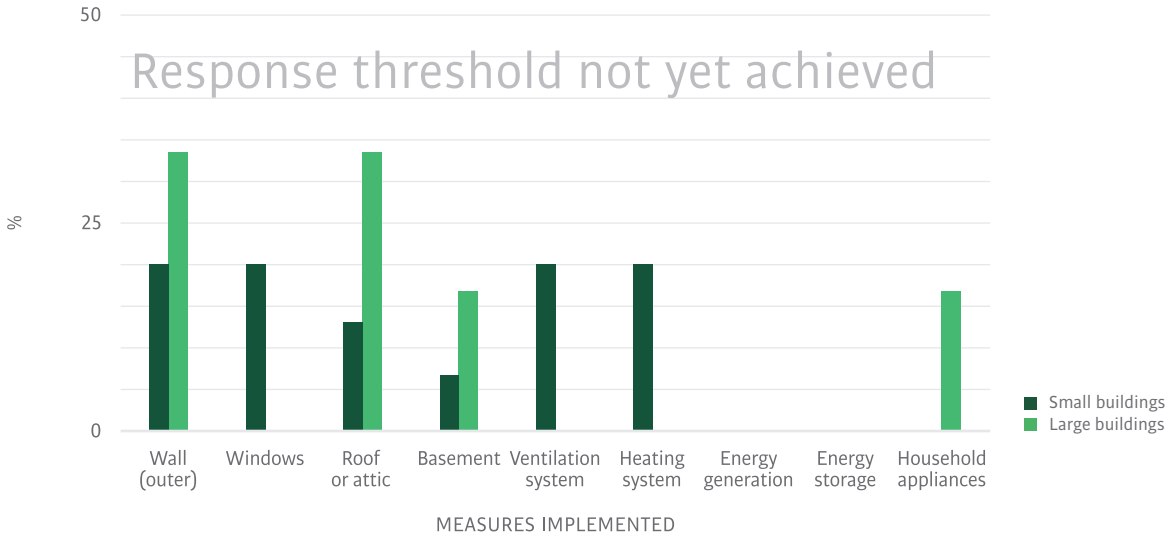
B3.1 – *Measures implemented in (c) overhaul or partial retrofit or refurbishment project in small building and (d) overhaul or partial retrofit or refurbishment project in large buildings in* **France**. *(preliminary results)*



With a **very high** level of agreement the interviewees confirm that partial retrofits are the most common types of renovation. The effort for renovation is driven by the urgent need to solve a problem, as repairing the roof, repainting the walls and the upgrade of the heating system. The first two are usually complemented by the insulation of the envelope and, the strengthening of the roof insulation. There is a medium agreement that the use of RES has been an interesting track but is still considered difficult to pay-out given the current energy prices.

In comprehensive retrofit projects, measures might vary between small to large building (graph B3.2). The most often implemented measure in small buildings is equally distributed between 'Wall (outer)' (20%), 'Windows' (20%) and 'Ventilation systems' (20%) and 'Heating systems' (20%). In large buildings, it is 'Wall (outer)' (33%) and 'Windows' (33%). Both in small and large buildings 'Heating generation (PV or solar collection)' and 'Energy storage' are seldomly selected (both with 0%).

***B3.2** – Measures implemented in (e) comprehensive retrofit project in small building, (f) comprehensive retrofit projects of large building in **France**.* *(preliminary results)*



It is emphasized by the interviewees that deep refurbishment/ comprehensive retrofit corresponds to the minority of the cases for small buildings (**very high** level of agreement). These renovations usually seek to upgrade the performance of the building on a global and sustainable way and improve their value. They are usually accompanied by the redevelopment of spaces that improve the conditions of comfort, health, security of accessibility and connectivity.

Heating systems are sometimes, but not in every case, supplemented by renewable energy sources at the moment of their improvement. The interviewees have a **medium** agreement that controlled ventilation systems are usually part of renovation work but the quality of implementation could be improved. Indeed, the regulations are very poor and it is assumed that the airtightness of the building is already managed.

Storage of electricity is unanimously considered as a big issue and resale to the grid is not perceived as satisfactory.

B4 *Deep-dive into stakeholder's interaction* *The technology selection*

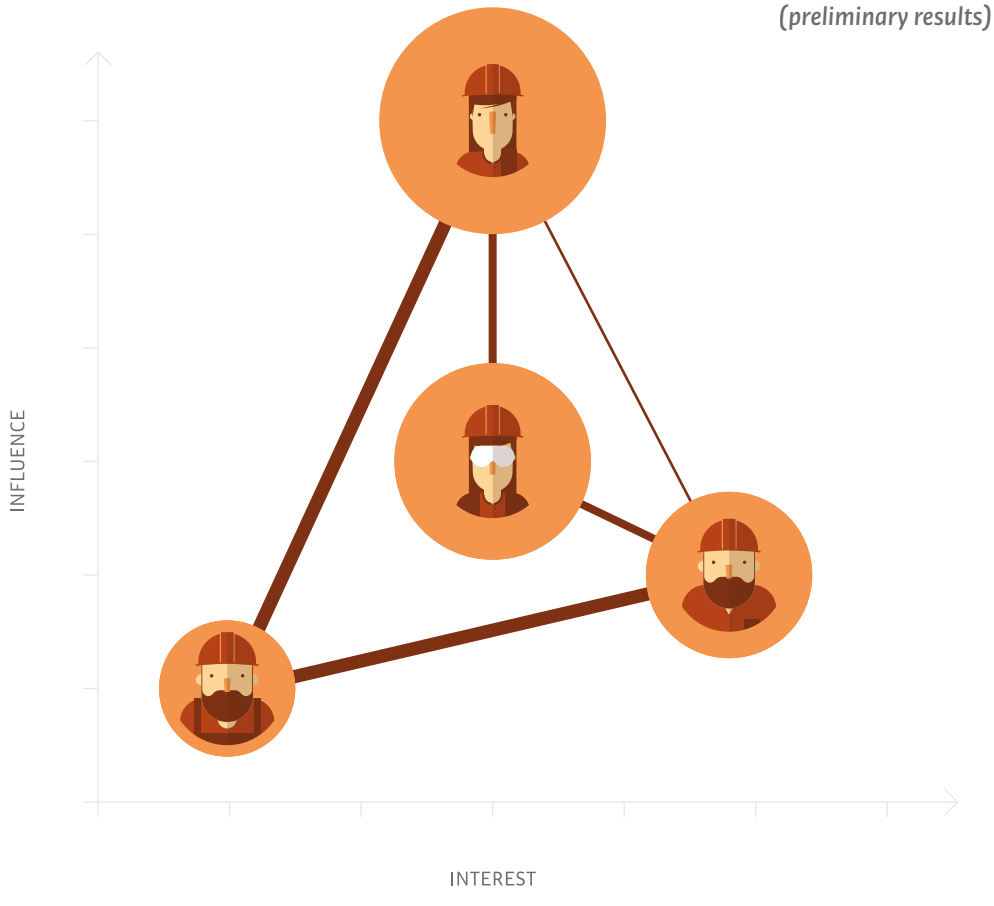
The stakeholder setup in the building sector is considered to be complex and fragmented. Furthermore, it varies across project types, phases or even decisions. This section assesses the level of power and interaction of the stakeholders involved in the technology selection for residential building projects in France.

Referred to their latest project, survey respondents were asked ***'What was your level of interest in the energy-efficiency and low-carbon strategy in your project?'***. And ***'How much did you communicate with the stakeholders about the energy-efficiency or low-carbon strategy in your project?'*** Followed by ***'What was the level of influence of the following stakeholders in the energy-efficiency and low-carbon strategy in your project?'*** This was complimented by ***'What was your level of interest in the technology selection in your project?'*** And, ***'How much did you communicate with the following stakeholders about the technology selection in your project?'***. Finally, ***'What was the level of influence of the following stakeholders on the technology selection in your last project?'***. Results are illustrated in the figures B4.1, B4.2 and B4.3 below, according to the project type. Interviewees were asked the same question and given the opportunity to contextualize and comment.

For the decision on what technology will be implemented in the project, 'architects' in France are perceived to have the highest level of influence though not of interest. This is contrary to the 'installers', who are perceived to have the highest level of interest but low influence. The stakeholder with the lowest level within these group of key stakeholders, for both interest and influence is the 'constructor', who is in close communication and interaction with the architect in this decision. In turn, the constructor interacts closely with the installer, who, in parallel, communicates with the engineer, though not so closely.

B4.1 – *Stakeholder interaction regarding the technology selection in* **France**.

(preliminary results)



The architect remains as the main interlocutor of the client to design the project, select, or at least pre-select technologies, and assign and coordinate the work. There is a **high** level of agreement among the interviewees on the architect's role. Particularly for the construction of large new buildings, the role of the architect is key, as the technologies must submit to the customer demands in terms of functionality and comfort. Reversely, his actual participation for the majority of the work is very limited for small new buildings.

The evolution of technologies, and regulations heavily reliant on engineering, have favoured more integrative and standard solutions, placing engineers and interdisciplinary networks as the main actors in building projects. Interviewees confirm this development with a very high level of agreement.

The role of the architect in overhaul and retrofit is significantly weaker in single component interventions than in systemic interventions, as the interviewees highly agree. The client is in many cases communicating directly with the engineer or with other stakeholders (like craftsmen) that in these cases also have significantly increased influence on the technology selection.

The influence of online media, marketing, and social networks is high in this type of projects with private clients (very high agreement among the interviewees).

In comprehensive retrofit projects, the legal framework in France makes deep refurbishment processes very similar to new building projects. There is a **high** level of agreement among the interviewees on this similarity.

Likewise, the interviewees highly agree that the role of the architect is even stronger in deep refurbishment than in new building construction as every project has a **high** degree of individuality and generalized solutions are difficult to apply.

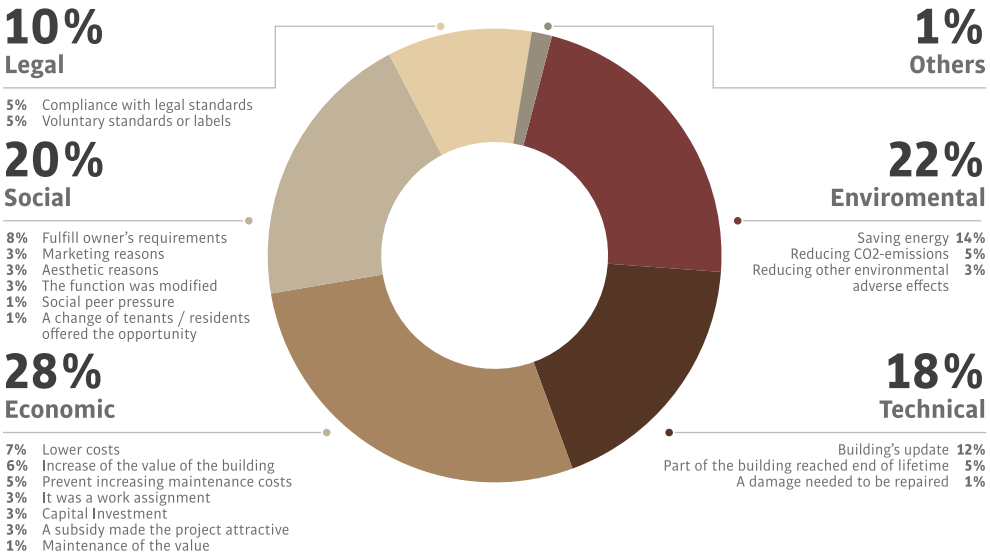
B5 Motivations and barriers behind projects
The demand-side's perspective

Motivations behind projects differ significantly depending on the project type, the building typology and the demand-side's perspective. The following section describes France's stakeholders' motivations behind projects as well as hindering factors in pursuing 'higher' performing buildings, meaning, even more performance energy-efficient or low-carbon technologies or solutions.

Survey respondents were asked ***'What were the main motivations for your project?'*** They were then provided with a pre-selected list of arguments structured into ***environmental, technical, economic, social and legal*** clusters as well as the option to select ***'Other'***, and ***'I don't know'***. This question allowed participants to choose more than one answer option. Thus, the percentage of answers is calculated on the basis of the total number of options selected. The final responses have been classified according to the professional organizations (POs) perspectives. Main motivations have been listed in table B5.1, indicating in each case the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment.

For professional organizations, main motivations are 'Saving energy' and 'Building's update or future-proof' (10% to 15% of the responses). One of the least identified motivations is 'A change of tenants / residents offered the opportunity to do the work now' or 'Social peer pressure' (both, 1%).

B5.1 – *Main motivations behind projects in* ***France****. The Professional organisation's perspective. (preliminary results)*



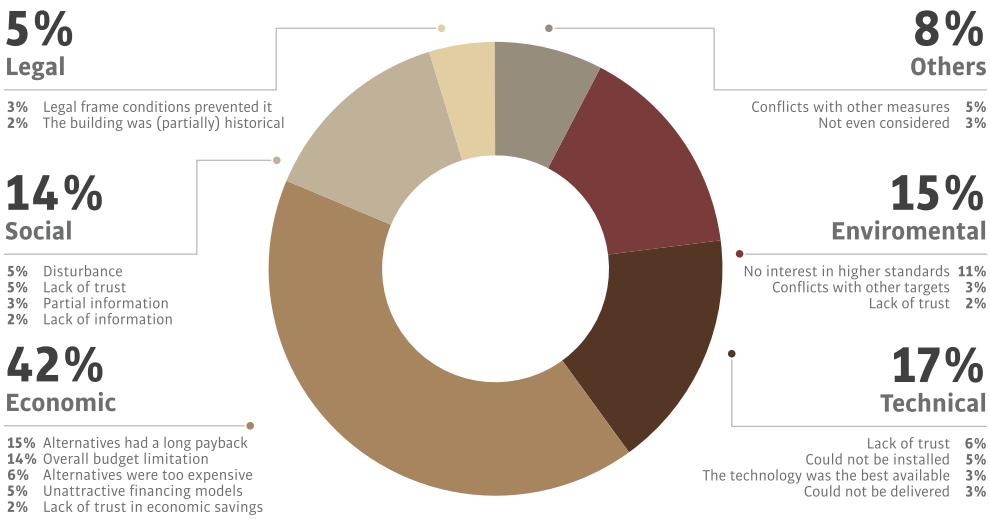
Despite the existence of environmental labels and the increasing awareness of energy and environmental issues, the decision to build or renovate is not often motivated by these factors (**high** level of agreement). Likewise, interviewees agree that the main motivations in small buildings are to improve the living environment and comfort and the property's value, combined with attractive financial incentives and low interests' loans. In contrast, the main motivations in the case of large buildings are the compliance with regulations and lower exploitation costs.

There is a **low** level of agreement that aesthetic reasons are an important driver.

To identify what were the main barriers to not pursue higher performing technologies, survey respondents were asked ***'What were the hindering factors for not implementing (even) more energy-efficient or low-carbon technologies in your project?*** They were then provided with a pre-selected list of arguments structured into environmental, technical, economic, social and legal clusters as well as the option to select ***'Other'***, and ***'I don't know'.*** Main barriers for not pursuing (even) more energy-efficient and/or low carbon technologies have been listed in table B5.2, scrutinized according to the professional organizations' perspective. In each case it is indicated the % of responses that were selected for that answer. Interviewees were asked the same question and given the opportunity to contextualize and comment.

Economic aspects are perceived to be, by far, the main barriers for not implementing 'higher' performing solutions for private as well as for professional owners. Technical aspects, are perceived as important barriers. The least hurdle are legal matters, as seen in figure B5.2.

***B5.2** – Main barrier for not implementing (even) more energy-efficient or low-carbon technologies in residential building projects in **France**. The PO's perspective (preliminary results)*



The main reasons for not overperforming are related with budget limitations, as the interviewees unanimously agree. Moreover, there is a **medium** agreement that the lack of credibility in the promised outcome of the project is one of the main reasons for not overperforming. The construction sector remains very obscure from the customers perspective, and its process perceived as full of obvious non-qualities and financial arrangements.

The interviewees **highly** agree that customer confidence can be restored if the promised outcome is fulfilled. An instrument of persuasion could be to seal the contract with the aid of modern tools of co-design, easy to master and communicate, limiting to the maximum the uncertainties on costs, performance, and reliability.

B6

Promising approaches to reach carbon ambitions

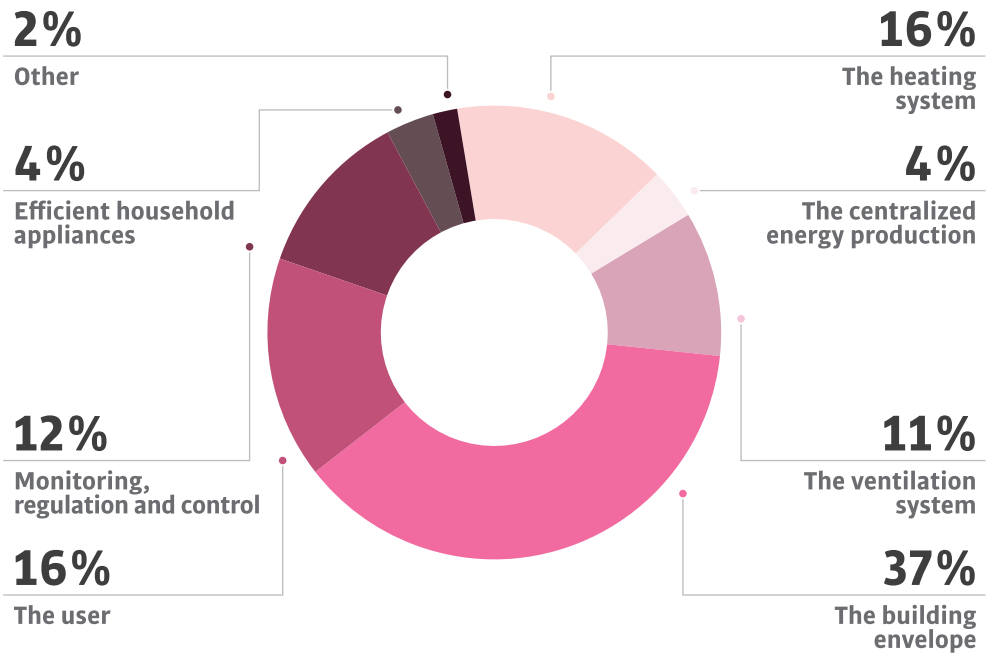
General potential in new and existing buildings

Buildings are complex systems formed by an extensive range of elements and components. The carbon performance of a building is highly dependent on the nature and conception of these components. This section identifies what building concepts do market actors see as most favourable to reduce carbon emissions and achieve climate-protection goals in France. Results are presented for new built and refurbishment projects.

Survey respondents were asked ***'What technology or approach has the highest potential to contribute to reach ambitious climate-protection goals in France'.*** They were then provided with a preselection of 8 aspects as well as ***'Other', 'I don't know' and 'none' for both new buildings and refurbishment***. This question allowed participants to choose more than one answer option. Thus, percentage of answers was calculated on the basis of the total number of options selected. Interviewees were asked the same question and given the opportunity to contextualize and comment.

'The building envelope' (37%) is perceived to have the highest potential in new buildings to contribute to reach ambitious climate-protection goals (Table B6.1). This is followed by 'the heating system' (16%) and 'the user' (16%). On the other hand, 'efficient household appliances' and 'centralized energy production' are rated the lowest (both with 4%).

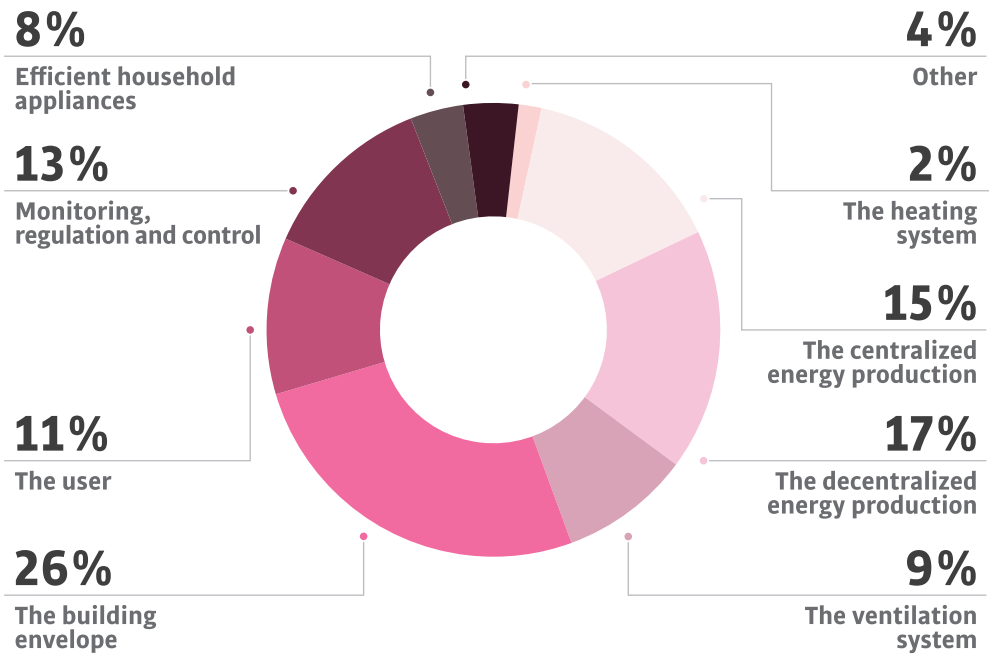
B6.1 – *Technologies perceived to have the highest potential to contribute to reach to climate-protection goals in* **France** *for new buildings.* *(preliminary results)*



With a **high** level of agreement among the interviewees share this view that the envelope elements (opaque, glazed and the roof) play the key role to achieve a good energy performance with good airtightness in new construction. It is followed by a higher penetration of RES, complemented by in-site production, particularly solar and heat pumps. Ventilation systems and energy management of buildings are elements that are usually considered for large new buildings (b).

When it comes to refurbishment projects, the 'Building envelope' (about one fourth of the statements) is the considered to be the measure with the highest potential to reach climate-protection goals, followed by the 'Centralized- 'and 'Decentralized energy production' with about 15% each (Graph B6.2). The efficiency of 'the heating system', on the other hand, is rarely identified to have a high potential in refurbishment.

***B6.2** – Technologies perceived to have the highest potential to contribute to reach to climate-protection goals in **France** in refurbishment projects. (preliminary results)*



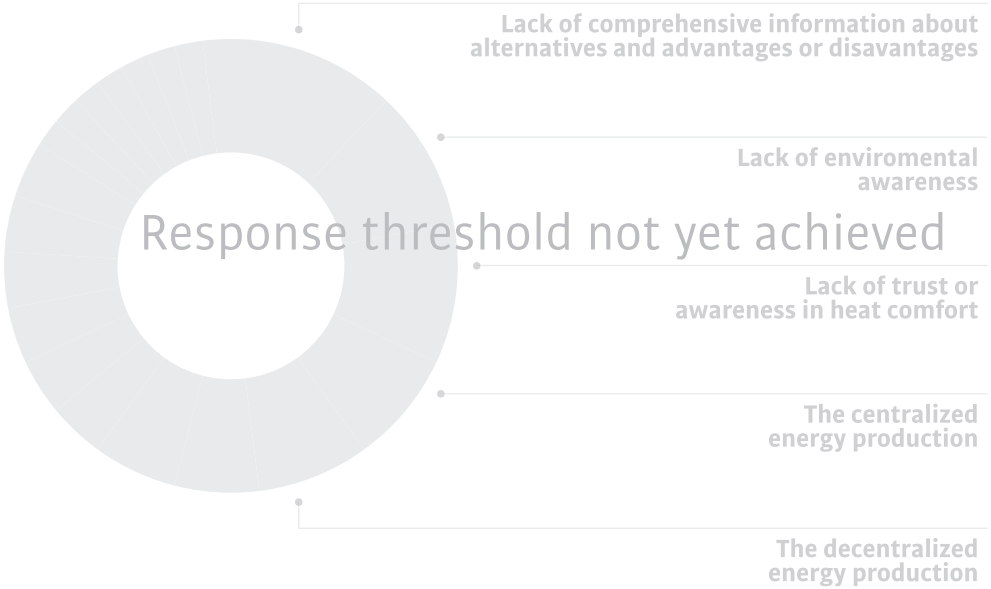
There is a **high** level of agreement that thermal insulation of the envelope and heat production systems are imperative to meet energy and environmental targets. There is a medium level of agreement that the adapted behaviour of the users is also one of the major aspects to consider and it is necessary to encourage the inhabitants to make a better use the building by bringing simple and readable information.

B7 *Drivers & barriers to reach carbon ambitions*
Towards promising approaches

Many barriers hinder the uptake of energy efficient and low carbon solutions. These barriers are context specific and, therefore, vary considerably depending on the country, building type, stakeholder group or even on the specific technology. The following section describes stakeholders' perceived drivers and barriers to the technology that had been identified in previous section B6 as hosting the highest potential (in refurbishment projects). This is the building envelope in the case of France.

Survey respondents were asked to state for which specific technologies they are experts in. For one of those they were questioned on ***'What is the biggest barrier for the upscaling of this technology in the France.'*** Figure B7.1 visualizes the results for insulation. Interviewees were asked the same question and given the opportunity to contextualize and comment.

B7.1 – *Perceived barriers to insulation in* **France.** *(preliminary results)*



Among the interviewees there is a **medium** agreement that there are no particular obstacles to the improvement of the envelope with regard to the opaque elements (interior and exterior walls insulation) apart from the inconvenience of interventions in occupied sites, and the feasibility constraints due to consistency with windows and joinery. There are some particular complications for certain types of buildings requiring "breathing walls".

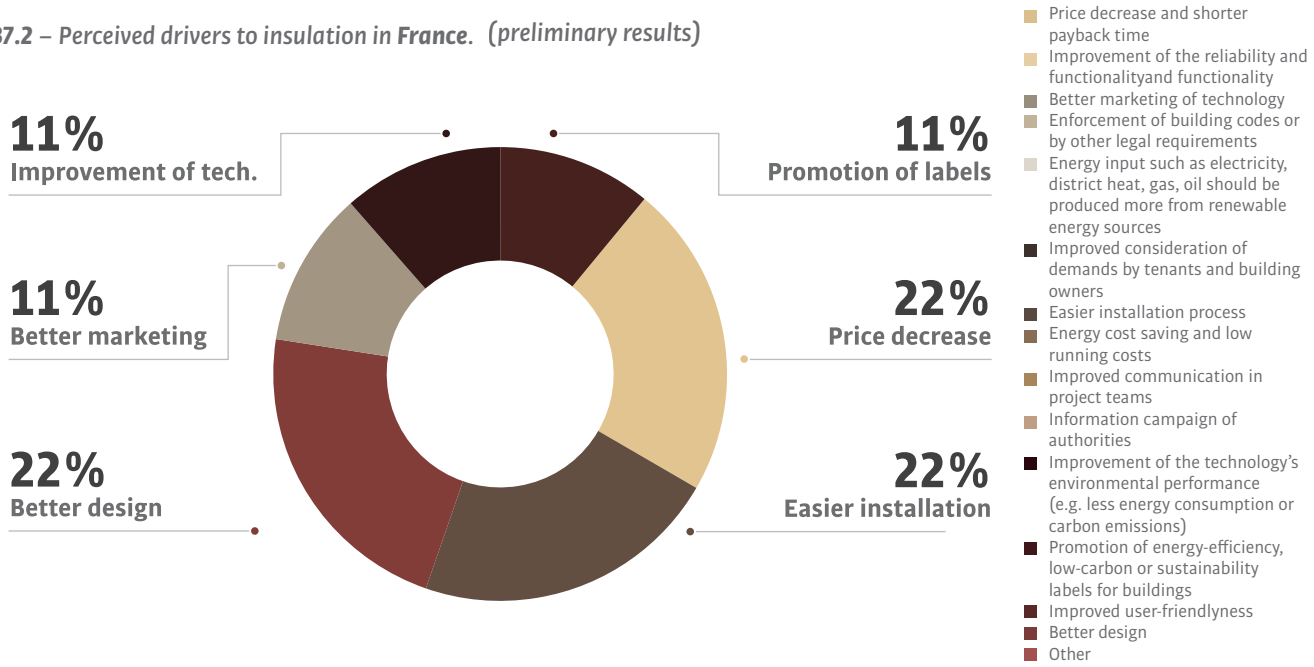
For heating systems, there is a **high** agreement that the lack of practical and reliable information on the advantages of low-carbon alternatives, particularly the economic ones, remains as an important barrier as the customer is mainly concerned by the reduction in his energy expenses.

For photovoltaics, there is a **medium** agreement that there is a situation of public mistrust after the sector crisis in 2012. However, there is a **high** agreement that there is a renovated impulse caused by the possibility of self-consumption and new instruments to make the process easier for the customer. This impulse accompanied by useful information could dissipate the doubt of the customers.

Identifying stakeholders' market specific drivers and motivations is crucial in order to trace effective marketing campaigns and policy instruments to foster their uptake of low carbon energy solutions. The following section describes stakeholders' perceived drivers to insulation.

Survey respondents were asked what were 'the most promising approach to support the market uptake of low carbon technologies.' Figure B7.2 visualizes the results for insulation. Interviewees were asked the same question and given the opportunity to contextualize and comment.

***B7.2** – Perceived drivers to insulation in **France**. (preliminary results)*



Among the interviewees there is a very high agreement that the most effective drivers for low-carbon technologies are regulatory pressure together with financial and fiscal incentives. The interviewees also highly agree about the particular success of the obligation to do an "Energy Performance Certificate" (DPE) for every transfer of owner or tenant. This analysis shows the energy and GHG performance of the property, and it is usually accompanied by a proposal of possible solutions to improve the performance of the building, related costs and the payback times of the investment. It is very highly agreed that this information helps the owners to take the decision to make renovations as a mean to maintain or increase the value of their property, lower the expenses and make it more attractive for sale or rent.

The offering by energy suppliers of energy saving certificates and the argument of maintenance of the green value of the building during an energy renovation, are an important driver in the adoption of low-carbon technologies. It helps the customers perceive them as a mean to reach their objectives in terms of comfort and development of buildings. This view is shared by almost all interviewees.

Yet there is only a medium agreement that an increasing awareness on the importance of low carbon technologies is responsible for the growing demand of these technologies among younger generations of customers.

C

Market volumes and economics

Aim

This chapter provides data concerning the current state of the building stock's greenhouse gas (GHG) emissions, as well as annual market volumes in the short, medium, and long term for two scenarios.

The first section of this chapter presents structural and GHG-related data concerning the building stock (Section C.1). The data concerning the building stock is collected from statistical sources, standards, and norms. Interviews with market experts complement this information. A synthetic building inventory of 10,000 representative buildings is generated based on the data collected. To set up this inventory, the building stock model (BSM) integrates a parametric variation approach.

At its core, the chapter describes the market volumes for a Reference Scenario and a 2-Degrees Scenario. The RS reflects current and decided energy and climate policy instruments and some moderate reinforcements that could be expected (similarly to the EU Reference Scenario). Both European and national policies are considered. The 2DS is designed to achieve ambitious climate-change mitigation goals. The < 2ºC goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that may typically be expected are reflected in the scenario definition (section C.2).

In both scenarios, the effect of an increase in energy efficiency and in the share of renewable energy sources (RESs) have been considered. The resulting market volumes for the various technology groups are listed. The aim is to provide realistic market volume estimates for different market segments.

All data sources are clearly marked to allow the reader to access more detailed information as needed. The complete list of sources can be found in the annex to the report. Key sources are listed as links in the side bar.

C

C1 Status quo of the building stock
Structure and greenhouse gas emission intensity

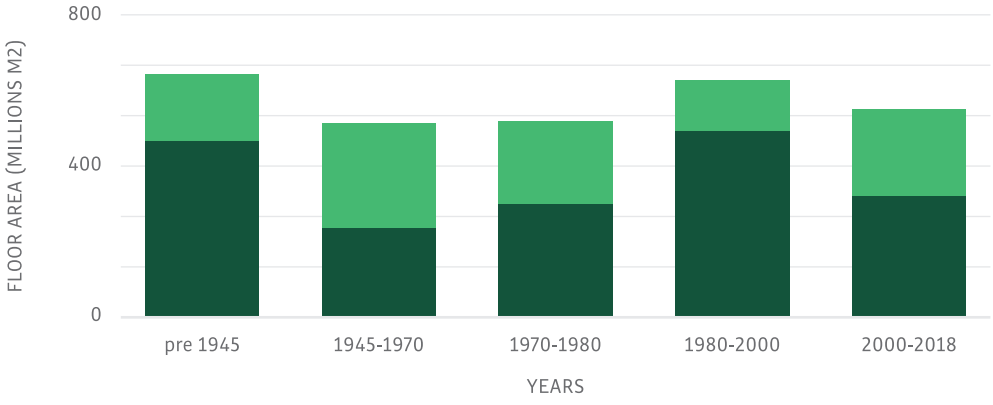
Notes:
This study is limited to Metropolitan France and main residences only. Overseas territories and second residences are not included.

The residential building stock of France currently encompasses around 29 million dwellings (and 16.9 million buildings), totalling about 2.9 billion m² of heated floor area in 2018. Single-dwelling buildings (SDB) represent about 94% of the building stock in terms of buildings, including row houses, detached, and semi-detached houses. As regards dwellings and heated floor area, the predominance of single dwellings typology is much less pronounced than in terms of buildings, with 54% of French residences located in SDB, representing 64% of the total floor area.

The age distribution of the building stock (see Figure C.1.1.) still shows a large share of old buildings, with about 40% of the heated floor area built before 1970. During this period, the absence of building codes (the first thermal regulations were introduced in 1974) and the need for rapid reconstruction after the Second World War translated in a large share of very poorly insulated buildings. The first large multi-dwelling buildings (towers and bars) appeared during this period. The rest of the stock was constructed thereafter, especially during the construction boom in the decade between 1970 and 1980, when 18% of the present floor area was added to the building stock. Since then, a decreasing amount of floor area has been added per decade.

C1.1 – *Age distribution of French building stock, differentiating between single-dwelling buildings (SDB), includding row houses, and multi-dwelling buildings (MDB).*

Sources:
TEP Energy & Chalmers University, BSM.



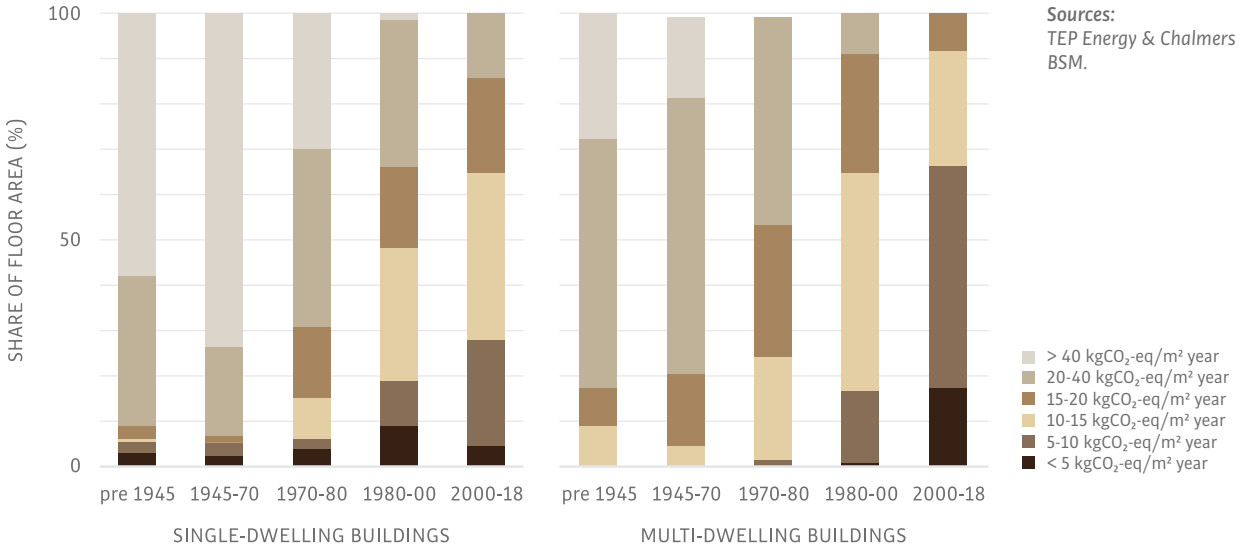
Notes:
GHG intensity: GHG emissions from final energy consumption include those from electricity for heating, hot water, ventilation and cooling from a life-cycle perspective. For example, 10 kg CO_2-eq per m² is equivalent to 45 kWh per m² in a gas-supplied building. GHG emissions embodied in the construction of the building are not included.

The effect of the first thermal regulation towards new, more energy-efficient buildings, which was introduced in 1974, led to a substantial decrease in the GHG intensity of the new stock added during the period from 1970 to 1980, especially in MDB, and the difference is very evident after 1980 (see Figure C1.2). In recent years, especially after 2000, the percentage of buildings that are low-carbon intensive has increased significantly. Due to their more compact form, MDB tend to exhibit lower CO_2 emissions per floor area compared to SDB, resulting in larger percentages of MDB with less than 10 kgCO_2-eq per m² (climate label 'B' in France); such buildings represent about 72% of the total floor area of MDB built after 2000.

In respect to the specific final energy demand per m² per year, a clear trend towards more energy-efficient new buildings can also be determined for buildings constructed after 2000 (see Figure C.1.3). Some effects of the renovation efforts, however, are visible in the percentage of buildings built before 2000 with an energy demand of less than 100 kWh/m² per year.

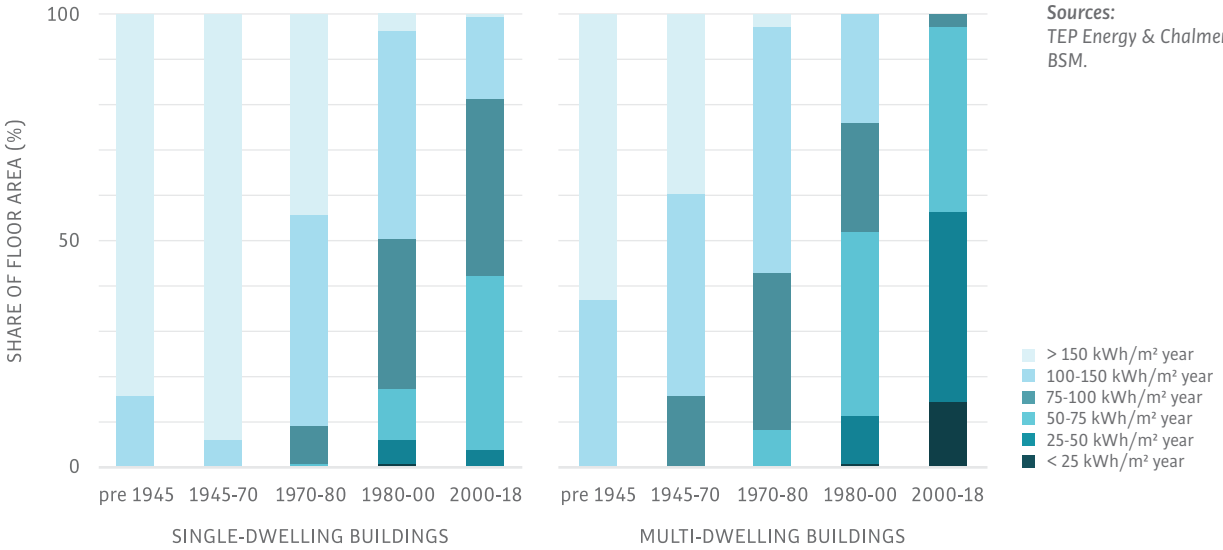
For both, the single-dwelling and multi-dwelling stock, the effects of French renovation programmes can be determined, with small shares of low-carbon buildings in older construction periods as well. However, there still remains a significant number of buildings with high GHG emissions that needs to be addressed, as well as a share of buildings built in recent decades that do not meet the targets of a nearly Zero Energy Building (nZEB), especially for SDB. This large share of buildings with high GHG-intensity remains to be addressed in the upcoming decades.

C1.2 – *GHG intensity of the building stock according to building age and building type.*



Sources:
TEP Energy & Chalmers University, BSM.

C1.3 – *Specific final energy demand distribution of the French building stock in 2018 according to building age and building type.*



Sources:
TEP Energy & Chalmers University, BSM.

C2 Policy scenarios
To shape carbon emissions

Notes:
The Reference Scenario (RS) represents an upper bound of future carbon emissions. It consists on current and decided energy and climate policy goals and instruments and some moderate reinforcements.

The 2-Degrees Scenario (2DS) is designed to achieve ambitious climate change mitigation goals. The < 2°C goal of the Paris Agreement of 2015 serves as a guideline. National peculiarities and implementation approaches that typically could be expected for France are part of this scenario.

At present, France has already implemented some policy instruments to foster energy efficiency and the use of RES, and to curb CO_2 emissions (see section A.3). The development of market volumes very much depends on economic and policy framework conditions. In order to reflect the uncertainties in these framework conditions, arising, for instance, from the fact that there are decisions about policy instruments that are yet to be taken, two scenarios have been defined. Market volumes are then calculated for these two scenarios to constrain uncertainties.

— Part of the Reference Scenario (RS) are current and decided energy and climate-policy goals and instruments. At the European scale these are the Renewable Energy Directive[1], the Energy Efficiency Directive[2], the Directive on Energy Performance of Buildings[3], and the Ecodesign Directive[4]. At the national scale, they are the Grenelle Environment laws I and II (adopted in 2009 and 2010, respectively), and more recently, the Energy Transition for Green Growth Act (2014). Particularly important for the building sector are the current thermal regulation, for new construction, RT-2012[6] (which has been applied since 2013), and the Plan for the Energy Renovation of Housing that sets the annual goals for renovation (2013)[7]. However, highly ambitious climate change mitigation goals are not part of the RS.

— The 2-Degrees Scenario (2DS) is designed to achieve ambitious climate-change mitigation goals. With the Energy Transition for Green Growth Act, France set the objectives and means to implement the Paris Agreement. For the building sector, it sets the goal of renovating all existing buildings by 2050 to a 'low consumption standard' (energy consumption < 50 [$kWh_{PE}/m^2.year$]), the current building standard for new construction[8]. Nevertheless, to reach the < 2°C goal of the Paris Agreement, certain further-reaching measures are needed. Currently in an experimental phase (on voluntary basis with labels and bonuses), a new building standard is expected to be launched by 2020 at the latest. This includes a nZEB standard for new construction, a tightening of the current standards for renovation, and the introduction of a new 'carbon' indicator that demands a life-cycle analysis (material, equipment, construction, and operation) that ensures the total GHG emissions of the building from its conception until the end of its service (50 years), do not surpass a certain limit[9]. Moreover, the New Plan for Buildings Energy Renovation (2018) confirms the ambitious goals for renovation and adds a new target to eradicate from the stock all buildings with extremely poor energy performance (Energy consumption > 330 [$kWh_{PE}/m^2.year$]) by 2025[10]. This is in line with France's objective of being a carbon-neutral nation by 2050, as set out in the 'Plan Climat' presented by Nicolas Hulot in July 2017.

To achieve these ambitious climate-change mitigation goals, tangible policy instruments need to be implemented. Specific assumptions are made to substantiate input for the BSM calculation and to underpin results for the short-, mid-, and long-term (2021, 2030, and 2050 respectively) development of different market segments.

The CO_2 tax in France *was introduced in 2014 as a component within the internal tax on the consumption of natural gas (TICGN), coal (TICC), and domestic energy (TICPE). It concerns domestic and small professional consumers (large consumers are subject to quotas)*

From 2017, a fraction of the revenue from the carbon component has been allocated to finance the energy transition.

— Building codes that are already ambitious in the RS are tightened in the 2DS, on the assumption that the experimental regulation becomes mandatory (e.g., nZEB standard for new buildings applied from 2020, mandatory renewable energy shares in the consumption, and the complete renovation of the park to a 'Low Consumption Building' standard (energy consumption <50 [$kWh_{PE}/m^2.year$]; in french 'bâtiment basse consommation').

— More ambitious mandatory energy-efficiency standards are introduced in the 2DS in order to assure an efficient use of electricity from RES, including self-produced solar energy (which is incentivised by feed-in tariffs and the new building standards regulation).

— In the 2DS, an extra effort is considered to reinforce compliance with codes and standards, and to secure the efficient operation of building technologies, particularly heating and hot water systems (e.g. by means of mandatory annual inspection).

— In order to foster the diffusion of low-carbon and efficient technologies and retrofitting measures, the existing CO_2 tax will be increased from the level of 2017 (€30.5 per ton of CO_2) to €86.2 per ton of CO_2 in 2022 in the case of the 2DS.[11]

— The subsidy programmes for retrofitting, tax incentives, and zero interest loans are maintained and reinforced (in line with the directives provided in the recently launched New Plan for Building's Energy Renovation.

— According with the Grenelle law, any new building project must consider the feasibility of connecting to a district-heating network. Special financing instruments are already in place for the creation, extension, and densification of networks. Further incentives are available if the networks are at least 50% renewable.

— These policy instruments are complemented and underpinned by an extensive network of local agencies and institutions that feed information (e.g. energy and performance labels and certificates) as well as education programmes to certify professionals in different low-carbon building technologies, materials and construction techniques.

*The **building stock model** (BMS) simulates the dynamics of the building stock and the energy- and climate-related decisions of building owners and tenants. Decisions, e.g. regarding choice of heating system or whether to retrofit depend on:*

— *Technology prices and their energy performance,*

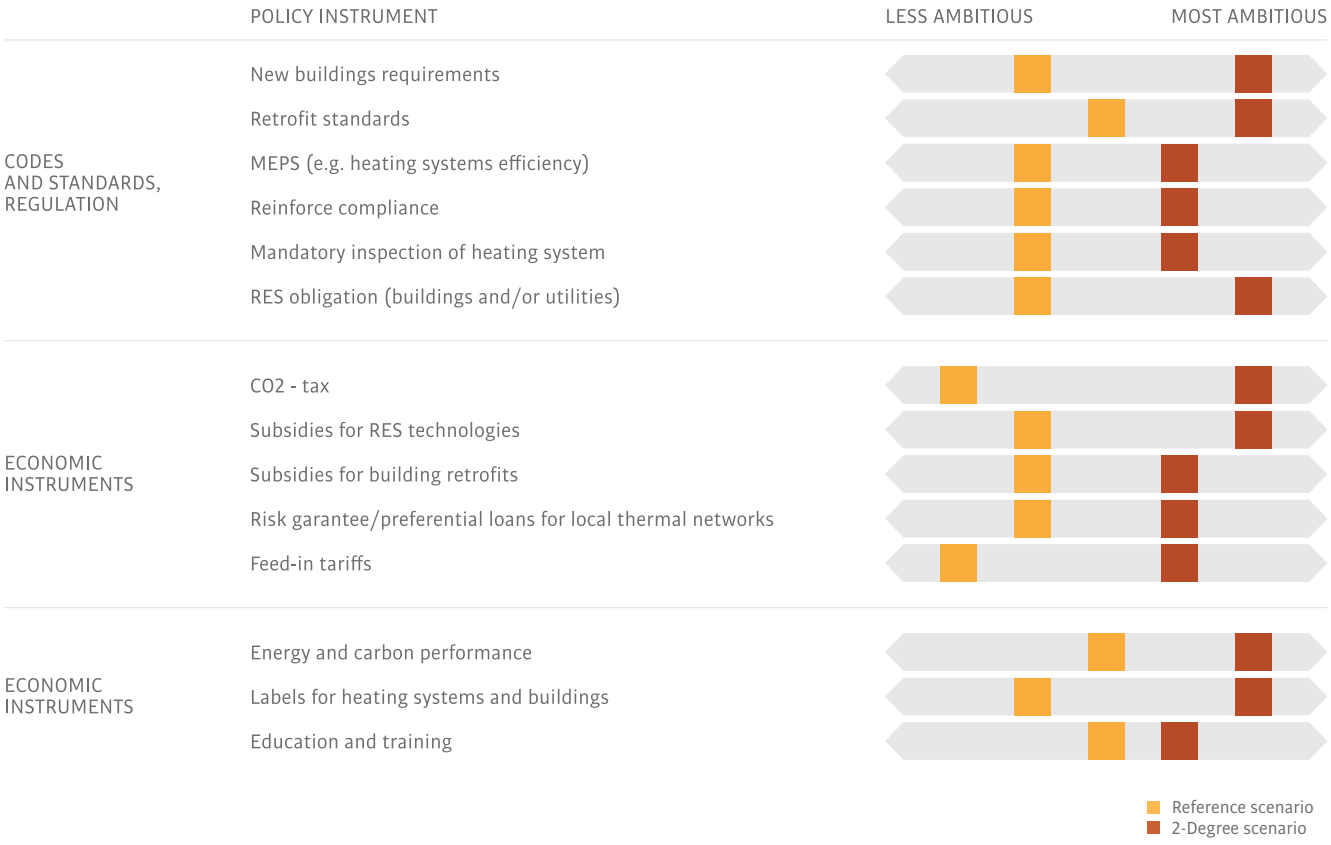
— *Energy prices (including taxes),*

— *Subsidies, tax exemptions and other financial incentives,*

— *Codes and standards, and*

— *Availability (e.g. of RESs and of energy infrastructure)*

***C2.1** – Scenario definition.*



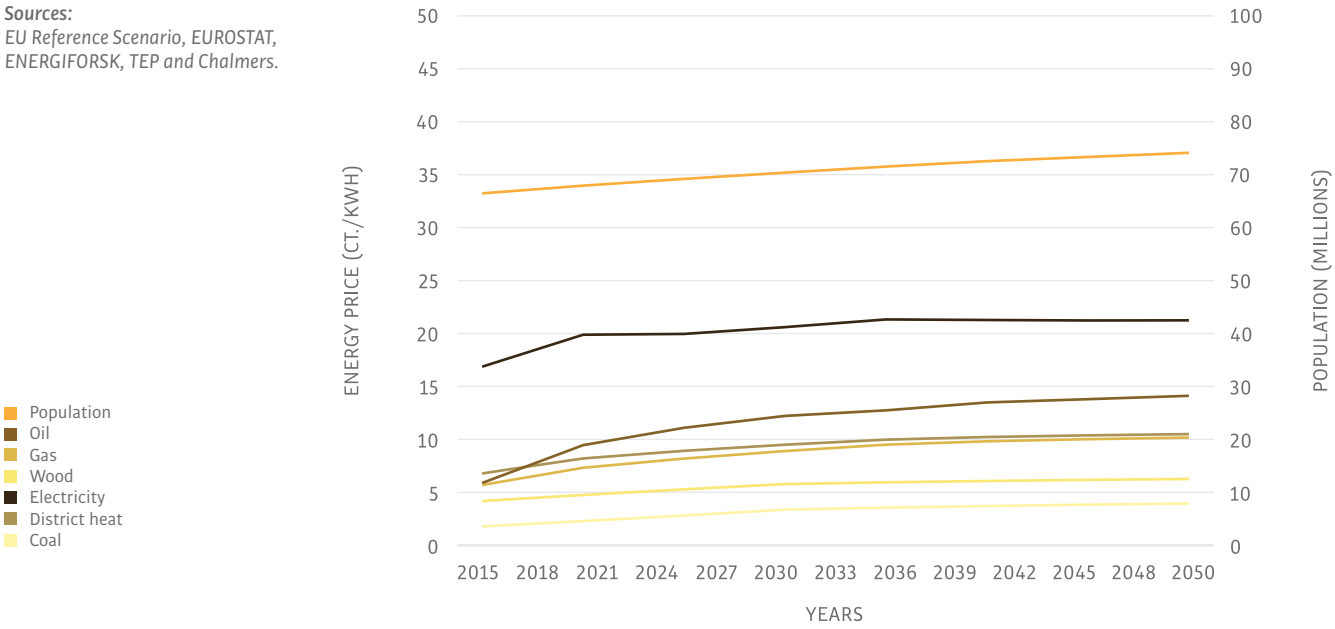
C3 Development scenario
Drivers and general implications

Drivers such as population growth and energy price developments are the same in both scenarios in order to improve comparability. Population growth is based on the EU Reference Scenario[12] (see Figure C.3.1) and depicted along with the assumed energy price development. These drivers target different aspects: I.e. the population development principally drives new construction activity in the market, while energy price development is a key driver for the diffusion of low-carbon technologies and retrofitting activities.

Notes:
The impact of these drivers is highlighted in sensitivity analyses available from the CUES Foundation.

C3.1 – *Population growth and energy price development.*

Sources:
EU Reference Scenario, EUROSTAT, ENERGIFORSK, TEP and Chalmers.



Notes:
Ambient Heat is the heat extracted by the heat pump from the air, ground, or groundwater to heat the building.

Based on the framework conditions outlined above, the main findings on final energy demand and GHG emissions are illustrated in Figure C.3.2 and can be summarized as follows:

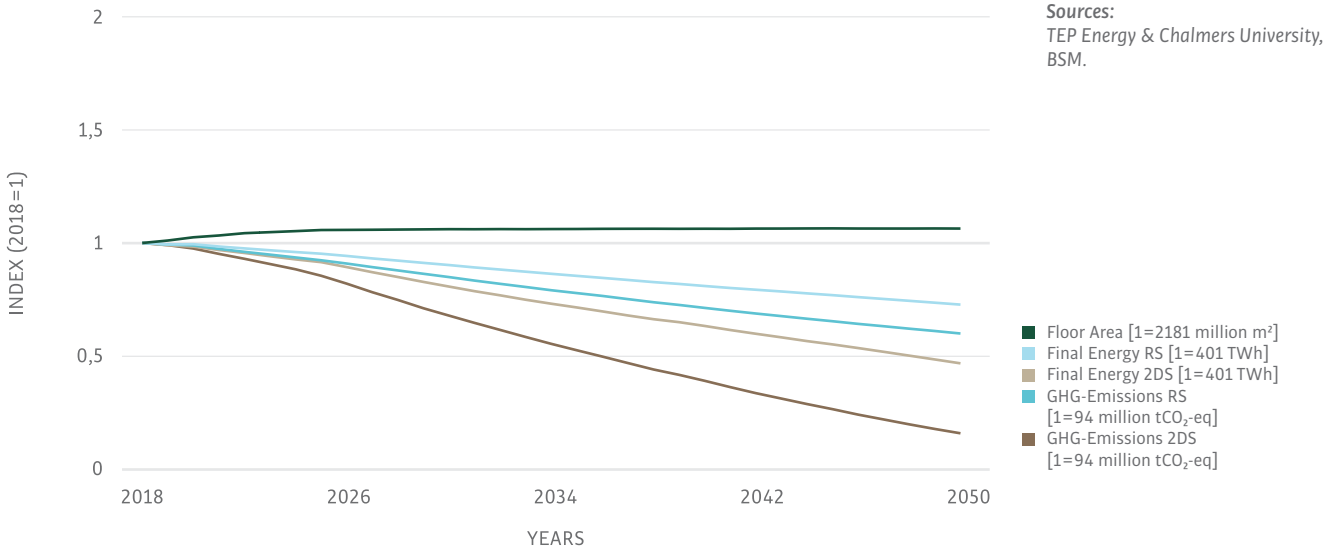
— Although the population is set to grow by 4.5% by 2030 and floor area by 8.6%, final energy demand for heating, hot water, and ventilation (including ambient heat) is decreased by about 4% in the RS and by more than 10% in the 2DS. For 2050, although a 10% growth in population is projected, final energy demand is reduced by 20% in the RS and by more than 31% in the 2DS. This is due to building code requirements for new construction and to retrofitting activities that take place in both scenarios. The additional reduction in final energy demand in the 2DS is due to the effect of a larger number of retrofitting activities and more stringent standards applicable than in the RS. In the 2DS scenario, retrofitting activity is fostered as a consequence of the larger availability of subsidies and attractive loans, and an increasing CO_2 tax which translates in a higher energy price for fossil fuels.

— Currently, gas is the dominant energy carrier for heating in the French housing sector (see Figure C.3.3). In the RS, demand for it remains more or less stable, with a slight increase in the medium term compensating for the decrease in heating systems fuelled by oil. In the 2DS, natural gas (as well as coal and oil) is phased out almost completely. Accordingly, the gas sector should be prepared to diversify its activities and to carefully manage its infrastructure assets. Renewable gas or developing heat pump-related energy services might be elements of new business strategies.

— Fossil fuel shares are partially compensated for by ambient heat (due to the deployment of heat pumps) and by district heating. Starting from a low level in 2018, the demand for ambient heat increases by more than 30 times in the RS and by more than 45 times in the 2DS until 2050 (compared to 2018), reaching a demand of 65 TWh and 1055 TWh, respectively. The demand for district heating also increases strongly, from around 12 TWh in 2018 to 51 TWh in the RS and 89 TWh in the 2DS by 2050.

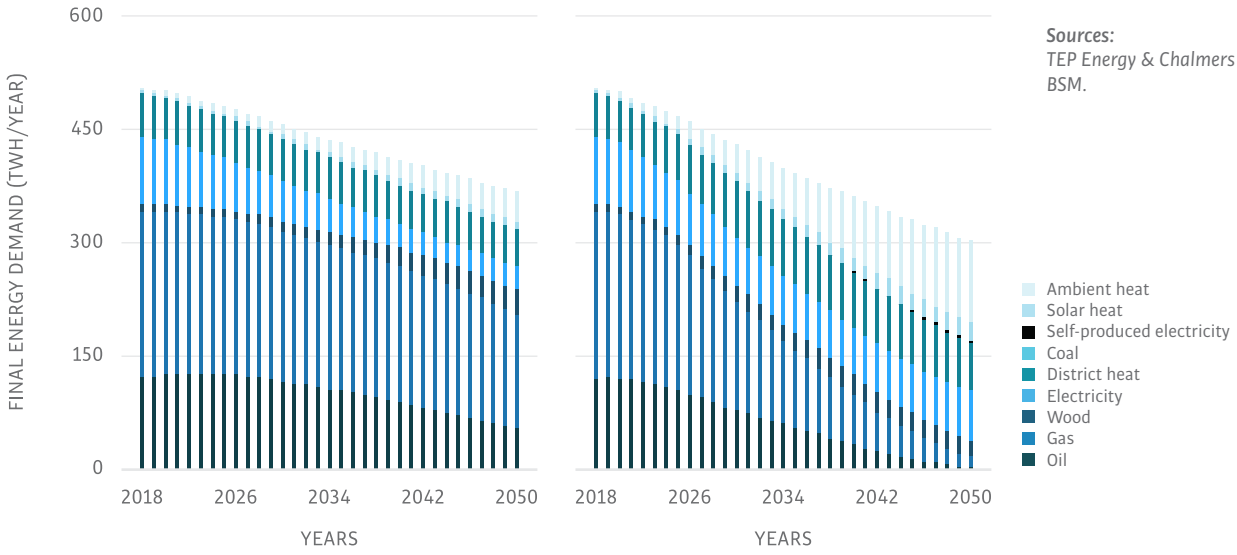
— More stringent building codes, increased retrofitting activity, and, principally, a structural change toward RES explains the reduction in GHG emissions which, although they are already reduced in the RS, in the 2DS decline by 40% in 2030 and by around 84% in 2050 (relative to 2018). The shift to RES is implied for electricity generation and district heating.

C3.2 – *Development of floor area, energy, and GHG emissions according to the modelled Reference Scenario (RS) and 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

C3.3 – *Development of final energy demand for heating, hot water, and ventilation according to energy carriers in the Reference Scenario (left) and 2-Degrees Scenario (right).*



Sources:
TEP Energy & Chalmers University, BSM.

C4 Structural change of the building stock
Short-, mid-, and long-term development

Notes:
According to the négaWatt scenario, the floor area per person will increase until 2030, when it will begin a slow decrease.

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Partially refurbished means that a building has 1–2 building components that have been refurbished in an energy efficient manner since 2015.

Comprehensively refurbished means that a building has 3 or more building components that have been refurbished in an energy efficient manner since 2015.

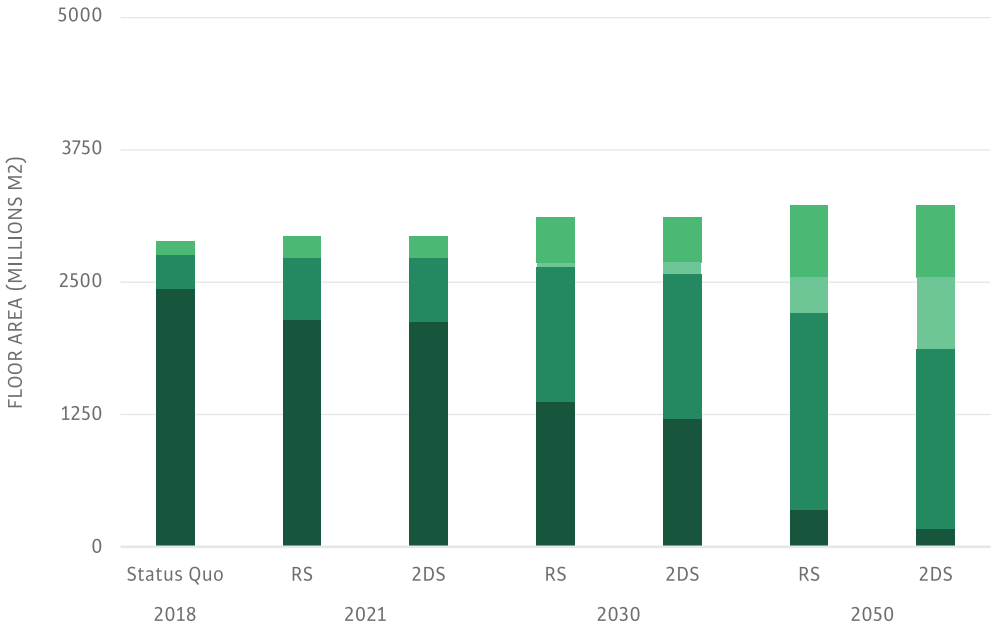
Both scenarios project that the residential building stock of France will expand by more than 345 million m² of floor area from present values to almost 3.2 billion m² of floor area by 2050. The currently existing stock, however, will decrease over this time period by almost 12% down to 2.5 billion m² in 2050 as a result of demolition. Overall, a net addition of 12% to the floor area by 2050 is expected, with newly constructed buildings making up 21% of the stock in 2050. This increase is mainly driven by a growing population (+10% in 2050) and, to some extent, by an increase in the demand for floor area per person. In terms of dwellings, the average surface area demonstrates an increasing trend in SDB and a decreasing one in MDB.[13]

Refurbishment of the existing stock is projected to be an on-going process up to 2050 (see Figure C.4.1), by which time both scenarios describe that most buildings will be partially or comprehensively refurbished. In the short term (until 2021), the refurbishment rate remains almost the same between the two scenarios, mainly as a result of component-based retrofits that will be subsequently result in similar percentages of partially refurbished buildings.

In the medium term (until 2030), 41% of the floor area is expected to be partially refurbished and only 1% is comprehensively refurbished in the RS. In the 2DS, the latter percentage is higher, comprising 4% of floor area and 43% of the floor area is partially refurbished. The increased refurbishment activity and more thorough renovations in the 2DS is a consequence of subsidies, tax incentives, and an increasing CO_2 tax. This trend continues in the long term until 2050, when a total of 20% of the stock is comprehensively refurbished in the 2DS, while only 10% is comprehensively refurbished in the RS.

C4.1 – *Refurbishment and new construction activities relating to building stock according to the Reference Scenario (RS) and the 2–Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



At present, more than half of the total residential floor area in France emits more than 20 kg CO_2-eq/m²/year (see Figure C.4.2). In the short term (until 2021), there are only minimal changes in the GHG intensity of the building stock in both scenarios. Nevertheless, the percentage of buildings emitting less than 10 kg CO_2-eq per m² doubles in the 2DS. This increase

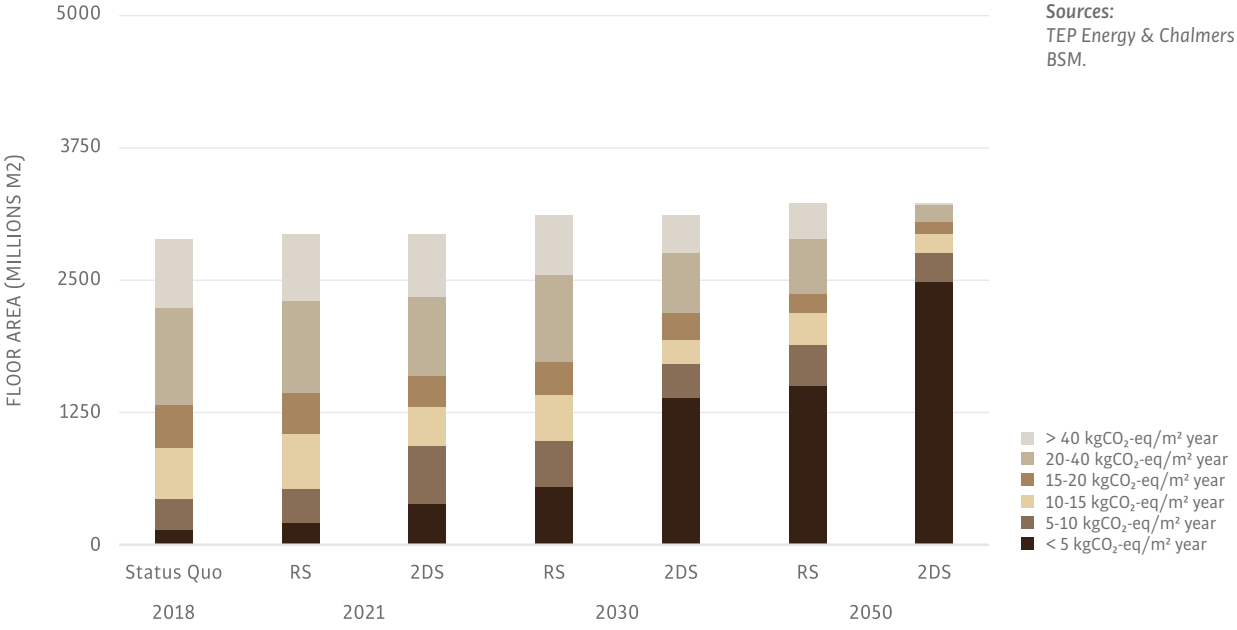
stems mainly from new buildings added to the stock after 2018, which have a carbon intensity of less than 10 kg CO_2 per m². Additionally, the rapid adoption of more stringent building codes in the short term contributes to this reduction in GHG.

A shift occurs until 2030, since at that point the majority of the buildings emit less than 20 kg CO_2-eq per m² in both scenarios. In the RS, buildings that emit less than 10 kg CO_2-eq per m² only make up 30% of the building stock. This is the case because only a moderate percentage of the stock has been comprehensively refurbished and the majority of the stock is still heated by fossil fuels. In the 2DS, the percentage of low-carbon buildings is significantly higher: buildings with a GHG-intensity of less than 10kg CO_2 per m² represent 55% of the total stock. This is a result of the larger number of comprehensive refurbishments and deeper partial refurbishments and the faster switch to RES compared to the RS.

After 2030, there is a clear shift to low-carbon buildings in the 2DS, resulting in the majority of the stock emitting less than 5kg CO_2 per m² (77%). This is triggered by the enforcement of dedicated policy instruments that favor low-carbon emission technologies and heating systems. The transition is primarily driven by a shift to electrically driven heat pumps, district heating, self-production, and continued efforts in building retrofitting.

Notes:
GHG intensity: GHG emissions from final energy consumption include those from electricity for heating, hot water, ventilation, and cooling from a life-cycle perspective. For example, 10 kg CO_2-eq per m² is equivalent to 45 kWh per m² in a gas-supplied building. GHG emissions embodied in the construction of the building are not included.

C4.2 – *Structural changes in the GHG intensity of the building stock according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

C5

Structural change of the building market
Short-, mid-, and long-term development

Notes:
Construction activities not directly related to energy and GHG emissions (e.g. structural or interior work, kitchens and bathrooms) are not included.

-

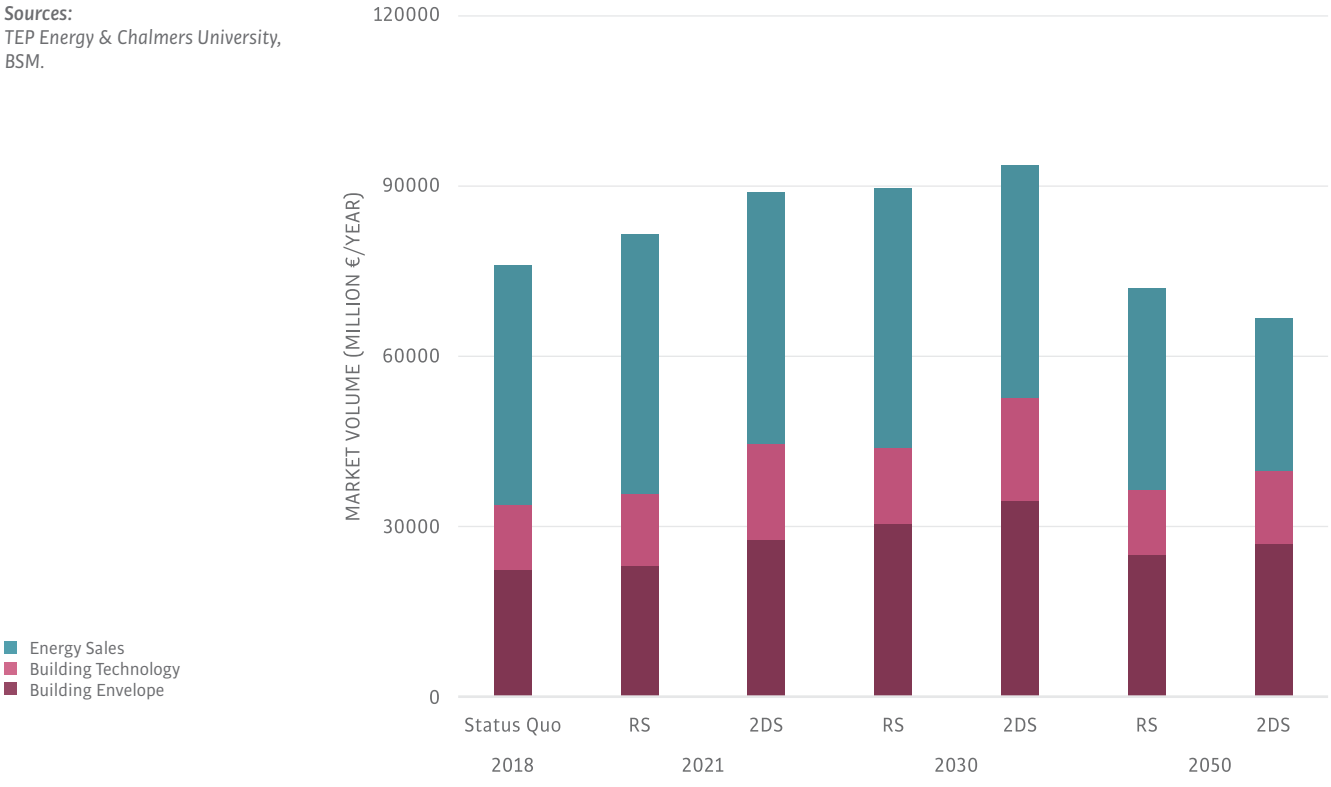
The market volumes presented in this and the next sections reflect the demand side. Possible limitations or shortages in capacity by the supply side to deliver (both in labour and material) are not explicitly taken into account.

In this and the following sections, the energy- and GHG-related building market is assessed. This includes the building envelope market, the building technology market, and related energy sales. Within this scope, the building envelope market encompasses all construction, retrofitting, and overhauling activities on building envelope components (walls, roof, floor and windows). The building technology market includes heating, hot water, and ventilation technologies. In the category of energy sales, all energy related to the building envelope and building technologies is included, whereas electricity sales for household appliances and CO_2 taxes are not included in the market volume. Hence, the entire value chain related to energy consumption and GHG emissions, including planning, installation, material and product sales, operation and maintenance, and the like, is covered for both existing buildings through refurbishment and for the construction of new buildings.

According to BSM calculations, the total market volume of the energy- and GHG-related building market, including energy sales, amounts to €76.5 billion per year in 2018 (see Figure C.5.1). More than half of this market volume comes from energy sales (€42.3 billion per year), even though electricity sales for household appliances are not included. The remaining percentages are split between the building envelope (€22.5 billion per year) and building technology (€11.8 billion per year).

C5.1 – *Development of energy-relevant market volumes in the residential building market according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.

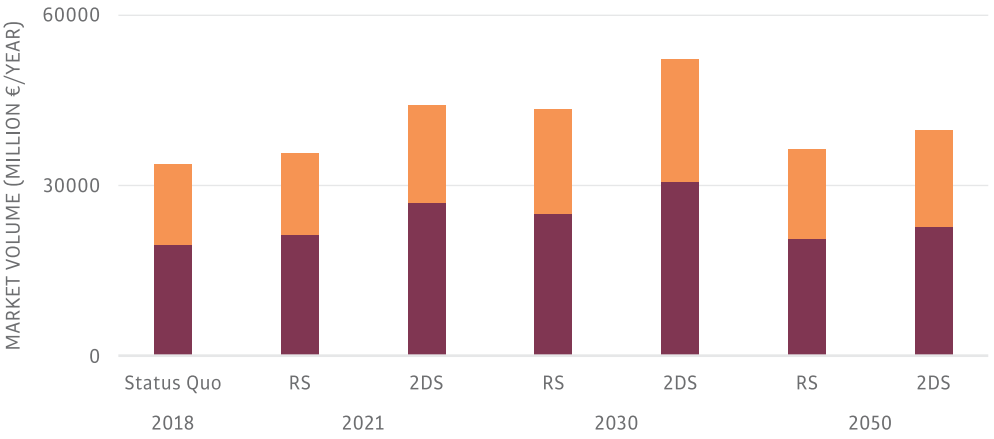


In the short term, the market volumes in the RS increase slightly. In the 2DS, there is already a significant increase of 24% in the market volume from the demand side for the building envelope and 42% for the building technology markets. This strong short-term increase in market volumes for the building envelope is the result of an increase in retrofit activity and new construction. This can be explained by the fact that a significant percentage of

the building stock was constructed during the decade between 1970 and 1980 (18% of the stock, compared to 9% to 11% in other decades), and based on the lifespan of the building elements for these buildings, large non-refurbished percentages need to undergo refurbishments in the short term. Moreover, the presence of asbestos and the construction style of these buildings with small living spaces and low solar gains result in the necessity of more thorough renovation at a higher cost or, in many cases, in demolition and new construction.

Until 2030, the total market volumes increase compared to 2018. For energy sales, this mainly arises as an increase in energy prices (including consumer taxes), rather than from an increase in sales. The price of electricity in France, today one of the cheapest in the Eurozone, is expected to strongly increase due to the high cost for dismantling nuclear power stations and investing in renewable energy sources. Energy sales, however, are reduced relative to 2021 in the RS and also relative to 2018 in the 2DS. The higher rate of refurbishment results in a lower energy demand that is not compensated for by the increase in the energy price, thus resulting in a reduction of the energy sales volume. In the 2DS, the building envelope market remains stable relative to 2021, while building technology sales continue to increase by 50% compared to the volume of 2018, based on the shift from gas to heat pumps and district heating.

C5.2 – *Development of energy-relevant market volumes (excluding energy sales) for material and technology, and installation and planning according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

In the long term (until 2050), the overall market volumes decrease in both scenarios, levelling out at present levels. The reduction of energy demand in the building sector in both scenarios leads to a decreased market volume of energy sales, which can no longer be offset by the shift to higher-priced energy carriers. At this point, energy utilities should have shifted their focus towards a comprehensive energy service business.

The market volume is split about 42%–58% between installation, engineering, and technical planning (€14.3 billion per year) and material and technology (€19.8 billion per year). This distribution remains almost stable across periods and scenarios. Smaller deviations can be observed e.g. due to the increase in market volume in the short term and medium term in the 2DS mainly from the material and technology category, where the market volume increases to almost €27 billion per year (+37%) in 2021 and €30.9 billion per year in 2030 (+56%).

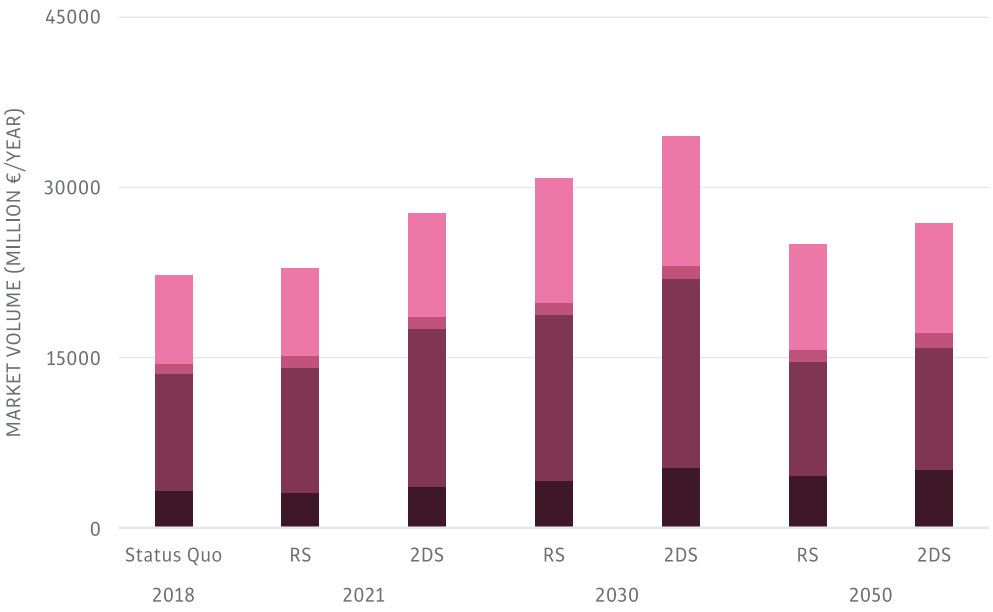
C6 Building envelope
Market volumes and development

The current annual market volume in the building envelope market amounts to €22.5 billion per year. This market volume is split between a variety of main building components (see Figure C.6.1). Wall insulation makes up the largest share (€10.2 billion per year), followed by windows (€7.9 billion per year). Significantly lower is the share of roof (€3.3 billion per year) and floor/basement ceiling insulation (€0.9 billion per year).

About one-third of the building envelope market stems from the construction of new buildings (currently, about 1% of floor area is added each year), and about two thirds from the retrofitting of existing buildings (an equivalent of about 1% of the building envelope is retrofitted to be energy-efficient, and an additional 1% is overhauled each year).

C6.1 – *Development of energy-relevant market volumes for various building components for both new construction and refurbishment according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*

Sources:
TEP Energy & Chalmers University, BSM.



In the short term, envelope market volumes are expected to increase only slightly in the RS (except for roofs, where volumes remain more or less the same), but more considerably in the 2DS due to a combination of the age of the building stock and the enforcement of stringent policies to increase the refurbishment rate and extent. Market volumes grow for all components, though most significantly for walls, which increases to €13.8 billion per year (+36%) and for windows, which increases to €9.3 billion per year (+18%).

In the medium term, market volumes continue to increase in both scenarios. This RS is characterized by the slow pace of the implementation of retrofitting, whereas in the 2DS, the envelope market volume starts to increase stronger. Market drivers in the 2DS are again, growing market volumes for wall refurbishment and window replacement.

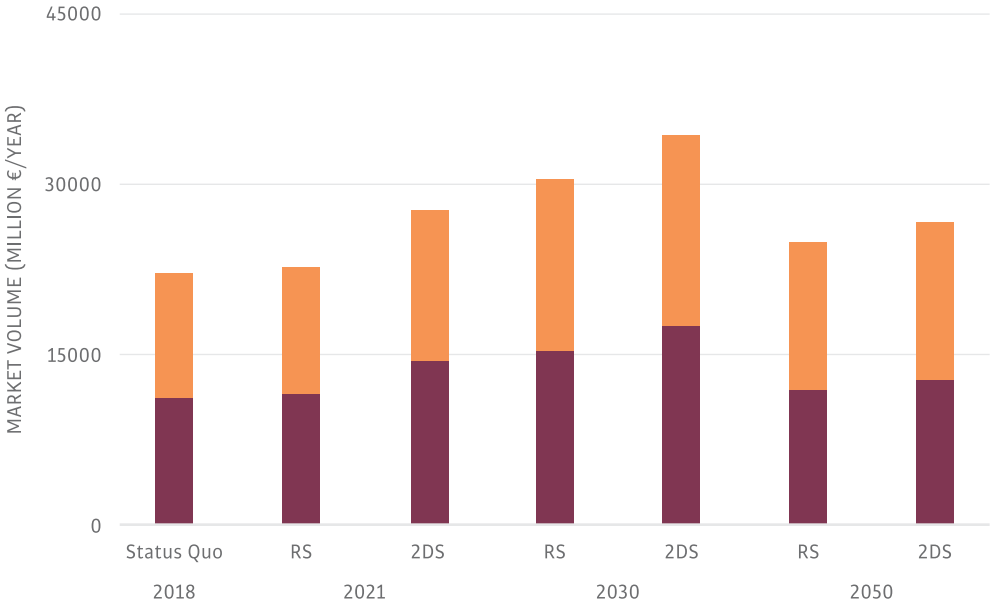
In the long run (up to 2050), the market volumes decrease in both scenarios and fall to slightly higher levels as compared to 2018. This reduction is explained until some extent by the decrease on partial refurbishments (usually linked to replacement of old elements) but also by a reduction in the demand for new construction. French population is projected to level

Notes:
Traditionally in France, walls are insulated from the inside. Yet, France is increasingly adopting the practice common to other European countries of insulating from the outside.

out its growth rate, with a tendency to stabilize and a slowdown the growth of the floor area per person after 2030.

The envelope market volume is split approximately in half between installation, engineering, and technical planning and material and technology, with €11.2 billion per year for each category (see Figure C.6.2). Given the overall trend in envelope markets development, the distribution between installation, engineering and technical planning and the material and technology category only varies slightly between scenarios and observation years. In the short term, the increases occur in both categories, though more notably in the material and technology category in the 2DS, for which market volume increases to €14.5 billion per year in 2021 (+30%). This results from an increase in the extent of refurbishment (e.g., the installation of thicker insulation and more efficient windows), an increase in the rate of refurbishment related to the age of the building stock and the presence of attractive incentives and more stringent codes.

C6.2 – *Development of energy-relevant market volumes for material and technology, and installation and planning for building envelope components according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

Notes:
In this analysis, ventilation does not include air conditioning. As cooling systems are mainly decentralized units in the residential sector, the demand is covered by the 'appliance' use.

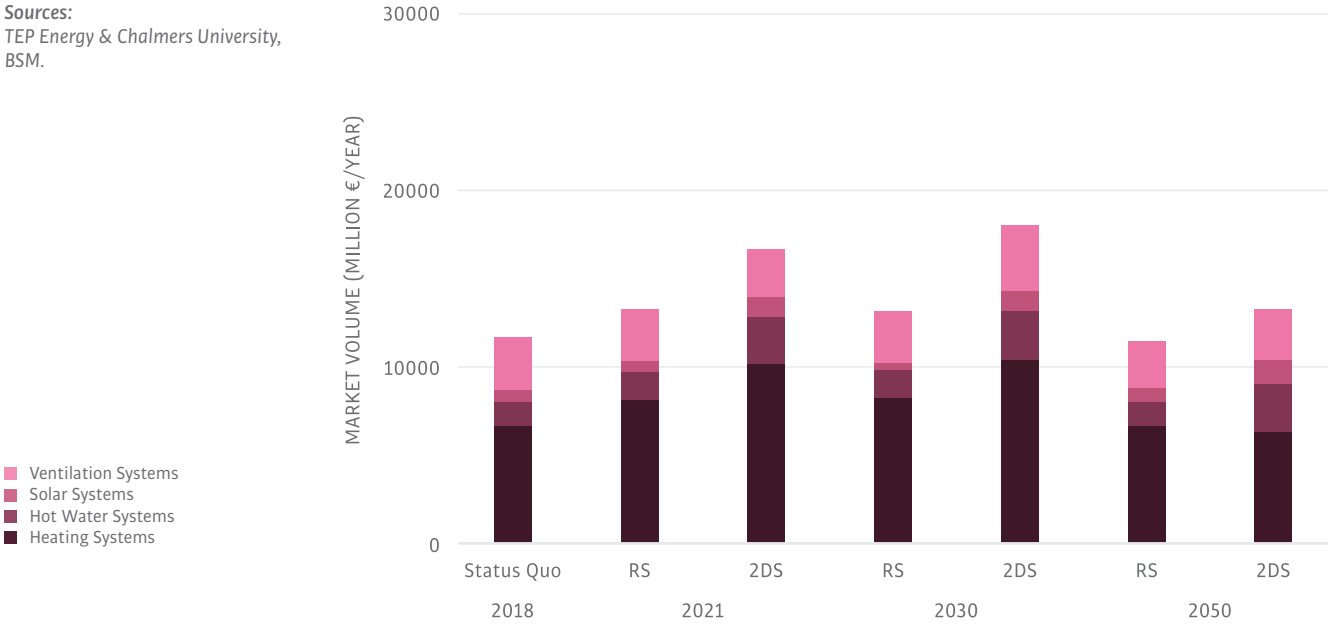
In the mid term, the market volumes further increase in both scenarios, whereas in the RS due to the lack of stringent codes and policy instruments, slower growth is observed. In the 2DS, the market volumes are growing further, given the more stringent refurbishment requirements in this scenario. In the long term, the market in both scenarios returns to similar levels as those that exist in 2018.

C7 Building technologies
Market volumes and development

The current market volume of French building technologies related to residential buildings amounts to €11.7 billion per year. About 70% of this market comprises heating and hot water systems, which amount to €6.7 billion and €1.4 billion per year, respectively (see Figure C.7.1). The remaining market volume is split between solar systems (both thermal solar collectors and photovoltaic systems) and ventilation systems, which amount to about €0.6 billion and €3.0 billion per year, respectively.

C7.1 – Development of energy-relevant market volumes for various building technologies for both new construction and refurbishment according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).

Sources:
TEP Energy & Chalmers University, BSM.



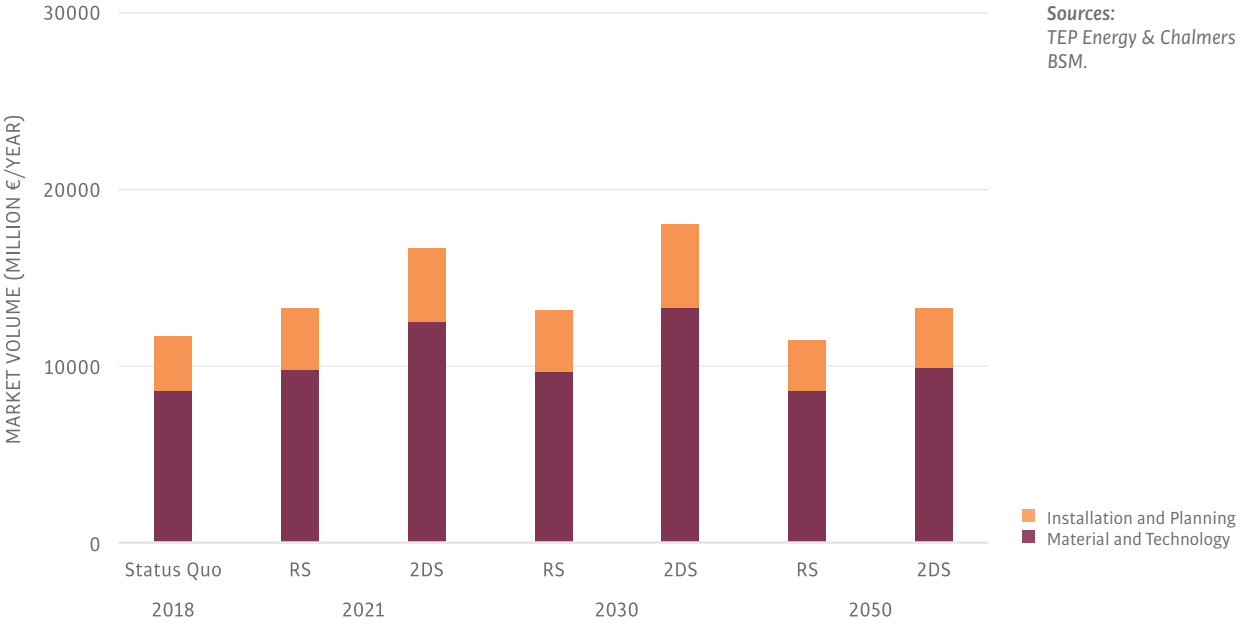
In the short term, the market volume for building technologies increases in both scenarios. In the RS, the most important relative increase is provided by heating systems (+20%, to €8.1 billion), while, in the 2DS, it is provided by hot water systems, doubling its market volume although solar systems and hating systems have also an important increase of above +50%. The main driver of this increase is the fast take-up of fossil fuel phase-out strategies and the installation of heat pumps and other renewable energy technologies as building regulations that favour low-carbon and carbon-neutral buildings take effect.

In the medium term (until 2030), market volumes decrease for the RS but further increase for the 2DS. In the latter, CO_2 tax lowers the economic viability of gas systems, and subsidies and tax incentives for renewable heating systems, helping to finance the transition to different energy carriers and heating solutions such as heat pumps. In this period, the heating systems market has its peak, with a market volume of €10.5 billion per year (for the 2DS).

In the long run, to 2050, the market volumes for both scenarios decrease, mainly due a strong reduction in the market volumes for heating systems. In the 2DS scenario, the market share for heating systems is decreased compared with 2018 (- 6.5%) and falls below the RS levels. The comprehensive refurbishment of buildings and higher standards for new construction, results in decreasing the installed capacities per heating system. This effect is amplified by

cost reductions, especially for heat pumps. The reduction for other technologies is explained by the decrease in the rate of partial refurbishments and new construction.

***C7.2** – Development of energy-relevant market volumes for material and technology, and installation and planning for building technologies according to the Reference Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

The building technologies market volume (see Figure C.7.2) currently comprises about 27% installation and planning (€3.1 billion per year) and 73% material and technology (€8.6 billion per year). The short-term increase of the market volume in both scenarios is primarily a result of the material and technology category, for which market volume increases to €9.8 billion per year (+15%) in the RS and €12.5 billion per year (+45%) in the 2DS. Installation and planning also has an important relative increase in both scenarios, with market volumes of €3.5 billion per year (+11%) and €4.2 billion per year (+33%), respectively.

In the medium term (up to 2030), there is a substantial increase of the market volume in the 2DS, with a market volume of €18.1 billion per year that represents an increase of +54% relative to 2018 levels. This significant increase is almost evenly distributed between installation and planning and material and technology, as the contribution of latter to the overall market volume only increases by 1%-points to 74%. Therefore, the phasing out of fossil fuel systems and the consequent increase in sales of more investment-intensive heat pumps does not have any significant impact on the market distribution amongst the named categories.

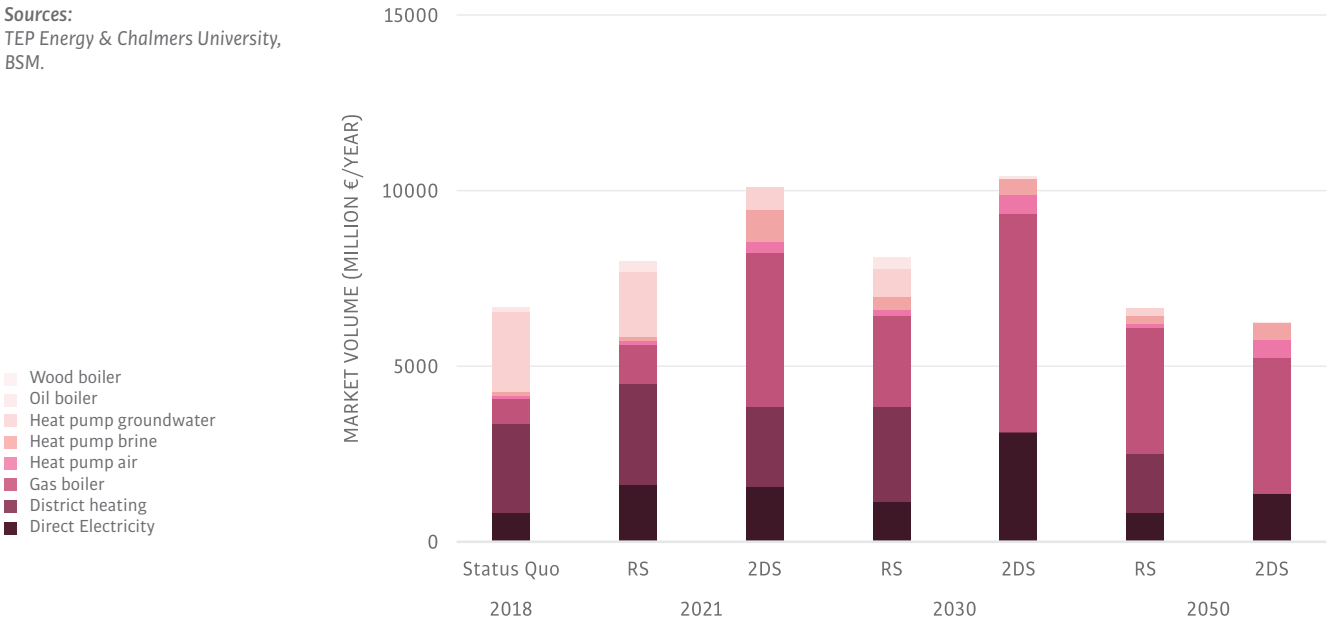
In the long term, the distribution between installation and planning and material and technology is expected to continue slightly shifting towards higher market volumes for material and technology which cover 75% of the market volume until 2050 (+1% compared to 2030).

C8 A deep dive into heating systems
Market volumes and development

The current annual market volume for heating systems amounts to €6.7 billion per year in France. The majority of this comes from the sale and installation of gas boilers, which has a market volume of about €2.6 billion per year. The second largest share comes from the sale and installation of oil boilers, which amounts to €2.3 billion per year (see Figure C.8.1).

In the short term, market volumes increase in both scenarios, based on the floor area increase and additional refurbishment work. In both scenarios, a strong reduction of oil boilers (-19% in the RS and -72% in the 2DS) is expected, with a shift towards more district heating and heat pumps in both scenarios, and additionally, higher market volumes for gas systems in the RS. In the 2DS, therefore, the policy of phasing out fossil fuel systems begins to take effect and reduces the market volume for such systems to €2.9 billion per year (-40%).

C8.1 – *Development of the market volumes of various heating system technologies (construction of new buildings and refurbishment of existing ones) according to the Refernce Scenario (RS) and the 2-Degrees Scenario (2DS).*



Sources:
TEP Energy & Chalmers University, BSM.

Up to 2030, both scenarios demonstrate a very low further increase in heating system market volumes compared to 2021. In the 2DS scenario, fossil fuel systems are fully replaced by renewable systems, whereas in the RS, oil boiler market volumes almost halve and the sale of gas boilers only slightly decrease compared to 2021.

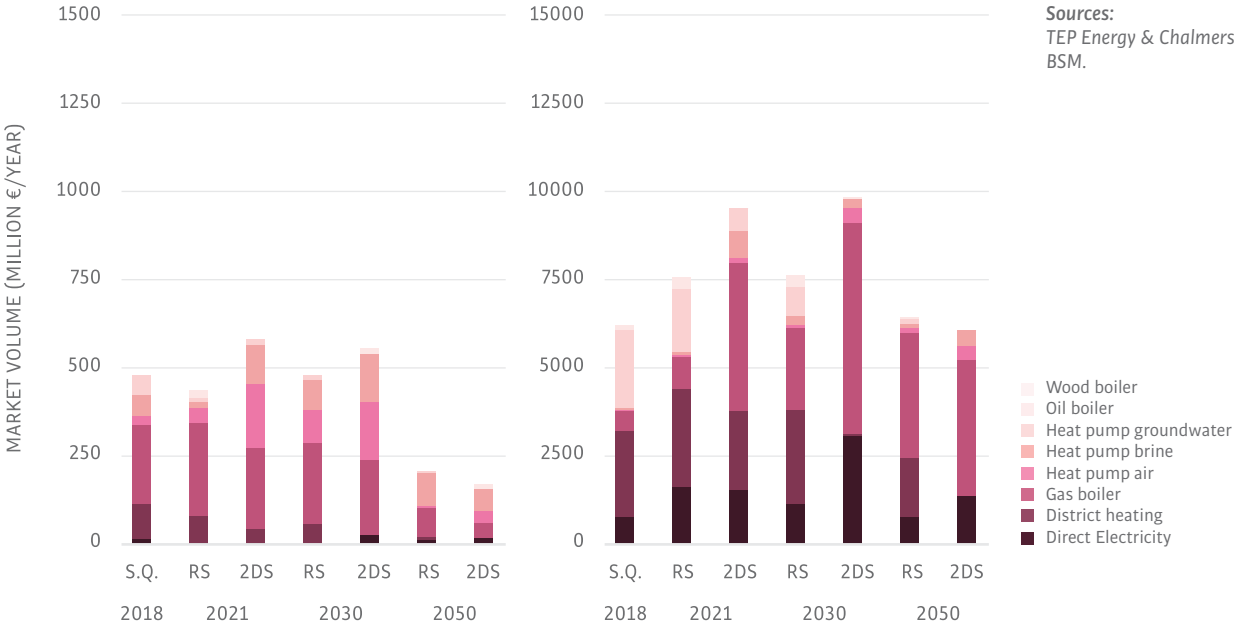
Notes:
For district heating, the calculations show demand-side potential which is subject to infrastructure availability.

Long-term development up to 2050 show decreasing market volumes in both scenarios, principally due to an overall reduction of costs for renewable heating systems and decreasing installed capacities per heating system. Market volumes in the 2DS decrease more relative to the RS, as the size of installed heating units decreases further due to larger efficiency gains in comprehensively refurbished buildings. Heat pump systems rapidly diffuse in the 2DS and dominate the market in 2050. Additionally, the RS shows an important reduction for gas boilers (-25%) that is mainly compensated by an increase in air-source heat pumps.

In 2018, the heating system market (see Figure C.8.2) is made up of about 7% new construction (€480 million per year) and 93% refurbishment (€6.2 billion per year). The refurbishment market is dominated by gas boilers, which make up 39% of the market volume. The

remaining market is primarily made up of oil boilers, with only a small percentage of heat pumps. In new construction, a shift to low-carbon technologies is evident, since heat pumps make up the largest percentage, followed by district heating.

C8.2 – *Development of energy-relevant market volumes for various heating system technologies according to the Refernce Scenario (RS) and the 2-Degrees Scenario (2DS) for the market segments new construction (left) and refurbishment (right).*



Sources:
TEP Energy & Chalmers University, BSM.

Heat pump systems remain as the dominant technology in new construction in both scenarios for all periods, with only a small percentage of fossil fuel heating systems in the RS and a complete phasing out of such systems in the 2DS accomplished by 2030. which is compensated for by heat pumps (€520 million per year for all types), and to a small degree by district heating (€26 million per year). In the long term, new construction projects need much smaller installed capacities and therefore, market volumes decrease.

For existing stock, gas-fueled heating is still highly relevant in the short term for both scenarios, with increases in the market volume of heat pumps (up to €1 billion per year in the RS and €5 billion per year in the 2DS) and district heating (up to €1.6 billion per year in the RS and €1.5 billion per year in the 2DS), most notably for the 2DS.

In the RS, gas remains the dominant technology in the existing stock in the medium term (and partially long term), with a moderate diffusion of heat pumps up to a market volume of €2.3 billion per year for air-source heat pumps in 2030 and €3.5 billion in 2050. In the 2DS, however, gas boilers are almost completely non-existent in the market by 2030, when the market volume for the replacement of heating systems is at its peaks. The main contributions to this change are the exchange of gas boilers by heat pumps (€6.0 billion per year for air-source heat pumps in 2030) and the creation and extension of district heating networks in French urban areas (€3.1 billion per year).

In the long term (until 2050), the market volume for different heating systems decreases due to the reduced need for space heating based on stringent envelope refurbishment.

F2 Building inventory factsheet

Single-dwelling
BUILDING

Construction period	1920	1945	1960	1980	1990	2000	2010	
Details								
Cumulative floor area (million m²)	0	0	0	0	0	0	0	0
Heated floor area (m²)	0	0	0	0	0	0	0	0
Average number of floors (#)	2	3	2	3	3	2	2	2
Envelope surface area (m²)	395	456	432	433	384	428	419	481
Window wall ratio (%)	10%	5%	6%	11%	8%	7%	6%	6%
U-Value (W/m² a)								
Wall	1.2	1.56	1.45	1.23	0.34	0.25	0.16	0.13
Roof	0.98	1.2	1.45	1.12	0.44	0.23	0.22	0.19
Floor	2.66	1.76	2.35	1.76	0.95	0.42	0.32	0.2
Window	4.31	4.31	3.34	2.42	2.7	2.38	1.7	1.41
Heating Systems								
Oil boiler	30%	32%	28%	28%	14%	13%	6%	8%
Gas boiler	40%	38%	39%	37%	24%	35%	35%	32%
District heating	0%	0%	0%	0%	0%	0%	0%	0%
Heat pumps	0%	0%	0%	0%	0%	0%	0%	0%
Wood stove	6%	7%	6%	6%	11%	5%	4%	5%
Direct electricity	24%	22%	24%	29%	51%	47%	56%	56%
Coal boiler	0%	1%	2%	1%	0%	0%	0%	0%

Multi-dwelling
BUILDING

Construction period	1920	1945	1960	1980	1990	2000	2010	
Details								
Cumulative floor area (million m²)	0	0	0	0	0	0	0	0
Heated floor area (m²)	0	0	0	0	0	0	0	0
Average number of floors (#)	6	7	6	8	6	5	6	6
Envelope surface area (m²)	2423	1569	1594	3482	4334	3004	4244	3474
Window wall ratio (%)	13%	10%	15%	24%	10%	8%	11%	14%
U-Value (W/m² a)								
Wall	0.84	1.71	2.07	1.22	0.52	0.21	0.19	0.1
Roof	1.58	1.92	1.54	2.32	0.55	0.41	0.29	0.23
Floor	2.78	2.64	2.62	2.27	0.46	0.41	0.27	0.27
Window	3.87	2.41	2.87	2.49	2.69	3.02	1.96	1.57
Heating Systems								
Oil boiler	4%	6%	18%	3%	3%	4%	0%	0%
Gas boiler	66%	66%	75%	66%	23%	57%	26%	34%
District heating	13%	8%	0%	5%	10%	4%	6%	0%
Heat pumps	0%	0%	0%	0%	0%	0%	0%	0%
Wood stove	0%	0%	0%	0%	0%	0%	0%	0%
Direct electricity	16%	20%	7%	22%	64%	36%	68%	66%
Coal boiler	1%	0%	0%	3%	0%	0%	0%	0%

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