I4CE
INSTITUTE FOR CLIMATE ECONOMICS
Une initiative de la Caisse des Dépôts et de l'Agence Française de Développement

Landscape of domestic climate finance

Low-carbon investment 2011 - 2017

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I4CE – Institute for Climate Economics is a think tank that provides public and private decision-makers with expertise on economic and financial issues related to the energy and ecological transition.

We strive to implement the Paris Agreement, and make global financial flows compatible with low-carbon development that is resilient to climate change.

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This report includes acronyms and translations for the names of some French institutions, instruments and programs. In their first occurrence in the report, acronyms are presented in their extended form, and translations are provided with their French equivalent in brackets.

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Foreword: five years of improving knowledge on climate finance for policy

Achieving the objectives laid out in the Paris Agreement to keep the increase in global mean temperature "well below 2°C" will require significant changes in how our societies and economies function. The transition to a low-carbon, resilient economic model implies significant investments in buildings, transport systems, vehicles, power plants and many other parts of the infrastructure that supports the economy – and our daily lives. In turn, the transition will also require changes in investments with climate-adverse effects (fossil fuels or energy-intensive technologies) that must be reduced and funds redirected to finance what we truly need for our future.

An improved knowledge base and policy assessments tools for shifting investments

I4CE is convinced that an important means of making these investment happen is having the correct signals to the economy to invest in a low-carbon, resilient manner – as well as ensure that finance is flowing from both public and private sources. However, shifting and scaling-up financial flows to meet national climate and energy objectives requires an improved knowledge base, as well as policy and project assessment tools for shifting domestic investment patterns and to engage financial and economic actors.

A "Landscape of climate finance" to track investments and support decision making

Landscapes of domestic climate finance are comprehensive studies mapping financial flows dedicated to climate change action and the energy transition. Covering both end-investment and supporting financial flows from public and private stakeholders, Landscapes capture how the financial value chain links sources, intermediaries, project managers and end-investment.

The resulting systematic tracking of domestic climate investment and related financing flows is a powerful process for supporting national climate and energy policy.

- First, highlighting the gap between current policies and climate objectives can help generate awareness and engagement with national stakeholders.
- Second, aggregating indicators from different sectors into a single, coherent view serves as a reference point to track where the transition stands year after year.
- Finally, sectoral analysis of the economic conditions in which low-carbon projects can thrive improves the understanding of investment policy successes and setbacks.

The results produced by I4CE using this approach have become an internationally-recognized reference on climate finance and investment in France. Since 2013, I4CE is continually improving and extending this approach to co-construct with both public and private stakeholders the tools and information needed to inform decision-makers and supporting public policies on the elaboration of financing strategies for the energy transition. We are currently extending this methodology to assess current climate-adverse investments, as well as produce forward-looking assessments of the investment needs of French National Climate Strategy (SNBC and PPE).

A report to learn about French climate policy through climate finance tracking

On one hand, this report has been designed for those that would like to learn more about climate policy and investments in France. The report presents an overview of French climate policy over the last decade, complemented with descriptions of the principal policies and approaches taken sector by sector. It presents the process around the SNBC & PPE, and an overview of the related investment needs. I4CE's experience in using the Landscape tool to support these discussions is explored, with the Results and Analysis chapters demonstrating what type of information the Landscape can generate,

Ian Cochran, Senior Advisor

Hadrien Hainaut, Project Manager

and how this can provide insights for decision makers.

On the other hand, it presents a deep-dive into the roots of the Landscape of domestic climate finance methodology. This includes an overview of the definitions used, the hypothesis developed to estimate end-investment and financing flows, and an exhaustive listing of the sources of data collected and aggregated by I4CE. Our objective is to provide a basis for constructive discussions on means to improve our approach, as well as support any actors who may wish to develop a Landscape in their country or area of interest.

An open invitation to work with us to improve knowledge for policy

Today, there is an opportunity to improve domestic tracking of climate finance in Europe and the world. Landscapes have been recognized as an important part of understanding the impacts of the broader 'greening' of the financial system on the real economy by both the High Level Expert Group on Sustainable Finance in Europe as well as the UNEP Inquiry into the Design of a Sustainable Financial System. While a number of countries to date have produced domestic landscapes, knowledge on domestic climate-related end investment, financial flows supporting this investment by public and private actors remains limited across the European Union and beyond.

We hope that this report will help those who know our work to better understand it – and to support, if not inspire, other researchers across Europe and around the world to produce this type of analysis in their given countries.

We invite all interested parties to get in contact us and look forward to working with you to achieve our shared climate objectives.

Best regards,

Ian & **Hadrien**


LANDSCAPE

CONTENTS

2017 Edition results summary

Between 2013 and 2016, up to €32 billion of investment contributed each year to climate mitigation in France.

In 2016, the investments are divided between 14.5 billion euros for energy efficiency, 5.9 billion euros for the development of renewable energies and 9.2 billion euros for construction and updating of sustainable transport and network infrastructure. Investments in the development and renovation of the country's nuclear capacity, in non-energy processes and the reduction of emissions of other GHGs than CO_2 are estimated at 2.1 billion euros.

THE STUDY IN BRIEF…

The Landscape of Climate Finance is a comprehensive study of domestic financial flows in favour of climate and the broader energy transition in France. The study maps the flows supporting investments leading to greenhouse gas mitigation across the French economy.

Findings are compared from year to year and assessed in comparison to projected investment needs to achieve national GHG reduction targets and other energy transition objectives.

The principal objective of the study is to support public debate on the role and relevancy of public and private financial flows in support of climate-related investments.

The Landscape of Climate Finance is based on the aggregation of a large number of publicly-available sources. All results reflect explicit methodological choices made by the authors and should thus be understood as estimates of the order of magnitude of flows, with varying degrees of uncertainty. Results are updated annually and revised according to the availability of new sources and evolutions in the methodology.

Between 2011 and 2013, investments increased by 2.6 billion euros to 32.1 billion euros. They were then stable in 2014, 2015 and 2016. The first estimates available for 2017 total 31.5 billion euros.

This overall stability masks more marked variations by investment areas: investments in energy efficiency increased between 2011 and 2016, from 11.6 to 14.6 billion euros. After increasing by 50% between 2011 and 2013, spending on sustainable infrastructure declined in 2014 and 2015, and has since been stable. Renewable energy investments decreased from 8.6 billion euros to 5.3 billion euros between 2011 and 2013, and have remained at this level since then.

64% of investment is made by households and private companies

Household spending totalled 10.8 billion euros, or 33% of climate investment in France in 2016. The majority of these investments were in the building sector. To finance these investments, households mainly used their own funds (4.4 billion euros) or commercial bank loans (3.3 billion euros). They benefited from a total of 2.7 billion euros of public grants and subsidies.

Companies and project developers invested 9.8 billion euros in favour of climate, 31% of climate investment in 2016. They made the majority of these investments in centralized power generation and networks, including renewable electricity generation (3.3 billion euros). Whether using project finance or balance sheet financing, companies mainly mobilize bank and bond financing (5.5 billion euros) or their own equity (2.5 billion euros).

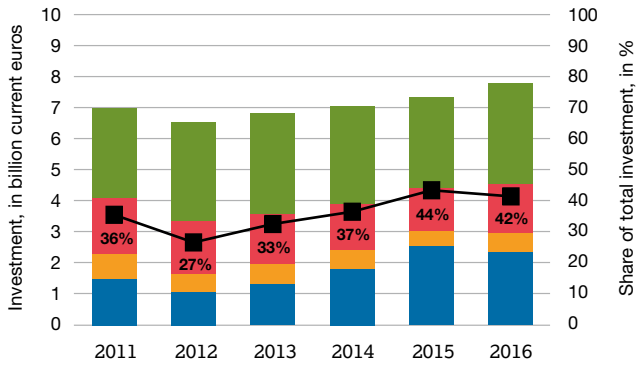
As project developers, the central government, local governments, social housing authorities and public infrastructure managers (such as SNCF Réseau and RATP) made 11.4 billion euros in investments in 2016. Their principal source of the funds for these investments came from public sources, totalling 3.8 billion euros. Social housing authorities also borrowed from Caisse des Dépôts (1 billion euros for energy efficiency works).

Since 2013, the public sector has driven more than half of the funding supporting investments

Measuring the share of publicly-driven funding allows an analysis of whether climate investments depend principally on public support, or on the economic and regulatory conditions making the financing of projects viable for the private sector.

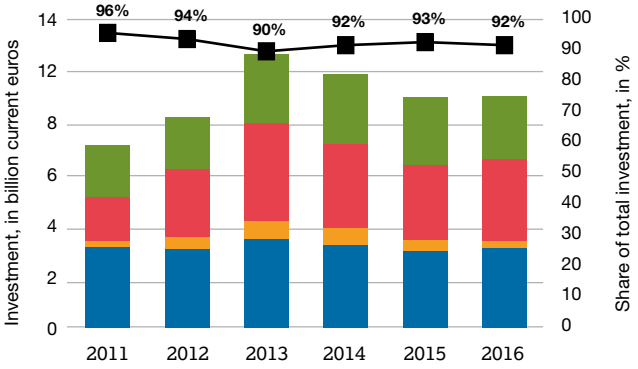
House retrofitting: an increase in investments and in the share of publicly-driven finance

Investments have risen since 2012, from 7.7 to 8.9 billion euros. Grants, subsidies and transfers have played an increasing role in funding these investments. Publicly-driven funding, which includes subsidies, concessional debt to households and investments by the central government, local authorities and social housing authorities, accounted for 44% of investments in 2015 and 42% in 2016.



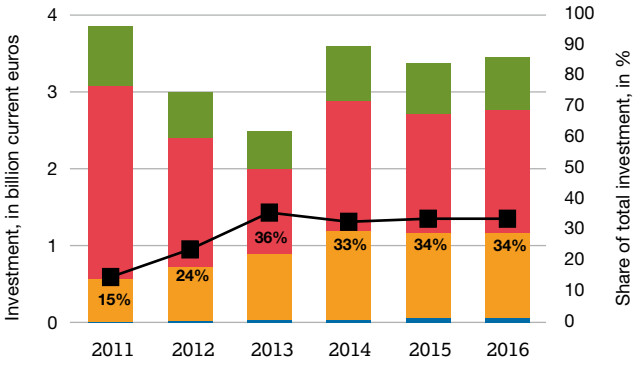
Transport: investment in infrastructure decreased since 2013, while investment in the purchase of low-carbon vehicles increased

In the transport sector, infrastructure investments totalled to 8.8 billion euros in 2016, and was characterized by a high proportion of publicly-driven funding in the form of projects combining public subsidies and disbursements from central, regional and local authorities and loans made by infrastructure managers. On the other hand, the purchase of low-carbon vehicles was mainly financed by households and businesses, increasing from €100 to €780 million between 2011 and 2016.



Renewable electricity generation: stabilizing investment levels and the role of public financial institutions

The decrease in renewable electricity purchase prices led to a fall in investments from 2011 to 2013. Since 2014, a constant average of 3.4 billion euros has been invested per year. Investment came principally from companies, in the form of special purpose vehicles mainly relying on bank lending. The share of funding from publicly-driven schemes, in particular concessional debt and credit lines issued by public financial institutions and banks, increased between 2011 and 2013 and has since been stable.



- Grants, subsidies and transfers
- Concessional debt
- Commercial debt
- Equity, own funds
- Share of publicly-driven finance (in %)

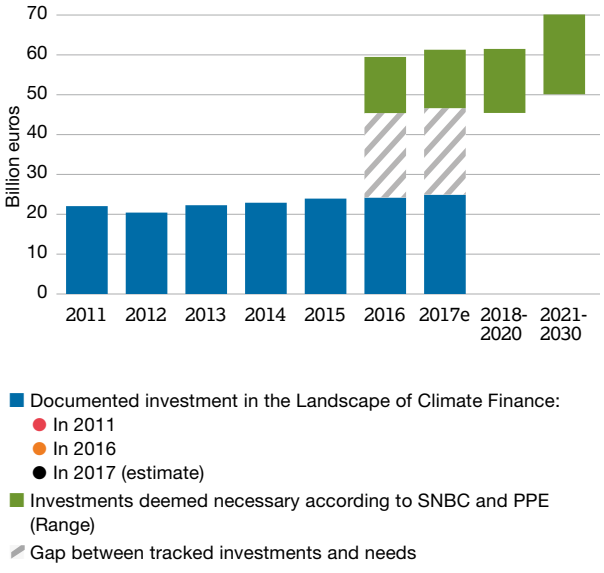
Publicly-driven finance is comprised of investments by public project developers (national and local governments, public housing offices and public operators including infrastructure managers) as well as grants, subsidies and transfers and concessional debt issued to private project developers (households and companies). For more information, see p.92 of this report.

Between 45 and 70 billion euros of annual investment by 2030 would be needed to achieve the objectives defined by the National Low Carbon Strategy (SNBC) and the Multiannual Energy Plan (PPE)

In 2016 and 2017, the annual gap between investments and needs represents between 20 and 40 billion euros

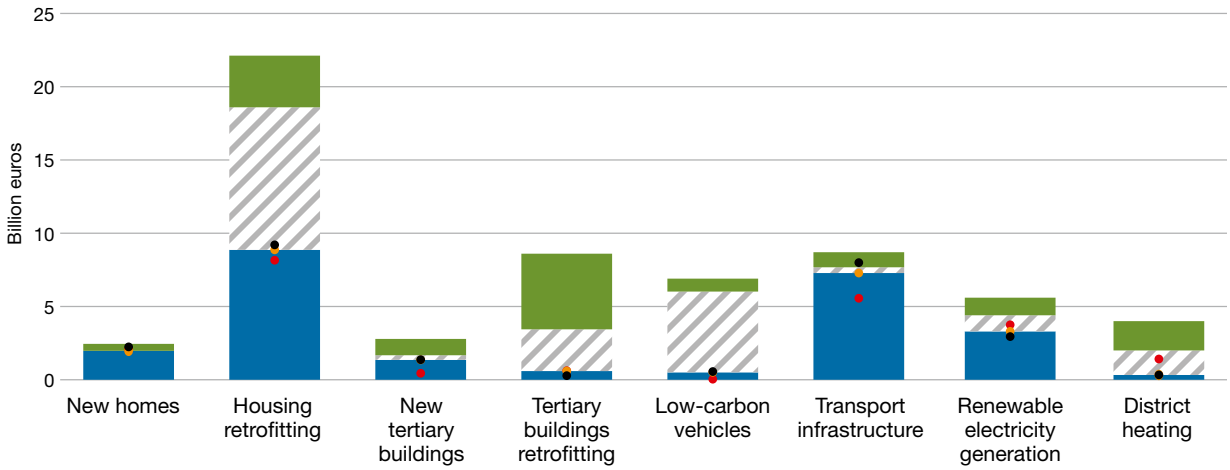
Using a comparable perimeter, climate investments identified in 2016 and estimated for 2017 amount to approximately 25 billion euros. At the same time, investment needs estimated from the National Low Carbon Strategy (SNBC) and the Multiannual Energy Plan (PPE) range from 45 to 60 billion euros. The annual estimated investment needs remains within this range up to 2020. Between 2021 and 2030, the annual investment needs are estimated between 50 and 70 billion euros.

COMPARISON OF INVESTMENTS TRACKED IN THE LANDSCAPE OF CLIMATE FINANCE AND ESTIMATED INVESTMENT NEEDS ACCORDING TO THE SNBC AND THE PPE



The needed investments are distributed unequally across sectors

Breakdown of investment gaps by sector



In absolute amounts, the gap between current investment and estimate investment needs is concentrated in the building sector, primarily in the retrofitting of private homes. For retrofitting of Tertiary buildings, low-carbon vehicles and district heating, investment needs are low in absolue amounts, but represent several times the level of current investment. For renewable energy production, sustainable transport infrastructure, current investment is close to the level of estimated investment needs.

The use of financing instruments depends mainly on the size of the project and the type of developer

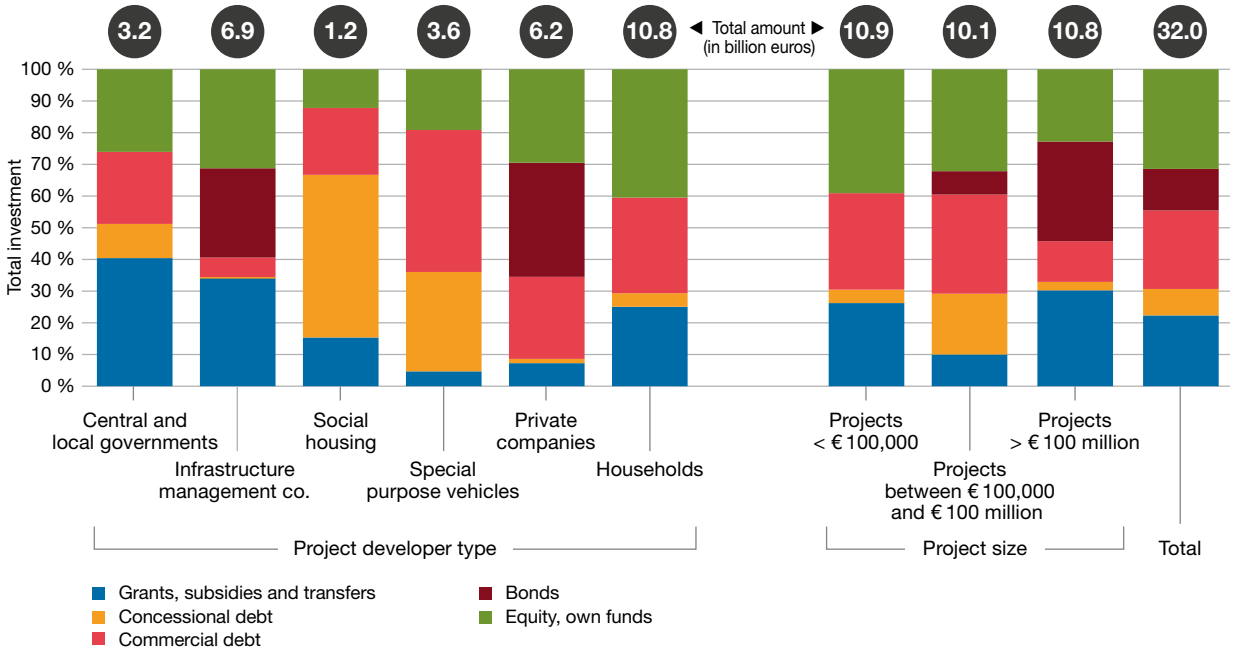
Each project developer used a specific mix of financing instruments

Subsidies, grants and subsidies represented more than 25% of the total projects for communities, infrastructure managers and households. For social housing authorities and renewable electricity special purpose vehicles, concessional loans, contracted from Caisse des Dépôts and BPI France, represented respectively from 30% to 50% of the total cost of the projects. In particular, large companies and infrastructure managers used bonds to finance their investments. The share of equity was the most important for households.

The size of projects also influences the type of instrument used

Grants, subsidies and payments were used for more diffuse projects (less than 100,000 euros), particularly by households for new construction, housing renovation or vehicle acquisition. These instruments were also used for major infrastructure projects (projects of more than €100 million). Conversely, concessional debt mainly financed medium-sized projects (€100,000 to €100 million), such as the renovation of public buildings or the generation of renewable electricity. Commercial debt from banks was used for diffuse and medium-sized projects, while large projects are characterized by a more frequent use of bond issuance by large companies, commercial banks and infrastructure managers. The share of equity was higher for diffuse investments, highlighting the difficulty of mobilizing private finance for smaller projects.

LOW-CARBON INVESTMENT FUNDING INSTRUMENTS BY PROJECT DEVELOPER AND PROJECT SIZE, 2016



PART 1

A tool to understand climate finance and investment

The Landscape of Climate Finance in France identifies investment expenditures contributing to climate objectives in France and analyses how expenditures were financed. The study documents the role of intermediaries as well as public and private instruments in the financing of energy efficiency, renewable energies and sustainable infrastructures. It covers the investments and finance flows for the years 2011 to 2016, updating previous editions.

Understanding the mobilisation of climate finance in France

The transition towards a low carbon economy that is resilient to climate changes involves a considerable transformation of economic and social activities

Such a transformation affects investment in technologies, fixed capital and infrastructures, especially those in the energy production and consumption sectors. In both developed and developing countries, it will require a reorientation of financial flows, all the way from the source of finance to the end sector of investment.

This is recognized by article 2.1-C of the Paris Agreement, which came into effect on 4 November 2016, with the objective of **"making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."** (Paris Agreement, 2015).

Tracking flows to assess their alignment with climate objectives

Documenting financial flows firstly involves examining the volumes of capital invested in climate-related areas and analysing the manner in which such investments are funded. This principally descriptive work reveals at times significant differences in orders of magnitude of total value of flows depending on the sector and area of investment.

The study secondly tracks how the "financial value chain" supports climate change action and the energy transition, in particular the route taken by financial flows through the French financial value chain and broader economy - from their source through to their sector and purpose of end use.

The aim of this descriptive assessment is to provide a basis to better understand the financing of the energy transition across sectors and the entire financial value chain, to highlight the principal trends, and to put forward an objective empiric foundation for public discussion.

Analysing the adequacy of climate investment and public and private financial flows

While the work conducted in the Landscape is essentially descriptive, the resulting dataset can be used as a basis to identify explanatory factors of climate investment. The Landscape assesses whether current investments are sufficient with to achieve national climate and energy objectives; whether certain sectors or areas are likely to expand – and if so, to what proportion.

For this, the report compares current and historical investment levels with investment needed to achieve the objectives of French national plans and strategies. This is essential to assess which instrument or combination of instruments is most adequate to increase and redirect finance flows towards investments aligned with a long-term development pathway compatible with climate change mitigation and adaptation objective.

Integrating results in the policy dialogue

Since 2015, the results of the Landscape have been included in the French government's budget planning process.

Article 174 of the Energy transition and green growth act (LTECV) requires the government to present an annual report to the Parliament which "**quantifies and analyses public finance, assesses private finance, and measures their adequacy with the financial requirements to achieve the objective and transition pace of the law**".

The Landscape of climate finance responds to this request by presenting a quantified overview of climate finance and investment in France.

- Results are quoted in a budget bill's annex dedicated to cross-policy climate expenditure (Document de politique transversale, DPT Climat).
- Results of this Landscape edition were presented at the French National Assembly in December 2017 during a conference followed by a debate.
- In 2017, a special report on the French strategy for green finance has called for the elaboration of a climate "business plan" through a systematic evaluation of investment needs and corresponding financial models (see Lemmet and Ducret, 2017).

FROM REPORTING TO DECISION-MAKING: WHY KEEP TRACK OF DOMESTIC CLIMATE FINANCE?

The Landscape of climate finance seeks to provide quantified estimates to support public discussion allowing:

- **Reporting to decision-makers** on the status of climate-related investment and financial flows;
- **Comparing the results** year on year and with similar work carried out in other European countries;
- **Identifying** the explanatory factors of observations and tendencies;
- **Recommending solutions** for reducing the variations between current financial structures and the objectives for national energy transition;
- **Developing strategies and plans** based on an overall view of the players involved and the financial flows mobilized.

Additionally, the results have been presented extensively to different formal advisory or deliberative bodies as well as businesses, NGOs, unions, local governments, etc.

National climate policy frames climate finance tracking

I4CE's Landscape of Climate Finance examines how policy choices affect climate investment. The scope of the study reflects the terms of climate policy in France. It is defined based on projects and priorities included in the French National Low-Carbon Strategy (SNBC, 2017) and the Multiannual Energy Program (PPE, 2016). Both of these documents outline how the government intends to reach its objective of reducing GHG emissions, and have begun to identify the order of magnitude of investments necessary to achieve these objectives.

Climate policy trends in France

This section provides an overview of the last decade of French climate policy.

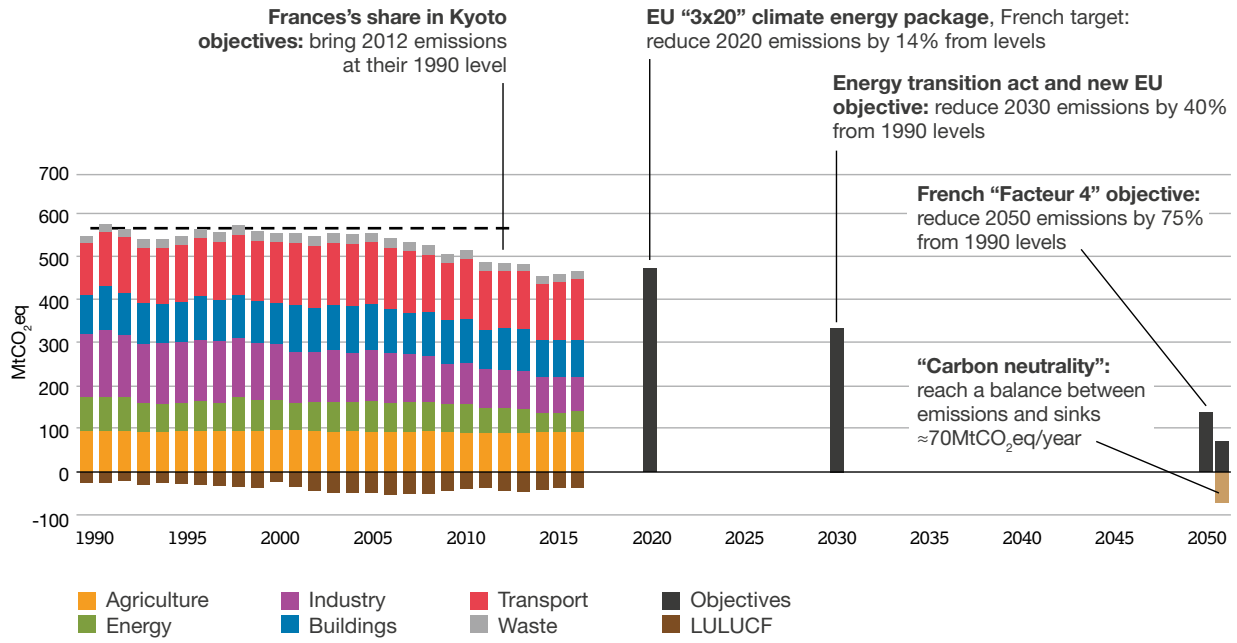
Since 2005, France has committed to reducing its greenhouse gas emissions (GHG) through the approval of multiple policy frameworks and objectives. The "Factor 4" objective of dividing GHG emissions by four between 1990 and 2050. This objective was adopted in the Law for the Orientation of Energy Policy (POPE law, 2005). This policy was reinforced by two consultative debate processes: the Grenelle Environmental Initiative (*Grenelle de l'environnement*, 2007) and the National Debate on the Energy Transition (*Débat national sur la transition énergétique,* DNTE, see Carbone 4, 2014). These initiatives have led to legislative advances particularly in the Grenelle laws I and II (2009 and 2010 respectively) as well as in the Energy transition and green growth act (LTECV, 2015).

In the context of the LTECV, the National Low Carbon Strategy (*Stratégie nationale bas-carbone*, SNBC) sets out the sector-based strategies necessary to reduce GHG emissions based on "carbon budgets". These carbon budgets specify sectoral mitigation objectives over time. Adopted in October 2016, the Multi-year Programming of Energy *(Programmation pluriannuelle de l'énergie, PPE)* extends the SNBC's principal objectives and organizes them into concrete actions in regulating energy consumption and production sectors that are the principal emitters of greenhouse gases in France.

GHG emissions in France are down since 2005, but with contrasting sectoral trends

Greenhouse gas emissions (GHG) in France totalled 463 million tonnes of CO_2 equivalent ($MtCO_2eq$) in 2016. Land use, land use change and forestry (LULUCF), which in France acts as a "carbon sink", reduced emissions by 36 $MtCO_2eq$ (CITEPA, 2017). The annual emissions per capita were 7.1 tonnes CO_2 equivalent (tCO_2eq), below the European average of 8.7 tCO_2eq/per capita (Eurostat, 2018) Among developed countries, France shows one of the lowest per capita emission levels (OECD, 2011).

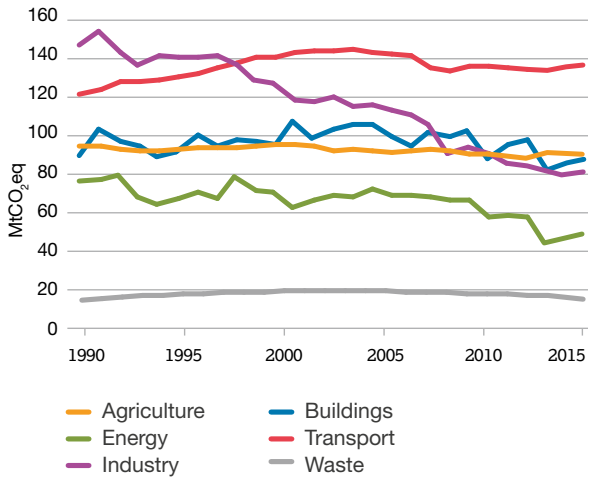
EVOLUTION OF GHG EMISSIONS IN FRANCE FROM 1990 TO 2016 AND REDUCTION TARGETS



Source: CITEPA

GHG emissions in France were stable between 1990 and 2005, and declined from 2005 to 2016. This overall reduction masks the more contrasting sector-based trends. While emissions from agriculture, the residential and tertiary sector and the energy industry are stable overall, industrial emissions have fallen by 45% since 1990, while emissions in the transport sector have increased by 12%.

EVOLUTION OF SECTOR-BASED EMISSIONS IN FRANCE FROM 1990 TO 2014



Source: CITEPA

The particularity of French GHG emissions is the low contribution from energy industries, particularly electricity generation. In 2016, 72% of French electricity came from nuclear, and another 19% from renewable sources, mainly hydroelectric (RTE, 2016b). Both of these sources emit low levels of GHG.

France's climate and energy objectives

An objective of stabilizing emissions in line with international negotiations

Following the signature of the Kyoto protocol under the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, the European Union committed to reduce its GHG emissions by 8% over the 2008-2012 period, compared with the emission levels in 1990. This reduction effort is shared between the 15 EU Member States. Due to its low per capita emission rates, France's short-term objective was to stabilize its emissions at 1990 levels over the 2008-2012 period as stated by Appendix II of the Effort sharing decision (Decision 2002/358/EC0). In 2012, GHG emissions (excluding LULUCF) in France were 18% lower than their level in 1990 (CITEPA, 2017).

The 'Factor 4' objective until 2050: a domestic commitment by France

France enshrined the "fight against climate change" as a national priority in the 2005 "POPE" law, committing to the long-term objective of dividing its GHG emissions by four

before 2050, compared with 1990 levels. Up to 2017, the "Factor 4" objective was deemed consistent with limiting global warming to +2°C as endorsed by the parties to the UNFCCC on the basis of the results of reports from the Intergovernmental Panel on Climate Change (IPCC).

Implications of the European 2020 climate and energy package at the French level

The European Council of March 2007 adopted the "3x20" objectives for 2020 compared with 1990: 20% reduction in GHG emissions; 20% improvement in energy efficiency; and 20% of renewable energies in gross final consumption of energy. The Energy & Climate Package adopted by the European parliament in December 2008 allocated these objectives among Member States in line with specific criteria.

In terms of energy efficiency (Directive 2012/27/EU), France has committed to reduce the volume of annual sales of energy by at least 1.5% per year, compared with the three most recent years.

The effort to reduce EU GHG emissions by 20% is spread between, on one side, emissions covered by the European GHG emission trading system (EU ETS), and, on the other side, emissions from the remaining non-ETS sectors.

- For emissions covered by the EU ETS, the objective of a 21% reduction from 2005 to 2020 concerns all Member Countries, without distinction.
- For emissions outside of EU ETS, the Effort Sharing Decision (ESD, decision 406/2009/EC) takes account of the per capita GDP, resulting in a commitment of -14% in GHG emissions for France between 2005 and 2020.
- Lastly, in connection with its initial situation and potential for integration of renewable energies, France is specifically committing to reach a 23% share of renewable energies in the gross final consumption of energy (Directive 2009/28/EC).

New European Energy/Climate Framework

In 2014, the Member States of the European Union adopted a new strategic framework for energy and climate. This framework plans for an emission reduction of at least 40% in 2030 compared with 1990 levels. The energy efficiency improvement objective has been raised to 27% compared with 1990 and the objective for the share of renewable energies to 27% of gross final consumption of energy in 2030 (European Council, 2014). These objectives, binding at European level, are not yet translated at Member State level.

In November 2016, the European Commission established the governance framework for the Energy Union, which requires Member States to develop integrated national energy and climate plans covering a 10 year period (European Commission, 2016). Member States must align their energy and climate related provisions, especially national action plans developed in application of the directive on energy efficiency (2012/27/EU) and on the development of renewable energies (2009/28/EC).

The Energy Transition and Green Growth Act (LTECV)

In France, the LTECV, enacted on 17 August 2015, established or reinforced national objectives in terms of energy transition:

- To reduce GHG emissions by 40% between 1990 and 2030 and by 75% between 1990 and 2050.
- To reduce final energy consumption by 50% between 2012 and 2050.
- To reduce primary energy consumption of fossil fuels by 30% between 2012 and 2030.
- To bring the share of renewable energies in gross final consumption of energy to 23% by 2020, and to 32% by 2030
- To limit the nuclear share in the production of electricity to 50% by 2025.

Sector-based orientations

In the building sector, the law sets the objective of 500,000 energy renovations per year starting in 2017, with half among low-income households. Local governments can set up financial contributions for exemplary buildings and participate in third party finance companies. A network of regional platforms for energy renovation is to be set up to inform private individuals.

The law encourages clean transport facilities, by asking local authorities to expand car sharing, install recharging infrastructure for electric vehicles, and include low- or no-emission vehicles when renewing vehicle fleets. Public procurement contracts on the transport of goods may give advantage, in the event of equivalent tenders, to low-emission solutions. For air quality, urban transport plans and local inter-municipal town planning programs must be compatible with the atmospheric protection plan.

The law replaced the existing feed-in tariff by a system of "feed-in premiums" for renewable electricity generation. The legislation also moved to facilitate investment in the production of renewable energies by authorizing the use of crowdfunding, the participation of local authorities in the equity of a renewable energy project company, and by extending the possibilities of production and sale by the local governments. The law also simplified procedures with a single environmental permit, facilitates the development of onshore wind projects and optimizes

the operation of hydroelectric energy. Local authorities were given responsibility for managing public heating or cooling network and must include energy networks in local town planning programs.

The National Low-Carbon Strategy (SNBC)

Article 173 of the French LTECV mandates the development of a National Low-Carbon Strategy *(Stratégie nationale bas-carbone, SNBC)*. This strategy has the objective of linking the numerous French objectives in terms of reducing GHG emissions and defines sectoral "carbon budgets" over 5 year period, with a first periods of 4 years from 2015 to 2018.

The elaboration of the SNBC involves the Ministry for Ecology, other ministries, as well as agencies such as the French national environment and energy management agency (*Agence de l'environnement et de la maîtrise de l'énergie*, ADEME). It was coordinated by the French Environmental Ministry's Directorate General for Energy and Climate (*Direction générale de l'énergie et du climat*, DGEC), with consultation of an information and steering committee bringing together company representatives, unions, environmental associations, consumer representatives and elected officials taking part in the National Ecological Transition Council (*Conseil national de la transition* écologique, CNTE).

Article 173 of the French LTECV also requires institutional investors to include in their annual report an estimate of their contribution to the international objective of limiting global warming, in respect of indicative targets defined in line with the National Low-Carbon Strategy[1].

France's 2017 Climate action plan sets carbon neutrality as the new long-term objective

In 2017, France introduced a new Climate Action Plan with the aim of reaching carbon neutrality by 2050 (MTES, 2017b). To attain carbon neutrality, France has to cut its GHG emissions and increase its carbon sinks until they reach an equilibrium[2]. Preliminary work conducted to prepare the revision of the SNBC and the PPE shows that carbon sinks in France could reach around 70 $MtCO_2eq$ per year by 2050, comprising 60 $MtCO_2eq$ from the forestry sector and around 10 $MtCO_2eq$ of industrial carbon capture and storage (CCS). Bringing emissions to the level of 70 $MtCO_2eq$ to match the capacity of the carbon sink would require reductions beyond the current "Factor 4" target, which corresponds to emissions around 140 $MtCO_2$/year. Such reductions could only be achieved by removing all carbon emissions related to energy, since agricultural and industrial processes would still emit at least 60 $MtCO_2eq$ per year in 2050 (MTES, 2018a). Besides carbon neutrality, the 2017 Climate Action Plan has also announced an ambitious retrofitting plan for buildings and called for the phase-out of carbon emitting vehicles by 2040.

Considerable investment needs: several tens of billions of euros

In parallel with the legislative advances, many studies have been carried out to estimate the investment and finance needs for the energy and climate-related transition in France. During the DNTE, four pathways emerged from the twelve scenarios proposed initially. Economic calculations for these four pathways estimated that annual investments required in the energy system from now until 2050 ranged between **€50 and 70 billion per year**, against an estimated volume of €37 billion that were invested in 2012 (CNTE, 2013).

- The forward-looking scenarios on energy, climate and air quality, going up to 2020-2030 and serving as reference for construction of the SNBC, were updated in 2015 and require **additional investments of between 1.9 and 2.6% of GDP** from 2017 to 2021 (CIO, 2015).
- The SNBC's macroeconomic assessment published in November 2016 confirms the order of magnitude of this estimate for needed investment over the first five to ten years of the transition (CGDD, 2016f).

It is important to note that given differences in perimeter and scope, these amounts are not immediately comparable with the results of the I4CE's Landscape of Climate Finance in France presented in this report. Choices of scope and methodology to calculate climate investment have a strong influence on the final results, especially concerning new building construction, transport infrastructures or the modernization of electricity networks. The chapter "Analysis and discussion" in this report devotes a section to this comparison p.92. Furthermore, these volumes of investment, while considerable, should be considered relative to the annual volume of investments in the French economy of around €400 billion per year (INSEE, 2015a).

A recurring focus: the mobilisation of private finance

With regard to the estimated volume of investment needed, public money will not be able on its own to support funding. The mobilization of private sector investment appears thus crucial to achieve climate

1 On this topic, I4CE is publishing three short analysis notes in the "Climate Review" format: *Why should financial actors align their portfolios with a 2°C pathway to manage transition risks?*, *How should financial players deal with climate-related issues arising in their portfolios?*, and *What analyses of climate-related issues can financial players carry out as of today?* See I4CE, 2017e, 2017a and 2017f.

2 For an introductory analysis of the meaning and effect of carbon neutrality on the Paris Agreement objectives, see Perrier 2017.

objectives. However, a combination of public and private finance appears often to be necessary to achieve the level of effort necessary.

Indeed, the needed low carbon investments are often concentrated in sectors dominated by the ownership of private entities: households for housing accommodation, businesses for industrial and energy production facilities. However, the blending or use of public resources to foster private finance is often needed to provide additional capital or incentivize the redirection of private financial flows. In other instances, public actors may raise debt from private actors to finance investments. In other words, there are several ways to structure public and private finance flows to support transition investments.

To ensure that public resources are used at the point where they will generate the best leverage effect, it is therefore important to make a detailed analysis of the finance channels mobilized for each type of investment.

A TOOL TO UNDERSTAND CLIMATE FINANCE AND INVESTMENT

PART 2

Methodology for domestic climate finance tracking

I4CE's methodology tracks domestic climate investment, i.e. annual spending in domestic gross fixed capital formation (GFCF) that enables mitigation of greenhouse gas emissions or adaptation to climate change. It then examines how different types of project developers interact with the financial value chain and financial instruments, to finance these investments.

I4CE's domestic climate finance tracking methodology evolved from previous work on climate finance

I4CE's initial domestic climate finance tracking methodology (or "domestic Landscape methodology") was developed in 2012-2013 based on the approach developed by the Climate Policy Initiative to assess global finance flows dedicated to renewable energy and climate-related international aid from development finance institutions (CPI, 2012; CPI, 2013; CPI, 2015b; CPI, 2017b). I4CE also learned how to assess climate finance for a domestic context through research conducted in 2012 in Germany (CPI, 2012). Finally, I4CE has drawn on international discussions held under the OECD Research Collaborative[3] which are increasingly focused on understanding the interactions between public and private international and domestic climate finance flows (McNicoll and Jachnik, 2017).

I4CE's biggest innovation lies in the introduction of project developers within the financial value chain. This is the result of structured dialogue with key project stakeholders[4] in France to produce a methodology tailored to assist policymaking focused on the French SNBC as well as sectoral-focused plans and programs. Nevertheless, the methodology developed by I4CE and presented below is a flexible analytical framework adaptable to a range of national and sub-national contexts.

From international to domestic financial flows

The "100 billion" commitment formed the initial scope of climate finance tracking

The topic of climate finance tracking started at the international level with the commitment taken by developed countries to raise a hundred billion dollars per year for climate actions in developing countries. In this context, several initiatives were undertaken to monitor international climate finance flows between countries such as the Global Landscape of Climate Finance from CPI, as well as the work by the Overseas Development Institute and the Research Collaborative of the OECD (CPI, 2015b, ODI, 2012; OECD, 2015b). Some of these works seek to make a distinction between:

- financial flows specific to climate that are additional to existing development assistance - and therefore recognised purely as flows for climate,
- financial flows relating to climate but are non-additional to development finance and thus represent the broader "greening" of official development assistance.

The Paris Agreement calls for climate finance to be tracked at the domestic level

Work from New Climate Economy has estimated the scale of needed capital redirections and investment to reach international climate objectives worldwide - measured in trillions of dollars over the next 15 years. The scale of the investment challenges thus far exceeds the expected efforts of official development assistance – particularly given that a large amount of investments must occur within developed and emerging economies (New Climate Economy, 2014). Other global projections, such as the ones provided by the IEA, have stressed the need for a complete redirection of domestic investment flows towards energy efficiency and renewables in order to achieve climate targets.

These concerns have been inscribed in the Paris Agreement as a stand-alone objective concerning financial flows. Article 2 of the Agreement calls for "**making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development**". Under this scope, all financial flows, whether international or domestic, are to be considered.

Scope of study

Tracking climate investment

Climate investment combines spending on material and immaterial assets that are part of gross fixed capital formation as well as some durable goods. For its application in France, the identification of climate assets is based on criteria derived from the French government's

3 The Research Collaborative is an open network, co-ordinated and hosted by the OECD, of governments, research institutions and international finance institutions. The goal is to partner and share best available data, expertise and information to advance policy-relevant research in a comprehensive and timely manner. More information is available at https://www.oecd.org/env/researchcollaborative/

4 Including the French Energy Management Agency (ADEME) and the Energy and Climate Division of the Ministry for the Ecological and Solidary Transition (MTES, DGEC).

National Low-Carbon Strategy that are applied to broad project categories. In some specific cases, climate investment is limited to a share of the total project's costs. Climate investment spans across five economic sectors and five low-carbon areas.

Climate investment combines part of the gross fixed capital formation and some durable goods

I4CE's domestic Landscape methodology assesses spending in gross fixed capital formation (GFCF). This includes spending on material assets, such as buildings, transport, network, energy generation or energy consumption infrastructure and equipment. Aside from GFCF, the study also documented spending in some durable goods acquired by households, such as road vehicles.

The 2016 edition of the French Landscape study provided a separate account of spending on research and development, a class of immaterial assets within GFCF. While other forms of intangible capital expenditures, for example on education, training and citizen awareness raising, can contribute to the reduction of GHG emissions, they are not accounted for in the domestic Landscape methodology.

It should be noted that I4CE's domestic methodology does not include the acquisition of financial assets as part of total of climate investment. Instead, the acquisition of financial assets (such as green bonds, equity shares) is considered under finance flows supporting climate investment.

Climate investment consists of projects outlined in the National Low-Carbon Strategy and other national reports on domestic climate action

In the absence of a globally accepted definition of what constitutes climate investment, the French Landscape studies adopt a transparent method in the choice and aggregation of the areas of investment covered. It is nonetheless based on existing standards[5], for example those for green bonds, and on the approaches used elsewhere in Europe and around the world (CBI, 2017; HLEG, 2018; MEDDE, 2015b).

The French Landscape studies adopt the French National Low-carbon Strategy (SNBC) as its principal reference document. Investments contributing to the implementation of the strategy, notably those that could contribute to the reduction of GHG emissions constitute the scope of the study. Another secondary source of guidance was found in the survey of domestic energy efficiency and renewable energy markets conducted annually by the ADEME. Both documents list project categories for which there is a strong agreement that they contribute to GHG reduction in five low-carbon areas:

- Energy efficiency, which corresponds to the investments aiming to reduce the quantity of energy necessary for supplying a service, such as heating or motorisation, or to modify the form of fuel used to provide this service. This includes thermal insulation of buildings, improvement of industrial processes and electrification of the stock of privately owned vehicles.
- The production and consumption of renewable energies, whether electrical or thermal, centralized (large-scale) or decentralized (small-scale or off-grid).
- The construction or maintenance of sustainable infrastructures, in particular network infrastructures (transport, electricity or heating networks) which enable the deployment of vehicles or production capacities with low emissions.
- The development and prolongation of energy components in existing nuclear plants.
- Investments aiming to reduce non energy-related GHG emissions. These investments may concern the increase of carbon sinks, particularly in the agriculture and forestry sector. They may also concern the decrease in greenhouse gas emissions such as N_2O or CFC/HFC in industry.

The domestic Landscape methodology's scope includes (a) project categories; (b) projects above certain performance threshold; or (c) projects benefitting from third-party labels that are estimated to have a positive climate impact in a majority of cases.

Certain areas of investment are currently too difficult to document and include in Landscape

Certain areas of investment that would fit within the Landscape methodology's scope could not be documented and were thus left out of the final results.

- Investment expenditures may correspond to the scope of the Landscape, but are difficult to measure and aggregate based on publicly available data. For example, the investments aimed at reducing GHG emissions other than energy combustion related CO_2 are not well documented. As a result, the majority of investments covered by the Landscape mostly concern the consumption and production of energy.
- Certain expenditures aiming to reduce GHG emissions in France are not considered as investments by the definition of national accounting outlined above. For

5 A detailed comparison between climate action definitions in this study and other references such as the Climate Bond Standard, the proposed EU taxonomy of the High-level expert group on climate finance or the French "TEEC" label is available as an online annex to this report.

example, expenditures on citizen-focused information campaigns to raise awareness and encourage energy savings, or operating expenditures to support individual projects by public or private operators are not included.

- The Landscape of climate finance in France has not covered expenditures related to climate change adaptation. In fact, there is no definition or list of project categories that might be applicable to the national context, and data on the resilience and suitability of infrastructures and facilities is patchy.

Taking into consideration these limitations, I4CE seeks each year to improve the domestic Landscape methodology and extend coverage to better capture the investments and the financial flows contributing to the transition towards a low-carbon economy in France.

In most cases, climate investment consists of the total overnight costs of projects

For a majority of projects, the domestic Landscape methodology considers the total overnight capital costs. These costs typically include the preliminary studies necessary for the project's setup, equipment costs and labour costs of installing the infrastructure or equipment. Operation and maintenance costs are typically not included in overnight capital costs[6].

In the case of new energy-efficient buildings, climate investment is defined as the difference between the project's total cost and the average cost of a baseline equivalent (for instance, a building under an energy standard before 2005).

Climate investment is disaggregated by individual economic sectors

The sectors correspond to the main economic activity of the project developers making the investment:

- Residential and tertiary sector buildings, i.e. all buildings except for industrial and agricultural buildings. In the Landscape, investments may concern new building or the renovation of existing buildings.
- Transport, irrespective of mode, for the transportation of both passengers and goods.
- Agriculture, defined as item 'A' in the French classification of economic activities (NAF) from the INSEE: agriculture, forestry and fishing.
- Industry, defined as items 'B' (extractive industries) and 'C' (manufacturing industries) in the French classification of economic activities (NAF) from the INSEE.
- Centralised energy production and networks. This last sector includes large-scale energy production capacities (not only power plants, but also district heating networks) as well as transmission and distribution networks (electricity and heat).

Tracking climate finance flows

The study focuses on resources secured to cover overnight capital costs at the time of expenditure on new projects, as opposed to project revenues generated during a given project's entire lifetime. For example, additional renewable power generation capacity is typically funded initially through a mix of equity and debt raised by the project developer. This debt and equity stakes are remunerated afterwards from revenues from the sale of electricity at a set price (feed-in tariff) or at the market price with a premium.

The domestic Landscape methodology only tracks the initial capital raised by the project developer, and does not estimate future revenues. Indeed, future revenues and their sources could only be estimated based on forecasting market prices; however, the Landscape study only considers current transfers. Furthermore, the cost of capital, such as the interest repaid by the project developer, may vary between projects and sectors and may evolve over time and is not captured in the flows tracked in the Landscape.

Nevertheless, this report details how a project developers' expectations of revenue (or, in the case of households, increased utility) and of the cost of capital are both essential to understanding the underlying drivers of investment. This could be a topic for future or parallel work.

Data collection

Climate investment expenditures and finance flows are documented using data gathered directly from existing reports and studies, or estimated based on informed hypotheses. The example of how this was done in France can serve to assist potential data sources in other contexts.

When possible, the Landscape methodology disaggregates investments by the number of projects or equipment and prices per unit. The volume of a given action is described in the units specific to each sector or purpose, such as the number of buildings

6 It should be noted that in the case of very large infrastructures such as power generation and transport networks, major maintenance work that leads to significant rejuvenation or upgrade of existing equipment is considered under capital formation in national accounts and thus falls within the scope of the domestic Landscape methodology.

OVERVIEW OF CLIMATE INVESTMENT AND CLIMATE FINANCE FLOWS INCLUDED IN THE DOMESTIC LANDSCAPE METHODOLOGY

	Tracked		Not tracked		
	Included in main total	Included in separate total (in some editions)	Excluded from totals due to insufficient data	Excluded from totals but considered in qualitative analysis	Excluded from scope
Climate investment					
Investment expenditure in material capital and certain durable goods					
• that reduce GHG emissions during the investment's lifespan	▲				
• improve resilience and adaptation to climate change			▲		
Investment expenditure in immaterial capital:					
• Research and development		▲			
• Awareness-raising					▲
• Public planning					▲
Operational expenditure					▲
Climate finance					
Financial resources covering investment expenditures	▲				
Finance flows contributing to a project's profitability over its lifetime				▲	

constructed, square meters of buildings retrofitted, megawatt of installed capacity, number of vehicles sold, etc. This distinction between volumes and price makes it possible to put in perspective upward or downward trends of investment expenditures in relation to capital formation.

Measuring climate investment

The domestic Landscape methodology tracks climate investment in each sector based on existing literature such as technical studies tracking the state of infrastructure stock (buildings, transport networks).

For the French Landscape studies, the following principal sources contributed to data collection:

- National accounts of the building sector (*Comptes du logement*, CGDD, 2012b, 2013b, 2014b, 2016b);
- National accounts of the transport sector (*Comptes du transport*, CGDD, 2012a, 2013 a, 2014a, 2015a, 2017h);
- National public budgets, including an annex providing projections for fiscal spending (PLF, 2010 to 2016), as well as cross-policy documents detailing government funding for climate action (Document de politique transversale Climat, see DPT Climat, 2014 to 2017);
- Annual studies conducted by the ADEME, including a survey of retrofitting works engaged by private household owners (ADEME, 2016g), as well as an annual market review for energy efficiency and renewable energy equipment (ADEME, 2014a, 2016f and 2017i);
- Studies conducted by the National Statistical Institute (INSEE), including two surveys dedicated to investment in the industry sector (INSEE, 2016a and 2016b);
- Annual reports of the Energy Regulation Commission (CRE) on regulated electricity tariffs (for instance, see CRE, 2014a, 2014b, 2015);
- Annual statistical report of the Union of Social Housing Companies (USH, 2013 to 2016a).

Data sources may include information on the number of projects implemented, the individual costs of different types of projects. Alternatively, data may be available as aggregated amounts spent on climate investment. It is thus sometimes necessary to compare and combine information from several sources.

Measuring climate finance flows

The domestic Landscape methodology measures finance flows supporting climate investment through two complementary approaches, which are described below.

Aggregating finance flows from specific instruments and programs

This approach was mostly used for finance flows from public sources, as contributions to climate investment projects could generally be isolated from budget reports or other documents. For example, the authors identified public subsidy payments or concessional loan programs designed to support low-carbon projects in the residential and transport sectors.

Whenever possible, the methodology distinguishes between support provided by central government, national agencies and local governments. Typical indicators recorded were the number of projects receiving support, the average subsidy or loan value per project, and the total amount disbursed. For loan programs, authors preferentially collected the amount of new loans issued annually, rather than on the evolution of outstanding loans. For large projects, such as in transport infrastructure, the public contribution was documented separately for each project.

The principal sources for this approach were the annual annexes to the French Budget law (PLF, 2011 to 2017a), annual reports of national public agencies (such as ADEME and the National housing agency or Agence nationale de l'habitat, ANAH), financial reports of public banks (such as BPI France, Caisse des Dépôts), as well as on the audits conducted by the French Court of Auditors on various topics in relation with energy, environment and climate (Cour des Comptes, 2016b). For projects receiving support from European funds, authors relied on budgetary execution reports of the European regional development fund (ERDF).

Estimated share of financial instruments in total investment

Limited data was publicly available in France concerning commercial loans or equity committed to climate investment. Commercial banks generally do not provide a breakdown of new loans to households and companies with the level of detail necessary to identify the specific projects eligible for inclusion in a domestic Landscape study. Similarly, individual or institutional investors generally do not report on their contribution to new projects in a detailed format.

In some cases, the share of these instruments in project costs was reported in existing sector-focused studies. For example, the share of household expenditures on thermal retrofitting that is financed through bank loans was reported in the ADEME's 'OPEN' study (ADEME, 2016g).

In other cases, a representative share of the investment could be attributed either to public budgets or to commercial financial instruments by relying on cofinancing data at the scale of the subsidy or loan program. For example, reporting on projects financed by the ERDF provides the average share of public and private cofinance at the level of thematic priorities such as energy efficiency.

Finally, in cases where project developers were private companies and no specific financial instrument was identified as having been used to cover investment expenditures, the attribution to private equity, commercial banking debt and bonds was based on the average composition of liabilities in balance sheets by French companies as reported by the Banque de France (Banque de France, 2017).

Using company-wide or sector-wide financing data to explain climate investment may hide the more specific financing structure of climate equipment. However, authors observed that many companies, especially large corporations, chose their funding instruments based on their overall investment program rather than through project-level arrangements.

Measuring sources of finance for financial intermediaries

In the domestic Landscape methodology, financial intermediaries provide funds for project developers, but at the same time rely on their own sources to gather those funds. For example, a public agency may derive its budget from government grants, while banks balance new loans with liabilities such as deposits or bonds.

Most often, the sources of finance for financial intermediaries in France were documented based on the available institutional or sectoral communication:

- The central government finances its interventions through taxes and public debt. The proportion of these two sources is estimated based on the national budget balance, described in the budget law (PLF, 2011 to 2017a) as well as the national accounts (INSEE, 2015b).
- Local governments finance their interventions with a combination of transfers from central government, local taxes, bank loans and bonds. The proportion between these instruments is principally estimated using the annual report on local authority accounts published by the Ministry of Interior (DGCL, 2014).
- Banking sector liabilities: in the domestic Landscape methodology, loans emitted by banks are covered with a combination of resources: deposits made by households and borrowing on financial markets (including the interbank lending market). These two flows are presented in simplified form, drawing from

the main components of the banking sector liabilities in France (ACPR, 2013).

- Company balance sheet financing: when private company spending is financed directly by the company's balance sheet, or when it was not possible to estimate project finance instruments, the Landscape assesses a combination of equity, bank debt and bond debt based on the proportion of these instruments in the total liabilities of French companies (Villeroy De Galhau, 2015, Banque de France, 2017).

Ensuring the consistency of data collected

One of the main challenges in applying the domestic Landscape methodology is to establish a quantitative consistency between sources that do not report investment in the same way as finance flows.

Delays between commitment and expenditure

Actual expenditure may take place several years after an investment decision is made. For example in the housing construction sector, the planning permission issuance date defines the energy performance regulation that the building will need to comply with, although the construction itself (and therefore the disbursement of funds) will take place several months or even years afterwards.

The domestic Landscape methodology tries, whenever possible, to attribute all project expenditures and financial flows to the year when the project commitment is made. This method cancels the delays of project realisation. In the case of the construction sector, project commitment happens when the planning permission is delivered.

However, in the case of high-value projects (typically more than €1 billion) and lengthy realisation timetables (more than 3 years), such as in the case of transport infrastructures or large-scale power plants, reported or estimated annual expenditures are broken down for each year of the construction phase of the projects.

Translating between commitments and annual expenditures

Gaps in amounts reported appear when financial intermediaries report their activities as the volume of loans signed or through statements of commitment, rather than providing the details on disbursements or payments. For example, the European Investment Bank (EIB) provides an online project database listing by year the amounts of loan commitments (signatures); however, the actual disbursement of funds may be spread over several years.

Two methods were applied to match commitments with annual disbursements:

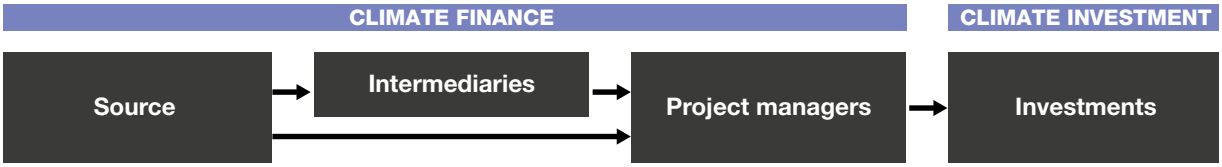
- When the amounts in terms of commitments are equal to or higher than the total amount of annual investments in the projects, the methodology divides the funds over the estimated time period, taking into consideration the nature of the project, typically between 2 and 5 years.
- When loan signatures take place in sectors with a large number of projects and where the annual variations of amounts in terms of disbursements and finance actions are limited, the methodology considers that time differences are cancelled out by the number of transactions and incorporate the entire commitment volume at the year of signature.

Because of these corrections, it is not always possible to match amounts described in the final Landscape reports with the institutional communication from financial institutions. While it is important to communicate transparently as two why this occurs, the domestic Landscape methodology's priority is to provide a relevant report on the orders of magnitude of the participation of the different financial actors by sector. As such, in some instances, commitments made today for future investment expenditures may be excluded from the Landscape totals.

Analytical framework

Climate investment and finance flows covered in the domestic Landscape methodology are arranged into a unified "financial value chain".

ANALYTICAL FRAMEWORK OF THE LANDSCAPE OF DOMESTIC CLIMATE FINANCE USED BY I4CE



FINANCIAL VALUE CHAIN LINKING CLIMATE INVESTMENT WITH SUPPORTING FINANCE FLOWS

Supporting finance flows			Climate investment
Sources	**Intermediaries**	**Project developers**	**Sectors**
• European budgets • Public tax revenue • Financial markets (holding equity + debt) • Bank deposits • Revenue and savings of households	• Central government • Agencies • Local governments • Public financial institutions • Commercial banks • Companies (balance sheet) • Companies (revenues and expenses)	• Central government • Local governments • Infrastructure management companies • Social housing companies • Private companies • Households	• Buildings • Transport • Industry • Agriculture • Centralized energy production & networks
Instruments			
• Grants, subsidies, transfers • Concessional debt • Commercial debt	• Equity • Balance-sheet financing (equity + debt)		

In the domestic Landscape methodology, the volume of funds provided by supporting finance flows is equal to the total climate investment for each project developer category.

Definition and role of project developers

Project developers are defined as the household, the public institution or the private entity that makes the investment and which is usually the owner of the capital generated in this manner. The concept of project developers allows the linking together of investment expenditure with the support provided by several categories of instruments: subsidies, grants, commercial or low-interest loans, private equity, etc.

The concept of project developer was introduced in the 2015 edition of the French Landscape and has been maintained in the subsequent editions. When initially introduced, the ability to account for the role of project developers in the relation between climate investment and climate finance flows set the domestic Landscape methodology apart from existing approaches.

In respect to the analysis carried out in the domestic Landscape methodology, each type of project developer is classified as either public or private. At times however, it is difficult to define whether actors are purely private or public given different investment and ownership models. The authors have considered that when the activity has taken place in a highly regulated sector, like social housing, the management of transport infrastructures or the connection of renewable energies to the electricity networks, project developers belong to the public sphere, even when they take the form of private companies.

PROJECT DEVELOPERS IN THE LANDSCAPE

Type of project developer	Description
Government	The central government as project developer, i.e. investing in its own building stock or acquiring vehicles.
Local and regional authorities	Local and regional authorities investing in their own building stock or acquiring vehicles. This category also includes transport organizing authorities (*autorités organisatrices de transports*, AOT), that are dependent on the local authorities and may be public-private non-profit bodies or public-private companies. Public-private companies are characterized by a majority ownership by public institutions. Given differences in structure and operation, the Landscape distinguishes between the transport authority of the French Île-de-France region (*Île de France Mobilités*, formerly STIF) from all other regional and local transport authorities.
Infrastructure operators	This category groups together public institutions and companies classified under French law as state-owned industrial and commercial establishments (*établissement public à caractère industriel et commercial*, EPIC) that invest in sectors that are highly regulated and principally financed by public funds. In the transport sector, this includes SNCF Réseau (formerly RFF), RATP and *voies navigables de France (voies navigables de France*, VNF). In the energy production and networks sector, this includes the network companies Enedis (formerly ERDF) and the French transmission system operator *(réseau de transport d'électricité*, RTE).
Public housing authorities	This category groups together companies managing social housing units, i.e. mainly public housing offices, social housing organisations, public-private companies and housing units managed by non-profit associations (respectively abbreviated as OPH, ESH and SEM/EPL). Private landlords offering housing units under conditions of means-testing (tax exemptions, conventions with the ANAH) should in principle be included in this category. In practice, their spending is likely to be grouped with private landlords, due to insufficient detailed in data gathered on the residential sector. It should be noted that the Landscape considers public housing authorities to be part of the public sphere, due to the strong regulation and use of public funds in this area.
Businesses	As project developers, businesses are mainly non-financial corporations making investments in sectors such as commercial buildings, industry, agriculture, and energy production. It should be noted that businesses may be project companies such as special purpose vehicles (SPV) or companies whose main activity is not related to climate. Financial corporations (banks, insurance companies) are not included in this category, except for investments made in their own building stock. Taking the available data into account, the Landscape does not make it possible to measure the exact proportion of capital held by public authorities in private businesses.
Households	Households, standing as project developers, i.e. primarily in new construction or the renovation of existing housing units and in the acquisition of vehicles. Households are considered as project developers even when construction work is carried out by private companies, like real estate development companies (construction) or building firms (construction and renovation).

Note: certain categories listed above also appear as financial intermediaries.

Financial intermediaries channel finance to project developers

Intermediaries are the entities that channel finance from sources to project developers. They thus have incoming flows (revenues or liabilities) and outgoing flows (funds provided to project developers through various instruments). Certain financial instruments do not involve the use of an intermediary. For example, households commit their own funds in the retrofitting of their house or to buy low-carbon vehicles, using their revenues or savings.

Cases were observed where funding also came in the form of revenue committed to investments. For example, social housing authorities are authorized to raise rents to fund new construction or retrofitting of their building stock. Alternatively, the rail infrastructure company SNCF Réseau receives an annual subsidy from the central government contributing to the use of revenues to fund its investments. When providing financial resources to other intermediaries and project developers, companies may pass the cost of taxation and other schemes on to their consumers, thus creating and extra revenue allocated to fund their support towards low-carbon projects.

FINANCIAL INTERMEDIARIES IN THE LANDSCAPE

Category	Description
Government	The government, as financer of project developers or other intermediaries such as agencies and local authorities. Tax expenditures are included in this category.
Public agencies	Public agencies, generally specialising in a specific topic or sector. The main agencies represented are the ADEME, ANAH, and the national urban renewal agency (*Agence nationale de la rénovation urbaine*, ANRU). Public agencies are financed by the mobilisation of public funding (allocations, budgets) or the use of fiscal resources, for example the general tax on polluting activities (*Taxe générale sur les activités polluantes*, TGAP) for ADEME until 2017. The ANAH benefits from the revenues generated by the auctioning of European emission trading system (EU ETS).
Local and regional authorities	This category groups together French local authorities ranging from the municipal to the regional level. Local authorities can finance project developers and mobilise resources made up of public funding, directly allocated public taxation, and also borrowing from banks and financial markets. In the context of European financial flows such as the European regional development fund (ERDF), local authorities are displayed as intermediaries to the extent that they define and coordinate the distribution of finance packages at a project level.
Government-owned financial institutions	Government-owned financial institutions active in France are Caisse des Dépôts (CDC), BPI France and the European Investment Bank (EIB). These institutions are characterised by public management of funds of public or private origin, and by an intervention motivated general interest objectives or complementarity to the competitive marketplace. Government-owned financial institutions are the principal issuers of concessional debt. Within the Caisse des Dépôts, equity investment can be distinguished from lending activities issued on the savings fund, the latter being derived from the centralisation of the regulated savings accounts of private individuals, including the *Livret A*, the *Livret développement durable* (LDD) and the *Livret d'épargne populaire* (LEP).
Commercial banks	This category groups together credit institutions, in particular commercial banks, as opposed to the government-owned financial institutions mentioned above. Commercial banks issue conventional loans or distribute concessional loans in the context of agreements with the government or government-owned financial institutions. The financial flows may involve the retail or branch bank or the finance of businesses or projects.

Sources of climate finance

Sources designate the origin of finance flows that intermediaries and project developers mobilize in order to realize their investments. They generally represent the point where tracking of finance flows dedicated to climate becomes indistinguishable from the general financing structure of the economy. For example, the liabilities of commercial banks are represented as flowing from their client's deposits as well as from financial markets, based on the analysis and reporting provided by the prudential and resolution supervisory authority (ACPR, 2014). Similarly, central and local government's funds that were not tied to specific resource streams are attributed to the general budget's breakdown between revenue from taxes and from borrowing.

SOURCES OF CLIMATE FINANCE IN THE LANDSCAPE

Category	Description
European budget	Grants and subsidies paid from European structural funds, in particular the European regional development fund (ERDF) and the European agricultural fund for rural development (EAFRD).
Public taxation	Tax revenues of the central government and local authorities.
Equity of public financial institutions	Equity capital of the Caisse des Dépôts, for example in renewable energy projects.
Financial markets	Source of finance for the bond debt or bank refinancing. Financial flows can either go directly to project developers (public and private) or through intermediaries (local authorities in particular).
Business assets and revenues	The assets of businesses correspond to investments made on equity capital, in building stock or production facilities. They also correspond to the capital increases necessary to finance the investments of the businesses, whether as project finance or balance sheet financing. A share of business revenues is collected and oriented towards the investment by the appropriate tax system, such as for example the transport levy (*versement transports*, VT) towards the local authorities or the general tax on polluting activities (TGAP) towards ADEME.
Household savings and revenues	The earnings and savings of households may be directly invested in new construction or the renovation of housing units or placed with government-owned and private banks. A proportion of the earnings of households may also be mobilised by means of payments towards project developers, in particular public ones: purchase of public transport fares, share of rents allocated to the investment in social housing units, etc.

The mobilisation of financial instruments

Financial instruments are grouped into four categories according to the nature of the commitments that link capital and the financed parties, with debt finance being divided between commercial and concessional products (see **table**). Since 2016, I4CE's tracking of financial instruments differ from other climate finance tracking methodologies (see CPI, 2017b) in that it takes into account the financial instruments linking intermediaries and projects. I4CE's domestic Landscape methodology tracks all instruments used by institutions in the financial value chain. This allows more conceptual flexibility in the representation of flows between intermediaries or between intermediaries and sources. For example, the refinancing of commercial banks and corporations through bonds (some of which green) is much easier to track and represent.

An additional category of instruments concerns risk management associated with a project. This category differs from the previous ones due to the fact that it does not provide funds directly to the implementation of projects, but intervenes as risk coverage for loans issued or to counteract certain operational risks associated with project implementation. The role of such instruments is generally to scale up public or private funding by reducing the risk exposure of certain parties. Some instruments of this type are outlined in the sector-based chapters of this report. Their quantification and inclusion in total financial flows raises a number of methodological difficulties: is it necessary to take into account the funds theoretically allocated to their operation, or their interventions, often one-off, to hedge the risks that may materialise? Whatever the option, the documentation of these instruments is often incomplete and has not permitted more detailed processing.

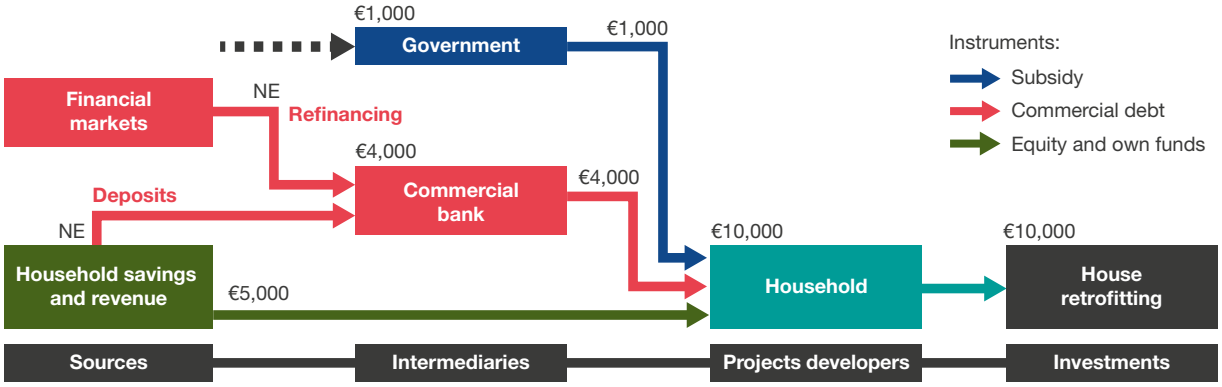
Examples of application of the analytical framework

The examples shown below illustrate the way in which the analytical framework of the Landscape has been applies to different examples of the flows transiting the financial value chain: one dominated by private finance (energy renovation of housing) and the other by public finance (finance of transport infrastructures). The order of magnitude of the figures is intended for illustrative purposes.

CATEGORIES OF FINANCIAL INSTRUMENTS IN THE LANDSCAPE

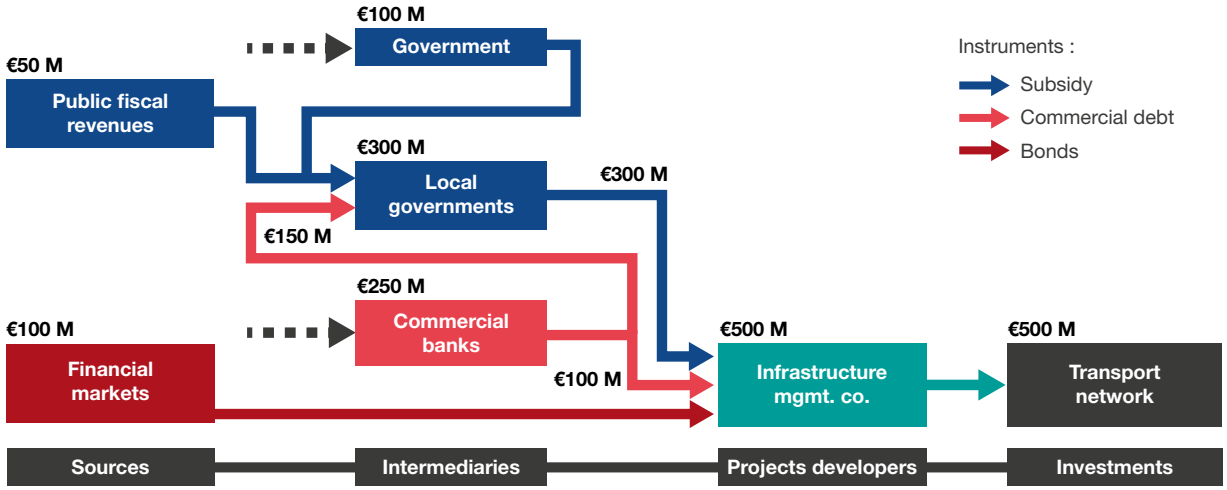
Category	Description
Grants, subsidies and payments	Funds paid to project developers without financial compensation. The grants and subsidies include tax credits when they are calculated on the basis of the investment expenditure. It also includes instruments through which private sources and intermediaries finance project developers in the context of a public mechanism. For example, White certificates (Certificat d'économie d'énergies, CEE) mandate private energy providers to finance or support energy efficiency measures. For project developers, the value of these certificates represent an extra subsidy to their projects.
Concessional debt	Lending instruments designed to give an advantageous rate, duration, payment facility or guarantee compared with standard market terms. The level of this advantage in relation to the market may vary from one instrument to another, or over time depending on the current circumstances of the commercial market. The concessional character of debt depends on the design of the instrument and the current circumstances or the nature of the issuer, generally a government-owned financial institution. In France, zero interest loans (PTZ+ and éco-PTZ) are examples of concessional debt instruments.
Commercial debt	Commercial debt includes loans, borrowing and bonds issued at market rates. Conditions (rate, duration, guarantees) may vary from one instrument to another and according to the nature of the project developer. In the French Landscape, commercial debt derives on one hand from the banking sector and on the other hand from the financial market (referred to as bond debt)
Own funds, equity, self-finance	For businesses, equity finance represents the portion of investment expenditures financed by increasing the corporate capital or by reinvesting annual operating surpluses. For households, own funds represent revenues or savings used to fund an investment without any intermediate.
Balance sheet finance	Balance sheet finance takes place when a business finances an investment through net profits and not by using a project's direct revenues. Balance sheet finance contrasts with project finance, where it is the project's revenues that are used to reimburse the finance raised initially. Balance sheet mobilises a combination of equity and debt, balanced in terms of the business's overall balance sheet.

ANALYTICAL FRAMEWORK APPLIED TO THE FINANCING OF A HOUSEHOLD ENERGY EFFICIENCY PROJECT



In this example, a household conducts energy renovation actions on its property for €10k. To finance the renovations, it benefits from a tax credit of €1k, paid by the Government. It takes out a loan with a commercial bank for €4k and finances the balance of €5k using its earnings and savings. Upstream in the financial value chain, the bank's loan is financed by the deposits from other households and by refinancing on capital markets.

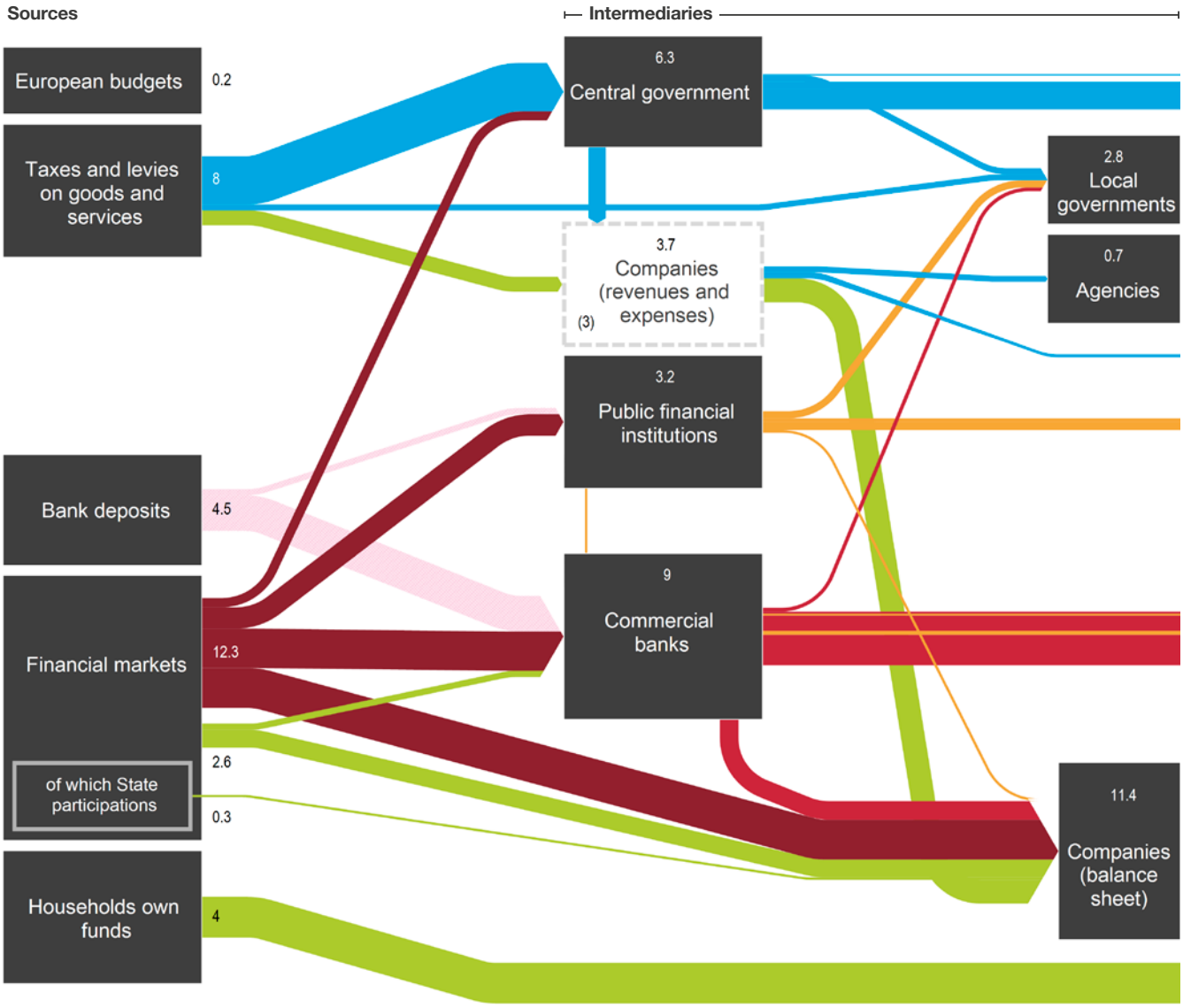
ANALYTICAL FRAMEWORK APPLIED TO THE FINANCING OF PUBLIC INVESTMENTS IN TRANSPORT INFRASTRUCTURES



In this example, a state enterprise – for example, SNCF Réseau (French rail network company, formerly RFF) – expands railway infrastructures by €500 million. For this, SNCF Réseau receives €300 million in subsidies from various local authorities, and borrows €200 million: half from banks and the other half from the financial markets (bonds). Local authority budgets are made up in part from earmarked public taxation, government subsidies and allocations, and finally from borrowing, mainly from private commercial banks.

RESULTS

Climate investment reached €31.7 billion in 2016 in France



THE LANDSCAPE OF DOMESTIC CLIMATE FINANCE IN FRANCE IN 2016

The Landscape of Climate Finance maps investment in tangible (physical) assets securing reduction of GHG emissions in France. This includes construction and equipment acquisition costs and some durable goods as used in national accounts (e.g. vehicles). This excludes the costs of, preparatory studies, operating costs, administrative costs and public procurement costs. Debt represented on the flowchart includes loans and bonds issued by or to project developers, but does not include the reimbursement of previously borrowed funds.

Acronyms:

NE = not estimated

<.1 = amounts of less than €100 million. To maintain clarity, these amounts are not represented graphically but are still included in the total of each box.

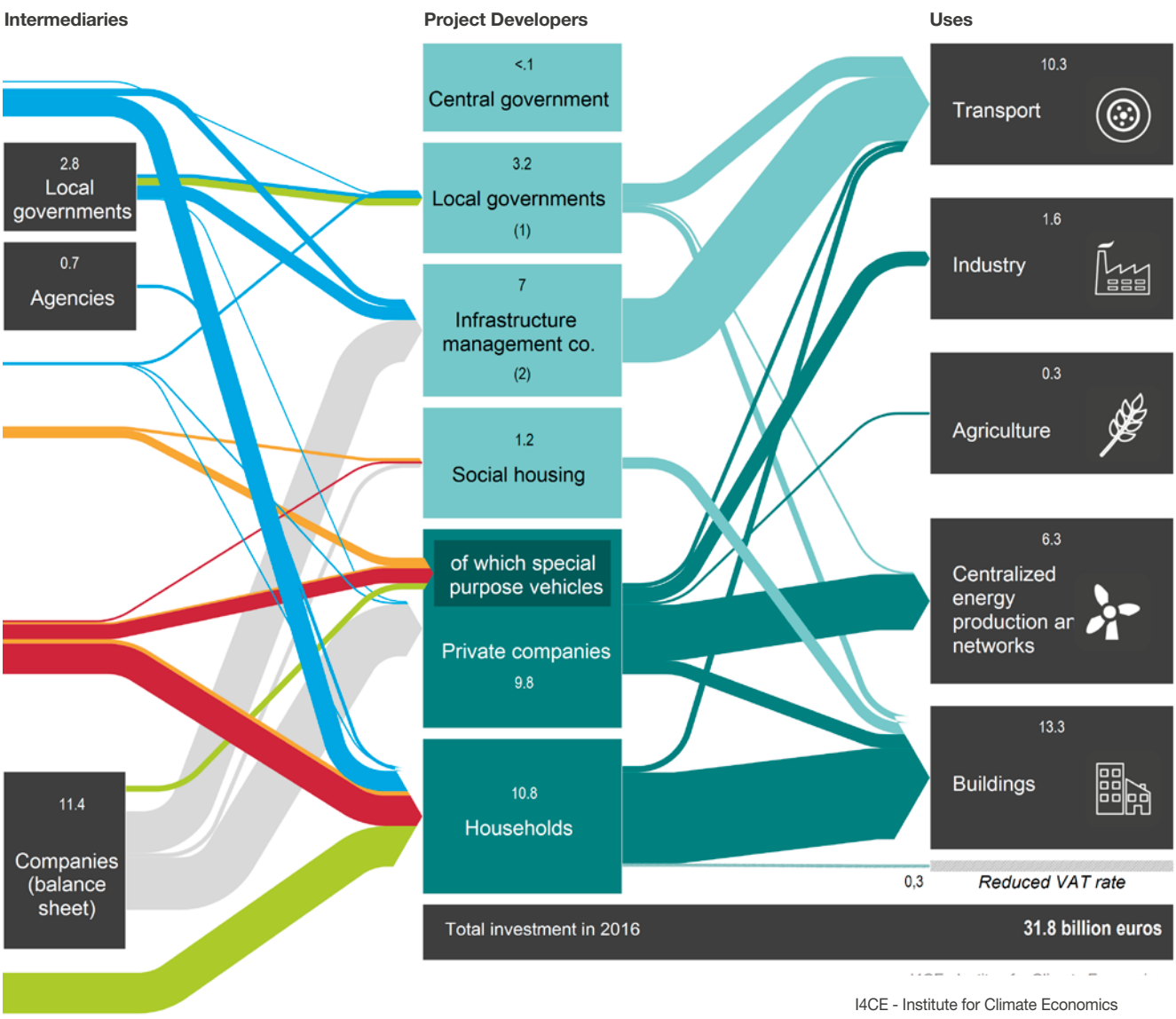
(1) As project developers, i.e. investing in their own buildings or durable goods. Local governments include public transport authorities ("autorités organisatrices des transports", or AOT).

(2) Public operators include SNCF Réseau (know up to 2014 as RFF), Voies Navigables de France (VNF) and RATP for investment in public transport infrastructure in the Ile de France region.

(3) Consumption of goods and services on which levies are raised. Proceeds from these levies are dedicated to the financing of low-carbon investment. This includes the transport levy ("versement transport"), carbon auction revenues and the value of white certificates (CEE).

The main sources of climate finance are:

- Public fiscal revenues, European budgets, and use and service charges mainly directed to the national and local governments;
- Financial markets, providing capital in the form of debt or equity to public and private intermediaries or directly to project promoters;
- Self-financing of projects by households.



I4CE - Institute for Climate Economics
Landscape of Climate Finance in France, December 2017

Financing instruments

4,5	Household deposits	2,7	Concessional debt		Balance-sheet financing	11,4	Publics investments
7,2	Grants, subsidies and transfers	7,9	Commercial debt	4,2	Bonds	20,3	Private investments
10,1	Equity, own funds						

To finance their investments, project developers employ four main types of instruments:

- Grants, subsidies and transfers, that include no financial obligation for the beneficiary;
- Concessional debt, in the form of loans with better interest rate, maturity or guarantees than market-rate debt;
- Commercial debt, loans issued by private banks at market conditions;
- Equity, in the form of the project developer's own funds and resources, generally mobilized without an intermediary.

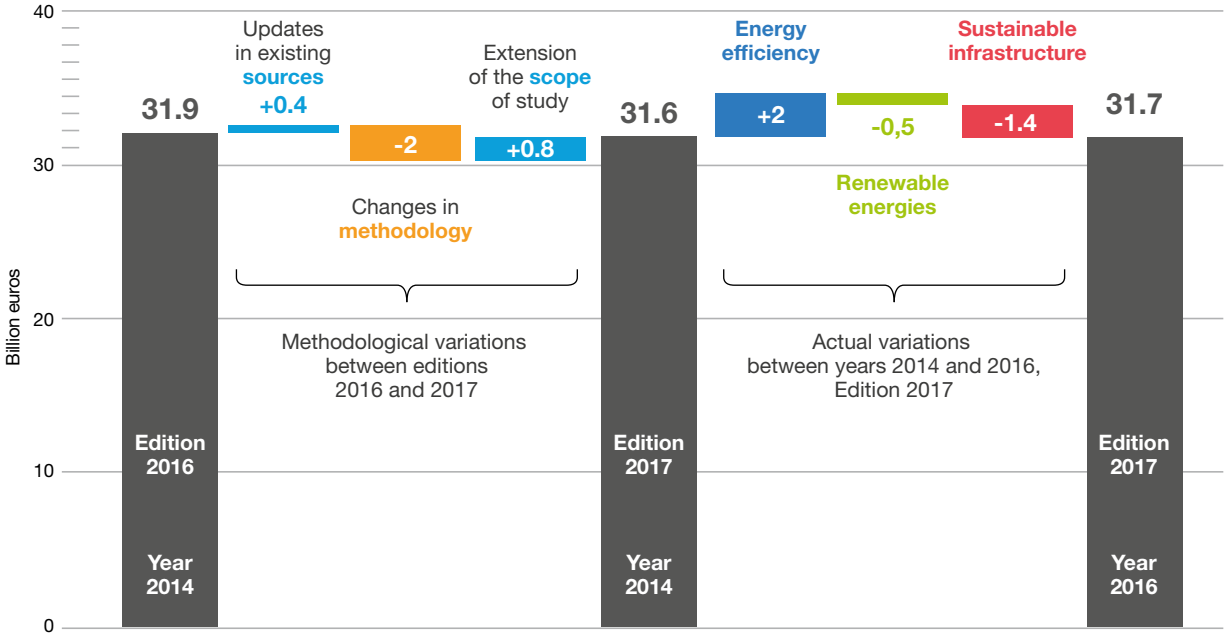
For companies (public or private), debt and equity are often raised at the corporate balance sheet level, while special purpose vehicles use principally non-recourse financing.

Public and private project developers are typically the owners of the assets generated by the investment. Their investments are made in several sectors; each sector can include actions in one or more uses related to climate change mitigation and the energy transition, such as energy efficiency, development of renewable energies or the building of sustainable infrastructure.

The Landscape of Climate Finance only aggregates spending and funds engaged at the time of the investment (capital expenditure). Some financial instruments contributing to a project's financial profitability during its lifetime, such as carbon pricing systems or feed-in tariffs for renewable energy, are not represented on the flowchart.

Variations in results from 2016 edition

Each edition of the Landscape improves and revises the methodology used for both the new years being covered all previous years since 2011. Results presented in each edition are thus updated to take into account revisions of sources, of methodology or variations in scope.



The 2016 edition of the Landscape estimated that climate-related expenditures totalled €31.9 billion for the year 2014 in France. This 2017 edition makes the following principal revisions:

- Investments for the retrofitting of private flats (multi-unit housing) were revised to exclude works that did not reach the "optimum" level in the scale defined by the ADEME for the OPEN questionnaire (see p.48 for more information).
- Investments in the retrofitting of social housing units were revised to exclude the cost of works that did not relate to energy efficiency (see p.49 for more information).
- Investments in the retrofitting of tertiary buildings were revised to include new projects that were not accounted for by the previous series provided by the low-consumption buildings (BBC) Observatory.
- Investments in the transport sector were revised to take into account new series on low-carbon vehicles (such as heavy-duty NG vehicles) and cycling equipment.

These modifications resulted in very little change in the total amounts under consideration, the new total for year 2014 being €31.6 billion.

Overall results

Up to €31.7 billion of investments contributed to climate mitigation in France. From this total, €14.6 billion were invested in energy efficiency projects, €5.9 billion in the development of renewable energy production, and €9.2 billion for sustainable transport and network infrastructures. Investment in new and existing nuclear plants and GHG reduction in sectors other than energy consumption (such as agriculture, forestry and industrial processes) totaled an estimated €2.1 billion.

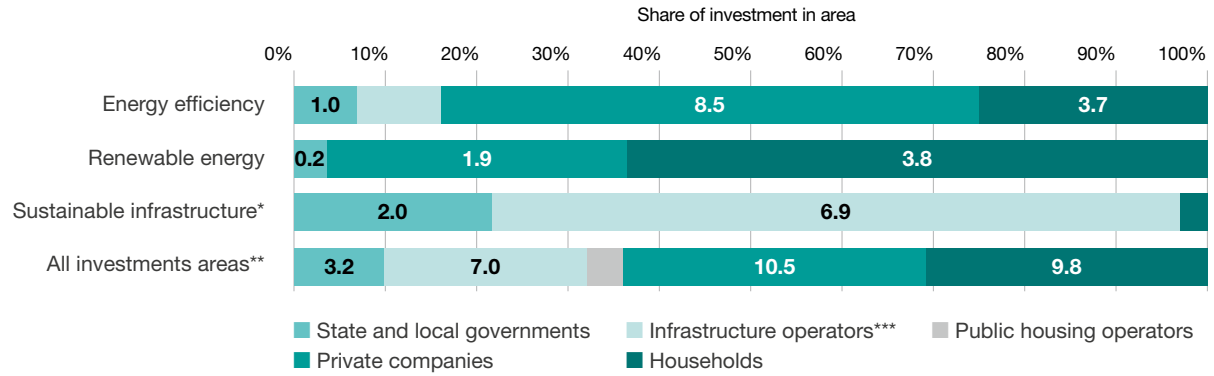
Unless indicated otherwise, the figures shown in this chapter refer to the year 2016. The results for the year 2017 should be understood as provisional (p), as not all final data sources were available at the time of updating the results in the Landscape. Estimates for year 2017 were made based on preliminary data for the first semester of the year, or on the pursuit of trends observed across 2015 and 2016.

Project developers

Households and private companies conducted 64% of climate investment

In 2016, households and private companies made 64% of climate investment. This relative share increases to 88% if only investments in energy efficiency and in renewable energy are taken into consideration. Conversely, in the area of sustainable transport and network infrastructures, climate investments are for the most part conducted by public bodies and infrastructure operators - totalling up to 91%. This predominance of the public sphere in the area of infrastructures is not specific to climate-related investments alone; rather it reflects the traditionally important role of public authorities in supporting and realising long-term collective investments in France (CGDD, 2017h).

BREAKDOWN OF INVESTMENTS BY PROJECT DEVELOPER IN LINE WITH AREAS OF INVESTMENT, IN 2016



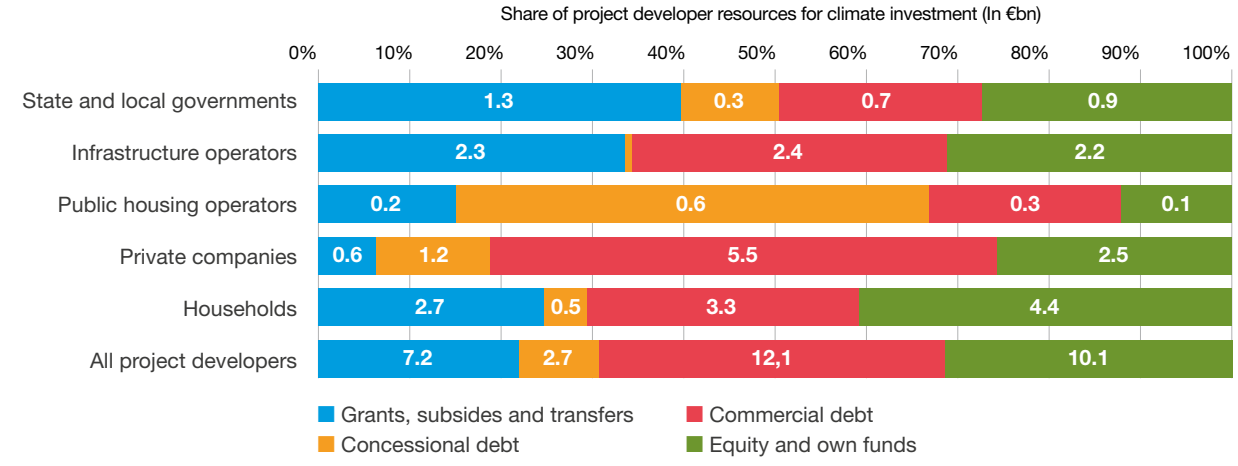
** Sustainable infrastructure include railway infrastructure, urban public transport, waterways and maritime ports, as well as the connection of renewable electricity generation sources to the electrical grid.*
*** The five climate investment areas of the Landscape are energy efficiency, renewable energy, sustainable infrastructures, nuclear power and emissions outside of the use of energy.*
**** Infrastructure operators include RATP, SNCF Réseau and VNF. Local governments include transport authorities (AOTs).*

Instruments

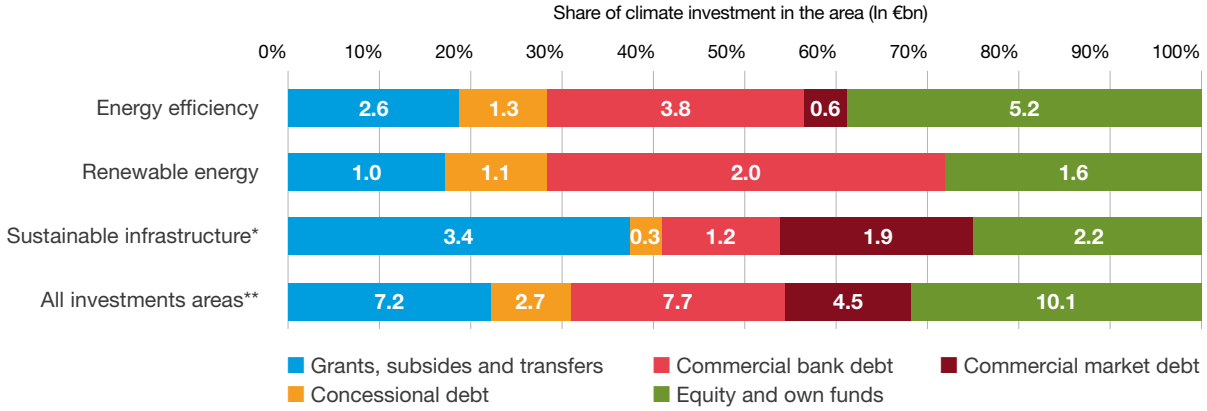
Use of financial instruments varies by type of project developers

The breakdown of the use of financial instruments highlights an apparent preference of each type of project developer for different methods of financing.

BREAKDOWN OF CLIMATE FINANCE FLOWS BY TYPE OF INSTRUMENT AND BY PROJECT DEVELOPER, IN FRANCE, IN 2016



BREAKDOWN OF CLIMATE FINANCE FLOWS BY TYPE OF INSTRUMENT AND BY AREA OF CLIMATE INVESTMENT, IN FRANCE IN 2016



** Sustainable infrastructures include railway infrastructure, urban public transport, waterways and maritime ports, as well as the connection of renewable electricity generation sources to the electrical grid.*

*** The five climate investment areas of the Landscape are energy efficiency, renewable energy, sustainable infrastructures, nuclear power and non-energy processes.*

- **Government, local governments and infrastructure operators** mainly financed investment expenditures through subsidies, generally paid by other public institutions. For example, local and regional authorities paid subsidies to SNCF Réseau for the development of railway infrastructures.
- **Public housing authorities** mainly used concessional debt, issued by the Caisse des Dépôts, to finance improved energy efficiency of new constructions and renovations.
- **Private companies** mobilised debt, either through banks or bonds, to finance their investment expenditures in terms of energy efficiency or renewable energies.
- **Households** mainly used their own savings to auto-finance their projects, in particular in the segment for energy renovation of housing. Commercial debt also played an important role. The use of concessional debt by households was limited, in particular compared to social housing operators and considering both project developers made most of their climate investment in the residential sector.

Contrasting financial models across climate investment areas

Use of financial instruments also varied between the three main areas of low-carbon investment: energy efficiency, renewable energy, sustainable infrastructure.

The financing of energy efficiency was primarily supported by a combination of equity and debt. The high proportion of equity and own funds (41% in 2016) can be explained by the predominant share of energy efficiency actions occurring in the building sector. The building sector itself concentrated 78% of energy efficiency-related finance and 52% of equity and own funds across all climate finance. Grants, subsidies and transfers represent another 20% of finance flows for energy efficiency. Concessional debt primarily benefited social housing operators.

In the area of renewable energies, commercial debt played a predominant part in the financing of investments (35% in 2016). Electrical renewable energy projects in centralised production (wind, PV on the ground, hydroelectric) were typically financed up to 80% using commercial debt contracted by special purpose vehicles. In this case, the guarantee of a steady purchase tariff over a long period of time made it possible to secure a high level of debt on the balance sheets of medium and large sized projects (CRE, 2014b).

Sustainable infrastructures, in particular urban transport and railway infrastructures, was financed on a very different model, with a high proportion of grants, subsidies and payments covering up to 48% of total investments in 2016. Due to their capital intensity and the long periods of depreciation for these infrastructures, the financial models of this type of project is rarely viable in France without significant involvement from the public sector.

Amounts provided as subsidies rose from 2011 to 2016

Based on the panel of data assembled for each year between 2011 and 2016, it is possible to examine variations across years in the use of financial instruments.

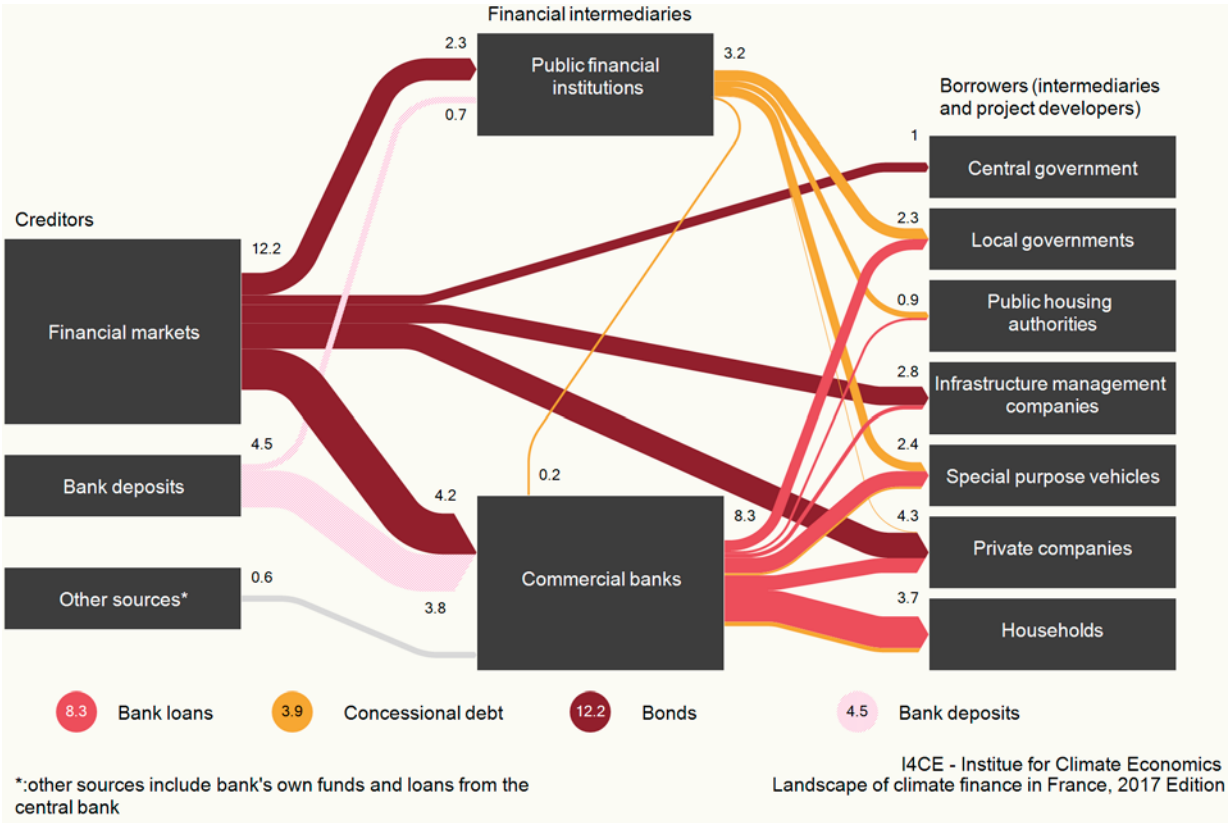
From 2011 to 2016, grants, subsidies and payments showed the greatest increase, not only in absolute value (€7.2 billion in 2016, versus €6.1 billion in 2011) but also in relative share.

EVOLUTION OF CLIMATE FINANCE FLOWS BY TYPE OF INSTRUMENT (2011-2016)

(in billions of euros)	2011	2012	2013	2014	2015	2016
Grants, subsidies and payments	6.1	5.5	6.3	6.7	7.3	7.2
Concessional debt	2.9	3.3	2.9	3.0	2.7	2.7
Commercial debt	11.2	11.5	12.1	11.6	11.3	12.1
Equity and own funds	9.5	9.6	11.0	10.7	10.3	10.1
Total	**29.6**	**29.9**	**32.2**	**32.0**	**31.6**	**32.1**

Concessional and commercial debt

DEBT FLOWS IN SUPPORT OF CLIMATE INVESTMENT IN FRANCE IN 2016 (In billion euros)



Commercial debt was the most common instrument used to finance investment expenditures, with €11.3 billion issued to project developers in 2016, i.e. 38% of total climate finance. Commercial debt was split between bank debt and bond debt. The proportion of bonds in commercial debt has increased from 27% in 2011 to 37% in 2016. This change may reflect a broader tendency towards the disintermediation of the financial market in France (ACPR, 2013; Villeroy De Galhau, 2015; Banque de France, 2017).

The role of debt does not concern only project developers, but also the financing of intermediaries. Regional and local governments for example used bank loans to cover part of their investment expenditures. In addition, public finance institutions such as the EIB financed or refinanced their loans to project developers through borrowing or bond issuance on financial markets.

Equity and own funds

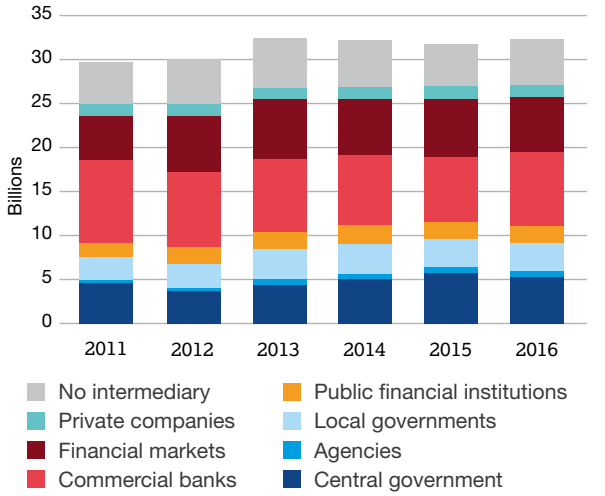
Equity and own funds provided €10 billion of climate finance in 2016.

Equity was used predominantly in the building sector (€5.2 billion) and the transport sector (€2.7 billion). In the building sector, it is mostly used by households and represents the first source of finance for private dwelling retrofitting projects. In the transport sector, the use of equity corresponds to the financing needs of large infrastructure management companies, such as SNCF Réseau and RATP. Their equity comes from public sources, in the form of direct subsidies from central or local governments.

Intermediaries

In the **figure**, we consider which intermediaries provided climate finance to project developers, including, in the case of companies, the composition of their balance-sheet supporting their investment. The remaining share of finance with no intermediary corresponds to funds mobilized by households from their own revenues or savings. In 2016, public administrations (central government, agencies and local governments) represented 28% of climate finance provided to project developers. Their role has increased since 2011, when they represented 25% of the total spent. Financial institutions, such as national public banks, the EIB, and financial markets, provided 52% of all climate finance. However, financial markets tended to provide funds for large corporations' balance sheet, while bank loans were used by small companies and individual projects. The study found no significant climate finance delivered through "project bonds". The remaining share of climate finance was provided by private companies, often in the form of a developer's equity participation in renewable projects and by households, in which case there was no intermediary between the project manager and the source of funds.

EVOLUTION OF CLIMATE FINANCE PROVIDED BY INTERMEDIARY IN FRANCE, 2011 TO 2016



RESULTS > SECTORS

Buildings

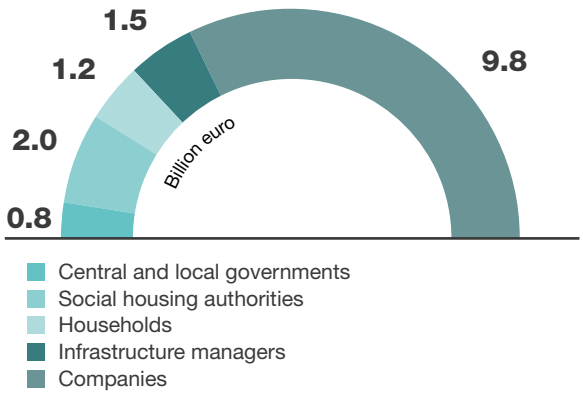
In 2016, climate investments in the building sector reached €13.3 billion, at their highest since 2011. Investment was focused principally on energy efficiency (€11.4 billion) and then renewable energy (€2.3 billion). Households were the main project developers. They financed their investment mostly via their own funds, bank debt, and public subsidies. The portion of publicly-driven finance in the sector's investment reached 40% in 2016; it has been on the rise since 2012.

€13.1 billion
In 2011

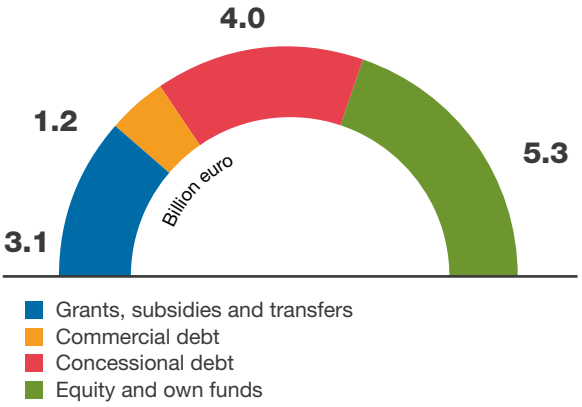
€13.3 billion invested in 2016

13.6 billion
In 2017 (projections)

WHO MAKES THE INVESTMENTS?



HOW WERE THEY FINANCED?



WHAT WAS THE ROLE OF THE PUBLIC SECTOR IN MOBILIZING FINANCE?

In 2016: 40% of the sector's finance was driven...

(In billion euros, see p.92 for more detail)

EVOLUTION OF CLIMATE INVESTMENT IN BUILDINGS

(in million current euros)	2011	2012	2013	2014	2015	2016	2017p
New private dwellings	1,341	1,334	1,480	1,267	1,375	1,580	1,839
New social housing	723	755	467	456	402	393	405
New tertiary buildings	442	374	1,633	1,477	1,384	1,357	1,370
Private dwelling retrofitting	7,342	7,256	7,232	7,420	7,681	8,029	8,369
Social housing retrofitting	816	388	720	617	666	837	837
Tertiary building retrofitting	670	857	693	520	979	650	345
Solar PV and biomass in collective housing	1,771	904	849	744	621	485	455
Total	**13,105**	**11,867**	**13,074**	**12,501**	**13,108**	**13,332**	**13,618**

P = provisional figures.

Context

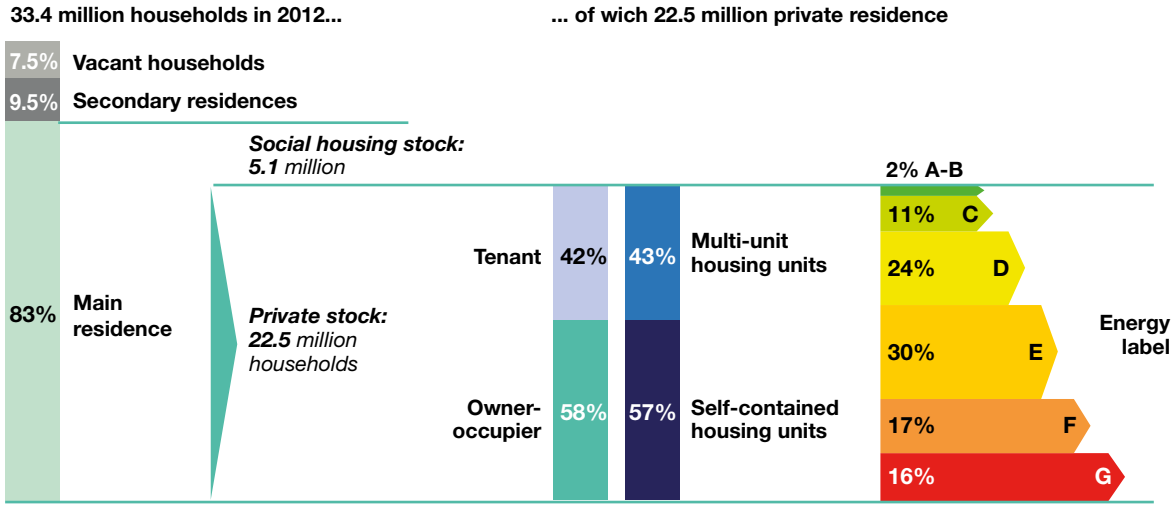
The dwelling stock is old and energy-intensive

In 2016, residential and tertiary buildings represented 43% of final energy consumption in France and 19% of greenhouse gas (GHG) emissions outside of LULUCF (CITEPA, 2017; SDES, 2018). The sector's total GHG emissions increased from 1990 to 2005, and then decreased to again reach their 1990 levels in 2016. Over the same period, the number of housing units increased from 21 to 29 million primary residences (INSEE, 2015c).

Approximately half of the existing buildings were built before 1975, i.e. before the introduction of the first thermal regulations aiming at curbing energy demand. As new construction and demolitions only represent a very small proportion of the existing stock, the majority of GHG emission reductions must come from retrofitting the existing building stock.

When it comes to primary residences, France's housing stock comprises around 16 million houses (self-contained housing units) and 13 million flats (multi-unit housing units, see INSEE, 2017a). In addition to the housing stock, buildings in the tertiary sector represented an estimated 850 million square meters of heated space in 2009 (*Plan Bâtiment Durable*, 2009). Around 40% of tertiary buildings belong to the central and local governments (DPT Immobilier, 2015; AMF, 2010). The energy performance of the building stock is low: as seen in the figure below, less than 13% of primary residences in 2012 belonged to A, B or C categories of the EU energy label.

THE HOUSING STOCK IN FRANCE



Source: Rénovons!, 2017a

The law set ambitious objectives for building retrofitting

Low carbon trajectories elaborated for the National debate on energy transition (*Débat national sur la transition énergétique*, DNTE, see Carbone 4, 2014), the National low-carbon strategy (*Stratégie nationale bas-carbone*, see SNBC, 2016) and the Multi-year programming of the energy sector (*Programmation pluriannuelle de l'énergie*, see PPE, 2016) have identified four priorities to reduce GHG emissions in buildings[2]:

- During the conception phase: orientation and structure of the building must be designed so as to maximise natural energy inputs and reduce the need for cooling in summer, the use of building materials with a low carbon footprint, such as wood, can be considered.
- On the building structure: better insulation of walls, doors, roofs and windows, heat recovery on air and water flows leaving the building, such as with ventilation.
- On heating systems: priority to be given to high efficiency systems (such as condensing boilers), renewable energies (wood stove or boiler, heat pumps, geothermal) and to connection to urban heat distribution networks.
- On the building's occupants behaviour: to avoid wasting energy, for example associated with inadequate heating temperature.

When combined, these actions are estimated to have the potential to reduce energy consumption by 24 to 42% in 2050, compared with 2010 level (Carbone 4, 2014). This would allow a reduction in the sector's CO_2 emissions by 85% from 1990 levels (CAS, 2011).

Beyond concerns at the building level, the reduction of GHG emissions also involves an approach at the district or city level, taking into account the significant interactions between urban structures and transport demand (Saunders et al., 2008).

In 2017, the government announced a plan for the energy retrofitting of buildings (*Plan de rénovation énergétique des bâtiments*, PREB). Building on the 2015 Energy transition for green growth act (*Loi de transition énergétique pour la croissance verte*, LTECV), the plan set the objective of retrofitting 500,000 housing units annually by 2020, of which 120,000 to be social housing units and 380,000 private housing units. Of the latter, 50,000 must target households at risk for energy poverty (ADEME, 2016d).

To put these objectives into operation, public policies seek to facilitate the implementation of energy retrofitting works for a majority of households. They rely on a combination of regulatory, fiscal and financial interventions and the coordination and guidance efforts of project developers.

Climate investment in the construction and retrofitting of buildings is rising

Investments in the energy performance of new buildings reached €3.3 billion in 2016

They are split between €2 billion in residential buildings and €1.3 billion in tertiary buildings. Climate investment in new buildings has been on the rise since 2014.

Two factors contribute to that evolution. Firstly, the adoption of a new thermal regulation in 2013 increased the number of buildings implementing energy efficiency solutions compared with voluntary labels in 2011 and 2012. Secondly, activity in the property business has recovered since 2014, with building permits growing from 353,000 to 429,000 per year up to 2016 (SITADEL, 2015).

Compliance with the thermal regulation (RT 2012) generated an estimated €3.2 billion, while adoption of higher performance levels under voluntary labels represented a much smaller share of climate investment, at an estimated €122 million in 2016.

Investments in the low-carbon retrofitting of existing buildings reached €9.5 billion in 2016

Out of this total, around €8 billion were invested in the retrofitting of private houses and flats, €0.8 billion in social housing units and €0.7 billion in tertiary buildings.

Climate investments in private dwellings were split between €5.2 billion on the building structure and €3.1 billion on the heating, ventilation and regulation systems, including €1.8 billion for systems based on renewable energy: mainly biomass, heat pumps, and thermal solar.

From €7.3 billion in 2011, investment in the retrofitting of private houses and flats reached €8 billion in 2016, and the first results available for 2017 indicate a continuation of the upwards trend for such investments, particularly in the segments of window insulation, condensation boilers and heat pumps (ADEME, 2016f).

Despite a marked increase in overall social housing retrofitting programs, investment in the energy performance of social housing units remained stable over the period 2011-2016, around €0.8 billion annually. Indeed, economies of scale have allowed social housing authorities to retrofit more housing units for the same price (CDC, 2016b).

Investments in the retrofitting of tertiary buildings have been estimated between 600 and €900 million per year between 2011 and 2016. Investments from the central government have been stable at around 50 to €70 million, while local governments contributed between 200 and €300 million per year to the retrofitting of schools, offices and other buildings. Investments in the private sector, mostly in the retrofitting of offices, have been recorded between 300 and €700 million per year, based on the number of applications for the Low energy-consumption building label (*Bâtiment basse consommation*, BBC, see Observatoire BBC, 2017).

Investments in renewable energy production in collective housing and the tertiary sector were estimated at around €500 million in 2016

Out of this total, about €260 million were dedicated to the installation of PV systems on residential and commercial rooftops. This segment of renewable energy deployment has declined since 2011 where it represented an estimated €1.4 billion of investments. This is due in part to the reduction of feed-in tariffs, the switch to competitive tenders for commercial rooftops, as well as to the decline in the prices of PV systems. Most of the remaining investments in renewable energy for collective and commercial sector buildings went to biomass through support from the ADEME's Fonds Chaleur. Because of the lack of information, such projects are not classified as either new construction or retrofitting.

Households and private companies realised 85% of climate investment in buildings in 2016

In 2016, households carried 85% of climate investments in the building sector, about €11.6 billion. The remaining climate investments were made by social housing authorities (€1.2 billion, 9% of total), and central and local governments (€0.8 billion, 6% of total).

The retrofitting of private houses and flats is supported by multiple public financial instruments

The public sector drove[7] around 40% of financial flows supporting investments in the building sector in 2016. Of this public intervention, €3 billion were targeted towards the retrofitting of housing units, in the form of the following public and private mechanisms.

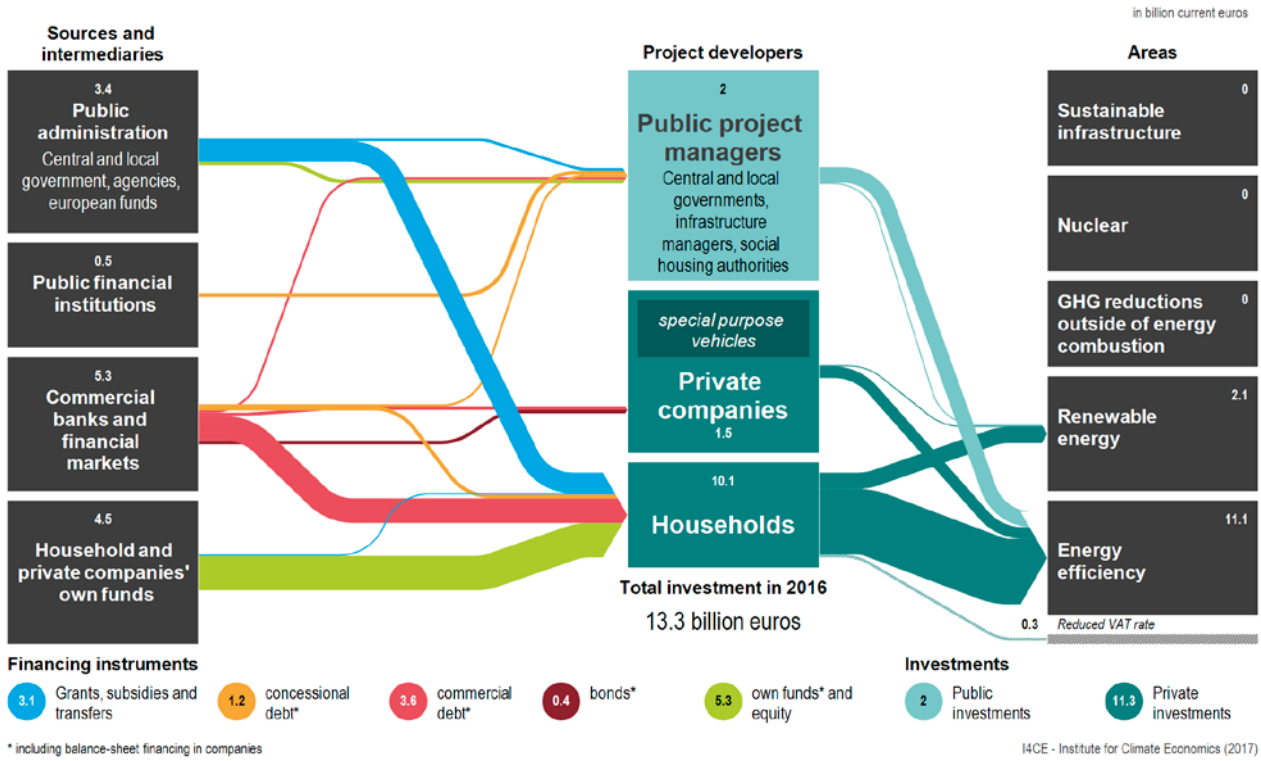
Public instruments represent a growing share of retrofitting finance

- The reduced rate of value-added tax (VAT) for energy efficiency equipment is estimated at €342 million for 2016[8], covering a comparatively small part of retrofitting works. For project developers, a reduced VAT rate represents an avoided expenditure compared with the normal VAT rate. Amounts delivered under this instrument tripled between 2013 and 2014 because of a change in reference VAT rates, and has been increasing ever since.
- The Energy Transition Tax Credit program (*Crédit d'impôt pour la transition énergétique*, CITE), directly granted by the government to households for a range of eligible works, represented €1.67 billion in 2016. Since 2014, the CITE funds the acquisition cost of eligible equipment at a single rate of 30%.

7 The definition of publicly-driven finance, within the meaning of this study, is available on p.92 in the discussion chapter of this report.

8 In the Government's budget, the reduced rate of VAT for energy efficiency utilities corresponds to a fiscal expenditure, calculated by the difference with the prevailing VAT rate. However, in the national accounting system, the investment corresponding to the same equipment is measured in terms of effective VAT, i.e. the reduced rate. Because of this, the fiscal expenditure connected to the reduced rate of VAT is shown in addition to the amounts actually invested, representing the charge that the project holders should have paid if the VAT had been at the prevailing rate instead of the reduced rate.

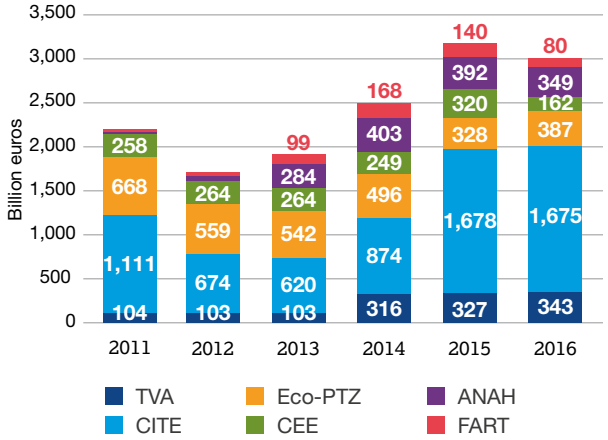
OVERVIEW OF CLIMATE FINANCE IN THE BUILDING SECTOR IN FRANCE, IN 2016



This instrument covers around 70% of total energy retrofitting works realised by households. After a decrease of CITE grants between 2011 and 2013, it has sharply increased since 2014.

- Grants from the French Housing Agency ANAH's "Habiter Mieux" program provided €349 million of grants in 2016, to which the government has added €80 million through the heat retrofitting support fund (*Fonds d'aide à la renovation thermique*, FART). This support program is intended for low-income homeowners in a situation of energy poverty, and therefore targets a niche market. The program initiated an amount of eligible works of €1.26 billion in 2016 (ANAH, 2017) among which it funded 27% of retrofitting works. Since 2011, the ANAH program grew to cover a much larger amount of eligible works, though it has decreased since 2014. Since 2013, the ANAH budget has been funded mostly through revenues resulting from the auctioning of European CO_2 emission quotas. In 2016, the sale of quotas contributed some 73% to ANAH's budget.
- The White Certificates program (*Certificats d'économie d'énergie*, CEE), of which 43% of the value was issued for building retrofitting works in 2016 (DGEC, 2017; Emmy, 2017), represented the equivalent of €162 million in subsidies in support to households in 2016. The average amount of EEC grants covers roughly 7% of the cost of retrofitting (CGEDD et al. 2014). The amount of EEC dedicated to households increased up to 2015, and decreased by half in 2016, in line with drop in value of individual certificates on the exchange market. The obligation to redeem certificates is set by the government to utilities, who pass their cost to final energy consumers through electricity or fuel prices.
- Concessional loans, in particular the zero-interest "eco-loan" (*éco-prêt à taux zéro*, éco-PTZ), where interest is paid by the central government and the principal distributed by commercial banks. In 2016, the issuances of zero rate eco-loans for energy retrofitting totalled €387 million (SGFGAS, 2016). Reimbursements of interest, concerning loans issued during previous years, reached €75 million in 2016 (PLF, 2016). Eco-loans cover a high proportion of project costs (80%) but is mobilized for a small share of total investment, despite the absence of any resource condition. Amounts distributed under the eco-loan program have been declining since 2011.

PUBLIC FINANCE FOR THE RETROFITTING OF PRIVATE RESIDENTIAL UNITS, 2011 TO 2016



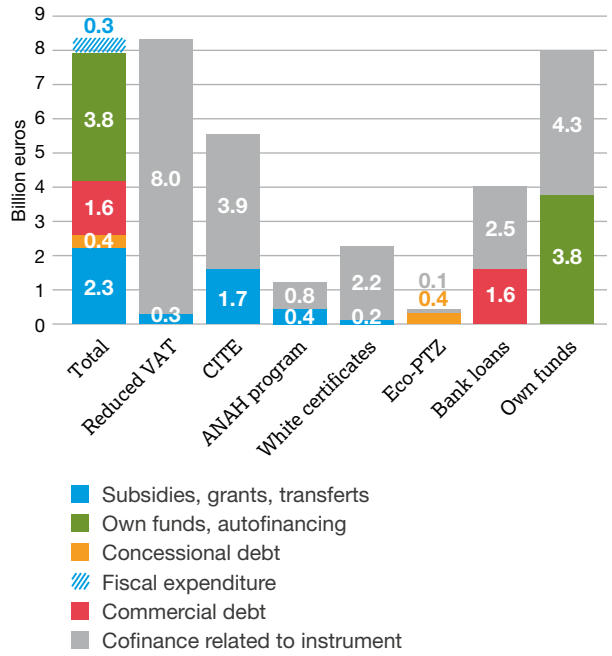
Private finance is made up mainly of households own funds

When it comes to retrofitting housing units, households are the principal source of finance with €3.8 billion from their own funds, i.e. available savings and current income, in 2016. This represented roughly 47% of total household investment in energy retrofitting.

Conventional bank loans, i.e. without preferential conditions on rates or duration, supplemented self-financing by €1.6 billion (according to ADEME, 2016g). At least 40% of households who undertook performant and very performant retrofitting operations resorted to bank loans. An average of €4 billion of households, retrofitting investments are cofinanced through commercial loans.

The following figure and Table show the amounts distributed by public and private finance instruments over the retrofitting of private homes (houses and flats) in 2016. For each instrument, the figure plots amounts provided to project developers as well as total eligible spending for each instrument. For example, the CITE tax credit covers 30% of the acquisition cost of its eligible equipment. Some instruments target a smaller market or segment, but ensure a high share of the costs, while others provide a marginal rebate over a high volume of investments.

COVERAGE OF FINANCING INSTRUMENTS FOR THE RETROFITTING OF PRIVATE DWELLINGS IN 2016



COVERAGE OF FINANCING INSTRUMENTS FOR THE RETROFITTING OF PRIVATE DWELLINGS IN 2016

(in euro million, in 2016)	Amount distributed through the instrument	Investment made in projects receiving support from the instrument	Rate of coverage (in %)
Subsidies, grants, transfers			
Reduced VAT (5.5%)	342	8 372	4%
CITE	1 675	5 583	30%
ANAH program	429	1 600	27%
White certificates	162	2 314	7%
Concessional debt			
Eco-loans (éco-PTZ)	387	495	78%
Commercial debt			
Bank loans	1 613	4 099	39%
Equity			
Own funds	3 764	8 029	47%

The proportion of publicly-driven finance in the retrofitting of private housing units rose from 36% of total investments in 2011 to 42% in 2016. This is primarily due to the 2014 reform and reinforcement of the sustainable development tax credit (*Crédit d'impôt développement durable* CIDD, renamed in 2014 *Crédit d'impôt pour la transition énergétique*, CITE). This mechanism has been made simpler and more attractive by a flat 30% rate on the expenditures incurred for the renovation of private housing units. In 2015, the increase in the use of the tax credit for energy transition (CITE) partly explains the decrease in the issuance of zero rate eco-loans, since the two mechanisms cannot be combined.

The increase in funds distributed through government mechanisms may have one:

- Encourage an equivalent increase in private finance (leverage effect);
- Crowd-out of private finance in case the projects would have been conducted even if public support had not been made available (windfall effect).

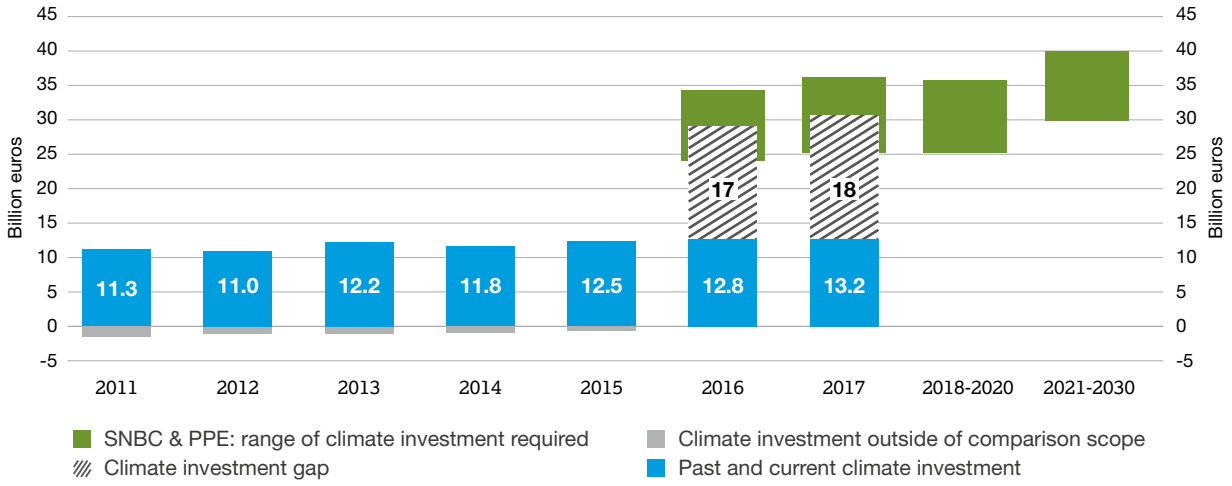
The 2014 edition of the OPEN study conducted by the ADEME provides an initial insight. Surveying a sample of households and asking about the impact of grants received on the project they had initiated, the study identified that a third of respondents emphasised the reduction of total cost they had to bear ("limit the impact of the works on my finances", 33% of responses), which could imply a crowding-out effect. However, around a quarter mentioned the trigger or leverage effect of public funding to start initiate the investment ("embarking on the works project", 25% of responses) (ADEME, 2016g).

Both effects (leverage and windfall) therefore seem able to coexist, depending on the situation of the households, their revenues and the type of work undertaken. The assessment of the sustainable development tax credit (CIDD) conducted in 2011 identified that the windfall effects could exist when households do not always undertake the most cost-effective work, even when subsidised. For example, loft insulation, although in principle very cost-effective, is often disregarded by households, whatever the level of subsidy (MEDDTL *et al,* 2011).

Most social housing expenditures were backed by loans issued by Caisse des Dépôts

Public housing authorities' investment in the retrofitting of social housing units made up 40% of publicly-driven finance in the building sector. Their expenditures were financed mostly through loans (such as the *Eco-prêt logement social, éco-PLS*) issued by the Caisse des Dépôts. The support granted through such loans to energy efficiency projects amounted to around €350 million in 2016 (*Plan Bâtiment*, 2013 and 2014; PPE, 2016; CDC, 2016b). That same year, grants from central and local governments, for a combined amount estimated at around €100 million, also contributed to these investments.

CLIMATE INVESTMENT GAP IN THE BUILDING SECTOR THROUGH 2030



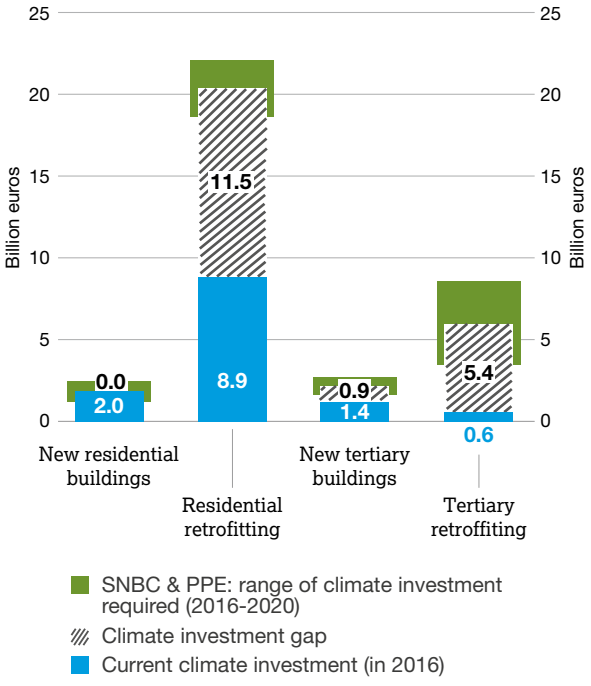
The introduction of new regulation RT 2012 involved more private finance in energy efficiency for new buildings

In 2011 and 2012, new constructions following the energy performance requirements of the 'low energy consumption building' label (*bâtiment basse consommation*, BBC) were able to benefit from public financial support, mainly through a 'zero-rate loan' program (*prêt à taux zero*, PTZ). Starting from 2013, new planning permissions must comply with the heat regulation "RT 2012", which lowers the threshold of conventional consumption levels to 50 kWh/m² (versus 150 kWh/m² previously). Since the regulation now applies to all buildings, the incentive mechanism for the majority of zero rate loans disappears, transferring the responsibility for the investment effort towards private finance, own funds and bank financing.

Current investment in the building sector falls short of the required levels to achieve low-carbon objectives

To achieve the objectives set in the LTECV and SNBC, climate investment in the building sector should reach between €25 billion and €35 billion per year. In comparison, current investment for comparable projects amounts to €12.8 billion in 2016. In that year, the climate investment gap for the building sector is thus estimated to be around €17 billion.

CLIMATE INVESTMENT GAP IN THE BUILDING SECTOR, PER ACTION, FOR YEARS 2016-2020



Investment needs are concentrated in the retrofitting of residential units. With an estimated €11.5 billion missing against SNBC & PPE objectives, this segment of climate action accounts for 60% of the national climate investment gap in 2016. The investment gap in the tertiary sector is smaller in volume at about €5.4 billion, but represents several times the level of current investment, which stands at €0.6 billion in 2016. Investment levels in new buildings, both residential and tertiary, are close

to the trajectory set by the SNBC and the PPE. Indeed, the strategy's scenario considers that the pace of new construction remains around the level observed in 2016, while no major regulatory change on energy efficiency takes place before 2020.

Changing the scale of building retrofitting

Achieving national climate objectives requires a change of scale in building retrofitting, in particular for private dwellings. This section of the building chapters explores obstacles to this change that have been highlighted in several studies. Some works focus on the insufficient articulation of public finance instruments, while others have highlighted the broader economic barriers faced by households. Furthermore, sociological approaches brush a different picture of the priorities to engage more households in retrofitting projects. Despite some degree of convergence between all these approaches, there remains considerable disagreement in France over which form of public policy would be most effective and efficient.

The current articulation of public finance instruments is inefficient with regards to national objectives

The current use of the public finance instruments presented in this chapter appear to be insufficient to provoke the change in scale in housing retrofitting. At the current pace, only 500,000 housing units with poor insulation (*passoires énergétiques*) will be renovated in 2025, against a stated objective of 7.4 million (Rénovons!, 2017b). Likewise, the objective of bringing all buildings to the target "low-consumption" levels (*bâtiment basse consommation*, BBC) seems out of reach under current conditions.

Complete versus step by step retrofitting

The debate on the articulation of instruments derives from consideration over whether retrofitting should be achieved in one or several steps.

- Complete retrofitting aims at bringing a targeted building to the highest performance level in line with long-term objectives. According to its promoters, this approach makes the most of base construction costs by treating all elements of the building simultaneously (Rénovons!, 2017a; Négawatt, 2018b), Energy audits can be conducted with the aim of optimizing and coordinating all interventions under a single project manager. Finally, it is easier to make energy or climate efficiency the goal of the works when they are undertaken at such a scale. Obstacles to this approach reside in its higher initial costs, longer construction phase, the requirement for homeowners to move out of their properties, and requirement for better trained professionals under a skilful coordination.
- Step by step retrofitting considers individual replacement of equipment with performance added incrementally over the years until the building reaches energy performance in line with national objectives. This approach takes advantage from the fact that many interventions in the current retrofitting market only target a single type of often broken or obsolete equipment (boiler, window). It targets opportunistic investments, for example replacements driven by energy price changes or the supply of relatively cheap insulation techniques. However, because of the lack of overall coordination, this approach may lead in some interventions undermining the progress of previous actions. With no energy audit, step by step retrofitting may ignore potential energy savings and increase construction costs.

Obstacles to retrofitting, whether complete or step by step

Public finance mechanisms provide different incentives to undertake either complete or step by step retrofitting. These mechanisms were developed independently and defined with different eligibility requirements. This results in the creation of different incentive effects from one instrument to another. For example, while funds delivered under the ANAH and éco-PTZ programs favour complete retrofitting, subsidies under the reduced VAT, CITE or white certificates divide incentives over individual actions.

Home-owners often lack information on the energy status of their housing, the potential gains from works (EEFIG, 2017) or on existing grant mechanisms (ADEME 2016d; CGEDD et al., 2014). Additionally, potential recipients of public funds have to obtain and submit a large amount of information on their property and the proposed works to demonstrate that they meet the eligibility criteria. This can involve considerable paperwork. To a certain extent, this complexity reduces the incentive provided by each instrument regardless of the retrofitting project itself.

Promoters of complete retrofitting often call for a unique climate-centred finance mechanism

To overcome these obstacles, proponents of complete retrofitting see it as necessary to reinforce the coherence and linkage of public instruments, refocus incentives towards complete retrofitting and reassert the priority of tackling energy poverty.

- A national governance of energy retrofitting could improve the coherence of these mechanisms and the coordination of public support at a local level (Rénovons!, 2017a).

- As current grants directed to energy poverty remain insufficient, implementing a subsidy indexed to households' income completed by bank loans mechanisms for the rest of investment could solve threshold effects and reinforce priority to low-income households (Rénovons!, 2017a).
- The option of a unique financing tool is considered to generate a change of scale in retrofitting. Attaching loans and subsidies to the building rather than the owner removes a constraint for households who do not intend to stay in the same home in the long run (such as elderly occupants or tenants). This means whatever current user of the dwelling would be in charge of the reimbursement, rather than the owner. By setting an eligibility condition based on a minimum energy performance, a unique finance mechanism could also be beneficial to improve households' incentive to invest in complete retrofitting (NégaWatt, 2018b).

However, a unique finance mechanism may not create the expected effects.

A unique finance mechanism may not be fitted for all specific cases: the current range of instruments is directly linked to the range of objectives set by public policies. For example, the reduced VAT rate covers energy efficiency, but is also a much broader measure supporting the construction industry in general. Likewise, the ANAH programs targets several objectives besides energy efficiency. Households have different needs, characteristics and resources that lead them to plan different types of retrofitting projects; as such, they may need different forms of support to complete them.

Furthermore, several public instruments may need to coexist because they are based on different financing sources, notably ones other than government budget. For example, eco-loans are provided by banks, white certificates are funded by private companies and the ANAH program by the sales of EU ETS allowances.

The success of a unique finance mechanism would rely on the quality of service. Professionals in this sector providing both advice to households and conducting the works. Indeed, households are reluctant to request subsidies based on the final performance of the works unless there is a guarantee on the quality of retrofitting works (NégaWatt, 2018b). However, such key elements are largely missing from the current market as reported by the French General Economic Council on Sustainable Development (CGEDD and IGF, 2014):

- Energy efficiency audits, as well as advice and guidance platforms, need skill improvement in order to encourage global retrofitting better.
- Work companies labelled RGE (*Reconnu garant de l'environnement*) do not provide specific guidance skills towards complete retrofitting and do not inform on works energy performance.
- The global cost of retrofitting may remain too important for some households, especially the most precarious ones, in spite of the subsidy system.
- Energy performance is not often accounted for the decision process of the household.

Alternatives improvements to the existing set of instruments

Instead of fusing instruments into a single system, reforming existing instruments and their eligibility conditions to target global retrofitting better and insuring their steadiness over time appears potentially more efficient (CGEDD and IGF, 2014). For example, the tax credit on energy transition fails to direct households towards the most energy efficient spending. Decreasing the tax credit rate to 20% and increasing the maximum amount distributed would better take in account the global cost of retrofitting works. Setting eligibility criteria to require at least two simultaneous retrofitting actions would tackle free-riding effects and encourage long-term complete retrofitting objectives. Finally, including the energy audit in the conditions could be an incentive for households to identify the most energy performant retrofitting actions.

Beyond the incentives provided by public instruments, households often do not take into account the economic benefits of retrofitting works

Households wanting to undertake energy retrofitting work must deal with several obstacles in a decentralised and scattered equipment market:

- The volatility of energy prices discourages households from carrying out energy efficiency works or making substitutions between sources. In the case of domestic heating oil, prices for private individuals doubled between 2009 and 2013 then were halved between 2013 et 2016 (SOeS, 2016a).
- Although more energy efficient, alternative utilities are often expensive to install. For example, a heat pump costs €12,000 on average to install, against only €1,600 (excluding labour costs) for an electrical convection heating system (ADEME, 2016f).
- The times of return on investment vary in line with energy prices, but generally stand between 15 and 25 years for heavy works (Carbone 4, 2012; CDC 2013). The rates of return on investment for retrofitting works across the lifespan of utilities are very sensitive to the

changes in energy prices (CGEDD et al., 2014), and to the discount rate. The latter, whether expressed or implied, may be very high, up to 20-25% per year as shown in studies devoted to energy efficiency (Howarth and Stanstad, 1995). In practice, energy savings, when expressed per year or per month, appear too low or too uncertain to justify the initial investment in own funds or even the time spent organising the retrofitting works.

- Retrofitting opportunities are often spread over time and, even when concentrated, are not fully exploited. Most households only replace appliances and equipment when it reaches the end of their lifespan, or as an emergency when a heating system has broken down during winter. Commercial practices do not systematically steer households towards comprehensive services (EEFIG, 2017). While the property transaction represents an ideal time to undertake heavy renovations since it combines empty housing, new home-owner and a pooling of financers, this is not yet sufficiently taken advantage of. In 2013, around 700,000 housing units were the subject of a transaction (CGEDD, 2015).
- When energy gains exist "on paper", their conversion into available future income, likely to reimburse the investments made, is not always guaranteed. Such potential gains are typically highlighted at the time of compulsory or voluntary energy audits. Actual energy use after retrofitting works often depends on the nature of the materials used, the quality of the installation and works as well as the behaviour of occupants (Branger, 2015).
- Incentives to retrofit may be split in the case that several homeowners occupy the same building (co-ownerships), or when building occupancy periods are too short to justify long-term investments: this is the case in particular for housing units with a rapid turnover of tenants (Charlier, 2015).
- Although a "green value" for housing units with enhanced energy performance is highlighted by statistical and economic studies, it does not generally exceed 10% of the selling price for the housing unit (CDC, 2013; DINAMIC, 2015), a level that is still not sufficient on its own to justify additional investments.
- Some households, typically elderly couples of low-income families, face reduced access to low-interest debt for energy renovation works (DG Trésor, 2017). Banks do not generally differentiate the lending rate for energy efficiency in relation to current consumer loans. Their study of borrower solvency is based above all on the appraisal of available revenues (recurring revenues minus fixed expenses) and very rarely on the potential revenues generated by the works (EEFIG, 2017).

Sociological approaches point to the lack of recognition of energy efficiency benefits by households

Economic and financial incentives are not the only explaining factors to households' energy efficiency investment. Most of them do not see or account for the benefits of energy efficiency as private companies would do, i.e. they do not behave as "Homo economicus" (CEDRE, 2017).

Households engaging in retrofitting their home follow a long thought and action process

The decision to initiate works is usually the culmination of a broader and longer thought process. The notion that households merely "act" on retrofitting is often misleading. Therefore, incentive mechanisms that only target this specific moment leave out all the other steps of the process. The investment decision of a household is a long and complex procedure, carried out in successive stages.

The following figure suggests a model to illustrate the decision process of the household.

- Ahead of the "acting", there is at first a raising awareness of an issue related to his/her habitat and a consideration on prospects for possible improvement.
- Then, the household progressively develops his/her project with the support of expertise and backing from many different media (professionals, family, internet sources…). Instruments of communication that trigger motivation can then help progress towards decision making. During this phase, the retrofitting project may evolve, become more ambitious and costly, or be reduced to a minimal intervention depending on all the information gathered. Additionally, the information collection process is time-consuming. Interacting with professionals by requesting quotations brings clarity and tends to involve households in an actual project, bringing deadlines to an otherwise open-ended reflection process.
- Following the turning point of signing the construction orders, the different actors insure the holding and execution of the retrofitting project until after the work completion. A monitoring is essential to evaluate the quality of works and to adapt the household's behaviour to his/her new living conditions, to avoid any rebound effect and insure significant energy savings. Eventually, it is up to the household to share his/her experiment and act as a vector of communication and information around him.

HOUSEHOLDS' DECISION PROCESS IN ENERGY RETROFITTING

	CONTEMPLATION	PREPARATION	ACTION	UPKEEP	USAGE
Steps	?	i			
Thoughts	"I am not aware of any "problem" with my house, nor am I ready to change or act"	"I am aware of a "problem" in my house and want to evolve. I consider options, but I have no definite project"	"I am ready to act and know how to do it. I just need the opportunity to act"	"I discover and adopt a new way of living"	"I enjoy the result, I discuss the merits and drawbacks of the change"
Triggers		I face new information…	My project is taking shape…	I have made my decision…	
Process	Collective communication The household is **recipient** of information		Interpersonal communication A dialogue is set between supply and demand. The household sets the demand.		Collective communication The household is **provider** of a feedback

Authors, based on CEDRE, 2017

The desire for improved home comfort can drive households from one stage to another

Sources of information and questions contribute to this feeling:

- Households are looking to make the best available the use of space in their home, which in turns will stoke the intention of making improvements and changes.
- Households may want to bring their current home closer to an "ideal home" that they have in mind;
- Relatives, neighbours, the media… influence how we perceive of our home and how it could be improve.
- The existence of physical, technical or comfort issues that incite the household to reconsider the arrangement of his/her home and to change of equipment.

These factors raise awareness on the potential of improvement of a household's living conditions. This marks the beginning of the decision process for the household, who starts considering changing of behaviour and planning actions to improve his/her home. However, most of the time energy efficiency is not directly one of these drivers.

Household perception of their home is key to drive their projects towards energy efficiency

Households typically adopt a wide variety of behaviours and choices which makes it difficult to treat them as a single target for policy instruments. It is necessary to point out different types of households and situations to conduct efficient incentive policies. This opens the possibility to identify incentives and barriers of each segment, and to optimize service and support according to the needs and attitudes of each type.

Households can be differentiated according to such criteria as:

- The main reason behind the introduction of energy efficiency in their projects. For some households, energy efficiency is a mean to achieve higher home comfort, for example through automatic regulation of heating and cooling in the house. Other households will see a problem of spending and try to solve through a direct control of their energy use.
- Their conception of housing, either as a private space that provide welfare and comfort, a place with permanent projects of improvement, a place where daily life activities take place…
- Their sociological type, as expressed through technical knowledge, environmental awareness, importance of aesthetic, quality of life or technological performance. In some cases, there may be a lack of those elements.
- Their age: young adults have many financial constraints and own less equipment, while the elderly must adapt their housing in accordance to the state of their health.

In the light of the decision-making process and specific typology of households, public policies would need to dispose of more than one mechanism to bring incentives towards housing retrofitting. In this sense, public policies

can be thought off less as a purely economic deal, but more as a package of information and instructions.

Focusing information spreading about energy retrofitting on notions of welfare, comfort and adaptation to physical constraints allows conciliating households' needs and desires with energy efficiency objectives. In this approach, the access to financial resources in not considered as an obstacle in itself. Households that build an interest in energy retrofitting will eventually be able to overcome financing issues.

Methodology

New residential buildings

Climate investment

Climate investment for the construction of new energy efficient residential units		Sources
Inclusion criteria	We include the additional cost necessary for the construction of new residential units that are energy efficient in the Landscape. In this context, energy efficiency is measured against the baseline of standard new construction. These units include self-contained housing units (houses) and multi-unit housing (flats).	
Screening metrics	We included energy efficient buildings that were certified by the following labels: • BBC (*batiment bas carbone* or low carbon building); • Effinergie+ and BEPOS (*bâtiment à énergie positive* or positive-energy buildings). We also include energy efficient units built after 2012, that follow the 2012 thermal regulation norm (*régulation thermique*, RT 2012)	
Number of projects	General information on the number of new residential units authorised for construction in France is available through the SITADEL database, which is updated by the MTES. Projects are grouped by year of authorization, which allows us to know whether they are realized under the RT 2005 or RT 2012 thermal regulations. We distinguish between flats (multi housing units) and houses (self-contained housing units), so we merged the housing classifications together: pure individual and grouped individual housing units as self-contained housing units; while multi-unit housing and other forms of housing as multi-unit housing. We were able to track the number of projects from various sources for each certification. We were able to track the number of Effinergie+ and BEPOS certification requests for houses and flats from the BBC Observatory. We were able to track the number of housing units that followed the RT2012 thermal regulation norm by subtracting energy performance label certifications such as BBC, Effinergie+ and BEPOS from the total number of authorized housing units reported by the SITADEL database. The BBC Observatory provides two time series on projects, one according to when they request certification and one according to when they obtain it. The first series, at the date of requesting certification, is closer to the series of building authorisations maintained by SITADEL. Therefore, we discount projects that were cancelled after they requested certification, or for which certification may have been denied. For this, we use the average cancellation rate of housing projects reported by the CGDD: 12 to 15% for houses and 12 to 21% for flats. The BBC Observatory tends to report label requests several months after the projects are authorized. For instance, projects authorized in 2012 may request a BBC label as late as 2015 or 2016. To calculate the share of buildings authorized in 2011 and 2012 that obtained a BBC certificate, we had to take into consideration a one-month delay between authorisation and BBC label request. Thus, we were able to identify the number of BBC accreditations, by multiplying net authorized constructions with the calculated share of buildings that requested BBC label accreditations. We were able to identify the number of housing units certified by the Effinergie+ and BEPOS labels from the label requests reported by the BBC Observatory.	SITADEL2, 2015 Observatoire BBC, 2017 SITADEL2, 2015 Observatoire BBC, 2017 CGDD, 2014b

Climate investment for the construction of new energy efficient residential units		Sources
Cost of projects	To calculate the amount of investments realized (in euro million), we multiply the unitary cost of each accreditation (in euros incl. taxes / housing unit) with its respective number of certified housing units (in thousand units). We first identify the average surface area of a housing unit (in m²) by dividing the total living area of authorized buildings (m²), with the number of authorized housing units. We then multiply the average surface area of flats and houses with the unitary cost of new energy efficient housing units, calculated by multiplying the VAT for new constructions - established at 19,6%- and the hypothesized surplus cost for each label and norm (in euros excluding taxes/m²) reported by the CGDD, compared to the baseline value of the 2005 thermal regulations: • 14% for houses and 9% for flats labelled BBC • 16% for houses and 10% for flats labelled Effinergie+ and BEPOS • 6% for both houses and flats following the RT 2012 norm To calculate the costs and unitary surplus costs of building new energy efficient housing units (in €HT/m²), we took into consideration several sources: The Scientific and Technical Centre for Construction (*Centre Technique et Scientifique du Bâtiment*, CSTB) used a baseline cost of 1,200 euros excl. taxes/m² for individual housing units and of 1,400 euros excl. taxes/m² for multi-unit housing. The CSTB considers energy efficiency generates a surplus cost of 10% above the reference cost. The ADEME's PREBAT program reports that exemplary energy efficient buildings constructed between 2007 and 2010 cost an average of 1300 excluding taxes/m² for multi-unit housing. The interest-free eco-loan (*éco-prêt à taux zero "plus"*, PTZ+) was used in 2011 and 2012 to finance new housing units. Some of these housing units meet the "BBC" energy efficiency standard (Effinergie label) and benefit from a favourable financing rate. We found that, on average, BBC buildings financed through this programme declared total costs that were 23% higher than non-BBC buildings. The French Building Federation (*Fédération Française du Bâtiment*, FFB) reports on various estimates of the evolution of construction costs in housing units since 2000, at a rate of +8% to 10% according to the FFB. Other professional bodies found cost increase of +8.5% to +10%. The reports from the FFB states that it is near impossible to isolate the effect of environmental norms from other possible sources of cost increase over this period. The Regional agency for environment, planning and housing (*Direction régionale de l'environnement, de l'aménagement, et du logement*, DREAL) of the Centre Val de Loire region found the 2012 thermal regulation caused an 11.9% increase in average house prices between 2009 and 2013 in that region. The CGDD reports the surplus cost for each label and norm (in euros excluding taxes/m², along with the baseline value of the construction of 2005 thermal regulation housing units. Finally, it is this value that we use to identify the total surplus cost of building BBC housing units.	SITADEL2, 2015 CGDD, 2015b CTSB, Interview d'expert ADEME PREBAT, 2011c SGFGAS, 2011b CGDD, 2015b FFB, 2013 DREAL, 2015
Attribution to project developers	Investments in the construction of new energy efficient housing units is attributed to several project developers, including households and social housing authorities. To determine the shared costs between these two project developers, we analyse the requests for energy efficient labels (BBC, Effinergie+, BEPOS). It must be noted that the construction rate of new social housing units has been stable at around 90,000 constructions per year, but label demands for this type of housing unit has been declining: 85% in 2011 to 65% in 2016.	Observatoire BBC, 2017

Zero-rate loan (*prêt à taux zéro*, PTZ+): we document amounts distributed through the annual SGFGAS report (*Société de Gestion du Fonds de Garantie à l'Accession Sociale*). For more information, see our bibliography at SGFGAS, 2018.

Grants from the National Urban Renewal Agency (*Agence Nationale de la Rénovation Urbaine*, ANRU): amounts are based on the annual report of its National Urban Renovation Programme (*Programme National pour la Rénovation Urbaine*, PNRU). For more information, see our bibliography at ANRU, 2014.

European Regional Development Fund (*Fonds européen de développement regional*, ERDF) grants: amounts were derived from a project-level analysis of the PRESAGE database with help from the "General Commission on Equality of Territories" (*Commissariat Général à l'Egalité des Territoires*, CGET).

Loans from the Savings Fund of Caisse des Dépôts for the construction of social housing are documented using the Funds' annual financial reports published by the (*Fonds d'Epargne de la Caisse des Dépôts*) and statistical reports by the Social Housing Union (*Union Sociale de l'Habitat*, USH). For more information, see SGFGAS, 2018 and USH, 2017.

Finally, the National Commission of Housing Finance (*Comptes du Logement*) reports serve as the basis for evaluating non-specific financing for energy efficiency improvements, particularly the share of resources from commercial bank loans and self-financing from household savings. For more information, see our bibliography at CGDD 2017c.

Retrofitting of residential buildings

Climate investment for the retrofitting of existing private dwellings		Sources
Inclusion criteria	We include upgrades made to existing private residential units that result in improved energy efficiency or the use of renewable energy sources.	
Screening metrics	In houses (individual housing units) We track the installation of thermal insulation materials, heat pumps, energy efficient or renewable HVAC systems (heating ventilation and air conditioning systems), renewable water heating systems and renewable electricity generation (solar PV). To avoid double-counting with investments recorded for the energy efficiency of new residential units, we isolate the sales of these materials and systems that take place in retrofitting projects from those installed in new residential units. In flats (multi-unit housing units), we track spending declared by the co-ownership which we attribute to either energy efficiency or renewable energy.	
Number of projects	The number of housing units that realized isolation works on facades, roof and walls is available through the study on energy efficiency and renewable energy (*Marchés et emplois de l'efficacité énergétique et des énergies renouvelables*, M&E) established by the ADEME. The M&E study draws on the results of the OPEN questionnaire. The OPEN observatory measures the progress of the thermal renovation market, to measure the penetration of high-performing energy equipment in dwellings. OPEN uses a classification of energy performance divided in three levels: Minimum (no isolation), Medium, and Optimum (isolation). We only include optimum for wall insulation & windows. The sales of fireplaces, wood stoves, and boilers are reported in the ADEME's "M&E" study, which is based on OBSERV'ER data on the sale of firewood combustion appliances. Based on the ADEME data, we assume that 25% of 2012 onwards sales of firewood combustion appliances are for renovation purposes. We were able to track the sales of different heat pumps (air/water, air/air, geothermal, and aerothermal) from the consolidated series published in the ADEME's ME study, which includes Eurobserv'ER data with the AFPAC trends of 2014 and 2015. However, this series does not distinguish between new constructions and renovations. We hypothesize on their repartition to make the distinction. We assume that all geothermal heat pumps are installed in new housing units due to the restrictions caused by the drilling and probe required for this type of heat pump. Based on ADEME recommendations, we distribute the installations of heat pumps for new housing units: 60% of air/water types, and 35% of total heat pumps. Based on the Observ'ER study, we make the hypothesis that 90% of air-air heat pumps are sold for renovated units, and allocate the remaining share of aerothermic and air/air in renovation projects to air/water heat pumps. We were able to track the total sales (in thousand units) of thermodynamic water heating systems (*chauffe-eau thermodynamique*, CET) installations in new and renovated self-contained housing units from the ADEME ME study. We were able to track installations of individual solar thermal panels (in m^2) in mainland France and French overseas departments and territories, as reported by the ADEME M&E study and the Eurobserv'ER barometer.	ADEME, 2014a OBSERV'ER, 2016b Observ'ER, 2017a Observ'ER, 2016c ADEME, 2016f

Climate investment for the retrofitting of existing private dwellings		Sources
Cost of projects	To calculate the amount of investments realized in the renovation of private dwellings, we track the unitary cost for each type of installation: isolation works, firewood combustion appliances, heat pumps, CET and solar thermal panels We track the unitary cost of each project (in euros excluding taxes per operation) from the ADEME M&E study. The M&E study is based on results gathered through the OPEN questionnaire. On top of these sources, we make several assumptions: • the cost of wall isolations is proportional to the number of surfaces isolated in a single house or flat (1, 2 or 3 for the minimum, medium and optimum level respectively) we only include the optimum level for windows although the ME study proposes a disaggregation of installation costs by level of performance. • We then identify the total spending as the sum of the product between the spending for renovation projects (in euros exclusive of taxes) and the respective tax for each type of project: 5.5% for renovation projects. • For flats (multi-unit housing units) we take OPEN data and attribute to energy efficiency or renewable energy.	
Attribution to project developpers	Investments in the retrofitting of private dwellings are attributed to households.	

For individual homeowners, the main instruments are tax credits (CIDD/CITE) and the éco-PTZ.

The amounts given as part of the CIDD/CITE are documented in the budget law initial project (PLF, from 2011 to 2016).

We noticed a significant increase in grants paid by the ANAH, supplemented by bonuses from the Fonds d'Aide à la Rénovation Thermique as part of the "Habiter Mieux" programme, which rose from €52 to €533 million between 2011 and 2014 (ANAH, 2011, 2012, 2013a). However, it was impossible to estimate grants from local and regional authorities. The CEE are considered as a subsidy in the point of view of the beneficiary. Their economic value is based on their production value, as registered in the EMMY database. (Emmy 2017). The bimonthly newsletter of the DGEC (DGEC, 2015 and 2016) described the emitted quantities.

Climate Investment in the retrofitting of existing social housing buildings		Sources
Inclusion criteria	We include upgrades made to existing social housing units that result in improved energy efficiency. These units include social housing units and council houses.	
Screening metrics	We included residential units that underwent thermal renovation retrofitting, especially ones financed by the Caisse des Dépôts under either: • The "social housing eco-loan" program (*éco-prêt logement social*, éco-PLS); • A program of hybrid "equity loans" (*prêt en haut de bilan bonifiés*, PHBB) started in 2016;	
Number of projects	We were able to track the number of loans issued by the Caisse des Dépots, as reported by the Plan Bâtiment Durable statistics for 2011 to 2013. They are reported by the Caisse des Dépôts and the PPE from 2014 onwards. Meanwhile, the Social housing Union (*Union Sociale Pour L'Habitat*, USH) reports about units retrofitting outside of the Caisse des Dépôts loan programs. Thus, we add the number of units from both sources to estimate the total number of units retrofitted per year.	Plan Batiment Durable, 2016 USH, 2014, 2015, 2016a, 2017 Le Moniteur, 2017
Cost of projects	We include the average cost of retrofitting per social housing unit as reported by Caisse des Dépôts. The reports distinguish works related to energy efficiency from those concerning other improvements (such as accessibility). While the average cost of retrofitting has increased from 2011 to 2014, the amounts spent on energy efficiency have slightly decreased, in part because of scale economies made possible by the larger numbers of units retrofitted each year. Based on reports from USH, the average cost for energy efficiency works can be broken down for thermal insulation of walls and floors, roofs, windows, heating and ventilation.	CDC, 2016b USH, 2016b
Attribution to project developers	Invetments in the retrofitting of social housing units is attributed to public housing authorities (*bailleurs sociaux*).	

New tertiary buildings

Climate investment for the construction of new tertiary buildings		Sources
Inclusion criteria	We include the additional cost necessary for the construction of new tertiary buildings that are energy efficient -compared to standard units- in the Landscape. Tertiary buildings include many non-residential buildings such as public and private offices, schools, educational premises (schools, universities), hospitals, shops and supermarkets, recreational buildings (cinemas, restaurants and cafés), transport buildings (such as train stations and airports) as well as warehouses. Industrial and agricultural buildings are excluded from this category, as well as buildings that aren't heated.	
Screening metrics	We included energy efficient buildings that were certified by the following labels: • BBC (*Bâtiment bas carbone* or low carbon building); • Effinergie+ and BEPOS (*Bâtiment à énergie positive* or positive-energy buildings). We also include energy efficient units built after 2012, that follow the 2012 thermal regulation norm (*régulation thermique*, RT 2012)	
Number of projects	We identify the total surface area (measured in thousand m²) of new energy efficient tertiary constructions from the BBC Observatory, that reports on various energy label requests in France: BBC, EFfinergie+, and BEPOS. The BBC Observatory provides two time series on projects, one according to when they request certification and one according to when they obtain it. The first series, at the date of requesting certification, is closer to the series of building authorisations maintained by SITADEL. Therefore, we discount projects that were cancelled after they requested certification, or for which certification may have been denied. For this, we use the average cancellation rate of housing projects reported by the BBC Observatory's certification report: 8% for tertiary buildings. We multiply this surface area with the share of projects held by each label and carried by one of three different project developers: • Projects attributable to the central government and its operators; • Projects attributable to local governments; • Projects attributable to the actors of the private sector. We estimate the distribution of projects between these actors and for each label, from indications reported on the Effinergie website.	Observatoire BBC, 2017 Effinergie, 2017
Cost of projects	To calculate the amount of investments realized (in euro million) for the renovation and construction of energy efficient tertiary buildings, we multiply the hypothesized unitary surplus cost of each accreditation (in euros incl. taxes/m² SHON) with its respective surface area (in thousand m²), estimated from the non-residential label requests reported by the BBC Observatory. We hypothesize the unitary cost of constructing an energy efficiency accredited tertiary building by multiplying the surplus cost rate (expressed in percentage) with the base cost of 1,75O euros excl. taxes/m² SHON, reported as the median construction cost in a reference framework of recent office building costs published by the Observatory for construction costs (*Observatoire du coût de la construction*, an initiative of the French social security). We assume that all tertiary buildings are multi-unit buildings, and thus use the surplus cost rate for energy efficient multi-unit housing units reported by the CGDD, compared to the baseline value of the 2005 thermal regulations: • 9% for multi-units labelled BBC; • 10% for multi-units labelled Effinergie+ and BEPOS; • 6% for multi-units following the RT 2012 norm. To calculate the costs and unitary surplus costs of building new energy efficient housing units (in €HT/m²), we consulted several sources, which are detailed in the New private dwelling methodology.	Sécurité Sociale, 2016 CGDD, 2015b

Climate investment for the construction of new tertiary buildings		Sources
Attribution to project developers	Investments in the construction of new energy efficient tertiary units are attributed to three different project developers based on the non-residential label requests reported by the BBC Observatory: local governments, the central government, and private companies. We were able to estimate the total surface of tertiary buildings held by the central government and its operators (including foreign and residential units) from the Cross-cutting Policy Document (*Document de Politique Transversale*, DPT) dedicated to public buildings. We were able to identify the total surface of tertiary buildings owned by local governments by crossing data from Schneider Electric, the Plan Grenelle Batiment, and the Centre for Economic Studies and Research on Energy (*Centre d'Etudes et de Recherches Economiques sur l'Energie*, CEREN) that is cited by the AMF. We were able to track the surface area of tertiary buildings held by the private sector by subtracting the buildings park held by operators of the central government and local governments.	DPT Immobilier, 2015 Schneider Electric, 2012 Plan Bâtiment, 2011 AMF, 2010

Retrofitting of tertiary buildings

Climate investment in the renovation of tertiary buildings		Sources
Inclusion criteria	We include upgrades made to existing tertiary buildings that result in improved energy efficiency or the use of renewable energy sources. Tertiary buildings include non-residential buildings, with the exception of industrial and agricultural buildings and buildings that aren't heated.	
Screening metrics	Screening metrics for this action vary depending on the type of project developer considered: • For buildings maintained by the central government, we tracked spending reported the Cross-policy document and the number of energy efficient accreditations reported by the BBC Observatory. • For buildings maintained by local governments, we included spending reported under several financing programs including those from EIB, ERDF, national local investment fund (*fonds de soutien à l'investissement local*, FSIL) as well as BBC Observatory accreditations. • For buildings maintained by private companies, we included projects reported to the BBC Observatory accreditation.	DPT Immobilier, 2015 Observatoire BBC, 2017

Climate investment in the renovation of tertiary buildings		Sources
Number of projects	We first identify the share of each label (BBC Effinergie, Effinergie+, BEPOS, and Rénovation BBC) carried by each of the three project developers from the detailed analysis of documented projects led by the BBC observatory: • We track the number of projects carried by the central government and its operators (in thousand m²) by multiplying all projects labelled Rénovation BBC (in thousand m²) with the identified share of projects carried by this project developer: 1% of projects. • We track the number of projects carried by local governments (in thousand m²) by multiplying all projects labelled Rénovation BBC (in thousand m²) with the identified share of projects carried by this project developer: 5% of projects. • We track the number of projects carried by private companies (in thousand m²) by multiplying all projects labelled Rénovation BBC (in thousand m²) with the identified share of projects carried by this project developer: 94% of projects. We then include spending and unitary project costs from the following sources: • We track the number of projects carried by the central government and its operators from the Cross-policy document, which details the ownership and general energy efficiency labeling of the tertiary building park in France. We consider this source as more accurate since a large number of BBC labelled tertiary buildings held by the central government are not reported to the BBC Observatory. • We track the amount of investments (in euro million) realized for the renovation of tertiary units held by local governments by consulting the five different sources listed below. Due to the absence of a single source that covers all renovated tertiary units, we identify the source with the greatest number of reported projects and added 50% to compensate for the lack of coverage of projects reported by the other sources: - The French Environnent and Energy Management Agency (*Agence de l'Environnement et de la Maîtrise de l'Énergie*, ADEME), - Public local Investment fund (*Fonds de Soutien à l'Investissement Public Local*, FSIL), - European Regional Development Fund (*Fonds Européen de Développement Economique Régional*, FEDER), - European Investment Bank (*Banque européenne d'investissement*, BEI), - BBC Observatory; • To track the amount of investment (in euro million) carried by the private sector, we multiply the surface area reported through the BBC Observatory with the unitary cost (euros/m²) of retrofitting derived from synthesis reports from the National Research and Experimentation Program on Buildings and Energy (*Programme national de Recherche et d'expérimentation sur l'Énergie dans les Batiments*, PREBAT).	Observatoire BBC, 2017 DPT Immobilier, 2015 Observatoire BBC, 2017 ADEME, 2011c CDC, 2016a Observatoire BBC, 2017
Attribution to project developpers	Investments in the energy efficiency retrofitting of tertiary buildings is attributed to private companies, local governments, and the central government. Each project developer's spending is calculated separately in the steps described above.	

Climate-specific financing in the tertiary sector is limited to ADEME and ERDF grants when such grants were unable to be traced to housing or public beneficiaries. The remaining expenditure is added to the public budgets of the French central government and local authorities, as well as to the financing reported in annual reports for private tertiary stakeholders. Credit lines extended by the European Investment Bank (EIB) for construction and "high environmental performance" (HPE) retrofitting to improve the energy efficiency of buildings owned by local authorities (namely middle and high schools) are taken into account (EIB, 2010 to 2014).

Renewable energy projects in new and existing large buildings

Photovoltaic installations disaggregated into output power categories (ADEME, 2016f), are distributed between the various building types: new construction, retrofit, housing and tertiary, public or private project initiator. We consider that 100% of installations with less than 9kWC are in residential sector, and that 35% of the installations on "large roofing" are in the tertiary sector. Financing for these installations depend on the specific instruments for each building category.

RESULTS > SECTORS

Transports

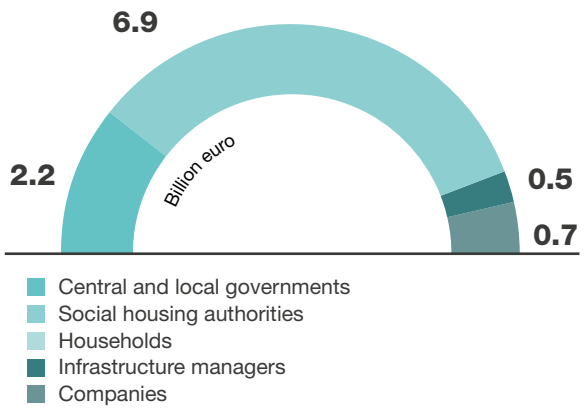
In 2016, the transport sector totalled 32% of climate-related investments, i.e. €10.3 billion. Most of this amount went to sustainable transport infrastructures, mainly the development of new rail networks and urban public transport. Expenditures connected with the electrification of privately owned vehicles (new vehicles and recharging infrastructures) have been increasing since 2011. 92% of the financing in this sector is driven by the public sector.

€8.1 billion
In 2011

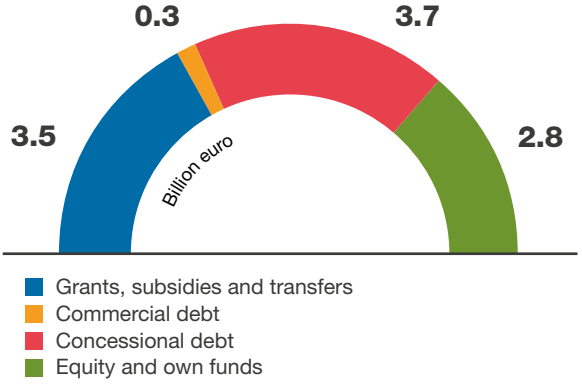
€10.3 billion invested in 2016

€10.7 billion
In 2017 (projections)

WHO MAKES THE INVESTMENTS?



HOW WERE THEY FINANCED?



WHAT WAS THE ROLE OF THE PUBLIC SECTOR IN MOBILIZING FINANCE?

In 2016: 92% of the sector's finance was driven

(In billion euros, see p.92 for more detail)

EVOLUTION OF CLIMATE INVESTMENT IN TRANSPORT

(in million current euros)	2011	2012	2013	2014	2015	2016	2017p
Low carbon vehicles	181	306	472	583	649	949	1,033
Infrastructures	7,475	8,624	11,231	10,242	9,135	8,852	9,166
Urban public transport	2,504	2,719	2,738	2,781	2,341	3,050	3,090
Railways – LGV	1,509	2,107	3,519	2,591	1,089	1,010	615
Railways – other than LGV	3,057	3,288	4,291	4,214	5,135	4,234	4,904
Inland navigation	200	200	220	180	200	190	190
Maritime transport	200	300	450	460	350	350	350
Electric vehicle charging stations	5	10	13	16	20	18	17
Soft transportation modes (e.g. cycling)	421	398	430	413	444	460	527
Total	**8,077**	**9,328**	**12,133**	**11,238**	**10,228**	**10,261**	**10,725**

P = provisional figures.

Context

The sector's CO_2 emissions are linked to human mobility and economic activity

In 2016, transport made up 29% of final energy consumption and the same proportion of greenhouse gas (GHG) emissions outside of LULUCF in France (CITEPA, 2017; SDES, 2018). The sector's GHG emissions had an overall increase of 11% between 1990 to 2016 (CITEPA, 2017), with a first period up to 2004 marked by a 20% increase over the level of 1990 level, followed by a steady reduction from 2004 to 2016 (SNBC, 2016).

Historically, the main driver of the overall demand for mobility of people and goods has been the level of economic activity measured through GDP (CGDD 2016c). From 1990 to 2016, inland passenger traffic, measured in passenger-kilometres, has increased by 30% while goods traffic, measured in tonne-kilometres, increased by 50% up until 2007, before decreasing by 18% since (CGDD, 2017a). In 2016, road transport accounted for 93% of the sector's emissions (CITEPA, 2017). From 2000 to 2016, the share of collective modes of transportation (bus, coach, train and tram) increased only from 18 to 20% in passenger land transport (CGDD, 2017a). Over the same period, the proportion of road transport in goods transportation maintained its dominance, rising from 71 to 85% (CGDD, 2017a).

The SNBC is looking for controlled mobility growth, significant progress in energy efficiency and modal shifts

Long-term projections for France forecast increased mobility. Passenger mobility, measured in passenger-kilometres, is forecasted to increase by 17% between 2012 and 2030 (CGDD, 2016c). Over the same period, freight, measured in tonne-kilometres, would increase by 45%, driven, in particular, by a high demand for international trade, both imports and exports.

The mobility of people and goods is the result of a decentralised process in which the daily decisions of thousands of individuals are aggregated (PREDIT, 2011). Since they are closely linked to individual lifestyles and personal preferences, as well as availability of technologies, the level of fuel prices and the transport offer for a given location, and the structure nature of infrastructure networks. As such, the systemic nature of the transport network makes it challenging to analyse the impact of a single transport investment project in terms of broader mobility trends and net reductions in transport-related GHG emissions. By virtue of the very long lifespan of these infrastructures, the risks of investments in a carbon model being locked in are very high (see SNBC, 2016; OECD, 2017a).

To disconnect increases in mobility from GHG emissions, the National low-carbon strategy includes several approaches (SNBC, 2016) including:

- Managing the mobility of passengers by limiting urban spread. This can be done through focusing on the distances travelled between home and work, shops, schools, leisure activities. The circulation of goods can be further managed through the circular economy and short supply chains. The development of teleworking and remote services also helps to curb the demand for regular journeys (CGET, 2015).
- Increasing the loading ratio of passenger and freight vehicles, for example through the development of carpooling and mobility services (ADEME, 2015a).
- Encouraging modal shift towards low carbon modes: public transport for short-distance urban trips, coaches (CGDD, 2016c) and rail for long distance, rail and waterway for freight. The development of 'soft transportation modes', such as walking, and cycling, can cover short distance trips with near-zero emissions (ADEME, 2015b et 2017b). However, given the preponderance of road-based modes in the transport sector's current modal shares, even a limited (e.g., 1%) shift towards modes corresponds to a sharp increase in the activity or the infrastructure of these modes. (CGDD, 2017h).
- Significant improvements in the energy efficiency of privately owned cars, utility and heavy-duty vehicles. This can be achieved via the optimisation of internal combustion engines, energy recovery and electric hybridisation of traction engines, reduction in vehicle weight, limitation of vehicle maximal speed to the maximal legal speed, and restrictions on the consumption of energy-intensive secondary equipment (CAS, 2008). In parallel, eco-friendly driving training can bring additional energy efficiency to many types of vehicles (Saint-Pierre and Andrieu, 2010). Reducing maximum speeds, especially on motorways, while not mentioned in the SNBC, would also make it possible to reduce the energy intensity of journeys (PREDIT, 2011).
- Reducing the carbon intensity of fuels. While oil represents 91% of the energy consumed in the transport sector for 2014, the shift towards low carbon depends on greater use of electricity (ADEME, 2016e), natural gas for vehicles (NGV and bio-NGV), biofuels (in particular second and third generations) and hydrogen. The deployment of these alternative fuels require major investments in research and development in order to remove the technological barriers (ADEME, 2011a).

To encourage these changes, the public authorities in France use four major types of instruments (PREDIT, 2011):

- Economic and fiscal instruments, the purpose of which is to provide a price signal that takes into account the environmental externalities of the consumption of fossil fuels (CO_2 emissions, noise, air pollution) in particular.
- Regulatory instruments, which define the maximum limits of environmental impact from vehicles in terms of energy consumption and air pollution. In many cases, regulatory and fiscal signals are complementary rather than mutually exclusive (CGDD, 2017d).
- Investments in collective transport infrastructures, in particular those for which the modal shift involves an ecological and energy gain (soft modes, rail, electrification, etc.).
- Support for project financing as well as for local and national governance, with a primary objective of reducing the risks of instability in policies and strategies.

Results

Increased expenditures for acquisition of low carbon vehicles, financed through the *bonus-malus* system and the use of leasing

Acquisition of low-carbon vehicles represented €950 million in 2016, of which €507 million for low-carbon (mainly electric) individual cars, €239 million for buses and coaches, and €201 million for hybrid or NGV trucks. Overall investment in low-carbon vehicles saw a significant increase since the 2011 level of €181 million. This increase in investments involves all purchasers (local authorities, businesses, households), and more notably private individuals. It can be explained by the favourable terms of public support systems as well as by the deliberate purchasing policies of central and local governments. Many businesses and public transport companies, both public and private, have committed to introduce low-carbon alternatives to petrol cars in their vehicle fleets. In 2017, the new government's Climate action plan features the aim of a complete ban on new petrol cars by 2040.

In 2016, government grants covered approximately 23% of the purchase cost of individual low-carbon vehicles. The grants are offered in the form of a premium ("bonus") to purchasers set at €6,300 per vehicle in 2016. The cost of this premium is covered by a tax ("malus") paid by purchasers of high-emission vehicles. Following a period in deficit from 2008 to 2011, this system has become balanced and currently makes a net contribution to the general budget (CGDD, 2013a; Court of Auditors, 2014a).

The remainder of the cost of purchasing individual low-carbon vehicles is most often funded through the practice of *leasing*. Leasing is similar to a commercial loan since the purchaser makes a monthly lease payment in exchange for the use of the vehicle.

Investments in sustainable transport infrastructures reached €8.9 billion in 2016

Investment expenditures on sustainable transport infrastructures increased from €7.4 billion in 2011 to €11.2 billion in 2013, before dropping to €8,9 billion in 2016.

Investments in urban public transport infrastructure rose from €3 billion in 2011 to 4,2 billion in 2016, following the implementation of a program launched at the *Grenelle de l'environnement* and sustained since then. This initiative included three national calls for projects, launched in 2008, 2010 and 2013 respectively. The projects focused in particular on the development of public transport in reserved lanes, such as adapted bus lanes or tramways (Court of Auditors, 2015).

Investments in railway infrastructures totalled €4 billion in 2016. Investment for the construction of new high-speed lines, which increased from €1.5 billion in 2011 to €3.5 billion in 2013, has declined due to the completion of key projects, such as the Sud-Est-Atlantique high-speed line between Tours and Bordeaux, the Bretagne-Pays de la Loire high-speed line and the Nîmes-Montpellier bypass. Investments in the maintenance and improvement of the rail network (aside from new high-speed lines) have shown a gradual increase from €2.5 billion in 2011 to €3.2 billion in 2016. This is the result of an agreed focus on upgrading the existing rail network, adopted between the government and SNCF Réseau (SNCF Réseau 2017).

Investments in cycling infrastructure and bikes reached €460 million in 2016, changing little since €421 million in 2011

Between 2011 and 2016, investment in bicycle sharing systems has declined, with most French cities having completed the deployment of their bicycle fleets. Meanwhile, households have bought more and more bicycles with electric assistance, their spending increased from €39 million in 2011 to €112 million in 2016. Several local governments offered subsidies to households acquiring bicycles with electric assistance (Altermove, 2018), while others have created infrastructures such as cycling lanes, or changed circulation rules to improve cyclists safety and comfort.

Moreover, the LTECV has introduced the possibility for companies to reimburse the employees travelling to work by bike as they already do for those who commute by car.

Publicly-driven finance supports almost all investments in the sector

Public project managers realised approximately 90% of investments in the transport sector in 2016. In particular, public institutions or publicly owned companies initiated virtually all transport infrastructure projects. Local governments own most public transport infrastructure, such as bus lanes, tramway lines, and make their investments through Transport Organising Authorities (*Autorités organisatrices des transports*, AOT). Public companies such as the Paris transport company RATP, (*Voies Navigables de France*, VNF) and SNCF Réseau (formerly RFF), carried out projects in urban public transport, waterways and railways respectively. The LISEA consortium was the only non-public company acting as a project developer in railway infrastructure for the construction of the high-speed TGV Sud Est Atlantique.

Subsidies, grants and public funds are the principal financing instrument for projects in the transport sector, around reaching €3.4 billion in 2016, i.e. 33% of the total. They come mostly from the central government, the "Agency for Financing Transport Infrastructures in France" (*Agence pour le financement des infrastructures de transport en France*, AFITF) and local governments. In addition to these subsidies, project developers raised debt in the form of commercial bank loans or bonds (€3.3 billion), some concessional loans from the EIB (€0.5 billion) and committed their own funds (€3.0 billion), all of which are often structured at the balance-sheet level rather than the project level.

Urban public transport infrastructure is mostly funded through local governments

Outside the Île-de-France region, the AOTs conduct investments in urban public transport infrastructure. Investments totalled €1.8 billion in 2016. To carry out their investments, the AOTs received subsidies from local governments (€142 million), the central government through the AFITF (€124 million), and from EU funds (€18 million). The EIB also funded local governments or the AOTs with concessional loans corresponding to an estimated €216 million in 2016. The remaining funds came from loans issued by commercial banks (around €650 million) and the AOTs own resources (€600 million) which are partly funded through the revenues of the obligatory transport 'payroll tax' (*versement transport*).

In Île-de-France region, for historical reasons, it is the public company RATP, rather than the AOT, that owns urban transport infrastructure. In 2016, the RATP invested €1.2 billion in infrastructure, mostly tramways and metro lines. Meanwhile, the local transport authority called Île-de-France Mobilités (previously *Syndicat des transports d'Île-de-France*, STIF), funded RATP's investment through grants of €285 million. In addition, grants from local governments (€530 million) and the central government (€60 million) were mobilized. The RATP also borrows from financial markets (€240 million in 2016), to close the gap between its expenditures and its investment resources.

SNCF Réseau receives government support for railway extension and upgrading

While investments from 2011 to 2015 have focused on high speed rail extensions, these projects have come near completion in 2016. Investment in new high-speed lines have dropped from €3.5 billion in 2013 to €1 billion in 2016.

Investments in the upgrading of the existing network represented €3 billion in 2016. This new focus implies a change in the way investments are funded. Indeed, while new high-speed lines relied on local government funding, European grants and in some instances private cofinance through public-private partnerships, the upgrading of existing network was principally funded through an the overarching multiannual grant agreed between SNCF Réseau and the French central government. SNCF Réseau funded the remaining investment through the emission of bonds. In 2016, SNCF Réseau emitted its first "green bond", the proceeds of which were directed towards upgrading rail infrastructure. The long-term debt of SNCF Réseau amounted to €43.6 billion in 2016 (CGDD, 2017h).

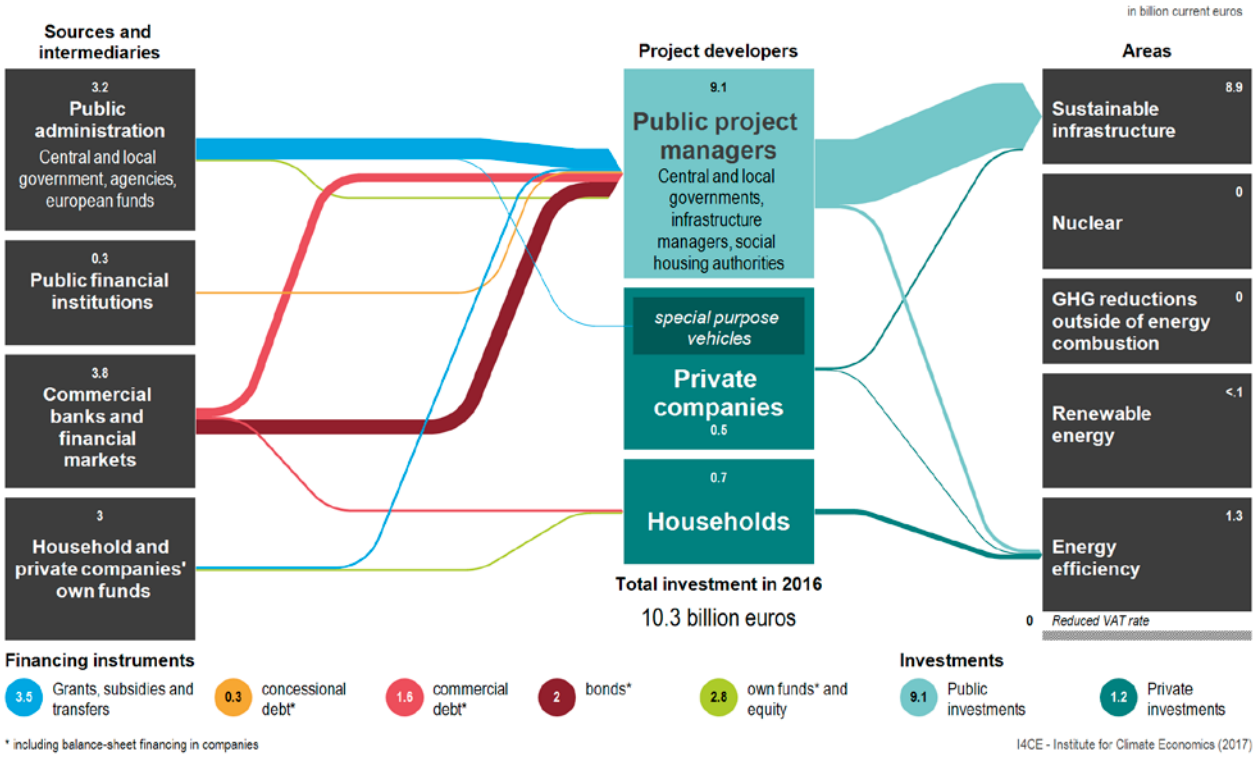
Investments in electrical recharging infrastructures concentrate on fast charging points

From 2010 to the end of 2016, the network of publicly available charging points for electrical vehicles grew to around 15,000 (AVERE, 2017). Installations peaked in 2013 and again in 2016, with more than 3,000 charging points brought into service. The corresponding investments reached around €20 million in 2015 and 2016. Recent installations concern recharging points that are faster and therefore more expensive (see methodology). Local governments represent about two thirds of total investments, with charging stations located on roads and parking spaces. The other third comes from businesses, with charging points in parking lots for shopping areas and offices.

Since 2013, the ADEME has financed a part of the projects through the Government's "Future investments programme" (*Programme des investissements d'avenir*, PIA), with grants totalling €50 million from 2013 to 2017.

Meanwhile, the European Commission supports the "Corri-Door" electrification project launched in 2015 that provides subsidies for the deployment of fast charging stations along the main highway (AVEM, 2016).

OVERVIEW OF CLIMATE FINANCE IN THE TRANSPORT SECTOR IN FRANCE, IN 2016



Analysis and discussion

Changes in fuel prices are not enough to secure rapid low-carbon investment

While energy consumption in the transport sector is sensitive to changes in fuel prices, not all consumers react immediately or in the same way to their increase. Studies based on observations across several decades show that energy consumption in passenger transport decreases faster when price increases last for a long time (Labandeira *et al*, 2016). Studies in the French context have shown that while urban households tend to adapt faster by switching to alternative modes, rural households tend to use their individual car, regroup or cancel their trips altogether. Poorer and intermediate households tend to reduce their consumption faster in response to price increases, while wealthier households tend to keep consuming by increasing their spending on transport (Calvet et Marcial, 2011). Overall, freight is more sensitive than passenger transport to changes in price signals (Bouguerra, 2013).

In the short term, the user of transport services does not only consider the cost of fuel, but also other factors such as the journey time, the certainty of having a means of transport at a given time and for a given journey, or the ability or not to postpone the travel until later. When acquiring an individual vehicle, users are concerned with the price rather than lifetime consumption. Additionally, factors such as security, comfort or the fact that individual vehicles remain a strong social status may drive consumers towards heavier, more powerful and energy-intense cars, despite of their higher price (TNS Sofres, 2014). Because of all these factors, cross price elasticities for various modes of travels, i.e. the variation of the use of one mode depending on a change in price of another mode, vary significantly depending on methods and motives (CGDD, 2016e).

Low and volatile fuel prices fail to deliver a strong investment signal

Although it represents the greater share of environmental taxes, the transport sector is less taxed in France than elsewhere in the EU (CGDD, 2017e). The withdrawal of the *"vignette"* (registration tax) in 2000 and the otherwise low taxes on the registration of new vehicles explain most of the difference with other European countries. In addition, the taxation of fuels, especially for road haulers, does not take into account their environmental impact (CGDD, 2017d). Fiscal rebates and tax reductions on fuels such as aviation kerosene, diesel for agriculture and freight trucks, induce an incentive to use of fossil fuels (*Cour des Comptes*, 2015).

Price instability reduces the incentive to invest in alternative modes because consumers may anticipate increases in fuel prices to be short-lived. For example, the drop in the global oil price between 2014 and 2016 amounted to a 170$/t$CO_2$ reduction in effective carbon rates[9].

To counteract this instability, in 2013 France introduced a carbon component to the domestic tax on the consumption of energy products *(Taxe intérieure de consommation sur les produits énergétiques, TICPE*). The rate of that component is based on the climate and energy contribution (*Contribution climat-énergie*, CCE). While amounts collected in this respect in 2016 represented only 0.11% of annual household income (CGDD, 2016d), the trajectory set in the LTECV and revised by the 2018 budget bill will see costs increase from €22/tCO_2 in 2016 to €65/tCO_2 in 2020 and €86/tCO_2 in 2022 (PLF 2018).

European standards improved the energy efficiency of individual vehicles, with a few caveats

As far as electric vehicles are concerned, in the absence of a supporting policy on incentives, the additional cost of purchasing the battery for rechargeable hybrid electric vehicles discourages buyers (IAU, 2016). Electric and hybrid drive systems have developed in niche markets, such as taxis in city centres or light buses on short urban routes. In a lifetime cost approach, from the user's point of view, electric and hybrid vehicles are generally less expensive than the combustion engine alternatives when the annual mileage is high, but the distances covered in individual trips are short (CGDD, 2011; France Stratégie, 2016). Economies of scale offer prospects of growth for these types of vehicles. However, other factors relating to the uncertainty of having sufficient range or finding a suitable recharging point, may continue to discourage potential buyers (AVERE, 2016).

European car manufacturers are subject to standards restricting the emissions of new car models. From 130gCO_2/km in 2015, the target for average new vehicles progresses each year to reach 95gCO_2/km in 2020. Manufacturers can chose which models they sell as long as the average of their sales meets the annual standard. However, the standard is corrected against the weight of the vehicles sold, with higher levels of emissions being tolerated for heavier vehicles. This has discouraged reductions in vehicle weight, even though it is major a source of energy efficiency (RAC, 2013). Furthermore, electric vehicles, which already benefit from government subsidies, are also double-counted when calculating the average emissions in manufacturer sales. This reduces the standard's efficiency for eliminating vehicles with the highest emissions.

Lastly, while conventional consumptions by vehicles are decreasing, they also do not reflect driving consumptions since they exclude the driver's behaviour and the use of energy-intensive accessories and equipment: air-conditioning, radio or media devices (TE, 2015; ICCT 2016).

Among the alternatives to road transport, rail and urban public transport require substantial investments

Historical alternatives of transporting passengers via road - the train and urban public transport - have been given substantial investments, increasingly since 2010 (CGDD, 2017h).

Public transport: the increase in costs reflects the spread of networks into suburban areas

There is generally a link between investments in urban public transport and their increased use (CGDD, 2016h). However, greater use of public transport systems can also be achieved through a better anticipation of urban journeys, and flexible transport services (MEDAD, 2008). Between 2008 and 2013, conurbations engaged in extending their public transport networks have extended the areas that they service to surrounding suburbs. In a majority of such territories, the density of population was lower and the distances to be travelled were greater than in city centres. As a result, the increase in operating expenses was therefore faster than the increases in main revenues such as the transport levy and subsidies from local authorities (Court of Auditors, 2015). This results in a reduced capacity to

9 In 2016, the OECD published a report on "effective carbon rates" (see OECD, 2016). Effective carbon rates consider all levies paid by consumers on fossil fuels, including taxes that may not be labelled as "carbon" taxes.

invest, which weighs on the capacity to develop this range of transports. Because of this, regional planning choices, in particular those that limit urban spread and encourage the concentration of new constructions, play a fundamental role in the ability of local authorities to propose alternative mobility offers to the individual car (CGEDD, 2017a; CGDD, 2016e).

Rail: investments are carried by both the user and taxpayer

While the debate on the quality and relevance of the railway offer, for passengers or goods, goes beyond the context of this study[10], it is nonetheless necessary to tackle existing tensions in the investment financing model. While the rail projects identified in the French national transport infrastructure plan (SNIT) in 2011 represented an investment of €67 billion over 25 years (MEDDE, 2011), the financing capacity of the three key players (Government, local authorities, and infrastructure manager SNCF Réseau) currently appear today to have reached their limits (Mobilité 21, 2013).

Several major difficulties are revealed by an assessment of the investment policy:

- In terms of investment strategy formulation, requirements are not explicitly broken down between development of new lines and modernisation of the existing network. In the context of ageing existing infrastructures, the latter becomes particularly important (Mobilité 21, 2013).
- The allocation of financial effort between key players is defined late into the process of formulating and implementing projects (Court of Auditors, 2016a). Opening up the financing of the investment to private funds, as for example the LISEA consortium, involves the risk that comes with operating the lines (Sénat, 2015).
- This operating risk is even more critical since the ex post assessment of several recent projects has demonstrated a propensity to underestimate the construction costs and overestimate traffic usage, by around 20% on average above and below initial studies (Sénat, 2015).

The final financial effort is shared between the user (passenger and goods) and the taxpayer, with the latter generally assuming final responsibility for the weight of the debt incurred in projects. In the rail sector, the breakdown is very variable depending on the operating system: TGV, TET or TER lines (Sénat, 2015).

While the development and maintenance of the rail network continues to be the subject of major government support due to the risk profile of projects and the socio-economic benefits that are associated with it, its current method of financing needs to change so that the necessary investments can be made.

Soft transportation modes

Soft transportation modes include walking, cycling, kick scooters and other individual small vehicles with or without electric assistance. The development of these modes required adequate infrastructure, for example in the form of cycling lanes. In general, investment in this infrastructure is funded through local government budgets.

Uncertainty regarding the deployment of innovative transport methods is delaying large investments

New innovative transport methods may be able to unlock significant potential for energy efficiency: carpooling, mobility services for businesses, car sharing, cycles or privately-owned vehicles in free access in conurbations, etc. In the longer term, the arrival of autonomous vehicles, for individual or collective transport systems, may also shake up mobility practices[11].

The economic models of these innovations are very diverse today but generally target a combination of the following factors:

- The end of the individual ownership of the vehicle as a prerequisite to mobility allows significant savings to be made on expenditures for the purchase of vehicles.
- The optimisation of journeys through driverless vehicles or other forms of connectivity allows for better energy efficiency while driving, for example by limiting congestion.

10 For components of the framework on the rail offer for passengers, see Mobilité 21, 2013, the report from the Court of Auditors on "High speed rail" (Court of Auditors, 2016a), or again the report on Trains for territorial balance (Commission TET, 2015). On the transport of goods, see "Public support for the rail transport of freight" (CGEDD, 2015) and the study "Rail freight": analysis of deciding factors for French and German traffic" (CGDD, 2013d).

11 For more information on the potential impact of autonomous vehicles on the energy efficiency of the transport system, see RAND, 2016, *Autonomous Vehicle Technology, a Guide for Policymakers* and Snyder, 2016, *Implications of Autonomous Vehicles: a Planner's Perspective*. We have not identified any study that applies such concepts to the French context.

- An increase in the load rate or usage rate of vehicles, reducing the total number of journeys necessary for a given level of mobility.

Great uncertainties remain over the future of these transport methods. User practices change rapidly, which can invalidate investment choices made on one or other of the innovations. The regulatory framework of these applications is not currently well known, as well as the reality of their potential above and beyond the first pilot applications launched. Because they benefit from public support for innovation deployment, they currently attract individual investors via the venture capital model. To benefit from a large-scale roll-out, these models need to demonstrate that they accompany a sound economic model.

Methodology

Choices of vehicles and modes selected in the Landscape reflect those in several national and international studies (CPI, 2013 and 2015b; MDB Group, 2014; HLEG 2018) as well as national priorities identified by the Mobilité 21 report (Mobilité 21, 2013).

Vehicles

Electric and plug-in hybrid cars

Climate investment in the renovation of tertiary buildings		Sources
Inclusion criteria	We consider light-duty road vehicles that emit less than 60g CO_2/km, which includes electric and hybrid cars. Although new vehicles do not fall within fixed capital in terms of national accounting, they are nevertheless durable goods due to their long lifetimes (around 15 years).	
Screening metrics	We were able to track the sales of vehicles per category (listed below) as reported by the Association for the development of electric mobility (*Association pour le développement de la mobilité électrique*, AVERE France) and the ADEME: • 100% electric vehicles; • gasoline-electric hybrid vehicles; • diesel-electric hybrid vehicles; • plug in hybrid vehicles.	AVERE, 2015 ADEME, 2017f
Number of projects	We track the yearly sales of each low carbon vehicle model as reported by the AVERE and Automobile Propre.	AVERE, 2015 Automobile Propre, 2018b
Cost of projects	In order to identify the weighted average unitary cost of acquisition of low carbon vehicles (in thousand euros), we weigh the yearly sales of each vehicle, reported by the AVERE, with their respective unitary cost (in thousand euros VAT, excluding bonuses) provided by the website *Automobile Propre*. The total amount of realized investment for the deployment of low emissions vehicles is thus calculated by multiplying the calculated weighted average cost with the total yearly sales of low emissions vehicles sold in France during the year.	AVERE, 2017 Automobile Propre,2018b
Attribution to project developers	Investments in low carbon emission vehicles are carried by three different project developers: • Private households, with the acquisition of individual hybrid and electric vehicles. • Local governments, with the acquisition of hybrid and electric vehicles. • Private companies, with the acquisition of low emission vehicle corporate fleets and low emission car-sharing services. Based on interview with experts, we distribute the acquisition of low carbon vehicles amongst professionals and private individuals. For example, private individuals represented 30% of low emissions vehicles sales in 2011, against 67% in 2017. Within professionals, we categorize between car sharing services and other professional buyers. Car sharing services are associated with the sales of the "Bluecar model". The rest of the sales were further equally divided between local governments and the private sector. This allows us to estimate the distribution of low carbon vehicles acquired by local governments, the private sector, individual households, and car sharing services.	AVERE, Interview with experts

Climate investment in the renovation of tertiary buildings		Sources
Ecological bonus	The amounts provided under this grant system to the buyers of low-carbon vehicles before 2013 are documented on the basis of the special fund accounts (*Compte d'affectation spéciale*, CAS) dedicated to the support of electric vehicles sales. The CAS is published annually as an annex to the budget law. For grants delivered after 2013, we use annual budget administration reports from the Court of Auditors (*Cour des Comptes*). Complementary information on the impact of the grant program was also derived from an evaluation conducted by the CGDD.	PLF, 2011 to 2016 Cour des Comptes, 2014a CGDD, 2013c
Leasing	Experts interviewed at AVERE observed that a very large majority of electrical vehicles were leased rather than purchased upfront. To represent the practice of leasing, we considered that the remaining initial cost that was not covered by the Ecological bonus to be financed through a commercial bank loan.	AVERE, interview with experts

Bicycles

Climate investment in bicycle and cycling infrastructure		Sources
Inclusion criteria	Equipment (bikes) and infrastructure (lanes) that support the development of soft transport modes are considered in the Landscape. This characterizes modes of transport without engines such as walking or cycling.	
Screening metrics	We track the number of individual bicycles, electric bicycles (VAE), bicycle sharing (VLS) terminals and bikes deployed, and the length of cycling paths built from the ADEME reports. The network of cycling paths includes: advisory cycle lanes, contra flow lanes, cycle lanes, dedicated cycle tracks, parking, cycle routes, greenways, car free zones and 30 km/h zones. Another study by ADEME details 6 activities within bike services: bicycle sharing, bike rentals, electrically-assisted bicycles subsidy, bike school, bike workshops, and intermodality. However, since the first activity holds the best coverage, the Landscape focuses on the investments realized in this activity.	ADEME, 2016f ADEME, 2016c
Number of projects	Regarding bicycle sharing services, the Landscape estimates investment expenditures (in euro million) by combining data reported by the ADEME on the construction of stations and the acquisition of bicycles. As for individual bikes, the ADEME tracks the number of bicycles (in thousands) sold and the unitary cost (€/bike) for three different sub-categories: city bicycles, electric bicycles, and folding bicycles. We hypothesize the number of cycling path kilometers established for each year by using a linear interpolation of the total cycling path length observed in 2006 and 2017. The 2006 data was published by the French tourism development agency, Atout France, while the 2017 data was released by a crowdsourced map, OpenStreetMap.	ADEME, 2016f Atout France, 2009 OpenStreetMap, 2017
Cost of projects	We use data published by the ADEME to multiply the number of vehicles sold (in thousands) with the corresponding unitary price (€/bike) for each type of bicycle (city bike, electric bicycles other than mountain bikes, and foldable bikes) to identify the total annual cost of acquisition (in euro million) for each type of bike. Investment (in euro million) for the extension of the cycling path network are the product of the unitary cost of bicycle path infrastructure and the number of cycling paths kilometers established each year. To measure the unitary cost (€/km) of bicycle path infrastructure we considered costs for each type of cycling path infrastructure (advisory cycle lanes, contra flow lanes, cycle lanes, dedicated cycle tracks, cycle routes, greenways, car free zones and 30 km/h zones) reported by the French Tourism development agency and the Ministry for the environment. We assumed the average unit cost was in the lower range of the costs provided by that agency as the costlier infrastructure types occur relatively rarely.	ADEME, 2016f Atout France, 2009 CGDD, 2015a
Attribution to project developers	Investments for the development of bicycle equipment and infrastructures are carried by two different project developers: • Households carry the investments for the acquisition of bicycles and electric bikes; • Local governments carry investments in bike sharing services, along with the construction of bicycle path infrastructures.	

Low-emissions commercial and heavy-duty vehicles

Climate investment in commercial and heavy-duty vehicles		Sources
Inclusion criteria	We consider low-emissions commercial and heavy-duty vehicles with a maximum authorized mass greater than 1.5 tons in the Landscape. This includes electric and hybrid vehicles such as buses, coaches, trucks, vans, and light good vehicles (LGVs).	
Screening metrics	We included the low carbon vehicles per following category: • 100% electric; • Diesel-electric; • Natural gas vehicle (NGV).	
Number of projects	We were able to track the yearly sales of vehicles as reported by the Sustainable Development Ministerial Statistical Department (*Service de la donnée et des études statistiques*, SDES), the AVERE, and from the websites Gaz mobilité and Actu transports.	CGDD, 2017f AVERE, 2015 Gaz Mobilité, 2017 Actu transports, 2017
Cost of projects	To calculate the amount of investments realized in euro million, we identify the unitary cost in euros of each vehicle and multiply it with its respective sales: • The unitary price for buses powered by hybrid diesel electric, 100% electric, and NGV fuel sources is reported by Gaz Mobilité, while sales are reported by the SDES. • For electric LGVs, the unitary price is estimated by averaging the three most sold vehicles reported by Automobile Propre, while the sales are reported by the AVERE. • For NGV LGVs, we calculate the average unitary price from the vehicle prices reported by the Natural & bio gas vehicle association (NVGA), while sales are reported by Gaz mobilité. • For NGV trucks, the unitary price is estimated by averaging the two most sold vehicles reported by Europe Camions and Actu transport, while the sales numbers are also reported by the latter and Gaz mobilité.	Gaz Mobilité, 2016 CGDD-SDES, 2017f Automobile Propre, 2018a AVERE, 2015 NGVA, 2017 Gaz Mobilité, 2017 Europe Camions, 2017 Actu transports, 2017 Gaz Mobilité, 2017
Attribution to project developers	Investments in low-emission commercial and heavy-duty vehicles are carried by three different project developers: • Outside of the Ile de France region, transport organization authorities, acquired the 100% electric, hybrid and GNV buses. • In the Ile de France region, we assumed that all investments in the acquisition of hybrid and GNV buses, since all of the projects that we were able to document individually were carried out in Paris, where RATP holds the public monopoly on collective transport. • Private companies, with the acquisition of electric and GNV LGVs, and GNV trucks.	

Low-emissions refuse collection vehicles (RCVs)

Climate investment in refuse collection vehicles (RCVs)		Sources
Inclusion criteria	We consider low-emissions Refuse collection vehicles (RCV) in the Landscape.	
Screening metrics	We included RCVs powered by electric and hybrid sources.	
Number of projects	We were unable to identify a comprehensive source on the total number of RCVs sold annually in France. Our methodology tracks individual projects set up by local government. For each project, we collect -the number of vehicles acquired, the year of completion, and the total cost. We documented projects by scanning various news sources such as Actu Environnement, Le Parisien, and 20 minutes, reports from associations such as the AVEM (*Association pour l'avenir du véhicule électro-mobile*), reports from the ADEME, local governments, and private corporations such as SUEZ.	Le Parisien, 2016 Actu Environnement, 2011, AVEM, 2015 ADEME, 2012 Longjumeau, 2011 Suez, 2011
Cost of projects	We were able to track the reported total cost of acquisition for some projects, which allowed us to estimate the average unitary cost of 100% electric and hybrid RCVs. In the case of NGV RCVs, 900 units were in use in 2017 according to GNVolontaires, but the lack of data on yearly sales did not allow us to derive annual investments.	AVEM, 2012 ADEME, 2012 GNVolaire, 2017
Attribution to project developers	We attribute investments in low carbon emission RCVs to local governments.	

Infrastructure

EV charging infrastructure

Climate investment in EV charging infrastructure		Sources
Inclusion criteria	The installation of charging infrastructures that support the development of low carbon emissions vehicles are considered in the Landscape, namely the Electric vehicle charging stations (EVSE) that supply electric energy to hybrid and electric vehicles.	
Screening metrics	We were able to build an annual series of installed EVSEs from the data published by the AVERE. Based on interview with experts, we assume that each charging station holds two charging points.	AVERE, 2016a Interview with AVERE expert
Number of projects	We distinguish three types of charging stations and distribute EVSEs according to the data reported by the AVERE, which allows us to build a series of additional annual installations for each type: • Standard charging stations (up to 11 Kw); • Accelerated charging stations (from 11 to 22 Kw); • Fast-charging stations (more than 22 Kw).	AVERE, 2014b
Cost of projects	We estimated the unitary cost of EVSE installations by averaging the price ranges obtained in interview conducted with AVERE experts: • 7.5 thousand euros per Standard charging station; • 10 thousand euros per Accelerated charging station; • 40 thousand euros per Fast-charging station. We multiplied the unitary costs (in euros) with the respective number of annual installations (in units) to identify the amount of investments realized.	Interview with AVERE expert
Attribution to project developers	Based on AVERE reports, investments in EVSE installations are carried by two different project developers: • Local governments; • Private companies. Since the AVERE reports on general EVSE installations established in 2015, we derive the distribution of project developers for all subsequent years from this data.	

Urban public transport

Climate investment in urban public transport		Sources
Inclusion criteria	We consider investment made in urban public transport infrastructure, such as railways for urban tramways and bus lanes. The rationale for inclusion is that such works extend the ability of urban public transport to replace individual vehicles in and around city centres. In 2013, a commission set up by the Ministry of the environment in order to identify the long-term strategic investments needed in the French transport system concluded that urban public transport had to play a major role in reducing the use of cars in cities. Note: the acquisition of conventional rolling stock was not included due to the difficulties in identifying the proportion of expenditure that corresponds to improvement in its energy efficiency, compared to a simple renewal of the stocks.	Mobilité 21, 2013
Screening metrics	We include all urban public transport infrastructure projects reported by the Ministry of the environment in the Transport Accounts (*Comptes des transports*). We were unable to sort between projects based on ex-ante or ex-post evaluations of their contribution to CO_2 emission reductions, given the large number of projects conducted every year and, for some projects, the difficulty to access to the detailed reports of such evaluations.	CGDD, 2017h
Expenditures	Expenditure for urban public transport infrastructure is reported in the Transport Accounts and includes two sub-groups : • Projects in the Île-de-France region; • Projects in the rest of France. Projects in the Ile de France region are further divided between those undertaken by the public company RATP (metro, tramways, bus lanes) and those undertaken by public company SNCF Réseau (suburban railways part of the national railway network). It is important to note that the latter amounts (SNCF Réseau's expenditures) are reported twice in the ministry's Transport Accounts since they also correspond to railway infrastructure investments. Since the 2016 Edition of the Landscape, these expenditures are included in the railways section, due to their financing mechanism being similar to other railway lines.	CGDD, 2017h
Attribution to project developers	Spending in urban public transport in the Ile de France region was attributed to the public company RATP, based on cross-checking the amounts from the Transport Accounts with the ones reported in annual financial reports of the RATP. Spending in urban public transport in the rest of France was attributed to the "local transport authorities" (*Autorités organisatrices des transports*, AOT). The AOT are public bodies formed by the association of one or more local governments in order to manage public transport systems in a metropolitan area. In the Landscape Sankey diagram, they are part of the local governments intermediary block.	RATP, 2011 to 2014

In terms of financing of investments in urban public transport infrastructures, data is taken from the Comptes des transports (CGDD, 2017h). For the urban public transport in Île-de-France, the received amounts of financing for projects are given by *Île-de-France Mobilités*' annual reports and the RATP's financial reports. Subsidies paid to transport companies are estimated using the annual survey carried out by the Groupement des autorités responsables de transport (GART, 2012 to 2014).

Given the complex structure of financing, it was not possible to separate the financing of infrastructures from the overall financing of investments (rolling stock, IT, etc.). This method may potentially underestimate state contributions (particularly from the AFITF) which, in principle, mainly pertains to infrastructures. (AFITF, 2013, 2014a, 2015a, 2015b).

Railways

Climate investment in railway infrastructure		Sources
Inclusion criteria	Investments in the extension and the upgrade of railway lines are considered in the Landscape.	
Screening metrics	We track investments in railways reported in the national transport accounts (*Comptes des transports*).	CGDD, 2017h
Expenditures	Investments reported in the national transport accounts are reported to the MTES by infrastructure management company SNCF Réseau. These investment include material investment on equipment, as well as some intangible investment, especially in software designed to manage the circulation of trains. We were not able to distinguish between material and immaterial investments and thus considered all reported investment in the scope of this study. It is to be noted that investments in railway lines of the Île-de-France region appear as urban public transport investment, because of their strong interaction with programs developed at this regional scale.	CGDD, 2017h
Attribution to project developers	Investments for the upgrade of the railway network were attributed to SNCF Réseau. Investments for the creation of high-speed rail *"Sud Est Altantique"* were attributed to the private consortium LISEA.	LISEA; 2015

Sources of finance for railway investment include information from SNCF Réseau's financial reports (SNCF Réseau, 2015; RFF, 2011b, 2012 to 2015). In addition to that, the report of the Cour des Comptes (*Cour des Comptes*, 2013), the annual budget of the AFTITF (AFTITF, 2013, 2014a, 2015a, 2015b) and the descriptive sheets of the projects as the LGV (see RFF, 2011a; LISEA, 2015) describe the finance for high-speed rail projects. In 2016, SNCF Réseau emitted bonds, including one green bond, to fund some investments in its railway infrastructure.

Waterways

Climate investment in inland waterway transport		Sources
Inclusion criteria	Investments in inland waterway transport are considered in the Landscape as they support the modal shift from road or air to water. The development of projects that avoid CO_2 emissions in this sector is characterized by the transport of freight and passengers on rivers.	
Screening metrics	We track inland waterway investments from data produced by the Navigable Waterways of France (*Voies navigables de France*, VNF) and reported by the General commission for sustainable development of the Ministry for an ecological and solidary transition.	CGDD, 2017h
Attribution to project developers	We consider that the inland waterway infrastructure manager, the VNF, entirely carries the development of projects.	

Maritime

Climate investment in Maritime transport infrastructure		Sources
Inclusion criteria	Maritime transport infrastructure projects in France are considered in the Landscape, as they support the modal shift from road or air to water transports. For example, development of low-carbon infrastructure in maritime transport includes the building of new docks, the electrification of existing docks and the improvement of intermodal connections.	CGDD, 2017h Ports de France, 2018,
Screening metrics	We track maritime investments from data reported by the General commission for sustainable development of the Ministry for an ecological and solidary transition. This includes investment spending in euro million for French maritime ports realized for the development of maritime infrastructures.	CGDD, 2017h
Attribution to project developers	We attribute all the investments to the French port authorities, a sub category of infrastructure management companies, part of public project managers.	

RESULTS > SECTORS

Agriculture

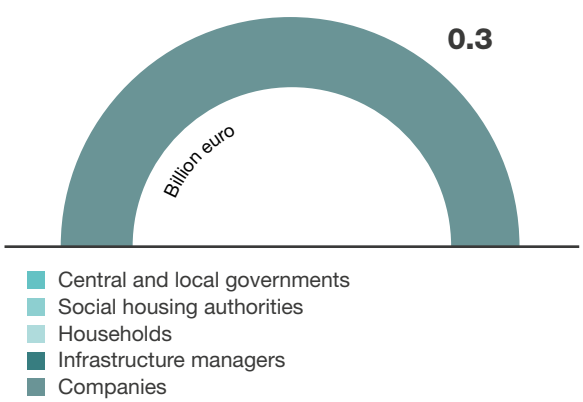
In the agriculture and forestry sectors, climate investments were estimated to be around €300m in 2016, i.e. just 1% of all climate investment covered in the study. Since publicly available data was fragmented, only investments relating to energy use and the development and improvement of forestry management could be estimated. Project developers active in these sectors used principally government grants and debt to finance their investments.

€0.3 billion invested in 2016

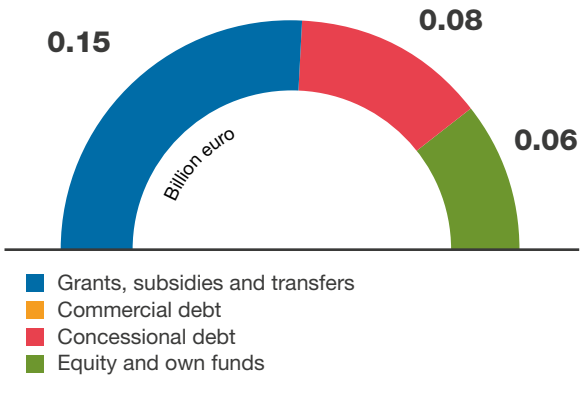
€0.5 billion
In 2011

€0.3 billion
In 2017 (projections)

WHO MAKES THE INVESTMENTS?

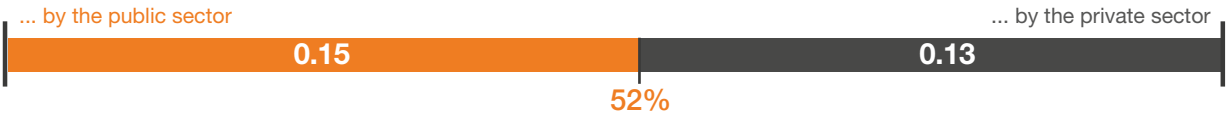


HOW WERE THEY FINANCED?



WHAT WAS THE ROLE OF THE PUBLIC SECTOR IN MOBILIZING FINANCE?

In 2016: 52% of the sector's finance was driven



(In billion euros, see p.92 for more detail)

EVOLUTION OF CLIMATE INVESTMENT IN AGRICULTURE AND FORESTRY

(in million current euros)	2011	2012	2013	2014	2015	2016	2017p
Energy efficiency	79	145	119	120	120	120	120
Renewable energies	311	152	140	124	111	90	107
of which photovoltaic solar	259	81	74	72	59	38	55
of which biomass	14	26	22	22	22	22	22
of which AD plants (biogas)	37	44	45	30	30	30	30
Forestry	70	70	70	70	70	70	70
Total	**459**	**367**	**330**	**314**	**301**	**280**	**297**

P = provisional figures.; AD plants refer to plants converting biogas obtained from anaerobic digestion of farming residue into electricity

Context

In 2016 the agricultural sector represented just 3% of final consumption of energy, but 20% of greenhouse gas emissions (CITEPA, 2017; SDES, 2018). Emissions for the sector have been stable since 1990. The sources of these emissions are diffuse and spread across cultivation and livestock management. Carbon dioxide (CO_2) from fossil energy combustion represent around 10% of the sector's GHG emissions, while nitrous oxide (N_2O) from nitrification and denitrification processes represent around 50%, and methane (CH_4) from fermentation under anaerobic conditions around 40% (see INRA, 2013). Many difficulties remain in the measurement and monitoring of these emissions, due in particular to the scattered nature of the sources.

In anticipating emission reduction potentials for different economic sectors in France, the *Trajectoires 2050* report estimates that to reach the national objective of diving emissions by four compared to 1990 levels, the agricultural sector needs to reduce its emissions by 50% in 2050 (CAS, 2011). Although this represents a lower reduction in emissions than those envisaged for energy processes, the expected contribution from the agricultural sector involves substantial transformations.

In 2016, French woodlands acted as a carbon sink sequestering 36 $MtCO_2eq$, i.e. approximately 8% of the country's gross emissions. The capacity of this carbon sink has increased since 1990, in association with the extension of woodland cover and the improvement of forestry management.

While investments in the adaptation to climate change are not covered in this report, the agriculture and forestry sectors are particularly exposed to the impacts of climate change. As a result, addressing adaptation issues in these sectors are central (MAAF, 2013a; RAC, 2014).

The policy frameworks and objectives addressing climate-related issues in the agriculture and forestry sectors are the result of both French national and European legislation.

The National Low-Carbon Strategy promotes agro-ecology in the agricultural sector

The French National low-carbon strategy (SNBC) proposes a strategy of agro-ecology consisting of basing production systems on functionalities of ecosystems to reduce pressures on the environment. The transformation of agricultural production systems proposed in the SNBC involves:

- the reduction of N_20 and CH_4 emissions;
- the increase of carbon storage in soils and biomass;
- the production of energy from biomass, which can take the place of fossil energies in agriculture and other sectors (SNBC, 2016).

Agro-ecology also requires a sustainable land management approach, which aims to halt and reverse the tendency for agricultural land to disappear to the benefit of other uses.

The European Common Agricultural Policy includes climate-friendly criteria

The Common Agricultural Policy (CAP) constitutes the main framework for European, national and regional government action in the agricultural sector. In 2013, the European Union adopted a new regime for the 2014-2020 period, disposing of close to €400 billion over five years (European Commission, 2013). This plan provides for a strengthening of the environmental requirements, in the form of a set of basic requirements, applicable to all CAP payments, and a direct "green" payment for farmers who comply with practices such as the maintenance of permanent grazing, the conservation of ecologically significant areas and the diversification of crops. However, ex-post assessment of the climate impact conduced over the previous period of the CAP (2003-2013) show that despite an overall positive result, interactions between the grant regimes and the practices implemented by farms remain complex[12].

The reduction of agricultural GHG emissions nevertheless depends on consumer behaviour

Since food is the main output of the agricultural sector, the SNBC proposes changes in eating habits that are desirable from a climate change perspective. Such changes include the reduction of food wastage, the development of local and seasonal supply chains, and an increased consumption of legumes. Animal products, while produced in lesser quantities, could evolve better quality instead (SNBC, 2016).

Maximising the contribution of the forestry and wood sector to climate mitigation

There is less regulation and policy directly addressing climate mitigation in the forestry sector. Drivers for climate mitigation in the forestry sector are linked to management practices currently exercised by a large number of small-scale woodland owners. Nevertheless, a number of mitigation actions are linked to areas that policy actions

12 On this subject, see in particular I4CE, 2015b, Climate Study N°49, The previous Common agricultural policy (2003-2013) reduced french agricultural emissions, M. Baudrier, V. Bellassen, C. Foucherot.

could foster: carbon sequestration in woodland, carbon storage in wood-based products, and the use of wood for replacing fossil energy combustion or the use of energy-intensive materials (CDC Climat, 2010).

The French SNBC includes recommended measures for both upstream and downstream stages of the forestry sector. For the upstream stages, the main recommended measures include the continuation of plantation investments (afforestation and reforestation) and the strengthening of sustainable management on managed plots. This will allow for an increase of wood removals, particularly in unmanaged woodlands, while preserving the long-term carbon sequestration capacity of the woodland (CGEDD, 2017b; SNBC, 2016).

In the downstream stages, an improved hierarchy of wood uses is recommended, notably towards a increased use of wood as a building material. However, the use of wood as an energy fuel is also hoped to make a significant contribution to the national renewable energy consumption objectives (SNBC, 2016; SNMB, 2018). It is thus important to take into account all possible uses of the wood resource.

Methodology

Monitoring climate investments in the agriculture and forestry sectors presents a number of challenges. Since most projects are realised by private companies, they are not reported to public institutions outside of specific investigations. In addition, certain climate-friendly actions require little investment, but rather changes in management practices or additional manpower, typically resulting in higher operating costs rather than capital investment. Lastly, the monitoring of central government grants for energy efficiency has been handed over to the decentralized Regional Councils in 2014, which has impeded the aggregation of national statistics to this date.

The INRA identified numerous actions resulting in GHG emission reductions

In 2013, the French National Institute for Agricultural Research (*Institut National de la Recherche Agronomique*, INRA) published a study on the contribution of French agriculture towards the reduction of greenhouse gas emissions (*Contribution de l'agriculture française à la réduction des émissions de gaz à effet de serre*, see INRA, 2013). This study groups the priorities for reducing emissions into four main categories:

- Reduction of inputs of mineral nitrogen fertilisers;
- Storage of carbon in the soil and biomass;
- Modification of animal feeds;
- Recycling of waste in order to produce energy and reduce the consumption of fossil energy by farms.

Based on the available sources and advice from experts interviewed, the 2016 edition of the Landscape has examined which agricultural investments would be necessary for each action and sub-action described in the study. The following table summarises the key conclusions of this approach.

EXAMPLES OF INVESTMENTS RELATING TO THE IMPLEMENTATION OF CLIMATE-RELATED ACTIONS IDENTIFIED BY THE INRA IN THE AGRICULTURAL SECTOR

Actions examined by the INRA study	Potential for reduction by 2030	Nature of investments required for implementing such actions	Possible financing sources for these investments
(1) Reducing the use of synthetic mineral fertilisers • Reducing the amount of mineral fertiliser • Replacing mineral nitrogen with organic nitrogen • Delaying the date of the first input of fertiliser until spring • Using nitrification inhibitors • Burying and targeting fertilisers in the soils	6.09 $MtCO_2eq$ (N_2O)	• Realising a study on nitrogen balance, including, if applicable, specialised software for such studies. • Obtaining nitrification inhibitor additives. • Obtaining fertilisation utilities with burier.	Possibly, grants from CUMA (French agricultural machinery cooperatives)[1] and from EEIGs[2] for carrying out nitrogen balance studies.
(2) Increasing the proportion of leguminous plants as an arable crop and in temporary grasslands	1.39 $MtCO_2eq$ (N_2O)	• Purchasing seed. • Research and development on suitable seeds and varieties. • Tools and equipment for storage.	"Plan protéines végétales". Coupled grants from CAP and PCAE[3]. Private financing of seed companies for R&D.

Actions examined by the INRA study	Potential for reduction by 2030	Nature of investments required for implementing such actions	Possible financing sources for these investments
(3) Developing zero till cultivation techniques	3.77 $MtCO_2eq$ (CO_2)	• Obtaining equipment.	No investment assistance has been identified.
(4) Introducing more intermediate crops, relay crops and grass strips	3.04 $MtCO_2eq$ (CO_2 and N_2O)	• Purchasing vegetable seed. • Establishment of intermediate crops or turfing. • Specific equipment for maintenance and cultivation.	Conditional grants from CAP "maintenance of topographical features" for grass strips around waterways.
(5) Developing agroforestry and hedges to encourage carbon storage in the soil	2.78 $MtCO_2$ (CO_2)	• Background and understanding on the conditions beneficial to agroforestry. • Purchasing seed and plant material • Planting trees and hedges. • Specific equipment for maintenance and cultivation.	Grants in respect of PDRH[4] and Plan Végétal. Regional agri-environmental measures up until 2013. Since 2014, conditionality of grants from CAP and "green payment" for ecologically significant areas.
(6) Optimising the management of grasslands	2.55 $MtCO_2$ (CO_2 and N_2O)	No specific investment has been identified, but there are opportunity costs related to changes in the way grasslands are used.	No investment assistance has been identified.
(7) Replacing carbohydrates with unsaturated fats and using an additive in rations for ruminants	2.37 $MtCO_2eq$ (CH_4)	Obtaining a mixer for the preparation of rations.	No investment assistance has been identified.
(8) Reducing protein intake in animal rations	0.71 $MtCO_2eq$ (N_2O)	Obtaining a mixer for the preparation of rations.	No investment assistance has been identified.
(9) Developing anaerobic digestion plants and installing flares on manure storage areas	9.56 $MtCO_2eq$ (CH_4)	• Obtaining and installing the biogas plant and ancillary equipment, connection to the electricity network. • Regular maintenance and servicing of the biogas plant. • Obtaining and installing watertight covers for holding tanks, installing flares.	Feed-in tariffs on electricity generated from anaerobic digestion. Feed-in tariffs for the direct injection of methane. No grant specific to the installation of flares has been identified.
(10) Reducing the consumption of fossil energy by agricultural buildings and equipment	1.89 $MtCO_2eq$ (CO_2)	• Obtaining efficient heat exchangers (radiant and fan). • Insulation of livestock buildings, thermal panels. • Insulation of hot water tanks. • Heat recovery equipment on milking lines. • Bench testing for tractors. • Eco-driving training.	Energy efficiency measures were covered until 2013 by the Energy performance plan via measures in the PDRH. Energy savings certificates. Bench testing helped by certain Regional Chambers of Agriculture[5]/Collectives for the development of agro-ecology[6].

(1) CUMA: Coopérative d'utilisation de matériel agricole / French agricultural machinery cooperative.
(2) EEIG: Economic and environmental interest group.
(3) PCAE: Plan de compétitivité et d'adaptation des exploitations agricoles / Competitiveness and adaptation plan for farms.
(4) PDRH: Programme de Développement Rural Hexagonal / Rural development programme for metropolitan France.
(5) CRA: Chambre régionale d'agriculture / Regional chamber of agriculture.
(6) CDA: Communauté d'agglomération / Urban community.

Sources: authors, according to INRA, 2013; CGAAER, 2015; MAAF, 2015, and interviews with experts

This table only covers the most direct investment expenditures: purchase of equipment and, as applicable, specific training. Certain indirect expenses that may occur at times prior investments that are included, such as access to information or equipment suppliers, are not assessed. In addition, while certain actions do not require substantial investment expenditures, they can nonetheless be discouraged by high opportunity costs. For example, switching crops to legumes is unattractive due to their relative lower profitability compared to other crops. The INRA study calls for a more in-depth analysis of the costs and benefits of each action. Lastly,

certain instruments supporting investment, in particular those distributed by regional and local governments, are not well documented and do not appear in the table.

The Landscape covers investments made in energy efficiency, the production of renewable energy and forestry

For energy efficiency, investments are estimated up until 2013 on the basis of actions identified by the Energy performance plan (*Plan de performance énergétique*). This plan, initiated in 2009, encourages investments in the energy efficiency of buildings, livestock equipment, greenhouses and agricultural vehicles. It also supports the purchase of renewable energy equipment such as solar water heaters, biomass boilers, heat pumps, as well as on-farm anaerobic digestion plants. Actions in respect to the plan are summarised in the Rural development programme for metropolitan France (*Programme de développement rural hexagonal*, PDRH).

The General council on food, agriculture and rural areas (*Conseil général de l'alimentation, de l'agriculture et des espaces ruraux*, CGAAER) produced an assessment report of the Energy performance plan. Based on this report, we estimate investments supported by a combination of government aids in the form of subsidies. Grants from the central government, local authorities and the European Agricultural Fund for Rural Development (EAFRD) cover on average 45% of the investment , the remaining share is attributed to the farmer's own funds (CGAAER, 2013).

In 2014, the French Competitiveness and Adaptation Plan for Agricultural Holdings (*Plan de compétitivité et d'adaptation des exploitations agricoles*, PCAEA) took over the budget from the Energy efficiency plan. However, grants issued in respect of the PCAEA are managed at regional level. The consolidation of grants in respect of energy efficiency have not been available at national level so far. **Therefore, the authors have decided to report the same amounts for the years 2014 to 2016 as were observed in 2013**.

For renewable energy production, the Landscape considers the amounts invested in the installation of on-farm anaerobic digestion (AD) plants, reported by ADEME (ADEME, 2016f). These are documented from grants provided by the ADEME's Fonds Chaleur and applications for connection to the power grid transmitted by distribution network managers to the Energy Regulatory Commission (*Commission de régulation de l'énergie*, CRE). Investments in large AD plants, which recycle waste coming from a number of sources, are allocated to the "centralised energy production" sector (see chapter p.79 ENE). Investments in solar PV on agricultural buildings are estimated from the results of a number of studies from the ADEME (see ADEME, 2015c and 2016f).

For the expenditures not covered by the grants mentioned above, we considered that they are financed at 75% by bank debt and 25% by the contribution of equity or own funds from project developers.

Investment expenditures in forestry include the costs of development and planting for afforestation operations and grants for the improved management of existing populations. These grants are described in a report from the Court of Auditors on the forestry sector (*Cour des Comptes*, 2014c). The report covers the period from 2007 to 2013. We have decided to consider the same amounts for 2014 to 2016.

Results

Climate investments in agriculture

Investment in photovoltaic equipment decreased between 2011 and 2016, dropping from €259 to €38 million.

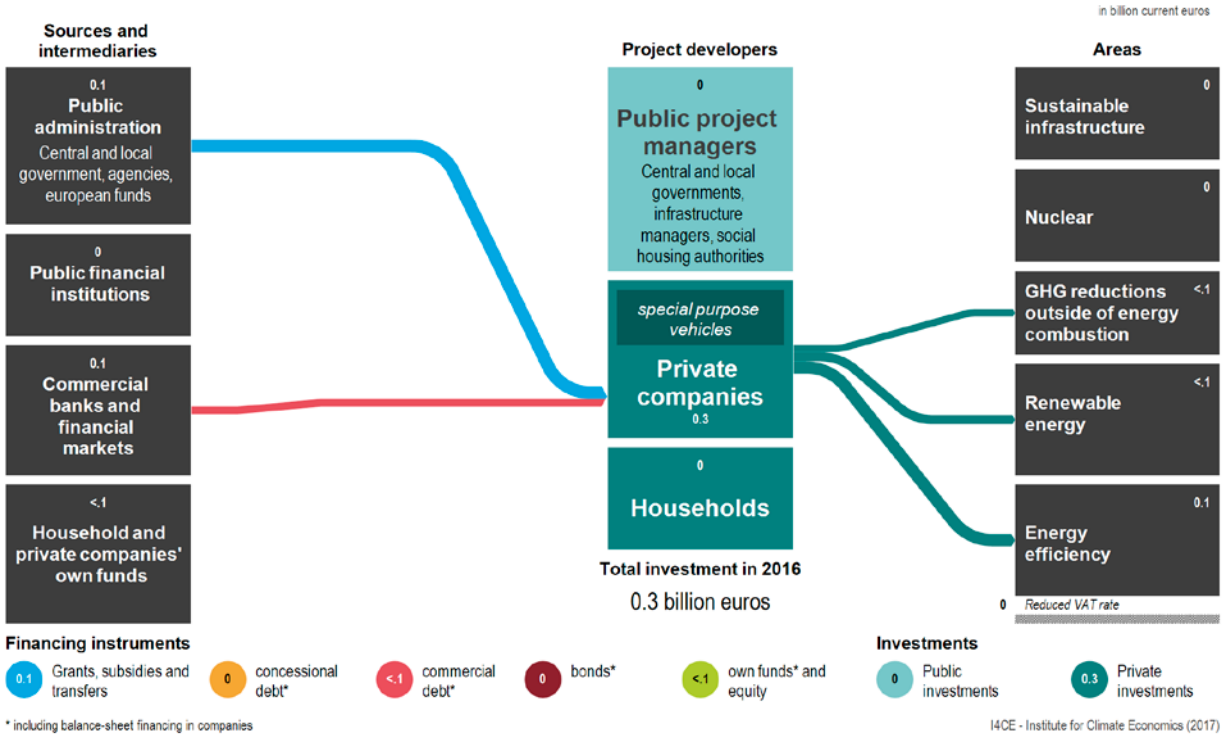
Besides solar PV, climate-related investment expenditures in the agricultural sector were estimated at around €240 million in 2016, of which :

- 70% went to energy efficiency projects, such as the insulation of agricultural buildings and the and recovery of heat on milking lines;
- 30% for renewable energies: farm-size AD plants, thermal solar, biomass for heating.

Investments in forestry

Upstream investments in forestry were assessed at €70 million on average annually from 2011 to 2016. It should be noted that this involves amounts covering only upstream of the sector, i.e. timber exploitation. Investments in the processing of the resource (sawmills, paper mill) could not be measured. As indicated in the following table, applications downstream are recorded in the sectors corresponding to their end purpose: building, industry and electricity production.

LANDSCAPE OF CLIMATE FINANCE IN AGRICULTURE AND FORESTRY, IN 2016



Note: as mentioned in this section, the authors have decided to report the same amounts for the years 2014 to 2016 as were observed in 2013.

CLIMATE-RELATED INVESTMENTS IN THE FORESTRY AND WOOD SECTOR IDENTIFIED IN THE LANDSCAPE, IN 2016

Sector	Investments (euro million)	Main sources
Forestry upstream	70	Cour des Comptes, 2014c
Harvest	Not measured	Not identified
Primary processing	Not measured	Not identified
Secondary processing	Not measured	Not identified
Biomass energy		
Residential	329	ADEME, 2016f, 2015d; Observ'ER, 2014b
Other buildings (1)	137	ADEME, 2016f
Industry	99	ADEME, 2016f
Agriculture	22	ADEME, 2016f
Electricity production	430	ADEME, 2016f; Observ'ER 2016a
Wood products	Not measured	Not identified
Total	**1,087**	

(1) includes investments in the use of biomass in heating networks, it has not been possible to distinguish from investments in independent heating.

RESULTS > SECTORS

Industry

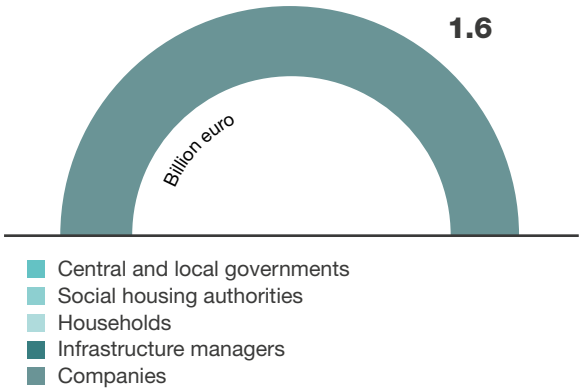
Climate-related investments in the industrial sector were estimated at €1.6 billion in 2016. There is considerable uncertainty concerning expenditures in energy efficiency due to difficulties in accessing data and the transparency of investments made by companies. While the large majority of investment was financed by bank loans and private funds, public banks - in particular BPI France and the EIB - were involved in financing this sector.

€1.6 billion invested in 2016

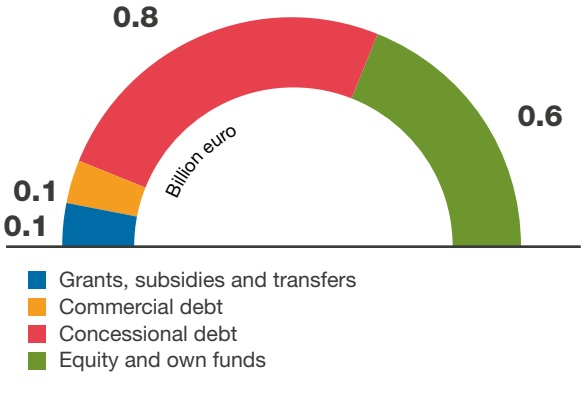
€2.4 billion
In 2011

€1.6 billion
In 2017 (projections)

WHO MAKES THE INVESTMENTS?



HOW WERE THEY FINANCED?



WHAT WAS THE ROLE OF THE PUBLIC SECTOR IN MOBILIZING FINANCE?

In 2016: 14% of the sector's finance was driven

(In billion euros, see p.92 for more detail)

EVOLUTION OF CLIMATE INVESTMENT IN INDUSTRY

(in million current euros)	2011	2012	2013	2014	2015	2016	2017p
Energy efficiency	1,402	1,550	1,431	1,378	1,265	1,311	1,311
Renewable energies	932	395	401	368	290	226	274
of which PV	863	271	245	239	197	126	183
of which biomass	68	123	155	129	93	99	91
of which thermal solar	1	1	1	0	0	0	0
Other	39	51	52	50	50	50	50
Total	**2,373**	**1,995**	**1,883**	**1,796**	**1,605**	**1,586**	**1,635**

P = provisional figures.

Background

In 2016, the industrial sector represented 17% of France's final energy consumption and 18% greenhouse gas emissions outside of LULUCF (CITEPA, 2017, SDES, 2018). In 2016, 63% of emissions came from energy combustion in the form of carbon dioxide (CO_2). Industrial processes also emitted nitrous oxide (N_2O) and hydrofluorocarbons (HFC).

GHG emissions have decreased at a near-constant rate between 1990 and 2016, and more than halved over the period (CITEPA, 2017). This evolution can be attributed to increased energy efficiency: GHG emissions per unit of added value were halved between 1990 and 2016 (SOeS, 2014b; I4CE & MTES, 2017). However, the rapid drop in emissions in 2009 can also be explained by the overall reduction in industrial activity in France following the 2008 financial crisis.

Information regarding climate investment expenditure in this sector is difficult to obtain given the private nature of industrial enterprises, and the sensitive nature of business-related information. Thus, tracking investment and finance in this sector has relied on a higher level of estimations and proxies than in other sectors. This is explained in detail below.

Changes in the sector help work towards creating a circular economy

The potential for reducing emissions in the industrial sector is estimated at -85% in 2050 compared to 1990 levels (CAS, 2011). While the measures to be deployed are specific to the main branches producing emissions (steel, cement, chemicals, paper, etc.), national government policy in this area also targets cross-cutting actions:

- Lowering requirements for carbon intensive industrial materials in final demand. This approach targets the final industrial products such as buildings and vehicles to limit their embedded energy and GHG footprints. Likewise, promoting household appliances with longer lifespan reduces the need for new material. The recycling and repair of appliances is part of this approach (SNBC, 2016).
- Increasing recycling rates for industrial materials. Manufacturing from recycled resources is generally less energy intensive than primary manufacturing, e.g. for aluminium, paper, steel or glass. Regarding these last two products, long-term projections consider recycling rates of around 90% and 80% respectively (CAS, 2011).
- Reducing raw material loss during the manufacturing process. For example, 3D printing certain components may make it possible to cut costs, compared to costs for material lost during the cutting and trimming process.
- Replacing materials that are carbon intensive or of fossil origin with bio-sourced materials. This is a key solution for the chemicals sector, where current inputs are derived from oil and gas[13].
- Increasing the energy efficiency of heat and electrical processes. The former can be achieved through the insulation of thermal pipes, ovens, the recovery of heat, the deployment of efficient boilers or the mechanical vapour compression (ADEME, 2017l). For the latter, replacement of fixed speed engines with variable speed engines, or the retrofitting of electrical transformers are promising. Additional measures such as modifications to industrial buildings (insulation, lighting, ventilation) and the digitalized regulation and management of energy use to optimise consumption (ADEME, 2015e; CEREN, 2010) can also be considered.
- Finding low carbon content substitutes for fossil fuels. Industrial applications of biomass, thermal solar energy and energy recovery from waste, as well as electric ovens or the mechanical compression of steam, may replace the thermal uses of conventional fuels.
- Improving methods for carbon capture, its storage or its reuse in processes, in particular steel making. Given the high costs of carbon capture, this concerns principally large industrial sites. Moreover, since carbon capture is not technologically and economically viable currently, its deployment for the industrial sector is not envisioned for at least another decade (CGDD 2016g, CAS, 2011).

These changes to the industrial sector fall under the broader policy of switching to a circular economy, which provides for extending the systematic approaches of eco-design, reuse and recycling[14]. Furthermore, the transition of the industrial sector towards low carbon requires technological and organisational innovations, which make it a major issue for research and development (ENEA, 2012).

The carbon price signal is a principal driver for climate investment in the industrial sector

Today, this price signal is generated by the European Union emissions trading system (EU ETS). This system sets out an emission cap for the industrial, electricity and heat production sectors that has been progressively

13 On this subject, see for example FranceAgriMer, 2012.
14 At the end of 2016 the French Government published a National plan for the reduction and recycling of wastes by 2025, contribution to the national strategy for transition towards the circular economy (see MEEM, 2016a).

decreasing since 2005 and expected to reach -43% of its initial level by 2030.

The industrial businesses that are subject to this system need to surrender quotas up to the amount of their annual emissions. A portion of the quotas is allocated free of charge, in particular in the sectors most exposed to international competition, while the rest is auctioned off by Member States. The quotas are then freely exchanged on a European market, where the price constitutes an incentive for businesses to implement measures to reduce their CO_2 emissions at the lowest possible cost. The total amount of quotas introduced each year decreases at a pace designed to reach the emission reduction objective by 2030.

However, since 2009, a surplus of quotas allocated to businesses has led to a drop in the price of quotas, from more than €20/tCO_2 to around €5/tCO_2 in 2016. In March 2018, the EU adopted a revised directive on the EU ETS[15]. This directive has introduced new mechanisms to reduce the surplus of quotas, such as an increase in the pace of reduction of the emissions cap or the withdrawal of quotas through a market stability reserve (MSR). Following this reform, the price of quotas has increased throughout 2017.

Methodology

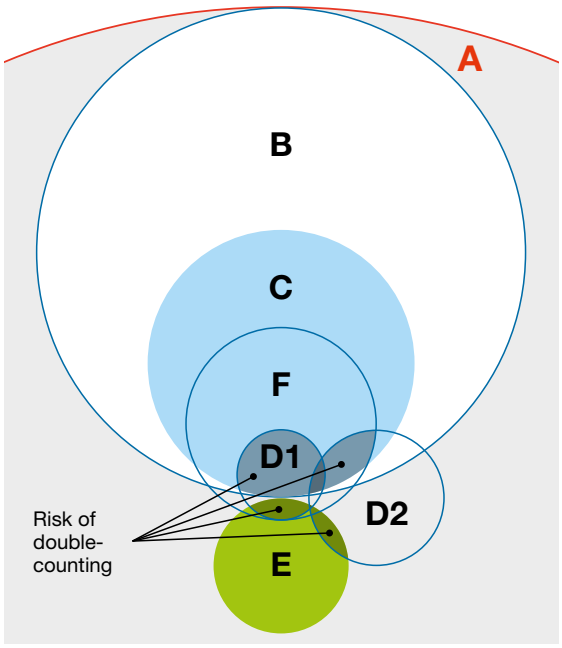
Major disparities persist between estimates of climate investments

Research carried out for this study has not been able to identify a comprehensive source to track climate-related investment expenditures in the industrial sector. We have therefore built on several sources in order to estimate such expenditures. The orders of magnitude of the final result vary on a scale of 1 to 30 depending on the methods used. Each approach is shown and described on the following figure:

15 An analysis of the issues surrounding the adoption of the new EU Climate and Energy Framework, and the coordination of instruments such as the EU-ETS can be found in I4CE's climate brief n°52, *Mind the gap: aligning the 2030 EU climate and energy policy framework to meet long-term climate goals* (I4CE, 2018b). For further analysis on the effects of proposed reforms of the EU-ETS, see the previous publications from the Coordination of policies on energy/climate (COPEC) research programme (I4CE, 2017g and I4CE, 2018a).

COMPARISON AND POSSIBLE OVERLAPS IN THE RESULTS COMING FROM DIFFERENT METHODS OF ESTIMATING CLIMATE-RELATED INVESTMENTS IN THE INDUSTRIAL SECTOR

	Scope of estimate	Source	Amounts
A	Investments realised by industrial companies	INSEE	€83 billion (2016)
B	Material investments multiplied by the frequency of energy efficiency reported as a motivation to invest by CEO	INSEE + authors	Around €4.3 billion (2016)
C	Dividing by 3 the result obtained in B to accunt for uncertainty in the methodology	INSEE + authors	Around €1.3 billion (2016)
D1	Investment expenditures for climate protection, as reported by the ANTIPOL survey	INSEE	$211 million (2016)
D2	Investment expenditures for the protection of air quality as reported by the ANTIPOL survey	INSEE	$316 million (2016)
E	Investment in projects having received support from the ADEME's Fonds Chaleur (biomass, thermal solar) as well as in solar PV	ADEME + authors	$226 million (2016)
F	Investment in projects that have received support from BPI France's "green loan" program	BPI France	Around €360 million (2016)



Note: methods C and E have been retained to estimate the investment expenditures in energy efficiency and renewable energy, respectively. Other methods are indicated by way of information in this chapter but are not retained in the overall results.
Source: I4CE

A. According to the INSEE, the industrial sector (defined as section A5-BE of the French classification of economic activities) invested €83 billion in 2016 (INSEE, 2017). Based on the ratio of the tangible investments to the total industrial investments for 2014 (INSEE, 2016d), we estimate that approximately 65% of this total, i.e. €54 billion, concerned tangible investments.

B. The INSEE's quarterly survey on industry investments asks business leaders about their reasons for undertaking investments. Energy savings represented 8% of responses quoted by business leaders in 2016 (INSEE, 2014 and 2016b). When applied to the volume of tangible investments, this proportion would indicate an order of magnitude of €4.3 billion worth of investments in energy savings.

C. However, singling out the amounts invested in energy savings on the basis of reasons stated by business leaders presents a number of difficulties. First of all, the survey does not present any objective definition of the energy savings being looked for, with the interpretation being left to respondents. Various intentions can therefore coexist: reducing energy consumption in relation to initial consumption; in relation to an alternative theoretical consumption; improving the energy per unit production ratio, etc. Furthermore, there may be a difference between the proportion of energy savings in the responses and in the actual volume of investments. Lastly, investments motivated by energy savings may not achieve the expected results. In order to take such uncertain factors into account, we propose to retain only one third of the amounts indicated by the method outlined in B, i.e. €1.3 billion in 2016. **This is the "central" estimate retained subsequently in this study.**

D. The INSEE surveys businesses on expenditures related to climate protection and air quality through the ANTIPOL survey (INSEE, 2016a). They cover investments and everyday expenses, including studies prior to investments. Investments may be part of industrial processes or be made up of specific actions such as the treatment of inputs, the measurement and inspection of installations, recycling, sorting or recovery of wastes or the prevention of pollution. In total, for 2014, the most recent year in the study, INSEE identified €211 million invested in climate mitigation and €316 million for air protection. These amounts, relatively low when compared with total investments, are in all likelihood limited to a small cluster of projects and probably do not include the more general energy efficiency investments of the industrial branches. Moreover, as the burning of fossil products can be a source of air pollution, it is possible that the totals partially include the same expenditures.

E. Since the central estimate presented in C only concerns investment in energy efficiency, industrial renewable energy projects need to be added. To estimate these investments, we totalled the projects supported by the ADEME's *Fonds Chaleur* program, in particular wood-energy and thermal solar, together with solar PV investments deployed on industrial roofing installations (ADEME 2011b; ADEME 2015d, see also energy production chapter). These investments were assessed at €99 million and €126 million respectively in 2016, i.e. a total of €226 million. They are taken into account in the Landscape.

F. BPI France issues "green loans" *(Prêts verts)* to manufacturers for the improvement of energy efficiency and the development of innovative solutions in connection with the energy transition (see BPI France, 2014a). We estimate the total amount invested by industrial businesses based on the issuance of green loans and secondary loans from BPI France. According to the data communicated by BPI France for this study, green loans lead to projects worth an average seven times the amount of the loan. The leverage effect of the secondary loans has been estimated at around five times the amount of the green loan. In sum, investments triggered by the issue of green loans are estimated at around €500 million for 2012 and €360 million for 2016. It needs to be taken into account that actual projects are spread over time. Lastly, certain investments financed by these loans are not tangible assets, but may concern intangible innovations, for example software or research. It has not been possible to accurately identify their share in this total.

The difficulties encountered in reconciling the different estimates presented above have led to us retain in the Landscape only the central estimates proposed in C, to which we also added the investments in renewable energies described in E.

Among climate investments reported by businesses, expenditures for GHG mitigation (N_2O in particular) are estimated at around 10% of the investment expenditures relating to air quality (INSEE,2016a; CGDD 2017e, CGDD 2018c).

Finance from BPI includes the amounts issued under the green loans programme (*Prêts verts*) as well as a proportion of the other development loans intended for industry. While the green loans programme focuses on improving the energy efficiency of industrial processes, other loans from BPI co-finance the development

of strategic ecological and energy transition sectors (BPI France, 2014b and 2015). The contribution from energy savings certificates, for standardised activities and specific activities, is documented using the Emmy base and newsletters from the Ministry of the Environment (Emmy 2017; DGEC 2015 and 2016).

Results

Investments primarily geared towards energy efficiency

Climate investment in the industrial sector were estimated at €1.6 billion in 2016. Of this total, energy efficiency represented 80% of expenditures, i.e. €1.3 billion, and renewable energy €0.2 billion.

A decrease in investment in renewable energy, in particular photovoltaic installations

While expenditures relating to energy efficiency have been stable since 2011, spending on the development of renewable energy have decreased - dropping from €930 million in 2011 to €226 million in 2016. This decrease is explained mainly by the decline of investment in photovoltaic installations. Estimated at €863 million in 2011, it fell to €126 million in 2016. Projects associated with investments in biomass applications, mainly projects supported by ADEME's Fonds Chaleur, represented €99 million in 2016.

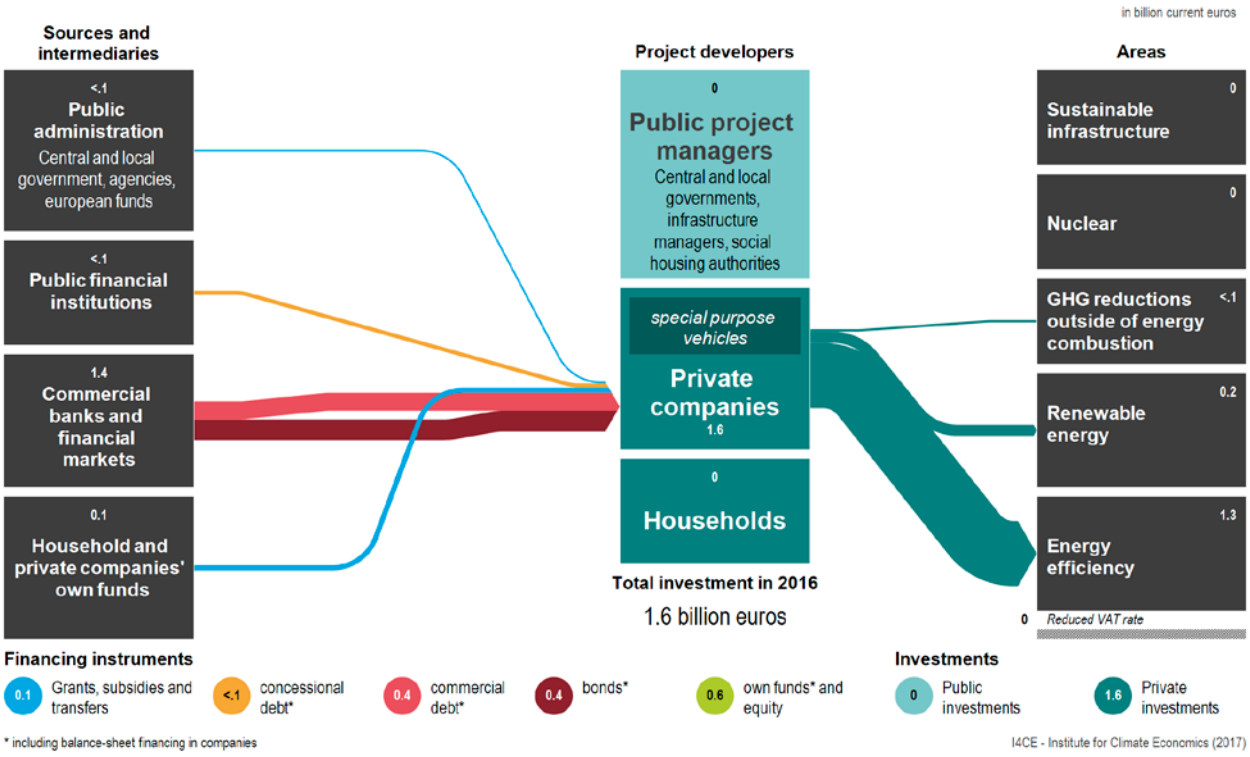
A sector dominated by private finance, but where government support is concentrated on the most ambitious projects

Overall, publically-driven finance only accounted for 14% of total investment made by the industrial sector in 2016. This is the sector of the study with the lowest proportion of publically-driven finance. However, this observation is very sensitive to the method of estimating climate-related investment expenditures, as outlined previously in this chapter. When restricting the estimation of investment expenditures only to the private co-financing of projects by ADEME and BPI France, the proportion of publically-driven finance reaches around 20 to 30% of the total cost of the projects.

Government support was divided between:

- Grants from ADEME, mainly from Fonds Chaleur projects, represented €37 million in 2016 and the subsidy equivalent to recovery of the energy savings certificates representing €104 million, including "specific projects", i.e. projects for which there is no standardised energy savings certificate file.
- Concessional loans. According to the information available, BPI France is the key player in energy efficiency finance, with €460 million issued between 2011 and 2016 through the "Green loans" within the framework of the ADEME's Strategic investment program (*Programme des investissements d'avenir*, PIA).

LANDSCAPE OF CLIMATE FINANCE IN THE INDUSTRIAL SECTOR IN 2016



RESULTS > SECTORS

Centralised energy production and networks

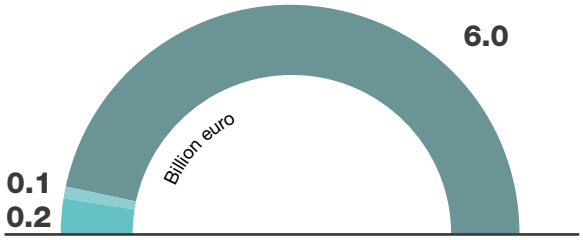
In 2016, the centralised energy production and networks sector invested €6.3 billion in favour of climate, including €3.4 billion for renewable electricity generation. Funding came mainly from the private sector, through special purpose vehicles or the investment arms of power companies.

€5.5 billion
In 2011

€6.3 billion invested in 2016

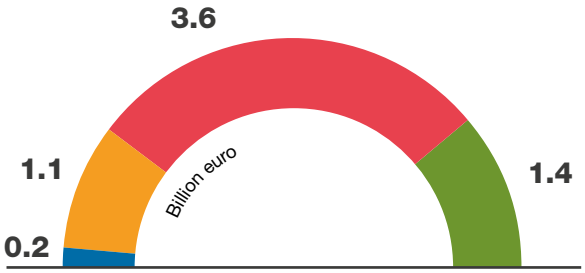
5.3 billion
In 2017 (projections)

WHO MAKES THE INVESTMENTS IN 2016?



- Central and local governments
- Social housing authorities
- Households
- Infrastructure managers
- Companies

HOW WERE THEY FINANCED IN 2016?



- Grants, subsidies and transfers
- Commercial debt
- Concessional debt
- Equity and own funds

WHAT WAS THE ROLE OF THE PUBLIC SECTOR IN MOBILIZING FINANCE IN 2016?

In 2016: 23% of the sector's finance was driven

(In billion euros, see p.92 for more detail)

EVOLUTION OF CLIMATE INVESTMENT IN CENTRALISED ENERGY PRODUCTION AND NETWORKS

(in million current euros)	2011	2012	2013	2014	2015	2016	2017p
Fuel switch coal/oil to gas	62	783	0	0	381	628	0
Renewable electricity	3,761	2,933	2,430	3,514	3,297	3,369	2,989
of which hydro	546	669	720	724	733	745	745
of which wind	1,045	1,044	905	1,616	1,329	1,782	1,687
of which ground-mounted PV	1,814	898	476	805	751	431	236
of which solid biomass	193	175	160	177	193	172	103
of which biogas	148	129	144	168	166	158	160
Renewable gas (biomethane injection)	9	0	7	13	109	66	43
Networks (electricity and heat)	216	221	277	388	328	310	263
Nuclear	1,467	2,327	2,000	1,960	2,005	2,000	2,000
Total	**5,506**	**6,264**	**4,707**	**5,862**	**6,011**	**6,306**	**5,253**

P = provisional figures.

Context

The Landscape groups into a single sector all climate investments in centralised energy production – in particular electricity, gas or heat – intended for sale and distribution through a network infrastructure. For example, this definition of perimeter includes ground-based and large-scale photovoltaic plants, but does not take into account facilities decentralised building-level energy investments, such as PV, thermal solar, and collective heating systems. These decentralised investments are included rather in as part of the balance sheets of the corresponding sectors (Buildings, Transport, Industry or Agriculture & Forestry).

In 2016, the energy production and processing sector in France was responsible for 11% of greenhouse gas emissions, aside from LULUCF (CITEPA, 2017). Emissions have decreased by 36% since 1990, mainly due to the replacement of thermal sources with new renewable forms of energy since the end of the 2000s. Emissions are lower in France compared to the European average of 29% of emissions in 2014 (I4CE & MTES, 2017, according to EEA). Since 2005, the electricity production sector has been covered by the EU Emissions Trading System (ETS), with a shared objective of reducing GHG emissions at the European level by 21% in 2020 compared with 2005[16].

In 2016, final electricity consumption amounted to 473 TWh, and district heat and cooling around 25 TWh (RTE, 2018 FEDENE, 2017). While electricity consumption tripled from 1973 to 2010, it has remained stable ever since, and even declined (IDDRI, 2017a; RTE, 2016c).

The sector is characterised by production facilities that are large in size and generally capital-intensive (OECD, 2012). In 2016, the total generation capacity of power plants was 130 GW, of which 22 GW were fossil fuel thermal plants, 63 GW were nuclear and 46 GW were renewables, including 25 GW hydroelectric (RTE, 2016b). The nuclear industry, with its large installed capacity and high load factor, supplies the largest proportion of the electricity produced in France, around 72% in 2014 (SDES 2018).

Electricity plants are changing as facilities age and are renewed[17]. Between 1977 and 1987, a phase of intense investment resulted in the linking to the grid of three quarters of France's nuclear production facilities, i.e. 6.6 GW. Today, the first reactors are reaching the end of their initial design lifespan of 40 years. Between now and 2025, half of all reactors will have reached this point. Their continual operation is subject to technical, economic and political uncertainties (IDDRI, 2017b). Since 2005, the deployment of solar and wind powered electricity production facilities has accelerated. 2011 was a record year in terms of additional renewable capacities, with +2.6 GW (CGDD, 2018c, RTE, 2016b, Observ'ER 2011 to 2016a). Since then, renewable power generation capacities grew between 1.7 and 2 GW per year [ENE/PRODELEC].

France's Energy transition for green growth act and the Multiannual energy plans aim for in-depth transformation of the energy production sector, for electricity in particular

France's Energy transition for green growth act (*Loi de transition* énergétique *pour la croissance verte*, LTECV) sets a number of objectives that are likely to affect the energy production sector, and electricity generation in particular (SNBC, 2017):

- Reducing, between now and 2050, final energy consumption by 50% compared with its 2012 level, with an interim objective of 20% by 2030. Seeking a reduction in final consumption, in particular through energy efficiency, affects in turn the need for production capacities.
- Increasing renewable energy's share of gross final consumption of energy to 23% by 2020, and to 32% by 2030. The 2020 objective corresponds to the European target adopted as part of the 2020 climate and energy package. Centralised production of electricity and heat from renewable sources contributes to this objective.
- More specifically, the LTECV states that the proportion of renewable energy in the production of electricity must reach 40% by 2030.
- France's LTECV also states that electricity of nuclear origin must only amount to 50% of production in 2025, against 72% in 2016 (SDES, 2018).

Depending on the effective level of electricity consumption and, with less impact the export balance, achieving last two objectives could lead to wide range of volumes of production (see IDDRI, 2016).

Lastly, the LTECV sets an objective between now and 2030 of multiplying by five the quantities of renewable and recovered waste heat and cold delivered through the heating and cooling networks compared with 2012.

16 For an analysis of the issues around reforming the EU-ETS and establishing an effective price signal for GHG emissions from electricity and heat production in Europe, see in particular the publications of the *Coordination of Policies on Energy/Climate* (COPEC) research programme, including *What role for the EU-ETS in the Energy Climate Package 2030?* (I4CE, 2015a and 2017g).

17 For a more detailed analysis of current issues in the French electricity system, reference can be made to recent studies from IDDRI, Electricity demand in France: what's at stake for the energy transition? (IDDRI, 2017a) and the Transition of the French power sector by 2030: an exploratory analysis of the main challenges and different trajectories (IDDRI, 2017b).

The national objectives are set out in several management tools

On one hand, the National low carbon strategy (*Stratégie nationale bas-carbone, SNBC*) establishes emission budgets by sector over five-year periods. On the other, the Multiannual energy plans (*Programmation pluriannuelle de l'énergie, PPE*) details implementation by sector and by energy. (IDDRI, 2016). For the first three carbon budgets, i.e. up until 2028, the SNBC limited the sector's emissions from centralised energy production to 55 $MtCO_2eq$, i.e. a decrease of 4% compared with the 2013 level (SNBC, 2016).

At the European level, the EU requires that Member States develop national action plan on renewable energies to address the European regulatory requirements. There requirements are currently changing within the proposed framework of EU energy governance (see European Commission, 2016).

At the territorial level, the national objectives are detailed through Climate-Air-Energy Plans (*Schéma régional climat-air-énergie,* SRCAE) developed by the Regional Councils. This process is evolving since the French LTECV, with the SRCAE plans being integrated in the next revision directly into the Regional Plans for Development, Sustainable Development and Territorial Equality (*Schémas régionaux d'aménagement, de développement durable et d'égalité des territoires*, SRADDET). Two plans specific to renewable energies are also connected to these objectives - the "Regional wind power plan" and the "Regional plan for renewable energy connection to the grid" (*Schémas régionaux de raccordement au réseau des* énergies *renouvelables*, S3REnR). This second plan covers the cost breakdown between producers and network managers for developing and strengthening the electricity transport and distribution infrastructure, made necessary by the roll-out of renewable capacities.

RENEWABLE POWER GENERATION CAPACITY AND 2023 OBJECTIVES IN LINE WITH THE MULTIANNUAL ENERGY PLANS (PPE)

(in MW)	Situation in 2016 [A] end Sep. [B] end Dec.	2023 objectives, low/high range (PPE, 2016)
Hydroelectric (1)	25,479 [A]	25,800 – 26,050
Onshore wind	11,116 [A]	21,800 – 26,000
Offshore wind and marine energies	241 [B]	3,100
Photovoltaic	7017 [A]	18,200 – 20,200
Biogas	103 [A]	237 – 300
Biomass	365 [B]	970 – 1040
Geothermal	17 [B]	53

(1) Including pumping stations (PSPS), up to 4500 MW.

Source: Observ'ER, 2016 barometer of renewable electricity energies in France.

Results

Investments in centralised energy production and networks reached €6.3 billion in 2016

In 2016, investments in centralised renewable energy generation reached €3.3 billion

This level was higher than 2015 and 2012, and just below the level of €3.5 billion reached in 2014.

The change in investment expenditures is explained by the convergence of two trends:

- The revision of policies on pricing supports (see Table below);
- The decrease in unit costs of installation, in particular for photovoltaic, where the average cost for ground-based plants fell from €2/W to €1.2/W between 2011 and 2016 (ADEME, 2016f, ADEME 2017i).

The following Table shows the investments in renewable energies by industry and by sector. As a reminder, only investments in centralised production are discussed in this chapter. Decentralised investments are shown in the corresponding sectors (building, industry and agriculture).

BREAKDOWN BY SECTOR AND BY INDUSTRY OF INVESTMENTS IN THE PRODUCTION OF RENEWABLE ENERGY, IN 2016

(in million of euros)	Building p.35	Transport p.53	Agriculture p.66	Industry p.72	Centralised energy production p.79	All sectors
Hydroelectric	0	0	0	0	745	745
Wind	0	0	0	0	1,782	1,782
Photovoltaic	263	0	38	126	431	858
Biogas	0	0	30	0	158	188
Biomass (large scale)	137	0	22	99	172	430
Biomass (small scale)	329	0	0	0	0	329
Geothermal (large scale)	0	0	0	0	15	15
Geothermal (small scale)	76	0	0	0	0	76
Waste incineration plant	43	0	0	0	0	43
Heat pumps	1,328	0	0	0	0	1,328
Thermal solar	57	0	0	0	0	57
Biomethane injection	0	0	0	0	0	0
Bio-NGV vehicles	0	0	0	0	66	66
Other	0	87	0	0	0	87
All renewable energies	2,234	87	90	226	3,369	6,006

Note: this table does not cover the expenditures for connecting renewable electricity energies to the network, nor for extending heating networks.

The investments in nuclear production facilities are stable and reflect the start of the "grand carénage" and continued work on the EPR construction site

Among the investments in the established fleet of nuclear plants, the Landscape looks at the replacement of "large components" such as steam generators and alternators. EDF's expenditures in this regard were estimated at €1 billion in 2016. This was the average annual expenditure in this category from 2011 to 2015. These investments correspond to the third ten-yearly in-service inspections of the 900 MW and 1300 MW series reactors. According to EDF, the replacement of steam generators involves two to three units each year (CRE, 2015).

The Landscape includes investments made by EDF in the construction of the EPR at Flamanville, which is the lead unit of the new generation of nuclear reactors. Since the start of construction, the costs of the EPR announced by EDF have seen a steep increase, rising from €3 billion to €10.5 billion (EDF, 2008, 2010, 2012b, 2014b, 2016a). The investments made in 2016 totalled approximately €1 billion. The commercial launch of the EPR is set for 2019 or 2020. The Government has recently extended the construction permit from 10 to 13 years to take into account the longer duration of the construction site.

Investments in connecting renewably-generated electricity to the grid are falling

The Landscape estimates the costs of connecting renewable energy on the basis of fixed prices calculated in the Regional connection plans (S3REnR, see methodology). From 2011 to 2013, these investments decreased, falling from €95 million to €50 million, before increasing once more to €70 million in 2016. It is important to note that this figure is for investments made necessary by the deployment of renewable electricity production facilities installed during a given year. Given the time frames for connection, investments may be staggered over time.

Rise of investments in the extension of heating networks

With respect to heating networks, costs of extending the networks and the expenditures for installing distribution substations are taken into account by the Landscape. While the proportion of renewable energy in the heating supply is significantly lower than fossil fuels, extending the heating networks is generally considered to be a prerequisite for supplying urban centres with renewable energy (ADEME, 2013b; Plan Batiment Durable, 2016). The investments, mainly funded by local authorities, amounted to €240 million in 2016, versus only €121 million in 2011. The ADEME, ERDF and White Certificates program provide project developers with subsidies ranging from €50 million to €100 million per year.

95% of investments made by private companies

Private companies made 95% of investments in the centralised energy production sector, while the remainder is made by managers of electricity and heating networks. For this, they use two types of financial arrangement:

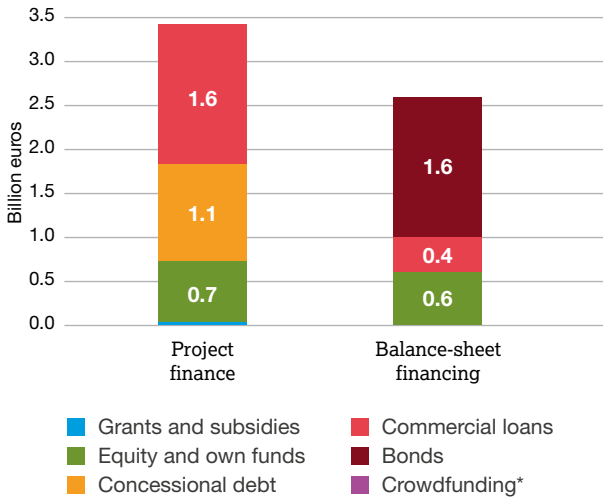
- **"Project" financing** is characterised by the reimbursement of debts and invested capital through the margin generated by the project. Such financing, which is often based on setting up a project company (SPV, or special purpose vehicle), limits the risk for outside investors and for the parent company. Project financing has expanded strongly in the area of renewable electricity. We estimate that this method of financing concerns around two thirds of the amounts invested by businesses in the centralised energy production sector, primarily in renewable energy projects.
- **Financing "through the balance sheet"** takes place when the generation of profits from a project is too distant in time, or carries too great a risk to finance the input of resources directly (capital and debt). In this case, the business making the investment posts the liabilities to its balance sheet, which it supports through the use of debt and capital. Financing through the balance sheet typically takes place in nuclear investments (IFRI, 2015). We estimate that this method of financing constitutes one third of the amounts invested in the centralised energy production sector, primarily in the nuclear industry, where EDF carries the EPR and "grand carénage" investments on its balance sheet.

Private finance, secured through the support framework for renewable energy deployment, covers 77% of investment expenditure

To finance their investments, businesses primarily use their equity capital and debt, of banking or bond origin. The graph shown below identifies the breakdown of financing obtained by project developers, classified by the instrument and the financial arrangement.

Bank debt has been mobilised mostly in the context of project finance, while the businesses carrying the investments on their balance sheet use a greater proportion of bond debt. Concessional debt, which represented 32% of the project finance for 2016, is included in publicly-driven finance (see below).

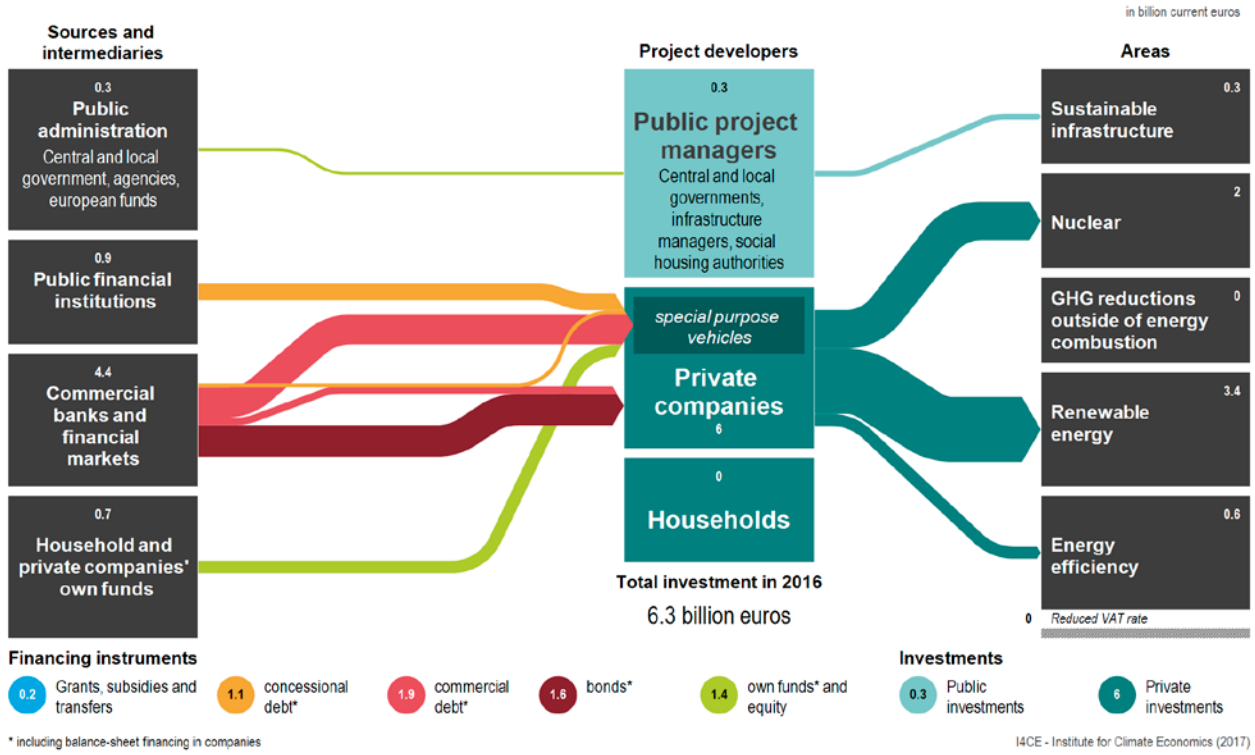
FINANCE MOBILIZED BY PRIVATE COMPANIES FOR CENTRALISED ENERGY PRODUCTION IN 2016, BY INSTRUMENT AND ACCORDING TO THE FINANCIAL STRUCTURING



Sources: Authors according to CRE, 2014a; EDF, 2011, 2012a, 2013, 2014a, 2015; EIB, 2011 to 2014; BPI France, 2013, 2014c, 2015; FPF, 2015.
** Crowdfunding represented €10 million in 2016.*

Concerning the production of renewable energy, the involvement of private finance in investment in this area (equity capital, bank and bond debt) depends to a great extent on government support mechanisms reinforcing project profitability. Among these mechanisms, the feed-in tariff usually constitutes the main source of revenues for producers of solar or wind powered electricity. To ensure that feed-in tariffs cover the investment costs and remuneration for the risk taken by financers at incentivized levels throughout the project's lifespan, they are financed through a levy on the selling price to the consumer of the French tax contribution to the public service charges for electricity (*Contribution au service public de l'électricité*, CSPE). The CSPE covers the difference in price between the wholesale market and the feed-in tariff.

LANDSCAPE OF CLIMATE FINANCE IN CENTRALISED ENERGY PRODUCTION AND NETWORKS SECTOR IN 2016



Publicly-driven finance covers 24% of expenditures[18]

Certain investments in the sector benefitted from the support of grants from ADEME, up to €125 million. This support is mainly oriented towards the less-mature renewable electricity segments, such as methanisation or biomass, as well as towards support for local authorities in the development of heating networks.

Concessional debt plays an ever-increasing role for project developers on renewable energies. BPI France co-financed project holders by means of concessional loans, up to €868 million in 2016. Lastly, we can see the escalation in credit lines opened by the EIB in order to enable commercial banks to finance investments in renewable energies, which increased from 90 to €220 million between 2011 and 2016.

Analysis and discussion

Achieving the national objectives for 2020 and 2023 requires a substantial increase in the pace of renewable energy deployment

While the proportion of renewable sources in the gross final consumption of energy doubled in the European Union between 2004 and 2015, it increased by only 61% in France. Although it was positioned above the European average in 2004, the proportion of renewable energy in France is now below the average for EU countries (Eurostat, 2017). At the start of 2017, France had already achieved 83% of the objective set for 2020, with a better score for electricity renewables than for thermal renewables (CDC, 2017).

In order to achieve the objectives set for 2020 and 2023 in the Multiannual energy plan (PPE), renewable power capacities have to be deployed faster: approximately doubled for wind and a 50% increase for photovoltaic (IDDRI, 2017b). With regard to the decrease in installation costs observed since the end of the 2000s, in particular for photovoltaic energy, the cost of investment necessary to meet the objectives is rising less rapidly (ADEME, 2016f).

18 The definition of publicly-driven finance, within the meaning of this study, is available on p.92 in the discussion chapter of this report.

In 2016, new support mechanisms increase the exposure of producers to market price

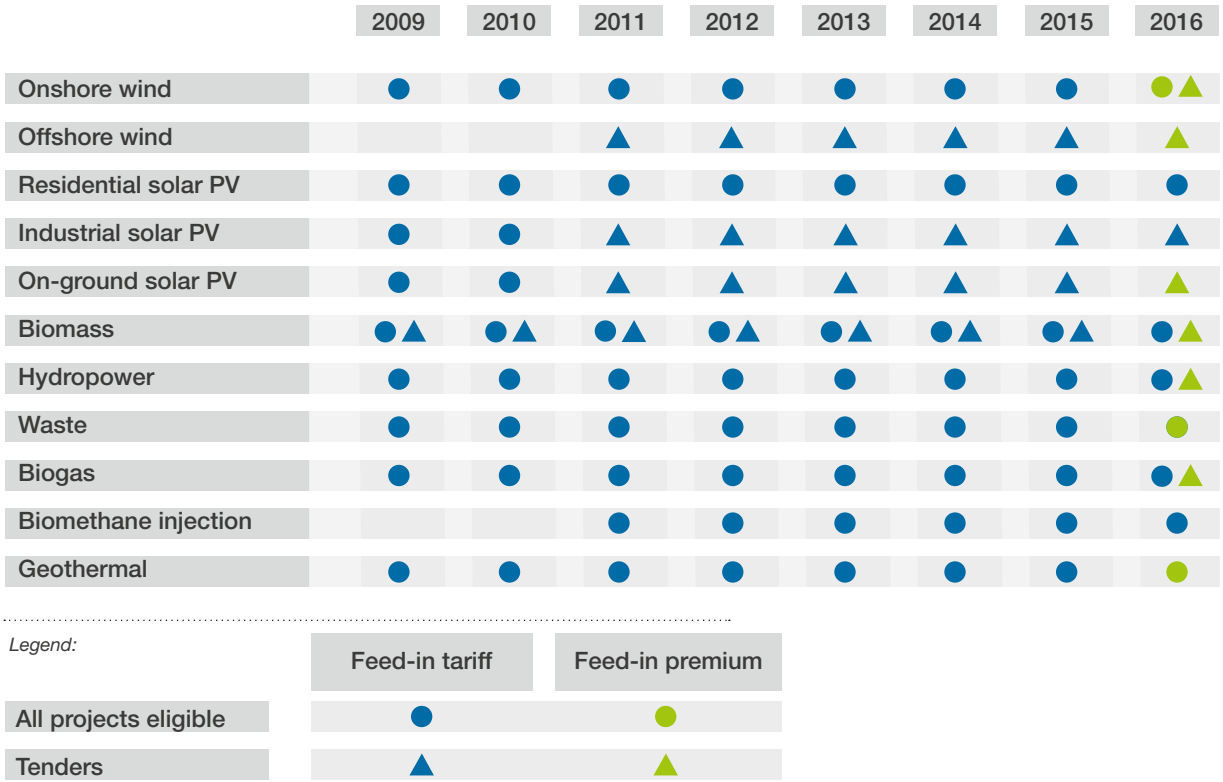
Compared with conventional energy sources, deploying renewable energy sources require a higher initial investment, but have lower operating costs (Ecofys and Fraunhofer ISI, 2016). This cost profile results in a higher investment risk from the investor's point of view. In order to reduce this risk and increase the volumes invested, government support measures have been introduced to create an attractive and appropriate compensation framework. There are several types of mechanisms, such as the feed-in tariff and the feed-in premium. For a comparison of theoretical and practical advantages and disadvantages of the various instruments, see Jenner et al., 2013, and for the French and European contexts Percebois, 2016; CREDEN, 2014 and Quirion, 2015.

The risks associated with the formulation of support policies are assessed as the most important by investors, ahead of market, social acceptance or technological risks (Ecofys, and Fraunhofer ISI, 2016). In France, under the impetus of directives from the European Commission, the support mechanisms for renewable energies have seen many changes, from which we can pick out two trends:

- The allocation of government support at the end of a competitive process in the form of invitations to tender, in particular for large-scale projects. This mechanism, deployed initially for the electricity produced from biomass since 2003, then for off-shore solar and wind powered sites from 2011, and most recently for wind powered sites with more than 6 masts in 2017. The aim of competitive mechanisms is to adapt the level of support to producers' effective costs while at the same time controlling the volumes installed;
- The replacement of feed-in tariffs by a feed-in premium, provided for in article 104 of the French LTECV. Applicable to new facilities in the main industries since January 2016, this mechanism obliges producers to sell their electricity on the market while at the same time receiving a premium calculated retrospectively in line with market prices.

In several sectors, the feed-in tariffs at open counter rates are maintained for small facilities.

DEVELOPMENT OF SUPPORT MECHANISMS FOR RENEWABLE ENERGY GENERATION FROM 2009 TO 2016



Sources: CRE, 2014a; Observ'ER, 2010 to 2016a; ADEME, 2016f, PPE, 2016

Heating networks: optimisation and investment incentives to encourage the 'densification' of existing networks

Targeted by a twofold objective under the French LTECV, heating networks need to multiply the quantities of heat and cold delivered to users by five and contribute towards using 38% renewable energies in the final consumption of heat in 2030 (CEREMA, 2016a and 2016b). The investments to be made involve the setting up of new networks, the retrofitting of existing old or dilapidated networks, and the densification of existing networks by connecting new users located close to the lines already in place. This last option is the most interesting for the French government, since it makes it possible to spread the depreciation of existing investments to new users and therefore reduce prices for all (*Plan Bâtiment Durable*, 2016).

The price of heat sold varies significantly from one network to another, from €37ex.tax/MWh to €134ex.tax/MWh in 2013 (AMORCE, 2013). Such variations are explained not only by the energy mix of the networks, but also by the state of dilapidation of certain facilities and their method of management (*Plan Bâtiment*, 2014). Above and beyond the possible gains from optimisation and modernisation of the least efficient networks, incentive for connections is created through grants issued by the Heat Fund, set up in 2009 with a budget to be doubled between now and end 2017 (ADEME 2015d).

Nuclear

In the short term, committed investments for the existing plants (*grand carénage*) and in the EPR construction site are carried on EDF's balance sheet, therefore financed through borrowing and the company's equity capital. In the long term, EDF's sources of revenues for remunerating the capital invested depend on both regulated and market mechanisms. Regulated mechanisms such as the so-called *Tariff for Regulated Access to Historical Nuclear Electricity* (ARENH) and the tariffs established for end consumers set the selling price at a level that should cover for investment costs in the means of production (CRE, 2015; Court of Auditors, 2014b). EDF can also sell the electricity produced to other suppliers on the wholesale market or offer non-regulated tariffs to its own customers.

The coexistence of regulated and free market mechanisms has existed since the 2005 French law on the new organisation of the electricity market (*Loi sur la nouvelle organisation des marchés de l'électricité*, NOME). This has accompanied the opening up of the electricity sector to competition which has led to the gradual disappearance of regulated tariffs.

The changeover to a free market system is increasing uncertainties on the sources of revenues likely to finance investment in new and existing nuclear plants. Investment costs are on the rise, with regard to raising safety requirements and extending the duration of the EPR construction site. Meanwhile, the relative stability of the final consumption of electricity since 2010 combines with increased competition from renewable energies, leading to lesser revenues for EDF (Marignac, 2014; AlphaValue, 2016; Assemblée Nationale, 2016).

These parameters, together with several others, are the subject of major uncertainties (Perrier, 2017). Faced with such uncertainties, the Government, as principal shareholder of EDF (holding 84% of its equity), has announced a recapitalisation of up to €4 billion in 2017 (Sénat, 2017).

Methodology

Substituting fossil fuels in power generation (fuel switch)

Climate investment in power generation fuel switch		Sources
Inclusion criteria	We include investments in gas-fired power plants when they coincide with the decommissioning of oil-fired and coal-fired power plants within the same year.	
Screening metrics	We track the investments corresponding to this rationale from the additional gas capacity installed during the year considered, which allowed us to estimate the offset of installed fossil fuel sources during the same year. Only projects that directly coincide with a reduction of power capacity from oil and coal sources are included. We track gas-fired power generation capacity additions as well as decommissioning of oil-fired and coal-fired power generation capacities. We take into consideration investments in gas-fired capacity additions that coincide with oil-fired and coal-fired capacity decommissions within the same year.	AIE, 2010
Number of projects	Power generation capacity additions and decommissions for gas, oil and coal-fired plants were derived from annual grid-connected capacities communicated by the French transmission system operator RTE. The power generation capacity from natural gas that contributes to the "fuel switch", measured in MW, is reported by the RTE study.	RTE, 2010 to 2013, 2014b, 2016a, 2016b.
Cost of projects	The unitary cost of gas-fired power generation capacity is reported by the IEA. Because the IEA doesn't communicate an assessment of unitary cost specific to France, we aligned with the unitary cost communicated for Germany, i.e. 1025$/kW, equivalent to 774 €/kW based on 2010 exchange rates (1EUR = 1,325$).	AIE, 2010
Attribution to project developers	Projects are carried out by utilities (private commercial companies).	
Financing	We estimate that financing of this investment comes from 50% equity and 50% debt.	(ALSTOM, 2006)

Renewable power generation capacity addition

Hydropower

Climate investment in hydropower		Sources
Inclusion criteria	We include inland water renewable energy projects that generate electricity from sources that replenish themselves naturally, as defined by the Eurostat statistical glossary. In our analysis, we take into account the investments realized for the operation, renovation, modernization, and routine maintenance of hydropower installations. We include small hydro projects that hold an electrical generation capacity of <10 MW, and large hydro projects that hold an electrical generation capacity of ≥ 10 MW. We do not take into account ocean energy projects (that generate electricity from the mechanical energy derived from tidal movement or wave motion).	Eurostat, 2018
Screening metrics	We were able to track investments for large hydro projects as indicated in ADEME's Markets and Employment study, that assembles annual activity reports from the main Hydroelectric utilities: Compagnie Nationale du Rhone (CNR), Société Hydro-Électrique du Midi (SHEM), and Électricité de France (EDF). Pumped Storage Waterplants (PSP) projects are considered a hydroelectric energy storage system and not a renewable energy source. They are not differentiated in the realized investments for large and small hydro projects reported by EDF. Nonetheless, due to their useful role in balancing energy supply during peak demand periods and their ability to store energy produced by renewable sources, we include this aggregation accepTable with regard to general objective of the Landscape. The investment for small hydro projects as reported in the ADEME study from the annual electricity reports published by RTE, the French transmission system operator.	EDF, 2016a RTE, 2016a ADEME, 2016f
Attribution to project developers	We consider that all projects were undertaken by special purpose vehicle companies (SPVs). SPVs for large hydro projects are primarily held by the two principal actors of the hydroelectric sector according to the ADEME: EDF and Engie. For small hydro, EDF operates around 200 small power plants, and SHEM operates about 40 power plants for 162 MW installed. Alongside those two actors, a thousand independent producers operate around 1,700 small installations.	EDF, 2016a

Wind

Climate investment in onshore wind power		Sources
Inclusion criteria	Projects that generate electricity from the kinetic energy of the wind into electricity are included in the Landscape.	
Screening metrics	We include onshore projects installed during the year, as reported by the ADEME. It is to be noted that as of 2016, investments in offshore wind generation projects have not started yet and will start to be included in the Landscape as they enter construction phase or on the project's date of completion.	ADEME 2017i
Number of projects	The end of year "installed power" in MW units reported in the ADEME study give us an estimate of the number of projects realized per sector during the year.	ADEME 2017i
Cost of projects	We estimate the unitary cost (in €/kW) of onshore wind installations by dividing the total investments (in millions EUR) with the number of projects installed during the year (installed power measured in MW units), as reported in the ADEME study.	ADEME 2017i
Attribution to project developers	Investments for the development of onshore wind projects are carried by special purpose vehicles (SPVs).	

Solar PV

Climate investment photovoltaic power		Sources
Inclusion criteria	Projects that generate electricity from solar energy through photovoltaic processes are included in the Landscape.	
Screening metrics	We were able to track annual installations by power category as reported by the ADEME. The power categories provided by the ADEME are residential (<9 kWc), roof-based (9 to 250kWc), and ground-based power stations (>250kW).	ADEME 2016f
Number of projects	These projects were then distributed across the five Landscape sectors: residential, tertiary, agriculture, industry, and ground-based power stations. We assumed that a majority of roof-based installations were made in the tertiary sector, followed by the industrial and the agricultural sectors.	ADEME 2014a, 2016f and 2017i
Cost of projects	To identify the amount of realized investments for each sector (in euros million), we used the unit cost of installations (in €/W) provided in the ADEME study and multiplied it by the installed capacity in the respective power category.	ADEME 2016f
Attribution to project developers	Investments for the development of ground-based photovoltaic power stations are carried out by special purpose vehicles (SPVs).	

Solid biomass

Climate investment in power generation from solid biomass		Sources
Inclusion criteria	Projects that generate power from the combustion of solid biomass and wood products are included in the Landscape.	
Screening metrics	We were able to track investments to develop solid biomass incineration plants from the ADEME study, by focusing on the end of year electric generation capacity of the realizations in the collective, industrial, and tertiary sectors.	ADEME 2016f
Number of projects	The ADEME study allows us to identify the number of commissioned installations that generate power from solid biomass sources. Due to a lack of homogeneous information over the years, the ADEME reconstitutes the commissioning series from three different sources: Sustainable Development Ministerial Statistical Department (*Service de la donnée et des études statistiques*, SDES) Regulatory commission of energy (*Commission de régulation de l'énergie*, CRE) and Observ'ER.	ADEME 2016f
Cost of projects	We identify the total amount of investments in this sector from the ADEME study, that calculates the value from the estimated average unitary cost. Investments for projects established under the framework of the 4th CRE tender amount to 1.4 billion euros for 420 MW commissioned. The average unitary cost is thus estimated at 3,3 M€/MWe. The ADEME also considers that the realization to be spread over three years: ¼ during the first year, ½ during the second year, and ¼ during the third year (the commissioning year).	ADEME 2016f
Attribution to project developers	Investments for the development of solid biomass incineration plants are carried out by special purpose vehicles (SPVs).	

Biogas

Climate investment in power generation from biogas		Sources
Inclusion criteria	We include power generation capacities from biogas, which itself is the result of the anaerobic digestion of organic matter such as livestock effluents, agro-food industry waste products, sewage sludge, household waste.	Observ'ER, 2010 to 2016a
Screening metrics	We include investment in additional power generation capacities from biogas as reported by the ADEME.	ADEME 2016f
Cost of projects and amounts of investment	We use the estimate of investments in biogas power plant projects provided by the ADEME based on its knowledge of the total cost of projects that received support from *the Fonds chaleur* and *Fonds déchets*. According to the ADEME, virtually all biogas power plant projects have received support from either of these two funds. The ADEME includes total investment in the project to be spread over three years ending with the year the project is completed: 25% of the investment is completed in the first year, 50% in the second year and 25% in the third year. Because of this method, investments reported annually by the ADEME and in the Landscape do not exactly follow the series communicated by Observ'ER in MW. Investments (in euro million) and unitary cost (euro million/MW) for installations that generate electricity from biomass sources are reported by the ADEME. Calculations are based on the annual realized installations of the commissioning series by following this hypothesis: installations are spread over three years: one-quarter the first year; half the second year; and one-quarter the third year (the commissioning year).	ADEME 2016f
Attribution to project developers	Projects generating power from biogas are split in two categories. Centralised projects include large multisource units (*unités territoriales*) and units extracting biogas from non-hazardous waste landfills (ISDND). They are included in the totals presented in this chapter. We assume that all centralised projects are developed by special purpose vehicles (SPVs). Decentralised projects include small units that produce biogas from agricultural waste at the scale of a single farm. They are included in the totals presented in the agriculture chapter and are developed by private companies (farms).	

Waste incineration

Climate investment in power generation from waste incineration		Sources
Inclusion criteria	Projects that generate power from the combustion of non-hazardous waste are included in the Landscape.	
Screening metrics	We track investments in municipal solid waste incineration plants (*usine d'incinération des ordures ménagères*, UIOM) as reported by the ADEME study.	ADEME 2016f
Number of projects	We take the renewable energy generation capacity (in MW) of municipal solid waste (MSW) installations reported by RTE.	RTE, 2015
Cost of projects	The ADEME extracts annual commissioned installations from the "SINOE déchets" database. This capacity is measured in tons per year. It is then converted in tons per hour based on an average usage of 8,000 hours per year. The ADEME then uses an average price of €5,9 million per ton hour to calculate the investment cost of units commissioned over the years. The ADEME allocates the investment cost over three years: ¼ in year n-2, ½ in year n-1 and ¼ in the year n: the commissioning year. It should be noted that the ADEME includes that only 14% of all investments in UIOM units contribute to the production of renewable energy. This estimation is reached with the pro-rata calculations to identify the value of renewable energy sales (estimated at 13 €/ton of waste combusted) compared to the value for waste elimination services without reclamation identified by the ADEME study (estimated at 90 €/ton).	ADEME, 2016f ADEME, 2017i
Attribution to project developers	Investments for the development of municipal solid waste incineration plants are carried out by special purpose vehicles (SPVs).	

Renewable gas generation capacities

Biomethane injection

Climate investment in biomethane production and injection into the natural gas grid		Sources
Inclusion criteria	The process of anaerobic digestion contributes to several environmental stakes, including waste reduction, renewable energy production, and GHG emission reductions. We include investments realized to create or extend biomethane production and injection into the public natural gas grid.	
Screening metrics	We include the maximum annual injection capacity (expressed in GWh/year) of the biomethane injection installations established during the current year, as reported by the Sustainable Development Ministerial Statistical Department (*Service de la donnée et des études statistiques*, SDES).	CGDD, 2017g
Number of projects	To identify the number of installations realized each year, we convert the theoretical maximum power production capacity of biomethane injection installations (GWh/year) -as reported in the aforementioned SDES study- into their equivalent physical flow (Nm_3CH_4/h).	CGDD, 2017g
Cost of projects	We include the investment cost per installation as reported by the ADEME study "technical, economic, and environmental study of biomethane injections in the natural gas grid". The study presents three different costs each relative to the maximum annual methane injection rate of each production farm, ranging from 20 to a 100 Nm_3CH_4/h: • Individual installations (such as farm-sized installations); • Collective installations (grouping several farms); • Centralised installations (such as a waste treatment plant). We decided to average the cost across all three types of installations. The weighted average takes into account the fact that a majority of projects are rather small, as documented in the publication "State of play of biomethane in France" by ENEA Consulting. Multiplying the weighted average unit cost with the annual maximum production capacity of biomethane injection projects, allows us to estimate the realized investments during the year.	ADEME, 2016h ENEA, 2017
Attribution to project developers	We consider that all projects were undertaken by special purpose vehicle (SPVs).	

Connecting renewable power generation capacity to the grid

Climate investment in power networks		Source
Inclusion criteria	In the Landscape we include the investments realized to connect new renewable generation capacity to the national electrical grid.	
Screening metrics	Following the scope of the "Regional Plans for Renewable Energy Connection to the Grid" (*Schémas régionaux de raccordement au réseau des énergies renouvelables*, S3REnR), we only include solar and wind electricity generation projects completed during the year. This excludes projects that generate electricity from biomass, biogas, waste and hydropower.	RTE, 2014a
Number of projects	We take the generation capacity (in MW) of solar and wind electricity generation projects completed during the year as reported by the ADEME.	ADEME, 2017i
Cost of projects	The unitary cost to connect renewable energy installations to the grid is calculated as the sum of: • The fixed payment paid by the producer to the distribution network operator (ENEDIS); • The fixed payment paid by the producer to the transport network operator (RTE); • The cost of network reinforcement estimated by RTE in the S3RENR synthesis divided by the amount of MW projected to be connected between 2015 and 2020. These payments and the remaining costs of connecting renewable electricity projects to the electrical grid are documented in the S3ReNR synthesis published in 2014 by RTE. The investments are then calculated by multiplying the installed capacity with the unitary cost.	RTE, 2014a
Attribution to project developers	We consider that the fraction of the total cost paid by the producer to the distribution network operator is attributed to ENEDIS, the fraction of the total cost to the transport network operator as well as the reinforcement costs are attributed to RTE. Both ENEDIS and RTE are part of the infrastructure management company category of the Landscape.	

District heating

The 2016 edition of the Landscape replaces the methodology used in the previous editions 2014 and 2015, which was based on the hypothesis of costs of the "Prévôt" report (CGM, 2006) and the statistical surveys of the FEDENE (FEDENE, 2011 to 2017). The new methodology align with the estimations of investments that are part of those projects financed by the Fonds Chaleur of the ADEME (ADEME, 2015d). These estimations include investment expenditures for the creation of heating networks or district cooling and extension of existing networks.

Climate investment in the extension of heating networks		Sources
Inclusion criteria	In the Landscape, we differentiate decentralised individual heating, the centralised production of renewable heating to feed distribution networks, and the extension of heating distribution networks that transport renewable and non-renewable heat to buildings. Under heat distribution networks, we include the latter, i.e. investments realized to create or extend heat distribution infrastructure (e.g. insulated pipes) and heat substations connecting buildings to the distribution network. Investment in centralised production of renewable heating are not included in this total, as it was impossible to separate such projects from large but decentralised production of renewable heat. Networks distributing heat generated at least in part from fossil fuels were also included on the basis that their flexibility can be exploited in the future by switching to renewable energy sources. This rationale is exposed in the French LTECV: "38% of the heat we consume will have to come from renewable sources (biomass, waste recovery, geothermal energy), along with the extension of the heat and co-generation networks."	LTECV, 2015
Screening metrics	Projects covered in the Landscape are those who received funding from the ADEME Fonds Chaleur. It should be noted that this includes networks distributing heat generated at least in part from fossil fuels.	
Amount of Investments	We identify the total investments of heat distribution projects as reported by the ADEME. The amounts correspond to the total cost of projects that received support from the ADEME's Fonds Chaleur.	ADEME, 2016f
Attribution to project developers	Heat distribution networks are the property of local governments. Their maintenance and development often is conducted by infrastructure management companies. In the Landscape, we represented investment as undertaken by local governments themselves.	

Nuclear power

While there is still continued discussion on the role of nuclear power in the 'energy transition' in France, the French Government does consider the development and prolongation of energy components in existing nuclear plants as part of its low-carbon strategy. The Landscape methodology thus includes these investments in a transparent and disaggregated fashion.

Climate investment in nuclear power generation		Sources
Inclusion criteria	We include investments in power generation from nuclear. We include investments in new plants, specifically, the EPR nuclear reactor under construction at Flamanville, and in the retrofitting or replacement of major components (vapor generator, circuits) of existing reactors. This excludes investments for improved security measures required after the Fukushima disaster (diesel emergency generators), maintenance, and general security.	PPE, 2016 HLEG, 2018
Screening metrics	Investments in nuclear reactors are reported by EDF to the CRE.	
Amount of Investments	We consolidate the nuclear series in two categories: the new EPR installation in Flamanville and the historical installations. We track investments (In euros billion) concerning the latter from the CRE publications on regulated electricity tariffs during the period 2011-2015, then from the data published by EDF for the post 2015 period. We use the annual electricity reports published by RTE to identify the installed power capacity of nuclear energy.	CRE, 2014b EDF, 2016b RTE, 2016a
Attribution to project developers	Projects are attributed to EDF as their financing is undertaken directly in the company's overall balance sheet.	

PART 4

Analysis and discussion

The stability of total climate-related investments over the past 3 years masks variations between the three principal areas of the energy transition in France. Additionally, the proportion of climate finance driven by the public sector is increasing faster than the total climate investment. Overall, however, investments remain insufficient in relation to the annual levels of investment estimated to be needed to achieve the objectives of the French National Low-Carbon Strategy (Stratégie Nationale Bas-Carbone, SNBC).

Climate investment is stable overall, but shows contrasting trends between areas

Climate investments covered in the Landscape have been stable since 2013 at around €32 billion per year, after having increased by €2.3 billion between 2011 and 2013. This stability masks contrasting trends among the three principal areas of the transition.

In the area of energy efficiency, which mainly concerns the building and industry sectors, annual investments have increased since 2011 and are provisionally estimated to reach €14.6 billion in 2016. This increase reflects several trends, including: gradual recovery in new building construction, strengthening of incentives for the renovation of private housing units, and the targeted programmes for the refurbishment of social housing units.

In the area of renewable energies, annual investments significantly decreased between 2011 and 2013, in relation to the end of support mechanisms favouring photovoltaic systems. From 2013 to 2016, investments were stable in the range of €3.5 billion to €4.2 billion.

In the area of sustainable infrastructures, annual investments significantly increased from 2011 to 2013, rising from €7.7 to €11.5 billion; but then decreased by €2 billion from 2013 to 2016. These variations mainly reflect the time table for major high-speed rail projects, which reached a peak in 2013, and for urban public transport projects in major metropolitan areas, which reached their peak in 2014.

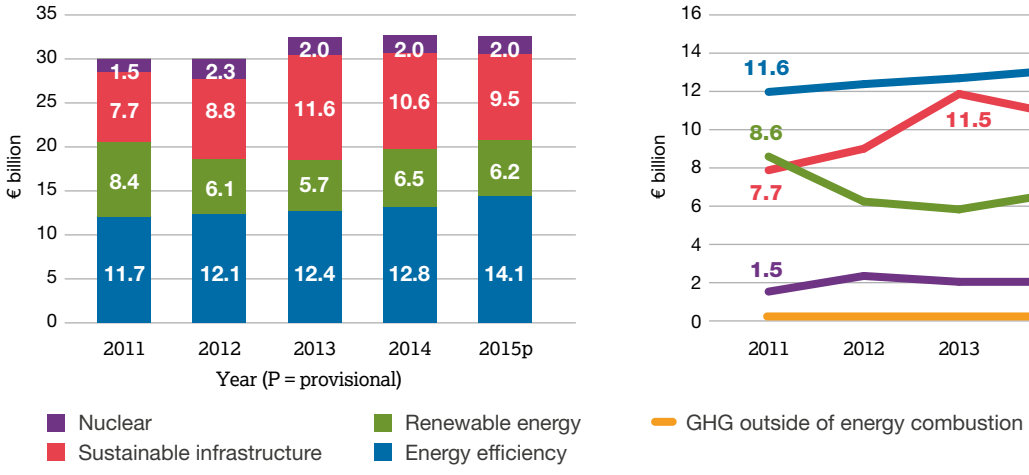
Investments in the nuclear energy, as well as in non-energy processes such as forestry, have remained stable since 2011.

The Landscape dataset allows improved analysis of the effect of public financial instruments on climate investment

It is essential to assess which instrument or combination of instruments is most adequate to increase and redirect finance flows towards investments aligned with a long-term development pathway compatible with climate change mitigation and adaptation objectives.

- A first area of analysis supported by the Landscape dataset is an improved understanding of the causes and impacts of changes in level of investment across time. An increase in the total volume of investment may be linked to different phenomena, such as a greater number of projects, an increase in the average quality of projects, or an increase in the average cost of projects regardless of their quality.
- Conversely, decreasing total investment may be associated with a fall in the average price of projects,

EVOLUTION OF CLIMATE INVESTMENT AREAS IN FRANCE BETWEEN 2011 AND 2016



such as observed in solar photovoltaics or, more recently, electric vehicles. It is thus important to take into account the changes in relative cost of key technologies within a sector and the implications for climate-related impacts.

Analysing the role of public finance for climate investment

The domestic Landscape methodology uses a broad definition to identify which finance flows are driven by public action. This definition takes into consideration criteria assessing both the project developer and the financial instruments used.

How to measure the impact of public intervention on climate investment and finance?

Publicly-driven climate finance regroups all financial flows supporting climate investment through public institutions or public intervention. As such, they group four distinct situations described in the Table below:

- Direct support to public investment in the form of subsidies grants and transfers to public project managers, as well as public equity in their own funds. Example of this form of intervention include central and local governments providing subsidies to social housing authorities, or having a share of equity in infrastructure management companies such as SNCF Réseau and RATP. This form of intervention represented €6.3 billion in 2016.
- Debt raised by public project managers from banks and capital markets. In this case, while the funds are provided by the private sector, the decision to invest is tied to the policy of a publicly-owned or governed institution. For example, local governments and public housing authorities rely on commercial debt to fund their investment in building retrofitting, while infrastructure management companies issued bonds to fund their investment programs. This form of intervention represented €5.2 billion in 2016, up from €3.8 billion in 2011.
- Grants and concessional loans provided to households and private companies are the most recognisable form of public finance as they play an important role to bring private project developers to make climate-friendly investments. Examples include the CITE for private dwelling retrofitting or subsidies of the ADEME's Fonds Chaleur supporting renewable heat in buildings and industry. This form of public intervention represented €4.8 billion in 2016.
- Financial transfers between private sector institutions can be driven by public intervention. This is the case for white certificates, where the government obliges utilities to obtain certificates through grants or rebates offered to households or other private companies. It can also concern the issuance of "eco-loans" (éco-PTZ) by commercial banks, since the principal of the loan is issued by banks and only the interests are covered by public funding. This form of intervention represented a much smaller share of publicly-driven finance, about €0.6 billion in 2016.

The share of climate finance driven by the public sector has increased from 2011 to 2016

Publicly-driven finance in France has increased from 2011 to 2015, both in absolute value (from €14.3 to €17 billion) and in proportion to total investments (from 48 to 52%). This trend is observed and explained in three sectors where the public finance instruments are deployed:

- In the building sector, grants and subsidies deployed by the French government have seen strong growth. This results from the budget increase for the energy transition tax credit program (*Crédit d'impôt pour la*

Climate investment	Climate investment in France in 2016 €32.1 billion				
	Public project developers €11.4 billion 32% of climate investment		Private project developers €20.6 billion 64% of climate investment		
Climate finance	Publicly-driven finance €16.7 billion 52% of climate finance				Private finance €15.3 billion 54% of cl. fin.
	Subsidies to and equity of public project managers €3.8 billion	Debt raised by public project managers €7.6 billion	Grants provided to households and private companies €4.9 billion	Organized transfers between private sector institutions €0.4 billion	Commercial debt and own funds €15.3 billion

transition énergétique, CITE) and, to a lesser extent, from the increase in amounts granted to the Fuel poverty program (*Programme habiter mieux*) set up by the French national housing agency (*Agence Nationale de l'Habitat*, ANAH). Total investment in this sector has also moved upwards since 2012, but more slowly than the share of public support mechanisms, which explains the more important role played by the latter in total volume of finance for the sector.

- In the transport sector, the period 2013-2015 shows an increase in the proportion of finance driven by the public sector, mainly due to the completion of the South East Atlantic high-speed rail construction project, in which private finance was channelled through the LISEA consortium.
- In the renewable electricity generation sector, mechanisms enabling producers to gain access to loans at favourable rates have been progressively deployed since 2011. This has been supported in particular through direct finance from the public bank BPI France, and through credit lines from the EIB negotiated with commercial banks.

Current climate investment levels are insufficient to achieve national objectives

The adequacy of current climate investment and financial flows tracked in the Landscape can be assessed against the estimated investment needed to achieve national climate objectives found in the 2016 SNBC and the Multiannual energy plan (PPE) of the same year.

Comparing current figures and estimated investment needs is a delicate exercise

Investment levels need to be based on a common perimeter of actions for which both current and forward-looking data is available. Figures on past and present climate investment presented in the Landscape are aggregated from public sources on each relevant action. However, forward-looking projections are often provided by macroeconomic models, which deduce investment from elasticities representing the average cost of several combined technologies.

Previous work lacks fine sectoral comparisons between current and required investment

Work conducted during the national debate on the energy transition concluded that the required investment to achieve climate objectives ranged between €47 and €76 billion per year between 2015 and 2050 (CNTE, 2013). The actions reviewed were mostly related to energy efficiency in buildings and vehicles, as well as the production of renewable energy, while range mostly encompasses differences between the technical pathways discussed during the debate.

Recent work conducted by the ADEME and CGDD for the SNBC process includes a macroeconomic assessment of the economic impacts of its policies and measures (CGDD, 2016f). This assessment found that investment (GFCF) was higher in the SNBC scenario (called AMS) compared to a current policy baseline (called AME). The increase in investment amounts to 1.9 to 2.7% of France's GDP per year between 2017 and 2021, which translates to around €50 and €70 billion. Notably, between €40 and €50 billion of investment can be traced to the SNBC's objective of increasing the pace of housing construction alone. However, the investment gap highlighted by the ADEME does not take into account investment increases associated with current policies, which might already represent an increase compared to past and current levels. Furthermore, the effect of implementing the strategy on gross investment levels for each sector or investment area of the energy transition was not calculated.

I4CE proposed a new method of estimating the levels of investment required to achieve SNBC and PPE

For the first time since its inception, the 2017 Edition of Landscape provides an estimate of the investment levels required to achieve objectives set in the SNBC and PPE. To do so, it considered the key national objectives that can be translated into equipment acquisition targets. For example, the SNBC sets the objective of retrofitting 500,000 housing units per year starting in 2017, while the PPE adopted a target of between 21.8 and 26 GW in wind power projects for year 2023.

It then adopted a hypothesis on the price at which such equipment could be available in the future. When available, price hypotheses were based on the strategic plans themselves. Otherwise, estimates are based on recent literature or reports from key expert institutions such as the ADEME's reference work on renewable electricity prices (ADEME, 2016a), estimates for transport infrastructure costs (CERTU, 2009) and current unit costs described in the Landscape. Authors did not consider a drop in equipment unit cost over time unless explicitly mentioned in the SNBC or PPE as in the case for solar energy and electric cars.

Both volumes and prices were expressed as ranges to represent uncertainty. Some objectives were expressed in the form of ranges in the national documents, for

example renewable electricity generation capacity targets in the PPE. Ranges were also used to reflect the observed spread of prices of low-carbon equipment in current markets. All assumptions and sources regarding adequate investment levels were published in a specific note accompanied by fully transparent calculation charts in MS Excel format (I4CE, 2017b).

Methodological issues and lack of data prevents the coverage of some sectors

The figure below presents the coverage of I4CE's estimate for each sector. Investment needs could not be calculated for the industry, agriculture and forestry sectors due to the lack of targets that could easily be translated into equipment acquisition. Typically, sector-wide targets in terms of energy efficiency do not indicate a particular technological pathway or equipment array which could be translated into investment figures. Obstacles to making investment estimates become even more significant for topics such as research and development or investment in adaptation to climate change. These areas were left out of the assessment altogether.

OVERVIEW OF CLIMATE INVESTMENT ACTIONS COVERED IN GAP ANALYSIS

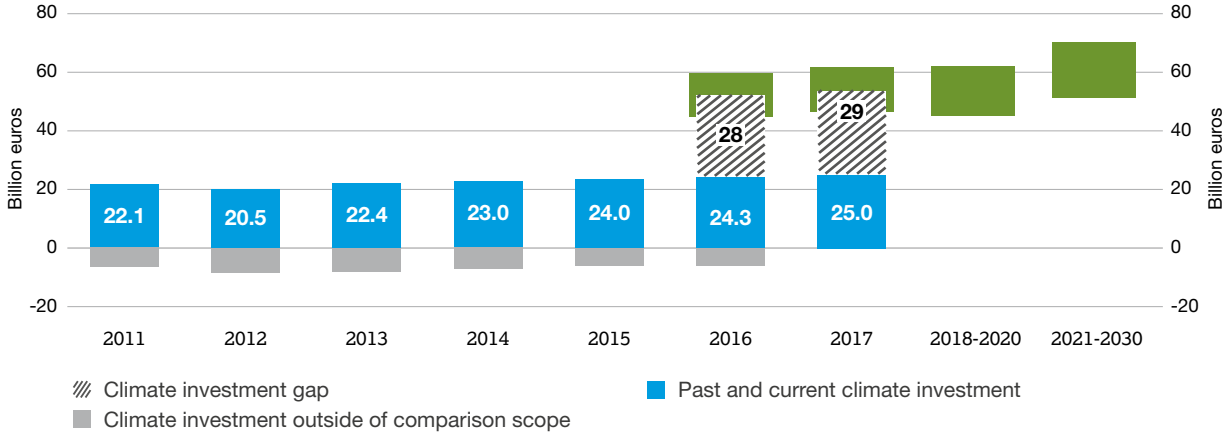
Sector	Current and past climate investment covered in the Landscape of climate finance, 2017 Edition	Investments needs documented from SNBC and PPE	
	Excluded from gap analysis	Included in gap analysis	Excluded from gap analysis
Buildings	Biomass in multi-unit housing and tertiary buildings	Energy efficiency in new buildings (housing & tertiary) Energy retrofitting of existing buildings (housing & tertiary)	Complete construction cost of new buildings (outside of energy efficiency)
Transport	Electric light-goods vehicles Electric and hybrid heavy-duty vehicles Electric, hybrid and NGV buses	Electric and hybrid cars NGV heavy-duty vehicles Railways (infrastructure) Urban public transport (infrastructure)	-
Industry	Energy efficiency*		Energy efficiency*
Agriculture	Energy efficiency Forestry	Power generation from biogas (anaerobic digestion)	-
Centralized energy production and networks	Nuclear (EPR and retrofitting of current plants) Geothermal electricity Biomethane injection	Renewable power generation (onshore wind, solar PV, biomass, biogas, small hydro). Extension of heating networks	-

** In the industrial sector, even though both current and required climate investment can be estimated, scope and sources differ too widely to allow a direct comparison*

COMPARISON BETWEEN CURRENT CLIMATE INVESTMENT AND ESTIMATES OF INVESTMENTS REQUIRED TO REACH FRANCE'S NATIONAL OBJECTIVES

	Current investment in low-carbon technologies		Estimates of investments required to reach France's national objectives (low – high)	
(In billion euros)	2011	2016	2016-2020	2020-2030
New residential buildings	2.1	2.0	1.2 - 2.4	2.6 - 3.1
Residential retrofitting	8.2	8.9	18.6 - 22.1	19.2 - 22.8
New tertiary buildings	0.4	1.4	1.7 - 2.8	3.8 - 5.7
Tertiary buildings retrofitting	0.7	0.6	3.4 - 8.6	3.4 - 8.6
Low-carbon vehicles	0.1	0.5	6 - 6.9	9.5 - 11.9
Transport infrastructure	5.6	7.3	7.7 - 8.7	6.7 - 8.5
Electricity generation	3.8	3.3	4.4 - 5.6	3.8 - 5.8
Heating networks	1.4	0.3	2 - 4	2 - 4
Total	**22.1**	**24.3**	**45 - 61.1**	**51 - 70.5**

COMPARISON BETWEEN CURRENT CLIMATE INVESTMENT AND ESTIMATES OF INVESTMENTS REQUIRED TO REACH FRANCE'S NATIONAL OBJECTIVES

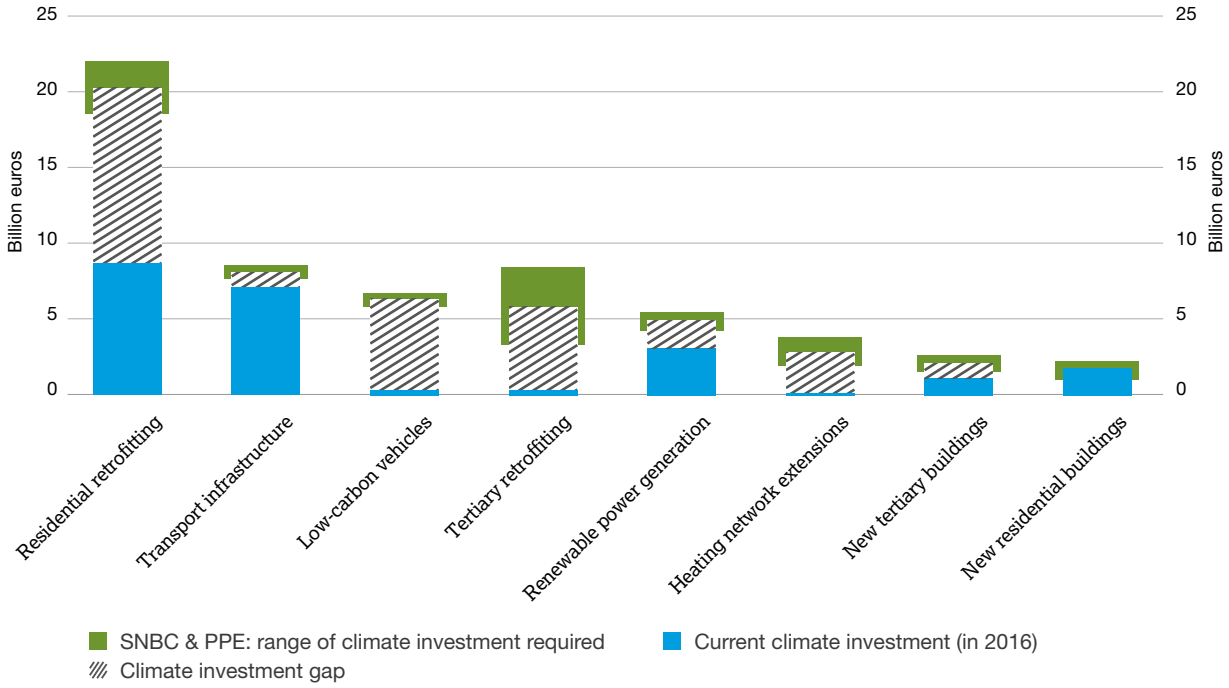


Between €45 and €70 billion of annual investment would be needed up to 2030 to achieve the objectives defined by the SNBC and the PPE.

Using a comparable perimeter, climate investments identified by I4CE in the France domestic Landscape in 2016 and estimated for 2017 total approximately €25 billion. Comparing these numbers indicates that there is currently an annual gap between investments and needs of between 20 and €40 billion.

In absolute amounts, the gap is concentrated in the building sector, primarily in the retrofitting of private homes, as presented in the figure below. For the retrofitting of tertiary buildings, low-carbon vehicles and district heating, investment needs are low in absolute amounts, but represent several times the current level of investment. For renewable energy production, sustainable transport infrastructure, current investment is close to the level of estimated investment needs.

CLIMATE INVESTMENT GAP IN FRANCE BY SECTOR



I4CE's analysis of the investment gap supports existing assessments

In the long term, establishing links between the Landscape of climate finance and the estimates of investment needs would make it possible to better characterize and assess proposals for extending or improving public and private financial instruments. This aims to contribute to the assessment of the best combination of tools given the economic and financial characteristics of each sector and of the climate-related investments and actions needed.

Chapter 8 of the PPE quantifies the level of funding public institutions should dedicate to the achievement of its objectives. It indicates that it will be necessary to increase current funding from €7.8 billion in 2015 to €14.7 billion on average from 2016 to 2023 (PPE, 2016). This order of magnitude is consistent with the gaps identified in the analysis presented in this study.

France, Germany, Belgium have comparable levels of climate investment, but contrasting funding models

Initiatives for the monitoring of domestic climate-related financial flows have proliferated around the world, with publications on Indonesia (CPI, 2016), South Africa (TIPS, 2013) and Ivory Coast (CPI, 2017a), and work under way in Colombia (DNP, 2017).

While increasing, the knowledge of climate-related investments in Europe and other OECD countries is patchy (EEA & Trinomics, 2017). Few countries today have carried out systematic studies of climate-related financial flows in their domestic economies. Two studies similar to the French Landscape were carried out in Germany and Belgium, in 2012 and 2016 respectively.

Landscape of climate finance in Germany

The Landscape of Climate Finance in Germany produced by the Climate Policy Initiative (CPI) assessing domestic climate finance flow in Germany for the year 2010 was the first study published in Europe on this topic. It estimated total climate-related investments at €37 billion, i.e. 1.5% of German GDP. The study found 95% of finance was from the private sector, although the definition of privately- and publicly-driven financial flows differs from that used

in I4CE's French assessment – particularly in terms of public transport. CPI's study shows a major part of investment went to renewable energies, at €26 billion, versus €7 billion for energy efficiency (CPI, 2012).

On initial examination, the volumes of investment identified in Germany were of the same order of magnitude as those measured in France for the years 2011 to 2014. However, the German study did not include transport infrastructures, which represent €8.9 billion in the French Landscape in 2016. In the building sector, the German study only covered a smaller portion of renovations given more restrictive eligibility criteria than used in the French Landscape. Lastly, the year 2010 in Europe marked a peak of investment in renewable energies, particularly in Germany. Other studies have indicated that levels in Germany decreased from 2010 to 2013, before bouncing back in 2014 to around €19 billion of investment (BMWI, 2015).

In terms of financial instruments, the German Landscape highlighted the central role played by KfW, the country's main public financial institution. Results from the study indicate that KFW played a principal role in structuring the 'onlending' intermediated lending model through the local branches of private banks. Around €16 billion in concessional loans for private individuals and businesses for energy efficient renovations of buildings were made available through this model.

In Germany, commercial banks are the primary financial intermediary for loans to project developers. Comparatively in France, the major part of concessional debt totalling €3.5 billion was issued directly by the government-owned financial institutions such as Caisse des Dépôts.

Landscape of climate finance in Belgium

The Landscape of climate finance in Belgium is a study commissioned by the Belgian Federal Public Service for the Environment and carried out by the Trinomics and Ernst & Young consulting firms in 2016. The study covers investments for both mitigation and adaptation in 2013. It identifies investments of €6.4 billion, i.e. around 1.6% of GDP and 7.3% of gross capital formation, proportions comparable to those identified in Germany in 2010 and in France in 2014.

Investments were concentrated in renewable energies and cogeneration (54% of the total), followed by energy efficiency of buildings (26%). These relative proportions of total investment are almost opposite compared to the French Landscape, where energy efficiency is the principal area of investment. Investments for adaptation represent only 1% of the total and are dedicated to flood management.

Financing identified in the study stemmed 47% from businesses (equity capital and debt), 34% from national and European public budgets, and 19% from households. The role of businesses providing financial flows is greater than in the French Landscape.

Publicly-driven finance consisted in providing incentives for projects to lower their energy or carbon footprint. Indirect interventions were also accounted for, including operations to reduce entry cost or to support projects such as energy audits, certification and standardisation mechanisms, and energy performance contracts. Concessional loans played a marginal role in finance flows (Trinomics, 2016).

The Table shown below summarises the three principal European landscapes of domestic climate finance.

COMPARISON OF THE SCOPE AND RESULTS OF LANDSCAPES OF DOMESTIC CLIMATE FINANCE IN EUROPE

	Germany		France		Belgium	
Authors	Climate Policy Initiative (CPI, 2012)		I4CE (CDC Climat, 2014; I4CE, 2015c)		Trinomics, Ernst & Young (Trinomics, 2016)	
Partners	-		MEEM, ADEME		Federal Public Service for Health, Security of the Food Chain and Environment	
Year covered	2010		2011 to 2015		2013	
Scope						
Mitigation	*covered*		*covered*		*covered*	
Adaptation	*not covered*		*not covered*		*partial coverage*	
Sectors						
Buildings	New	*yes*	New	*yes*	New	*yes*
	Renovation	*yes*	Renovation	*yes*	Renovation	*yes*
Transport	Vehicles	*yes*	Vehicles	*yes*	Vehicles	*yes*
	Infras.	*yes*	Infras.	*yes*	Infras.	*yes*
Agriculture	Energy	*yes*	Energy	*yes*	Energy	*yes*
	Other GHGs	*yes*	Other GHGs	*partial*	Other GHGs	*partial*
Industry	yes		yes		yes	
Energy	Fossil	*partial*	Fossil	*yes*	Fossil	*yes*
	Nuclear	*no*	Nuclear	*yes*	Nuclear	*no*
	RE	*yes*	RE	*yes*	RE	*yes*
	Networks	*yes*	Networks	*partial*	Networks	*partial*
R&D	*partial*		*partial* (1)		*partial*	
Investment	(in 2010)		(in 2014)		(in 2013)	
Total	**€37 billion**		**€32 billion**		**€6.4 billion**	
% of GDP	1.4%		1.4%		1.6%	
% of GFCF(2)	7.3%		6.4%		7.3%	
Financing	The study indicates that 95% of finance comes from private sources, of which half is in the form of concessional loans issued by government-owned institutions.		The public sector supported more than half of finance (55% in 2014). The main instruments are direct grants and subsidies to project developers.		The principal financial tools are equity capital and bank debt. Concessional debt represented only 3% of total finance. However, public investments represented 34% of the total	

Source: I4CE, CPI, Trinomics, according to comparison Table designed by I4CE for the EEA workshop "Domestic Landscapes of Climate and Green Finance in Europe" of 25 October 2016, Eurostat

(1) Separate coverage in the context of this edition: the amounts invested in R&D are not included in total investments.

(2) Gross fixed capital formation (GFCF) is a national accounting indicator that describes the investment expenditures during a given year. The GFCF takes into account for investment expenditures on some intangible capital.

Linking discussions on 'greening' the financial centre and climate investment and finance

The financial sector is increasingly called to contribute to achieving long-term climate and sustainability objectives. Article 2.1(c) of the Paris Agreement includes the objective of *"[m]aking finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development"*. This represents the first direct call to both public and private financial sector actors to assess and improve their contribution to achieving the objectives of the Paris Agreement. This formal call to action coincided with growing recognition by financial actors that climate change poses both tangible risks to their activities – whether stemming from direct physical impacts or public policy changes to drastically reduce fossil fuel consumption.

Little data is available on the impact of greening the financial sector on the real economy

- On one hand, data is increasingly available in terms of the volume of use of specific green financial products (such as green bonds) or the total volume of assets under management of financial institutions that have taken commitments to reduce 'brown' or non-aligned investments (such as in the fossil fuel sectors) or scale-up "green" investments.
- On the other hand, studies such as the Landscape of Domestic Climate Finance make data available on the levels of annual investment in terms of fixed capital formation contributing to sustainability objectives, particularly in terms of climate-related objectives. However for the moment, there is little connection being made the two.

An Increasing Awareness of Sustainability Concerns within the financial sector...

Within both national and supra-national governmental organizations, the role of the financial sector in combating climate change and improving sustainability has received extensive attention. The UN Environmental Program (UNEP) launched in 2014 an 'Inquiry into the Design of a Sustainable Financial System' (UNEP Inquiry).[1] In 2015, G20 Finance Ministers and Central Bank Governors asked the Financial Stability Board (FSB) to review how the financial sector can take account of climate-related issues leading to the creation of an industry-led task force: the Task Force on Climate-related Financial Disclosures (TCFD).[2] In Europe, the European Commission's Directorate-General for Financial Stability, Financial Services and Capital Markets Union (FISMA) launched a High Level Expert Group on Sustainable Finance, which has in turn led to the 2018 EU Action Plan on Financing Sustainable Growth.[3] At a national level, countries such as France have begun to integrate mandatory climate-related reporting and disclosure requirements into their financial sector regulation.[4]

In turn, building off of existing market-led responsible investment initiatives, a number of financial centers have launched dedicated sustainable finance initiatives. While varying in nature and scope, these initiatives often aim to exchange experience and facilitate joint action to expand and scale-up green or sustainable finance. In 2018, the International Network of Financial Centres for Sustainability (FC4S) was launched as a partnership between financial centers and UNEP, the latter acting at Convener and Secretariat.[5] In some instances, these financial center-focused initiatives receive government support as a means of financing the investments estimated as needed to reach climate and broader sustainability objectives.

1 *The mandate of the UNEP Inquiry into the Design of a Sustainable Financial System was to identify and consider potential changes to the "rules governing the financial system" that would better align the system's workings and consequences to sustainable development. These rules include financial and monetary policies, financial regulations and standards, financial system-facing fiscal measures and nongovernmental standards and rules (such as those originating with credit rating agencies, the accounting profession and industry groups). The Inquiry grounded its work in country-level innovative practices, and is building on this and associated cross-cutting analysis and international engagement into a practical set of suggested actions, principally by central banks, ministries of finance, financial regulators and standard setters.*

2 *Put in place by the G20's Financial Stability Board the Task Force on Climate-Related Financial Disclosures (TCFD), composed of 32 international experts, was mandated to "develop voluntary, consistent climate-related financial risk disclosures". The TCFD was announced at the end of 2015 and presented its final recommendations in June 2017. These recommendations have been broadly taken up by other initiatives and promote disclosures in four different areas: governance, strategy, risk management, and metrics and targets. As of June 2018, over 250 organizations have expressed their support for the TCFD.*

3 *The High-level Expert Group on Sustainable Finance (HLEG) analyzed, between end of 2016 and early 2018, the challenges and opportunities for sustainable finance in Europe. The report and recommendations address sustainability issues in general, with a special focus on climate-related issues, notably regarding climate-related financial risks. The recommendations of the HLEG form the basis of the* Action Plan: Financing Sustainable Growth *published by the European Commission on March 8th 2018.*

4 *For more information on Article 173 of the French Energy Transition Law, see* https://www.frenchsif.org/isr-esg/wp-content/uploads/Understanding_article173-French_SIF_Handbook.pdf.

5 *See* https://www.fc4s.org/ *for more information on this network.*

... but continued limited understanding of impact on real economy 'green' investment

However to date, relatively little quantifiable or empiric data is available on the impact on the real economy of the 'greening' of the financial sector. This disconnect has makes it difficult to assess both quantitatively and qualitatively:

1. How do initiatives to 'green' or align the financial sector with sustainability objectives lead to reorientation of investment in fixed capital formation (broadly referred to as 'infrastructure') towards 'green', 'climate' or 'sustainable' areas?
2. Given the global nature of the financial sector, how can the impact of the 'greening' of a given financial center be assessed in terms of contributing to climate or sustainability objectives in a given country or region?

The value of responding to these two questions is two-fold and requires further research and attention:

- As governments increasingly take action to incite and supporting the alignment of the financial sector with climate and sustainability objectives, officials will need improved understanding of how this contributes to achieving national and regional policy objectives.
- As financial centers develop roadmaps to 'green' their activities, it is important to understand the links between the financial and the 'real' economy to prioritize those actions and activities that contribute to international and national objectives.[6]

Overview of the metrics and measurement of the 'greening' of the financial sector[7]

Paradoxically, a number of the measures of the 'greening' of the financial sector may not lead provide information on whether financial actors are contributing to a net increase in the investments needed to achieve climate- and sustainability goals. While these measures demonstrate that steps are being made to green the activities of financial actors and sectors, it is not currently possible to assess whether this is leading to changes in what governments typically define as needed climate or sustainable fixed capital investment.

Green financial products and commitments:

- **Tracking of specific financial products and services**: the tracking of specific green financial products and assets has been seen as a principal means of evaluating how the financial sector is contributing to sustainable and climate objectives. For example, while the total volume of green bonds or other financial products is an important measure of an actor of financial center's uptake and use of these products, only data on new issuance or use of the products in question can provide insights into contribution to the transition. The labeling of all eligible assets can help improve tracking and internal integration of sustainability issues; however, aggregate data may not provide information on annual contributions to new 'climate related' end investment.
- **Tallying of divestment commitments**: divestment and exclusion of climate-adverse activities (whether through black lists, thresholds or other measures) is one of the principal strategies used to align financial activities with climate and sustainability objectives. While these pledges and commitments provide clear evidence that financial actors are reducing their exposure to some types non-aligned assets, they do not necessarily translate into a corresponding increase of financing and investment in 'green' activities. To understand the impact of divestment in terms of contributions to public fixed capital investments on climate change and other sustainability topics, it is necessary to collect the data needed to assess the reorientation of financial flows to low-carbon or green assets
- **Tallying of green investment commitments**: financial sector actors have been making an increasing number of commitments to finance climate-related or sustainable projects, companies or sectors. These commitments have a strong communications value to signal to economic actors, the financial sector and the broader public that these types of investments are being prioritized. Tracking these commitments can provide insights into the scale and relative share of future climate-related investments. However, this does not provide insights into the resulting fixed capital investment on the ground; connecting the financing "announcements' made by financial institutions to concrete climate or sustainable investments is difficult in practice.

6 *This report does not explicitly explore in detail the rationales behind why the financial sector should take action to address climate change. For more on this, please see I4CE's three climate briefs on the management of climate-related risks by financial actors:* https://www.i4ce.org/download/three-notes-on-the-management-of-climaterelated-risks-by-financial-actors/.

7 *A more detailed assessment of the current metrics and measures will be published in a forthcoming I4CE report.*

Insights provided by emerging performance frameworks

A number of frameworks have been developed to assess the 'green' performance of the financial system. These frameworks either seek to characterize this performance at either the national level, or at the level of a 'financial center'. The following provides an overview of how fixed capital investment and finance in the real economy is being tracked within identified performance, index and benchmarking approaches.

- **UNEP Inquiry Performance Framework**: In 2015 and 2016, the UNEP Inquiry into the Design of a Sustainable Financial System developed a white paper laying out the schematic 'performance framework'.[8] The proposed framework explicitly notes that *"... a market design that aligns with sustainability and inclusiveness must be sufficiently efficient and effective to generate financial flows that fully fund capital requirements"*.[9] While not widely implemented, UNEP Inquiry made substantial progress in developing the methodological framework for a country-by-country analysis of the country's financial sectors performance on sustainability topics. The proposed methodology focused on a macro 'system' level, paired with indicators proposed for 'deep dives' into five sub-sectors of the financial industry. The 'macro' system level proposed including indicators in of 'flows' towards concrete investments in fixed capital related to different areas of sustainability – similar to those captured in the Landscape of Domestic Climate Finance approach. Unfortunately, pre-existing country-by-country documentation and tracking of these flows was – and continues – to be limited beyond a few specific case.
- **Z/Yen Global Green Finance Index (GGFI)**: In March 2018, Z/Yen – a commercial for-profit think tank based in the City of London – and Finance Watch published the first edition of its Global Green Finance Index (GGFI), sponsored by the Mava Foundation.[10] The objective of the Index was announced as aiming to "*chart the progress of the world's financial centres towards a financial system that delivers sustainable development, and values people and the planet as much as profit*" (Y/Zen and Finance Watch 2018, 2). The methodological approach taken by the GGFI seeks principally to assess how each financial centre is adopting green finance. The principal component of the Index is the survey-based qualitative 'Financial Centre Assessment'. The qualitative data is combined with quantitative 'Instrumental Factors' data from 113 different sources. This Index, however, provides very little information on how financial centres are contributing to climate- or suitability-related fixed capital investment objectives. Currently, it appears that only the inclusion of the Climate Bond Initiative's data on green bonds by exchange provides the only direct link to fixed capital investment.
- **FC4S / Climate KIC Benchmarking the 'greeness' of financial centres**: In December 2017 in the side-lines of the One Planet Summit in Paris, Climate-KIC, I4CE and PwC published a benchmark of the 'greenness' of financial centres. Rather than attempting to rank financial centres, the benchmark seeks to act as *"a tool for comparison of approaches between financial centres and for follow-up of each one's progress by means of its annual publications, making it possible to measure the progress achieved"*.[11] The benchmark's 2017 methodology focuses on gathering existing data and information on indicators looking at five characteristics of the 'greeness' of financial centres (2017, 6): Transparency of information; Availability of green finance; Green intensity; Integrity of green finance; Dynamics of the green financial centres. While providing insights into progress being made by each financial centre, the 2017 methodology unfortunately provides only limited information to track and assess the contribution to national and international fixed capital investment objectives. An updated benchmark using a revised methodology is expected in 2018.

Steps to improve the tracking of the contribution of green finance – and financial centres – to climate and sustainability objectives be improved

I4CE has identified a number of pathways for improving the understanding of the contribution of the greening of the financial sector, and in particular financial centres with green initiatives, to climate-related objectives. A brief overview is presented here; each will be explored in more detail in a forthcoming report from I4CE.

- **Development of landscapes of domestic climate investment**: A basic component of better understanding the contribution of the financial sector to climate and sustainability investment goals is to

8 http://unepinquiry.org/wp-content/uploads/2016/11/Towards_a_Performance_Framework_for_a_Sustainable_Financial_System.pdf.

9 *Turbeville, Wally. 2016. "Towards a Performance Framework for a Sustainable Financial System." 16/14. Inquiry Working Paper. UNEP Inquiry: Design of a Sustainable Financial System.* http://unepinquiry.org/wp-content/uploads/2016/11/Towards_a_Performance_Framework_for_a_Sustainable_Financial_System.pdf.

10 *See* https://www.greenfinanceindex.net/GGFI1/Report/

11 *Climate-KIC. 2017. "Benchmarking the Greenness of Financial Centres." Climate-Kic, I4CE & PwC.* https://www.i4ce.org/wp-core/wp-content/uploads/2017/12/0118-Climate-KIC2752-Rapport-Benchmarking.pdf.

ensure that the progress to date to meet these goals is itself being tracked and assessed. France is the only country today for which an annual assessment of climate investment is conducted. As the European Environment Agency indicated in its 2017 report, only partial climate investment data is available from other European countries.[12] Even less data is available in terms of where the financing that supports this investment is coming from.

- **Improved tracking by financial institutions and increased external reporting**: Understanding of the contribution of the financial sector and financial entities to climate and objectives will most likely require improved tracking and reporting by financial institutions themselves. While no comprehensive assessment has been completed to date, evidence suggests that the data management systems – including the nomenclature for classifying transactions and activities – is not currently adapted for financial institutions to track internally what portion of their activities (in volume, percentage, turn-over, etc.) contribute to these objectives. While the spread of green financial products, and the increasingly use of green labelling by financial institutions may be slowly changing this, a more extensive shift in practice may be needed.
- **Centralized tracking and reporting by financial centers (including both domestic and international financial flows)**: In addition to improved tracking and reporting at the entity level, financial centers could have a role to play in aggregating this information to demonstrate how the members of each financial center contributed either to national objectives through domestic finance – or international objectives if they were involved in activities outside of the country or region. A means of incentivizing financial centers to do this could be to include more explicitly metrics to track to achieving climate- and sustainability fixed capital investment objectives within the performance frameworks, indices and measures of 'greenness' discussed here. While the information may not currently be available, this explicit request could ensure that financial centers have this on their agenda as they move forward.
- **Including end-investment in the EU Sustainable Finance Observatory**: Over the last three years, the subject of how to track progress made on sustainable finance has been increasingly discussed at the European level. Both the intermediate and final High-level Expert Group on Sustainable Finance (HLEG) reports both directly called for the creation of an 'EU Observatory on Sustainable Finance' to support evidence-based policy-making (HLEG 2018). The final HLEG report recommends the EU "Establish an EU Observatory on Sustainable Finance to support member state and EU level public policy development and evaluation, as well as public finance interventions in sustainable finance". Moving forward, it is essential that both the 'market data' and the information on 'end-investment' needs and flows is retained within the scope of the Observatory. This could :
  1) Improve the visibility over and understanding of current financial flows toward sustainable outcomes;
  2) Create a common framework for strengthening climate (and later sustainable) finance tracking at Member State level.

12 *EEA, and Trinomics. 2017. "Assessing the State-of-Play of Climate Finance Tracking in Europe." European Environment Agency & Trinomics Consultancy.*

Conclusion and next steps

Climate investment in France reached €32 billion in 2016

- From this total, €14.6 billion were invested in energy efficiency projects, €5.9 billion in the development of renewable energy production, and €9.2 billion for sustainable transport and network infrastructures. Investment in new and existing nuclear plants and GHG reduction in sectors other than energy consumption (such as agriculture, forestry and industrial processes) totaled an estimated €2.1 billion.
- For the most part, investment was made by household and private companies, while 52% of climate finance was driven by public authorities under various supporting instruments.
- Between €20 and €40 billion would be needed on top of current climate investment to reach national objectives set in the SNBC and the PPE.

Next steps

Further work on the Landscape of climate finance will aim at informing decision-makers and supporting public policies on the elaboration of financing strategies for the energy transition.

Assessing climate-adverse investments in France will further detail the Landscape picture

While continuing to pursue an accurate and up-to-date tracking of climate investments, the French Landscape of climate finance will develop new tools to assess the level of investment into areas with climate-adverse effects. Indeed, it is essential to put green investment figures in context with investments made in fossil fuels or energy-intensive technologies. This work will provide a sound basis to evaluate if the redirection of investment from 'climate-adverse to climate-aligned' is happening at the scale required by national objectives.

Updating climate investment needs based on the upcoming editions of the SNBC and PPE

In 2017, the French government initiated a review of its SNBC and PPE with the aim to refine and adapt its strategy and include new measures announced in its 2017 Climate action plan, including the aim to make France climate-neutral by 2050.

Following this review, the estimates of the level of climate investment required to achieve national objectives will be updated and compared with the latest Landscape results.

There is opportunity to improve domestic tracking of climate finance in Europe

In 2016, I4CE and the European Environment Agency (EEA) organised a workshop in Copenhagen on the topic of domestic climate finance tracking. Representatives of Member States, research institutes or advisory bodies and representatives of the European Commission attended this meeting (see the summary report of the workshop I4CE, 2016c).

This workshop and work commissioned in parallel by the EEA has highlighted that improving the transparency and tracking of domestic climate-related finance flows in Europe is essential for measuring, assessing and improving climate-change and energy transition policies (EEA and Trinomics, 2017). More broadly, data on climate-related end investment and how it is financed by the financial value chain is increasingly being seen as a key indicator to understand the broader 'greening' of the financial system.

This topic has been taken up by the High Level Expert Group on Sustainable Finance in Europe, as well as internationally by the United Nations Environment Project's Inquiry into the Design of a Sustainable Financial System.

However, the inventory drawn up by the EEA reveals that knowledge on domestic climate-related end investment, financial flows supporting this investment by public and private actors remains limited across the European Union. This is particularly an issue given the requirement for Member States to design, implement and track implementation of Integrated Energy and Climate plans under the Energy Union (EEA and Trinomics, 2017; European Commission, 2016).

The establishment of a more systematic coverage of climate finance in Europe therefore appears to be a priority. Alongside other partners interested by this subject, I4CE hopes to continue exploring its usefulness as a public policy tool. I4CE will continue to improve its methodological approach (adaptation, R&D) and aims to help other researchers and countries to learn from its experience in tracking and assessing domestic climate finance flows.

References & acronyms

The Landscape of Climate Finance reviews a large number of sources, generally in the form of technical studies and institutional reports. Sources are listed below, ordered by institution and date of publication.

Accord de Paris	2015	Convention Cadre des Nations Unies, Accord de Paris, Nations-Unies.
ACPR	2013	Autorité de contrôle prudentiel et de résolution, Banque de France, Les chiffres du marché français de la banque et de l'assurance.
	2014	Les chiffres du marché français de la banque et de l'assurance.
Actu Environnement	2011	Actu Environnement, Inauguration de l'entrée en service de la première benne à ordure 100 % électrique.
Actu transports	2017	Actu transports, Camions + 15 tonnes.
ADEME	2011a	Agence de l'Environnement et de la Maîtrise de l'Énergie, Feuille de route biocarburants avancés.
	- b	Fonds Chaleur, bilan et perspectives, Dossier de presse.
	- c	Philippe Léonardon, Les bâtiments exemplaires BBC PREBAT, bilan de la première phase 2007-2010.
	2012	Energie et patrimoine communal enquête 2012.
	2013a	Collecte des déchets en BOM hybrides GNVlectriques, Optigede, Ademe et Siom.
	- b	Y. Durand, Le photovoltaïque en France en 2012, Version française du rapport rédigé pour le programme photovoltaïque de l'Agence Internationale de l'Energie.
	- c	Visions énergétiques 2030-2050.
	- d	Gaëtan Brisepierre, Analyse sociologique de la consommation d'énergie dans les bâtiments résidentiels et tertiaires.
	2014a	Marchés et emplois de l'efficacité énergétique et des énergies renouvelables, Edition 2014.
	- b	Club de l'Amélioration de l'Habitat, Business Information Intelligence Services, Observatoire permanent de l'amélioration énergétique du logement (OPEN), Campagne 2014, Résultats 2013.
	2015a	Covoiturage de longue distance: profils, pratiques et impacts, Synthèse de l'étude réalisée par le bureau 6T.
	- b	Evaluation de la mise en œuvre expérimentale de l'indemnité kilométrique pour les vélos, Etude réalisée pour le compte de l'ADEME par INDDIGO.
	- c	Patricia Sidat (ADEME), Guillaume Neveux, Julien Paulou, Ali Hajjar, Valentin Vermeulen (I Care Environnement), Alexandre Bouchet (E-Cube), Etienne Jan (E-Cube), Laurence Haeusler, (In Numeri), Filière Photovoltaïque Française: Bilan, Perspectives et Stratégie, Etude réalisée pour l'ADEME par le groupe I CARE, Ecube et In Numeri.
	- d	Fonds Chaleur: bilan 2009-2014, Relance et nouvelle dynamique.
	- e	Innover pour remettre l'efficacité énergétique au cœur de la dynamique industrielle, ADEME&Vous, Stratégies et études n°42.
	- f	Panorama des financements du bâtiment, Etude réalisée par Burgeap et Batitrend.
	2016a	Marie-Laure Guillerminet, David Marchal, Raphaël Gerson, Yilène Berrou, Coordination: Patrice Grouzard, Coûts des énergies renouvelables en France, Edition 2016.
	- b	Mathieu Chassignet, Etude d'évaluation sur les services vélos, Rapport de diagnostic.
	- c	Etude d'évaluation sur les services vélos, synthèse technique, Etude réalisée pour le compte de l'ADEME par INDDIGO SAS, n° de contrat 10004221.
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