Building a low-carbon scenario for France

How a participatory approach can enhance social and economic acceptability

- Scientific report -

Project: ENCI-LowCarb

Engaging Civil Society in Low-carbon Scenarios

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The core activity of this project was the development of a methodology for the transparent integration of stakeholder contributions in the scenario creation process in order to enhance the stakeholder acceptance of the resulting low carbon pathways.

By adding this element an important step is made from showing what is technically and economically possible to what is feasible and accepted.

Today a wide range of scenarios published are emphasizing that they are build on the base of a public consultations or stakeholder contributions but nevertheless transparency is lacking concerning the methodology relative to how contributions were weighted and translated in assumptions that are usable by the modelling tool.

The project ENCI-Lowcarb aimed at exploring this scientific gap.

Energy scenarios are outlining possible low carbon energy futures based on assumptions concerning fossil fuel price development, technological choices and the evolution of energy demand and supply etc.

Scenarios are influential tools in political decision-making processes because they visualize that investments allocated today have a long-term impact on the future energy consumption patterns especially concerning infrastructures.

So it is even more important that these pathways are built on visions of essential national stakeholders.

In this publication we have the pleasure to present you energy scenarios for France that represent the outcome of a collaborative scenario creation process including the contributions of a wide range of French stakeholders (trade unions, private companies, associations). The modelling exercise was based on the contributions of the participating stakeholders and represents only policy measures and technology choices that were acceptable in the eyes of the stakeholders.

[1]The project (April 2009 – March 2012) was financed by the 7th Framework Program for research of the European Commission. The project team was composed by research institutes (CIRED and PIK) and NGOs (RAC-France - coordination, Germanwatch and Inforse-Europe).

More information on the project: www.enci-lowcarb.eu

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7th Framework Programme for Research and Technological Development

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement N° *213106 . The contents of this report are the sole responsibility of the ENCI-Lowcarb project Consortium and can in no way be taken to reflect the views of the European Union.*

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Chapter 1

Introduction

The core activity of this project was the deve lopment of a methodology for the transparent integration of stakeholders' contributions in the scenario design process to enhance the stake holders' acceptance of the resulting low carbon pathways. This attempt at integrating acceptability in scenario-making constitutes an important step to distinguish what is technically and economi cally feasible from what is acceptable. Today, a wide range of published scenarios emphasize the fact that they are built on public consultations or stakeholders' contributions. However, transparency is lacking concerning the methodology relative to how contributions were taken into account and translated into assumptions that can be used by the modeling tool. The project ENCI-LowCarb aimed at exploring this scientific gap.

Energy scenarios outline possible low-carbon futures built around assumptions on fossil fuels prices evolution, technological choices and the mechanisms of energy demand and supply, among others. Scenarios are influential tools in political decision-making processes since they shed light on the long-term impacts of today's investment decisions, especially regarding infrastructures. This is why it is crucial that these pathways derive from discussions with main stakeholders.

In this report, the French project team (CIRED and RAC-F) has the pleasure to present energy scenarios for France which derive from a colla borative scenario design process including the participation of a wide range of French stakehol ders (civil society organizations including trade unions and non-governmental organizations, private companies, banks, statewide and local authorities). In this report, the French project team (CIRED and RAC-F) has the pleasure to present energy scenarios for France which derive from a colla borative scenario design process including the participation of a wide range of French stakehol ders (civil society organizations including trade unions and non-governmental organizations, private companies, banks, statewide and local authorities).

Participating stakeholders were asked to define or select acceptable CO2 emissions mitigation measures. Their contributions were implemented in the technico-economic model Imaclim-R France to create a scenario that is economically and technically consistent as well as acceptable by stakeholders. This methodology allowed an assessment of the level of achievable emissions reductions with stakeholders' «acceptable» mea sures.

This publications summarizes the study results. Chapter 2 presents the collaborative scenario design process. Chapter 3 presents the modeling tool used for the scenario creation. Finally, chapter 4 presents the quantitative results of the study, especially the acceptable scenario. Each chapter of the report is meant to be readable on its own, with a short explanations of the other parts of the study in each.

Chapter 2

Stakeholders' meetings

2.1 Collaborative scenario design process

Experts & Stakeholders workshops

Synthesis report of the French scenario workshops

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Introduction

The objective of the EU7 project ENCI-LowCarb was the development and implementation of a methodology for a collaborative scenario creation process that permits a more transparent involvement of stakeholders in the process, which can then result in a higher degree of stakeholder acceptance towards the produced scenarios.

A German[1] and a French[2] project team composed by NGOs and research institutes implemented the methodology that was developed within this project:

This report focuses on the experience in France. It includes:

1. A short description of the different steps of the methodology and the used modeling tool (respectively chapter 1, 2 and 3)

2. Notes from the experts and stakeholder meetings that represent the integral part of this project (respectively chapter 4 and 5)

[1] Postdam Institute for Climate Imapct Research (PIK) & Germanwatch
[2] International Research Center for Environment and Development (CIRED) & Climate Action Network – France (RAC-F)

1. Methodology: Steps towards a "Collaborative scenario creation process"

Many energy scenarios are based on public or stakeholders consultations. However, few attribute importance to the scenario design process and explain in a transparent way how contributions are taken into account and integrated in a modeling tool, that is to say how the translation process was carried out from an idea supported by contributors to its representation in the modeling tool.

A first question one might ask is: "Why is stakeholder involvement important when discussing energy scenarios?" First, most stakeholders can provide additional expertise to the technical and economic hypotheses as well as initiate discussions around sensitive issues. Second, the exchanges with stakeholders bring to light the main cleavages and obstacles to reaching a decarbonized society. Thus, the dialogue can lead to finding a common ground for possible solutions and outlining a robust strategy. Finally, consultation with stakeholders enhances the ownership of the created scenarios by the stakeholders.

In conclusion, there are many reasons why stakeholders should be consulted and if possible actively integrated in the scenario-making process. Today, the challenge is to avoid limiting the influence of stakeholders to a non-interactive communication (as in the case of online consultations). If scenarios aim at representing the contributions of stakeholders, a deeper thought has to be given to the design of the process to make it interactive. Gathering people for multi-stakeholder discussions, collecting their contributions and then elaborating the scenario behind closed doors can be a source of disengagement for participating stakeholders.

Therefore, the innovation of the ENCI-LowCarb project resides less in the resulting energy scenarios than in the process itself. The project hypothesis consisted in stating that if national stakeholders can recognize their contributions (even if those were amended by the contributions of others) in the resulting scenarios they would eventually be more supportive of this scenario than in a case where a non-transparent procedure was followed. Using collaborative procedures can increase stakeholders' acceptance and generate political support for energy scenarios and the resulting policy measures. Reaching this positive outcome also implies more involvement for both stakeholders and modelers – particularly in terms of time and shared understanding of the issues at stake and of the functioning of the used modeling tool.

A transparent stakeholder consultation process requires the existence of a common ground: model parameters and input variables of the model have to be carefully translated into tangible, real-life, implications which stakeholders can assess. The considerations emerging from the stakeholder consultation can then be translated back into technical model parameters, i.e. political framework conditions, which will result in different low carbon energy system scenarios. This "translation work" is necessary to work with such modeling tools and needs a considerable effort of communication to avoid the feeling that all contributions are entering a black box without any traceability.

<u>The modeling work of this project was following two main principles:</u>

- *Acceptance*: Reaching a maximum degree of stakeholders' acceptance
- *Realism*: Satisfying technical and economic limits

Social acceptance or stakeholders' acceptance
Within the frame of the project ENCI-LowCarb it was not possible to evaluate "social acceptance", and the focus was rather on "stakeholders' acceptance". Social acceptance has different aspects that cannot be assessed with the available project tools. In the context of energy system strategies, social acceptance has three dimensions (Wüstenhagen 2007)[3]: (i) socio-political acceptance, referring to the acceptance of technologies and policies by the public, key stakeholders and policy makers, (ii) community acceptance of site-specific local projects and (iii) market acceptance, referring to the process of the adoption by consumers and investors of innovative low-emission products. Community acceptance is a highly important topic concerning the building of new energy infrastructure (electricity grid, windmills, nuclear waste deposals etc.) but it cannot be directly represented in a modeling tool with no spatial dimension.

Within the ENCI-LowCarb project, one challenge was the use of macro-economic hybrid models for the scenario design task (IMACLIM-R[4] and REMIND-R[5]), which are often characterized as "black-boxes"[6]. This implies at least a basic introduction to the model dynamics: What are the main mechanisms? What is the degree of detail of the sectoral representation? What are exogenous and endogenous variables? etc). The form of the modeling tool indeed shapes the form of the dialogue.

2. L'outil de modélisation Imaclim-R

Imaclim-R France[7] is a computable general equilibrium model. This model was used for the collaborative scenario design process of French energy scenarios within the project ENCI-LowCarb. It models the evolution of the French economy split into 15 sectors: energy sectors (crude oil, refined oil, gas, coal, and electricity), transport sectors (freight terrestrial transport, water transport, air transport, public road passenger transports, and rail passenger transport), construction, energy intensive industries, agriculture and services.

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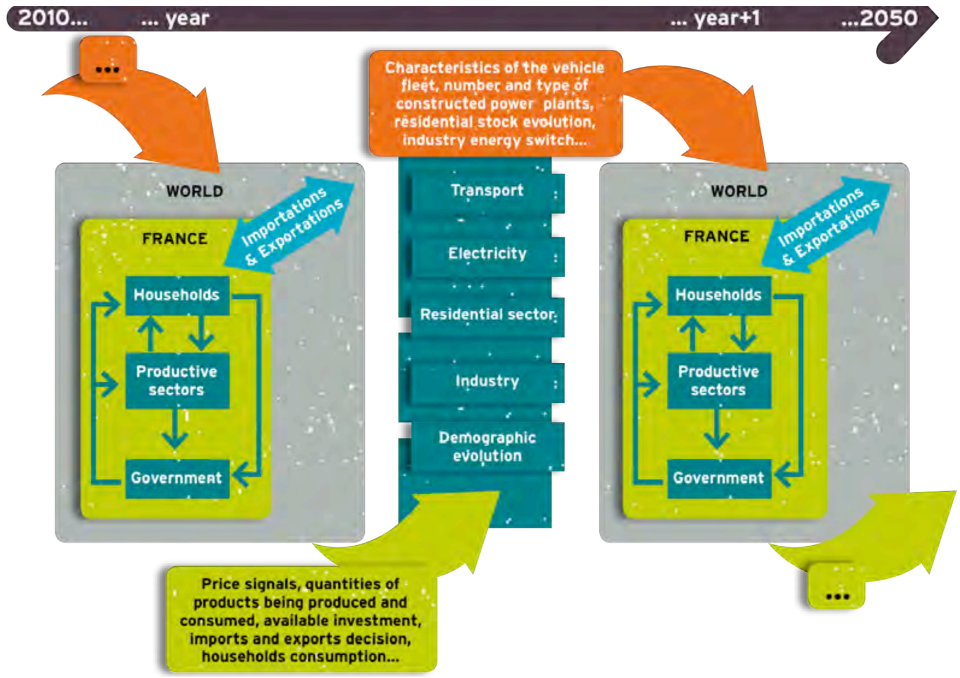
[3] Wüstenhagen R, Wolsink, M, Bürer MJ 2007, 'Social acceptance of renewable energy innovation: An introduction to the concept', Energy Policy, vol. 35, no. 5, pp. 2683-2691.
[4] http://www.imaclim.centre-cired.fr/spip.php?article129&lang=env
[5] http://www.pik-potsdam.de/research/sustainable-solutions/models/remind
[6] Sandrine Mathy, Meike Fink, Ruben Bibas (2011): "Quel rôle pour les scénarios Facteur 4 dans la construction de la décision publique ?", Revue Développement Durable et Territoires, Numéro Spécial sur le Facteur 4; Vol. 2, n° 1 | Mars 2011: http://developpementdurable.revues.org/8802
[7] Imaclim-R France is part of the Imaclim models family developed by the CIRED.



The Imaclim-R model computes the evolution of the economy and the energy system with a strong consistency between 2004 and 2050. This is why Imaclim-R is what is called a hybrid model compared to economic models or to technical models. The first type of models focuses on economic dynamics but include a weak representation of the energy system. The second type of models focuses on technologies and energy but have a poor representation of economic constraints and dynamics (particularly the interaction between prices and demand for energy and commodities).

In Imaclim, energy is explicitly represented in both values and physical quantities so as to capture the specific role of energy sectors and their interaction with the rest of the economy. The existence of explicit physical variables (e.g. number of cars, number of dwellings or energy efficiency of technologies) allows a rigorous inclusion of sector-based information about how final demand and technical systems are transformed by economic incentives.

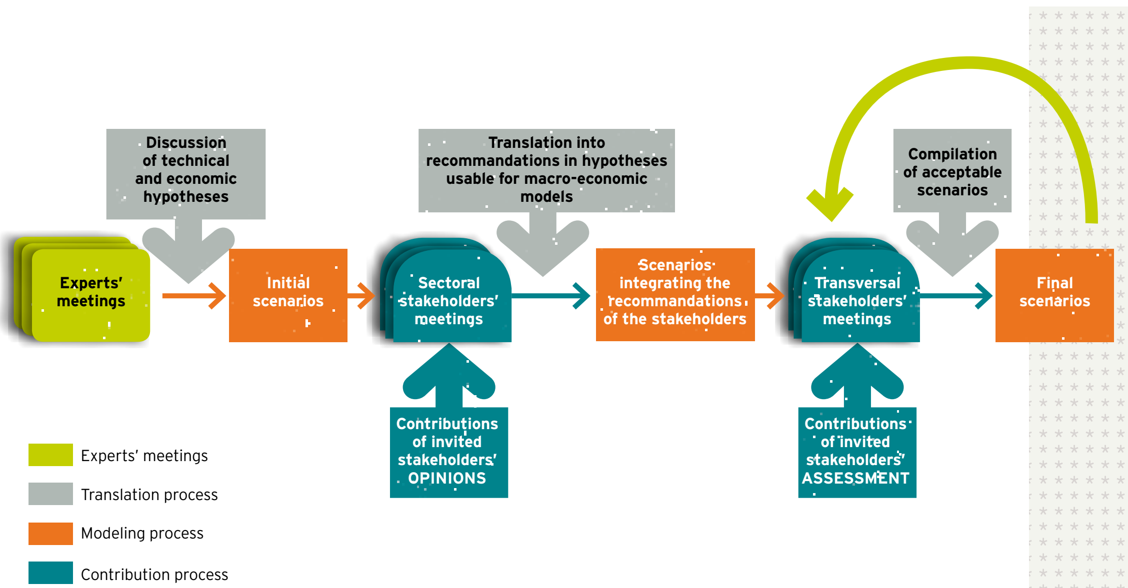
In Imaclim-R, each year an economic equilibrium (e.g. GDP, sectoral prices, sectoral investments, household consumption in each sector, unemployment rate or international trade) is computed. Two successive annual equilibria are linked by “dynamic sectoral modules” such as an electricity module, a residential module, etc. These sectoral modules represent the specific sector dynamics given economic constraints (including available investment in the sector, intermediate consumptions and energy prices) and physical constraints (e.g. inertia in technological infrastructures and appliances limiting the extent of energy efficiency). One limitation of Imaclim-R France is that it computes only energy-related CO_2 emissions. Other greenhouse gases are not represented. Also, crude oil, gas and coal prices are exogenous, hey are calibrated on the World Energy Outlook report by the International Energy Agency (2011).

The collaborative scenario- design process relies on Imaclim-R France for integrating all the inputs from stakeholders. Therefore, the modeling tool strongly impacts the form of the interaction with stakeholders, the format of the meetings as well as the manner to discuss the issues. Indeed, the fact that Imaclim-R is built recursively with dynamic sectoral modules prompted us to organize sectoral experts meetings first, then sectoral stakeholders meetings so as to embrace the vastness of debates when decarbonizing triggers a structural transformation of the sector. Then, with all the richness of the debate embarked in the model, a step back was taken to look at the interactions between all the different sectors in a transversal feedback seminar. The following part describes this process in more details.

3. Description of the "Collaborative scenario creation process"

The collaborative scenario creation process developed within the project is divided in different steps:

1. Organization of expert meetings
2. Stakeholder mapping- Identification of the national stakeholders
3. Organization of sectoral stakeholder meetings
4. Translation of stakeholder contributions in modeling parameters
5. Organization of a transversal feedback seminar



I. Expert meetings

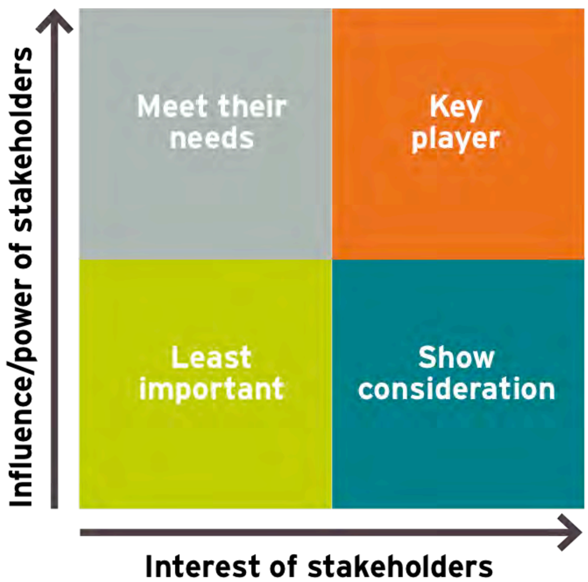
In order to assess the degree of economic and technical realism of the modeling tools, expert meetings were organized in order to correct and to update exogenous hypotheses (costs, potentials, investments, learning curves etc.) as well as dynamics of the models itself: investments in the electricity sector or the dynamics of the residential sector.

- Residential sector January 26th 2011
- Transport sector February 14th 2011
- Electricity December 13th 2010)

b. Stakeholder mapping- Identification of the national stakeholders

In order to select and to invite those stakeholders who play an essential role in the energy sectors at stake (residential, transport, electricity), we adopted the methodology of a stakeholder mapping via a "power-interest-grid". Based on this analysis, main stakeholders were identified and a contact list was established.

"Power versus interest grids"



"Power versus interest grids typically help determine which players' interests and power bases must be taken into account in order to address the problem or issue at hand."[8]

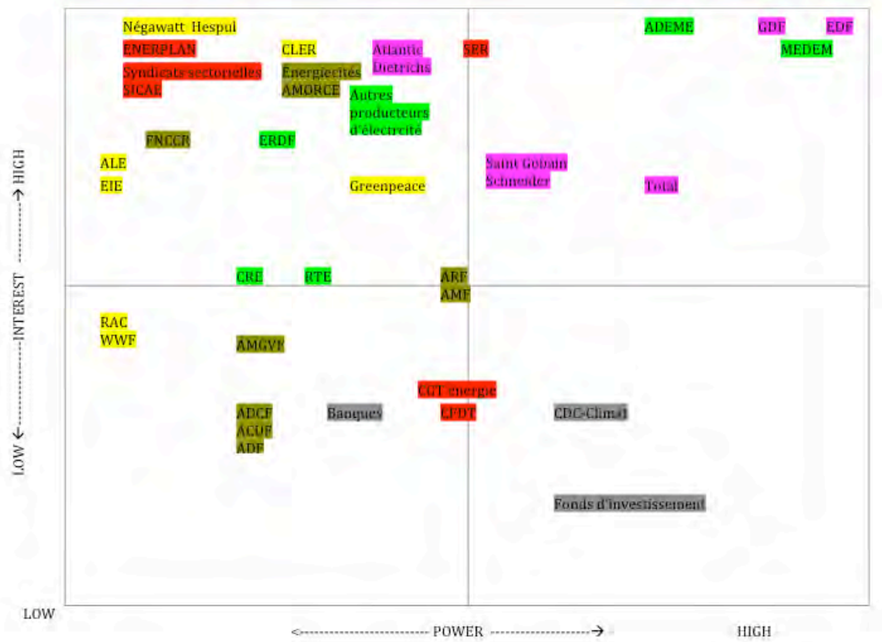
The aim of the ENCI-Project was to select mainly those stakeholders situated in the quadrants to the right: "Key-Players" and "Show consideration". As the evaluation concerning the "interest and influence" of specific actors is highly personal, the interviews were repeated with at least three different experts of the concerned sector in order to crosscheck the evaluations.

Structure of the interviews:

1. Discussion on the main challenges of the specific sector
2. Establishment of a list of actors, development of a typology of those actors (private companies, ministries, associations, trade unions, banks…)
3. Mapping of the identified actors on the power-interest grid

Here one example for the French electricity sector (the colors stand for the different typologies of the actors):

[8] Bryson, J. (1995) Strategic Planning for Public and Nonprofit Organizations, San Francisco, CA: Jossey- Bass



c. Organization of sectoral stakeholder meetings

In order to create scenarios with a high degree of “stakeholder acceptance” the project team ENCI-LowCarb invited the selected representatives of national stakeholder organizations to sector specific meetings (transport, residential, electricity etc.). During these meetings, stakeholders could express their vision on the evolution of technology choices, policy measures and economic incentives necessary and acceptable to reduce CO2 emissions.

The meetings were recorded in order to collect a maximum of viable information, all stakeholders answered a questionnaire and minutes were taken from the ongoing discussions.

It was decided to limit the number of stakeholder to 15 to foster in-depth discussions.

The meetings were divided in three steps:

1. Presentation of the project methodology
2. Gathering input concerning the main sector specific topics
3. Detailed presentation of several selected subjects and discussion with the invited stakeholders

A questionnaire was developed for each of the subjects under point three, and energy scenarios were modeled based on the answers of the stakeholders to these questionnaires and the content of the ongoing, moderated discussions.

For each of chosen 3 main-subjects a professionally moderated **stakeholder meeting** was organized:

- “Residential sector” November 23rd 2011,
- “Transport sector” December 7th 2011,
- “Electricity” December 12th 2011

The meetings were divided in 3 steps:

1) Presentation of the project methodology
2) Input concerning the main issues of the sector
3) Detailed presentation of several selected subjects and discussion

For each of the subjects under point 3 a questionnaire was developed. Based on the answers of the stakeholders to these questionnaires, which were collected at the end of the meetings and the content of the ongoing, moderated discussion on the subjects, energy scenarios were modeled.

d. Translation of stakeholder contributions in modeling parameters

Between the evaluation of the contributions of stakeholders and the modeling exercise, an important step was the translation of the stakeholder visions into model parameters.

The information gathered within the sector specific stakeholder meetings was translated by the project team in model parameters and added together to “scenario #1”. Points of disagreement were laid open and handled by the development of scenario variants.

Example translation process: residential sector – refurbishment
One of the main obstacles for the refurbishment of houses identified by the stakeholders is the still predominant aversion of homeowners to refurbish their houses or apartments even if many financial incentives exist. The aversion is even higher if one is only tenant. A barrier for owners is that the access to tax incentives and subsidies is conditioned to a high personal financial contribution. Even the access to a zero interest loan is difficult without collaterals. The stakeholders recommended solutions to overcome this barrier: the creation of an obligatory refurbishment fund for jointly-owned buildings and a long-term third party financing. As these solutions cannot be integrated one-to-one into the modeling tool, alternative modeling strategies had to be developed. For instance it is possible within the Imaclim-R tool to change the specific “risk-aversion level” of the different agents (house owners, tenants etc.).

The refurbishment obligation did not reach consensus of the majority of stakeholders. However, an important minority was in favor. In addition, it can be a very impactful tool for triggering the needed structural change in the residential sector. Therefore, the refurbishment obligation was included in the less consensual, more ambitious scenario.

e. Organization of a transversal feedback seminar

As the first round of stakeholder meetings was sector specific, the second one was transversal in order to overcome the artificial separation of energy system related questions between sectors. It is difficult to overlook existing interactions between transport and residential choices concerning topics like “urban sprawl” or electricity and housing related issues considering the question of “electric heating”. However, it was important to break down the energy system in “sub-sectors” from the beginning in order to be able to define clear visions and policies.

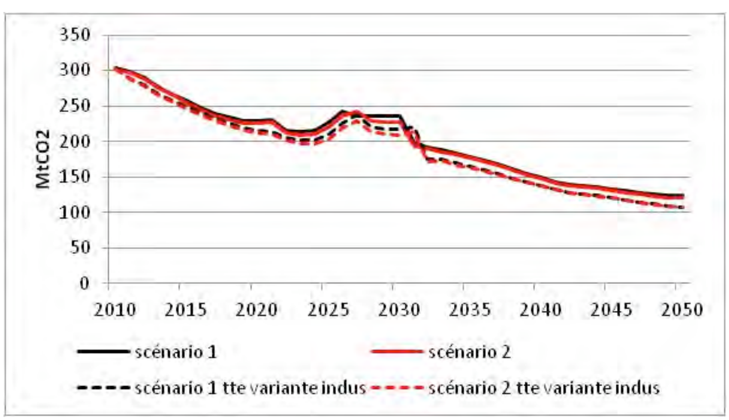
The main objective of the transversal meeting was to get a feedback on “scenario #1”. The stakeholders’ comments were then incorporated into the model. Points of disagreement arising from the evaluation of the outcomes of the first meetings were presented in the form of scenario variants.

Unfortunately, the emissions reduction in the scenario only based on policy measures that are acceptable in the eyes of at least half of the stakeholders was too low to achieve neither the necessary reduction consistent with the recommendations of the IPPC nor the French objective for 2050 – a reduction about -75% of the emissions against 1990.

Indeed, the policy measures that were judged acceptable only achieved a CO2 emission reduction about 68%.

Within the ENCI-LowCarb project we decided to present in a transparent manner additional measures that are not considered acceptable by a majority of the stakeholders but which are necessary to achieve ambitious climate targets. These measures need further political discussion. The main objective of this transversal meeting was to get a feedback on the “scenario – # 1” from the same stakeholders that were invited to the first round of sector specific meetings. The **transversal meeting** took place in February 8th 2012. The comments of the stakeholders (during the meeting and later by e-mail) were then again reintroduced in the model.

Different emission pathways depending on the strength of policy measures



4. Expert meetings in France

I. Expert seminar on climate policies in the French power sector

December 13th 2010

CIRED French researchers organized a workshop with experts and professionals of the French power sector, which took place December 13th 2010, in order to discuss key elements for modeling the power sector evolution. This short article presents some key issues that emerged during the discussion.

a. The investment dynamic in the power sector

The drivers of the investment decision

One of the challenges for modeling the evolution of the electricity sector in a liberalized market is the representation of the investor behavior, especially through the economic criteria justifying their decisions for investing or not. These criteria can either be the internal rate of return, the net present value or the payback period. The choice of the criteria depends upon some sector-specific features.

First, observation shows that investment decisions in the power sector tend to favor short payback periods. The uncertainties surrounding future regulations, end-use consumption evolution and maturity of technologies make technologies with upfront investment reimbursed in a few years only the most attractive. These technologies represent the best insurance against uncertain futures.

Current fossil fuel price volatility is a major element of financial risk for investment in the power sector. To minimize this risk, investors will prefer technologies like combined gas cycle turbines which combine low investment costs and production costs strongly correlated to the electricity price.

In economy, the parameter used by investors to reflect their risk aversion is the discount rate. Usually private investors have a lower risk aversion than public investors and private sector decisions rely on a higher discount rate (between 8-15%) than in the public sector (between 4% and 8%). But in the context of liberalization in the power sector, it appears that the discount rate used by investors is strongly linked to the nature of technology as well (life time, level of technology maturity, risk of evolution of the legal framework linked to a specific technology ...).

To reach 2020 objectives related to renewable and GHG emission reduction and to orient investments in specific technologies, the social planner will have to provide coverage on the investment risk inherent to some technologies, so that the risk premium considered by players willing to invest in a non-carbon technology is limited.

The lack of investment in peak-load capacity

One of the specific issues in France is the investment in peak-load capacity corresponding to hours in the year with very high demand. Indeed, the high proportion of electric heating in France creates a peak demand that requires the use of power plants operating a few hours per year only. These facilities, even with significant levels of hourly revenues are hardly profitable. As a consequence, France experiments a deficit of investment in these specific capacities. This endangers the supply-demand balance.

The recent law NOME (Electricity Market New Organization) assigns to the French electricity suppliers an obligation for investing in peak power capacity to ensure equilibrium between supply and demand at each hour in a year.

b. Peak capacity and interconnections

Another issue related to the evolution of the French power production is the capacity to rely on imports to solve the problem of peak capacity. Imports are indeed a major criteria in investor decision as in France, most of the time, the marginal power plant in the electricity generation mix is a German (coal) power plant. This has several consequences:

- Imports raise the CO2 content per kWh consumed in France, even if these emissions are not taken into account in the national GHG emissions inventories.

- The price of electricity in France is mainly determined by the production capacity in Germany.

- An analysis of future import potential is taken into account in investment decisions and leads to under-investment in peak technologies, since usually electricity imports contribute partly to satisfy peak demand. As a result, imports raise electricity prices in France. It is therefore crucial for the representation of the evolution of French power system to embark imports within investment decisions.

This questions the legitimacy of modeling the electricity sector at the national level while the process of the European integration pushes for a broadened analysis focusing on the Western European mainland (France, Germany, Denmark, Belgium, Netherlands and Luxemburg).

c. Grids

Successful evolution of the power sector towards a low carbon system requires a drastic evolution of transmission and distribution grids.

Transport grid

High-voltage grids will integrate large production units in remote areas, including offshore wind-farms. This should go hand in hand with improved interconnection and with the development of a European Supergrid for delivering electricity from renewable energies especially for periods of possible regional overproduction. These developments call for a stronger planning, especially since the installation of power lines creates local opposition. This concerns the needs for i) grid reinforcement to overcome congestion points especially when considering the European integration perspective and for ii) development of new transmission grids – submarine DC cables connecting offshore wind parks with consumption centers. The issue of cost allocation between actors (producers, suppliers and consumers) for the financing of this grid development is a critical but still unresolved issue.

Distribution grid

Distribution networks will integrate small-scale electricity generation capacities like wind and decentralized or individual photovoltaic. The development of medium and low voltage grids are required to effectively manage the system that will become more complex with the integration of intermittent energy sources at a decentralized level and the development of demand side management and smart meters. There is so far little exercise on the deployment of intelligent networks.

II. Expert seminar on climate policies in the French residential sector

January 26th 2011

French researchers at CIRED and NGO members at RAC organized in January within the ENCI-LowCarb project a seminar on climate policies and the state of the art of modeling for the residential sector. The seminar gathered experts from public agencies, the energy sector and research institutes. This short article presents some key issues that emerged during the discussion.

a) The French residential sector

In France, the dwelling stock consists of 31 million of dwellings (26 million primary residences and 5 million vacation houses). The housing sector yearly consumes 560TWh, i.e. 30% of the French final energy consumption. Heating represents 70% of consumption for main dwellings and domestic hot water production represents 10%. For the dwellings built before 2001, final energy consumption for heating and hot water production are respectively 160kWh/m^2 and 23kWh/m^2. The contribution of housing to CO_2 energy emissions is lower because of the lower dependency on fossil energies compared to other sectors (transports). Indeed, only 21% come from housing (85 MtCO_2 out of 400 MtCO_2).

The French government recently set targets for the building sector: residential energy consumption for existing buildings has to decrease by 38% between 2008 and 2020 and the thermal regulation for new dwellings was reinforced by the introduction of a new label: the BBC[9] label.

b) Modeling issues

The seminar was organized around the comparison of two studies with different methodologies:

The first study relies on a bottom-up approach: **« Habitat Facteur 4 - Étude d'une réduction des émissions de CO_2 liées au confort thermique dans l'habitat à l'horizon 2050 »** (Factor 4 housing :

[9] BBC= bâtiment basse consommation, i.e. low-consumption building

CO_2 emission mitigation related to thermal comfort in housing in 2050) from J.-P. Traisnel, D. Joliton, M.-H. Laurent, S. Caffiaux and A. Mazzenga, Les Cahiers du CLIP, n°20, *2010*[10].
This study represents 4 trajectories. Each corresponds to a technological optimum according to 4 exogenous energy scenarios in the residential sector. The 4 trajectories are contrasted according to the priority given to the three remaining energy sources used for heating and hot water production that remain in 2015 (wood, gas and electricity). The choice of the energy for heating is decisive. For this energy use, wood is favored – residual energy needs come from two alternatives (gas or electricity). 4 combinations are possible to supply demand: Wood/Gas/Elec, Wood/Elec/Gas, Gas/Wood/Elec and Elec/Wood/Gas. The demand reduction follows the same trajectory for all scenarios: new buildings energy consumption follow thermal regulation standards (low consumption building from 2012 and positive energy building from 2020) and all existing buildings are supposed to be retrofitted during the next 40 years. Three main leverages of emissions reduction are identified: reduction of heating needs (demand), more efficient equipment (efficiency) and the choice of low carbon energies (substitution).

The objective is to assess the maximum potential of different energy solutions, with different energy performances for wood, gas or electric equipment and different carbon contents.

In all energy scenarios, final energy demand for heating is halved in 2050 and the governmental objective of 38% of primary energy for heating and hot water production) is reached. These results are reached due to optimistic assumptions related to the availability of wood resources, as 100TWh of this energy resource are needed for energy scenarios favoring wood.

Besides, the emission reduction of the residential sector can be considered highly optimistic. The scenario Wood/Elec/Gas achieves a reduction of -94% of the CO_2 emissions but the scenarios that are prioritizing gas have a lower reduction potential: the scenario Gas/Wood/Elec reaches an emission reduction about only -60%.

The second study which was presented was realized with the Imaclim-France model (a hybrid technico-economic model): **« Evaluation des mesures du Grenelle de l'environnement sur le parc de logements français - Impact des mesures existantes et supplémentaires sur la consommation de chauffage dans le cadre d'une modélisation hybride »** (Assessment of the measures of the "Grenelle process" on the French housing sector – impact of existing and of additional measures on heating consumptions with an hybrid modeling approach) from L.-G. Giraudet (CIRED)[11].

The approach is based on an economic efficiency approach. It assesses the technico-economic impacts of policies and measures: existing measures (fiscal incentives, tax rebate, and thermal regulation for new buildings) and additional measures (retrofitting requirement, carbon-energy tax).

The model used is Imaclim-France including a specific module representing the evolution of dwellings according to landlords behavior (concerning the choice to retrofit their own dwellings or not). The number of retrofitting operations is endogenous to the model depending on the profitability of the operation. Different levels of retrofitting are considered, and to each level of retrofitting a given

[10] http://www.iddri.org/Publications/Les-cahiers-du-CLIP/Habitat-Facteur-4
[11] For a complete description of the model, refer to L.-G. Giraudet, C. Guivarch and P. Quirion, 2011, "Exploring the potential for energy conservation in French households through hybrid modeling", http://www.centre-cired.fr/spip.php?article1221&lang=en

profitability is associated and computed – including the energy saved for each kind of energy class reached, the discount rate of the dwelling owner, the energy prices and the cost of the operation. With such criteria, an increase in energy prices will increase the profitability of operations and more retrofitting will be done.

Results are much less optimistic compared to the previous study as existing measures are not ambitious enough to reach governmental objectives (-38% between 2008 and 2020 of primary energy and -75% of CO_2 emissions in 2050). Additional measures are necessary to achieve the Factor 4: a high carbon-energy tax, the extension of fiscal measures, of tax discounting and the implementation of a retrofit obligation. The study also shows that fiscal incentives are less efficient than regulation, that policies dedicated to energy efficiency improvements have to take into account the rebound effect, and that the carbon energy tax is virtuous.

The comparison of these two studies shows that:

- The question of wood resource availability and of the structure of timber industry is decisive to reach mitigation objectives
- The rebound effect can deter the efficiency of energy efficiency measures
- The question of the evolution of the CO_2 content of the electric kWh for heating is also decisive.

III. Expert seminar on climate policies in the French transport secteur

February 14th 2011

The French researchers at CIRED organized a workshop with experts on transport issues on February 14 2011. The purpose of the meeting was the discussion of key elements for modeling the evolution of the transport sector. This short article presents the issues that emerged during the discussion.

a. The evolution of mobility in France

The transport sector (passengers and goods) significantly contributed to the increase of energy consumption in France. The sector share in total final consumption of energy is 31%, against only 13% in 1960. The sector heavily depends on fossil fuels, which represent 93% of supply.

In 2008, the road transport emissions represented 31% of the global French CO_2 emissions (2.1% for other transport modes). Transport emissions have risen extremely (+473% between 1960 and 2008, and +9% between 1990 and 2008).

The drivers of individual mobility

Local mobility represents 89% of the total trips. This type of regular mobility includes: commuting, leisure activities, regular shopping and trips to school or university.

The long-distance mobility covers trips over 80 miles from home, whether for business or personal purposes. It represents 40% of the traveled distance. CO_2 emissions due to long-distance mobility increased by 33% since 1994. The table below shows the evolution of modal shares from 1994 to 2004. There was a net decrease in car travel, compensated by a net increase of rail travel. Calculated in passenger-kilometers, the modal share of the private vehicle, however, represents more than 51%, and the share of air transport reached about 30%, given the vast distances.

Modal shares of long-distance mobility (in number of trips)		
Mode	Share in 1994	Share in 2008
Car	75.2%	73.4%
Rail	14.1%	17.1%
Air	5.1%	5.8%
Bus	4.4%	2.5%

The frequency of travel for private reasons mainly depends on the socio-economic background. For example, the annual number of private travel activities is 3.8 for a worker and 11.4 for an entrepreneur. But this gap tends to decrease.

This overview shows that different political measures have to be applied in order to influence the various drivers of individual mobility. For instance, to reduce emissions due to commuting, car-sharing or special shuttle systems to connect firms with the next public transport station can be organized. Long-term urban planning could integrate economic centers in urban structures in order to avoid urban fragmentation and the separation of working and living spaces.

Freight transport

France is one of the major crossroads in Europe. European countries represent the most important export and import partner of France in terms of freight weight and of value. Between 1990 and 2000, the national freight transport in France rose by 30%, with an increase of nearly 70% of transit traffic. Dominated by road transport, freight transportation has been particularly affected by successive increases in oil prices: the share of energy in the cost of road transport is now an average of 25% (for trailers of 40 tons over long distances) - it was around 16% ten years ago. But apparently the transport costs in comparison to the whole chain are not high enough to avoid unnecessary km like concrete exemplas are demonstrating.[12]

Political will is needed to get freight transport from the road on the rail or water. Investment in infrastructures has to be made and a more effective planning of the supply chain is necessary. One possibility is the taxation of road transport to finance rail infrastructures.

b. Solutions have to be adapted to local situations

The French mobility survey (2008)[13] indicates that residential location impacts commuting distances and transport modes, which are more or less CO_2 intensive. Parisians and inhabitants of major regional urban centers tend to travel long-distance trips. However, the low use of cars for their regular local mobility needs is more than offsetting these additional emissions. While the Parisian

[12] http://www.telegraph.co.uk/news/uknews/1534286/12000-mile-trip-to-have-seafood-shelled.html
[13] http://www.statistiques.equipement.gouv.fr/article.php3?id_article=1275

transport emissions were 1,3kg CO_2/cap/yr, those of an inhabitant of urban area of 500.000 to 10.000.000 inhabitants but living outside the urban center reaches up to 2,8kg CO_2/cap/yr.

The number of owned vehicles depends on the households living standards, but it is also closely linked to the type of territory they live in. The number of vehicles per adult ranges from 0.8 in rural municipalities to 0.7 in rural centers and centers of urban areas with fewer than 100.000 inhabitants and is of 0.6 in the centers of urban areas with over 100.000 inhabitants and the suburbs of Paris. In Paris the number is falling to 0.3. Thus, people living close to major urban centers are less equipped in individual cars.

Daily travel times remained relatively stable over the last thirty years across the country. However, developments are contrasted between areas. In dense areas, mobility (distances and travel times) declines whereas in low-density areas, mobility is stagnant and travel distance (as well as time) is increasing. The daily time spent in transport depends on the localization and vary from 47 to 75 minutes. It is less than 50 minutes in rural areas and in the distant periphery of cities. In these areas, the travel distances are far from being negligible (close to 30 km per day) but the use of the cars on uncongested roads increases travel speed. Residents of suburban communities have the longest distances. But they also move with greater speed due to intensive use of cars.

Instead, residents of central cities of major urban centers move with less speed because they often walk. So Parisians who have to face only short distances have the longest travel times (75min/day).

This short overview shows that consistent transport solutions have to be adapted to specific local situations. Urban planning, car sharing and telework are important elements of a reasonable low carbon transport policy.

c. Technical solutions or behavioral changes?

The contribution of technology (improvement of efficiency or new technologies) and behavioral changes differs among low carbon scenarios. It is difficult to identify a robust strategy. The négaWatt scenario from 2006 includes no electric vehicles and no biofuels. The scenario from the German environmental ministry (2008) includes only a marginal share of electric vehicles and hydrogen and is quite hesitant with the deployment of biofuel. As both scenarios are anticipating an increase of individual mobility, an improvement of efficiency is the key strategy.

The scenario Zero Carbon Britain (2010) is based on the following potential contribution of different energy consumption and emission reduction strategies:

Action	Effect
Reduction of total pkm / cap	-20% of demand
Increase of occupancy levels of cars	-23% of mode
Technology change	Up to -80%
Passenger modal shift	-12% to -23%

The majority of the transport carbon savings in ZeroCarbonBritain2030 comes from efficiency savings and new fuels.

d. Electric vehicle and biofuels

The French government has announced in 2009 that France will develop the electric vehicle (2 million hybrid and plug-in vehicles in 2020 and 4.5 million in 2025). The battery cost is the main obstacle to a wider use for now. The necessary infrastructures (electric charging points) are a debate point as well. Another option would be a battery renting system but the costs of batteries are still expensive in comparison to their storage capacity – so more research is needed.[14]

It is obvious that the deployment of plug-in vehicles means a change of the mobility structures. An electric vehicle will only be valuable (at least for the next decades) in a short distance context and so it is important to avoid that electric vehicles replace zero-emission transport modes (bicycle and walking). Hybrid vehicles are showing wider deployment opportunities and should be observed closely.

There is a general agreement that a strong deployment of 1st generation biofuels is economic, social and ecological non-sense[15]. The existing national potential should be used for specific local problem zones – freight transport in rural areas etc. 2nd and 3rd generations of biofuels still are in infancy.

Impact of the electric vehicle on the grid stability and peak capacity

If a significant portion of the vehicle fleet is composed of hybrid and electric plug-in cars the impacts on the power systems can be considerable. Recharge in the evening (during peak consumption time) may increase the level of the peak demand – sharpening the already high demand for electric heating especially during winter months - and therefore also impact the production price of electricity (additional capacity). The following figures shows the impact on peak level and price for a linearly growing stock of electric vehicles of 10 million in 2050, used at a rate of 13,000km/year with a consumption of 20kWh/100km (that is 26 TWh).

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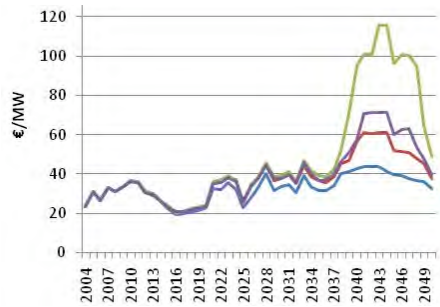
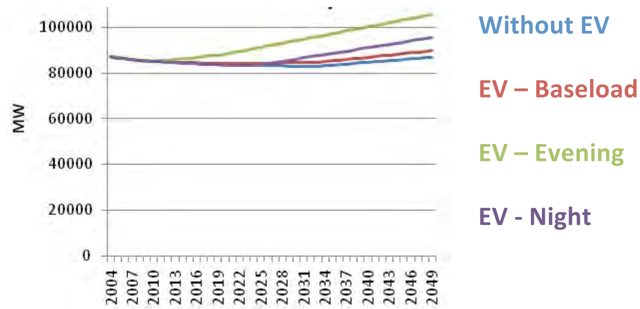
[14] Batteries can account for up to 75% of the extra cost of hybrid and plug-in hybrid electric vehicles. Li-ion batteries can cost from 770 EUR per kWh to 2,000 EUR per kWh. Electric cars usually use between 0.11 and 0.2 kWh/km, while most cars have a range of 160 km. This means a battery for such an electric car needs between 17 and 32 kWh. "How to avoid an electric shock - Electric cars: from hype to reality", Transport & Environement - 2009

[15] "Anticipated Indirect Land Use Change Associated with Expanded Use of Biofuels and Bioliquids in the EU – An Analysis of the National Renewable Energy Action Plans", IEEP – 2010 http://www.ieep.eu/topics/climate-change-and-energy/energy/bioenergy/2010/11/anticipated-indirect-land-use-change-associated-with-expanded-use-of-biofuels-and-bioliquids-in-the



Electricity mean price



Peak level

Besides, the concept of "vehicle-to-grid", would allow owners of electric cars to earn money by storing energy. The batteries would store excess energy in base load and inject the stored energy in the network during peak demand. Despite the fact that it would need an enormous number of electric vehicles to have a significant impact, the human factor has to be taken into account. It is not said that people won't use their cars during peak demand time…

Conclusions

Discussions on the future of low carbon mobility raise many questions – and it is evident that there is not necessarily a single answer. How the needs of individual mobility and goods will evolve? How can we make the necessary travel more efficient and leisure travel more expensive without disadvantaging low-income households?

Technical and political responses to these questions will differ depending on whether a person is located in an urban, suburban or rural area. There is a consensus that freight transport should use more rail and inland waterways, taking into account that the "last mile" is often the most carbon-intensive - therefore sophisticated logistic delivery systems must tailored to local needs. Investment in railway infrastructure development still represents an important barrier.

The development of a flexible and economic transportation of persons in rural area is necessary (carpool and virtual bus lines) to be competitive with the advantages of using a private car without being able to replace it completely.

Many problems still have to be resolved concerning the electric vehicle. Their use requires an intelligent management of battery charging in order to avoid destabilization of the electricity grid or an increase of electricity peak production. Even if the electric vehicle is suitable for short distances, that it replaces zero carbon modes (cycling, walking) in urban areas should be avoided.

5. Stakeholder meetings

I. Stakeholder meeting "Residential sector"

November 23rd 2011

a. Introduction – residential sector

The meeting started with a presentation of the program and each participant.

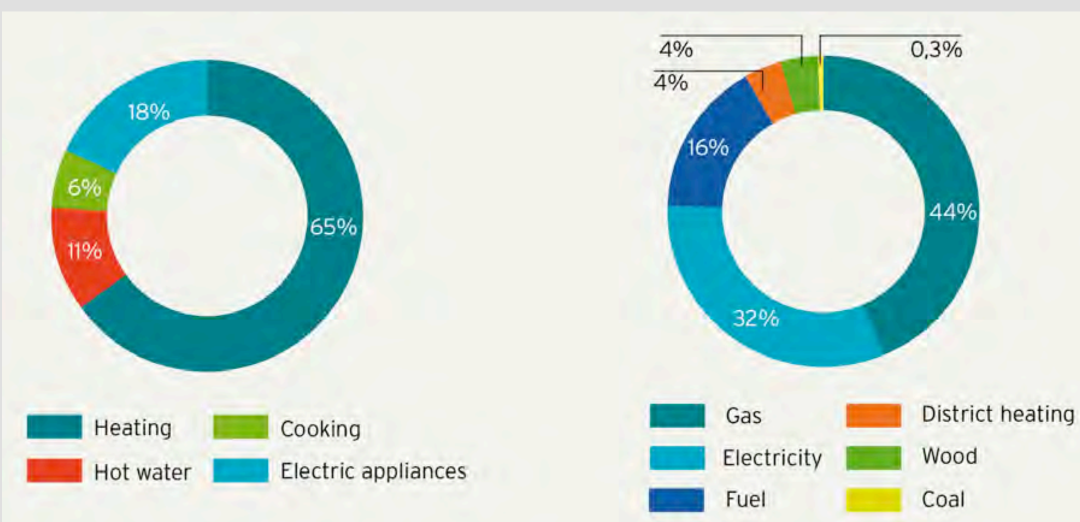
Then the project team introduced the project methodology for a collaborative scenario creation process and gave an overview on the sector specific challenges.

The residential sector in France consists of 32.6 million dwellings, 6% of them being vacant and 10% of them being secondary residencies. 57% are individual houses and 43% apartment buildings. Nearly 60% of the overall building stock has been constructed before the adoption of the first thermal regulation in 1975.

The most important energy sources used for heating are gas and electricity, providing 76% of heating for the building stock. Fuel and wood is mostly used in individual housing whereas district heating concerns almost exclusively apartment buildings.

Composition of the residential final energy consumption (2010)

Final energy mix for heating in the residential sector (2010)



In 2009, the residential sector emitted 16% of the overall CO2 emissions – this share has remained approximately stable since 1990. However, the emissions of the residential sector increased about

15% in absolute terms. This number goes to 22% if the emissions from electricity production and district heating are included (those are generally counted under “energy industry”).

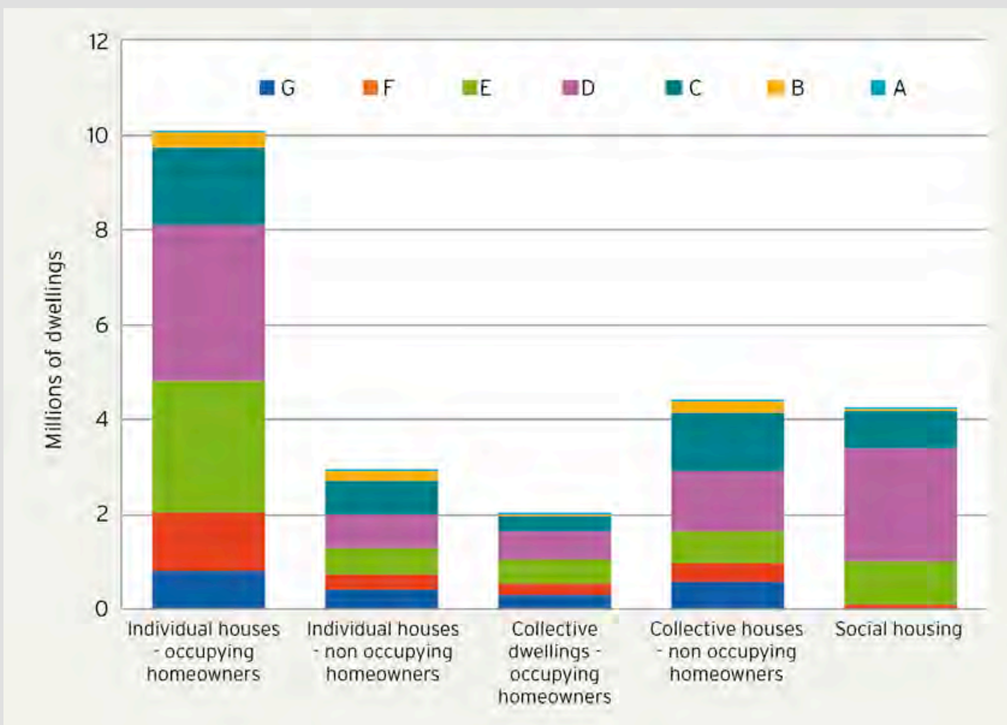
In 2010, the residential sector was responsible for 30% of the final energy consumption. In comparison to 1973, the consumption has increased about 25%, but has remained stable since 2000. The main energy consuming service is heating with 65% of the final energy consumption.

Approximately 30% of all dwellings correspond to the energy efficiency class D. Less than 1% satisfies the criteria for class A and hardly more 3% achieve class B.

The existing building stock has a long lifetime because of the low share of destructions, about 20-30000 dwellings each year. New constructions mainly contribute to the growth of the building stock and not to replace demolished buildings.

How to increase the performance and rate of refurbishment is the main challenge for climate and energy policies within this sector since two thirds of the residential stock in 2050 is already built!

Building Stock Composition, primary résidences (2007)



Climate & energy objectives

The French legislation includes several objectives concerning the residential sector:

- A reduction about 38% of the primary energy consumption of the residential sector until 2020.
- A 40% reduction of the primary energy consumption of public buildings
- Refurbishment of all social housing dwellings consuming more than 230 kWh pe/m2/year until 2020
- Up from 2013 an annual refurbishment rate about 400000 dwellings

After these first presentations one of the main challenges identified in the discussion e stakeholders was the refurbishment of the existing building stock.

Here a list of blocking factors that were pointed out by the invited stakeholders which have to be addressed in order to increase the number and performance of the retrofitting actions:

- Human factor: home is a “secure place” charged with a lot of emotions and non rational feelings => decisions concerning this crucial / central place in each persons life are often irrational
- Missing technologies to retrofit small houses / irregular forms etc.
- People are not action as “homo economicus”: often “bad” decisions are taken from an energy saving point of view: only the windows are changed which is less effective that isolation etc. How you can achieve that subsidies finance retrofitting actions that are not the priority of the persons concerned?
- Psychological obstacles: Energy savings are not perceived as positive
- House or apartment owner have not enough resources in order to assure the necessary own contribution to the existing subsidies or do not have enough guaranties to gain access to zero interest loans.
- Administrative procedures to obtain the subsidies are too complicated
- There are fiscal opportunities that should be better exploited (exoneration of the real estate tax etc…)
- Complexity: Concentrated, structured information has to be available at the decisive moment (how this information gets to the people?)
- Small and medium enterprises in France have to be developed; the demand has to be structured – for the moment it is difficult for the big enterprises to develop an adequate response strategy because the feedback on what is needed is not univocal. So they have a doubt concerning the profitability.
- It is difficult to identify well informed but independent contact persons who can give advice on the planning step by step of the retrofitting of buildings
- Collective wishing is not translated in an individual solvent demand
- Understand what are the real needs: Nobody is searching for energy efficiency but for more thermal comfort.
- Tenants and not occupying owners are less interested in retrofitting the house or apartment they are living in – he first because he is not benefitting economically from the appreciation and the second because

b. Private housing market – Individual homes

France accounts for 16 million individual houses.

The two most important economic incentives concerning for the stimulation of retrofitting for this type of buildings are a tax credit (CIDD) on insulation and the zero interest loans (eco PTZ).

But a first evaluation[16] shows that these measures do not enhance in depth renovation but only superficial changes (changes of the windows etc.).

After a short input presentation on the topic of individual houses a questionnaire was distributed. The invited stakeholders answered to the questions and then the different topics were discussed further.

Here the questions and the answers of the stakeholders:

1. **Do you think that the strengthening of existing incentive tools (Tax credit and eco-PTZ) can help achieving a division by 4 in 2050 of the CO2 emissions of the 16million existing individual houses?** Yes No

→ Only 20% of the stakeholders thought that these incentive tools could achieve the objective even if their ambition was strengthened.

2. **One obstacle to the implementation of thermal renovation in individual homes is the payback of this type of operation. To overcome this obstacle, are the following measures desirable?**

- Use of third party financing companies
- Attaching of the loan to the property and not to the person
- Strong incentive on roof insulation

→ 60% of the stakeholders think that it is a good idea to use third party financing companies. 50% are in favor of the other two proposals.

Other measures that were added by the stakeholders:

- Confiscation of a share of the added value depending on the energy performance of the building before selling it.
- Attendance of the house owners during the preparation phase of the retrofitting project
- Communication on the benefits of retrofitting
- Analysis of the total cost of the retrofitting and comparison to the cost of non-action
- Define the level of subsidies depending on the revenues of the household
- Retrofitting obligation (under certain circumstances)
- Acknowledgement of the role of local authorities

3. **With all these measures, how many houses could be renovated every year?**

The majority of the stakeholders could not specify a number of houses. Two figures were discussed: conceivable maximum 300,000 but 400,000 should be targeted

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[16] Ademe (2010) "Chiffres clefs du bâtiment"

4. **All these incentives together would they allow achieving a division by 4 of the CO_2 emissions in 2050?** Yes No

→ 90% of the stakeholders were convinced that these measures would not be powerful enough to achieve the objective.

<u>Retrofitting obligation for individual houses</u>

5. **With the above-mentioned incentives, would a retrofitting obligation for individual houses be acceptable?** Yes No

→ Even with the measures mentioned earlier only 44% of stakeholders believe that the obligation to renovate for individual houses is acceptable.

The arguments against are:

- Only under certain conditions: Understand the uniqueness of each local housing market and address social problems
- A prerequisite is to have knowledge about the contributive capacity of individual homeowners
- We are facing a collective need and cannot deal with individual applications.
- An obligation may be triggered in many different forms.
- Refusal on behalf of individual liberty
- This measure may result in unaffordable costs for some households that may otherwise have a modest CO_2 balance concerning their food behavior (position well above habitat) or mobility

6. **What should be the criteria for the planning and implementation of a retrofitting obligation?**

- Energy Performance Level
- Date of last renovation
- Change of occupant
- Change of ownership

→ 77% believe that the property change is the most appropriate moment for the implementation of retrofitting obligation. This choice is followed by order of preference: the energy performance level, change of occupancy and date of last renovation.

7. **What should be the annual number of retrofitted houses?**

- 70,000 (renovation of the park in 100 years)
- 100,000 (renovation in 70 years)
- 150,000 (renovation in 45 years)
- Other?

→ This issue has caused many abstentions. The average response indicated the figure of 175,000 renovations per year. A person considers that the maximum possible is the number of houses that are changing ownership and another said the objective has to be adjusted to local situations.

8. **What should be the energy performance target of retrofitting actions?**

- 50kWh/m2.an
- 80 kWh/m2.year
- 150 kWh/m2.year

→ Following to the answers of the stakeholders the objective in terms of energy performance is expected to be around 69kWh/m2.an. Several people specified that the values should be presented in primary energy.

Other comments:

- The objective depends on the typology of the buildings and the climate zone
- The m2 energy consumptions are theoretical consumption. Everything depends on the intensity of use. The definition of possible staged renovations has to be applied. Even if the first retrofittings brings the consumption only down to 150kWh/m2 a second can decrease the consumption to BBC standard.

Roundtable discussion:

- Reduce the investment contribution for the house owners (balance between loan repayment and gains on the energy bill)
- Planning of a retrofitting obligation based on the local real estate markets (the refurbishment effort, availability, prices of housing, social criteria)
- Compare the refurbishment effort with the overall objectives (-75% of CO_2 emissions)
- Incentive tools focus on energy and not on CO_2 emissions => problem
- Retrofitting obligation => proposal: Combine the access to refurbishment loans to energy criteria
- Strengthen zero interest loans and tax credits with regional subsidies (the French region Alsace gives 1370 Euros for the installation of a solar water heater)
- Reduction of 75% of the emissions requires to have access to the global energy balance of the building and to know exactly which are the priorities. Sometimes it can be better tor demolish and to rebuild.
- An optimization of each element of a building will not lead necessarily to a 75% reduction - an overall analysis is needed
- Perhaps it would be more useful / effective to concentrate on the 30% of the building stock with the worst energy performance and to concentrate subsidies and economic incentives on it.
- It is not possible to impose retrofitting as energy expenses correspond to approximately 3% of the household budget
- Retrofitting obligation is not “magic button”: different management and architectural problems won’t be solved automatically

c. Joint tenancies

The number of condominium units in France amounted to nearly 7.6 million

French legislation

- Changing majority rules and introducing the concept of "shared interest / responsibility also concerning private parts of the building ",
- Energy Performance Certificate or mandatory energy audit
- Energy service contracting for joint tenancies

<u>Financing the refurbishment of joint tenancies - Incentives</u>

1. **What are the financial tools necessary to fund the retrofitting of joint tenancies? Are they all necessary?** Circle yes or no and then rank the following tools in order of need (from the less important 1 to the most important 8)

Third party financing	86%
Energy performance contracting	71%
possibility to allocate a portion of the cost of work as a rent increase	63%
Eco loans for joint tenancies	86%
Tax credits	43%
Grant equal to a % of the total refurbishment costs	57%
Establishment of a mandatory refurbishment fund to cover a % of the refurbishment costs	100%
Energy service obligation	100%

→ 100% believe that the energy service obligations and the establishment of a mandatory renovation fund are needed; followed by third party financing and a zero interst eco loan for joint tenancies.

2. **What other financial measures are needed ? Would improvements of existing systems be desirable?**

- Third party financing coupled with a government guarantee supported by local savings
- Combine the mandatory faced refreshment with an energy audit of the whole building
- Focus on the share of the existing joint tenancy buildings with the worst energy efficiency. Given the structural complexity of joint tenancies (legal, social, cultural, divergence of interests) all interest should be bundled.

3. **With all these measures, how many joint tenancies could be renovated every year?**

→ The vast majority of people could not specify a number of houses to be renovated annually. Two figures have been mentioned: 100,000 to 200,000 and "need to target 150,000." Someone wanted to add that the number depends on the level of safeguards and monitoring condominium fragile.

4. **All these incentives together would they allow achieving a division by 4 of the CO2 emissions in 2050?** Yes No

→ 44% of the stakeholders think that with the presented measures the objective can be achieved.

Retrofit obligation for joint tenancies

5. **With the above-mentioned incentives, would a retrofitting obligation for joint tenancies be acceptable?** Yes No

→ With the incentives mentioned 55% of attendees believe that the obligation to renovate for condominiums is acceptable.

Other arguments:

- Acceptable if the refurbishment aims at the socio-economic optimum, not the maximum that is technically feasible
- Not acceptable – because a general retrofitting obligation is not taking into account the social diversity and the different capacity of households to provide own financial contributions. Such a requirement would be terrible for fragile households
- It is far too complex to create a systematic obligation (but mandatory energy audit in case of renovations)
- In the case of copro, the obligation to work the sale does not allow pardons overall treating the building as a whole
- Mandatory training for all actors: owner / manager / caretaker

6. **What should be the criteria for the planning and implementation of a retrofitting obligation?**

- Energy Performance Level
- Date of last renovation
- Obligation of the façade refreshment
- Change of ownership

→ 71% think that the façade refreshment or the energy performance certificates are the best planning criteria. 42% think that the last renovations date would be appropriate and only 14% believe that that date of construction should be considered.

7. **What should be the annual number of retrofitted joint tenancies?**

- 70,000 (renovation of the park in 100 years)
- 100,000 (renovation in 70 years)
- 150,000 (renovation in 45 years)
- Other?

→ This question raised a lot of abstention; those who answered were in favor of 150000 refurbishments per year.

8. What should be the energy performance target of retrofitting actions?

- 50kWh/m2.an
- 80 kWh/m2.year
- 150 kWh/m2.year
- Gaining 2 energy etiquettes
- Other ?

→ The avergade of the answers is a regurbishment target around 69kWh/m2.year. Several people specified that is should be expressen in primary energy . Another proposal was: a gain of 2 energy labels every 15 years.

Other remarks:

- The objective for each bulding depends on the specific typology of the building and the local climate

Roundtable discussion:

- Big buildings > 100 apartments should be targeted first
- Central heating => obligation, individual heating (no requirement for super efficiency) = 60%
- Joint tenancies are better served by the existing situation within the energy service obligations system as if they were eligible => EDF, GDF, local suppliers or negotiating the price of MWh via the energy saving certificates. But how the value is shared?: via a third party to provide maximum value to the customer (4300 euros/GWcumac GW, 70% to the customer and 30% to the rest of the entire value chain). Same logic as domestic CO_2, domestic carbon credit (national) – Joint implementation.
- New incentive tools: problem of public funding
- Help fund the quality control of the retrofitting work
- Problem of finding a common understanding
- Better use existing tools: obligation façade cleaning (but insulation from the outside is not possible an all buildings)

d. Social housing

France had in 2010, 4.508 million of public social housing units. Only 30% were built after 1985.

French legislation:

"The objective of the French government is the refurbishment of the entire social housing stock. For this purpose, 800 000 social housing whose energy consumption exceeds 230 kWh primary energy consumption per m2/ year will refurbished before 2020 in order to reduce their annual consumption to less than 150 kWh/m2/year. The renovation program is planned as followed:

Years	*2009*	*2010*	*2011-à 2020*
Refurbished social apartments	*40000*	*60000*	*700000 per year*

For this purpose, an amount of low interest loans will given to providers of social housing organizations. Agreements between the State and these agencies will define the conditions for implementing the program especially for the financing of the investments (including a financing via the achieved energy savings). The government may award grants that can be up to 20% of the cost of work "

<u>Financing of the renovation in social housing - Incentives</u>

1. **What are the financial tools necessary to fund the renovation of social housing? Are they all necessary?**

third party financing	67%
Energy performance contracting	57%
possibility to allocate a portion of the cost of work as a rent increase	67%
Eco loans for social housing	100%

→ 100% believe that special low interest loans for social housing are essential tools followed by third party financing and the possibility to allocate a share of the retrofitting costs as a rent increase (67%). Energy performance contracting is supported by (57%).

2. **What other financial measures would be needed or improvements of existing systems would be desirable?**

- Integrate climate and energy concerns as one of the main principles in the conventions between the state and the social housing associations
- Increase the capital of social housing associations

- Modify the performance criteria of the zero interest loan for social housing (150kWh/m2/an now should be replaced by 80)

3. With all these measures, how many social housing apartments could be renovated every year?

→ The vast majority of people could not specify a number of houses to be renovated annually. One figure was mentioned: 150,000.

4. **All these incentives together would they allow achieving a division by 4 of the CO2 emissions of the social housing sector in 2050?** Yes No

→ 71% of people have thought that with these measures it will be possible to reach the emison redction objective concerning the social housing sector.

Retrofitting obligation for the social housing

5. With the above-mentioned incentives, would a retrofitting obligation for social housing be acceptable? Yes No

→ Only 40% believe that the obligation to renovate for individual houses is acceptable. The conviction is shared that this sector needs less than the others a retrofitting obligation because it is more structured than the rest of the building stock.

Other arguments:

- An obligation is not useful because the housing agencies if they have the necessary funding, will retrofit anyway even without obligation.

6. What should be the criteria for the planning and implementation of a retrofitting obligation?

- **E**nergy Performance Level
- Date of last renovation
- Obligation of façade cleaning
- Date of construction

→ 100% think that the duty of cleaning is the most appropriate moment for the implementation of an obligation to renovate. Nobody thinks that the date of construction is a good criterion but 75% believe that the energy performance level and the date of last the renovation could also be feasible moments.

7. What hould be the annual number of retrofitted houses in the social building park?

- 50.000 (refurbishment of the park in 90 years)
- 70.000 (refurbishment of the park in 65 years)
- 100.000 (refurbishment of the park in 45 years)

→ This question generated a lot of abstentions. Those who answered were in favour of 100,000 renovations per years.

8. What should be the energy performance target of retrofitting actions?

- 50kWh/m2.an
- 80 kWh/m2.year
- 150 kWh/m2.year

→ According to the answers the objective in terms of energy performance should be set at 80/m2.an. Several people specified that it should be expressed in primary energy.

One added the following comment: We must aim at the economic optimum without impeding a possible second refurbishment stage 50kWh/m2/year.

<u>Zero interest loans for social housing:</u>

- Doubt on the leverage effect of this tool

- Planning of the retrofitting of the social housing stock: the tools do not trigger the desired renovations, financing requests submitted remain below expectations

- Incentives do not create new initiatives / assessment of the last two years of using this tool = little impact

Roundtable discussion:

- HLM-bodies have today more financial incentives to demolish than to improve the existing

- Energy contraction is completely useless for this sector;

- Actors are not afraid to have a payback period of 30 years - but the necessary investment budget has to be provided

- This is not the most problematic sector

- Any requirement brings its opposite (as it will be bypassed anyway) - argument against mandatory renovation

- This is the only part of the building sector, which has already a refurbishment planning

- A high share of the social housing buildings can be refurbished quite easily (the techniques are known and approved)

- If you are the owner of a social housing building you can pass on a share of the renovations cost to the tenants (at least via the energy savings)

- Thermal sieves: demolition, deconstruction and reconstruction can be cheaper and more effective than renovation; Issue of embodied energy?

- The public housing park is not the worst (rather better than the private rental market); much of the public social housing has been renovated in the 80th

e. Building sector - jobs

In 2009, the entire building industry employed 3,5 million persons (including 1,2 million craftsmen).

If the money (about 6 bn €) for training (initial and continuing training of trainers) was made available:

1. **How many years would be needed to train the entire building industry to be able to respond to the challenges of thermal retrofitting?**

→ According to the answers of the stakeholders it will take about 10 years (average 8.75).

Other comments:

- Attention: the question of initial training and advanced training are different. How you can bring craftsmen back to “school”.

2. **When the building industry might be ready to respond to the requiremens of a retrofitting obligation about 400,000 per year?**

→ There is not a clear answer emerging from this question but a probable link between the announcement effect of an obligation on the speed of the trainaing rate.

Some reactions of the stakeholders:

- The artisans of the building sector ill be readyafter 2020
- 1 to 2 years after the announcement of the obligation
- Now – up from the moment where a retrofitting obligation is decided
- When IRR (internal rate of return) of the projects is > 10%
- The industry will begin to learn new skills when the demand exists

3. **The adaptation of a retrofitting obligation – would it allow a faster development of the capacities of the employees of this sector (triggered by the visibility concerning the evolution of the demand)?** Yes No

→ 66% of people actually believe that the establishment of an obligation to the renovation will allow the industry to grow faster.

D’autres commentaires :

- Formation initiale doit être financé par l’état
- L'état doit poser des critères, au privé d'y répondre
- La filière elle-même doit financer la formation

4. **Funding: Who should pay for the training?**

- State
- Local authorities
- Energy Savings Certificates
- Private Sector
- Other

- → 100% believe that the private sector should fund the training of the sector, followed by (in decreasing order of importance) the state, the energy saving credits and local authorities

Other comments:

- Initial training must be funded by the state
- The state must raise standards, the private sector has to respond
- The industry itself should fund training

5. Is it necessary co-fund the creation of jobs for new specialization?

→ Responses do not give a clear answer.

What is need is a transformation from the refurbishment that is done today in energy retrofitting; this creates probably less jobs that many people imagine

Discussion:

- Where is the political will: there is only one person responsible for the topic of training in the building sector in the Directorate general of the ministry responsible for housing
- For SMEs it is difficult to use innovative processes because they represent insurance problems for micro-enterprises => bottleneck
- Rather than to find funding is to find new and adequate forms of organization
- Demand for training is quite low today => incentive have to be developed to become the sector attracted to the existing trainings / conditionality of access to subsidies
- In France, unlike to Germany, materials and processes are labeled rather than business. The labeling of the enterprises would promote training
- Two different obstacles:
  - Initial training: problems working with the National Education (at least 10 years) => problem of skilled labor
  - Advanced training: problems of small businesses (if enterprises have only 1 or 2 employees they cannot send them to long trainings); advances trainings should take place on site
- Dynamic FEEBAT stagnates because the market is not there => but there is a potential market
- On the organization, some companies change their mode of organization, eg: group (comprehensive energy)
- OR: yes, no => going to be a brake on the market (yes versus no visibility and for the market) => issue of acceptance of the obligation copros +: can we force everyone at the same time
- Funding: no problem, problem: getting people to form (never a good time) => new formation mechanisms (go home, on site)
- 20 billion: restructuring of the markets => breaking the btp / renovation

f. Evolution m2 per person

	1990	2010	2020	2030	2040	2050
Size households - B	2,57	2,25	2,16	2,08	2,04	2,01
Size households - H	2,57	2,24	2,14	2,04	1,99	1,96

Source: INSEE : extention by CLIP facteur 4

	m2 per person – individual housing	m2 per person – joint housing
2010	42	28
2050 – Size households - B	50	35
2050 – Size households - H	56	40

→ This increase in surface area is accompanied by an increase in the need for heating and domestic hot water

1. What evolution concerning the household size and so the m2 per person is realistic (the two scenarios are based on forecasts INSEE)?

→ 75% of those who answered consider the H scenario as more likely.

2. Can you imagine any financial and / or policy measures that would move one trajectory to the other?

A list of ideas:

- Taxes and regulation
- Regulation of real estate prices
- Revaluation of share of services
- Teleworking

→ The scanrios of INSEE are true and false at the same time:
The number of households is growing faster than population => INSEE underestimates the space needed for regularly but temporailiy accommodation by a third party (children haven rooms oin each of the new households of their seprerated parents are not taken into account)

Problem: the size of the appartments of the existing building stock is difficult to influence

- Strong decrease in the number of people per household anyway => + aging marriage and first child later

- Dwelling size => is in general not a free choice but depends on the m2 price
- Should the government ask households to lodge old people?
- Who are the house owners? Rather, the old people
- Dwelling size and household size:
    - Real estate prices => should it be regulated in order to regulate the size of housing
- Physical restraints for densification
- Telecommuting: elimination of offices and everyone works at home or in "district offices" and not in "offices of the company"
- Shared guest rooms shared and common laundries
- What is the energy service behind a m2-energy consumption?
- The surface of new houses are becoming larger

g. Taxes

The report “Quinet” [17] on the shadow carbon price proposed the a carbon tax about 32 € / tCO_2 in 2010 whose value would increase annually to reach 100 € / tCO_2 in 2030.

Impact of a tax about 32 € / tCO_2 depending on the typology of the buildings and the choice of energy used for heating (additional annual cost induced by the tax in € on average per dwelling)

Gas		Fuel		GPL		Coal	
collective	individual	collective	individual	collective	individual	collective	individual
84	127	117	169	60	77	146	142

- Acceptability problems: the problem is not necessarily the amount, but fears of inequality, social injustice etc.
- Comprehension problem regarding the wider public
- How the tax revenues are used / redistributed?
- Injustice: not every citizen has access to the same infrastructures (low carbon collective heating etc.)

1. Assuming the establishment of a new tax on energy which assumptions are considered acceptable:

A. Tax base:
• Taxing carbon alone
• Taxing carbon and energy (including electricity)

→ 60% preferred the establishment of a carbon & energy tax. One person added that renewables should be excluded from this tax (should avoid taxing renewable energy consumption => solar etc..) Another representative expressed positions in opposition to the need of a tax: Its recommendation was to replace the tax by a domestic carbon market.

B. Tax level in 2012
• 32 € / tCO_2
• Higher
• Lower Level

→ 75% are favor a tax higher than 32 € / tCO_2 in 2012.

C. Tax level in 2030
• < 100 € / tCO_2
• 100 € / tCO_2

[17] QUINET Alain (2009) “La valeur tutélaire du carbone” Centre d'analyse stratégique

• > 100 € / tCO_2

→ 60% are in favor of a tax higher than 100 € / tCO_2 in 2030.

2. Growth of the tax: Should the evolution of the tax be communicated transparently today?

→ 100% think the evolution of the tax should be known today.

3. **Which tax recycling options of the tax revenues are desirable?**
   - Decrease in labor costs
   - Research & Development (green)
   - Green check to households
   - Support for energy efficiency and renewable energy
   - Debt reduction

→ The two preferred options for recycling by the representatives are:
- Support for energy efficiency and renewable energy (one person has expressed the need to specifically support: thermal renovation of houses occupied by vulnerable populations - low income and high energy bills)
- Research & Development (green)

Debt reduction was the least chosen option.

Tax revenues:

- Not well integrated into the heads of politicians: investing in energy efficiency is = reducing trade deficits

- The explanation why the revenues should be used to reduce labor cost is too complicate

- The main economic argument is that in the long-term lower labor costs are creating economic development → difficult to comprehend by the public

- Making it difficult to accept a carbon tax is the fear of paying relatively more than others (oil dependence, no access to public transport etc..) - Redistribution acts against this fear, we need more education

- Clarification of R & D and green check:

    - Green check: to households: global redistribution - the people who are in a lock-in situation and cannot change their consumption should have access to more redistribution and out of this situation

    - Green check: to households: individual incentives never works very well (better: structures of third party funding)

    - Green check: to households: complexity; most households in the situation of fuel poverty have also other problems and should be approached more holistically than only by a "green check", the reasons why they are in this situation has to be analyzed

h. Fuel poverty

In France 3.4 million households spend over 10% of their resources to pay their energy bills. 62% are homeowners. 2.1 million households are concerned primarily those whose resources are modest. 90% of them live in individual houses, mostly built before the first thermal standards of construction put in place in 1975.

Social tariffs

What exists

The Tariff of First Necessity (TPN) provides a discount rate on the electric subscription and on the first 100 kWh used each month. The reduction represents 40 to 60% of the annual bill based on the household composition. The average annual reduction is about 88 €.
Special Solidarity Tariff for gas (TSS) offers a discount on all invoices in the case of an individual contract or a fixed annual reduction in the case of a collectively heated building. For a household of two or more persons, the annual reduction is between 22 € (hot water) and 118 € (hot water / heating).

What should be done?

1. Application of a progressive tariff

• on heating consumption yes no

• on electricity consumption yes no

→ 80% are in favor of the establishment of a progressive tariff on heating consumption and 83% on electricity consumption.

2. **Establish a green check-tested**

→ 50% are in favor of establishing a green check to households, one person added the comment that the check should only be used for energy retrofitting.

Economic incentives for retrofitting

What exists

"Better living" is a program initiated by the State in the frame of the "Investment for the Future" which has a budget about 1.35 billion Euros. Launched in 2010, the goal is to assist 300,000 households (10% of households in fuel poverty) within 7 years (by 2017) to improve their housing conditions by thermal efficient retrofitting, in order to gain comfort, quality of life and purchasing power. The objective is to achieve at least a 25% reduction of the energy consumption. Fixed at € 1.100€ it may be increased to € 1.600, by contributions from local authorities. At its launch more than 50 departments were involved in this program.

But subsidies for retrofitting such as zero-interest loan, eco-subsidies and the tax credit for sustainable development, are not accessible to the poorest families.

What should be done

1. **Allow the accumulation of subsidies under the program "Better living" with zero interest loans and / or tax credits**
2. **Increase the threshold for improving energy efficiency of housing**
3. **Increase the level of assistance per household**
4. **Fund roof insulation for households in fuel poverty**
5. **Increase the number of homes of vulnerable insecure households that are retrofitted each year**

→ 75% think that roof insulation for vulnerable households should be financed. 66% agreed with increasing the level of assistance per household. 60% would increase the number of homes retrofitted each year and allow the accumulation of subsidies within the frame of the program "Better living". Only 40% think that increasing the minimum energy performance standard required would be a good idea.

Two other ideas put forward were:

- The establishment of a micro-credit "fuel poverty"
- Creation of a third party investing fund

Discussion:

- Link fuel poverty and energy tax: electric heating

- Financial support is needed for households with electric heating for insulation

- Progressive tariff is politically difficult to adopt, there are always winners and losers (thermal comfort is not the same for everyone)

- To calculate the progressive tariff smart metering is needed

- Is the application of a progressive tariff an adequate tool to fight against fuel poverty? Individuals living in badly insolated houses do not heat – reducing the costs will lead to more consumption and no changes.

- A progressive tariff sends a price signal but is not a good tool to fight against fuel poverty

- It does not subsidize energy but help to find sustainable solutions (renovation)

- Problem of definition of fuel poverty / it is better to talk about the vulnerability

i. Heating system

Interdiction of electric heating

Discussion:

- Ban – yes! Reuse of electric heating possibly when we have retrofitted our building stock

- We must look at reality: there will be an increase in electricity prices

- Pedagogically it is important to say that we should not use the noblest form of energy (electricity) to produce heat

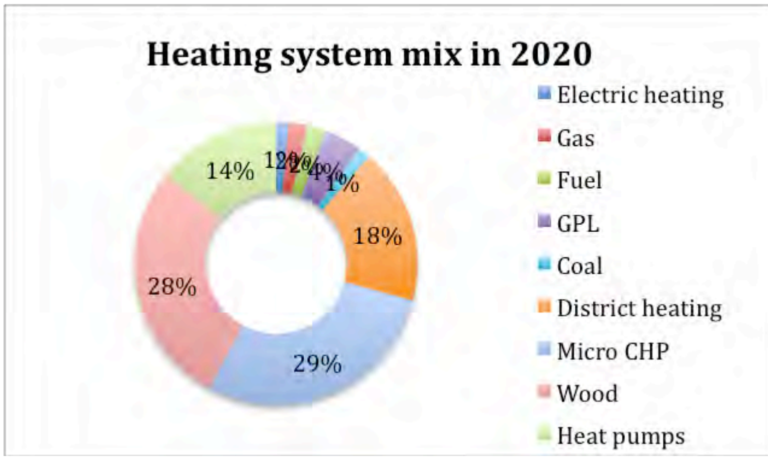
- High temperature heat pumps – problem: this technology should not receive subsidies or tax credits

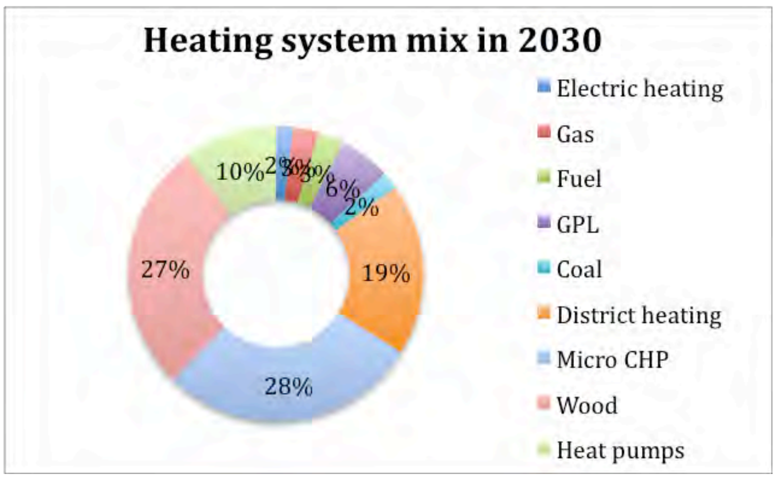
Energy	Actual use	Potential in 2020
Wood	88 TWh/year	130 TWh/year
Geothermal		140 TWh/year
Wast		8 TWh/year
District heating	18 TWh/year	12 TWh/year renewable

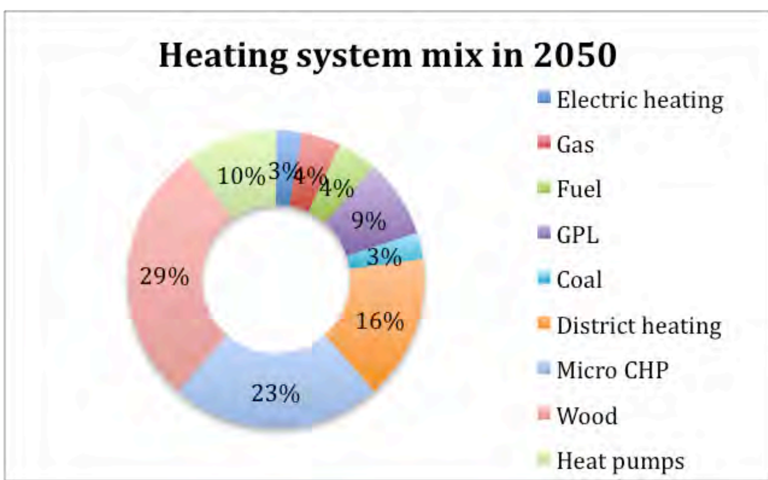
What heating systems should be developed?

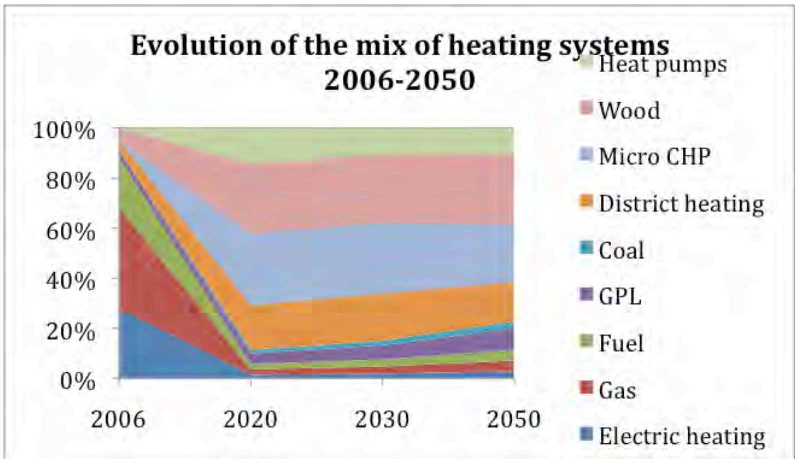
Stakeholders were invited to rate the different options from 1 (least support) to 10 (maximum support) in 2020, 2030 and 2050.

	Investment costs without subsidies k€	Investment costs including subsidies k€	gCO2/kWh final energy	2006	2020	2030	2050
Electric heating	4	4	180	28%			
Gas	10	9	205	40%			
Heat pumps	16	12					
Wood	12	9,5	0	5%			
Fuel			271	20%			
GPL	11	11	231	3%			
Coal			355				
District heating			200	4%			
Micro CHP							


Heating system mix in 2020
Electric heating
Gas
Fuel
GPL
Coal
District heating
Micro CHP
Wood
Heat pumps
14%
1%
18%
28%
29%


Heating system mix in 2030
Electric heating
Gas
Fuel
GPL
Coal
District heating
Micro CHP
Wood
Heat pumps
10%
6%
2%
27%
19%
28%


Heating system mix in 2050
Electric heating
Gas
Fuel
GPL
Coal
District heating
Micro CHP
Wood
Heat pumps
10%
3%
4%
4%
9%
3%
29%
16%
23%



→ The graphs are showing a rapid decrease of gas, fuel and electricity (excluding heat pumps) for heating. The share of micro- Combined heat and power installations, wood and heat pumps increases substantially.

1. Interdiction of electric heating

- In the case of retrofitting obligation

- In new constructions

- Up from a threshold electricity consumption kWh/m2/year

- Depending on the energy performance class

→ 80% wished to forbid electric heating for new construction. Only 20% supported the idea of interdiction in the other 3 cases.

2. Interdiction of fuel for heating

- In the case of retrofitting obligation

- In new constructions

- Up from a threshold electricity consumption kWh/m2/year

- Depending on the energy performance class

→ 75% wished to forbid fuel heating in new construction. Only 25% supported the idea of prohibition in the other 3 cases.

3. What are the financial tools necessary to fund the transfer of one heating system to another?

- Third party financing
- Tax credits
- Direct subsidies
- 5.5% VAT reduction
- Energy savings certificates

→ Responses to questions were not usable. A careful analysis may indicate that people think that all the tools could help in a more or less important way to the financing of heating change. The Energy saving certificates system does not fund the change of energy for heating.

II. Stakeholder meeting "transport sector"

7th December 2011

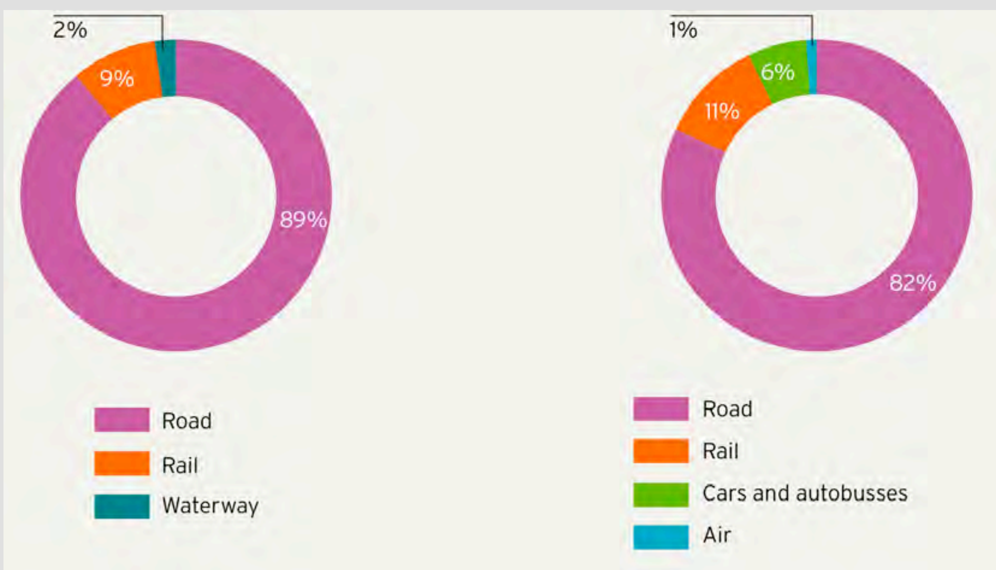
a. Introduction transport

The meeting started with a presentation of the program and each participant.

Then the project team introduced the project methodology for a collaborative scenario creation process and gave an overview on the sector specific challenges.

The transport sector is responsible for 33% of the CO2 emissions in 2010. Its emissions increased of 16% between 1990 and 2010. The main cause of these emissions is the fuel combustion for the road transport. Regarding the modal split, both passengers' transport and freight transport are highly dominated by road transportation.

Modal split in freight transport - 2010 **Modal split in passenger transport - 2010**



The trips for less than 50 km represent 89% of the journeys. Trips over 500 km correspond to only 1.3% of the journeys but 40% of the traveled distances. Irrelevant in terms of km but important in number of journeys are our feet: 22% of local mobility is walking but it only sums up to 2% of the km.

In 1990, the transport sector was responsible for 29% of the total French final energy consumption ; in 2010, it increased to 32%. But in absolute num- bers, this evolution represents an increase of 25%. Transport needs infrastructures and the investment during the recent decades shows that the road transport mode was clearly favored. The

road network increased from 5,300 km in 1980 to 11,054 km in 2008. Between 1994 and 2008, the highway traffic has increased about 55%. The high-speed rail network (TGV) has only increased from 1,574 km in 1994 to 1,847 km in 2008 – but the number of passengers raised about 146%.

Freight traffic decreased about 15% during the economic crises in 2009 but since then, it is slowly returning to its former level.

Climate and energy objectives:

The French legislation includes several objectives concerning the transport sector:

- Reduction of the greenhouse gas emissions of the transport sector about 20% in 2020 (base year 2005)

-Adoption of an eco-tax on heavy road freight transport in 2011 (has been delayed)

- Increasing the share of non road and flight traffic from 14% to 25% in 2022

- +25% on non-road and flight traffic in 2012 (objective is not achieved)

- Launch of the construction of 2000km of high-speed train before 2020

- 50% reduction of the energy consumption by passenger and km of the flight traffic until 2020

Passenger transport

II. Urban sprawl

The agricultural and natural areas are losing every seven years an area of the size of an averadge French department (610,000 ha).

What instruments are effective and acceptable to limit urban sprawl?

- Reforming of financial instruments for the housing sector:
    - Redefine the geographical zoning of the “Scellier instrument”[18] and other investment instruments focussing on renting of new construction by limiting them to intra-urban zones or to areas with access to public tranport;
    - Limiting of the zero interst loan + (EcoPTZ+ à taux zéro) to intra-urban zones or to areas with access to public tranport;
    - Remove the ability of local governments to exempt 50% of the tax on the of planning individual homes in rural areas by using the PTZ +.
- Obligatory payment for municipalities if their bulding density remains under a certain threshold
- Carbon tax to increase fuel prices
- Urbain road charges
- Regulate the price of housing
- Develop housing near urban centers or public transport
- Plans for extsding urban areas have to respect a certain density threshold
- Refurbishment of 2 million appartments in need of rehabilitation

[18] http://www.scellier.org/

→ The instruments considered most effective by the stakeholdersare:

- Carbon tax to raise fuel prices
- Reforming financial tools for the building sector
- The establishment of conditions of urbanized areas to a minimum density threshold.

The stakeholders see problems of acceptability concerning the following instruments:
In their eyes the establishment of a road charge bears the danger of creating inequality. Also the introduction of a carbon tax is considered to be a source of social injustice.

Other proposals:

- Incentive flat sharing, divide big flats in 2 or 3 smaller ones
- Bonus-malus: Incentives on flat sharing and extra tax on individual housing
- Property tax necessary to feed public policies
- Local development plan (SDRIF, SCOT)
- Guide the urban / transport planning processes (SCRAE, SCOT, ... PCET)
- Limit the development of centralized big shopping centers
- Work on the location of jobs
- Limit transformation / declaration agricultural land to building areas

Do you think these tools are able to:

Reduce the transformation of agrocultural soils in buidling land?
→ 70% of respondents believe the previously mentioned measures can halve the impact.

To slow urban sprawl?
→ 80% of respondents believe the previously mentioned measures can devide by two the impact of urban sprawl.

Densification of cities and urban centers?
→ 70% of respondents believe the previously mentioned measures are not able to densify cities.

At what time horizon, these tools could have a significant impact?
→ 45% of respondents believe that the measures can have an impact only in 2040 and 36% believe that already in 2030 significant impacts will be visible. Only 9% believe in an impact in 2020.

Discussion with the stakeholders:

- Instruments can be quite different; all has to be exploited: regulatory instruments, incentives, increase the price of transport (road pricing)
- "The problem is that measures on transport and mobility try to compensate for bad urban planning." But tools as the “SCOTS”[19] are trying to bring coherence in the planning of land use and mobility concerns.
- Does urban sprawl is a problem or a solution? Urban sprawl generates greater potentials for energy autonomy → another hypothesis is that urban sprawl is a climate problem? - It depends on what energy is used; but for sure: a rural area depending on local renewable energies are no climate problem

[19] Schémas de cohérence territoriale (SCOT):
ttp://fr.wikipedia.org/wiki/Sch%C3%A9ma_de_coh%C3%A9rence_territoriale

- Is metropolisation inevitable? - Sustainable cities have a population size between 40 and 60,000 inhabitants

III. Local mobility

How to reduce the modal share of cars in rural areas?

- Public transport
    - Improve the level of service and accessibility of public transport in urban areas
    - Increase the comfort level
    - Increase speed
    - Increase frequency
    - Advantageous pricing or free public transport
    - Develop infrastructure in transport (more offers, new lines)
- Facilitate multimodality
    - Creation of multimodal platforms
    - Single information interface for all different kinds of public transport (bus, train…) for multimodal information in real time (also as smart phone application)
    - single tariffication
- Increase the price of car use
    - road taxation
    - carbon tax
    - Increased cost of parking
- Restrictions on car use
- Develop bike paths

→ The proposals judged to be most essential for rural areas are:

- Improve the level of service and accessibility by public transport in urban areas
- Creation of multimodal platforms
  followed by:
- the establishment of a carbon tax
- Increasing the frequency of transport

Proposals that received less approval:

- Increasing the comfort level of public transport
- Advantageous pricing or free public transport
- Single tariffication and
- Restricting car use

Other proposals:

- Higher taxes on fossil fuels
- Promote systems for car rental
- Propmte car sharing, development car pools
- Better security for walking, cycling
- Ensure absolute frequency and significant transport

How to reduce the modal share of the car in the parisien area?

- Public transport
    - Improve the level of service and accessibility of public transport in urban areas
    - Increase the comfort level
    - Increase speed
    - Increase frequency

- Advantageous pricing or free public transport
  - Develop of new infrastructure
- Facilitate multimodality
  - Creation of multimodal platforms
  - Single information interface for all different kinds of public transport (bus, train…) for multimodal information in real time (also as smart phone application)
  - single tariffication
- Increase the price of car use
- Restrictions on car use
- Develop bike paths

→The proposals considered most essential for the Paris area are:

- The increased frequency of public transport

Followed by:

- Improve the level of service and accessibility by public transport in urban areas
- Creation of multimodal platforms
- Increased cost of parking
- carbon tax

Proposals that received less approval:

- Advantageous pricing or free public transport
- Increase the comfort level of public transport

Other proposals:

- Promote electric two-wheelers (assisted bicycles…)
- Promote car renting and car sharing
- Lines are already there in Paris and the suburbs are growing. The problem lies in the service and line frequency over the complexity of intermodal
- Fight urban sprawl and geographiic segmentation (reduce distance between employment and housing)
  Creation of bus lanes
- The important thing is to change the content of carbon mobility, not so much mobility as such
- Virtual Mobility (telecentres, telecommuting, visioconfernces)

Other obstacles to the development of public transport infrastructure?

- Not enough state investment in public transport
- Not enough funding from local authorities and risk of increasing local taxes
- Insufficient profitability
- Physical constraints to the urban planning

→ "Not enough profit" is the main obstacle in the eyes of the stakeholders followed by "Physical constraints related to urban planning." On the third place "Not enough state investment in public transport."

Other proposals:

- The ability to effectively meet the mobility needs
- The most profitable lines are already built -> Problem of density and costs
- Lacking political will

In 2009, € 1 billion was invested in public transport in public transport autside of the parision region , and € 1.2 billion by the RATP and rail network in in the parisian region. Are these amounts are sufficient?

→ 73% of attendees believe that the investment will not be enough nor in the provinces or in Paris.

Would it be acceptable to invest more in the development of public transport in urban areas?
→ 64% think it would be acceptable to invest more in urban PT.

How much?
→ Despite the large number of abstention on this issue: 36% think 4 billion € should be spent per year and 18% are in favor of a 2 billion €/ year.

During how many years?
→ The majority of responses oscillated around 10 to 15 years

How these investments should be funded?
- Increase the share of consumption tax on petroium products
- Revenues of a carbon tax
- Increase the State investment
- Increase the existing "transport contribution" of priviate businesses in urban areas

→ "Income of a carbon tax" is the option that gats the most support followed by "Increaseing the share of consumption tax on petroium products". On the third place "Increasing the State investment".

Other proposals:
- Modulation of property tax based on the accessibility of public transport
- Transport contribution" of priviate businesses in urban areas: no threshold

Can you imagine a decrease in the number of cars in town?
→ 73% imagine a sharp decline.

Prohibition of a conventional combustion engine vehicle city - would this be acceptable?
→ 64% are against a ban on conventional combustion vehicles in cities.

To reduce the number of cars in town, it is effective and acceptable that communities are subsidizing a system such as Autolib[20] in Paris?
→ 73% believe that support for such initiatives is effective. One person added that it is certainly efficient, but not useful because the car-sharing systems are already happening without help.

Discussion:
- Time spent in transport is a crucial topic (determines the choice in favor or against public transport)
- By 2050, we expect a very significant technological evolution: a reduction of cars in cities implies that the car remains "dirty". With "clean" vehicles the number does not has to decrease necessarily?!
- Noise, space, housing costs are also part of the problem of cars in cities.

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[20] http://www.autolib.fr/autolib/

- In many smallet towns, traffic is structured by 4-5 big lines and by many empty bus lines → better than one person in a bus is one person in a car.
- Nowadays the vehicles occupation rate is lower than 10 years ago.
- Problem of multi-purpose transport => take non-students in the school bus
- Question of speed reduction (8km / h vs 60km / h)
- Interesting example Tokyo: prohibition of having a car without a parking space
- WE have to go beyond ownership: Transition to car sharing is necessary
- Collective taxi, mini bus
- Change the use of the car / shape of the car (over 4 * 4)
- Electric car: a very “French” discussion because of the decarbonisation level of electricityis low in coparison to other countries, but nothing is certain about the evolution of the electric car

IV. Rural transport

How to limit car use in rural areas?

- Maintenance or redeployment of public services in rural areas and local shops
- Development "collective taxis" or "citizen busses " on request (no regular schedule)
- Development of car-sharing
- Increase the price of car use (for example through taxation such as a carbon tax)

Development of “express bus lines”

→ All policy proposals except "Increasing the price of car service" wee almost supported by 100% of the stakeholders.

Is it necessary to identify households at risk of mobility lack in the suburbs and rural area and develop specific support?

→ 62% of respondents believe it is necessary to identify these households. They support the following measures:

- Incentives for volontary removal
- Carpooling
- More bus stops
- Transport on request

Who should fund the provision of public transport in rural areas?

- State
- Local authorities
- People
- Users
- Pribvate enterprises in the concerned area

→ The more people believe that local authorities and businesses of the area should fund the provision of transport.

Other comments:

- For local authorities: Financial adjustment between urban and rural areas
- For state and local authorities: solidarity principlae
- For enterprises: Obligatory mobility planning

Discussion:

- Lack of discussion: average age of the population (also valid for public transport) / "What is the average age in rural areas? "" Physical accessibility or transport schedules? "
- Common Transport accessibility: physical limits of accessibility for older / handicapped people (100 or 200 steps) or more, this argument is also valid for inter-and multi-modality

- In the city center: the people choose their housing + transportation modes
- in the suburbs: choice is made in fonction of the price + also the mode of transport (often long distances)

V. Commuting

What strategy should be applied to limit car use for commuting?

- Carpooling and development of economic incentives for carpooling
- Provide financial incentives to companies to set up businesses travel / mobility plans
- Reform of the incentive sytem (remove the reimbursment of vehicle km for commuting)
- Develop telework (creation of centers equipped with video conference sytemsetc.) and provide benefits to those who telework
- Road taxation
- Fiscally penalize companies do not locating near public transport facilities

→ The three strategies with the most support are:

  - Develop telework (creation of centers equipped with video conference sytemsetc.) and provide benefits to those who telework
  - Carpooling and develop ment of economic incentives for carpooling
  - Reform of the incentive sytem (remove the reimbursment of vehicle km for commuting)

Other proposals:

- No parking at the working place (to pay for parking at work is already done in some companies in the United States)
- Support for carpooling, why not also for car rental

VI. Long distance transport

Long distance transport (>80km): 1.3% of trips but 40% of distances

Leisure and holidays

How rail traffic can regain market shares on the road and air transport for long distances?

- Price
- Creating a one-stop shop for all railway organizations in Europe for more accessible information
- Service rendered, comfort
- Transport time
- Intermodality guarantee arrival or departure via public transportation or a flexible and affordable car rental system
- Development of regional trains

→ These conditions were considered to be the most important:

  - Intermodality guarantee arrival or departure via public transportation or a flexible and affordable car rental system
  - Price

The condition is least important according to the stakeholder is the creation of a one-stop shop for all railway relted information

Does the coach express companies should replace unprofitable train lines?

→ 32% of stakeholders believe that it is a good idea and 27% more agree with this choice as long as the busses are very effective. 27% are opposed it.

Should there be a transregional express bus offer connectig long-distance medium-sized cities?

→ 45% support the idea of creating this offer. 27% support the idea under the condition that the busses are very effective. 18% are opposed to thisproposal.

Are more high-speed tlong-distance train lines needed in order to compete with the airplane?
→ 73% think that more high-speed lines are needed to compete with airplanes.

Is the indterdiction of subsidies by local authorities for "low cost" flight companies is acceptable?
→ 60% are in favor of a ban on subsidies.

Is the kerosene tax exemption for air acceptable? (The exemptions from a tax on petroleum products and VAT on kerosene for aviation accounts for about € 6 billion per year.)
→ 82% find that the exemption tax on kerosene for aviation is unacceptable.

These measures do they represent in the medium-term options able to significantly reduce the demand for long-distance mobility?
- Take fewer but longer holidays

→ 64% of respondents believe that the development of working time is a good idea but having only a moderate impact. 18% think it is a good idea and 18% are opposed.

- Living in a “sustainable city” reduces the need for espcapng elsewhere (at the countryside etc.)

→ 82% of respondents believe that living in a pleasant town reduces the need to travel far but onle moderately. 9% think it has no impact and 9% believe is has a important impact.

Other proposals:
- Generalisation of videoconferences in order to reduce professional mobility needs
- The creation of lines of speed boats (ferries) to certain destinations may be interesting

<u>Professional mobility</u>

How rail traffic can regain market shares on the road and air transport for long distances?
- Relative decrease of prices
- Better service rendered, comfort
- Lower transport time
- Intermodality guaranteed at arrival or departure via public transportation or a flexible and affordable car rental system
- Development of regional trains

→ These conditions were considered to be the most important:
- Guarantee for intermodality at the arrival or departure via public transportation or a flexible and affordable car rental

  Other conditions are considered important:
- Reduced travel time
- Relative decrease in the price

The condition with the least support is:
- Development of regional trains

What are the potentials of these measures to limit demand for long-distance mobility for business travel?
- Videoconferences
- “Free” organisation / adaptation of working time
- Increase the price of air transport (kerosene taxation, VAT, carbon tax or carbon quotas)
- Bonus system for employees who do not use the air transport for trips that can be carried by rail over a period of less than 4 hours.
- Interdiction of the use of “Free Miles Systems”

→ The proposals considered to have the most potential impact are:
- Videoconferencing

- Increase the price of air transport (kerosene taxation, VAT, carbon tax or carbon quotas)

The following two options got the lowest support:

- “Free” organisation / adaptation of working time
- Interdiction of the use of “Free Miles Systems”

Discussion:

- What exactly is “long distance”? Problem of definition
- Are international emissions included in the emisisons scope?
- Better to think in terms of time efficiency and not distance
- Problem: centralised network around Paris
- Local authorities finance the low costs => problem of governance / local authorities fund to create jobs and economic activity at local
- Forced choice of vacation destinations is unacceptable
- Development rail infrastructure: Main problem is maintanence:
    - Retrofit existing infrastructure (Paris-Limoges-Toulouse was faster 40 years ago)
- Sometimes a full car is better than an empty train (especially diesel)
- Question of the value of speed (issue taxis for the last km, intermodality, redevelopment of railway stations, stop in "every" city)
- Is there a enough demand to build transverse lines for mass use?
- Problem of vicious cycle: less demand => less revenue => less maintenance => less demand; ex. Local train = the offer creats the demand. Creation of long distance lines is more complicated than for the short distance.
- The density of regional airports is 3x higher than in Germany
- Twentieth century the railroad was considered “dead”; public policy in France has not invested in railways: but the energy problem has brought rail transport back on the agenda
- Important to maintain different areas concerning school holidays
- Existing contradiction: Trains have to be fast but they should stop everywhere

VII. Véhicules

Should vehicles with too high CO2 emissions bee banned?

→ 59% of respondents think we should ban vehicles that emit too much.

Should we ban vehicles ablre to run boyond a certain speed limit?

→ 73% of respondents are in favor.

<u>Which type of car for the inner cities?</u>

Does we need a technology specialization or a mix of technologies?

→ 100% of people believe that in urban areas a mix of different technologies is needed.

In the coming decades (research and investment) should be given to which technology priority?

- Electric cars (plug-in)
    - Loading at home
    - Loading in public service stations
    - Changing batteries in service stations (type: better world)
    - V2Grid
- Hybrid vehicles
- Auto’lib (car renting systems)
- Traditional but very efficient car 1l/100km (energy efficiency: lightweight materials, stop and go etc..)
- Biofuels
- Gas

→ A majority of stakeholders gives priority to the traditional but efficient car 1l/100km and Hybrid Vehicles
Few people think that electric vehicles is a priority, much less gas or biofuels.

<u>Which car in rural areas?</u>

Does we need a technology specialization or a mix of technologies?
→ 100% of people believe that in urban areas a mix of different technologies is needed.

In the coming decades priority (research and investment) should be given to which technology?

- Electric cars (plug-in)
    - Loading at home
    - Loading in public service stations
    - Changing batteries in service stations (type: better world)
    - V2Grid
- Hybrid vehicles
- Auto'lib (car renting systems)
- Traditional but very efficient car 1l/100km (energy efficiency: lightweight materials, stop and go etc..)
- Biofuels
- Gas

→ The answer is the same as for the urban area: A majority of stakeholders gives priority to the traditional but efficient car 1l/100km and Hybrid Vehicles. Few people think that the electric vehicle is a priority. Only biofuel is considered to be an interesting option as electric vehicles.

Roundtable: What is your vision of the futur veicle?

- Efficiency, simplicity, renewable energy => gas methanation
- Two different solutions: for urban and rural areas
    - Rural vehicle: hybrid very low consumption
    - Urban: mix: battery change in service stations or auto'lib but not to go on vacation
- Low consumption vehicles exist: reduce vehicle weight + less engine, but inertia of existing parc has to be overcome
- Fewer cars, development of hybrid vehicles
- First hybrid batteries before a transition to all electric
- Technology will adapt to use
- Defend sustainable mobility, the effort should focus on efficiency and reducing consumption
- driver behavior (eco-driving has become mandatory , initial training and regular upgrading), not only focus on CO_2 (the bonus-bonus system has boosted sales of small diesel engines not equipped with filters adopted to small particles => disaster); other externalities should not be neglected
- Regardless of energy, mass and velocity: speed limit (270kg at 80-90 km) and utilisation problem (often cars stay 90% of the time in the parking lot compared to 20 minutes deriving per day)
- Development of private car sharing

VIII. Carbon tax

The carbon tax
The governmental report "Quinet[21]" on the carbon shadow price advocated the establishment of a carbon tax about 32 € / tCO2 in 2010 which would increase annually to reach 100 € / tCO2 in 2030.

Impact of a carbon tax of 32 € / t CO2 by type of fuel (additional annual cost in €)

	Diesel	Super lead free
Consumer price in October 2011 (€/l)	1,42	1,58
Share of the energy tax (TIPP) in the consumer price (€/l)	0,42	0,59
Carbon tax share in the consumer price (€/l)	0,07	0,07
Additional annual cost (€/an)	82	58

Assuming the establishment of a new tax on energy which assumption is more acceptable

1. **Tax base:**

Taxing carbon / Taxing carbon and energy (including electricity)
→ 55% are in favor of taxing carbon and energy (including electricity), 36% are in favor of a carbon tax and there were only 9% of abstentions.

2. **Level of taxation in 2012**

32 € / tCO2 / higher / lower
→ 36% are in favor of a tax level about 32 € / tCO2; 36% believed it could be even higher. 18% support lower level.

3. **Level of taxation in 2030**

100 € / tCO2 / more / less
→ 55% are in favor of a tax higher than 100 € / t CO2 in 2030, 36% prefer a level of 100 € and 0% want a lower tax.

Tax growth: should the futur growth of the tax for the years ahead be cleary presented in advance?
→ 100% think that the evolution of the tax should be known.

What recycling options for the tax revenues you consider desirable out of the following options?
- Lower payroll taxes
- Research & development (Green Innovation)
- Lump sum transfert to households
- Subsidies for energy efficient equipment and renewable energy
- Debt decrease

→ The option is deemed the most acceptable was "Subsidies for energy efficient equipment and renewable energy". Followed by:
- Lower payroll taxes

[21] Quinet, Alain (2009) "La valeur tutélaire du carbone", Centre d'analyse stratégique

- Research & development (Green Innovation)

The least support was given to option:

- Lump sum transfert to households

Tax on fossil petroleum products

This tax includes several exemptions. Shall they be deleted?

- Biofuels (196m € / year)
- Aviation (3600M € / year)
- Road transport (390M € / year)

→ 82% are in favor of abolishing the exemption of kérosen and 73% are in favor of eliminating exemptions for biofuels and road transport.

Today the revenu about 24 billion € par is allocated in the following way: 57% general budget of the state, 17% to the regions and 25% for department (French administration level)

Proposal for other recycling option?

- Equity between the taxation of diesel and gasoline
- Maintenance and updating of the public transport network
- 1/3 state, 1/3 regions, 1/3 departments

Bonus / Malus[22]

The financial results for the state budget of ecological bonus-malus should be:

- Neutral, recepies should be not higher as spendings
- Ok if the spendings are higher that recepies
- Positive: Focus on public accounts: recepies have to be positive

→ 55% think that the balance should be positive, against 36% who think it should be neutral and 9% who feel that even with a negative balance this tool is interesting.

Transport tax

Should the payment of companies for public transport in their area be increased (revenues are about 6 billion allocated to transport authorities)?

→ 55% are in favour of an increase; 36% are against and 9% prefer not to vote.

[22] http://www.developpement-durable.gouv.fr/Evolution-du-bonus-malus.html

Freight transport

IX. Growth and material consumption

Are we moving toward a decoupeling of economic growth and comuption of natural ressources that would involve less transport of goods?
→ 70% think we're moving towards a less material consumtion style.

French green house gas emissions have increase looking on the production related emissions of the French territory. But the opposite is the case if you are looking at consumption related emissions from household consumption, business and government (taking into account the carbon footprint of imports and exports).

Will production be reshored?
→ 60% think that production will be reshored to France.

What might encourage a reshoring of production?

- A border adjustment tax
- Development of producers' platforms selling directly to consumers
- Reduction of labor costs

→ According to the stakeholders a border adjustment tax that would foster reshoring followed by a development of producers' platforms.

The number of kg of goods transported to France per person per year is stable, but the type of goods transported has evolved to more manufactured goods. **How the amount of freight transport in France is going to evolve in the coming decades?**
→ 50% of the stakeholders believe that the amount of tons transported in France will remain stable, 30% see a decrease and 20% think it will increase.

How tonnes*km will evolve in France over the coming decades?
A tonne*km is a measure aggregating both the weight of goods moved (ton) and the distance they travel (km).
→ The answers to this question are highly dispersed: 35% think there will be an increase or a decrease and 30% imagine a stabilisation.

Discussion:

- The border adjustment tax (France or Europe) bears the danger of protectionism, while rich countries protect themselves already ...
- Everyone is against outsourcing but in favour of cheap goods → contradiction
- Judging border adjustment tax against labour costs
- Reduce labour costs => bias: hourly wage of the person, it must consider productivity (25% of Panasonic screens worldwide in a factory on 5 acres with 15 people)
- Problem of fragmented value chain)
- Why people want to be delivered in 24/48h? Can we not wait eight days?

X. Modal shift – freight transport

Is the "Grenelle goal" still reachable (- 25% of non-road freight traffic in 2020)?
→ 100% think that the goal of the Grenelle will be missed.

What are the obstacles to the development of piggybacking, combined transport or rail transport?
- The cost of infrastructure development
- The lack of "high speed" infrastructure
- The lack of infrastructure other than high speed (transversal lines?)
- Reloading disruptions
- The cost for the carrier
- Traffic conditions offered by the rail carrier
- Oil prices too low
- Competition from carriers of countries in Eastern Europe
- Technical problems between the countries
- Closures of stations
- Abadoning of unique wagon transport (instead of intire trains)

→ The following four were considered to be the most important obstacles that prevent the development of combined transport:
- The reloading disruptions
- The cost for the carrier
- Oil prices too low
- Competition from carriers of countries in Eastern Europe

The obstacle considered the least important is: The lack of "high speed" infrastructure

How the primacy of road transport could be challenged by rail?
- Establishment of an eco tax on heavy vehicles
- Creation of a toll system in all European countries
- Speed limits for trucks
- Development of additional infrastructure
- Improvement of existing infrastructure
- Improvement of traffic conditions offered by the rail carrier
- Privatization of rail
- Obligation to construct rail access for each new industrial area

→ The three factors considered to be best able to foster modal shift to rail would be:
- Establishment of a eco tax on heavy vehicles
- Obligation to construct rail access for each new industrial area

The least important proposals were following to the stakeholders:
- The privatization of rail
- Development of additional infrastructures

What alternative mode of transport to road should be favored by public policy for freight transport?
- Rail
- River
- Maritime
- Air

→ The stakeholders believe that the rail and then the sea should be the preferred alternative modes.

What alternative mode of transport to road has the biggest growth potential for the freight transport?
- Rail

- River
- Maritime
- Air

→ The stakeholders believe that the rail and then the sea would be the alternative modes having the greatest potential for development.

Who should fund the development of alternatives to road transport?

- The State
- SNCF / RFF
- Private companies
- Local authorities

→ A large majority think that companies should develop alternatives to road transport followed by the state. Local authorities are considered to be the least important.

In 2010, € 2.8 billion were invested in rail infrastructure (€ 0.9 billion in high-speed rail network and € 1.9 billion in the core network).

Are these amounts sufficient?

- For high-speed network
- For the core network

→ Very few people have answered this question. But their answer tend to show that amounts are too low even on concerning the maintannce of the main network (excluding high speed).

What annual invetsmebt amounts by 2020 would be needed to rebalance the modal split of freight transport to rail?

→ For the high speed and core rail infrastructure the answers lie between 2 and 4 billion / year.

Acceptability for businesses and consumers to pay for goods with a low carbon footprint that are more expensive

→ 50% think it is acceptable for companies but only 37.5% for consumers.

Obstacles:

- Why trains cannot transport freight and passengers together?
- Problem of time reliability for freight transport
- Absence of alternative operators (including local freight transport)
- Lack of competitiveness of French ports and rail network: a lot of international carriers prefer to do 200km more and to avoid France / the same is valid for the ports (Barcelona is preferred)
- No economic model of the freight transport wagon in the current economic model
- Preference is given to trucks
- 44 tons trucks instead of 40 tons => road destruction
- Road transport: 300 000 unskilled drivers
- Technical barriers (United States vs. CANADA): fastening systems; maximum length in France 750 m (3 km in the United States)
- Pressure on water canals / rivers (eg Rhine) → Climate Change

XI. Carbon content of the last km of freight delivery

How to improve the carbon content of the last km of freight delivery?

- Prohibition of inefficient vans in cities
- Creation of multimodal logistic platforms in all major urban centres
- Low cost rental (or free) provision of hybrid or electric vehicles by cities, supermarkets

Other proposals:

- Road charges infrastructure
- Development of home delivery
- Taxation - Apply the polluter pays principle

XII. What kind of truck for the XXIst century?

Do we have to choose one technology or shall we aim at a mix of technologies?
→ 81% is in favor of a mix of different technologies.

In the coming decades which technology should be given priority (research and investment) to?

- Electric truck (plugin)
- Hybrid vehicles
- Standard but very efficient combustion truck
- Biofuels (second generation)

→ Following to the stakeholders priority should be given to:

- Standard but very efficient combustion truck
- Biofuels (second generation)

Biofuels

- The carbon balance of biofuels has to be analysed (First generation Land use change emissions are an important issue)
- Europe has decided to reduce by one third its sugar production

XIII. Tax instruments

Carbon tax

A carbon tax set at the level that was planned in 2009 (32€/t CO_2), would it be able to undermine the competitiveness of road transport?

→ 80% believe that the establishment of a carbon tax would not represent a risk for the competitiveness of road transport.

Would a tax be acceptable for road transport?

→ 70% think that such a tax is acceptable for road transport.

Border tax adjustment

A border tax adjustment would it be acceptable?

→ 80% believe that the establishment of a border tax adjustment would be acceptable

Eco tax on heavy road transport:

The mileage rate should vary, depending on the category and EURO class, ranging from 2.5 to 20 c €. Expected incomes are about 1.2 billion € per year. Collection costs are estimated at 15%, net revenue is estimated reaching approximately € 0.88 billion.

What is the preferred level for this tax?

→ 64% are in favor of a mileage rate higher than expected, 0% to a rate below the proposed level and 9% are in favor of an unchanged rate.

Should an eco tax on heavy road transport be charged on all roads (granted, not granted)?

→ 64% are in favor of an eco-tax on all roads, 18% are against.

Discussion:

- Biofuel taxation: irrelevant by 2050 (will disappear between 2013 and 2015)
- Proposed EU Directive on energy taxation
- Second generation biofuels are not ready yet (no preference for the first generation)

Final roundtable

- Questions have to make a clearer distinction between explorative/ normative elements
- The principle of the meeting is interesting but time was too short (a little frustrating not to have more time for exchanges). Forced to superficiality.
- It might be more satisfactory to study scenarios with four different technological déclinations
- Problem: sectoral approach; difficuly to discuss issues like urban sprawl

III. Stakeholder meeting “Power production”a

December 12th 2011

Introduction

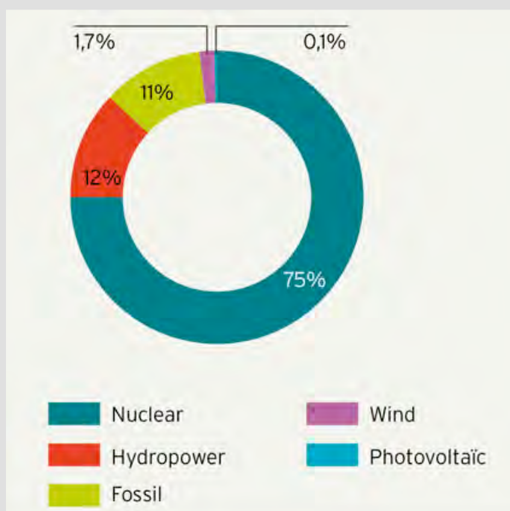
The meeting started with a presentation of the program and each participant.

Then the project team introduced the project methodology for a collaborative scenario creation process and gave an overview on the sector specific challenges.

In 1990, electricity represented 36% (83 Mtoe) of the primary energy mix but only 18% (26Mtoe) of the final energy due to the high share of nuclear in the mix. In 2010, 550TWh were produced. It represented 43% (115Mtoe) of the primary energy mix and 24% of the final energy. 67% of the primary electricity is lost in the transformation process.

In 2010, the renewable electricity share was about 15%, with a high share of hydropower. The electricity export import balance was positive in 2010 but the imports achieved a historical maximum about 19.5 TWh. 50 TWh were exported.

Energy mix of the electricity sector - 2010



The CO_2 emissions of electricity production decreased about 19.7% in comparison to 1990. In 1990, 39 $MtCO_2$ (10% of the overall CO_2 emissions) were emitted by the electricity sector compared to 31 $MtCO_2$ (9%) in 2010.

68% of the final electricity production is consumed by the residential and tertiary sector, 25% by the industry and 3% by the transport sector. In comparison with the other European countries, electricity costs 25% less so average per capita consumption

is 21% higher than the European average and even 49% higher considering only residential consumption. The French specificity of electricity demand is electricity heating (Joule effect) in one third of the buildings. This creates a high climate sensitivity of the power sector particularly during peak load hours in winter. Every cold wave enhances the blackout risk as each degree less causes an additional consumption need of 2.3 GW. Another controversial question is the future evolution of the demand, for instance what will be the impact of new end-uses (electric vehicles, electronics…) on the total final energy consumption?

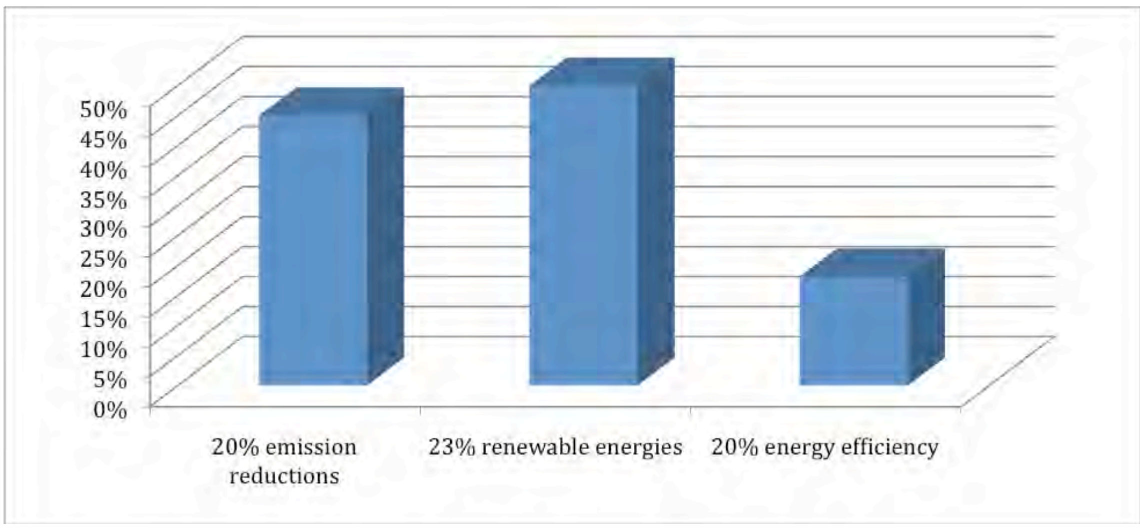
Climate and energy objectives:

- The objective fixed in the French law in 2005 to reach 21% of renewable energies in the electricity mix in 2010 was not achieved.

- The objective of reducing the energy intensity of 2% per year was not achieved either. The target for 2020 is a share of 27% of renewables in the final electricity production in 2020.

a. French climate objectives

Will the French 2020 objectives of the European energy and climate package be achieved?

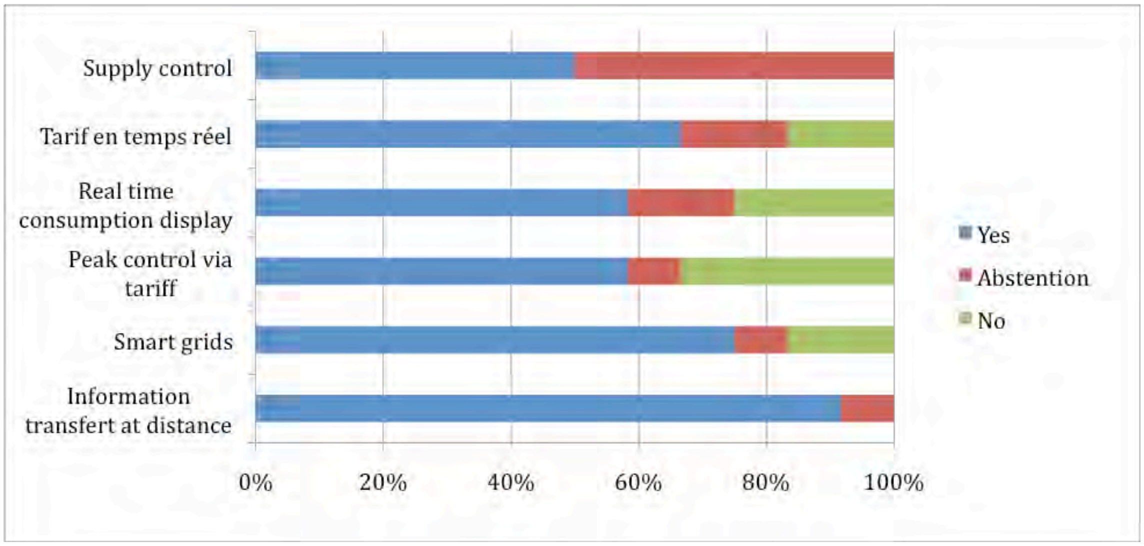


→ Half of the stakeholders believe that the renewable energy objective will be achieved. Fewer stakeholders believe in an achievement of the emission reduction target and even less imagine that the energy efficiency objective is respected.

b. Energy demand

Smart meters

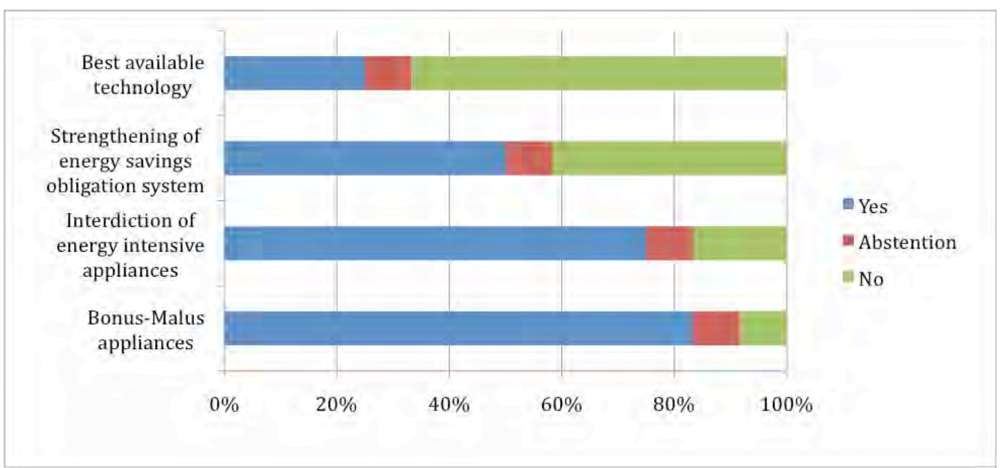
What should be functionalities of smart meters?



→ The most important functions of smart meters following to the stakeholders are "Information transfer at distance" and the compatibility to "smart grids"

Energy efficiency

What measures are acceptable for strengthening energy efficiency?

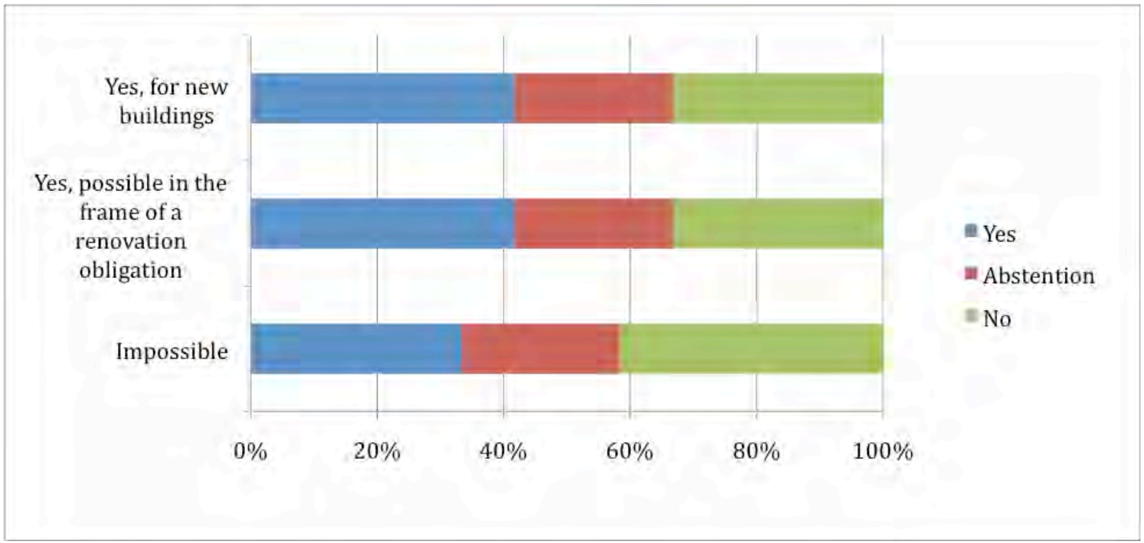


→ The most acceptable measure following to the stakeholders is a "Bonus-Malus" on appliances, following by the interdiction of energy intensive appliances.

- Other important measures: very efficient – heat pumps (air-air) and efficient electric bulbs (4 TWh energy savings for 960€ invested)

Electric heating

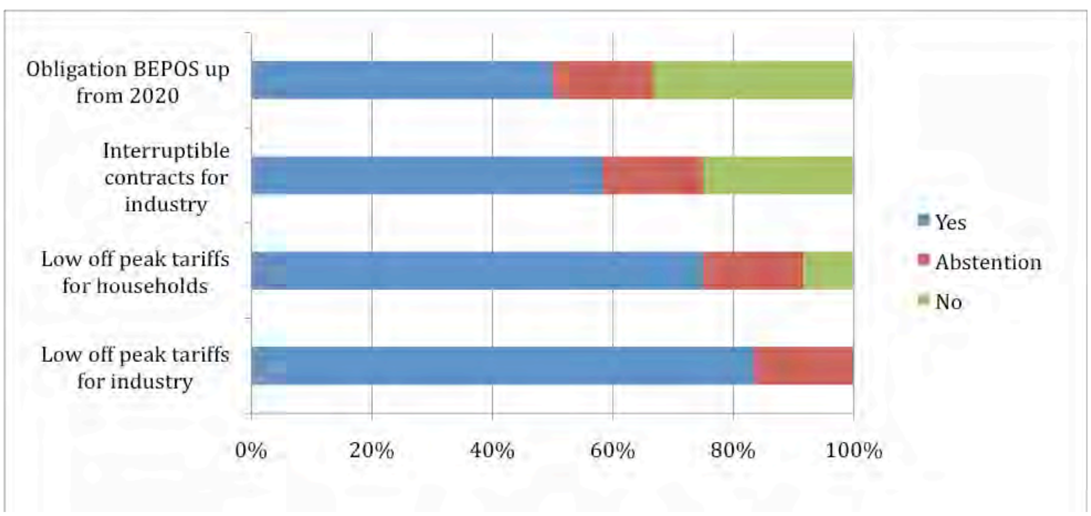
Is it acceptable to ban electric heating (excluding heat pumps) – besides in secondary residences?



→ Stakeholders have no clear opinion regarding this question. 40% think that is possible for new constructions and in the frame of a refurbishment obligation.

Demand side management and tariffication

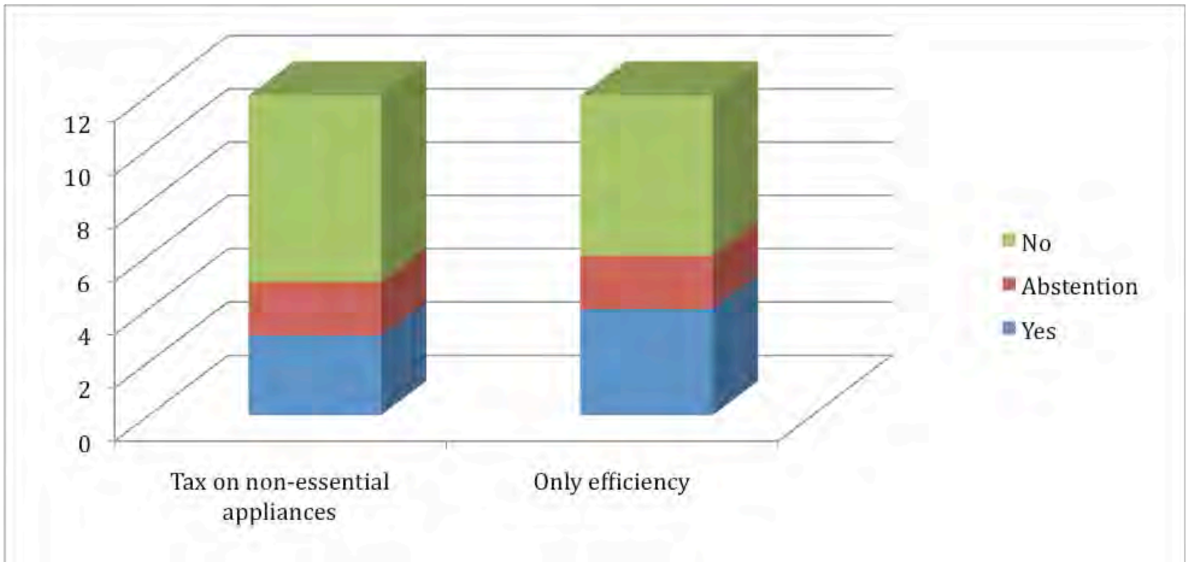
Irruptable contracts, demand side management and tariffication – which are acceptable measures?



→ More than 80% agree that low off-peak electricity prices for the industry are an acceptable measure for DSM (demand side management). Still a majority agree with the same kid of tariffs for households (they already exist in France) and irruptable contracts for the industry.

New electric services and appliances

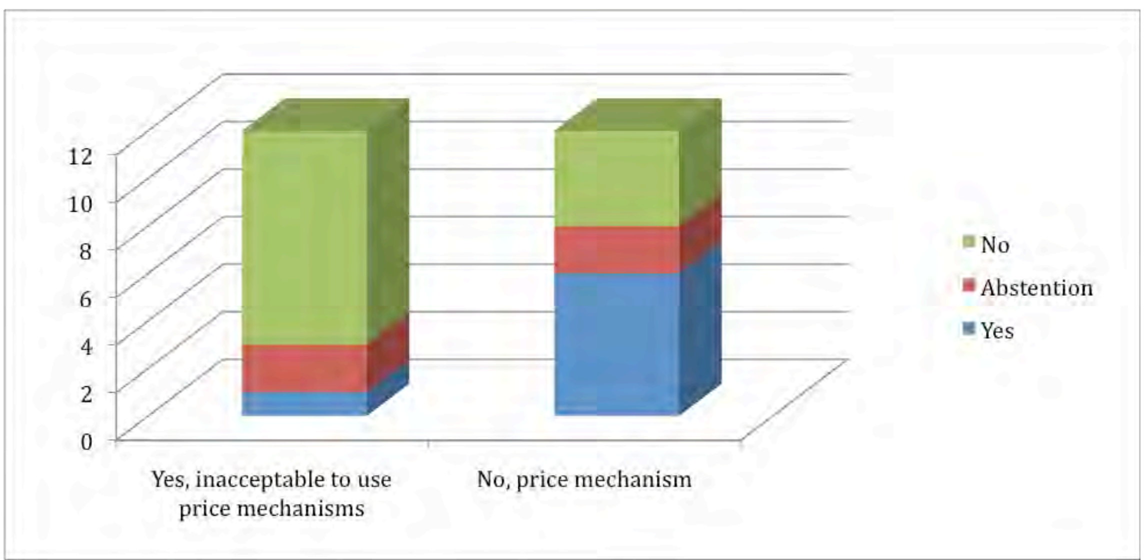
Is it acceptable / necessary to fight against the increase of electricity consumption du to new appliances (WIbox etc.)?



→ Stakeholders do not think it is acceptable to fight agianst the additional electrcity consmption of new appliances – netheir by taxes nor by additional energy efficiency efforts.

Energy sufficiency and the rebound effect

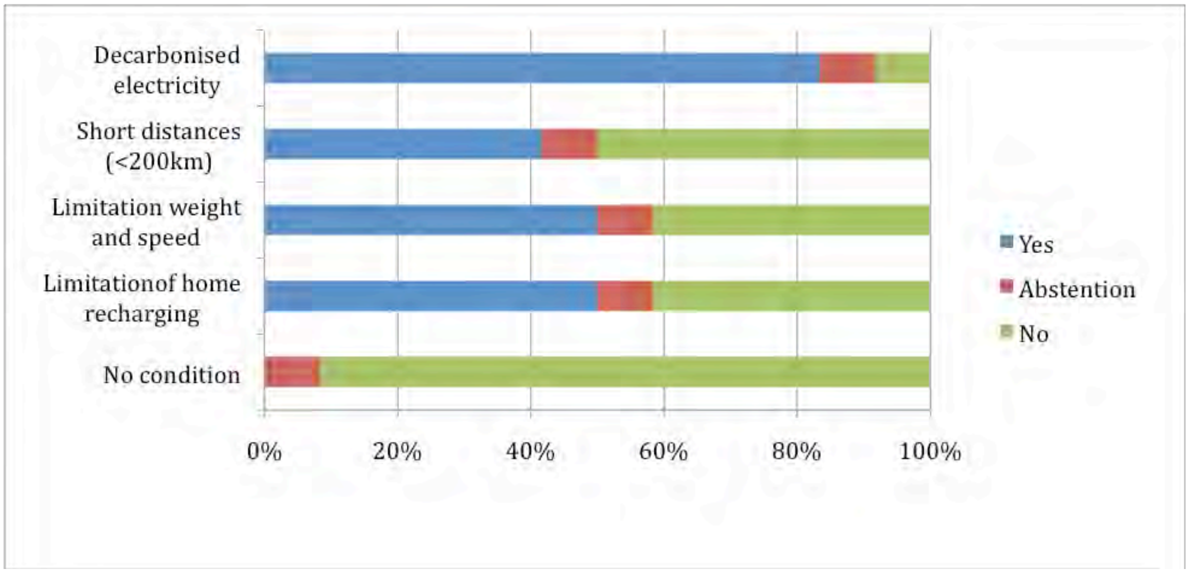
Is the rebound effect and its impacts on energy efficiency gains an inevitability?



→ Stakeholders are in favor to use price mechanisms to fight against the rebound effect that cancels efficiency (and economic) gains by more consumption.

Electric vehicles

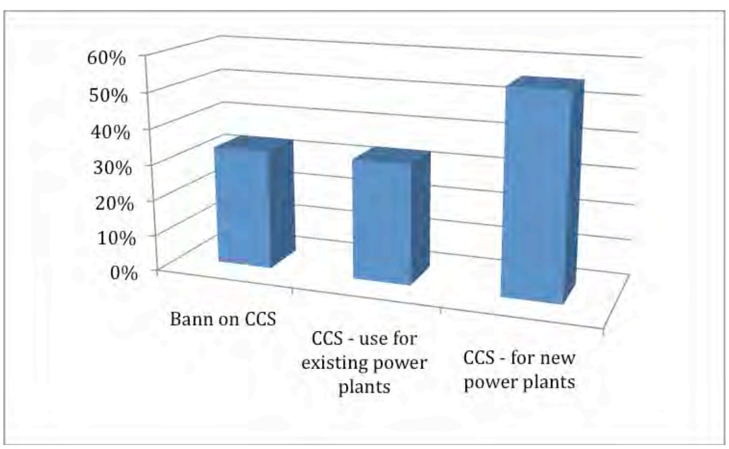
Under which conditions the development of electric vehicles is acceptable?



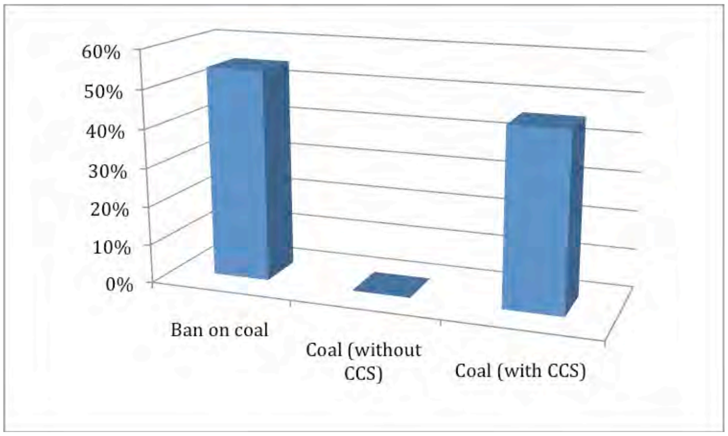
→ The main condition for the development of electric vehicles underlined by the stakeholders is the have access to decaronised electricity. They do not think that electric vehicles are under any condition a good solution. Still a majority thinks that the limitation of speed and weight and the limitation of home charging (peak consumption) are necessary prerequisites?

c. Supply technologies

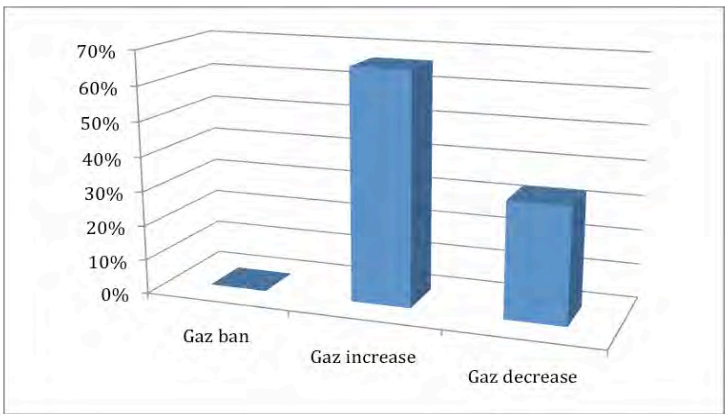
Stakeholder acceptance concerning the CCS (Carbon Capture et Storage) technology



→ Stakeholders are against a ban of the CCS technology and wish that new power plans are equipped for this technology.

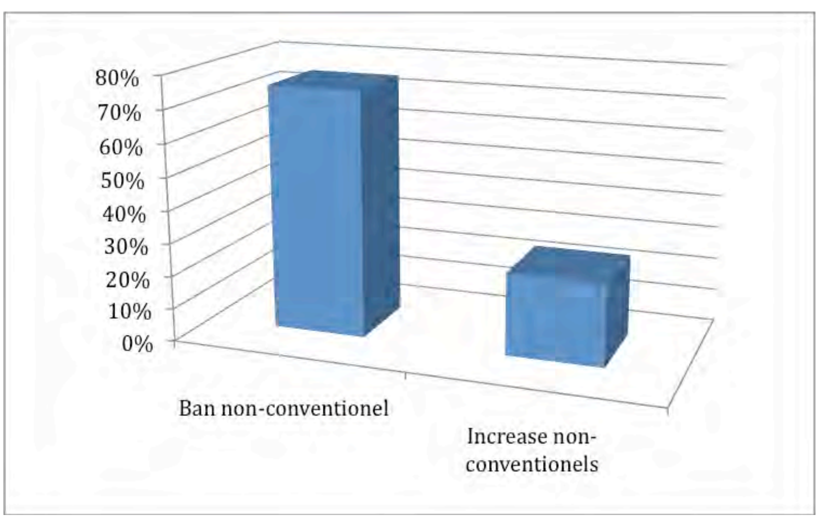


→ Stakeholders wish to ban coal power plants but think they are acceptable if they are equipped with the CCS technology.



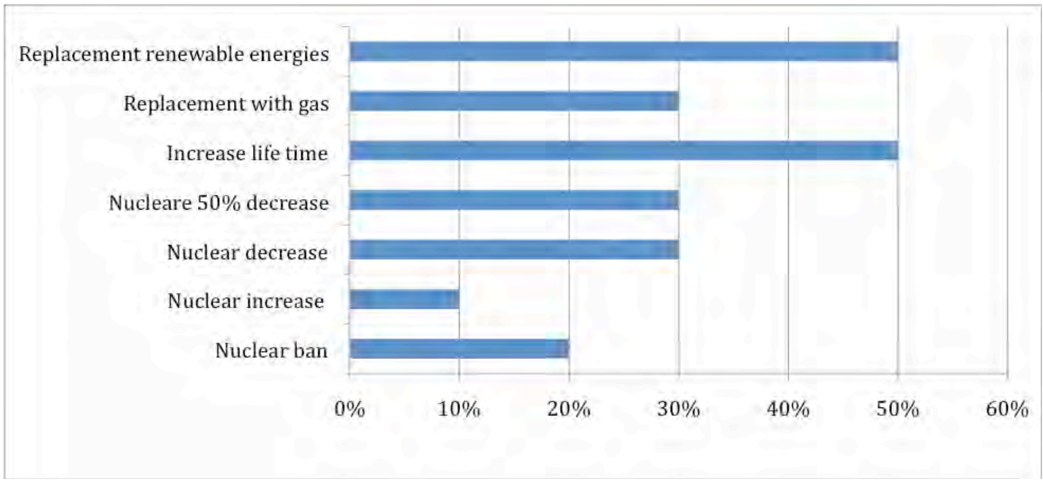
→ Stakeholders see an increase in gas power plants.

<u>Stakeholder acceptance concerning non-conventional fossils</u>



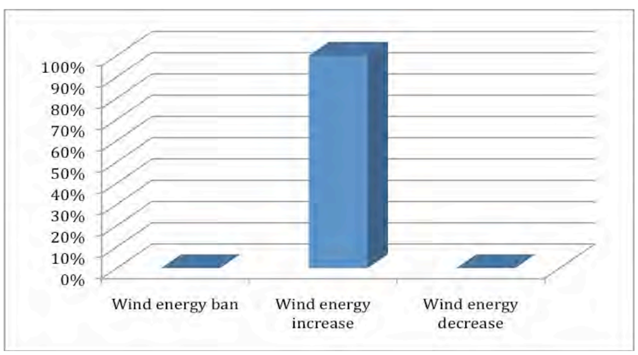
→ A ban of the exploitation of non conventional fossil fuel sources is supported by the stakeholders.

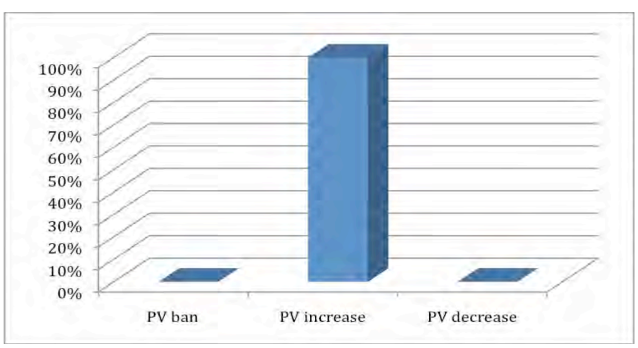
Stakeholder acceptance concerning nuclear energy

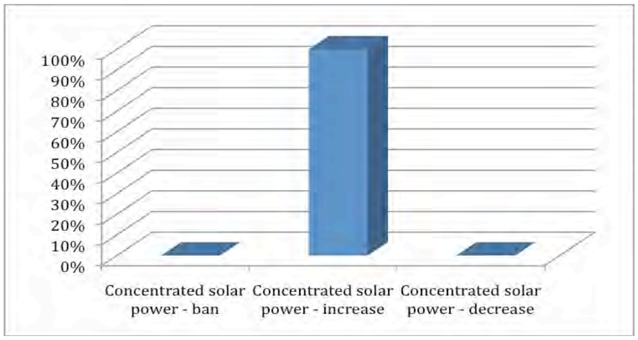


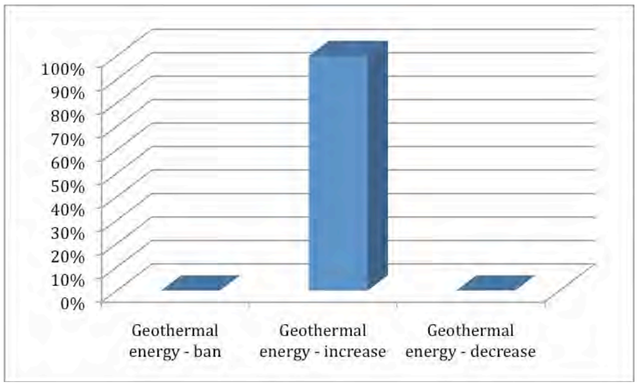
→ The answers concerning nuclear energy are ambigous. 50% of the stakeholders are in favor of an increase of the lifetie of existing nucelar power plants and a remplacement of nuclear acpacit by renewable energies. Still 20% want to ban nuclear energyand only 10% lelieve that an increase of nuclear electrcity production acceptable.

Stakeholder acceptance concerning renewable energies



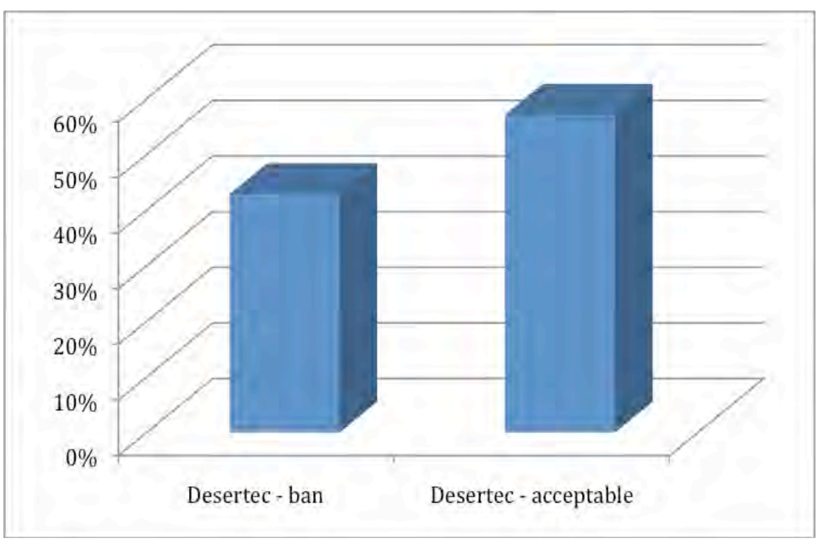






→ 100% think that an increase of wind, photocoltaic, centralised solar power and geothermal electcity is acceptable.

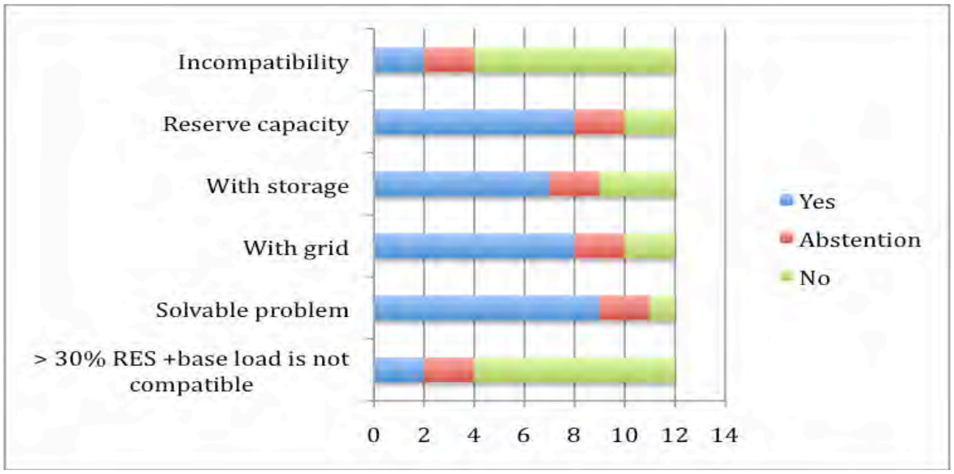
Stakeholder acceptance concerning Desertec



→ A slight majority of stakeholders think that the Desertec project is acceptable.

Incompatibility of baseload and variable renewable electricity production

Is there an incompatibility problem of baseload production and variable renewable electricity production? If yes how can it be solved?



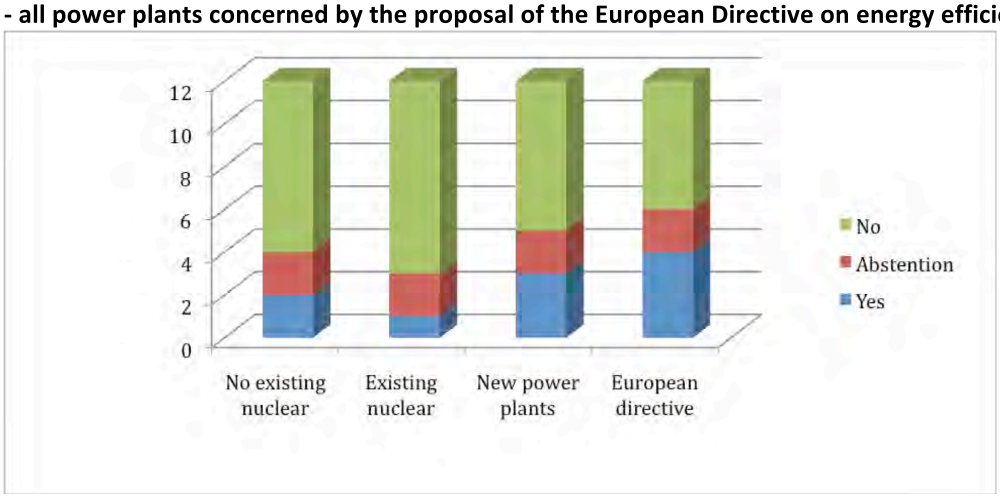
→ Only few stakeholders believe that are is an elementary incompatibility problem. Strategies to tackle variability of renewable supported by stakeholders are: electricity storage, grid management and the construction of backup capacity.

Feed in tariff for renewable energies

→ Feed in tariffs shall continue (Photovoltaic decrease, geothermal increase) until renewable energies are competitive with traditional capacities.

CHP (Combined heat and power) obligation

Is an obligation for Combined heat and power acceptable for:
- Nuclear power plants (not acceptable, acceptable for existing or future plants)
- all power plants concerned by the proposal of the European Directive on energy efficiency[23]



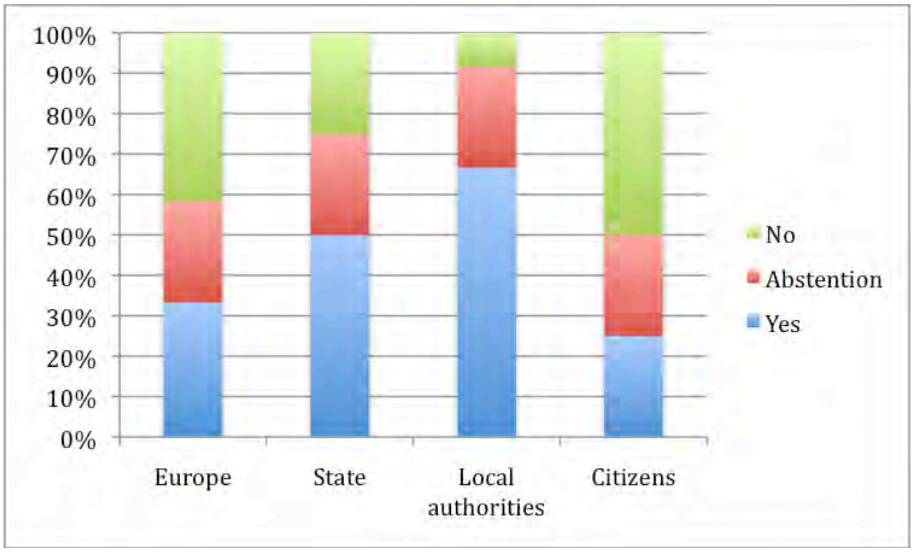
→ Stakeholders are against the introduction of a CHP obligation for existing and new power plants.

[23] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

IV. Gouvernance

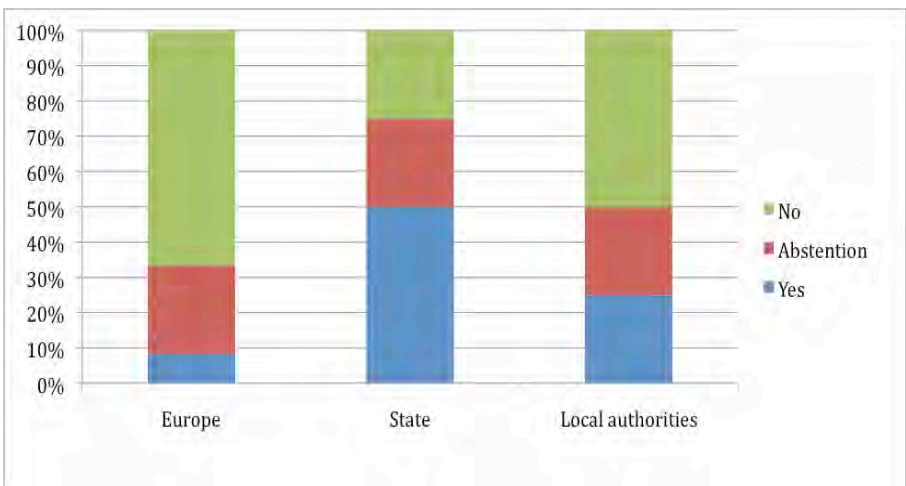
Governance levels and competences

What is the governance level the best suited to develop renewable energies?



→ Following to the stakehodlers the local level (local authorities) is the best governance level to develop renewable energy potentials.

What is the governance level the best suited to develop centralized thermal power plants?



→ Following to the stakehodlers the state level is the best governance level to develop traditional power plants.

Do we need a governance transfer concerning the electricity distribution?

→ A majority of the stakeholders (87.5%) think that the role for the electricity distribution is well defined and managed by ERDF.

Planning strategy

What principle should guide the development of electricity capacity?
→ Stakeholders agree that planning is better suited than the free market to develop the needed electricity capacities.

How a planning of additional power capacity should be organized?
→ 89% of the stakeholders believe that a bottom up logic should be the best especially for the development of renewable but still 44% believe in the efficiency of a top down logic. Though both approaches are needed.

Do we need a legally binding pluri-annual planning for the investment in new power capacities? -
→ All stakeholders are in favor of a binding pluri-annual planning document.

Electricity storage

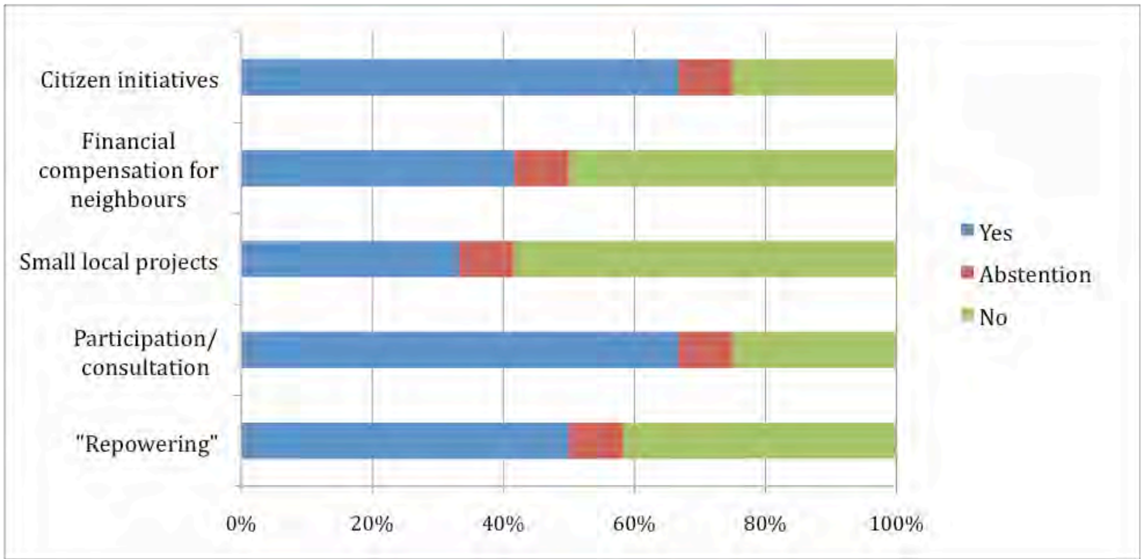
- Good management is more important than the question of ownership of storage capacities
- Cold water – STEP and hot water (hot water storage)
- Storage capacities besides hydro (STEP) are not economically viable
- How the benefits of storage can be divided between owner, grid operator, and consumer
- Another important question: Who pays for the hyper reactive fossil fuel peak-capacity?

Who should pay for the necessary storage capacity needed to compensate the intermittent production of renewable energies?

- 13% are in favor that renewable energy capacity owners have to pay for it
- 25% believe all electricity producers should share these extra costs
- 25% think the households should contribute via the CSPE
- 38% do not believe in one of these solutions

Local acceptability of renewable energies

How to enhance acceptance for renewable energies at the local level? -



→ Stakeholders believe that small local renewable energy projects, citizen initiatives and “repowering” of existing renewable installations can enhance local acceptance.

Imports and exports

- Also RES can be used for exports
- It is important to base decision also on the variability of production of the neighbor countries.
- In a system with a high Res share will the French power system stay competitive (perequation between different energy sources)
- France is only one part of the European system. If acceptable all power capacities for Europe could theoretically be constructed in only one country…
- If the household contribution via the CSPE increases this will cause resistance
- The mix on the European level is more divers –> better situation for balancing demand and supply

Acceptance of electricity imports?

→ 80% of the stakeholders think that electricity imports are acceptable for assuring supply security. Only 30% think that imports should be used for a significant part of the consumption.

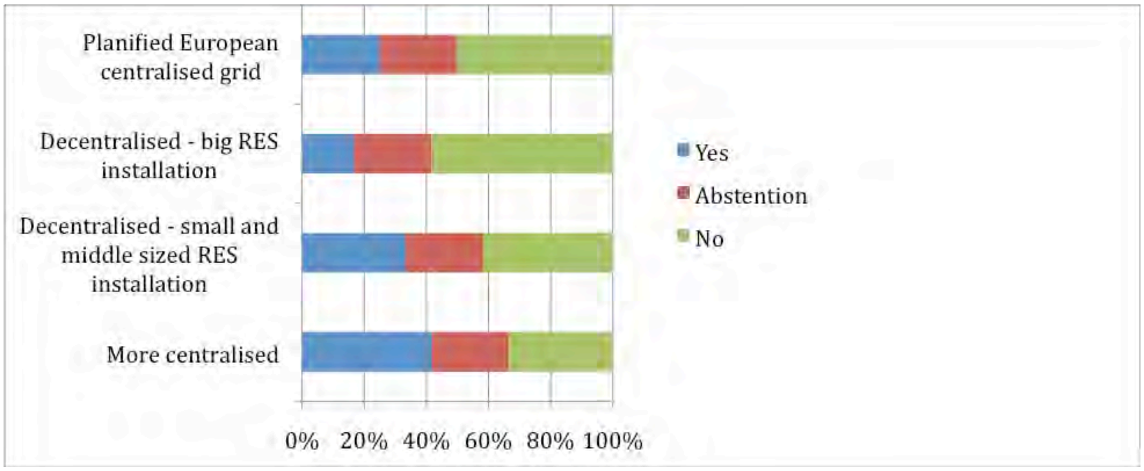
Acceptance of electricity exports?

→ All stakeholders are against the construction of power plants for exporting electricity.

Do we need a transparent planning of power capacities on the European level in order to avoid over or under capacity?

→ All stakeholders think that a European planning of the construction of power capacities is important to avoid overproduction or supply bottlenecks.

V. Electric grids



→ 100% of the stakeholders believe hat different electricity grid structures can co-exists depending. Stakeholders are slightly more in favor of a centralized grid but opposed to the creation of a European centralized grid.

VI. Job creation

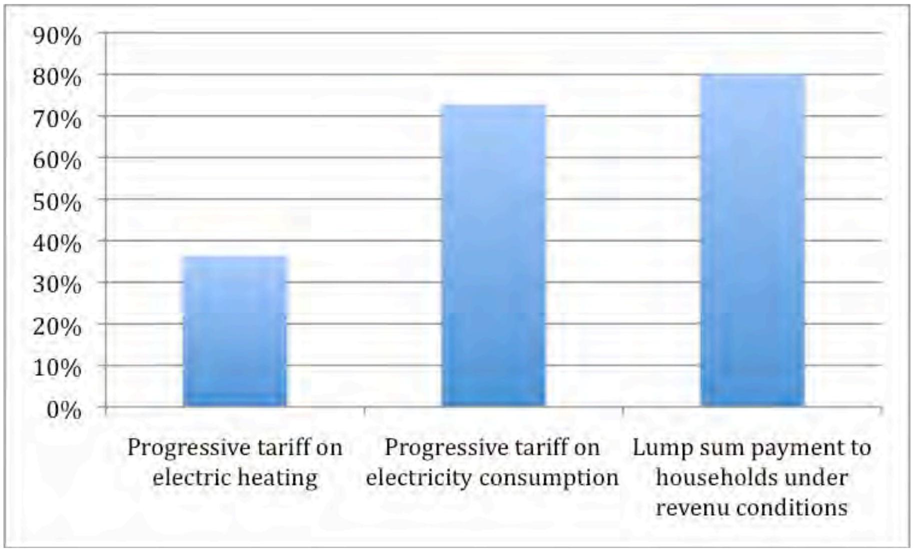
- Via the feed in tariff foreign businesses are financially supported.
- Buying PV is now seen like giving subsidies to other countries- but how this tendency can be inversed?
- France is late (concerning wind, PV) ; the government was not in the front line in supporting French RES business activity and with the creation of "calls for proposals"

Pensez-vous que la France pourrait être à la pointe pour la production des équipements ?	
PV	71%
Eolien terrestre	78%
Eolien marin	100%
PAC	100%
Biogaz	86%

→ 72% of the stakeholders are in favor of developing public policy support for the development of renewable energies produced in France.

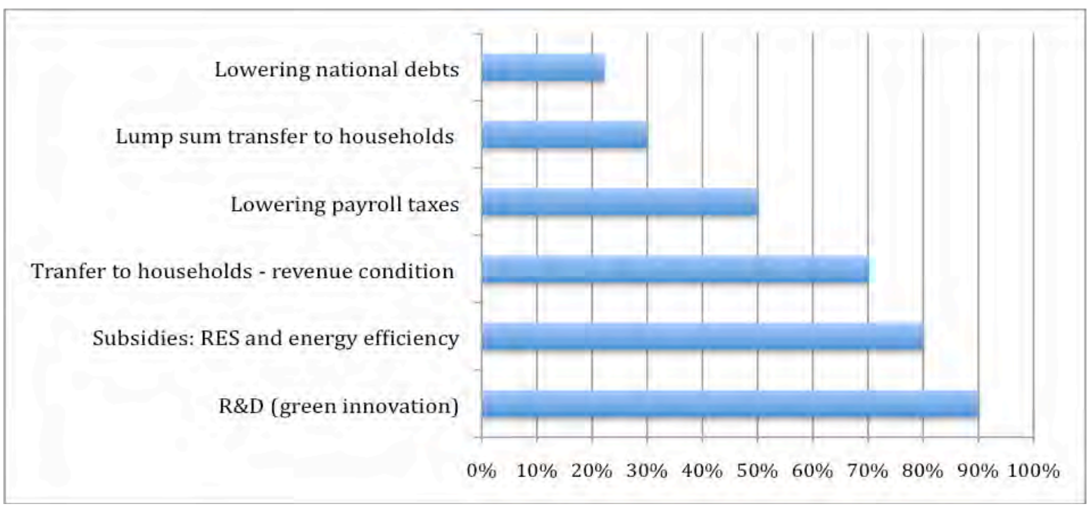
VII. Tariffication

Progressive tariff



→ Stakeholdersare in favor of the establishment of a progressive tariff on electrcity consuption if tere is a lump sum ptransfert to modest housholds.

Recycling of the carbon tax revenues



→ Stakeholders are in favor of a use of the carbon tax revenues for Green R&D, subsidies for RES and energy efficiency and Lump sum transfer to households. Still 50% believe hat revenues could be used for lowering payroll taxes.

CSPE (Contribution to the public service of electricity)

- 82% agree that the principle of the CSPE is acceptable to finance renewable energies the maximum amount being 11,5€

IV. Cross-sectoral feeback seminar

February 8th 2012

All stakeholders that were invited for the first round of sectoral seminars were again invited for this cross-sectoral feedback seminar in order to discuss not only the sector specific aspects but also the independencies between topics like urban sprawl and the overall results of the scenario creation process.

The meeting was divided in two main parts: the presentation of the energy scenario based on the stakeholder contributions going along with discussions and recommendations and a discussion on the methodology of the project.

Here a list of the main discussions sorted by typology:

1. Verification / more details needed
2. Sensitivity analysis needed
3. Recommendations concerning the presentation of the results
4. Remarks concerning the project methodology

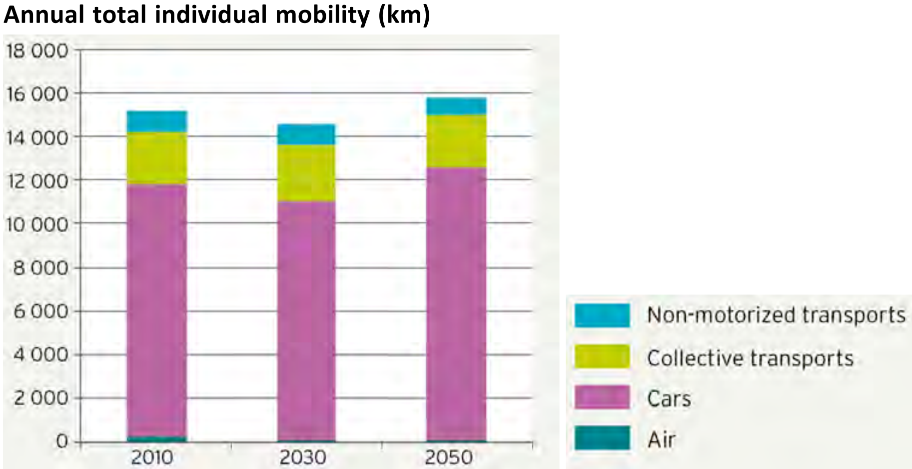
1. Verification / more details needed

Verification was demanded by the stakeholders concerning:

- The modal share of walking and cycling, which seemed to be high in the presented scenarios.

→ The modal chare on non-motorized transports has been checked (Comptes du transport 2010):

Annual total individual mobility (km)



- The occupancy rate of private vehicles

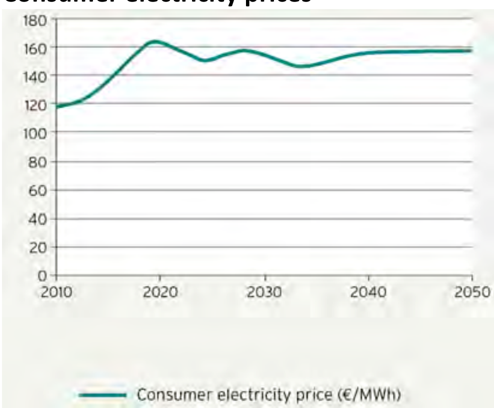
→ Explanation in the final version of the "acceptable scenarios:

Cars occupation rate: Incentives (promotion by firms of employee transport plans as well as carpooling) are considered to increase the cars occupation rate for urban transport from 1.25 to 1.5.

- <u>An explanation concerning the evolution of the electricity price</u>

→ The electricity prices for households show a sharp increase between 2010 and 2020, climaxing at 41% in 2020 compared to 2010. The price stabilizes thereafter around 160€/MWh (16c€/kWh). It represents an increase of 34% compared to the price in 2011. The peak in prices around 2020 is due to the combination of (i) the penetration of gas combined cycle replacing some of the nuclear capacities (ii) the acceleration in the installation of renewable capacities and (iii) the oil-fuelled turbine to face the variability of renewables. The stable long-term increase is due to renewables being more expensive than the old nuclear thermal power generation units and the need for new capacity building during the period.

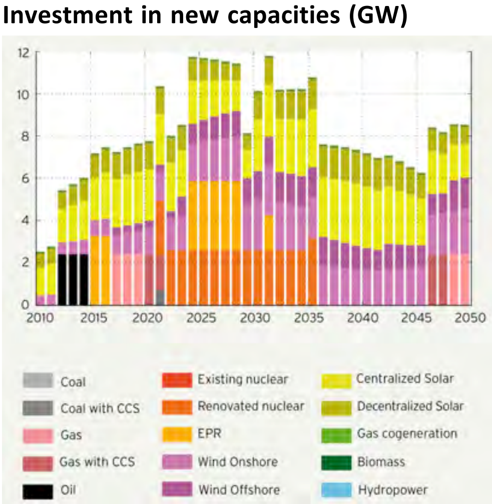
Consumer electricity prices



- <u>An explanation why the CSPE (Contribution to the public service of electricity) is still quite high in 2040 although most of the renewable energies should at this stage be competitive.</u>

→ The expenditures for the feed in tariff (an important part of the CSPE) are still high in 20540 as a major part of the investment in renewable energies is only taking place at this moment.

Investment in new capacities (GW)

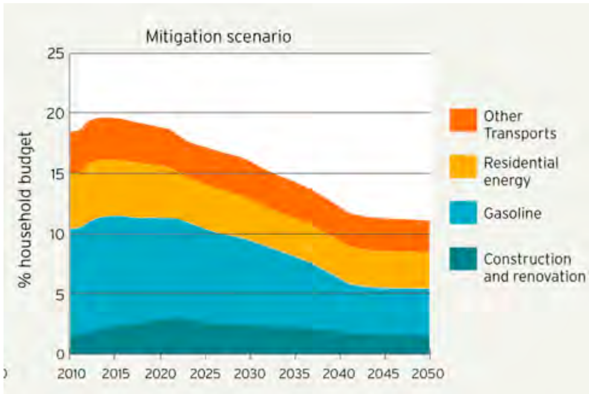


Fiscal measures (Billion €)					
Feed-in tariffs	2010	2020	2030	2040	2050
Additionnal CSPE Income = feed-in tariffs expense	2.9	1.9	7.2	17.8	12.7
Carbon Tax	0	13.7	18.1	23.9	34.8

- <u>The refurbishment costs and how they are composed and evolving over the time</u>

→ The evolution of household expenditure is explicitly shown in the scenario.

Household expenditures



Questions concerning the representation of certain parameters in the modeling tool and the scenarios:

- <u>Why the personal mobility is reducing in 2030.</u>

→ In the middle term (2030), the increase of energy prices and the inertia in developing alternative collective transports lead to a constrained mobility with a 4.5% decrease in individual mobility.
Urban sprawl has an ambivalent impact over time: it keeps increasing, particularly in urban areas outside Paris, until 2030, and starts decreasing after 2030. Congestion increases for all transport modes in urban areas, until more collective transports are available. In the short run, avoiding the impact of increasing oil prices relies on reducing mobility by teleworking and the increase of the vehicles occupation rate. These measures translate the generalization of employee transport plan in firms.

- <u>Is it possible to differentiate between urban and inter-urban mobility?</u>

→ As the modeling tool IMACLIM-R has no spatial dimension no differentiation between urban and inter-urban transport could be made.

- <u>What is the amount of money necessary for the investment in infrastructures and where does it come from?</u>

→ Infrastructure investment is redirected from road to tail and urban public transport. It comes from different sort of taxes:

	2010	2020	2030	2040	2050
Fiscal measures (billion €)					
Heavy trucks eco-tax	0	1.3	1.1	1.1	1.2
Kerosene tax	0	1.6	1.1	1.4	1.3
Impact on domestic consumption tax on petroleum products	23.8	21.4	17.9	13.4	12.9
Carbon tax	0	13.7	18.1	23.9	34.8
Investments on infrastructures					
Urban transports	+3 billion € each year from 2012 until 2030				
Railways	+3 billion € each year from 2012 until 2030				
Road transports	-6 billion € each year from 2012 until 2030				

- Recommendation to consider a higher electrification of the transport sector via plug-in hybrids (impact on the electricity production)

→ In the "acceptable emission reduction scenarios" electric vehicles occupy only niche markets for urban mobility with a penetration limited to 5% of the total vehicles fleet in 2050. They refer to car sharing systems in urban areas. Hybrid range extender vehicles massively penetrate after 2030. They are best suited to urban use but can also be used for long journeys.

- What are the solutions to deal with the electric peak consumption? Is cheap energy not boosting electricity consumption and the use of electric heating?

→ The electric module of IMACLIM-R is designed in order to represent the specificities of the French power sector. It calculates the evolution of the demand load shape to take into account peak load capacity needs, the evolution of the hourly electricity price and the dynamics of investments in new power plants.

Electricity imports are used to satisfy the peaking heating demands in winter. The retrofitting of the residential sector that is increasing energy efficiency for heating and the switch from electric heaters to heat pumps reduces the electricity peak in winter. But approaching 2050 the peak increases due to a replacement from gas heating by heat pumps reaching a maximum of 103 GW.

Peak demand canalso be managed either with peak capacities (including oil-fuelled turbines, peak hydropower or pumped-storage plants) or with interruptible contracts remaining at the same level as today.

- Is the windfall gain concerning the tax credits for refurbishment, which is raising artificially prices, taken into account?

→ This effect cannot be represented explicitly in the model.

2. Sensitivity analysis needed

The stakeholders proposed several parameters for sensitivity analysis:

Sensitivity analysis were undertaken on several parameters: the availability of carbon capture and storage, investment costs of new nuclear plants, the extension costs of existing nuclear plants lifetime, investment costs of renewable electricity plants, and the availability of biofuels.

We considered here a "no biofuels" alternative scenario in which second generation biofuels never achieve economic and technical viability and first generation biofuels are banned because of their weak environmental performances and their impact on land use change. We considered here the "expensive RNE" alternative scenario where the pace of cost decrease for renewables is half the pace of cost decrease assumed in the "acceptable scenario" (meaning that it takes twice as long in the "expensive RNE" scenario to reach the same cost as in the original scenario).

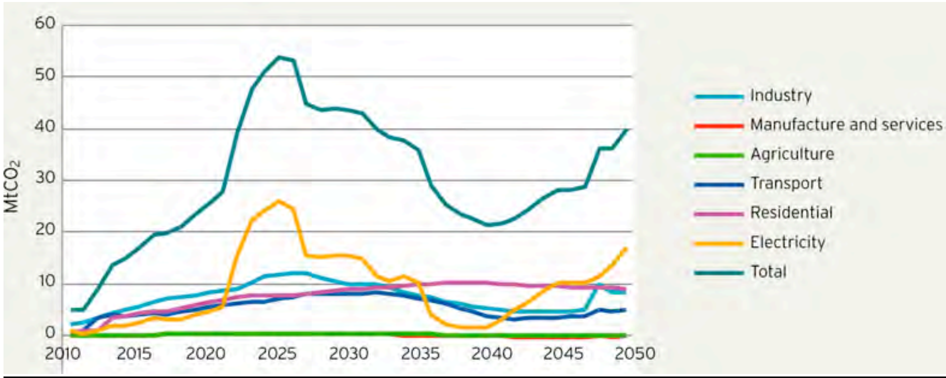
- Cost of nuclear power production

→ The default setting for the construction of nuclear power plants of about 2 900 €/kW was changed to 4 500€/kW in a sensitivity analysis. Also the cost for the life tile extension was issue of an additional analysis (from 700 €/kW to 1 400€/kW)

- How important is the impact of the carbon tax on the results? What are the impacts of other main measures?

→ The marginal impact of the exogenously fixed carbon tax has been calculated:

CO2 emission reductions induced by the carbon tax



- <u>What is the impact of different world visions (existence of a climate tray, evolution of fossil fuel prices and the costs of low carbon technologies)?</u>

→ The impact of three different fossil fuel price developments was analyzed: high (+30%), central, and low (-30%)

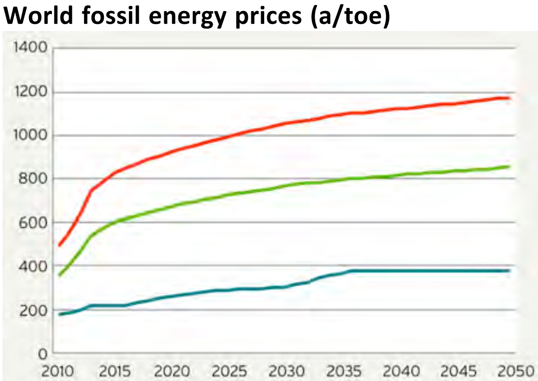
- <u>Changing lifestyles (less consumption and relocalisation of production).</u>

→ Ina scenario "with additional measures" consumption changes have been represented:
The decoupling of consumption styles: French households are considered to change their consumption patterns and to consume less material goods and more services.
→ The ability of an economy to grow without corresponding increases in environmental pressure, particularly in terms of the use of natural resources, is referred to as decoupling or eco-economic decoupling.
The reshoring of production capacities back to France: French consumers and producers prefer to consume French products instead of importing higher in 2050, and CO2 emissions are between 1 and 3% higher compared to the acceptable scenario in 2050. Overall competitiveness decreases, but more of the French consumption is produced in France.
→ Reshoring is defined as the relocation of activities from foreign countries back to France, as
In an additional variant, the additional impact of the implementation of a border tax adjustment (BTA) at the EU27 level was analyzed.

- <u>What happens if the gas stays indexed to oil prices?</u>

→ The decision was taken to keep gas prices indexed to oil prices:

World fossil energy prices (a/toe)



3. Reccomandations of the presentation of the results

- Presentation of the main drivers of the modeling tool IMACLIM-R

→ For further collaborative scenario processes the project team recommends to spend more time on the explanation of the model dynamics. Stakeholders want to understand which are the main drivers of the modeling tool.

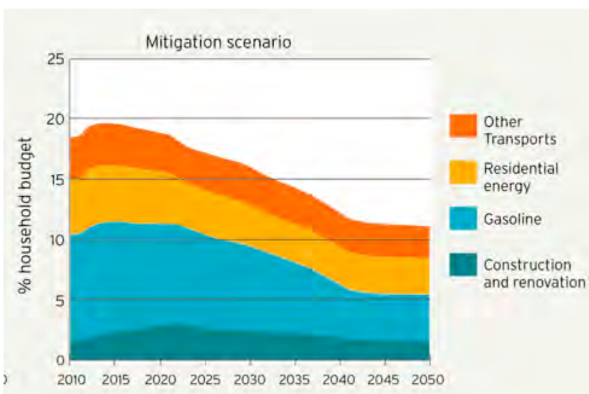
- It is more interesting to have several contrasted scenarios than only one

→ It was decided that within the French study only scenario was developed – an "acceptable emission reduction scenario" based on policy measures judged to be acceptable by stakeholder. This scenario was completed by a scenario "with additional measures" and sensitivity analysis.

- Investments: It is important to show the evolution of the household budget by needs: heating (energy, refurbishment etc.), mobility (fuel, tickets etc.)

→ The evolution of household expenditure is explicitly shown in the scenario.

Household expenditures



- A transparent presentation of who pays for what (in which sector) and the evolution of the money flows is recommended.

→ The investments and expenditures of households and the government were summarized in a table

Policies and measures financial balance (mitigation scenario) en Mrd€

	2010	2020	2030	2040	2050
TRANSPORT					
Heavy trucks eco-tax	0	1.3	1.1	1.1	1.2
Kerosene tax	0	1.6	1.1	1.4	1.3
Impact on domestic consumption tax on petroleum products	23.8	21.4	17.9	13.4	12.9
INFRASTRUCTURE INVESTMENTS					
Urban transports	+3 billion € each year from 2012 until 2030			-	-
Railways	+3 billion € each year from 2012 until 2030			-	-
Road transports	-6 billion € each year from 2012 until 2030			-	-
ELECTRICITY					
CSPE Income = feed-in tariffs expense	2.9	1.9	7.2	17.8	12.7
RESIDENTIAL SECTOR					
Tax credit	-	-3.3	-2.5	-0.8	-0.5
Eco-loan	-	-3.3	-1.9	-0.6	-0.4
Construction	-	-9.5	-9.4	-7.7	-6.3
Refurbishment	-	-14.9	-10.3	-3	-1.8
OVERALL MEASURES					
Carbon tax	0	13.7	18.1	23.9	34.8
BILAN	**26,7**	**8,9**	**21,3**	**45,5**	**53,9**

- Nuclear energy and renewable energies have no emissions in the scenario because their up and downstream emissions are allocated elsewhere. This has to be explained.

→ Here the explanation given in the final text: Nuclear energy and renewable energies have no emissions in the scenario because their up- and downstream emissions are allocated in other sectors. For example the construction of the building for a nuclear power plant is captured by the building sector. Only the combustion emissions of the electricity sector are allocated the power sector.

- The consumption of Heat Pumps should be clearly indicated.

→ The following explanation is given concerning the role of heat pumps:

In all subcategories of existing buildings, transitions to upper energy classes appear jointly with an important energy substitution from gas and fuel towards electricity for heating that corresponds in the model to a significant penetration of heat pumps (7 millions). This substitution is driven by the evolution of relative final energy consumption prices.

The electricity imports are used to satisfy the peaking heating demands in winter. The retrofitting of the residential sector that is increasing energy efficiency for heating and the switch from electric heaters to heat pumps reduces the electricity peak in winter. But approaching 2050 the peak increases due to a replacement from gas heating by heat pumps reaching a maximum of 103 GW.

- <u>The impact of the rebound effect should be clearly indicated.</u>

→ The following explanation is given concerning the rebound effect:

Given a behavior function, the model computesthe gap between the theoretical energy consumption for heating and real energy consumption after a retrofit action or in new energy efficient buildings, e.g. the rebound effect. In this scenario, given the assumptions of high global prices for fossil energy, and additional fiscal measures (progressive tariffs on electricity and carbon tax on fuel and gas), the rebound effect is quite limited. It is negative until 2034 and is limited to 4% on final energy consumption in 2042.
The model builds on a logistic relation that links the "service factor" (which reflects the gap between effective and conventional energy consumption) to the annual heating expenditure, as a proxy for the price of the heating service. It states that the higher the efficiency of the dwelling, the higher the service factor, thus inducing sufficiency relaxation. Conversely, the higher the energy price, the lower the service factor, thus inducing sufficiency strengthening. Investments that move a dwelling from a domain of low efficiency to a domain of higher one (e.g. from class F to class C) increase the service factor, i.e. induce a rebound effect. Similarly, switching from a given energy carrier to one fuelled by a cheaper energy (e.g. from fuel to wood) within the same efficiency domain implies a higher service factor.

- <u>Costs of the construction of grid infrastructure should be clearly indicated over the scenario period.</u>

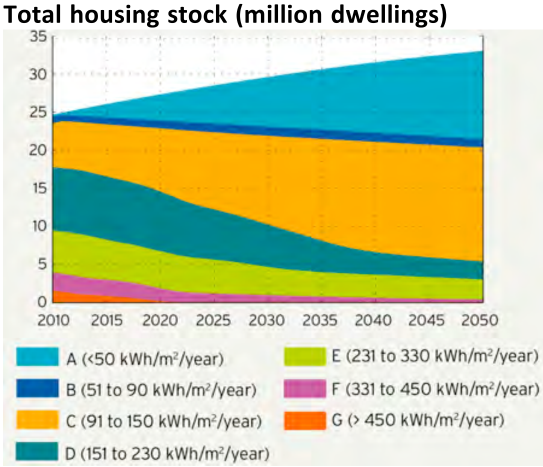
→ Grid costs are explained in the following way:

The construction of renewables with variable production triggers additional grid investments, thus increasing the electricity price for 1€/MWh in reference and 3€/MWh in the mitigation scenario.

The following publications have been used for costs evaluation:
- Deutsche Energie Agentur (2005): Integration into the national grid of onshore and offshore wind energy generated in Germany by the year 2020.
- Richard Green (2009): Climate Change Mitigation from Renewable Energy: Its Contribution and Cost.
- House of Lords Select Committee on the European Communities, 12th Report, Session 1998-99.
- House of Lords, Economic Affairs Committee, 2008"The Economics of Renewable Energy", Session 2007-08, Economic Affairs Committee Publications.

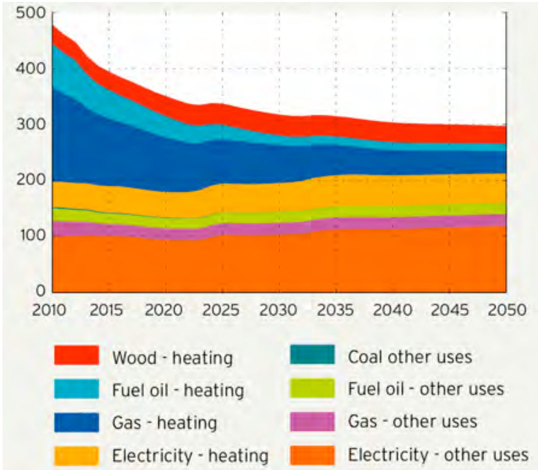
- <u>Presentation of the responsibilities of the different policy measures in the observed effects:</u>
    - Evolution of refurbishment

Total housing stock (million dwellings)



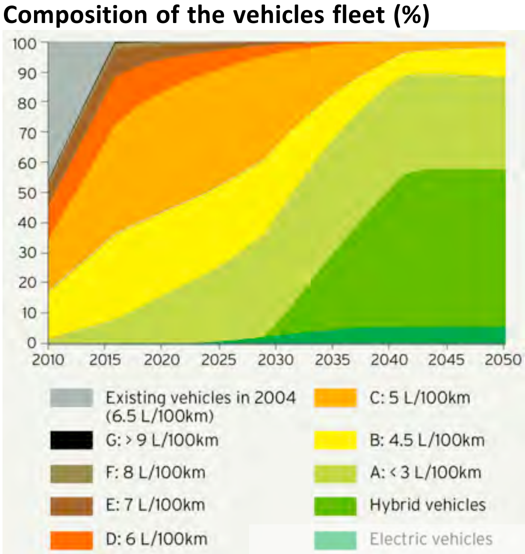
- Evolution of the heating mix

Residential final energy consumption (tWh)



- Evolution of the energy efficiency of vehicles

Composition of the vehicles fleet (%)



- Modal transfer

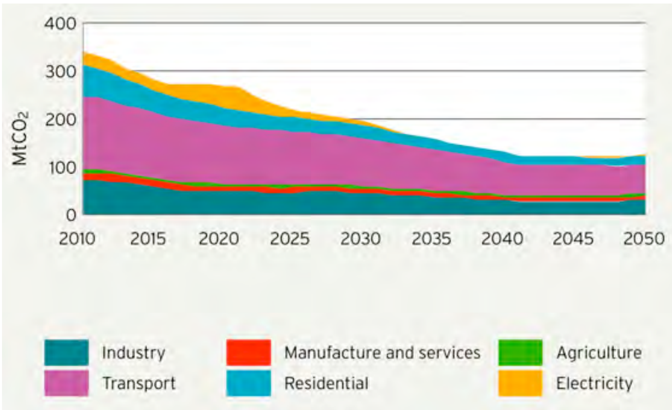
→ Here the explanation given in the final text:

For passenger transports, a “time-budget constraint” sets an upper boundary for daily time spent in transportation. This methodological choice relies on the empirical rule named “Zahavi’s law”. It shows that since many decades, each day, house- holds usually spend the same amount of time on transport. The modal choices depend on the relative prices and speed of each mode. Each mode is characterized by a speed that decreases with a higher utilization rate of a specific transport infrastructure. Indeed, the more people use a specific transport infrastructure (each infrastructure has a given capacity limit depending on the dedicated investments), the higher the risk of congestion is, which reduces its speed. As people are bound to a stable time budget, when a specific transport infrastructure is close to congestion, other modal choices will be preferred.
The maximum capacity of each modal infrastructure depends on the investment allocated to the specific infrastructure.

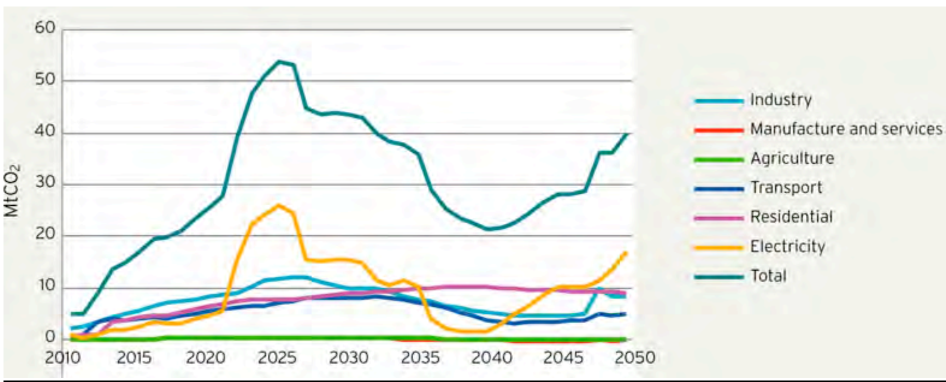
- Analyze of the impact of each policy measure in order to hierarchies their impact on energy consumption and emission reduction

→ The marginal impact of the exogenously fixed carbon tax has been calculated:

Sectoral co2 emissions



CO2 emission reductions induced by the carbon tax



- Are the national and European climate and energy objectives achieved?

→ The emission reduction target in 2020 is achieved but the French renewable electricity objective about 27% in 2020 is not achieved neither the European energy efficiency target.

- Explanation of the effort sharing: energy efficiency, fuel switch, behavior

→ A distinction between energy efficiency and sufficiency was not possible. But as no explicit behavioral change was integrated in the scenario (besides for example a 10% tele-working share), globally, energy efficiency and structural changes represents two thirds of the emissions reductions and the penetration of decarbonized energy represents one third of the emissions reductions.

- Explain clearly that only CO2 emissions are considered.

→ A specific chapter in the final reports explains the emission scope of the scenario and its limitation to domestic CO2 emissions.

4. Remarks concerning the project methodology

- It is important that it is explained how the contributions of the stakeholders are weighted.
- The idea of an iterative dialogue is helpful to cross the line between a simple discussion and policy measures and to get in touch with the modeling constraints.
- The methodology was not clear enough for the participants from the beginning on. Time needs to be spent on a detailed explanation of the methodology. For the stakeholders it would have been interesting to have a deeper insight in the dynamics of the modeling tool. More interaction would be necessary to have a broader common understanding.
- Questions for the first round of stakeholder meetings were too narrow. More time for discussion would have been useful.
- More time would have been needed to: explain the scenarios and to establish an iterative dialogue between the modeling team and the stakeholders

The social background of the participants is important especially concerning questions on costs and investments. 300€/t CO_2 were acceptable in the eyes of the invited stakeholders but it was stated that the incomes of these people were not

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2.2 Sectoral stakeholders' questionnaires

2.2.1 Residential sector

Contexte mondial

Quel mode de coordination du changement climatique au niveau international?

Hiérarchiser de 1 (le plus réaliste) à 4 (le moins réaliste) les possibilités suivantes quant à un mode de coordination international sur le changement climatique

Accord international ambitieux (division par 2 en 2050 des émissions de GES)	Action coordonnée au niveau des pays riches (type G8)	Action unilatérale (France – Europe)	Rien
……..	……..	……..	……..

Quelle typologie de mix technologique / énergétique au niveau mondial ?

Quels seront les technologies, types d'énergie ou priorités données au système énergétique d'ici 2050 dans le monde ? Numérotez de 1 (priorité maximale ou part la plus importante dans le mix énergétique) à 6 (priorité minimale ou part la moins importante dans le mix énergétique).

Nucléaire

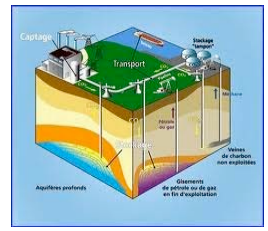
……..

ENR

……..

Fossiles

……..



Capture et stockage

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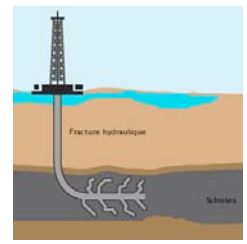


Non conventionnels

……..

Efficacité énergétique

……..

Certaines de ces technologies doivent elles être bannies pour des raisons d'acceptabilité et/ou de risques dans le monde? Cochez celles qui devraient être bannies.

Nucléaire

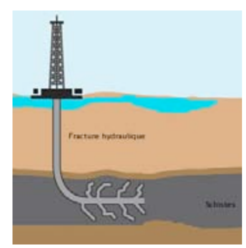
☐

ENR

☐

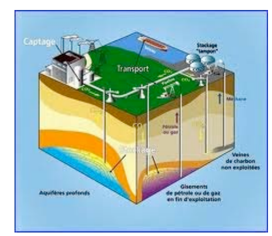
Fossiles

☐



Non conventionnels

☐



Capture et stockage

☐

Certaines de ces technologies doivent elles être bannies pour des raisons d’acceptabilité et/ou de risques en France? Cochez celles qui devraient être bannies.

Nucléaire

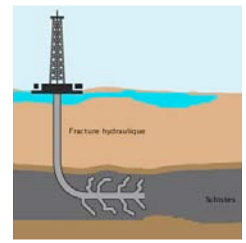
☐

ENR

☐

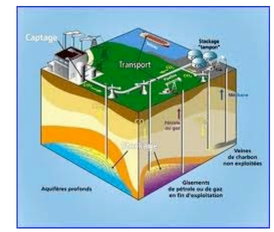
Fossiles

☐



Non conventionnels

☐



Capture et stockage

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Modes de consommation

Quels seront dans les décennies à venir les modes de consommation à l'échelle de la planète ? (de 1 : le plus probable à 3 : le moins probable)

Société de consommation

……

Plus de sobriété

……

Maintien des inégalités Nord-Sud

…….

Prix du pétrole

Quelle sera l'évolution du prix du pétrole

En 2030 ?

☐ 50 $/ baril ☐ 100 $/ baril ☐ 150 $/ baril ☐ > 200 $/ baril

En 2050 ?

☐ 50 $/ baril ☐ 100 $/ baril ☐ 150 $/ baril ☐ > 200 $/ baril

Dans les décennies à venir, la part de la production française dans la consommation française sera (de 1 : plus probable à 3 : moins probable):

Plus importante	identique à aujourd'hui	moins importante
…..	…..	….

Maisons individuelles

Le nombre de maisons individuelles s'élève en France à 16 millions.

Les deux dispositifs les plus importants existants sont le crédit d'impôt développement durable et l'écoPTZ. Le retour d'expérience montre les limites de ces seuls outils incitatifs. Ils sont améliorables à la marge (voir rapport du Plan Grenelle Batiment).

Incitations à la rénovation des maisons individuelles

Pensez-vous que le renforcement des outils incitatifs existants (CIDD et eco-PTZ) puisse permettre de réaliser le Facteur 4 en 2050 pour les 16M de maisons individuelles existantes ?

☐ Oui ☐ Non

Un des obstacles à la mise en œuvre de la rénovation thermique dans les maisons individuelles est le temps de retour de ce type d'opération. Pour pallier à cet obstacle, les mesures suivantes sont-elles souhaitables ?

- Recours à des sociétés de tiers investisseur.. oui non ....
- Adosser le prêt au bien et non à la personne.. oui non ....
- Incitation forte sur isolation des combles.. oui non ....

Autres mesures souhaitables:

....

....

....

Avec l'ensemble de ces mesures, combien de maisons individuelles pourraient être rénovés chaque année ?

....

L'ensemble de ces mesures incitatives permettrait-il de réaliser le Facteur 4 en 2050 pour les 16M de maisons individuelles existantes ?

☐ Oui ☐ Non

Obligation de rénovation pour les maisons individuelles

Avec les mesures incitatives ci-dessus, une obligation de rénovation pour les maisons individuelles est-elle acceptable ?

☐ Oui ☐ Non

Si non, pourquoi ?

……

Quel devrait être le critère de mise en œuvre d'une l'obligation de rénovation des maisons individuelles?

☐ Etiquette énergie ☐ Date de dernière rénovation ☐ Changement d'occupant ☐ Cession de bien

Quel devrait être le nombre annuel de rénovation obligatoire pour les maisons individuelles ?

☐ 70.000 (rénovation du parc en 100 ans) ☐ 100.000 (rénovation en 70 ans) ☐ 150.000 (rénovation en 45 ans) ☐ Autre ?…………………

Quel devrait être l'objectif de consommation d'énergie visé lors des opérations de rénovation?

☐ 50kWh/m2.an ☐ 80 kWh/m2.an ☐ 150 kWh/m2.an

Copropriété

Le nombre de logements en copropriété s'élève en France à près de 7,6 millions

Ce que dit le Grenelle

- Modification des règles de majorité et introduction de la notion de « travaux d'intérêt collectif sur partie privative »,
- DPE ou audit énergétique obligatoire
- CPE en copropriété

Mode de financement de la rénovation des copropriétés - Incitations

Quels sont les outils financiers indispensables au financement de la rénovation pour les **copropriétés**? Sont-ils tous indispensables ? Entourer oui ou non puis classer les outils suivants par ordre décroissant de nécessité (de 1 le plus indispensable à 8 le moins indispensable)

- Sociétés de tiers investisseur…… oui non ….
- Contrat de performance énergétique…… oui non ….
- Possibilité d'imputer une partie du coût des travaux sous forme d'une augmentation de loyer…… oui non ….
- Ecopret Copropriété…… oui non ….
- Crédit d'impôt Développement Durable…… oui non ….
- Subventions correspondant à ……. % du cout total de rénovation…… oui non ….
- Mise en place d'un fond de rénovation obligatoire (ex. Pays Bas) pour couvrir ….% du coût de la rénovation…… oui non ….
- Certificats d'économie d'énergie…… oui non ….

Quelles autres mesures financières seraient indispensables ou quelles améliorations des dispositifs existants seraient souhaitables ?

……

……

……

Avec ces mesures, combien de logements en copropriétés pourraient être rénovés chaque année ?

……………………………………………………………………

L'ensemble de ces mesures incitatives permettrait-il de réaliser le Facteur 4 en 2050 pour les 7,6M de copropriétés existantes ?

☐ Oui ☐ Non

Obligation de rénovation pour les copropriétés

Avec les mesures incitatives ci-dessus, une obligation de rénovation pour les copropriétés est-elle acceptable ?

☐ Oui ☐ Non

Si non, pourquoi ?

……

Quel devrait être le critère de mise en œuvre d'une l'obligation de rénovation des copropriétés?

☐ Etiquette énergie ☐ Date de dernière rénovation ☐ Obligation de ravalement ☐ Date de construction

Quel devrait être le nombre annuel de rénovation obligatoire pour les logements en copropriétés ?

☐ 70.000 (rénovation du parc en 100 ans) ☐ 100.000 (rénovation en 70 ans) ☐ 150.000 (rénovation en 45 ans) ☐ autre ?…………………

Quel devrait être l'objectif de consommation d'énergie visé ?

☐ 50kWh/m2.an ☐ 80 kWh/m2.an ☐ 150 kWh/m2.an

☐ gain de 2 étiquette énergie ☐ autre ?…………………………

Logement social

La France comptait en 2010, 4,508 millions de logements HLM. Trois logements Hlm sur dix ont été construits après 1985.

Ce que dit le Grenelle

« L'Etat se fixe comme objectif la rénovation de l'ensemble du parc de logements sociaux. A cet effet, pour commencer, 800 000 logements sociaux dont la consommation d'énergie est supérieure à 230 kilowattheures d'énergie primaire par mètre carré et par an feront l'objet de travaux avant 2020, afin de ramener leur consommation annuelle à des valeurs inférieures à 150 kilowattheures d'énergie primaire par mètre carré. Ces travaux concerneront en particulier 180 000 logements sociaux situés dans des zones définies par l'article 6 de la loi n° 2003-710 du 1er août 2003 d'orientation et de programmation pour la ville et la rénovation urbaine. Pour définir les priorités du programme, il sera tenu compte du niveau de charges de chauffage payées par les locataires, du niveau de la consommation annuelle et de l'importance des économies envisagées. Ce programme de rénovation est ainsi réparti :

ANNÉES	*2009*	*2010*	*2011 à 2020*
Logements sociaux rénovés	40 000	60 000	70 000 par an

A cet effet, une enveloppe de prêts à taux privilégiés sera accordée aux organismes bailleurs de logements sociaux. Des conventions entre l'Etat et ces organismes définiront les conditions de réalisation du programme et prévoiront les modalités de financement des travaux de rénovation, notamment à partir des économies réalisées grâce à ces travaux de rénovation. A l'appui de ces conventions, l'Etat pourra attribuer des subventions qui pourront s'élever jusqu'à 20 % du coût des travaux »

Financement de la rénovation dans le logement social - Incitations

Quels sont les outils financiers indispensables au financement de la rénovation dans le **logement social** ? Sont-ils tous indispensables ? oui ou non. Classer les outils suivants par ordre décroissant de nécessité (de 1 à 4)

- Sociétés de tiers investisseur………………………………………………… oui non ….
- Contrat de performance énergétique……………………………………………… oui non ….
- Possibilité d'imputer une partie du coût des travaux sous forme d'une augmentation de loyer……………… oui non ….
- Ecopret logement social………………………………………………… oui non ….

Quelles autres mesures financières seraient indispensables ou quelles améliorations des dispositifs existants seraient souhaitables ?

……

……

Avec ces mesures, combien de logements sociaux pourraient être rénovés chaque année ? ………………………………………………

L'ensemble de ces mesures incitatives permettrait-il de réaliser le Facteur 4 en 2050 pour les 4,5M de logements sociaux existants ?

Oui ☐ Non ☐

Obligation de rénovation dans le logement social

Avec les mesures incitatives ci-dessus, une obligation de rénovation pour les logements sociaux est-elle acceptable ?

☐ Oui ☐ Non

Si non, pourquoi ?

………

Quel devrait être le critère de mise en œuvre d'une l'obligation de rénovation dans le logement social?

☐ Etiquette énergie ☐ Date de dernière rénovation ☐ Obligation de ravalement ☐ Date de construction

Quel devrait être le nombre annuel de rénovation obligatoire dans le parc social ?

☐ 50.000 (rénovation du parc en 90 ans) ☐ 70.000 (rénovation du parc en 65 ans) ☐ 100.000 (rénovation du parc en 45 ans)

Quel devrait être l'objectif de consommation d'énergie visé ?

☐ 50kWh/m2.an ☐ 80 kWh/m2.an ☐ 150 kWh/m2.an

Organisation filière et emplois

En 2009, l’ensemble de la filière bâtiment employait 3.484.000 actifs dont 1.200.000 artisans et entrepreneurs de réalisation de travaux.

Si l’argent nécessaire (environ 6 Mrd €) pour la formation (initiale, continue et la formation des formateurs) était mis à disposition :

1) Combien d’années seront nécessaires pour former l’ensemble de la filière du bâtiment aux enjeux de la rénovation thermique rénovation) : ……………..

2) À partir de quand la filière pourrait être prête pour pouvoir répondre à la demande émanant d’une obligation à la rénovation, soit environ 400.000 rénovations par an: ……………..

3) La mise en place d’une obligation à la rénovation permettrait-elle à la filière de se développer plus rapidement (visibilité quant à l’évolution de la demande) :
Oui ☐ / Non ☐ / Pourquoi……………

Financement :
Qui doit financer la formation de la filière ? Public Etat ☐ Collectivités ☐ Certificats d’économies d’énergie ☐
Secteur privé ☐ Autres ☐ ……………………

Est-ce qu’il faut cofinancer (par exemple par le dispositif emplois tremplin) la création de certains postes spécialistes ?
Oui ☐ / Non ☐

CHAUFFAGE

Quels systèmes de chauffage devraient être mis en avant selon vous ?
Noter de 1 (minimum de soutien) à 10 (maximum de soutien) en 2020, 2030 et 2050. Votre réponse sous-entend un soutien à la filière pour en rendre le coût comparable aux systèmes de chauffages les moins chers (tout au moins en coût d'investissement).
NB :

Energie	**Prélèvement actuel**	**Réserve disponible en 2020**
Bois	88 TWh/an	130 TWh/an
Géothermie		140 TWh/an
Déchets		8 TWh/an
Réseaux de chaleur	18 TWh/an	12 TWh/an en renouvelable

	Coût HT d'investis-sement hors aides - k€	Coût HT d'investis-sement avec aides - k€	CO2 en gCO2/kWhEF[1]	2006	2020	2030	2050
Chauffage électrique	4	4	180	28%			
Gaz	10	9	205	40%			
Pompes à chaleur	16	12					
Bois	12	9.5	0	5%			
Fioul			271	20%			
GPL	11	11	231	3%			
Charbon			355				
Réseaux de chaleur			200	4%			
La micro-cogén.							

[1] Intensité carbone calculée selon l'approche « moyenne saisonnière »

Interdiction du chauffage électrique (classique) :

- dans le cadre du chantier de l'obligation à la rénovation ☐
- dans la construction neuve ☐
- à partir d'une consommation de ……. kWh/m2/an ☐
- à partir de la classe ……... ☐

Interdiction du chauffage au fioul :

- dans le cadre du chantier de l'obligation à la rénovation ☐
- dans la construction neuve ☐
- à partir d'une consommation de ……. kWh/m2/an ☐
- à partir de la classe ……... ☐

Quels sont les outils financiers indispensables au financement du changement de système de chauffage ?
Sont-ils tous indispensables ? oui ou non.
Classer les outils suivants par ordre décroissant de nécessité (du plus important 1 au moins important 5)

- Sociétés de tiers investisseur	oui	non	….
- Crédit d'impôts	oui	non	….
- Primes ANAH	oui	non	….
- TVA à 5.5%	oui	non	….
- Certificats d'économie d'énergie	oui	non	….

Evolution m2 par personne / taille des ménages

	1990	2010	2020	2030	2040	2050
Taille ménage B	2,57	2,25	2,16	2,08	2,04	2,01
Taille ménage H	2,57	2,24	2,14	2,04	1,99	1,96

Source : INSEE : prolongement CLIP facteur 4

	m2 par personne - Habitat individuelle	m2 par personne - Habitat collectif
2010	42	28
2050 – Taille ménage B	50	35
2050 – Taille ménage H	56	40

→ Cette augmentation de la surface s'accompagne par une augmentation du besoin de chauffage et de l'eau chaude sanitaire

Quelle évolution de la taille des ménages est réaliste (les 2 se basent sur des prévisions INSEE)?

Taille ménage B ☐

Taille ménage H ☐

Et-ce qu'il y a des mesures financières et politiques qui permettraient de passer d'une trajectoire à l'autre ?

………

………

………

Fiscalité carbone

Le rapport Quinet sur la valeur tutélaire du carbone préconisait la mise en place d'une taxe carbone de 32€/tCO2 en 2010 et dont la valeur croitrait chaque année pour atteindre 100€/tCO2 en 2030. Le projet de loi de 2009 prévoyant une taxe carbone à17€/tCO2 et qui s'appliquerait aux carburants et aux énergies de chauffage hors électricité a finalement été jugé inconstitutionnelle.

Impact différencié d'une taxe de 32€/tCO2 en fonction du type d'habitat et du mode de chauffage (surcoût annuel en € en moyenne par logement)

Gaz domestique		Fuel		GPL		Charbon	
collectif	individuel	collectif	individuel	collectif	individuel	collectif	individuel
84	127	117	169	60	77	146	142

Impact d'une taxe de 32€/tCO2 en fonction du type de carburant (surcoût annuel en €)

	diesel	Super sans plomb
Prix à la pompe en octobre 2011 (€/l)	1,42	1,58
TIPP dans le prix à la pompe (€/l)	0,42	0,59
Part de la TC dans le prix à la pompe (€/l)	0,07	0,07
Surcoût annuel (€/an)	82	58

Dans l'hypothèse de la mise en place d'une nouvelle fiscalité sur l'énergie quelle hypothèse est la plus acceptable

a. Assiette de la taxe :
- ☐ Taxer le carbone seul
- ☐ Taxer le carbone et l'énergie (y compris l'électricité)

b. Niveau de taxation en 2012
- ☐ Fixer à 32€/tCO2
- ☐ Niveau supérieur
- ☐ Niveau inférieur

c. Niveau de taxation en 2030
- ☐ 100€/tCO2
- ☐ Niveau supérieur à 100€/tCO2
- ☐ Niveau inférieur à 100€/tCO2

d. Croissance de la taxe : faut-il afficher dès maintenant la croissance de la taxe pour les années à venir ? .... oui non

e. Quelles options de recyclage des revenus de la taxe vous paraissent souhaitables parmi les options suivantes ? les hiérarchiser par ordre croissant d'acceptabilité (de 1 le plus acceptable à 5 le moins acceptable)

   i. Baisse du coût du travail.. oui non ....
   ii. Recherche & développement.. oui non ....
   iii. Chèque vert.. oui non ....
   iv. Soutien à l'efficacité énergétique et aux énergies renouvelables.. oui non ....
   v. Endettement.. oui non ....

Précarité énergétique

En France 3 400 000 ménages consacrent plus de 10% de leurs ressources à régler leurs factures d'énergie. 62% sont propriétaires de leur logement. Ce sont ainsi 2,1 millions de ménages concernés dont essentiellement ceux dont les ressources sont les plus modestes. 90% d'entre eux résident dans des maisons individuelles, majoritairement construites avant les premières normes thermiques de construction mises en place dès 1975.

Aides paiement des factures – tarifs sociaux

Ce qui existe

Le Tarif de Première Nécessité (TPN) permet d'avoir une réduction sur l'abonnement électrique ainsi que sur les 100 premiers kWh consommés chaque mois. La réduction représente de 40 à 60% de la facture annuelle en fonction de la composition du foyer. La réduction moyenne constatée sur une facture annuelle est de 88 € TTC.

Tarif Spécial Solidarité (TSS) Gaz donne droit à une réduction sur chacune des factures dans le cas d'un contrat individuel ou d'une réduction forfaitaire annuelle dans le cas d'un immeuble chauffé collectivement. Pour un foyer composé de deux personnes ou plus, la réduction annuelle est comprise entre 22 € TTC (option eau chaude) et 118 € TTC (option eau chaude / chauffage).

Ce qu'il faudrait faire

Généraliser la mise en place d'un tarif progressif

- sur les consommations de chauffage………………………………………………………………… oui non
- sur les consommations d'électricité……………………………………………………………………… oui non

Instaurer un chèque vert sous condition de ressource…………………………………………………… oui non

Aides aux travaux

Ce qui existe

Habiter mieux est un programme initié par l'Etat dans le cadre des Investissements d'avenir qui est doté de 1,35 milliard d'euros (600 millions d'euros de l'Anah, 500 millions de l'Etat et 250 millions des fournisseurs d'énergie). Lancé en 2010, l'objectif consiste en 7 ans (d'ici 2017) à aider 300 000 ménages (soit 10% des ménages en situation de précarité énergétique) à améliorer leur logement par des travaux de rénovation thermique efficaces, afin de gagner en confort, en qualité de vie et en pouvoir d'achat. Il s'agit d'atteindre au minimum 25% de gain énergétique par logement rénové. Fixée à 1.100€, l'aide de l'Anah peut être portée à 1.600€, par une ou plusieurs collectivités locales ''p*our les propriétaires occupants qui réalisent des travaux améliorant d'au moins 25% la performance énergétique de leur logement''*. A son lancement plus de 50 départements étaient engagés dans ce programme.

Les aides aux travaux, comme le prêt à taux zéro, le micro-crédit personnel, l'écosubvention de l'Anah ou le crédit d'impôt développement durable, ne sont pas accessibles aux familles les plus modestes.

Ce qu’il faudrait faire

- Permettre le cumul des aides dans le cadre du programme Habiter Mieux avec l’éco-prêt à taux zéro et/ou le CIDD……………………………………oui non ….
- Augmenter le seuil requis d’amélioration de l’efficacité énergétique du logement…………………………………………………………………………………… oui non ….
- Augmenter le niveau d’aide par ménage…… oui non ….
- Financer l’isolation des combles pour les ménages en situation de précarité énergétique…………………………………………………………………………… oui non ….
- Augmenter le nombre de logements de ménages précaires rénovés chaque année……………………………………………………………………………………oui non ….

2.2.2 Passenger transport sector

Transports de passagers : Quelle acceptabilité des mesures Facteur 4 dans les transports de passager ?

Ce questionnaire établi conjointement par le Centre International de Recherche en Environnement et Développement et le Réseau Action Climat-France vise à évaluer, au-delà des potentiels techniques existants, l'acceptabilité pour le déploiement de modes de transports compatibles avec la division par 4 des émissions de gaz à effet de serre en 2050 et l'acceptabilité de mesures visant à modérer la croissance de la demande de mobilité. Les réponses de ces questionnaires permettront d'alimenter le modèle économique Imaclim-R de manière à élaborer des scénarios de réduction des émissions de gaz à effet de serre ne mettant en œuvre que des politiques acceptables.

Sommaire

I. Lutter contre l'étalement urbain et le mitage du territoire

Les espaces agricoles et naturels perdent actuellement la superficie d'un département français moyen (610 000 ha) tous les sept ans.

Quels sont les instruments efficaces et acceptables pour limiter l'étalement urbain et le mitage ? Hiérarchisez les propositions selon leur impact dans la lutte contre l'étalement urbain et le mitage du territoire avec 1* (peu d'impact et/ou peu acceptable) à 3* (beaucoup d'impact et/ou acceptable) en début des lignes suivantes.**

… Réformer les dispositifs de financement du logement :

   … Redéfinir le zonage géographique du dispositif Scellier et autres régimes d'investissement locatif dans le neuf en réservant ce dispositif à l'intra-urbain et/ou à proximité des transports en commun ;

   … Réserver le Prêt à taux zéro+ (PTZ+) dans le neuf aux logements intra-urbains et/ou à proximité des transports en commun en site propre.

   … Supprimer la possibilité qu'ont les collectivités territoriales d'exonérer de 50 % de la taxe d'aménagement les maisons individuelles en milieu diffus financées à l'aide du PTZ+.

… Rendre obligatoire le Versement Sous Densité pour toutes les communes

… Taxe carbone pour augmenter le prix des carburants

… Péage urbain

… Réglementer le prix des logements

… Développer les logements sociaux à proximité des centres urbains ou des transports en commun

… Soumettre des projets d'extension urbaine économes en sol, avec des zones à urbaniser à un seuil de densité minimum.

… Taxer annuellement les terrains bâtis et non bâtis constructibles sur la base de valeurs vénales réalistes, c'est-à-dire correspondant à la valeur marchande des biens

… Réhabiliter et habiter les 2 millions de logements insalubres

Autres………

……

Pensez-vous que ces outils sont à même : (entourez la réponse)

- De diminuer l'artificialisation du territoire ? Oui, complètement Oui, de moitié Non
- De ralentir l'étalement urbain ? Oui, complètement Oui, de moitié Non
- De redensifier les villes et centres urbains ? Oui, beaucoup Oui, modérément Non

A quel horizon temporel, ces outils pourraient avoir un impact significatif ? 2020 2030 2040 2050

II. Mobilité locale

II.1. Quel type de transport en milieu urbain ?

Comment diminuer la part modale de la voiture dans les <u>VILLES DE PROVINCE</u>? Cochez les propositions incontournables et expliquez si nécessaire les conditions d'acceptabilité.

- Transports en commun
  - Améliorer le niveau de desserte et d'accessibilité en transport en commun en milieu urbain
  - Augmenter le niveau de confort des transports en commun
  - Augmenter la vitesse des transports en commun
  - Augmenter la fréquence des transports en commun
  - Gratuité ou tarification avantageuse des transports en commun
  - Développer les infrastructures de transports en commun (plus d'offre, nouvelles lignes)

- Faciliter la multimodalité
  - Création de plateformes multimodales
  - Plateforme unique d'informations multimodales en temps réel en application smart phones
  - Tarification unique

- Augmenter le prix de l'usage de la voiture
  - Péage urbain
  - Taxe carbone
  - Augmentation du coût de stationnement

- Restrictions d'usage de la voiture

- Développer les pistes cyclables

Autres……
………
………
………

Comment diminuer la part modale de la voiture dans L’AGGLOMERATION PARISIENNE? Cochez les propositions incontournables et expliquez si nécessaire les conditions d’acceptabilité.

- Transports en commun
  - Améliorer le niveau de desserte et d’accessibilité en transport en commun en milieu urbain
  - Augmenter le niveau de confort des transports en commun
  - Augmenter la vitesse des transports en commun
  - Augmenter la fréquence des transports en commun
  - Gratuité ou tarification avantageuse des transports en commun
  - Développer les infrastructures de transports en commun (plus d’offre, nouvelles lignes)

- Faciliter la multimodalité
  - Création de plateformes multimodales
  - Plateforme unique d’informations multimodales en temps réel en application smart phones
  - Tarification unique

- Augmenter le prix de l’usage de la voiture
  - Péage urbain
  - Taxe carbone
  - Augmentation du coût de stationnement

- Restrictions d’usage de la voiture

- Développer les pistes cyclables

Autres……
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…….

Quels sont les obstacles au développement des infrastructures de transports collectifs ? Cochez les réponses qui vous semblent pertinentes

- Pas assez de financement de l'Etat sur les transports en commun
- Pas assez de financement des collectivités territoriales et risque d'augmentation des impôts locaux
- Pas assez de rentabilité
- Contraintes physiques liées à l'agencement spatial
- Autre………
  ………
  ………

En 2009, 1 milliard € était investi dans les TCU de province, et 1,2 milliards € par la RATP et le réseau ferré en Ile de France.

Ces montants sont-ils suffisants ?

- En province Oui Non
- En région parisienne Oui Non

Serait-il acceptable d'investir plus massivement dans le développement des transports collectifs en milieu urbain ?

Oui Non

Combien ? Entourer la réponse qui vous semble pertinente 2 Mds /an 4 Mds /an 6 Mds /an 8 Mds /an

Pendant combien d'années 5 ans 10 ans 15 ans 20 ans 30 ans

Si oui comment financer ?

- Augmenter la part de la TIPP vers les collectivités
- Revenus d'une taxe carbone
- Augmenter la contribution de l'Etat
- Augmenter le versement transport
- Autre………
  ………
  ………

II.2. La voiture en ville ?

Peut-on imaginer une diminution du nombre de voiture en ville ? Entourez la réponse

Oui, une forte diminution   Oui une diminution modérée   Non, le nombre de voitures en ville ne pourra qu'augmenter

Une Interdiction du véhicule à combustion classique en ville serait elle acceptable ?   Oui   à partir de l'année ……….   Non

Pour diminuer le nombre de voitures en ville, est ce efficace et acceptable que les collectivités subventionnent un système tel qu'Autolib à Paris ?

Oui   Non

II.3. Mobilité en milieu rural

Quelles orientations seraient efficaces pour limiter le recours à la voiture en milieu rural ? Cochez.

- Maintien ou redéploiement des services publics en zone rurale et des commerces de proximité   Non   Oui
- Développement de services de « taxis collectifs » ou de « bus citoyens » à la demande   Non   Oui
- Développement du co-voiturage   Non   Oui
- Augmenter le prix du service automobile (par la fiscalité par exemple telle que taxe carbone)   Non   Oui
- Développement des services autocar express plus fréquents pour remplacer et compléter le service des lignes de train à faible traffic (Une liaison par autocar = 300000€ ; une ligne ferrée régionale = 6 million / 3-4€ par véhicule/km contre 15€ par train/m / dans certains régions les taux d'occupation est <25% ; les TER sont financés à seulement 26% par les usagers)   Non   Oui
- Autres……
  ………

Est-ce qu'il faut identifier les ménages en danger de l'isolement en banlieue / en zone peu dense et développer des aides spécifiques?

Non   Oui   Quel type d'aide ?..

Qui doit financer l'offre de transport collectif dans les milieux ruraux ? Cochez

- Etat
- Collectivités
- Habitants
- Usagers
- Entreprises du bassin de vie

II.4. Transports domiciles – travail

Quelle stratégie (or infrastructures) devrait être suivie pour limiter le recours à la voiture pour les trajets domicile-travail ? Hiérarchisez les propositions selon leur possible impact dans la réduction des trajets domicile-travail avec 1* (peu d'impact) à 3* (beaucoup d'impact).**

… Développer le covoiturage et les incitations économiques au co-voiturage

… Donner des incitations financières aux entreprises à la mise en place de plans de déplacement entreprises

… Réformer le système des frais réels (supprimer la déduction des frais kilométriques)

… Développer le télétravail (création de centres par quartier équipés en vidéo-conférence etc) et donner des avantages à ceux qui font du télétravail

… Péage urbain

… Pénaliser fiscalement les entreprises ne s'implantant pas à proximité de transports en commun

III. Transports longue distance

1,3% des déplacements (+80km) mais 40% des distances

III.1. Loisirs et vacances

Quelles sont les conditions pour que le rail regagne des parts de marché sur la route et l'aérien pour le transport longue distance ? Classer par ordre d'importance. Hiérarchisez les propositions selon leur possible impact pour l'augmentation de la part de marché du rail avec 1* (peu d'impact) à 3* (beaucoup d'impact).**

… Prix
… Création d'un guichet unique pour tous les organismes ferroviaires en Europe pour une information plus accessible
… Service rendu, confort
… Temps de transport
… Intermodalité garantie à l'arrivée ou au départ via des transports en commun ou un système flexible et accessible de location de voiture
… Développement du réseau TER

Est-ce que l'autocar « express international – avec arrêts nationaux» devrait se développer pour :

- prendre la place de lignes de train non rentables	Oui	Non	Seulement avec des cars très efficaces
- créer une offre de transport en commune longue distance pour les villes moyennes	Oui	Non	Seulement avec des cars très efficaces

A-t-on besoin de plus de lignes à grande vitesse pour le développement du ferroviaire longue distance pour concurrencer l'avion ?

Oui Non

Interdire les subventions par les collectivités territoriales aux compagnies « low cost » est-il acceptable?

Oui **Non**

Acceptabilité exonération taxe sur le kérosène pour le transport aérien ? (Les seules exonérations de la taxe intérieure sur les produits pétroliers (TIPP) et de la TVA pour le kérosène aérien représentent quelque 6 Md€ par an.)

Oui **Non**

Ces mesures représentent-elles à moyen terme des options pour réduire considérablement la demande de mobilité longue distance ?

- Aménagement temps de travail pour partir loin moins souvent mais plus longtemps (exemple des comptes épargne temps)
  Oui, beaucoup **Oui, mais modérément** **Non**

- Créer une ville durable agréable diminuant le besoin de partir loin pour s'aérer la tête
  Oui, beaucoup **Oui, mais modérément** **Non**

- Autres……… ……………………………………………………………………………………………
  ……
  ……..

III.2. Déplacements professionnels

Quelles sont les conditions pour que le rail regagne des parts de marché sur la route et l'aérien pour le transport longue distance des déplacements professionnels ? Classer par ordre d'importance (de 1 à 5 (1 peu important – 5 très important)

- Diminution relative du prix
- Augmentation du service rendu, confort
- Réduction du temps de transport
- Intermodalité garantie à l'arrivée ou au départ via des transports en commun ou un système flexible et accessible de location de voiture
- Développement du réseau TER

Quels sont les potentiels de ces mesures pour limiter la demande de mobilité longue distance pour les déplacements professionnels ? (de 1 à 5 (1 peu important – 3 très important)

- Visioconférence/NTIC
- Aménagement temps de travail
- Augmenter le prix du transport aérien (Taxation kérosène, TVA, taxe carbone ou quotas carbone)
- Système de prime pour les employés n'ayant pas recours à l'avion pour des trajets pouvant être effectués par le rail sur une durée de moins de4 heures.
- Interdire les systèmes de Miles

Interdire les subventions par les collectivités territoriales aux compagnies « low cost » est-il acceptable?

Oui **Non**

IV. Fiscalité

IV.1. La fiscalité carbone

Le rapport Quinet sur la valeur tutélaire du carbone préconisait la mise en place d'une taxe carbone de 32€/tCO2 en 2010 et dont la valeur croitrait chaque année pour atteindre 100€/tCO2 en 2030. Le projet de loi de 2009 prévoyant une taxe carbone à17€/tCO2 et qui s'appliquerait aux carburants et aux énergies de chauffage hors électricité a finalement été jugé inconstitutionnelle.

Impact d'une taxe de 32€/tCO2 en fonction du type de carburant (surcoût annuel en €)

	diesel	Super sans plomb
Prix à la pompe en octobre 2011 (€/l)	1,42	1,58
TIPP dans le prix à la pompe (€/l)	0,42	0,59
Part de la TC dans le prix à la pompe (€/l)	0,07	0,07
Surcoût annuel (€/an)	82	58

Dans l'hypothèse de la mise en place d'une nouvelle fiscalité sur l'énergie quelle hypothèse est la plus acceptable

a. Assiette de la taxe :

☐ Taxer le carbone seul ☐ Taxer le carbone et l'énergie (y compris l'électricité)

b. Niveau de taxation en 2012

☐ Fixer à 32€/tCO2 ☐ Niveau supérieur ☐ Niveau inférieur

c. Niveau de taxation en 2030

☐ 100€/tCO2 ☐ Niveau supérieur à 100€/tCO2 ☐ Niveau inférieur à 100€/tCO2

d. Croissance de la taxe : faut-il afficher dès maintenant la croissance de la taxe pour les années à venir ? …………………… oui non

e. Quelles options de recyclage des revenus de la taxe vous paraissent souhaitables parmi les options suivantes ? les hiérarchiser par ordre croissant d'acceptabilité (de 1 le plus acceptable à 5 le moins acceptable)

i. Baisse du coût du travail………oui non ….
ii. Recherche & développement (innovation verte)…………………………………………………………………………oui non ….
iii. Reversement forfaitaire aux ménages…………………………………………………………………………………………oui non ….
iv. Reversement forfaitaire aux ménages sous condition de ressources……………………………………………oui non ….
v. Subvention aux équipements efficaces et et aux énergies renouvelables………………………………………oui non ….
vi. Endettement……oui non ….

IV.2. La TIPP/TIC

La TIPP/TIC comprend plusieurs exonérations. Celles-ci devraient elles être supprimées :

- Agrocarburants (196M€/an) oui non
- Aviation (3600M€/an) oui non
- Transport routier (390M€/an) oui non

Affectation de la TIPP. Aujourd'hui sur les 24 milliards d'€ de recettes issues de la TIPP, 57% est affecté au budget général de l'Etat, 17% aux régions et 25% aux départements

Proposition pour une autre affectation ?

………

………

IV.3. Bonus/Malus

Le bilan financier pour le budget de l'Etat du bonus-malus écologique devrait-il être :

- Neutre : il faut calibrer le bonus malus de manière à ce qu'il y aie autant de recettes que de dépenses
- Tant pis si le budget est déficitaire pour l'Etat, le but est de tirer le marché vers des véhicules faiblement émetteurs et de donner un fort bonus sur les véhicules faiblement émetteurs
- Positif : Priorité aux comptes publics, le bonus malus écologique peut devenir bénéficiaire si on met un fort malus quitte à diminuer le niveau du bonus

IV.4. Versement transport

Faudrait-il augmenter le Versement transports des entreprises (aujourd'hui ses recettes sont de 6 milliards affectées aux autorités organisatrices de transports) ?

Oui **Non**

V. Les véhicules

Faut-il interdire la mise sur le marché de véhicule trop émetteur de CO_2 ? Oui Non

Faut-il interdire la mise sur le marché de véhicule pouvant rouler au-delà d'une certaine vitesse (bridage des moteurs) ? Oui Non

V.1. Quelle voiture en ville ?

Est-ce qu'il faut une spécialisation sur une technologie ou un mix de technologies ?

- Spécialisation
- Mix de différentes technologies

Dans les décennies à venir il faudrait donner la priorité (recherche et investissement) à quelle technologie ? Cochez maximum 3 options.

- La voiture électrique (plug-in)
    - Chargement à la maison
    - Dans des stations « de service »
    - Changement de batteries dans des stations de service (type : better world)
    - V2Grid
- Véhicules hybrides
- Autolib
- Voiture classique 1l/100km (efficacité énergétique : matériaux légers, stop & go etc.)
- Biocarburants
- Gaz

V.2. Quelle voiture en zone rurale ?

Est-ce qu'il faut une spécialisation ou une mix de technologies ?

- Spécialisation
- Mix de différentes technologies

Dans les décennies à venir il faudrait donner la priorité (recherche et investissement) à quelle technologie ? Cochez maximum 3 options.

- La voiture électrique (plug-in)
  - Chargement à la maison
  - Dans des stations « de service »
  - Changement de batteries dans des stations de service (type : better world)
  - V2Grid
- Véhicules hybrides
- Voiture classique 1l/100km (efficacité énergétique : matériaux légers, stop & go etc.)
- Biocarburants
- Gaz

2.2.3 Freight transport sector

Transport de marchandises

Ce questionnaire établi conjointement par le Centre International de Recherche en Environnement et Développement et le Réseau Action Climat-France vise à évaluer, au-delà des potentiels techniques existants, l'acceptabilité pour le déploiement de modes de transports compatibles avec la division par 4 des émissions de gaz à effet de serre en 2050 et l'acceptabilité de mesures visant à modérer la croissance de la demande de transport de marchandises. Les réponses de ces questionnaires permettront d'alimenter le modèle économique Imaclim-R de manière à élaborer des scénarios de réduction des émissions de gaz à effet de serre ne mettant en œuvre que des politiques acceptables.

Sommaire

I. Contenu matériel de la croissance

Va-t-on vers une croissance moins consommatrice de ressources naturelles qui impliquerait moins de transport de marchandises ?

Oui Non

Les émissions de gaz à effet de serre en France ont baissé si l'on considère les émissions issues de la production sur le territoire français. Elles ont par contre augmenté si l'on considère les émissions issues de la consommation des ménages, entreprises et administrations (tenant compte du bilan carbone des importations et exportations).

Va-t-on vers une relocalisation de la production ?

Oui Non

Qu'est ce qui pourrait favoriser une relocalisation de la production ?Hiérarchiser de 1 (le plus fort impact) à 3 le mois fort impact

… Appliquer une taxe d'ajustement aux frontières

… Multiplier de plateformes de producteurs vendant directement aux consommateurs

… Réduire le coût du travail

Le nombre de kg de marchandises transporté en France par personne et par an évolue peu, par contre ce qui a le plus évolué c'est la nature des marchandises transportées avec plus de produits manufacturés. Comment la quantité de tonnes transportées en France va-t-elle évoluer dans les décennies à venir? Cochez la réponse qui vous semble pertinente.

- A la hausse
- A la baisse
- Stabilisation

Comment les tonnes.km vont évoluer en France dans les décennies à venir? Cochez la réponse qui vous semble pertinente.

Une tonne.km est une mesure agrégeant à la fois le poids des marchandises déplacées – tonne ainsi que la distance qu'elles parcourent – km.

- A la hausse
- A la baisse
- Stabilisation

II. Multimodalité du fret

Est-ce que l'objectif du Grenelle est encore atteignable (- 25% du trafic de marchandises non routier en 2020) ?

Oui Non

Quels sont les obstacles au développement du ferroutage, du transport combiné ou du transport ferroviaire? Hiérarchisez les propositions selon leur impact en termes de blocage dans le développement du transfert modal vers les rails : 1* (peu d'impact) à 3*** (beaucoup d'impact).

… Le coût de développement des infrastructures
… Le manque d'infrastructures « grande vitesse »
… Le manque d'infrastructures hors grande vitesse (lignes transversales ?)
… La rupture de charge
… Le coût pour le transporteur
… Sillons accordés par RFF
… Conditions de circulation offertes par le transporteur ferroviaire
… Le prix du pétrole trop bas
… La concurrence des transporteurs des pays d'Europe de l'Est
… Problèmes techniques entre les pays
… Fermetures de gares
… Abandon du wagon isolé
… Autres………
………
………

La compétition aujourd'hui encore incontestée du mode routier pourrait-elle être mise à mal par le transport ferroviaire et si oui quels en seraient les déterminants ?
Hiérarchisez les propositions selon leur importance: 1* (peu d'impact) à 3*** (beaucoup d'impact).

… Réduction du prix du service transport ferroviaire (soutien du wagon isolé)
… Mise en place d'une écoredevance poids lourd
… Création d'un système de péage dans tous les pays européens
… Limitation de vitesses pour les poids lourds
… Limitation des ruptures de charge du transport ferroviaire
… Développement des infrastructures additionnelles sur certains axes
… Amélioration des infrastructures existantes
… L'amélioration des conditions de circulations offertes par le transporteur ferroviaire

… La privatisation du transport ferroviaire
… Obligation de construire un accès aux rails pour chaque zone industrielle
… Autres………
……
……

Quel mode de transport alternatif à la route devrait être privilégié par les politiques publiques pour le transport de marchandises ? Hiérarchisez de 1 (le plus privilégié) à 4 (le moins privilégié)

- Le rail
- Le fluvial
- Le maritime
- L'aérien

Quel mode de transport alternatif à la route possède le plus gros potentiel de développement pour le transport de marchandises ? Hiérarchisez de 1 (le plus de potentiel) à 4 (le moins de potentiel)

- Le rail
- Le fluvial
- Le maritime
- L'aérien

Qui devrait financer le développement des alternatives au transport routier ? Hiérarchisez de 1 (le plus important) à 5 (le moins important) – il peut y en avoir plusieurs au même niveau

- L'Etat
- SNCF/RFF
- Les compagnies privées
- Les collectivités territoriales
- Les entreprises

En 2010, 2,8 Mds € étaient investis dans les infrastructures ferrées (0,9 Mds dans le réseau grande vitesse et 1,9 Mds dans le réseau principal hors LGV).
Ces montants sont-ils suffisants ?

- Pour le réseau grande vitesse oui non
- Pour le réseau principal hors LGV oui non

Quels montants annuels d'investissements d'ici 2020 seraient nécessaires pour rééquilibrer le partage modal du transport de marchandises vers le transport ferroviaire ?

- Pour le réseau grande vitesse	2Mds/an	4Mds/an	6Mds/an	8Mds/an
- Pour le réseau principal hors LGV	2Mds/an	4Mds/an	6Mds/an	8Mds/an

Acceptabilité pour les entreprises et les consommateurs à payer des biens ayant une empreinte carbone faible donc plus chers

- Entreprises :	oui	non
- Consommateur:	oui	non

III. Le contenu carbone du « dernier km de livraison »

Comment améliorer le contenu carbone du dernier km de livraison en zone urbaine ? **Hiérarchisez de 1* (très important) à 3 (pas important) – il peut y a voir plusieurs au même niveau**

… interdiction d'utilitaires « peu efficaces »dans les villes
… création de plateformes multimodales + bases logistiques urbaines dans toutes les grandes villes
… Mise à disposition par la ville et les supermarchés en périphérie à faible couts de location (ou gratuitement) des utilitaires hybrides et / ou électriques
… Autre :………
……
……
……
……

IV. Quel type de poids lourds au XXIème siècle?

Faut-il une spécialisation ou un mix de technologies ?

- Spécialisation (un type de véhicule dominant)
- Mix de différentes technologies

Dans les décennies à venir il faudrait donner la priorité (recherche et investissement) à quelle technologie ?

- Le camion électrique (plug-in)
- Véhicules hybrides
- Camion à combustion standard mais très efficace
- Biocarburants (deuxième génération)

V. Fiscalité

La fiscalité carbone

Une taxe carbone fixée au niveau qui était envisagé en 2009, serait-elle à même de porter atteinte à la compétitivité du mode routier ?

Oui Non

Serait-elle acceptable pour le transport routier ?

Oui Non

Taxe d'ajustement aux frontières

Une taxe ajustement frontières serait-elle acceptable?

Oui Non

TIPP/TIC

La TIPP/TIC comprend plusieurs exonérations ou défiscalisation. Celles-ci devraient elles être supprimées :

- Agrocarburants (196M€/an) oui non
- Aviation (3600M€/an) oui non
- Transport routier (390M€/an) oui non

Ecoredevance poids lourd :

Le taux kilométrique devrait varier, selon la catégorie et la classe EURO du poids lourd, dans la fourchette 2,5 c€ à 20 c€. La recette brute attendue est de 1,2 milliard € par an. Les coûts de collecte étant estimés à 15%, la recette nette AFITF est évaluée à environ 0,88 milliard €.

Le taux kilométrique de l'écoredevance poids lourd devrait-il être :

- Plus ambitieux
- Moins ambitieux
- Inchangé

L'écoredevance poids-lourds devrait-elle être perçue sur toutes les routes (concédées et non concédées) ?

Oui Non

2.2.4 Electricity sector

Electricité

Quelle acceptabilité des mesures Facteur 4 dans le secteur de l'électricité?

Ce questionnaire établi conjointement par le Centre International de Recherche en Environnement et Développement et le Réseau Action Climat - France vise à évaluer, au-delà des potentiels techniques existants, l'acceptabilité des mesures politiques qui visent à réduire des émissions de gaz à effet de serre de la production, distribution et consommation d'électricité.

12 décembre 2011

Demande

1. **Compteurs intelligents**

   Quelles devraient être les fonctionnalités d'un compteur intelligent ? – Cochez les fonctionnalités qui sont acceptables pour vous.

   ☐ Télé-relève
   ☐ Intégration au réseau intelligent (L'intervention sur la ligne à distance)
   ☐ Contrôle de la charge par le compteur en fonction du tarif
   ☐ Affichage des consommations par usage
   ☐ Affichage du tarif en temps réel en fonction de la consommation instantanée
   ☐ Autre...
   ....

2. **Efficacité énergétique**
   Quels outils sont acceptables pour améliorer considérablement l'efficacité énergétique ? – Cochez les outils qui sont acceptables pour vous.
   ☐ Bonus-malus sur les équipements
   ☐ Interdictions pure et simple de appareils les plus consommateurs
   ☐ Renforcement des objectifs des certificats économies d'énergie
   ☐ Appliquer le principe du « Front – runner » ou BAT (Best available technology)
   ☐ Autre……
   ……………………………………………………………………………

3. **Chauffage électrique**
   Est-il acceptable d'interdire le chauffage électrique à effet joule (sauf dans les résidences secondaires) ? – Cochez la/les réponse(s).
   ☐ Non
   ☐ Oui, dans le cadre du chantier d'une obligation de rénovation
   ☐ Oui, dans la construction neuve
   ☐ Autre……
   ……………………………………………………………………………

4. **Effacement de consommation, MDE et Tarification – Cochez les outils qui sont acceptables pour vous.**
   ☐ Acceptabilité tarification EJP (Effacement Jour de Pointe) pour les industriels
   ☐ Acceptabilité EJP pour les ménages
   ☐ Acceptabilité contrats interruptibles pour les industriels
   ☐ L'obligation de construction BEPOS (bâtiments à énergie positive) à partir de 2020
   ☐ Autre……
   ……………………………………………………………………………

5. **Nouveaux usages**
   Faut-il agir contre l'augmentation de la consommation électrique spécifique du fait des nouveaux usages (WIbox etc.) ? Cochez selon votre avis.
   ☐ Oui il faut développer une taxe pour des appareils qui ne correspondent pas à un usage « essentiel »
   ☐ Non, il faut seulement assurer l'efficacité des ces appareils
   ☐ Autre……
   ……………………………………………………………………………

6. **Sobriété et effet de rebond**

L'effet de rebond du fait des gains d'efficacité énergétique sur l'électricité spécifique est-il une fatalité ? - Cochez la/les réponse(s).

- ☐ Oui, c'est une réaction humaine et il serait inacceptable de lutter contre par des mécanismes de prix
- ☐ Non, on pourra le diminuer avec des mécanismes de prix (taxe, tarif progressif etc.)
- ☐ Autre………

………………………………………………………………………………

7. Acceptabilité du véhicule électrique

Sous quelles conditions le développement du véhicule électrique est-il acceptable ? – Cochez des conditions nécessaires pour que le développement devienne acceptable pour vous.

- ☐ Aucune, le développement du véhicule électrique est inacceptable
- ☐ Mettre des limitations pour la recharge à la maison pour ne pas aggraver les problèmes de gestion de pointe électrique
- ☐ Limitation du poids et de la vitesse des voitures
- ☐ Utilisation de préférence pour des distances courtes (<200km)
- ☐ Faible contenu en carbone de l'électricité
- ☐ Autre………

………………………………………………………………………………

Offre – Technologies

1. **Les objectifs français attenants à l'électricité seront-ils atteints ?**
   ☐ Oui ☐ Non Réduction d'au moins 20% des émissions de gaz à effet de serre
   ☐ Oui ☐ Non 23% de l'électricité d'origine renouvelable
   ☐ Oui ☐ Non Augmenter de 20% l'efficacité énergétique à l'horizon 2020 par rapport au développement tendanciel (ou -14% en 2020 par rapport à 2005)

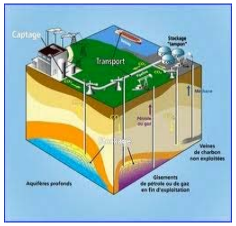
   ☐ Oui ☐ Non Multiplier par cinq la production de chaleur renouvelable actuelle d'ici 2020 (aide annuelle de 1Mrd d'€ sur la période 2009-2011)

Si non pourquoi ?

………
………
………
………
………
………

2. Acceptabilité technologies :

Pour chacune de ces technologies : doit-elle être bannie, sa capacité installée augmentée ou réduite pour des raisons d'acceptabilités et/ou de risques en France ? Cochez ce que vous semble être acceptable.



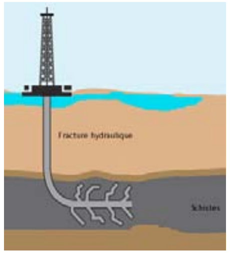
CCS
Banni ☐
☐ Equipement des centrales fossiles existantes
☐ Equipement des centrales fossiles en construction

Charbon
Banni ☐
Nouvelles centrales (sans CCS) ☐
Nouvelles centrales (avec CCS) ☐
PPI

Nucléaire
Banni ☐
Augmentation ☐
Baisse ☐
Baisse : 50% du mix en 2025 (accord Vert/PS) ☐
Prolongation parc actuel ☐
Replacement par Gaz ☐ ENR ☐

Eoliennes

Banni ☐
Augmentation ☐
Baisse ☐

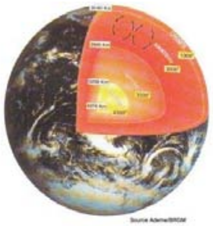


Non-conventionnels

Banni ☐
Augmentation ☐

Solaire PV

Banni ☐
Augmentation ☐
Baisse ☐

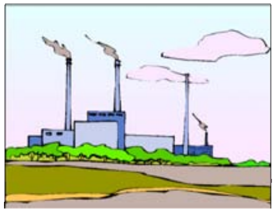


Géothermie

Banni ☐
Augmentation ☐
Baisse ☐

CCS + biomasse (émissions négatives)

Banni ☐
Augmentation ☐



CCS émissions de procédé industriels

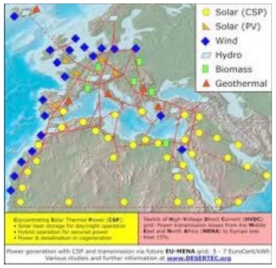
Banni ☐
Augmentation ☐

Gaz

Banni ☐
Augmentation ☐
Baisse ☐

Solaire CSP

Banni ☐
Augmentation ☐
Baisse ☐



Desertec

Banni ☐
Acceptable ☐

3. **A-t-il des incompatibilités entre des systèmes de production de base et variable (ENR)? – Cochez la / les réponses qui vous semble être correctes.**

☐ Oui, un part d'important d'énergies renouvelables variables (solaire, éoliens) +30% combiné avec des systèmes de production de base peu variable (nucléaire) pose des problèmes de compatibilité.
☐ Oui, il y a des problèmes de compatibilité qui peuvent être équilibrés par la construction de réseaux électriques ☐ sites de stockage ☐ construction de capacité de réserve flexible ☐.
☐ Non, c'est compatible.
☐ Autre..
....

4. **Quelles politiques de soutien aux énergies renouvelables**

Les trois premières colonnes du tableau présentent les différents tarifs d'achat actuels pour chacune des énergies renouvelables. Selon vous ces tarifs d'achat devraient-ils être poursuivis (oui ou non), si oui à quel niveau (1= revu à la baisse ; 2= maintenu au niveau actuel; 3=augmenté) et jusqu'à quand (2020, 2030 ou lorsque la technologie sera compétitive avec les moyens classiques (dans ce cas donner une date approximative de compétitivité)

Moyen de production	**Tarif d'achat actuel (c€/kWh)**	**Durée des contrats (ans)**	**Politique de tarif d'achat à poursuivre (oui ou non)**	**Niveau du tarif d'achat** **1 = Diminué** **2 = Identique** **3 = Augmenté**	**Jusqu'à quelle date ?** **1 = 2020** **2 = 2030** **3 = Compétitivité avec les moyens thermiques classiques**
Hydraulique (barrages)	6.5 – 9	20			
Hydraulique marin	15	20			
Géothermie	20 – 28	15			
Eolien terrestre	8 pendant 10 ans 3 – 8 pendant 5 ans	15			
Eolien en mer	13 pendant 10 ans 3 – 13 pendant 10 ans	20			
PV intégré au bâti	30 - 46	20			
PV - autres	12	20			
Cogénération	6 – 9	12			
Déchets ménagers sauf biogaz	5	15			
Biomasse (végétale et animale)	12 – 17	20			
Biomasse végétale	13 – 18	20			
Farine animale	12 – 17	20			
Biogaz	8 – 14	15			
Méthanisation	11 – 20	15			
Autres	8 – 10	15			

5. **Une obligation d'équipement en cogénération est-elle acceptable pour : (Cochez les cas pour lesquels un tel équipement est acceptable)**

☐ Pour les unités de production d'électricité existantes (hors nucléaires)
☐ Pour les centrales nucléaires
☐ Pour les futures centrales
☐ Dans le cadre de la Directive européenne sur l'efficacité énergétique (Art 10) : Toutes les constructions nouvelles de centrales thermiques en dessus d'une capacité de 20MW et dans le cas d'une modernisation substantielle des centrales existantes

Gouvernance

1.1 Echelon territoriaux et compétences

1. **Quel est l'échelon décisionnel le plus adapté pour le développement des énergies renouvelables? (Cochez ce qui vous semple être l'échelon le plus adapté)**
   ☐ Europe (transfert de compétences)
   ☐ Etat
   ☐ Collectivités territoriales (transfert de compétences)
   ☐ Citoyens (projet : énergie partagée) (transfert de compétences)

2. **Quel est l'échelon décisionnel le plus adapté pour le développement de centrales thermiques classiques? (Cochez ce qui vous semple être l'échelon le plus adapté)**
   ☐ Europe (transfert de compétences)
   ☐ Etat
   ☐ Collectivités territoriales (transfert de compétences)

3. **Qui doit financer les investissements pour le renouvellement du parc ? (hiérarchisez l'importance de 1 = très important à 4 = faible)**
   …. Etat
   …. Producteurs privés
   … Collectivités
   …. Citoyens

4. **Faut un transfert de gouvernance de la distribution de l'électricité ? (Cochez l'option qui vous semple être la plus souhaitable)**
   ☐ Non, le rôle de ERDF est bien définît
   ☐ Oui, il faut créer des régis à l'échelle locale
   ☐ Autre……
   ……………………………………………………………………

1.2 Planification

1. **Qu'est-ce qui doit guider le développement des moyens de production d'électricité ?**
   ☐ Planification
   ☐ Libéralisation
   ☐ Autre...
   ....

2. **Comment devrait se faire une planification des besoins de moyens supplémentaires de production ?**
   ☐ Minimisation du coût des investissements dans une logique « top-down »
   ☐ Faire émerger les potentiels des territoires dans une vision « Bottom-up »
   ☐ Autre...
   ....

3. **Faudrait-il que la PPI soit opposable ? (Cochez la réponse qui vous semble être souhaitable)**
   ☐ Oui ☐ Non. ☐ Autre...
   ....

1.3 Stockage de l'électricité et biens publics

1. **Unités de stockage**
   Une unité de stockage s'apparente à un bien public (pour la gestion du réseau et la sécurité d'approvisionnement).
   ☐ Acceptabilité de la propriété privée et du risque de ne recourir au stockage que lorsque cela est rentable
   ☐ Acceptabilité de la propriété par RTE
   ☐ Autre...
   ....

2. **Qui devrait payer pour le stockage nécessaire du fait du risque supplémentaire de volatilité de production du fait de la pénétration d'énergies intermittentes ?**
   ☐ Les ENR intermittentes

☐ Tous les producteurs
☐ Consommateur (via la CSPE)
☐ Autre………
……………………………………………………………………………………………

1.4 Acceptabilité locale des énergies renouvelables

1. **Comment améliorer acceptabilité locale des énergies renouvelables à l'échelle locale ? (Cochez les / la piste(s) d'action qui vous semble(nt) être acceptable(s))**
   ☐ « Repowering »
   ☐ Organiser plus participation / consultation des citoyens concernés dès le début du projet
   ☐ Préférer des projets de petite taille pour la consommation locale
   ☐ Mise en place d'une récompense financière pour les riverains
   ☐ Promotion des initiatives citoyennes style « énergie partagée »

1.5 Imports – Exports

2. **Acceptabilité des importations d'électricité ? (Cochez les / la raison(s) qui vous semble(nt) être acceptable(s))**
   ☐ Uniquement pour assurer sécurité d'approvisionnement
   ☐ Pour fournir une part non négligeable de notre consommation
   ☐ Autre………

3. **Acceptabilité des exportations d'électricité**
   - Est-il acceptable de construire des centrales au gaz pour exporter ? ☐ Oui ☐ Non
   - Est-il acceptable de construire des centrales au charbon pour exporter ? ☐ Oui ☐ Non
   - Est-il acceptable de construire des centrales nucléaires pour exporter ? ☐ Oui ☐ Non

   - Qui paie les infrastructures (lignes de transport) entre différents pays?………………………………………………………………………………………………………
   - A qui reviennent les bénéfices ?
   ………

4. **Faut-il une planification transparente des capacités à installer à l'échelle européenne pour éviter des sur ou sous capacités ?**
   OUI ☐ NON ☐

Réseaux électriques

Quel réseau électrique pour quelle production ? Centralisation versus décentralisation

1. **Faut-il faire évoluer le réseau électrique français vers un système :**
   - ☐ Plus décentralisé (vers l'autonomie des régions) mais avec des sites de production importants
   - ☐ Décentralisé (vers l'autonomie des régions) avec des sites de production de moyen et petit taille (plutôt ENR)
   - ☐ Centralisé pour maximiser l'utilisation des ENR là où le potentiel est important (éolien dans la mer du nord, PV dans le sud de la France etc.)
   - ☐ Développer un réseau électrique centralisé et planifié à l'échelle européenne (éolien dans la mer du nord, Desertec, PV dans l'Espagne etc.)
2. **Plusieurs systèmes peuvent-ils coexister ?** OUI ☐ NON ☐

3. **Acceptabilité locale des infrastructures de transport d'électricité haute et très haute tension**

   Comment améliorer acceptabilité de la création d'infrastructures? (Cochez les / la piste(s) d'action qui vous semble(nt) être acceptable(s))
   - ☐ Organiser plus de participation / consultation des citoyens concernés dès le début du projet
   - ☐ Mise en place d'une récompense financière pour les riverains
   - ☐ Proposer dès le début l'option de la construction sous terre (plus chère)

4. **Priorités de développement**

Quel ordre de priorité en termes d'urgence selon le niveau de (dé)centralisation (de 1 à 4 avec 1 = la 1ère priorité / 2 = la 2ème priorité…) ?

- Décentralisé (vers l'autonomie des régions) avec des sites de production de moyen et petit taille (plutôt ENR)

- … Développement des réseaux électriques haute tension
- … Développement des réseaux électriques basse tension
- … Développement de moyens de stockage
- … Construction de réserves de capacité pointe
- … La gestion de la demande

- Centralisé pour maximiser l'utilisation des ENR là où le potentiel est important (éolien dans la mer du nord, PV dans le sud e la France etc.)

- … Développement des réseaux électriques haute tension
- … Développement des réseaux électriques basse tension
- … Développement de moyens de stockage

… Construction de réserves de capacité pointe

… La gestion de la demande

Emplois, filières et marchés

Chiffre d'affaires dans quelques filières d'énergie d'origine renouvelable

	Eolien	*PV*	*Total*
Allemagne	5,8	9,5	15,3
Espagne	3,3	16,4	19,7
France	2,7	0,9	3,6

2008 : en milliard d'euros ; source EurObserv'ER Etat des énergies renouvelables en Europe

	2006	Evolution 2006/09 tcma	2009	Evolution 2009/12 tcma	2012
Marché (Millions €)					
Dévpt ENR	5200	16,9%	8300	15,4%	12700
Production ENR	4300	20,4%	7400	10,7%	10100
Total	9500		15700		22800
Emplois (équivalent ETP)					
Dévpt ENR	34000	15,8%	52700	13,3%	76700
Production ENR	20900	10,5%	28100	6,8%	34200
Total	54900		60800		110900

Source : Marchés, emplois et enjeu énergétique des activités liées a l'amélioration de l'efficacité énergétique et aux énergies renouvelables : Situation 2008-2009 – perspectives 2010, ADEME, 2010

La France importe une partie importante des équipements liés au développement des ENR. Pensez-vous pour chacune des filières suivantes qu'elle pourrait devenir en pointe dans la production des équipements :

PV Oui ☐ Non ☐ Commentaire...
Eolien on shore Oui ☐ Non ☐ Commentaire...
Eolien off shore Oui ☐ Non ☐ Commentaire...
Pompes à chaleur Oui ☐ Non ☐ Commentaire...
Biogaz Oui ☐ Non ☐ Commentaire...

Pourquoi la France importe-t-elle autant d'équipement ENR ?

....

....

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....
....
....
....
....
....

Serait-il acceptable de mettre en place des politiques de soutien spécifiques pour le développement d'ENR produites en France ?

OUI ☐ NON ☐

Tarification

1.6 Tarification progressive

Lesquelles de ces propositions sont acceptables ?

Tarif progressif sur les consommations de chauffage électrique (à effet joule) OUI ☐ NON ☐

Tarif progressif sur l'ensemble de la consommation d'électricité OUI ☐ NON ☐

Instaurer un chèque vert sous condition de ressources OUI ☐ NON ☐

1.7 Taxe carbone

Le rapport Quinet sur la valeur tutélaire du carbone préconisait la mise en place d'une taxe carbone de 32€/tCO2 en 2010 et dont la valeur croitrait chaque année pour atteindre 100€/tCO2 en 2030. Le projet de loi de 2009 prévoyant une taxe carbone à17€/tCO2 et qui s'appliquerait aux carburants et aux énergies de chauffage hors électricité a finalement été jugé inconstitutionnelle.

Dans l'hypothèse de la mise en place d'une nouvelle fiscalité sur l'énergie quelle hypothèse est la plus acceptable

a. **Assiette de la taxe :**

☐ Taxer le carbone seul (y compris l'électricité) ☐ Taxer le carbone et l'énergie (y compris l'électricité)

b. **Niveau de taxation en 2012**

☐ Fixer à 32€/tCO2 ☐ Niveau supérieur ☐ Niveau inférieur

c. **Niveau de taxation en 2030**

☐ 100€/tCO2 ☐ Niveau supérieur à 100€/tCO2 ☐ Niveau inférieur à 100€/tCO2

d. **Croissance de la taxe : faut-il afficher dès maintenant la croissance de la taxe pour les années à venir ?**
……………………… oui non

e. **Quelles options de recyclage des revenus de la taxe vous paraissent souhaitables parmi les options**

suivantes ? les hiérarchiser par ordre croissant d'acceptabilité (de 1 le plus acceptable à 5 le moins acceptable)

Baisse du coût du travail..	oui	non	....
Recherche & développement (innovation verte)...	oui	non	....
Reversement forfaitaire aux ménages..	oui	non	....
Reversement forfaitaire aux ménages sous condition de ressources............	oui	non	....
Subvention aux équipements efficaces et et aux énergies renouvelables.....	oui	non	....
Résorption de la dette..	oui	non	....

1.8 Taxe sur la consommation finale d'électricité (TCFE)

La TCFE est reversée aux communes et aux départements. Elle dépend de la commune. Le taux maximal (et généralement constaté) s'élève donc à 9 euros / MWh.
Les recettes de la taxe locale sur l'électricité aujourd'hui ne sont pas affectées au secteur électrique.

Les recettes de cette taxe devraient-elles être utilisées pour financer des investissements dans (Cochez si vous pensez que l'utilisation est acceptable):

- ☐ Développement de la production électrique au niveau local
- ☐ Gestion de la demande au niveau local
- ☐ Non il faut maintenir la liberté de choix d'utilisation des collectivités
- ☐ Autre ....

....

Si oui, serait-il acceptable de l'augmenter? OUI ☐ NON ☐

1.9 CSPE

	2008	2009	2011
Montant de la CSPE (€/MWh)	4,8	4,5	7,5

CSPE moyenne 2011 = 42 TTC, soit 8 % de la facture moyenne. Hausse de la facture moyenne au 1er janvier 2011 due à la CSPE = 3 %

Les charges prévisionnelles au titre de 2011 (3,4 Mds €) résultent pour:

- 42 ,4 %, des charges dues aux énergies renouvelables en métropole continentale ;
- 35 %, des charges dues à la péréquation tarifaire dans les zones non interconnectées (elles intègrent le surcoût de production des ENR dans ces zones) ;
- 21,2 %, des charges dues à la cogénération (et à des contrats d'achat concernant des diesels dispatchables) ;
- 1,4 %, des charges liées à la solidarité envers les plus démunis.

Alors qu'en 2010, c'était encore la péréquation tarifaire qui générait le plus de charges (38 % des charges prévues au titre de 2010), c'est dorénavant le poste « énergies renouvelables » qui est prépondérant, en raison essentiellement du fort développement du photovoltaïque et, dans une moindre mesure, de l'éolien. Ainsi, les charges dues au photovoltaïque devraient représenter 30 % des charges au titre de 2011, soit environ 1 milliard d'euros.

1. **Le principe de la CSPE est-elle acceptable pour développer les ENR?** OUI ☐ NON ☐

2. **Quel montant de la CSPE est acceptable pour soutenir le développement des énergies renouvelables (cochez le niveau qui est acceptable selon vous) :**
   ☐ 5 €/MW ☐ 7,5 €/MW ☐ 10 €/MW ☐ Autre..............

Chapter 3

Imaclim-R France model

Ruben Bibas, CIRED

This chapter provides detailed information on modeling assumptions in the static equilibrium (section 3.1), on the Nexus describing technical change in the energy sector (section 3.2), on data defining the calibration date and "natural" growth drivers (section 3.3), and on the assumptions and calculations supporting the analytical analysis of the drivers of mitigation costs (section 3.4).

3.1 Equations of the static equilibrium

We distinguish between endogenous variables (marked in bold) and fixed parameters of the static equilibrium at date t. For the sake of readability, indexes i and j are used for sectors, and index k is reserved for regions.

3.1.1 Table of variables

Table 3.1 details the list of variables calculated by the static equilibrium.

$Income$	Households total revenues
$transfers$	Transfers from government to households
p_i	Production price of good i
pC_i	Final consumption price for households for good i
pGk_i	Final consumption price for government for good i
pI_i	Price for investments for good i
$pIC_{j,i}$	Intermediate consumption price for sector i for good j
p_{ind}	Households final consumption price index
wp_i	International price of good i
p_i^{imp}	Import price of good i
w_i	Unitary salary in sector i
Ω_i	Increasing cost factor in sector i
Q_i	Volume of production of good i
C_i	Households final consumption volume of good i
$S_{mobility}$	Households' demand for mobility services
pkm^{mode}	Passengers.kilometers traveled per mode (air transport, public transport, private vehicle, non motorized mode)
I_i	Volume of good i purchased for Gross Fixed Capital Formation (Investment)
z	Unemployment level
M_i	Volume of imports of good i
X_i	Volume of exports of good i
χ_i	Volume of the international market of good i
MS_i^X	Market share of exports in the international market of good i
$shareC_i^{imp/dom}$	Imports (/Domestic production) share in households final consumption of good i
$shareG_i^{imp/dom}$	Imports (/Domestic production) share in States final consumption of good i
$shareI_i^{imp/dom}$	Imports (/Domestic production) share in investments of good i
$shareIC_{j,i}^{imp/dom}$	Imports (/Domestic production) share in sector i intermediate consumption of good j
NRB	Net regional savings
GRB	Gross regional savings
$InvFin_i$	Investment allocated to sector i
$pCap_i$	Price of one unit of productive capital in sector i
ΔCap_i	New productive capital in sector i

Table 3.1: Variables of the static equilibrium

3.1.2 Table of parameters

Table 3.2 details the parameters, which are fixed in each static equilibrium and are modified in the recursive framework by dynamic modules.

G_i	States final consumption of good i
$IC_{i,j}$	Sector j intermediate consumption of good i
L	Total active population
l_i	Quantity of labor per unit of output in sector i
aw_i	Wage curve parameter for sector i
π_i	Markup rate in sector i
ptc	Households propensity to spend (one minus saving rate)
div_i	Share of profits in sector i given as revenues to households
bn_i	Basic need of consumption of good i
α_{Ei}^{cars}	Mean consumption of energy Ei per passenger.kilometer by car
$\alpha_{Ei}^{m^2}$	Mean consumption of energy Ei per square meter of residential buildings
$Tdisp$	Total households travel time
Cap_i	Productive capacity of sector i
$Captransport_j$	Total capacity of transport mode j
tax_i^w	Labor tax rate in sector i
tax_i^M	Tax rate on imports of good i
tax_i^X	Tax rate on exports of good i from region k
tax_i^{domC}	Tax rate on households final consumption of domestic production of good i
tax_i^{impC}	Tax rate on households final consumption of imports of good i
$shareExpK$	Share of gross regional savings of region k exported to the international "pool" of capital
$shareImpK$	Share of the international "pool" of capital imported
$shareInvFin_i$	Share of net regional savings of region k allocated to sector i
$\beta_{j,i}$	Quantity of good j necessary to build one unit of productive capacity of sector i
nit_i^{it}	Transport need in mode it for imports of good i
ξ_i^C,ξ_i^S	Parameters of the utility function
b_{mode}	Calibration parameters for the constant elasticity of substitution function giving the transport service in function of passengers.kilometers per mode
η	$\eta = \frac{s-1}{s}$, with s the elasticity of substitution of the function giving the transport service in function of passengers.kilometers per mode
w_i^{ref}	Salaries at calibration date in sector i
p_{ind}^{ref}	Households final consumption price index at calibration date
z^{ref}	Underutilization of the labor force at the calibration date
ρ_i	$\rho = \frac{1-\sigma}{\sigma}$
σ_i	Armington elasticity for good i
b_{dom},b_{imp}	Calibration parameters for Armington expression for good i
θ_i	$\theta = \frac{1-\lambda}{\lambda}$
λ_i	Armington elasticity in the international market for good i
ψ_i	Calibration parameter for Armington expression for exports of good i from France in the international market "pool"
$\eta_i^{imp/dom}$	Parameter for the expression of the imports (/Domestic production) share in households' final consumption of good i
η_i^X	Parameter for the expression of the market share of exports from region k in the international market of good i

Table 3.2: Parameters of the static equilibrium

3.1.3 Core equations of the static equilibrium

Income formation

$$Income = \sum_{sectors\ i} \Omega_i \cdot w_i \cdot l_i \cdot Q_i + \sum_{sectors\ i} div_i \cdot \pi_i \cdot p_i \cdot Q_i + transfers \tag{3.1}$$

Governments' budget

$$\sum taxes = \sum_{sectors\ i} G_i \cdot pG_i + transfers + InvInfra \tag{3.2}$$

The sum of taxes corresponds to the total of tax revenues, i.e. the tax rates (parameters) applied to the taxable amounts (often endogenous in the equilibrium).

Utility maximization

$$U(\vec{C},\vec{S}) = \left[\prod_{goods\ i} (C_i - bn_i)^{\xi_i^C}\right] \cdot (S_{mobility} - bn_{mobility})^{\xi_i^S} \tag{3.3}$$

$$S_{mobility} = \left[\left(\frac{pkm^{air}}{b^{air}}\right)^{\eta} + \left(\frac{pkm^{public}}{b^{public}}\right)^{\eta} + \left(\frac{pkm^{cars}}{b^{cars}}\right)^{\eta} + \left(\frac{pkm^{non-motorized}}{b^{non-motorized}}\right)^{\eta}\right]^{\frac{1}{\eta}} \tag{3.4}$$

Income constraint

$$ptc \cdot Income = \sum_{sectors\ i} pCi \cdot Ci + \sum_{Energies\ Ei} pC_{Ei} \cdot \left(pkm^{cars} \cdot \alpha_{Ei}^{cars} + S^{m^2} \cdot \alpha_{Ei}^{m^2}\right) \tag{3.5}$$

Travel time budget constraint

$$Tdisp = \sum_{transport\ mode\ j} \int_0^{pkm^j} \tau_j\left(\frac{u}{Captransport_j}\right) du \tag{3.6}$$

where τ_j represents the marginal efficiency in transport time (the time necessary to travel an additional passenger.kilometer with mode j):

$$\tau_j(x) = a_j \cdot x_j^{trans} + b_j \tag{3.7}$$

The first order conditions give $N+S$ equations, with N the number of consumption goods and S the number of mobility services, and add two unknowns, the Lagrange multipliers for both constraints.

Sector budget (supply curve)

$$p_i = \sum_{sectors\ j} pIC_{j,i} \cdot IC_{j,i} + (\Omega_i \cdot w_i) \cdot l_i \cdot (1 + tax_i^w) + \pi_i \cdot p_i \tag{3.8}$$

where $\Omega_i = \Omega\left(\frac{Q_i}{Cap_i}\right)$ represents an increasing cost (or decreasing returns) function of the productive capacities utilization rate. The functional form for Ω is:

$$\Omega_i = a_\Omega - b_\Omega \cdot tanh\left(c_\Omega \cdot \left(1 - \frac{Q_i}{Cap_i}\right)\right) \tag{3.9}$$

Labor market (wage curve)

$$z = 1 - \frac{\sum_{sectors\ i} l_i \cdot Q_i}{L} \tag{3.10}$$

$$\frac{w_i}{p_{ind}} = aw_i \cdot \frac{w_i^{ref}}{p_{ind}^{ref}} \cdot f\left(\frac{z}{z^{ref}}\right) \tag{3.11}$$

Equilibrium constraints on physical flows

$$M_i = shareC_i^{imp} \cdot C_i + shareG_i^{imp} \cdot G_i + shareI_i^{imp} \cdot I_i + \left(\sum_{sectors\ j} Q_j \cdot shareIC_{i,j}^{imp} \cdot C_{i,j} \right) \tag{3.12}$$

$$Q_i = shareC_i^{dom} \cdot C_i + shareG_i^{dom} \cdot G_i + shareI_i^{dom} \cdot I_i + \left(\sum_{sectors\ j} Q_j \cdot shareIC_{i,j}^{dom} \cdot C_{i,j} \right) + X_i \tag{3.13}$$

Investment formation

$$NRB = GRB \cdot (1 - shareExpK) + \left(\sum_{countries\ k'} GRB_{k'} \cdot shareExpK \right) \cdot shareImpK \tag{3.14}$$

$$GRB = Income \cdot (1 - ptc) + \sum_{sectors\ j} \pi_j \cdot p_j \cdot Q_j \cdot (1 - div_j) \tag{3.15}$$

$$InvFin_i = NRB \cdot shareInvFin_i \tag{3.16}$$

$$pCap_i = \sum_{sectors\ j} (\beta_{j,i} \cdot pI_{j,i}) \tag{3.17}$$

$$\Delta Cap_i = \frac{InvFin_i}{pCap_i} \tag{3.18}$$

$$I_j = \sum_{sectors\ i} \beta_{j,i} \cdot \Delta Cap_i \tag{3.19}$$

3.1.4 Intermediate variables for international trade

Armington goods

$$C_i = \left(b_i^{dom} \cdot \left(C_i^{dom}\right)^{-\rho_i} + b_i^{imp} \cdot \left(C_i^{imp}\right)^{-\rho_i} \right)^{-\frac{1}{\rho_i}} \tag{3.20}$$

$$pCi = \left(\left(b_i^{dom}\right)^{\sigma_i} \cdot \left(p_i \cdot \left(1 + tax_i^{domC}\right)\right)^{1-\sigma_i} + \left(1 - b_i^{dom}\right)^{\sigma_i} \cdot \left(p_i^{imp} \cdot \left(1 + tax_i^{impC}\right)\right)^{1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}} \tag{3.21}$$

$$shareC_i^{dom} = \left(b_i^{dom} \cdot \frac{pC_i}{p_i \cdot \left(1 + tax_i^{domC}\right)} \right)^{\sigma_i} \tag{3.22}$$

$$shareC_i^{imp} = \left(\left(1 - b_i^{dom}\right) \cdot \frac{pC_i}{p_i^{imp} \cdot \left(1 + tax_i^{impC}\right)} \right)^{\sigma_i} \tag{3.23}$$

Similar equations to equations (3.20) to (3.23) are valid for public consumptions, investments and intermediate consumptions.

$$p_i^{imp} = wp_i \cdot \left(1 + tax_i^M\right) + \sum_{transport\ mode\ it} wp_{it} \cdot nit_i^{it} \tag{3.24}$$

$$X_i = \left[\psi_i \cdot \frac{wp_i}{p_i \cdot \left(1 + tax_i^X\right)} \right]^{\lambda_i} \cdot \chi_i \tag{3.25}$$

Energy goods

$$C_i = C_i^{dom} + C_i^{imp} \tag{3.26}$$

$$pC_i = shareC_i^{dom} \cdot p_i \cdot \left(1 + tax_i^{domC}\right) + shareC_i^{imp} \cdot p_i^{imp} \cdot \left(1 + tax_i^{impC}\right) \tag{3.27}$$

$$shareC_i^{imp}(t) = \frac{shareC_i^{imp}(t-1) \cdot \left(\frac{p_i^{imp}(t) \cdot \left(1+tax_i^{impC}(t)\right)}{p_i^{imp}(t-1) \cdot \left(1+tax_i^{impC}(t-1)\right)}\right)^{\eta_i^{imp}}}{shareC_i^{imp}(t-1) \cdot \left(\frac{p_i^{imp}(t) \cdot \left(1+tax_i^{impC}(t)\right)}{p_i^{imp}(t-1) \cdot \left(1+tax_i^{impC}(t-1)\right)}\right)^{\eta_i^{imp}} + \left(1 - shareC_i^{imp}(t-1)\right) \cdot \left(\frac{p_i(t) \cdot \left(1+tax_i^{domC}(t)\right)}{p_i(t-1) \cdot \left(1+tax_i^{domC}(t-1)\right)}\right)^{\eta_i^{imp}}} \tag{3.28}$$

$$shareC_i^{dom}(t) = 1 - shareC_i^{imp}(t) \tag{3.29}$$

Similar equations to equations (3.26) to (3.29) are valid for public consumptions, investments and intermediate consumptions.

$$p_i^{imp} = wp_i \cdot \left(1 + tax_i^M\right) + \sum_{transport\ mode\ it} wp_{it} \cdot nit_i^{it} \tag{3.30}$$

3.2 The dynamic modules of Imaclim-R

The purpose of this section is to describe the Nexus of Imaclim-R, which determine technical change through the evolution of production costs and end-use equipments. We start by describing the evolution of the constraints on fossil fuel production (oil, coal, gas) before turning to energy transformation (liquid fuels and electricity). Finally, we turn our attention to the technical coefficients driving final energy consumption in both stationary uses (industry and residential uses) and non-stationary uses (freight and passenger transportation).

3.2.1 Energy transformation

3.2.1.1 Liquid fuels

The "substitutes to oil" Nexus considers two large-scale substitutes to oil for liquid fuel production.

The first large-scale substitute to oil for liquid fuels production consist in first and second generation biofuels from renewable land resources. Their diffusion is controlled by supply curves: at each date, biofuels' market share is an increasing function of oil price, carbon tax included, Sbio(t,poil).[1] This captures, although in a simplistic manner, the competition between biofuels and oil-based liquid fuels: everything else being equal, the former are more competitive and their penetration into the market is more prominent when higher oil price make the latter more expensive. The supply curves include asymptote representing explicit limits on production due to constraints on land availability and competition with other biomass uses. They are modified from one date to the other to account for learning-by-doing improvements. The diffusion of biofuels is in addition submitted to the constraint of a time delay, $\Delta tbio$, which captures inertia on the deployment of raw products (biomass) and of refining capacity.

The second alternative to oil is Coal-To-Liquid (CTL). We consider it as an inexhaustible[2] backstop technology but submitted to capacity constraints. In line with Amigues et al. (1998), production of the inexhaustible substitute starts before all the least-cost deposits of the exhaustible resource are exploited. To capture competition with oil-based fuels, Coal-To-Liquid becomes competitive (and then enters the market) as soon as oil prices (carbon tax included) exceed a threshold value pCTL. To determine their market potential at a given date, CTL producers form (imperfect) anticipations about future agents' endogenous decisions in terms of liquid fuel demand D(t) and supply by other sources (refined oil and biofuels) S(t). CTL producers are then willing

[1] This captures in a simplistic manner the competition between biofuels and oil-based liquid fuels: everything else being equal, the former are more competitive and their penetration into the market is more prominent when higher oil price make the latter more expensive.

[2] We assume that coal is a sufficiently abundant input factor.

to fill the expected gap by targeting a production level [D(t)-S(t)]. But, CTL production may be limited by constraints on delivery capacity due to past investment decisions if, due to imperfect foresight, profitability prospects for CTL were underestimated. These prospects are an increasing function of oil prices at each point in time[3] and cumulative investment on CTL over time is then a function of the sum of past oil prices: , where the time delay $\Delta tCTL$ represents investment inertia. The dynamics of investment affects the availability of production capacity and imposes limits on the share s of the targeted CTL production that can be realized at a given date. We adopt a linear dependence between s and cumulative investments measured by. As soon as the oil price exceeds pCTL , the contribution of CTL to the supply on liquid fuel markets is given by:

$$CTL(t) = s\left(p_{cum}(t)\right)\left[D(t) - S(t)\right]. \tag{3.31}$$

3.2.1.2 Electricity generation

The “power generation” Nexus represents an explicit set of standard technologies, either already active or close to maturity.[4] Each of them is characterized by its technico-economic parameters determining the average production discounted cost per kilowatt hour produced. These parameters are: capital costs (dollars per kilowatt installed), energy efficiency (in percentage, for technologies functioning with fossil fuels), exploitation and maintenance costs, fixed or variable costs (respectively in dollars per kilowatt and in dollars per kilowatt hour). The discount rate incorporates capital opportunity cost and a risk factor, which covers both the risk of defect and the social risk associated to controversial technologies (nuclear, CCS). The technico-economic parameters are calibrated either on sectoral technological models (for example the POLES model) or on information from the literature (Grübler et al., 2003; Rao et al., 2006; Sims et al., 2007). They evolve in time according to technical progress, including learning-by doing processes.

Technological choices are based on a investment procedure for profit maximization given the average production total cost compatible with future electricity demand across 179 segments of the load curve, representing the annual fluctuations of electricity demand.[5] This investment procedure for choosing power generation technologies under imperfect anticipations is decomposed into four steps:

- projecting future demand and fuel prices with adaptive anticipations of electricity demand growth over the coming technologies lifetime years and with future fossil fuels prices.
- choosing renewable production production distinguished between hydroelectricity and onshore and offshore wind, especially peak hydropower production. This share of renewables is bounded by the saturation of production potentials and the limits of intermittent production.
- projecting the optimal investment for the conventional production park under demand constraint by comparison of unitary discounted profit among technologies.
- allocating investments to reorient the existing production park towards the expectedly profit-maximizing production park under the constraints of available capital.

New investment choices affect total production capacity only at the margin, given the inertia in the renewal of the park. We represent the park in capital vintages, and a formerly installed production unit remains available for a certain period in function of its life time. However, available capacities are not necessary mobilized for actual production, which is allocated to production units ensuring lower operational costs. This choice is differentiated along the seven segments of the load curve to represent the different mix of technologies for base and peak production. This assumption allows representing operational flexibility through early retirement of those capacities that, although installed, are not profitable in current economic conditions.

[3]Indeed, higher oil prices drive higher prices of liquid fuels, including those produced from coal, and then higher profitability prospects for CTL.

[4]Coal-powered units, two gas-powered units (Gas Conventional Thermal, Gas Turbines Combined Cycle), two oil-powered units (Oil Conventional Thermal, Oil Fired Gas Turbines), two nuclear technologies (standard and new design – EPR), renewables (hydropower, onshore wind, offshore wind, solar thermal and solar PV, and biomass). In addition, one technology with CCS is available for coal- and gas-powered units, respectively.

[5]The six segments are divided according to broad categories of annual load length defined by 179 threshold values between 0h and full year operation (8760h): 40 1-hour segments, 138 60-hours segment and a residual base segment.

3.2.2 Final energy demand

Historically, the literature on the decoupling between energy and growth has focused on autonomous energy efficiency improvements (implicitly encompassing end-use energy efficiency and structural changes) and on the energy efficiency gap, i.e. the difference between the most energy efficient technologies available and those actually in use.

However important it may be, energy efficiency is not the only driver of energy demand. Indeed, the rate and direction of technical progress and its energy content depend, not only on the transformation of the set of available techniques, but also on the structure of households' demand. This is why the NEXUS endogenize both energy efficiency *stricto sensu*, and the structural change resulting from the interplay between consumption,technology and localization patterns. This enables us to capture the effect of non-energy determinants of energy demand, such as the prices of land and real estate, and political bargaining (set exogenously) over urban infrastructure to be represented. This endogenization of technical change is made for both stationary uses (industry and services, buildings) and non-stationary uses (freight and passenger transportation).

3.2.2.1 Stationary uses

3.2.2.1.1 Industry and services

The industrial and services sectors are represented in an aggregated manner, each of them covering a large variety of economic sub-sectors and products. Technical change then covers not only changes and technical progress in each sub-sector but also the structural effects across sectors. In addition to autonomous energy efficiency gains, the "Industry" and "services" Nexus represent the structural decrease in energy intensity due to a progressive transition from energy-intensive heavy industries to manufacturing industries, and the choice of new techniques which results in both energy efficiency gains and changes in the energy mix.

On the one hand, the progressive switch from industry to services is controlled by saturation levels of per capita consumption of industrial goods (in physical terms, not necessarily in value terms), via an asymptote at κ_{ind} multiplied by its level in 2001. For developing countries, these saturation levels represent various types of catch-up to the consumption style in developed countries.

On the other hand, changes of techniques are driven by operational costs, including energy costs and the other costs linked to their use (capital, maintenance, variable costs). The share of each energy in the new capacities is decided in a logistic function with arguments the total cost of using each energy source and a market heterogeneity parameter measuring the substitutability potentials. In these sectors, these decisions affect the selection of new production capacities but do not influence existing ones. This putty-clay assumption implies that changes in final energy use are dependent on the turnover rate of production capacities, defined by their lifetime Δt_{ind}.

3.2.2.1.2 Buildings

The 'Housing and Buildings' nexus represents the dynamics of energy consumption as a function of the energy service level per square meter (heating, cooling, etc.) and the total housing surface. It was developed by Giraudet et al. (2011).

The former is represented by coefficients encompassing the technical characteristics of the existing stock of end-use equipment and buildings and the increase in demand for energy services: heating, cooking, hot water, lighting, air conditioning, refrigeration and freezing and electrical appliances. The evolution of resulting energyneeds per square meter is captured by coefficients for coal $\alpha^{res}_{coal}(t)$, gas $\alpha^{res}_{gas}(t)$, liquid fuels $\alpha^{res}_{fuel}(t)$ and electricity $\alpha^{res}_{elec}(t)$.

We also account for the diffusion of "Very Low Energy" buildings at very high energy price, carbon price included. They are represented by a unique alternative housing with annual energy consumption at 50kWh/m2 (80% electricity and 20% gas). The diffusion of this technology in rupture with current trends represents implicitly a multiplicity of advancements, including the autonomous production of energy, the efficient insulation of buildings but also large plans of thermal renovation and regulations reforms in developing countries.

Housing surface per capita has an income elasticity of η_H, and region-specific asymptotes for the floor area per capita, hmax. This limit reflects spatial constraints, cultural habits as well as assumptions about future development styles (including the lifestyles in emerging countries vis-à-vis the US, European or Japanese way of life). In the constitution of scenarios, the hypotheses about these asymptotes are made coherent with those concerning the infrastructures of transport, keeping in mind that all are linked to territorial and urban zoning policies.

3.2.2.2 Non-Stationary uses

3.2.2.2.1 Freight transport

In the "Transportation NEXUS", the dynamics of the energy intensity of freight transport is driven by an exogenous trend $\mu_f(t)$ and a short-term fuel price elasticity ϵ_f. They capture autonomous and endogenous energy efficiency gains as well as short-term modal shifts, with the long-term price response resulting from the sequence of those short-term adjustments.

Total energy demand is then driven by freight mobility needs, in turn depending on the level of economic activities and their freight content. Even though the share of transportation in total costs is currently low,decoupling freight mobility demand and economic growth is an important determinant of long-term mitigation costs. In the absence of such a decoupling (constant input-output coefficient), and once efficiency potentials in freight transportation have been exhausted, constraining sectoral carbon emissions from freight transportation would amount to constraining economic activity.

3.2.2.2.2 Passenger transport

Passenger mobility needs and their modal breakdown across four travel modes (ground-based public transport, air transport, private vehicles and non-motorized modes) result from the maximization of households' utility under the assumption of constant travel time (Zahavi and Talvitie, 1980) and budget constraints. This helps to represent two crucial determinants of the demand for passenger transportation, namely the induction of mobility demand by infrastructure and the conventional rebound effect consecutive to energy efficiency gains on vehicles (Greening et al., 2000).

The former effect operates through the travel time budget constraint. Indeed, the attractiveness of each transportation mode is determined by vehicle performance and the degree of infrastructure saturation. When mobility demand exceeds the normal load conditions of a given type of infrastructure (e.g., road, airport), speed decreases. In the absence of further investment, households will reallocate their travel time budget to other, more efficient, modes in order to restore efficiency. We can represent the effects of the deployment of alternative infrastructure: a policy in which the building of transportation infrastructure follows the evolution of modal mobility favoring roads for private car mobility vs. public policies that redirect part of the investment to railways and other public transport infrastructure.

A drop in mobility costs (mainly the user's car costs), along with progress in the energy efficiency of vehicles, endogenously generates are bound effect on mobility demand as a result of utility-maximization under income budget constraint. Energy efficiency in private vehicles results from households' decisions on the purchase of new vehicles, based on a mean cost minimization criterion between different types of available technologies (including standard, hybrid and electric vehicles). These vehicles types are differentiated by their capital costs and unitary fuel consumption, the former decreasing in function of the learning-by-doing process at the rate γ for each doubling of cumulated investment in the technology.

In addition to the availability of transportation infrastructure and energy efficiency, mobility needs are dependent upon agents' localization choices (Grazi et al., 2008). This is captured by differences in regional households' motorization rates, everything else being equal (income, energy prices), with dispersed spatial organizations implying a higher dependence on private transport. In each region, the motorization rates increase with disposable per capita income through variable income elasticity η_{mot}: (a)low for very poor people whose access to motorized mobility relies on non-motorized and public modes; (b) high for households with a medium per capita income with access to private motorized mobility (c) low again,because of saturation effects, for per capita income level comparable to that of the OECD. In addition, the impact of local location choices is represented through basic needs of mobility, which represent the travels imposed by daily journeys (especially, for commuting to work and access to services).

3.3 Data

3.3.1 Calibration

Calibration of the Imaclim-R model is based on the French national accounts, which provides a set of balanced input-output tables of the French economy. In addition, national energy statistics were used to provide consistency with monetary flows.

From this basic material, calibration is done by aggregating the national accounts database according to the Imaclim-R mapping in 15 sectors and by embarking information from external datasets giving physical quantities for energy and passenger transportation sectors. This hybrid matrix ensuring consistency between money flows and physical quantities is built by modifying input-output tables to make them fully compatible with 2004 energy balances (in Mtoe) and passenger mobility (in passenger-km) from (Schafer and Victor, 2000). This forcing ensures that energy and mobility quantities are preserved, but brings about some adjustments in the input-output tables to restore sectoral supply-use equilibrium conditions in monetary values. This last step is done by reporting the gap in equilibrium conditions in the composite sector.

3.3.2 "Natural Growth" drivers

The natural growth rate of the economy defines the growth rate that the economy would follow if it produced a composite good at full employment, like in standard neoclassical models developed after Solow (1956). It is given by exogenous assumptions on active population and labor productivity growth. Demographic data for active population are derived from medium UN scenario (UN, 2007) and are summarized in table 3.3.

Year	Millions
2004	24.8
2010	25.4
2020	25.5
2030	25.4
2040	25.8
2050	25.9

Table 3.3: Active population in the Imaclim-R France model

Labor productivity growth is built upon a convergence hypothesis (Barro and Sala-i-Martin, 1992), the parameters being calibrated on historic trajectories (Maddison, 1995) and "educated guess" assumptions of long-term trends (Oliveira-Martins et al., 2005). Basically, we assume that USA remains the world leader in productivity per worker with a steady growth of 1.7% per year, whereas the dynamics of productivity in other countries is driven by a partial catch-up. This means that regions with lower absolute productivity per worker in a country experience the faster labor productivity growth (see table 3.4).

Period	%
2010 - 2020	1.7
2020 - 2030	1.5
2030 - 2040	1.2
2040 - 2050	1.0

Table 3.4: Average labor productivity growth in the Imaclim-R model

3.4 An analytical analysis of the drivers of mitigation costs in second best economies

We detail here the simplified model used to identify the major determinants of mitigation costs in the Imaclim-R model. To this end, we incorporate the core specificities of second-best macroeconomic interactions in the static equilibrium of the Imaclim-R model: imperfect competition and imperfect labor markets. To ensure analytical resolution, we consider an economy producing a composite good with energy and labor as input factors.

Imperfect competition is represented through a mark-up pricing rule for the composite good resulting in a margin rate π over production costs:

$$p = p_E \cdot e \cdot (1 + \tau_E) + w \cdot l + \pi \cdot p \tag{3.32}$$

where e and l are the unitary energy and labor requirements for production, p_E the price of energy, τ_E a tax on energy (taken as a proxy for a carbon tax in case of climate policy) and w the wage rate.[6]

Imperfect labor markets are described by a wage curve introducing an inverse relationship between the real wage rate and unemployment (or under-utilization of the labor force).[7] With Q the total production and L the total labor force, the unemployment rate z is:

$$z = 1 - \frac{l \cdot Q}{L} \tag{3.33}$$

The wage curve is then given by:

$$\frac{w}{p} = a \cdot z^{-\alpha} \tag{3.34}$$

where, a is a constant and $\alpha > 0$ is the elasticity of the wage curve: the higher α, the more flexible the labor markets.

We introduce Q_0, w_0 and z_0 as the production level, the real wage rate and the unemployment rate in absence of carbon tax. They are implicitly defined by:

$$p_E \cdot e \cdot (1 + \tau_E) + w \cdot l = p_E \cdot e + w_0 \cdot l \tag{3.35}$$

$$\frac{p_E \cdot e \cdot \tau_E}{w_0 \cdot l} + \left(\frac{z}{z_0}\right)^{-\alpha} = 1 \tag{3.36}$$

$$\frac{L}{l} = \frac{Q_0}{1 - z_0} \tag{3.37}$$

Combining equations (3.33) to (3.37), the production level Q can then be derived as: (SM-44)

$$Q = \frac{Q_0}{1 - z_0} \cdot \left[1 - z_0 \left(1 - \frac{p_E \cdot e \cdot \tau_E}{w_0 \cdot l}\right)^{-\frac{1}{\alpha}}\right] \tag{3.38}$$

The variation of activity $\Delta Q = Q - Q_0$ is then given by:

$$\frac{\Delta Q}{Q_0} = \frac{z_0}{1 - z_0} \cdot \left[1 - \left(1 - \frac{p_E \cdot e \cdot \tau_E}{w_0 \cdot l}\right)^{-\frac{1}{\alpha}}\right] \tag{3.39}$$

[6] Equation (3.32) is a simplified version of the price equation in IMACLIM-R, which incorporates a term of decreasing static returns when production capacity approaches saturation (see Section 3.1 above).

[7] Microeconometric evidence for such formulation was given in a seminal contribution by Blanchflower and Oswald (1995) and extensive theories have been developed to support such representation of the labour market (see (Layard et al., 2005; Lindbeck, 1993; Phelps, 1992) for an overview). The basic idea is that high unemployment represents an outside threat that leads workers to accept lower wages as from either the bargaining approach (Layard and Nickell, 1986) or the wage-efficiency approach (Shapiro and Stiglitz, 1984). The former emphasizes the weakening of the power of workers' unions in wage setting negotiations at high unemployment. The latter adopts firms' point of view, who set wages so as to discourage shirking; this level is lower when the threat of not finding a job after being caught shirking gets higher.

Bibliography

Amigues, J. P., Favard, P., Gaudet, G., and Moreaux, M. 1998. On the optimal order of natural resource use when the capacity of the inexhaustible substitute is limited. *Journal of Economic Theory* 80:153–170. 170

Barro, R. J. and Sala-i-Martin, X. 1992. Convergence. *Journal of political Economy* pp. 223–251. 174

Blanchflower, D. G. and Oswald, A. J. 1995. An introduction to the wage curve. *The Journal of Economic Perspectives* 9:153–167. 175

Giraudet, L. G., Guivarch, C., and Quirion, P. 2011. Exploring the potential for energy conservation in french households through hybrid modelling, in revision in. *Energy* . 172

Grazi, F., Bergh, J. C., and Ommeren, J. 2008. An empirical analysis of urban form, transport, and global warming. *The Energy Journal* 29:97–122. 173

Greening, L., Greene, D., and Difiglio, C. 2000. Energy efficiency and consumption—the rebound effect—a survey. *Energy policy* 28:389–401. 173

Grübler, A., Nakićenović, N., and Nordhaus, W. D. 2003. Technical Change and the Environment. IIASA, Laxenburg, Austria. 171

Layard, R., Layard, P. R., Nickell, S. J., and Jackman, R. 2005. Unemployment: macroeconomic performance and the labour market. Oxford University Press. 175

Layard, R. and Nickell, S. 1986. Unemployment in britain. *Economica* 53:121–169. 175

Lindbeck, A. 1993. Unemployment and macroeconomics, volume 3. MIT Press. 175

Maddison, A. 1995. Monitoring the world economy, 1820-1992. OECD Development Center. 174

Oliveira-Martins, J., Gonand, F., Antolin, P., De la Maisonneuve, C., and Yoo, K. Y. 2005. The impact of ageing on demand, factor markets and growth. Technical Report 420, OECD Economics Department. 174

Phelps, E. S. 1992. Consumer demand and equilibrium unemployment in a working model of the customer-market incentive-wage economy. *The Quarterly Journal of Economics* 107:1003–1032. 175

Rao, S., Keppo, I., and Riahi, K. 2006. Importance of technological change and spillovers in long-term climate policy. *The Energy Journal* 1:123–140. 171

Schafer, A. and Victor, D. G. 2000. The future mobility of the world population. *Transportation Research Part A: Policy and Practice* 34:171–205. 174

Shapiro, C. and Stiglitz, J. E. 1984. Equilibrium unemployment as a worker discipline device. *The American Economic Review* 74:433–444. 175

Sims, R., Schock, R. N., Adegbululgbe, A., Fenhann, J., Konstantinaviciute, I., Moomaw, W., Nimir, H. B., Schlamadinger, B., Torres-Martinez, J., and Turner, C. 2007. Energy supply Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. 171

Solow, R. M. 1956. A contribution to the theory of economic growth. *The quarterly journal of economics* 70:65–94. 174

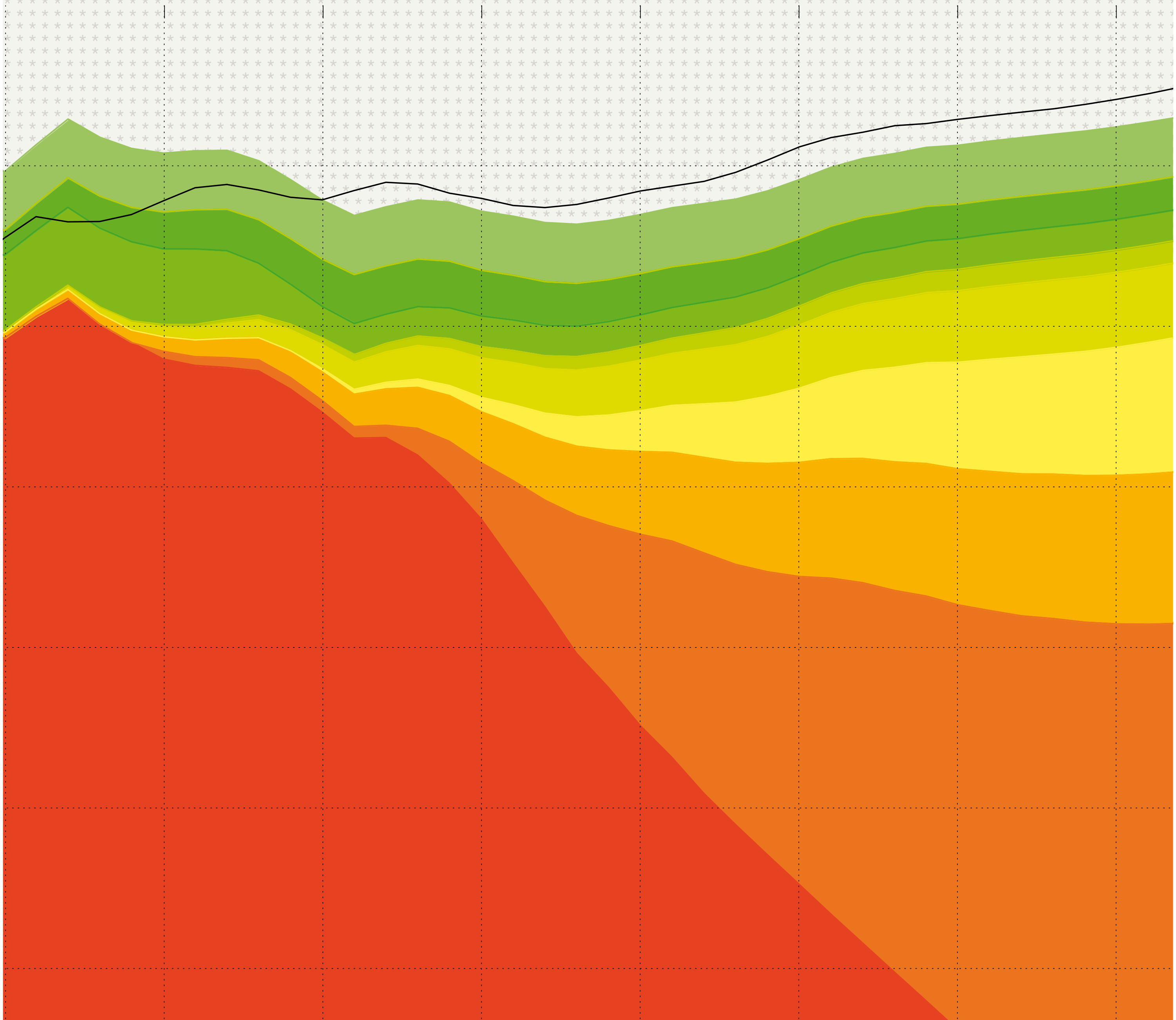
Zahavi, Y. and Talvitie, A. 1980. Regularities in travel time and money expenditures. *Transportation research record* . 173

Chapter 4

Scenarios analyses

Building a low carbon scenario for France

How a participatory approach can enhance social and economic acceptability



Contents

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Introduction This publication presents the French case study of the European ENCI-LowCarb research project: **Engaging Civil Society in Low Carbon scenarios**[1].

1

The core activity of this project was the development of a methodology for the transparent integration of stakeholders' contributions in the scenario design process to enhance the stakeholders' acceptance of the resulting low carbon pathways. This attempt at integrating acceptability in scenario-making constitutes an important step to distinguish what is technically and economically feasible from what is acceptable. Today, a wide range of published scenarios emphasize the fact that they are built on public consultations or stakeholders' contributions. However, transparency is lacking concerning the methodology relative to how contributions were taken into account and translated into assumptions that can be used by the modeling tool. The project ENCI-LowCarb aimed at exploring this scientific gap.

Energy scenarios outline possible low-carbon futures built around assumptions on fossil fuels prices evolution, technological choices and the mechanisms of energy demand and supply, among others. Scenarios are influential tools in political decision-making processes since they shed light on the long-term impacts of today's investment decisions, especially regarding infrastructures. This is why it is crucial that these pathways derive from discussions with main stakeholders.

In this report, the French project team (CIRED and RAC-F) has the pleasure to present energy scenarios for France which derive from a collaborative scenario design process including the participation of a wide range of French stakeholders (civil society organizations including trade unions and non-governmental organizations, private companies, banks, statewide and local authorities).

Participating stakeholders were asked to define or select acceptable CO_2 emissions mitigation measures. Their contributions were implemented in the technico-economic model Imaclim-R France to create a scenario that is economically and technically consistent as well as acceptable by stakeholders. This methodology allowed an assessment of the level of achievable emissions reductions with stakeholders' «acceptable» measures.

This project report is organized as follows: **part 2** presents the methodology of the collaborative scenario design process in detail, **part 3** describes the low carbon scenario – the outcome of the stakeholder discussions. **In part 4**, other drivers of CO_2 emissions and additional measures are explored. Chapter 5 introduces additional sensivitity analysis. **Part 6** concludes.

The energy scenarios presented in this report do not reflect the views of CIRED or RAC. The "acceptable" scenario derives from the outcome of the stakeholders' group discussions, without necessarily representing the vision of any individual stakeholder. In addition, further analyzes carried out depart from the "acceptable" scenario to explore uncertainties and possible measures to reach ambitious mitigation targets. The analyzes contained in this report are based on the results of modeling exercises carried out with the Imaclim-R model, which is designed to provide a coherent picture of energy and economy at a medium and long-term horizon. The various scenarios considered in this document represent coherent technico-economic pathways resulting from technical, economic and behavioral assumptions incorporated in the Imaclim-R framework after discussions with stakeholders and sectoral experts. In such a modeling approach, the quantitative figures given as model outcomes have no predictive value, but serve as a basis for characterizing and revealing the major mechanisms at play in the complex dynamic system made of several economic sectors and agents linked by multiple socio-economic interactions.

1- *The project (April 2009 – March 2012) was funded by the 7th Framework Program for research of the European Commission. The project team consisted of two research institutes – CIRED and PIK – as well as three NGOs – RAC-France (coordinator), Germanwatch and INFORSE-Europe. More information on the project: www.enci-lowcarb.eu*

2

Methodology: steps towards a "collaborative scenario design"

I. The need for involving stakeholders

Many energy scenarios are based on public or stakeholders consultations. However, few attribute importance to the scenario design process and explain in a transparent way how contributions are taken into account and integrated in a modeling tool, that is to say how the translation process was carried out from an idea supported by contributors to its representation in the modeling tool.

A first question one might ask is: "Why is stakeholder involvement important when discussing energy scenarios?" First, most stakeholders can provide additional expertise to the technical and economic hypotheses as well as initiate discussions around sensitive issues. Second, the exchanges with stakeholders bring to light the main cleavages and obstacles to reaching a decarbonized society. Thus, the dialogue can lead to finding a common ground for possible solutions and outlining a robust strategy. Finally, consultation with stakeholders enhances the ownership of the created scenarios by the stakeholders.

In conclusion, there are many reasons why stakeholders should be consulted and if possible actively integrated in the scenario-making process. Today, the challenge is to avoid limiting the influence of stakeholders to a non-interactive communication (as in the case of online consultations). If scenarios aim at representing the contributions of stakeholders, a deeper thought has to be given to the design of the process to make it interactive. Gathering people for multi-stakeholder discussions, collecting their contributions and then elaborating the scenario behind closed doors can be a source of disengagement for participating stakeholders.

Therefore, the innovation of the ENCI-LowCarb project resides less in the resulting energy scenarios than in the process itself. The project hypothesis consisted in stating that if national stakeholders can recognize their contributions in the resulting scenarios (even if those were amended by the contributions of others), they would eventually be more supportive of this scenario than in a case where a non-transparent procedure was followed. Using collaborative procedures can increase stakeholders' acceptance and generate political support for energy scenarios and the resulting policy measures. Reaching this positive outcome also implies more involvement for both stakeholders and modelers – particularly in terms of time and shared understanding of the issues at stake and of the functioning of the used modeling tool.

A transparent stakeholder consultation process requires the existence of a common ground: model parameters and input variables of the model have to be carefully translated into tangible, real-life, implications which stakeholders can assess. The considerations emerging from the stakeholder consultation can then be translated back into technical model parameters, i.e. political framework conditions, which will result in different low carbon energy system scenarios. This "translation work" is necessary to work with such modeling tools and needs a considerable effort of communication to avoid the feeling that all contributions are entering a black box without any traceability.

The modeling work of this project was following two main principles:

* **Acceptance:** Reaching a maximum degree of stakeholders' acceptance.
* **Realism:** Satisfying technical and economic limits.

Social acceptance or stakeholders' acceptance?

Within the frame of the ENCI-LowCarb project it was not possible to evaluate "social acceptance", and the focus was rather on "stakeholders' acceptance". Social acceptance has different aspects that cannot be assessed with the available project tools. In the context of energy system strategies, social acceptance has three dimensions (Wüstenhagen 2007)[2]: (i) socio-political acceptance, referring to the acceptance of technologies and policies by the public, key stakeholders and policy-makers, (ii) community acceptance of site-specific local projects and (iii) market acceptance, referring to the process of the adoption by consumers and investors of innovative low-emission products. Community acceptance is a highly important topic concerning the building of new energy infrastructure (electricity grid, windmills, nuclear waste deposals etc.) but it cannot be directly represented in a modeling tool with no spatial dimension.

Within the ENCI-LowCarb project, one challenge was the use of macro-economic hybrid models for the scenario design task (IMACLIM-R[3] and REMIND-R[4]), which are often characterized as "black-boxes"[5]. This implies at least a basic introduction to the model dynamics: What are the main mechanisms? What is the degree of detail of the sectoral representation? What are exogenous and endogenous variables? etc). The form of the modeling tool indeed shapes the form of the dialogue. *

II. The IMACLIM modeling tool

Imaclim-R France[6] is a computable general equilibrium model. This model was used for the collaborative scenario design process of French energy scenarios within the project ENCI-LowCarb. It models the evolution of the French economy split into 15 sectors: energy sectors (crude oil, refined oil, gas, coal, and electricity), transport sectors (freight terrestrial transport, water transport, air transport, public road passenger transports, and rail passenger transport), construction, energy-intensive industries, agriculture and services.

The Imaclim-R model computes, between 2004 and 2050, the evolution of the economy and the energy system with a strong consistency. This is why Imaclim-R is what is called a hybrid model compared to economic models or to technical models. The first type of models focuses on economic dynamics but includes a weak representation of the energy system. The second type of models focuses on technologies and energy but has a poor representation of economic constraints and dynamics (particularly the interaction between prices and demand for energy and commodities).

In Imaclim-R, energy is explicitly representing both: values and physical quantities so as to capture the specific role of energy sectors and their interaction with the rest of the economy. The existence of explicit physical variables (e.g. number of cars, number of dwellings or energy efficiency of technologies) allows a rigorous incorporation of sector-based information about how final demand and technical systems are transformed by economic incentives. In Imaclim-R, each year the equilibrium provides a snapshot of the economy and gives GDP, sectoral prices, sectoral

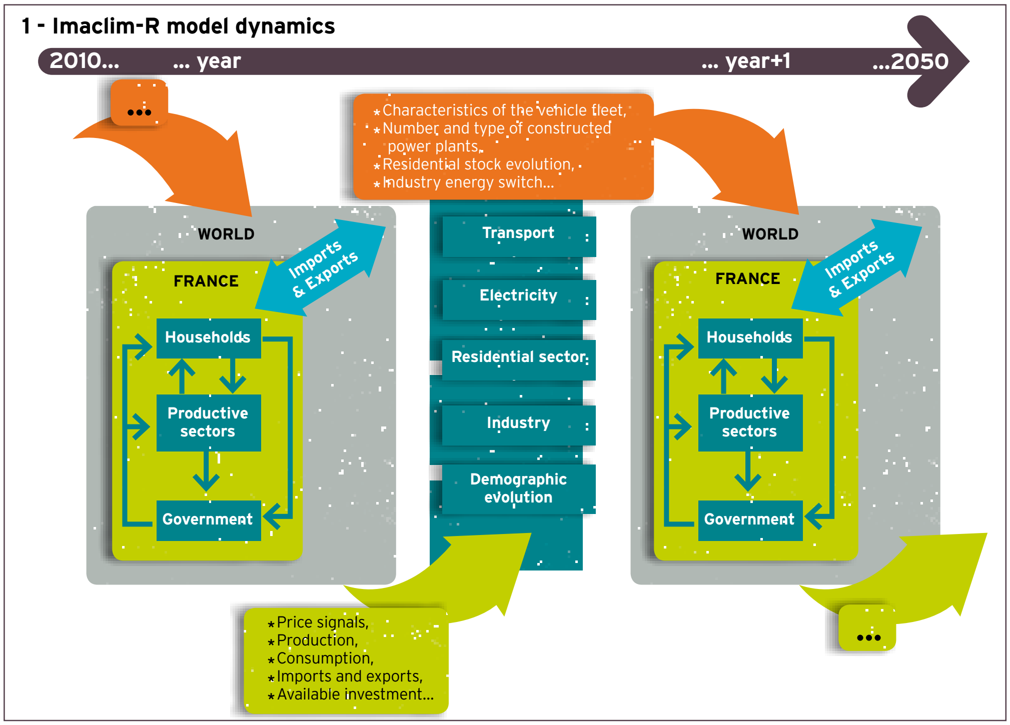
2- *Wüstenhagen R, Wolsink, M, Bürer MJ 2007, 'Social acceptance of renewable energy innovation: An introduction to the concept', Energy Policy, vol. 35, no. 5, pp. 2683-2691.*

3- *www.imaclim.centre-cired.fr/spip.php?article129&lang=env*

4- *www.pik-potsdam.de/research/sustainable-solutions/models/remind*

5- *Sandrine Mathy, Meike Fink, Ruben Bibas (2011): "Quel rôle pour les scénarios Facteur 4 dans la construction de la décision publique ?", Revue Développement Durable et Territoires, Numéro Spécial sur le Facteur 4; Vol. 2, n° 1 | Mars 2011: http://developpementdurable.revues.org/8802*

6- *Imaclim-R France is part of the Imaclim models family developed by the CIRED.*



investments, households consumption in each sector, unemployment rate and international trade. Two successive annual equilibria are linked by "dynamic sectoral modules" such as an electricity module, a residential module, etc. These sectoral modules represent the specific sector dynamics given economic constraints (including available investment in the sector, intermediate consumptions and energy prices) and physical constraints (e.g. inertia in technological infrastructures and appliances limiting the extent of energy efficiency.

Imaclim-R France is an open economy model. Thus, an important modeling assumption is that crude oil, gas and coal prices are exogenous, they are calibrated on the World Energy Outlook report by the International Energy Agency (2011). A limitation of Imaclim-R France is that it computes only energy-related CO_2 emissions. Other greenhouse gases are not represented).

The collaborative scenario design process relies on Imaclim-R France for integrating all the inputs from stakeholders. Therefore, the modeling tool strongly determines the form of the interaction with stakeholders, the format of the meetings as well as the manner to discuss the issues. Indeed, the fact that Imaclim-R is built recursively with dynamic sectoral modules prompted us to organize sectoral experts' meetings first, then sectoral stakeholders meetings so as to embrace the vastness of debates when decarbonizing triggers a structural transformation of the sector. Then, with all the richness of the debate embarked in the model, a step back was taken to look at the interactions between all the different sectors in a cross-sectoral feedback seminar. The following part describes this process in more details. *

III. Description of the collaborative scenario design process

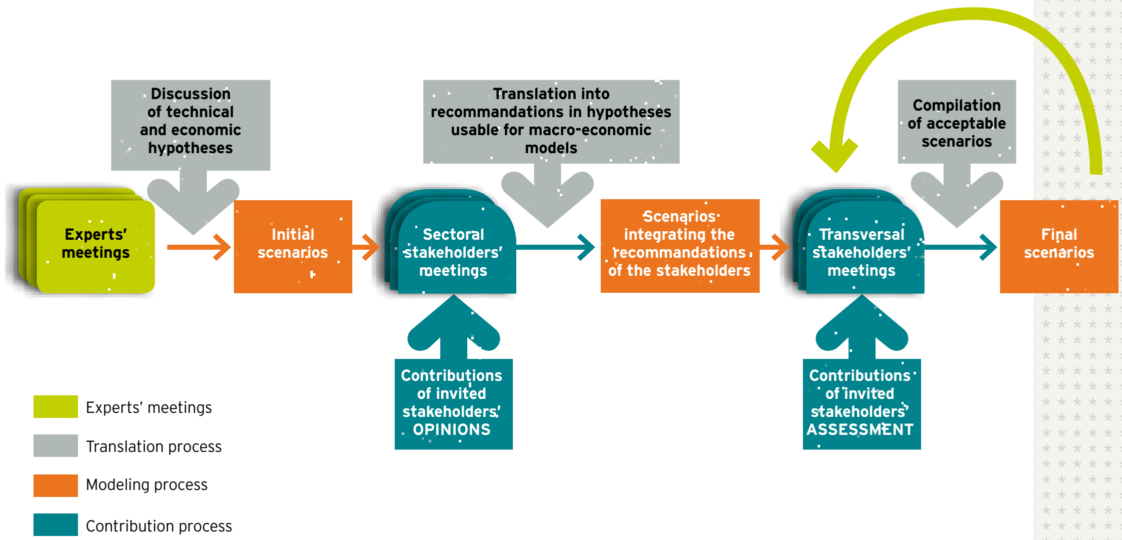
The collaborative scenario design process developed within the project was divided in several steps:

1. Organization of experts' meetings.
2. Stakeholder mapping: Identification of national stakeholders.
3. Organization of sectoral stakeholders' meetings
4. Translation of stakeholders' contributions into model parameters.
5. Organization of a cross-sectoral feedback seminar.

1. Expert meetings

In order to assess the degree of economic and technical realism of the modeling tools, expert meetings were organized in order to correct and update exogenous hypotheses (costs, potentials, investments, learning curves etc.) as well as the dynamics of the models itself: investments in the electricity sector or the dynamics of the residential

2 - Collaborative scenarios creation process



sector. Experts' meetings were organised concerning the residential, transport and power sector.

2. Stakeholder mapping - Identification of the national stakeholders

In order to select and to invite those stakeholders who play an essential role in the energy sectors at stake (residential, transport, electricity), we adopted the methodology of a stakeholder mapping via a "power-interest-grid". Based on this analysis, main stakeholders were identified and a contact list was established.

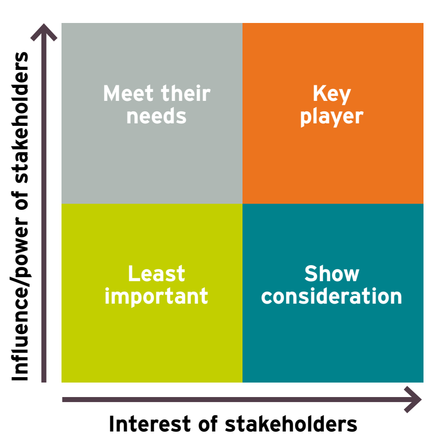
"Power versus interest grids typically help determine which players' interests and power bases must be taken into account in order to address the problem or issue at hand."[7]

The aim of the ENCI-Project was to select mainly those stakeholders situated in the quadrants to the right: "Key-Players" and "Show consideration". As the evaluation concerning the "interest and influence" of specific actors is highly personal, the interviews were repeated with at least three different experts of the concerned sector in order to crosscheck the evaluations.

Structure of the interviews:

I. Discussion on the main sector specific challenges.
II. Establishment of a list of actors, development of a typology of those actors (private companies, ministries, associations, trade unions, banks...).
III. Mapping of the identified actors on the power-interest grid.

3 - Power versus interest grids



3. Organization of sectoral stakeholders' meetings

In order to create scenarios with a high degree of "stakeholder acceptance" the project team ENCI-LowCarb invited the selected representatives of national stakeholder organizations to sector-specific meetings (transport, residential, electricity etc.). During these meetings, stakeholders could express their vision on the evolution of technology choices, policy measures and economic incentives necessary and acceptable to reduce CO_2 emissions. The meetings were recorded to collect a maximum of usable information; all stakeholders answered a questionnaire and minutes were taken from the ongoing discussions.

It was decided to limit the number of stakeholder to 15 to foster in-depth discussions.

The meetings were divided in three steps:

1. Presentation of the project methodology.
2. Gathering input concerning the main sector specific topics.
3. Detailed presentation of several selected subjects and discussion with the invited stakeholders.

A questionnaire was developed for each of the subjects under point three, and energy scenarios were modeled based on the answers of the stakeholders to these questionnaires and the content of the ongoing, moderated discussions.

7- *Bryson, J. (1995) Strategic Planning for Public and Nonprofit Organizations, San Francisco, CA: Jossey- Bass.*

Example of the translation process : residential sector – refurbishment

One of the main obstacles for the refurbishment of houses identified by the stakeholders' is the still predominant aversion of homeowners to refurbish their houses or apartments even if many financial incentives exist. The aversion is even higher if one is non-occupying homeowner. A barrier for owners is that the access to tax incentives and subsidies is conditioned to a high personal financial contribution. Even the access to a zero-interest loan is difficult without collaterals. The stakeholders' recommended solutions to overcome this barrier: the creation of an obligatory refurbishment fund for jointly-owned buildings and a long-term third party financing. As these solutions cannot be integrated one-to-one into the modeling tool, alternative modeling strategies had to be developed. For instance it is possible within the Imaclim-R tool to change the specific "risk-aversion level" of the different agents (occupying and non-occupying homeowners etc.).

The refurbishment obligation did not reach consensus of the majority of stakeholders'. However, an important minority was in favor. In addition, it can be a very impactful tool for triggering the needed structural change in the residential sector. Therefore, the refurbishment obligation was included in the less consensual scenario including additional measures in chapter 4.

4. Translation of stakeholders contributions in modeling parameters

Between the evaluation of the contributions of stakeholders and the modeling exercise, an important step was the translation of the stakeholder visions into model parameters.

The information gathered within the sector specific stakeholder meetings was translated by the project team into model parameters and added together to a first version of the "acceptable mitigation scenarios". Points of disagreement were laid open and handled by the development of scenario variants.

5. Organization of a cross-sectoral feedback seminar

As the first round of stakeholder meetings was sector-specific, the second one was cross-sectoral in order to overcome the artificial separation of energy system related questions between sectors. It is difficult to overlook existing interactions between transport and residential choices concerning topics like "urban sprawl" or electricity and housing related issues considering the question of electric heating. However, it was important to break down the energy system in "sub-sectors" in the beginning in order to be able to define clear visions and policies.

The main objective of the cross-sectoral meeting was to get a feedback on the first version of the "acceptable mitigation scenarios". The stakeholders' comments were then incorporated into the model. Points of disagreement arising from the evaluation of the outcomes of the first meetings were presented in the form of scenario variants.

The emissions reduction in the scenario only based on policy measures that are acceptable in the eyes of at least half of the stakeholders was too low to achieve neither the necessary reduction consistent with the recommendations of the IPPC nor the French objective for 2050 – a reduction about -75% of the emissions against 1990.

Indeed, the policy measures that were judged acceptable only achieved a CO_2 emissions reduction of 68% compared to 1990.

Within the ENCI-LowCarb project, we decided to present in a transparent manner additional measures (section 4) that are not considered acceptable by a majority of the stakeholders but which are necessary to achieve ambitious climate targets. These measures need further political discussion.

An **acceptable** low carbon energy scenario for France

3

Introduction

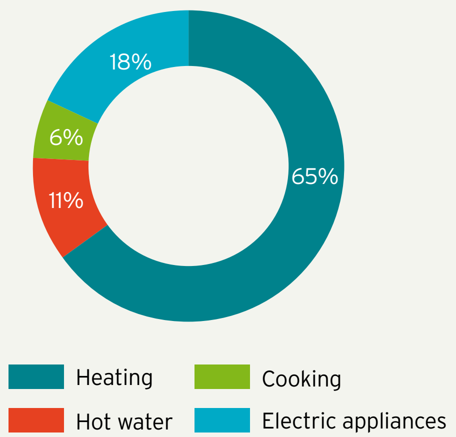
The scenario detailed over the following pages was elaborated with the specific collaborative approach, which was explained in part 2. The technical, economic and political variables that served as input for the scenario were directly defined by the stakeholders in collaboration with the modeling team.

The focus of the project was to evaluate "stakeholder acceptance" rather than "social acceptance" in the broader sense. Indeed, social acceptance goes beyond the project approach as it includes for example the dimension of "local acceptance" and would require a much broader sample of participating stakeholders and even of individual citizens.

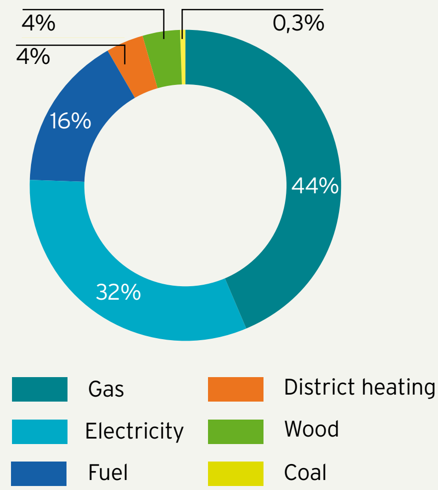
The developed scenario presents a set of policy measures and technical variables that were judged "acceptable" by a majority of the selected stakeholders. The presentation of different elements of the scenario is divided in the following subchapters: residential sector, transport sector, industry and services sector, electricity sector and macroeconomic analysis. The presentation concludes with an overview on the ambition of the energy scenario in terms of CO_2 emissions reductions.

Residential sector

4 - Composition of the residential final energy consumption - 2010



5 - Final energy mix for heating in the residential sector - 2010



The most important energy sources used for heating are gas and electricity, providing 76% of heating for the building stock. Fuel and wood is mostly used in individual housing whereas district heating concerns almost exclusively apartment buildings.

The residential sector in France consists of 32.6 million dwellings, 6% of them being vacant and 10% of them being secondary residencies. 57% are individual houses and 43% apartment buildings. Nearly 60% of the overall building stock has been constructed before the adoption of the first thermal regulation in 1975.

I. Overview

In 2009, the residential sector emitted 16% of the overall CO_2 emissions – this share has remained approximately stable since 1990. However, the emissions of the residential sector increased about 15% in absolute terms. This number goes to 22% if the emissions from electricity production and district heating are included (those are generally counted under "energy industry").

In 2010, the residential sector was responsible for 30% of the final energy consumption. In comparison to 1973, the consumption has increased about 25%, but has remained stable since 2000. The main energy consuming service is heating with 65% of the final energy consumption.

Approximately 30% of all dwellings correspond to the energy efficiency class D. Less than 1% satisfies the criteria for class A and hardly more 3% achieve class B.

The existing building stock has a long lifetime because of the low share of destructions, about 20-30000 dwellings each year. New constructions mainly contribute to the growth of the building stock and not to replace demolished buildings.

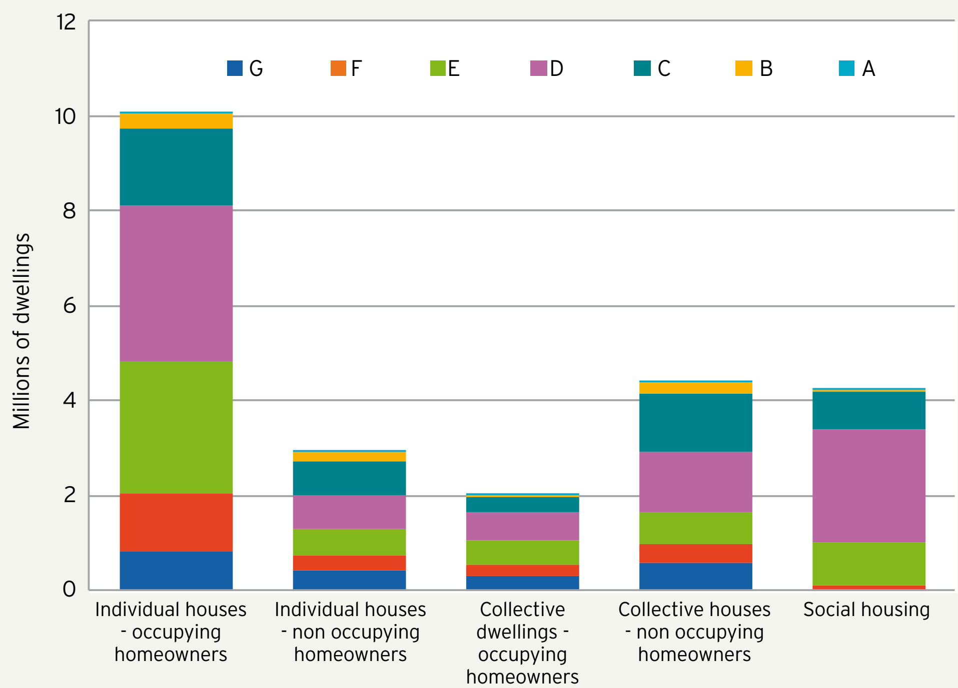
How to increase the performance and rate of refurbishment is the main challenge for climate and energy policies within this sector since two thirds of the residential stock in 2050 are already built!

Climate & energy objectives:

The French legislation includes several objectives concerning the residential sector:

* A reduction about 38% of the primary energy consumption of the residential sector until 2020.
* A 40% reduction of the primary energy consumption of public buildings.
* Refurbishment of all social housing dwellings having a higher energy consumption than 230 kWh primary energy/m^2/year until 2020.
* Up from 2013 an annual refurbishment rate of about 400.000 dwellings.

6 - Building Stock Composition, primary residences in 2007



II. Representation of the residential sector in Imaclim-R

This section gives a short description of the representation of the residential sector in the modeling tool Imaclim-R.

1. Technological representation of the building stock

Imaclim-R describes the dynamics of the French household sector through the construction of new buildings and the retrofitting of the existing ones. Only primary residences are considered here and auxiliary heating appliances are not taken into account (e.g. auxiliary electric heating and firewood for fireplaces). The residential building stock is disaggregated by energy carrier (electricity, gas, fuel oil, wood, coal); by energy class, as labeled by the French energy performance certificate, from A (50kWh/m²/year of primary energy) to G (over 450 kWh/m²/year of primary energy); and by agents and typology of housing (occupying or non-occupying homeowners of individual or collective dwellings and social housing). No explicit technologies are represented. Therefore, implicit packages of measures on the envelope (insulation, glazing) and the heating system reach the various levels of thermal performance. Each year, population growth, increased surface per person and the compensation of some building demolition create a demand for new constructions. The performance of the buildings constructed from 2008 onwards is split into three categories: the 2005 thermal regulation level (from 250 to 120 kWh/m²/year of primary energy, depending on the local climate), starting from 2012 low consumption buildings (50 kWh/m²/year) and zero-energy buildings in 2020, which produce at least as much energy with renewable sources as they consume with energy-efficient appliances.

2. Drivers of energy savings

In existing buildings, energy efficiency improvements result from investments to upgrade existing dwellings to upper energy classes (e.g. transitioning from G to F... until A; from F to E... until A), as well as from fuel substitution. Such transitions include the lifecycle cost of each option, including investment costs and lifetime-discounted energy operating expenditures. Heterogeneous discount rates are used to account for the "landlord-tenant dilemma", which splits incentives between five types of investors: occupying or non-occupying homeowners of individual or collective dwellings, in addition to social housing. Imperfect information is emphasized through the calibration of "intangible costs". The intangible costs add to the overall costs when the agent takes the investment decision but are not paid when actually refurbishing, thus fill the gap between observed technology choices and choices that would be made under perfect information, by estimating the monetary value of this gap. The gap is narrowed in the long-term by a decreasing function of intangible costs with cumulative knowledge, representing information acceleration or the "neighborhood effect". Overall, energy efficiency improvements (i.e. increased quantity and/or quality of retrofits) are derived from changes in the relative profitability of various retrofitting options, induced by energy price increases and sustained by retrofitting cost decrease.

III. Policy measures in the residential sector

1. Tax credits

The purchase of refurbishment elements, which increase energy efficiency like double-glazing, insulation, efficient boilers or heat pumps, is eligible to income tax credits. The rates range from 15 to 50% of investment costs. Increased rates and an extended eligibility base compared to the former subsidy scheme are modeled from 2009 until 2050 through a uniform tax rebate of 30% of the investment. Tax credit for all transitions to upper energy classes are capped at 8,000€ per dwelling.

2. Zero-interest loans for retrofitting actions

0% interest loan apply for retrofit packages with a maximum amount at 30,000€ per dwelling. The credit duration period is about 10 years for individual houses, and 15 years for social housing and collective dwellings.

3. Progressive tariff

This measure aims at reducing electricity consumption by increasing the prices above a fixed base consumption. In the scenario the progressive tariff is applied on all household electricity consumption. For all households, any consumption above 60 kWh/m^2 is paid at an augmented tariff. The prices per additional kWh increase of 5% after 2014 in case the consumption exceeds this limit and of 10% after 2030.

4. Biogas

The biogas penetrates gradually between 2012 and 2050. Its share reaches 17% in the gas in 2050.

5. Thermal regulation for new buildings

From 2012, new constructions respect a maximum primary energy consumption level about 50 kWh/m^2/year of primary energy. After 2020, the standard increases: new buildings have to be net producers of energy.

6. Carbon tax

A carbon tax gives a price signal to reduce highly carbonized energy consumptions and to shift the energy production system to low carbon technologies. The carbon tax used in the project scenario is equal to 32€/tCO_2 in 2012, increasing gradually to 56€/tCO_2 in 2020, to 100€/tCO_2 in 2030, to 200€/tCO_2 in 2040 and to 300€/tCO_2 in 2050. In this scenario, the carbon tax income is given back to households through lump-sum transfers.

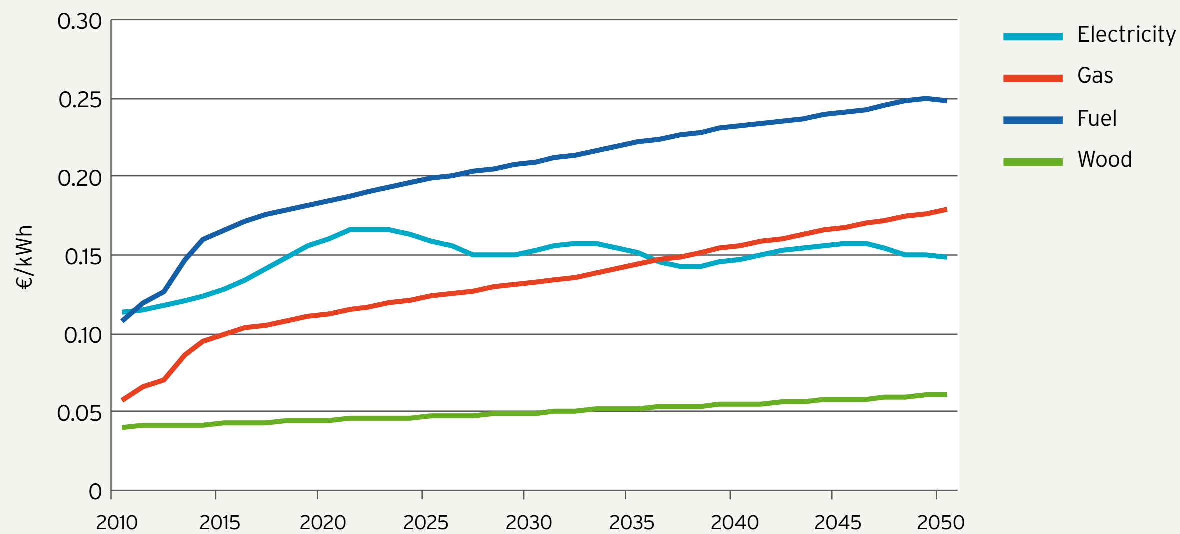
One of the main obstacles for the refurbishment of houses identified by the stakeholders is the still predominant aversion of homeowners to refurbish their houses or apartments even if many financial incentives exist. The aversion is even higher if one is only tenant. A barrier for owners is that the access to tax incentives and subsidies is conditioned to a high personal financial contribution. Even the access to a zero-interest loan is difficult without collaterals. The stakeholders recommended solutions to overcome this barrier: the creation of an obligatory refurbishment fund for jointly-owned buildings and a long-term third party financing. As these solutions cannot be integrated one-to-one into the modeling tool, alternative modeling strategies had to be developed. For instance it is possible within the Imaclim-R tool to change the specific "risk-aversion level" of the different agents (house owners, occupying and non-occupying homeowners etc.).

The refurbishment obligation did not reach consensus of the majority of stakeholders.In addition, it can be a very impactful tool for triggering the needed structural change in the residential sector. Therefore, the refurbishment obligation was included in a scenario with additional measures in section 4.

IV. Evolution of energy consumption in the residential sector

Energy efficiency gains arise from retrofitting of inefficient dwellings and from fuel switches. Over the scenario period, the existing building stock shows a progressive disappearance of the

7 - Final energy consumer prices in the residential sector



low-efficiency classes G to D, and a gradual penetration of classes C due to economic incentives and learning-by-doing which decreases retrofitting costs. Most of the retrofitted stock reaches class C in 2050. Nearly no ambitious retrofit to class B or A appear, since these retrofitting options remain too costly for households given the economic incentives and energy prices in the scenario. Even the existence of an obligatory renovation fund for jointly-owned buildings and the availability of third-party financing do not decrease the risk aversion of the owners of individual houses and jointly-owned buildings enough to make such ambitious transitions happen. The pace of the transition is highest for social housing, this being consistent with the French legislation which requires refurbishment of all social housing to reduce the energy consumption of the dwellings exceeding 230 kWh/m²/year before 2020 to 150 kWh/m²/year[8]. Furthermore, this share of the residential building park is the most structured and is not facing the same challenges as it is the case for jointly-owned buildings were complicate decision making procedures delay action.

The graphs on page 14 and 15 illustrate the transformation of the residential building stock according to the energy label transitions and the evolution of the energy mix for individual houses, social housing, jointly-owned buildings and new constructions. In all subcategories of existing buildings, transitions to upper energy classes appear jointly with an important energy substitution from gas and fuel towards electricity for heating that corresponds in the model to a significant penetration of heat pumps (7 millions). This substitution is driven by the evolution of relative final energy consumption prices.

At the end of the period, final energy consumption per square meter for heating is divided by 3.2, total final energy for heating by 2.4 and total primary energy for heating by 1.8.

Given a behavior function, the model computes[9] the gap between the theoretical energy consumption for heating and real energy consumption after a retrofit action or in new energy efficient buildings, e.g. the rebound effect. In this scenario, given the assumptions of high global prices for fossil energy, and additional fiscal measures (progressive tariffs on electricity and carbon tax on fuel and gas), the rebound effect is quite limited. It is negative until 2034 and is limited to 4% on final energy consumption in 2042.

Concerning energy uses other than primary heating in residential, the shares of gas and fuel (mainly for cooking and for secondary heating devices) remain stable. The specific electricity[10] consumption slightly increases until 2050 (+24% compared to 2010). This evolution is the combined effect of improved energy efficiency (autonomous following current trends and induced by a 40% increase in electricity prices between 2010 and 2020) which is more than compensated by the development of new electric appliances mainly multimedia devices and the population increase (+15%).

Globally, the final energy consumption (heating and other uses) per capita is divided by 2 and the total final energy consumption decreases by 37% between 2010 and 2050. The CO_2 emissions of the residential sector (excluding electricity emissions that are included in the power sector) decrease of 75% between 2010 and 2050. *

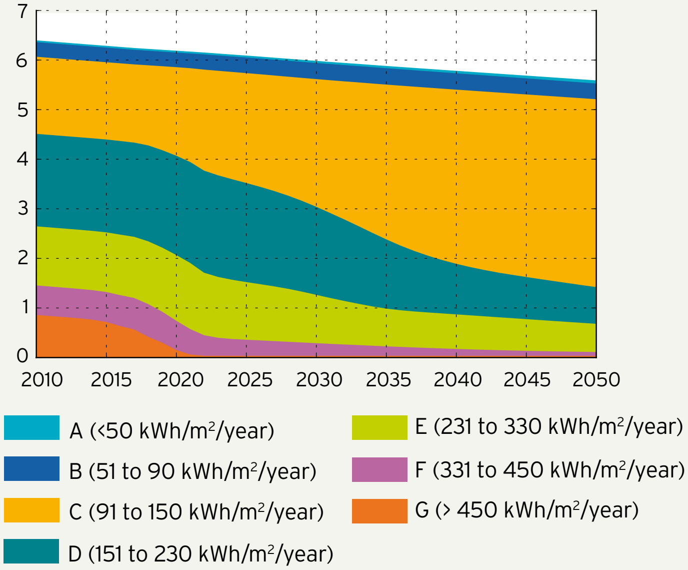
8- *These figures correspond to primary energy.*

9- *The model builds on a logistic relation that links the "service factor" (which reflects the gap between effective and conventional energy consumption) to the annual heating expenditure, as a proxy for the price of the heating service. It states that the higher the efficiency of the dwelling, the higher the service factor, thus inducing sufficiency relaxation. Conversely, the higher the energy price, the lower the service factor, thus inducing sufficiency strengthening. Investments that move a dwelling from a domain of low efficiency to a domain of higher one (e.g. from class F to class C) increase the service factor, i.e. induce a rebound effect. Similarly, switching from a given energy carrier to one fuelled by a cheaper energy (e.g. from fuel to wood) within the same efficiency domain implies a higher service factor.*

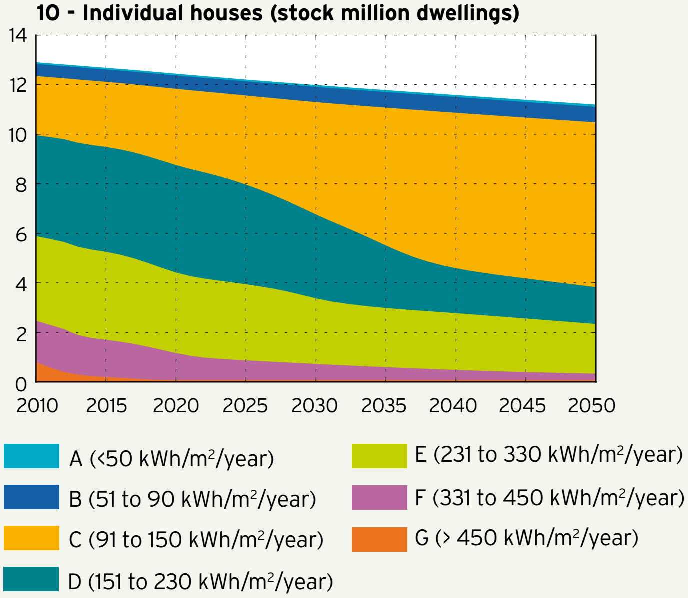
10- *Specific electricity refers to electric consumption in other residential uses, mainly electric appliances, including secondary heaters.*

ENERGY LABELS

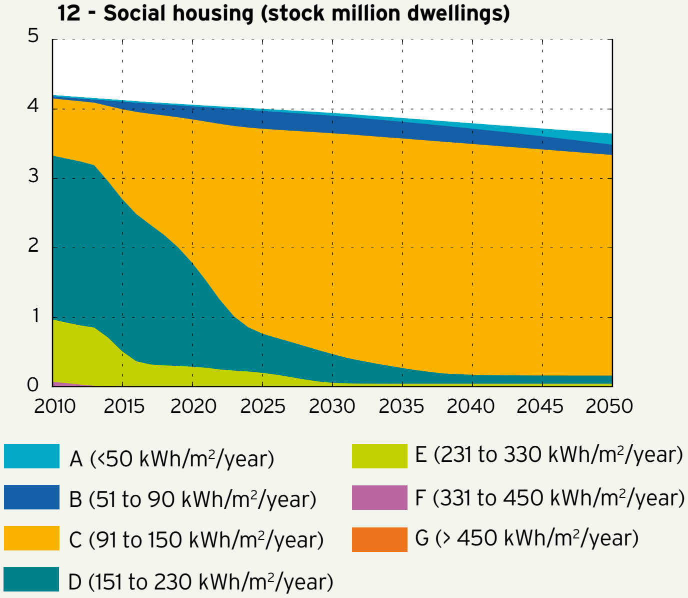
8 - Jointly-owned housing stock (million dwellings)



10 - Individual houses (stock million dwellings)

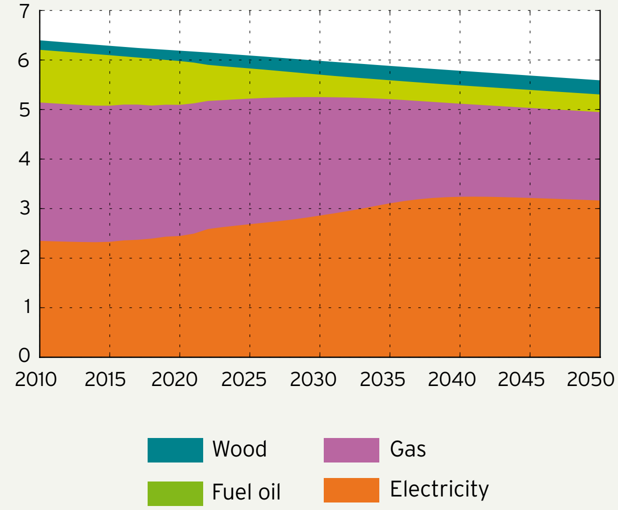


12 - Social housing (stock million dwellings)

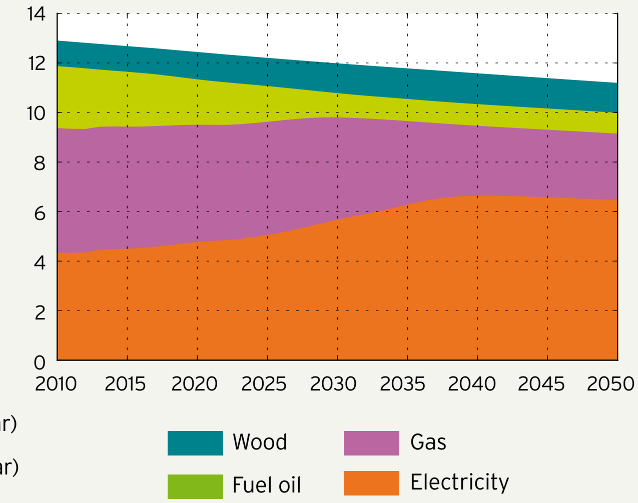


ENERGY MIX

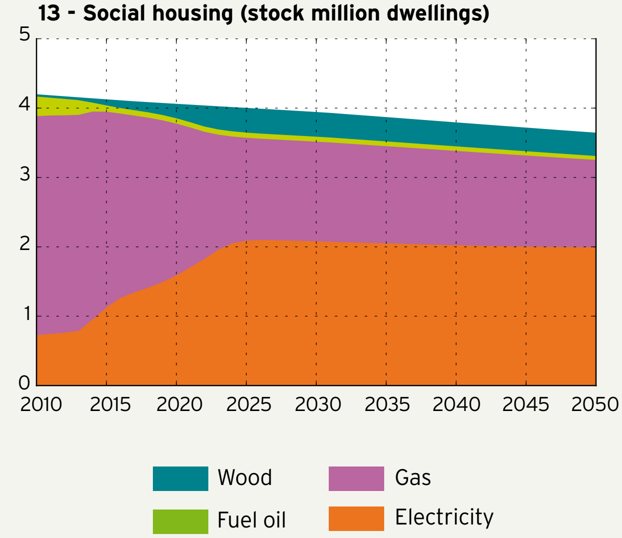
9 - Jointly-owned housing stock (million dwellings)



11 - Individual houses (stock million dwellings)

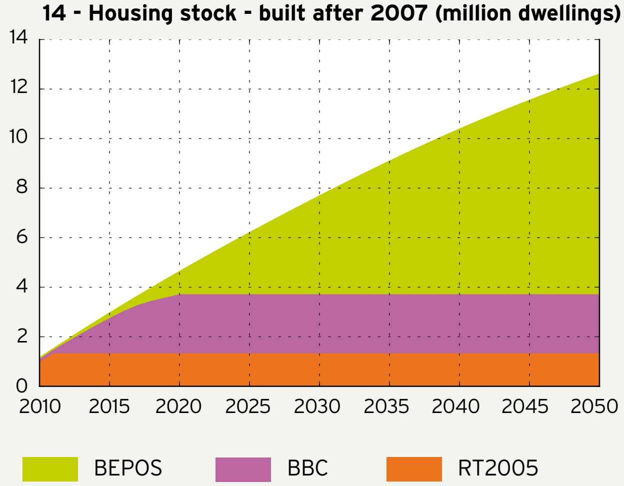


13 - Social housing (stock million dwellings)



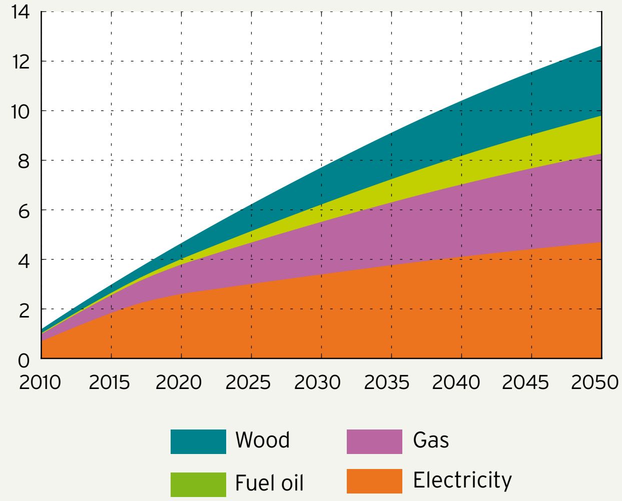
ENERGY LABELS

14 - Housing stock - built after 2007 (million dwellings)

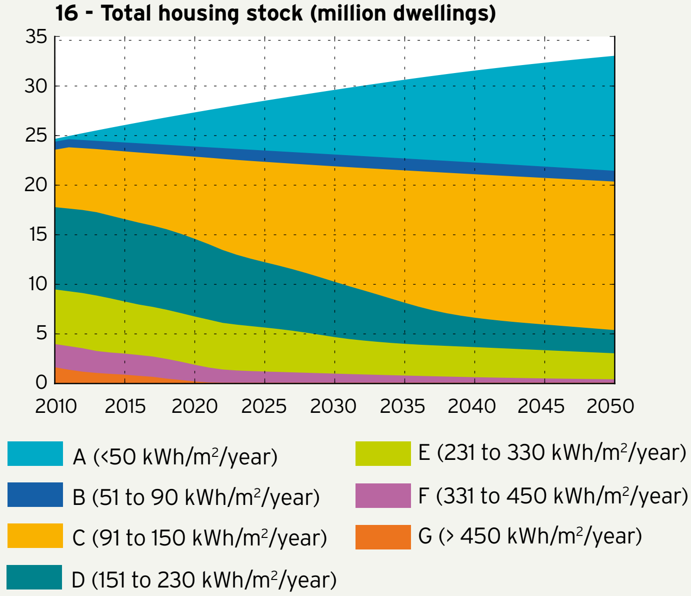


ENERGY MIX

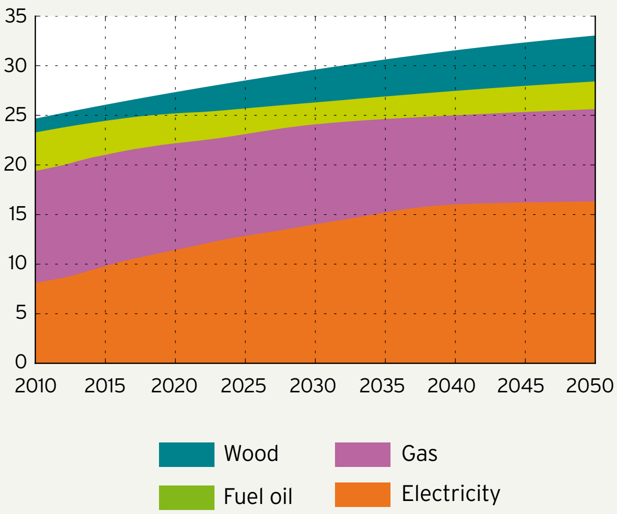
15 - Housing stock - built after 2007 (million dwellings)



16 - Total housing stock (million dwellings)

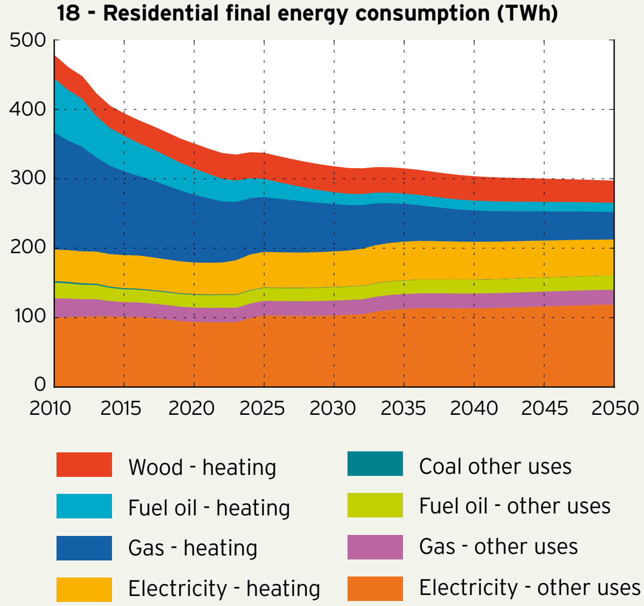


17 - Total housing stock (million dwellings)

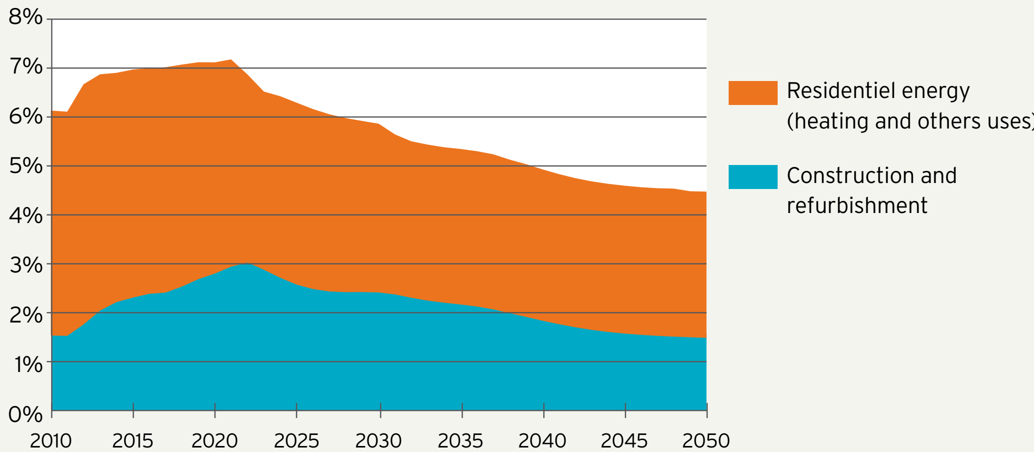


CONSUMPTION

18 - Residential final energy consumption (TWh)



19 - Households budget shares for residential



V. Investment and policy costs in the residential sector

The governmental subsidies for the transformation process of the residential building park decrease over the scenario period. Households carry the main share of the charges used for the refurbishment of the residential sector and energy efficient constructions.

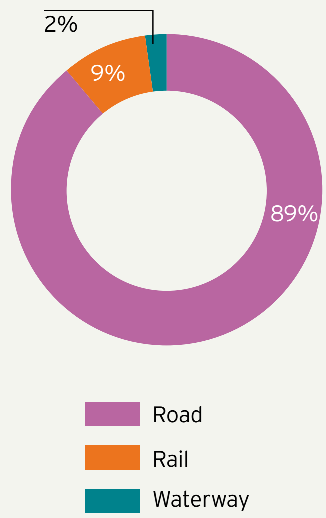
The households' expenditures for energy consumption, refurbishment and construction in the residential sector decrease over the scenario period from 6 to 4,5% of the overall household budget. The energy expenditures peak in 2012. Energy efficiency measures reduce the energy consumption and thus the allocated energy budget of households.

The expenditures for construction and refurbishment peak later in 2022 which is consistent with the transformation process of the residential building stock and the investments necessary for the switch from class D to C. *

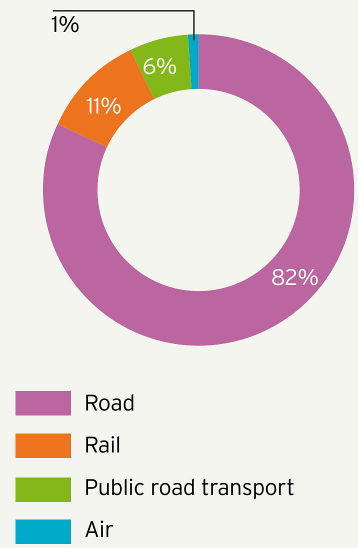
	2020	2030	2040	2050
Policy measures costs for the government (Billion €)				
Tax credit	-3.3	-2.5	-0.8	-0.5
Eco-loan	-3.3	-1.9	-0.6	-0.4
Additional costs for households (Billion €)				
Construction	-9.5	-9.4	-7.7	-6.3
Refurbishment	-14.9	-10.3	-3	-1.8

Transport sector

20 - Modal split in freight transport - 2010



21 - Modal split in passenger transport - 2010



I. Overview

The transport sector is responsible for nearly 40% of the CO_2 emissions in 2010. Its emissions increased of 16% between 1990 and 2010. The main cause of these emissions is the fuel combustion for road transport. Regarding the modal split, both passengers transport and freight transport are highly dominated by road transportation.

The trips for less than 50 km represent 89% of the journeys. Trips over 500 km correspond to only 1.3% of the journeys but 40% of the traveled distances. Irrelevant in terms of km but important in number of journeys are our feet: walking represents 22% of local mobility but only sums up to 2% of the traveled distances.

In 1990, the transport sector was responsible for 29% of the total French final energy consumption; in 2010, it increased to 32%. But in absolute numbers, this evolution represents an increase of 25%.

The investment in transport infrastructures in the recent decades shows that the road transport mode was clearly favored. The road network increased from 5,300 km in 1980 to 11,054 km in 2008. Between 1994 and 2008, the highway traffic has increased about 55%. The high-speed rail network (TGV) has only increased from 1,574 km in 1994 to 1,847 km in 2008 – but the number of passengers raised about 146%.

Freight traffic decreased about 15% during the economic crises in 2009 but since then, it is slowly returning to its former level.

Climate and energy objectives:
The French legislation includes several objectives concerning the transport sector:

* A 20% reduction of the greenhouse gases emissions in 2020 (base year 2005).
* The adoption of an eco-tax on heavy road freight transport in 2011 (has been delayed).
* Increasing the traffic share of all transport modes except air and road from 14% to 25% in 2022. The intermediate objective in 2012 corresponds to an increase of 25% compared to 2007 (the share has decreased since then therefore the objective is not likely to be achieved).
* The construction of 2,000 km of high-speed train before 2020.
* 50% reduction of the energy consumption by passenger and km of the air traffic before 2020.

II. Representation of the transport sector in Imaclim-R

Imaclim represents two different kinds of transport activities: transports are either bought transport services that are used by individuals or satisfying a sector specific transport demand (air transport[11], water transport, terrestrial freight transport, terrestrial passenger transports – taxis or collective transports), or self-produced services (with individual cars or non-motorized transports).

11- *Imaclim-R France only represents domestic air traffic.*

12- *This means that a 1% price increase induces a 0.4% decrease in consumption*

For **passenger transports**, a "**time-budget constraint**" sets an upper boundary for the time spent daily in transportation. This methodological choice relies on the empirical rule named "Zahavi's law". It shows that since many decades, each day, households on average spend the same amount of time on transport. The modal choices depend on the relative prices and speed of each mode. Each mode is characterized by a speed that decreases with a higher utilization rate of a specific transport infrastructure. Indeed, the more people use a specific transport infrastructure (each infrastructure has a given capacity limit depending on the dedicated investments), the higher the risk of congestion is, which reduces its speed. As people are bound to a stable time budget, when a specific transport infrastructure is close to congestion, other modal choices will be preferred. The maximum capacity of each modal infrastructure depends on the investment allocated to the specific infrastructure.

The **evolution of transport infrastructures** is represented according to public and private investment decisions. In the reference scenario, the infrastructure development follows the evolution of the modal transport demand, either through governmental spending in infrastructures or through private investment from transport sector investors. Climate policies are translated for example in an investment transfer from road construction to public transport infrastructures.

The **evolution of the motorization rate** is linked to the evolution of households' income and to the urban density but is quite insensitive to fuel price changes. On the contrary, climate policies such as urban planning may lead to a decrease in the motorization rate in the long term.

The **efficiency of the fleet of individual cars** depends on the households' consumption choices and on technical change. The vehicles fleet is disaggregated according to the year of first circulation and to the energy label (conventional from G to A, hybrids or electric). This representation includes the specifications of the vehicle related to costs, energy efficiency, fixed and variable maintenance costs.

The **evolution of energy prices** is integrated in the evolution of the transport service price for each transport service sector (for example in the train or bus ticket price) and for individual transport through fuel prices at the time of purchase and at the time of effective consumption.

Energy consumptions for freight transport result from the following energy efficiency improvements assumptions:

* In air transport, intermediate fuel consumptions decreases by 0.7% each year. It reflects technological improvement in plane design to lower kerosene consumption and traffic management measures to increase occupancy rates.
* In water transport, energy consumption per unit of transported good remains unchanged.
* In terrestrial freight transports, the average liquid fuel consumption is the result of a fuel price elasticity[12] set to -0.4 and to a maximum 25% energy efficiency improvement. The evolution of intermediate energy consumption in these sectors reflects at once technology changes, modal shifts (particularly between rail and road freight transport) and modifications of structural components of this sector resulting from changes in relative weights of transported materials of sub-sectors that compose it.

The **freight transport** demand in Imaclim-R is the aggregated demand from goods transport demand for each productive sector. The **freight content of economic growth** is directly linked to the consumption styles and to the structure of the economy (more services or more industrial production). On the contrary, freight activities are only weakly sensitive to energy prices. Modal freight choices rely on logistics and the organization of the supply chain. Given the uncertainty of the reaction of firms to energy price variations (concerning organizational and logistical decisions), these parameters and their evolution are set exogenously as scenario variables.

In the reference scenario, the energy consumption for freight transport is only influenced by the energy efficiency improvement of heavy trucks.

In the mitigation scenarios, assumptions related to spatial organization may lead to a decoupling of economic growth and freight transport and by this to a decrease of freight transport demand. Assumptions related to a change of consumption styles or to the structure of the economy may lead to a general dematerialization of economic growth that induces a decrease in freight transport needs. These orientations of the economy are only investigated in alternative scenarios in part 4. *

III. Policy measures in the transport sector

1. Urban and local transports

Urban planning: Economic incentives and regulations aim at limiting the increase in urban sprawl. These measures are considered to have an impact only from 2030 because of inertia. The increase in urban sprawl slows down gradually until 2030. After 2030, the trend is reversed and the urban density increases again.

Urban transports investment program: Investments in urban transports (buses, tramways) are doubled during 15 years from 2012. A retrofitting railway program is implemented to enhance regional rail traffic and intermodality is improved. The time inertia in the construction of infrastructures is taken into account.

Teleworking: the assumption related to teleworking is that an average of one day of work out of ten is carried out by teleworking, taking into account that not all activities can be subject to teleworking.

Cars occupation rate: Incentives (promotion by firms of employee transport plans as well as carpooling) are considered to increase the cars occupation rate for urban transport from 1.25 to 1.5.

2. Long distance travels

Rail investment program: Investments in road infrastructures are limited to covering the maintenance of infrastructures only. A shift of investments from road to rail for 20 years aims at ensuring the retrofit of existing railways infrastructures to allow an increase of rail market shares for regional transports. The construction of new high-speed infrastructures favors the competitiveness of high-speed trains against airplanes.

Kerosene tax: A tax on kerosene consumption for air transport is introduced in 2012. It represents 400€/toe.

3. Individual cars and technological change

Bonus-malus: The "bonus-malus" measure on the emissions reductions of new vehicles is extended until 2050. It is calibrated in order to foster the penetration of clean vehicles (label A+, A and B) and to obtain a positive annual financial balance for the government budget or at least close to 0.

4. Freight transports

Heavy truck environmental tax: an eco-tax on the liquid fuel consumption of heavy trucks is introduced in 2012. It is calibrated to bring in 1.3 billion€ in 2012.

Logistics: Policies aiming at improving supply chains for production and distribution reduce the transport content of consumption. This is represented by an annual decoupling of freight transport needs of 1% per year for all sectors.

Infrastructures: A program is implemented to develop alternatives to the road for the freight transport by improving the supply chain of rail freight transport and developing rail freight capacity. This is represented in the model by additional investments in the freight sector from the government. The inertia in this sector is considered to be important. This is why the exogenous assumption is that the modal share of rail transport in freight reaches only 20% in 2030.

Carbon tax: A carbon tax gives a price signal to reduce highly carbonized energy consumptions and to shift the energy production system to low carbon technologies. The carbon tax used in the project scenario is equal to 32€/tCO_2 in 2012, increasing gradually to 56€/tCO_2 in 2020, to 100€/tCO_2 in 2030, to 200€/tCO_2 in 2040 and to 300€/tCO_2 in 2050. In this scenario, the carbon tax income is given back to households through lump-sum transfers.*

IV. Evolution of energy consumption in the transport sector

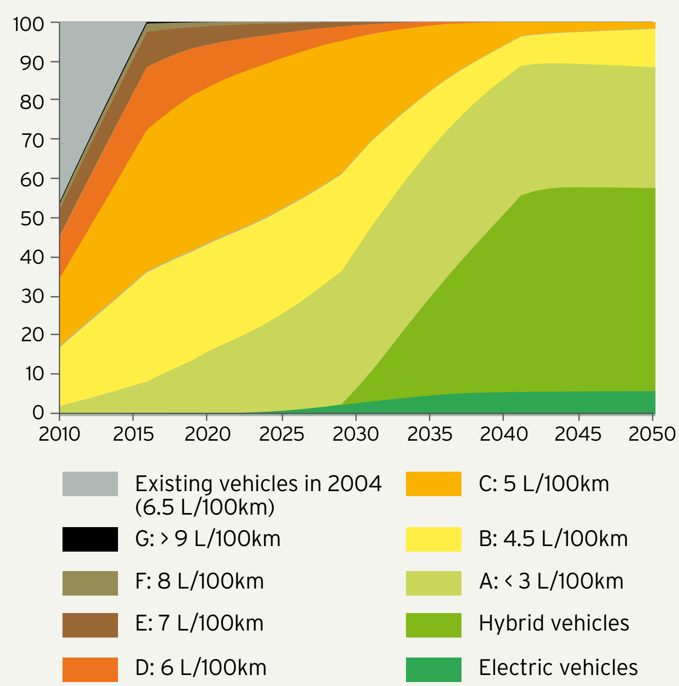
In this scenario, two mitigation strategies are implemented for passenger mobility: Limiting current increase in individual mobility with urban planning and incentives to limit voluntarily mobility demand.

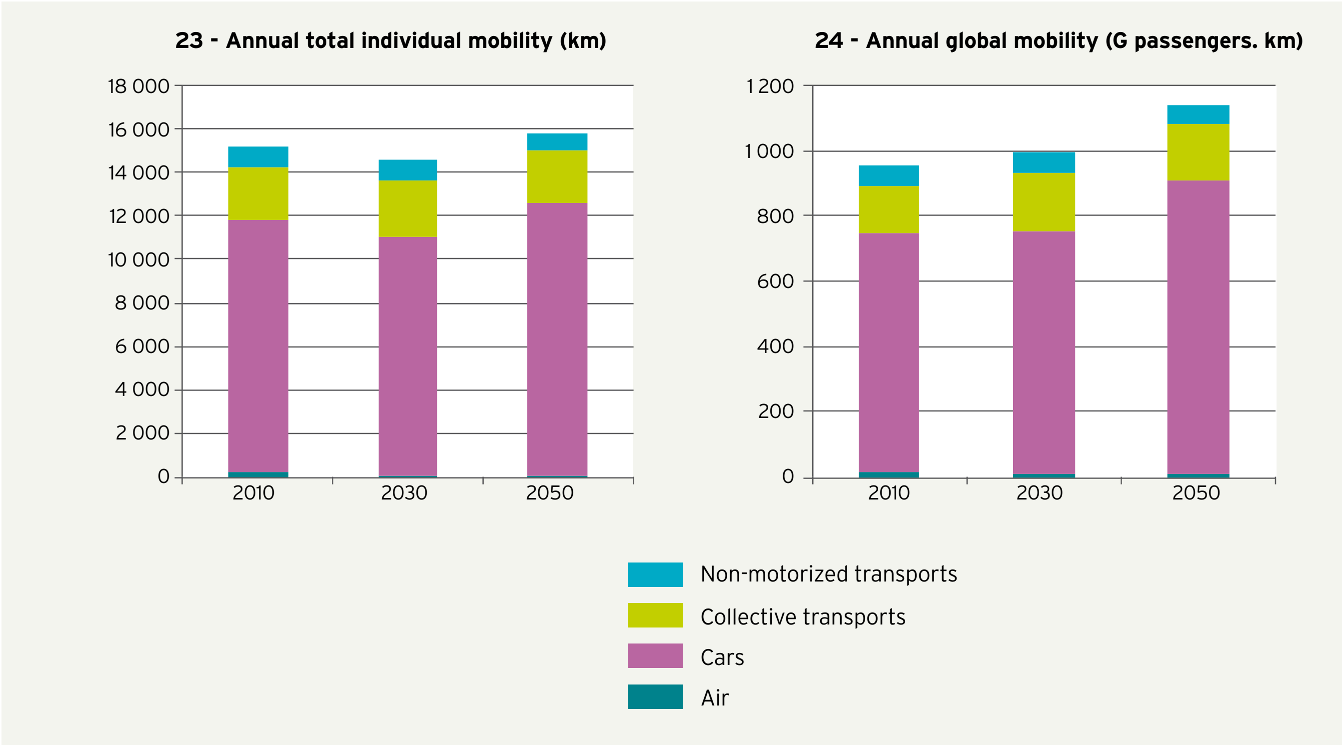
1. Penetration of decarbonized vehicles

The bonus-malus measure is calibrated from 2010 to 2050 to result in a positive or neutral financial balance for the government. It is reevaluated every five years to favor energy efficient vehicles. The most emitting vehicles disappear. Electric vehicles occupy only niche markets for urban mobility with a penetration limited to 5% of the total vehicles fleet in 2050. They refer to car sharing systems in urban areas. Hybrid range extender[13] vehicles massively penetrate after 2030. They are best suited to urban use but can also be used for long journeys.

[13]- Range extender hybrid vehicles are designed to counter the small autonomy of electric vehicles and the high cost of batteries. The motor includes both a combustion and electric motor. The small internal combustion engine is used only as a generator to power the electric motor or to recharge its batteries. Unlike a conventional engine, which operates over a wide variety of power settings and operational conditions, the range extender can be operated under optimum conditions at all times. Compared to a classical hybrid vehicle, range extender hybrid vehicles have a bigger electric engine that is not assisted by the internal combustion engine

22 - Composition of the vehicles fleet (%)





14- *ADEME (2010) "Analyses de Cycle de Vie appliquées aux biocarburants de première génération consommés en France", Rapport final.*

2. Biofuels development

The scenario is based on the biofuel development scenario in the "World Energy Outlook 2006". In the policy scenario in 2030, 147 Mtoe of biofuels are produced in the world (7% of the total demand for road transport fuels). Biodiesel accounts for 15% of the biofuel use. In Europe, biodiesel use drops from well over 50% of the consumption to under 30% in 2030.

The biofuel consumption in the here presented scenario is about 5 Mtoe in 2020 and 16 Mtoe in 2050 (respectively 9% and 39% of total refined petroleum products). A technology switch takes place around 2030 concerning the first-generation ethanol production (from agricultural sugars and starches) towards second-generation biofuels (ligno-cellulosic ethanol) as production costs of the latter decrease. The use of second-generation biofuels attenuates most of the negative impact of the biofuels first generation: competition with food production, use of agricultural production and additional emissions due to land use change (that can even exceed those of classical fossil fuels[14]).

3. Evolution of the individual mobility

On average, the mitigation scenario leads to a slight increase of individual mobility on the long term (+3% compared to 2010 level). This translates into a 19% increase of total passengers' mobility. Nevertheless, in the middle term (2030), the increase of energy prices and the inertia in developing alternative collective transports lead to a constrained mobility with a 4.5% decrease in individual mobility and a 4% increase in total passengers mobility compared to 2010 levels.

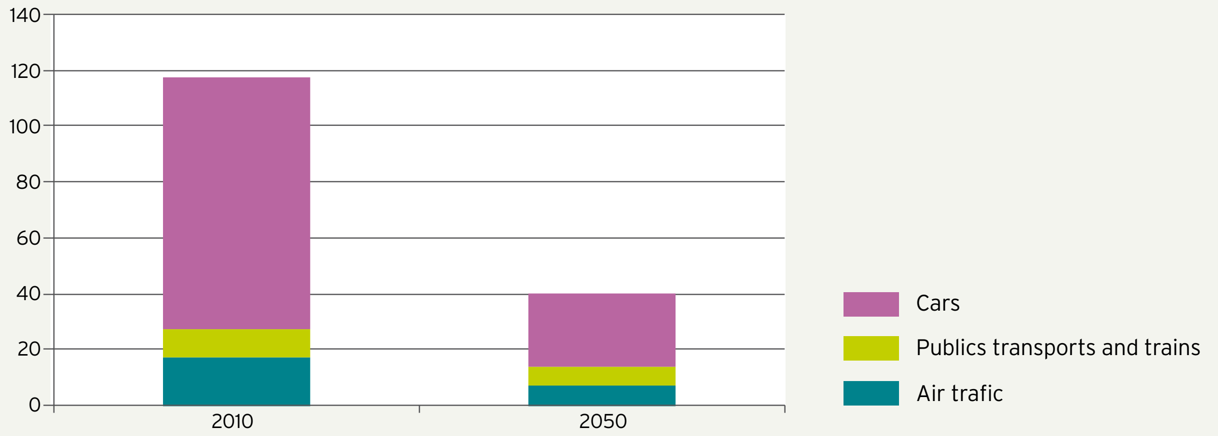
This mitigation scenario is therefore not a restriction or a rationing scenario but a scenario with mobility management that takes into account bottlenecks and asymptotes in urban sprawl and motorization rates.

4. Urban and local mobility

The objective of policies and measures implemented for urban mobility is the limitation of the increase of urban sprawl, while favoring more collective transport infrastructures. Because of the inertia of the existing system, these measures begin to have a significant impact only after 2030. The mobility in urban areas mainly refers to a constrained mobility (daily commuting). The two determinants of the total urban mobility are the demographic trends in urban areas and the urban sprawl. The urban sprawl has an ambivalent impact over time: it keeps increasing, particularly urban areas outside Paris, until 2030, and starts decreasing after 2030. Congestion increases for all transport modes in urban areas, until more collective transports are available. In the short run, avoiding the impact of increasing oil prices relies on reducing mobility by teleworking and the increase of the vehicles occupation rate. These measures translate the generalization of employee transport plan in firms.

5. Long distance mobility

The general implementation of constraints for urban transports restrains long journeys: the widening of congestion in urban areas decreases the time available for long journeys particularly with a more expensive air transport (kerosene tax) and inertia in the development of road alternatives. This explains partly the decrease in total passengers' mobility in 2030. After 2030, more train transport



capacity is available and part of the time constraint is released.

Passenger transport emissions decrease by 66% between 2010 and 2050. This reduction results from the combination of (i) an average 70% reduction in oil consumption of individual cars, (ii) the penetration of biofuels and (iii) a 23% increase in car passengers-km. Emissions reductions in air traffic are the results of a slight decrease of demand and of a 40% energy efficiency improvement.

6. Freight transport

The eco-tax for heavy trucks enhances technical change towards more efficient technologies. In 2030, the energy efficiency of heavy trucks is 25% higher.

Overall, the emissions of the freight terrestrial sector decrease by 40% between 2010 and 2050. This results from (i) a 9% increase of the freight demand during the period, (ii) a 30% energy efficiency improvement for road transport per unit of good transported, (iii)a modal shift towards rail for 7% and (iv) 12% for biofuel penetration.

In total CO_2 emissions in the transport sector (passenger and freight) decrease by 60% between 2010 and 2050, and final energy consumption decreases by 41%.*

V. Investment and policy costs in the transport sector

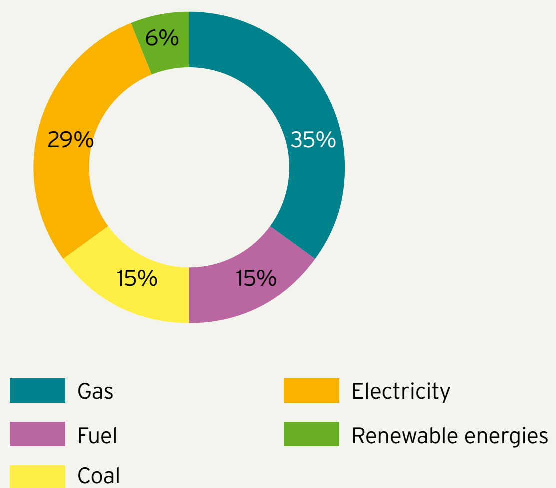
The fiscal measures applied to the transport sector positively impact the financial balance of the government, except for the domestic consumption tax on petroleum products whose receipts decrease significantly over time. Thus, the income of this tax decreases of 10% in 2020, 25% in 2030 and about 50% in 2050. However, the tax rate remains the same. Therefore, the income reduction is fully attributable to the decrease in consumption of imported petroleum product. This would impact negatively the government income.

For the infrastructural investments, all the operations are done neutrally if compared to the reference scenario. Indeed, the total amount of investment does not change, only the repartition between transport modes. 6 billion euros are withdrawn from the road investment and dedicated half to urban road collective transports and half to railroads. *

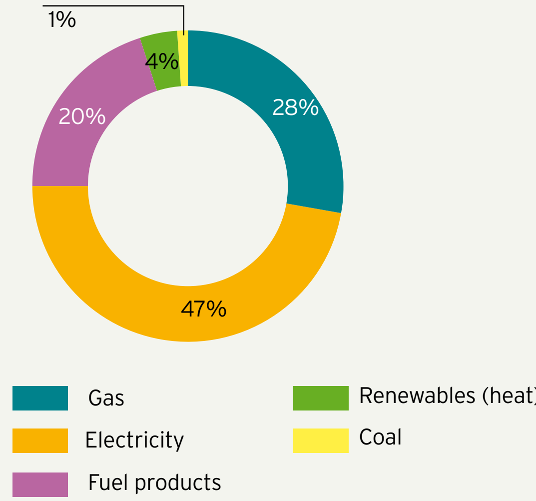
	2010	2020	2030	2040	2050
Fiscal measures (billion €)					
Heavy trucks eco-tax	0	1.3	1.1	1.1	1.2
Kerosene tax	0	1.6	1.1	1.4	1.3
Impact on domestic consumption tax on petroleum products	23.8	21.4	17.9	13.4	12.9
Carbon tax	0	13.7	18.1	23.9	34.8
Investments on infrastructures					
Urban transports	+3 billion € each year from 2012 until 2030				
Railways	+3 billion € each year from 2012 until 2030				
Road transports	-6 billion € each year from 2012 until 2030				

Industry and services

26 - Final energy mix of the industry sector - 2010



27 - Final energy mix of the tertiary sector - 2010



I. Overview

1. The industry

The energy mix of the industry sector is dominated by fossil fuels (65%). The industrial final energy consumption decreased from 27% (38 Mtoe) in 1990 to 22% (35 Moe) in 2010.

Several industrial sub-sectors contribute with more than 10% to the industrial emissions:

* Non-metal minerals and construction materials (27%).
* Chemical industry (24.7%).
* Metallurgy and steel (17.1%).
* Food industry (12%).

The industrial process emissions comprise emissions from fossil fuels combustion as well as emissions caused by chemical reactions such as during the heating of calcium carbonate for cement production. The abatement of these emissions can be realized through changing the process itself or using carbon capture and storage technologies (CCS) if the technology is available.

The recent economic crisis impacted the French industry production and the induced final energy consumption (- 13% and even about -27% for the steel industry). However, in 2009-2010, along with the economy, the industrial production recovered, and the energy consumption increased about 21%. The CO_2 emissions of the industrial sector decreased about 22% between 1990 and 2010. In 1990, the industry emitted 28% (85 $MtCO_2$) of the global CO_2 emissions and in 2010 only 23% (67 $MtCO_2$).

The issue for the future is the industrial level of France consitent with a low carbon pathway. Indeed, the evolution of the imports of manufactured goods and the relocation of industry in France – desirable from an economic point of view – would critically affect industrial emissions.

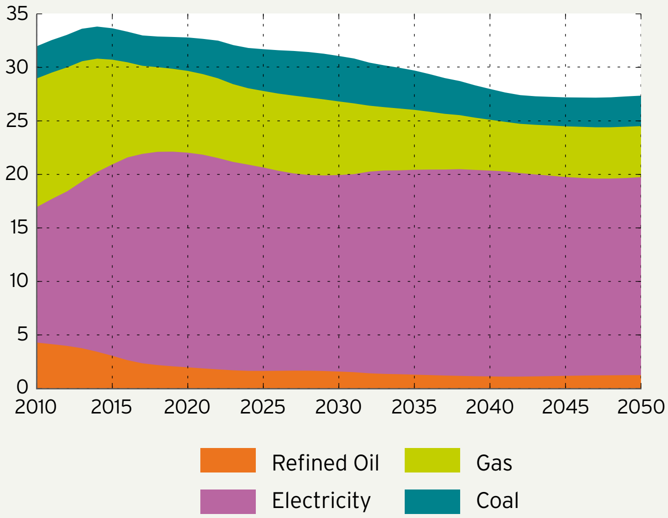
2. The services

The tertiary sector used 11% of the total final energy consumption in France in 2010 (21.7 Mtoe). The energy consumption mix is dominated by electricity (47%). In addition to the renewable share in the electricity mix, thermal renewable sources represent only 4%. The CO_2 emissions of the tertiary sector increased about 9% between 1990 and 2010, from 28 $MtCO_2$ to 31 $MtCO_2$.*

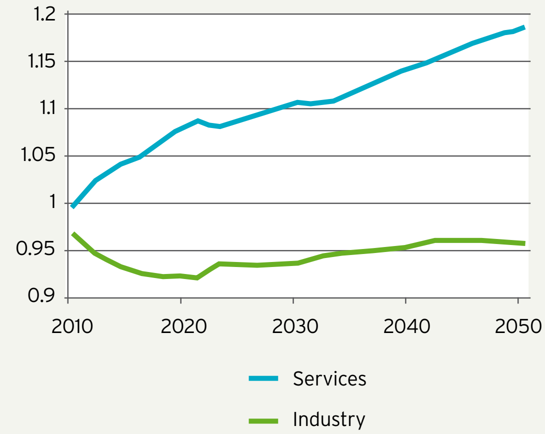
II. Representation of the productive sectors in Imaclim-R

The industry (apart from transport and energy) aggregates very diverse activities, preventing Imaclim-R from explicitly representing individual production units. Nonetheless, the inertia of the installed capacities and technologies remains explicit through a description in capacity vintages. Hence, the various industrial processes are summarized by the average consumption of inputs. Therefore, the variations of the average consumptions translate not only into the improvement of technologies but also into structural changes between the various subsectors aggregated (for instance reducing the share of energy-intensive services and increasing the share of other services). **Three**

28 - Final energy consumption of industry (Mtoe)



29 - Competitiveness index for services and industry



mechanisms are taken into account: (i) autonomous technical change over time, (ii) a trend in structural decrease of energy intensity (iii) the improvement of production techniques through more efficient technologies and energy substitutions induced by the evolution of energy prices.

In the mitigation scenario, the autonomous technical change is increased by 30%. In addition, increasing energy prices trigger some substitution relying on price competition (favoring less carbon-intensive energies) and endogenous technical change.

The same description applies for the tertiary sector.

III. Evolution of energy consumption in the industry sector

In Imaclim-R France the industry sector[15] roughly represents 26% of the final energy consumption in 2010. After energy efficiency improvement across the whole economy, the industry still accounts for 26% in 2050. Since the industry sector in the model includes the energy-intensive industries such as steel, aluminum and chemistry, the final energy demand is structurally very important, even if it decreases over time. However, behind a demand for energy that appears to remain stable, the energy efficiency of the industry sector is greatly improved. Indeed, the final energy used in the sector only decreases by 15%, when the level of activity increases by almost 35%, leading to an increase in energy efficiency of 37%[16].

Furthermore, the energy sources undergo a major change. The supply of coal remains roughly the same, but most of the oil and half of the gas are replaced by electricity because of a very competitive electricity price compared to gas. Most of the competition stems from the relative prices of the two energies. The prices of electricity and gas are very close until 2025. Thereafter a gap appears, clearly favoring electricity (the prices for industry being 40% lower for electricity than for gas for the same amount of energy).

The switch from gas to electricity and the energy savings induce a decrease of the industrial CO_2 emissions[17] from 53 to 23 $MtCO_2$ in 2050. The use of the CCS technology for process emissions could further reduce the carbon impact of this sector[18].

The graph 29 illustrates the increase in competitiveness of France against global supply[19]. The higher the index, the more favorable the competition for France (without giving an absolute level, this graph shows the trend). The industry index remains close to 1 for the whole period, which indicates that industrial goods are neither more nor less competitive than at the beginning of the period. One the other hand, the services competitiveness index steadily increases, showing that the French tertiary sector improves its price competitiveness.
This is due to the evolution of energy costs in productions costs for these sectors. In the tertiary sector, energy efficiency improvement reduces energy costs. On the contrary, in the energy-intensive industries, energy efficiency improvement is structurally bounded. Therefore costs cannot be reduced as significantly.

15- *This sector includes steel, cement, chemistry, non-ferrous metals, equipment and paper in Imaclim.*

16- *This energy efficiency increase corresponds to a 37% reduction of energy intensity, computed as the ratio between final energy and added value (GDP) for the industry sector.*

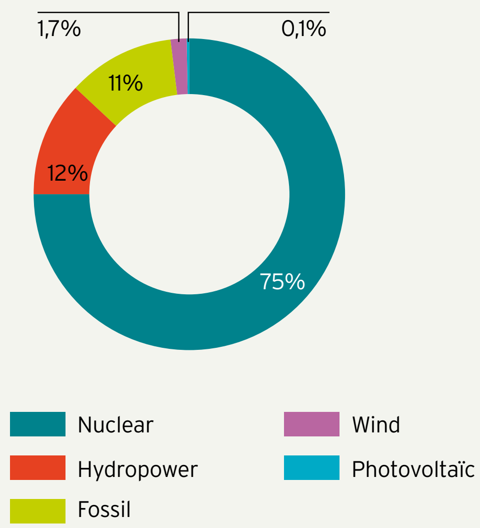
17- *The industrial emissions correspond to direct emissions (excluding electricity generation).*

18- *This scenario is based on a conservative assumption for CCS: it only marginally penetrates the power sector and is not available for industry.*

19- *This index is computed as the ratio between the world price index and the French price index for industry. If there is a 80% increase in the world price and only a 20% increase in the French price, the competitiveness index equals 1.5(=$\frac{180}{120}$), which is in favor of the French goods. The base year for the computed indices is 2004.*

Electricity sector

30 - Energy mix of the electricity sector - 2010



I. Overview

In 1990, electricity represented 36% (83 Mtoe) of the primary energy mix but only 18% (26Mtoe) of the final energy due to the high share of nuclear in the mix. In 2010, 550TWh were produced. It represented 43% (115Mtoe) of the primary energy mix and 24% of the final energy. 67% of the primary electricity is lost in the transformation process.

In 2010, the renewable electricity share was about 15%, with a high share of hydropower. The electricity export import balance was positive in 2010 but the imports achieved a historical maximum about 19.5 TWh. 50 TWh were exported.

The CO_2 emissions of electricity production decreased about 19.7% in comparison to 1990. In 1990, 39 $MtCO_2$ (10% of the overall CO_2 emissions) were emitted by the electricity sector compared to 31 $MtCO_2$ (9%) in 2010.

68% of the final electricity production is consumed by the residential and tertiary sector, 25% by the industry and 3% by the transport sector. In comparison with the other European countries, electricity costs 25% less so average per capita consumption is 21% higher than the European average and even 49% higher considering only residential consumption. The French specificity of electricity demand is electricity heating (Joule effect) in one third of the buildings. This creates a high climate sensitivity of the power sector particularly during peak load hours in winter. Every cold wave enhances the blackout risk as each degree less causes an additional consumption need of 2.3 GW. Another controversial question is the future evolution of the demand, for instance what will be the impact of new end-uses (electric vehicles, electronics...) on the total final energy consumption?

Climate and energy objectives:
The objective fixed in the French law[20] in 2005 to reach 21% of renewable energies in the electricity mix in 2010 was not achieved. The objective of reducing the energy intensity of 2% per year was not achieved either. The target[21] for 2020 is a share of 27% of renewables in the final electricity production mix.

II. Representation of the electricity sector in Imaclim-R

The electric module of IMACLIM-R is designed in order to represent the specificities of the French power sector. It calculates the evolution of the demand load shape to take into account peak load capacity needs, the evolution of the hourly electricity price and the dynamics of investments in new power plants.

The demand side: The demand from each sector in Imaclim is aggregated in a total hourly demand. The specificities of seasonal demand for electric heating, is integrated by deforming the shape of the hourly demand. For each year, the hourly demand is rearranged in a load duration curve[22] (LDC) that classifies by decreasing order the level of capacity required. The load duration curve allows segmentation of the demand in three demand typologies: the "base demand" corresponding to the level of capacity required during more than 5000 hours a year, the "semi base demand" situated between 500 and 5000 hours and "the peak demand" corresponding to a needed utilization of capacities below 500 hours.

The supply side: The investment dynamics in the power sector are represented via profit-seeking investors who invest on the liberalized market. Electricity producing technologies are therefore competing on the spot electricity market. Different technologies have different total production cost curves (composed by investment, maintenance and fuel costs). Some technologies like nuclear or hydropower have high investment cost and low fuel cost. These technologies are usually more suited to satisfy base load demand. Other technologies have

20- *POPE Law (2005).*

21- *As expressed in France National Renewable Energy Action Plan.*

22- *The Load Duration Curve represents the hourly demand for capacities (in GW) against the capacity utilization (the number of hours that the capacities are called in a year). It is formed by taking the hourly demand for capacities (GW) and sorting this demand by decreasing order. The resulting curve shows synthetically the peak load, the base load and the possible discrepancies between the amount of peaking plants needed and the number of hours those are used.*

23- *The variable cost is the part of the power generation costs that is proportional to the production: mainly fuel costs, carbon taxes and any operation and maintenance costs that are proportional to the production.*

low investment costs but high fuel costs (oil power plants). These technologies having a high variable cost[23] are used less than the base load production technologies and respond to peak load demand.

Balancing supply and demand: To satisfy a given demand, the least expensive capacities (in terms of variable costs) run first, more and more expensive technologies are added with increasing demand. The spot price is equal to the variable cost of the marginal plant, which is the last capacity to be called in service.

The profitability for each technology is determined by the difference between the income from electricity sales on the spot market and investment and operating costs. The (inframarginal) rent for a technology on the spot market is determined by the difference between the spot price and the variable production costs.

Investment dynamics: In this scenario, only projects with an expected return rate on investment superior to 8% are implemented, with preference to short return periods in case of multiple profitable investments possible. Technologies that are competing on the spot market are coal and gas with or without CCS, oil and nuclear (EPR technology).

Renewable energy technologies (hydropower, wind on-shore, wind off-shore, decentralized photovoltaic, solar plants, geothermal) do not compete in the merit order of the electricity spot market (since their production is non-dispatchable, which means "unavoidable"). In the scenario, most renewable electricity is absorbed and used; very little curtailment happens. The construction of renewable energy capacities is induced by feed-in tariffs high enough to ensure the profitability of the technology. The level of the feed-in tariffs decreases over time until these technologies become competitive. Feed-in tariffs are paid by all consumers through a contribution integrated in the electricity price (named Contribution to the Electricity Public Service - CSPE in France). The construction of renewables with variable production[24] triggers additional grid investments, thus increasing the electricity price for 1€/MWh in reference and 3€/MWh in the mitigation scenario[25].

Demand side management measures lead to a decrease in aggregated power demand but may also lead to a smoothing of the shape of the LDC. This also contributes to a lower marginal electricity spot price. *

III. Policy measures in the electricity sector

Progressive tariff: This measure aims at reducing electricity consumption by increasing the prices above a fixed base consumption. In the scenario the progressive tariff is applied on all household electricity consumption. For all households, any consumption above 60 kWh/m^2 is paid at an augmented tariff. The prices per additional kWh increase of 5% after 2014 in case the consumption exceeds this limit and of 10% after 2030.

Feed-in tariffs: Feed-in tariffs for renewable energies are economic incentives to facilitate the market penetration of these technologies to accelerate the learning effect. Feed-in tariffs are normally decreasing over time and end when the technologies achieve price competitiveness with other technologies.

Contribution to the Electricity Public Service[26]: This tax is calibrated at base year. The increase in the value corresponds to the increase of the payment of feed-in tariff to renewable producers.

Carbon tax: A carbon tax gives a price signal to reduce highly carbonized energy consumptions and to shift the energy production system to low carbon technologies. The carbon tax used in the project scenario is equal to 32€/tCO_2 in 2012, increasing gradually to 56€/tCO_2 in 2020, to 100€/tCO_2 in 2030, to 200€/tCO_2 in 2040 and to 300€/tCO_2 in 2050. In this scenario, the carbon tax income is given back to households through lump-sum transfers.

Demand side management: Peak demand can be managed either with peak capacities (including oil-fuelled turbines, peak hydropower or pumped-storage plants) or with interruptible contracts remaining at the same level as today. In addition, when the electric consumption due to electric heating decreases, peak demand decreases and conversely.

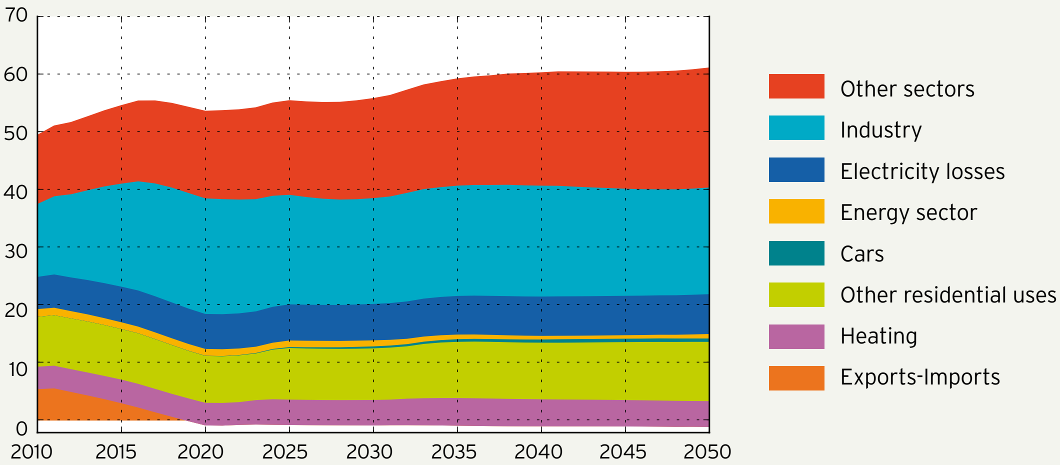
Interdiction of electric heating (Joule effect): Electric heating is not banned. However, the implementation of the thermal regulation up from 2012 de facto excludes electric heating (exception heat pumps) from the technology choices for new buildings. As the maximum energy consumption is defined in primary energy per m^2 per year and the conversion factor is about 2.58 (between primary and final electricity), electricity exceeds the limit.

24- *Also known as « intermittent » renewables.*

25- *Cf. the following publications for costs evaluation:*
- Deutsche Energie Agentur (2005): Integration into the national grid of onshore and offshore wind energy generated in Germany by the year 2020.
- Richard Green (2009): Climate-Change Mitigation from Renewable Energy: Its Contribution and Cost.
- House of Lords Select Committee on the European Communities, 12th Report, Session 1998-99.
- House of Lords, Economic Affairs Committee, 2008"The Economics of Renewable Energy", Session 2007-08, Economic Affairs Committee Publications.

26- *This tax supports feed-in tariffs, electricity supply in isolated territories and social tariffs.*

31 - Electricity demand disaggregation (Mtoe)



Lifetime extension of nuclear plants: The oldest existing nuclear plants (23GW) are decommissioned when their lifetime reaches 40 years. This decommissioning is smoothed in time in order to spread the construction of new capacity that is needed for the replacement over a wider time period. Lifetime of the remaining 40 GW of existing nuclear plants is extended to 60 years for an additional investment cost of 0.7bn€/GW. In 2050, still 10GW of the today existing plants are operating

Technologies acceptance: All technologies for electricity production are considered as acceptable, save shale gas.*

IV. Evolution of energy consumption in the electricity sector

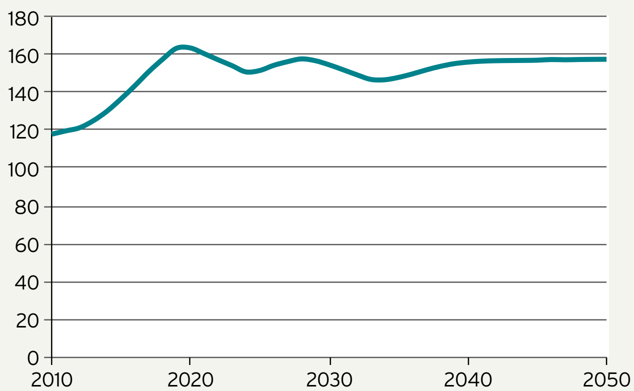
The total electricity production increases over the scenario period from 50 Mtoe to 60 Mtoe in 2050. This increase of 20% is relatively low compared to the threefold increase in the same amount of time between 1973 and 2010. The main sectors responsible for the increase are the industrial and tertiary consumption mainly because gas is substituted by electricity.

The stakeholders disapproved of the construction of new power plants for exports so the electricity exports in this scenario are rapidly declining. France is no longer a net exporter of electricity after 2020; some imports (for less than 1 Mtoe or 12 TWh) remain throughout the period. The electricity imports (the part of the graph under zero) are used to satisfy the peaking heating demands in winter. The retrofitting of the residential sector that is increasing energy efficiency for heating and the switch from electric heaters to heat pumps reduces the electricity peak in winter. But approaching 2050 the peak increases due to a replacement from gas heating by heat pumps reaching a maximum of 103 GW.

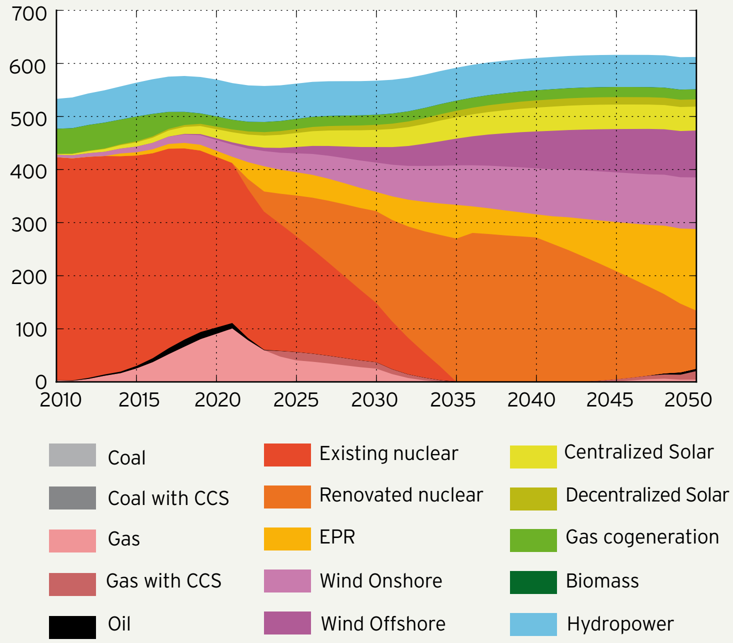
The partial fuel switch from gas to electricity in the industry sector takes place before 2020. On the contrary, the consumption of the services steadily increases at a rate exceeding 2% before 2025 and around 1% afterwards. The electricity consumption of energy producing industries (for example oil refineries) decreases slowly. Electricity transport losses are following proportionally the increasing electricity consumption.

In the residential sector, the electricity use for heating is slightly increasing as gas for heating is replaced by heat pumps. Residential uses other than primary heating decrease before 2020 (from 9 to 8 Mtoe) and increase until 10 Mtoe after 2020. Due to more and more new electricity devices (especially multi-media), the consumption especially for these energy services increases over the scenario period. Traditional domestic electricity services

32 - Consumer electricity price



33 - Electricity production mix (TWh)



like lighting, washing, cooking etc. decrease with increasing energy efficiency.

Before 2030, the consumption of electric vehicles does not appear on the graph since does not represent with 0.4 Mtoe an important share of the overall consumption. It increases until 2040 and stabilizes at 0.6 Mtoe. In this scenario, the charging occurs evenly during 24 hours a day since the electric vehicles fleet corresponds to car sharing systems. Thus, the supplementary demand due to charging adds to base load, and does not worsens peak imbalances thanks to the diversity and the dispersal of the demand.

Prices

The electricity prices for households show a sharp increase between 2010 and 2020, climaxing at 41% in 2020 compared to 2010. The price stabilizes thereafter around 160€/MWh (16c€/kWh). It represents an increase of 34% compared to the price in 2011. The peak in prices around 2020 is due to the combination of (i) the penetration of gas combined cycle replacing some of the nuclear capacities (ii) the acceleration in the installation of renewable capacities and (iii) the oil-fuelled turbine to face the variability of renewables. The stable long-term increase is due to renewables being more expensive than the old nuclear thermal power generation units and the need for new capacity building during the period.*

V. Investment and policy costs in the electricity sector

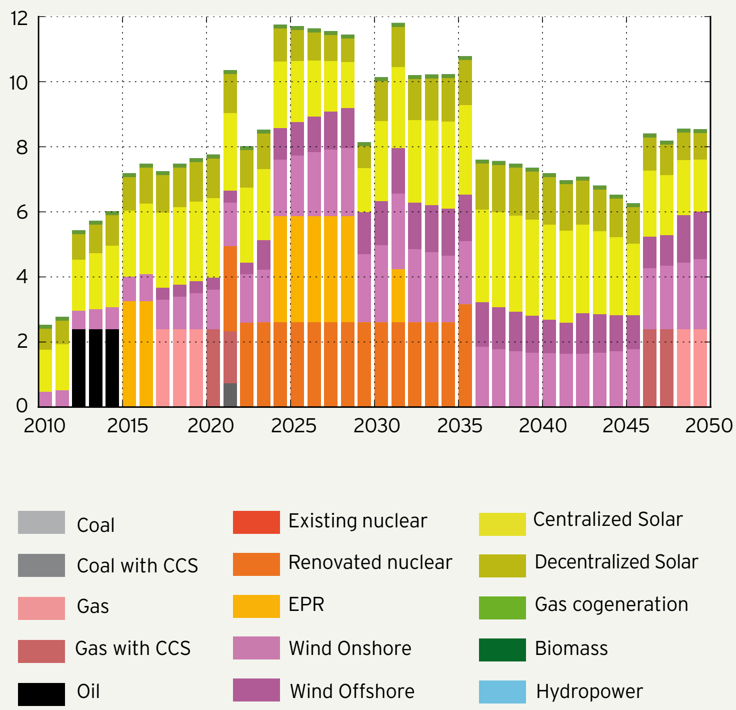
Investments

The investments in generation capacities throughout the period are mostly directed at building renewable capacities. The share of renewables in the electricity mix is 20% in 2020 and 50% in 2050. In addition, 43 GW of nuclear plants are extended during 20 years for 700 million euros per GW. Renewables and nuclear plants extension constitutes the bulk of the investment until 2050. In addition, 9 nuclear plants (European Pressurized Reactor) are built to compensate part of the decommissioning occurring between 2020 and 2030 for 2,9 bn €/GW, each of them with a capacity of 1630 MW. The investment amount steadily rises from 8 billion € in 2010 to almost 17 billion € in 2026 to finance the transition. After that, it steadily decreases to 6 billion € in 2050.

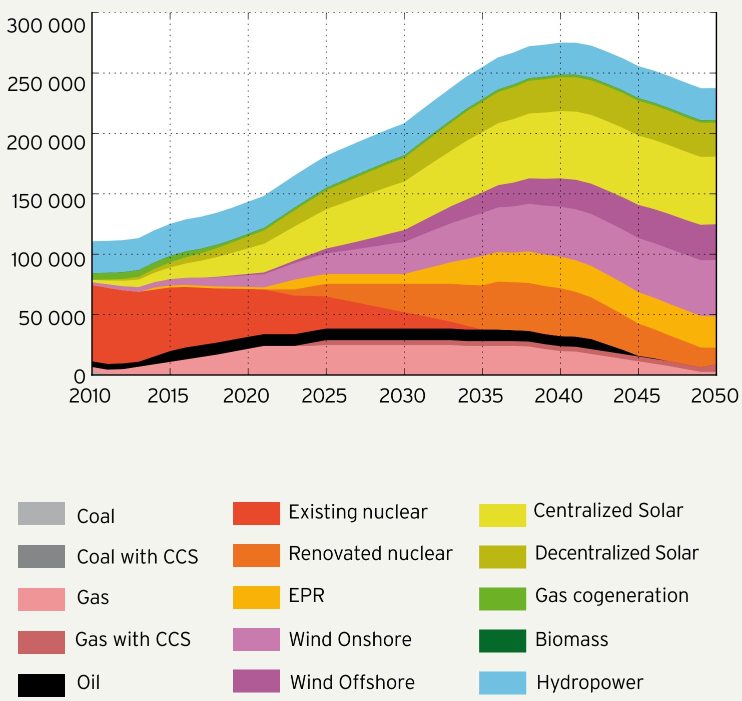
Average annual expenditures for electricity generation (Billion €)

Period	2011-2020	2021-2030	2031-2040	2041-2050
Investment	12	15	9	6
Fuel costs	1	1.4	0.1	0.6
Carbon costs	8.7	10.9	2.8	3.5

34 - Investment in new capacities (GW)



35 - Available capacities (MW)



The period between today and 2025 is the most critical one. Indeed, the beginning of nuclear plants' decommissioning, in addition to the growing share of variable renewables and the uncertainties surrounding the electricity supply market induce the construction of power plants fuelled by fossil energies. Between 2010 and 2020 more than 10 GW of oil-powered gas turbines and gas-fuelled combined cycles plants are built, which explains the emissions peak with an increase of 49% in the electricity sector. This reinforces the emergency in implementing energy efficiency and demand-side management to avoid building these carbon-intensive power plants. However, this transition from a nuclear-dominated mix to a mix relying also on renewables is short-lived, with emissions receding after 2030[27]. The fast decommissioning of the extended nuclear plants after 2040 creates some tensions in the electricity supply, leading to a return of some emissions in the electric sector, because of gas (mainly gas with CCS).

Policies costs

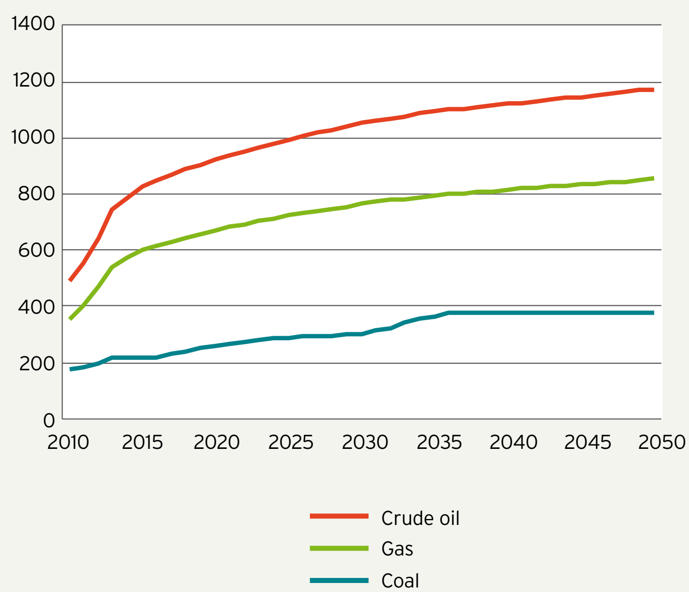
In the model, fiscal policies for the electric sector are reduced to the contribution towards financing feed-in tariffs and the carbon tax. The feed-in tariffs are neutral in the balance of the government since they are fully paid by the final consumers. Most demand-side management measures are paid for either by consumers or the electricity supplier. *

Fiscal measures (Billion €)					
Feed-in tariffs	2010	2020	2030	2040	2050
Additionnal CSPE Income = feed-in tariffs expense	2.9	1.9	7.2	17.8	12.7
Carbon Tax	0	13.7	18.1	23.9	34.8

27- Nuclear energy and renewable energies have no emissions in the scenario because their up- and downstream emissions are allocated in other sectors. For example the construction of the building for a nuclear power plant is captured by the building sector. Only the combustion emissions of the electricity sector are shown in the graph 47 that means only the emissions of fossil fuel based electricity production.

Macroeconomic impacts & scenario results

36 - World fossil energy prices (€/toe)



I. Global context and world visions

The scenario's global context sets up the framework for the study. This global vision answers the following questions. What outcome for international climate negotiations? How abruptly will the Peak-Oil shock western economies? What orientation for technical change? What consumption styles will prevail? For developed economies? For emerging economies?

Consumption styles in Europe and in France are considered to remain material-intensive. We have not considered in this scenario any change in consumption styles or consumers' preferences. A decoupling of growth and resources use will be further investigated in section 4. In the scenario presented here, no global climate agreement is reached; climate policies coordination only exists at the EU level. This situation leads to a world with a high energy demand, and to high fossil energy prices. Energy prices follow the "World energy outlook" 2011, as required by the stakeholders (graph 36). Crude oil prices reach 160€/barrel in 2050. Because of this high fossil energy prices, technological innovation focuses on renewable and energy efficiency, as well as on carbon capture and sequestration.*

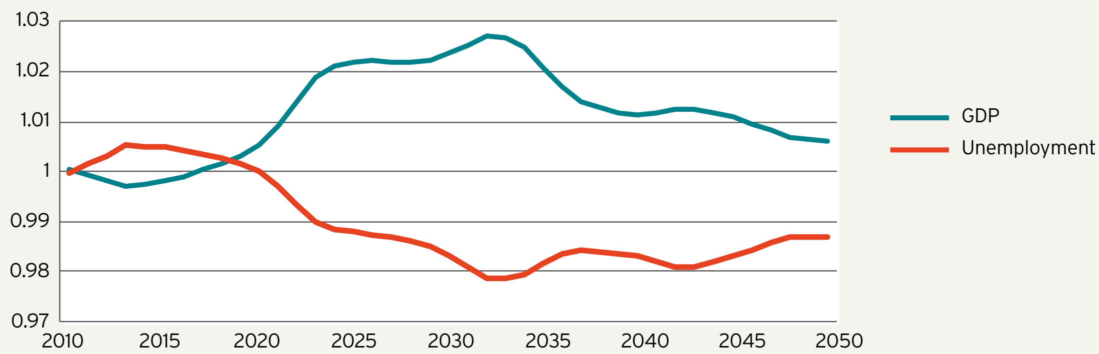
II. Macroeconomic dynamics of the mitigation scenario

1. Economic growth rate

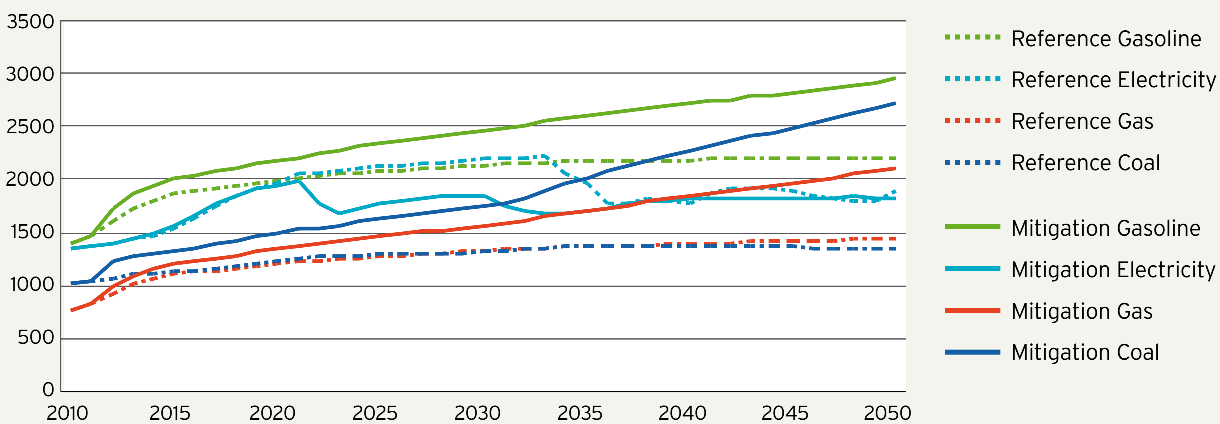
The growth engine in Imaclim conventionally consists of exogenous demographic trends and labor productivity changes, and is fuelled by regional net investment rates and investments allocation among sectors. Endogenous disequilibria are possible so as to capture transition costs after a policy decision or an exogenous shock. Investment decisions are driven by profit maximization under imperfect expectations in non-fully competitive markets.

The population follows the 2010 INSEE central demographic scenario and equals 72.3 million in 2050, i.e. a 15% increase compared to 2010. In the reference scenario (also called Business As Usual scenario, i.e. without climate policies), the average annual economic growth rate is about 1.24% between 2010 and 2050. The overall economic impact of the mitigation measures is positive, except in the short-term, with a negative impact until 2017 due to the introduction of the carbon tax in 2012. Thereafter, GDP is higher and unemployment is lower than in the reference scenario.

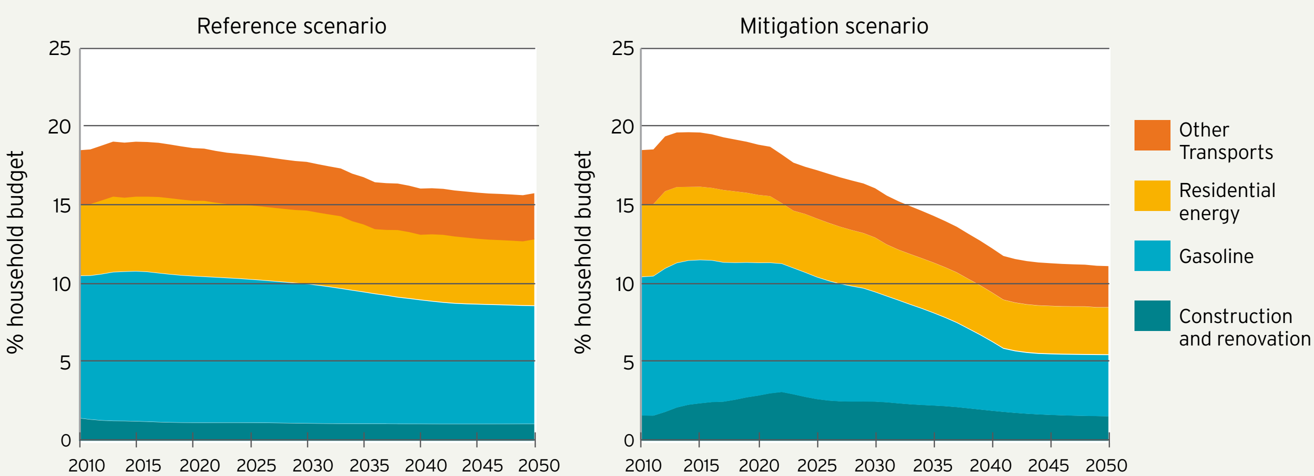
37 - Macreconomic trends in Mitigation scenario / Reference (base 1 in 2010)



38 - Consumer energy prices €/toe



39 - Household expenditures



Annual average GDP growth rate

	2010-2020	2020-2030	2030-2050	2010-2050
Reference	1.19	1.29	1.2	1.22
Mitigation	1.24	1.47	1.11	1.24

The impact is particularly positive from 2025 to 2035. At this date, the electricity price in the mitigation scenario is around 25% lower than in the reference scenario. Moreover, fossil energy prices get much more expensive than in the reference scenario because of the carbon tax. The combination of both factors induces a substantial energy switch towards electricity for productive sector and households. In addition, energy efficiency measures induce a decrease of the energy expenditures:

* In the household budgets (which is not compensated by the increase in construction and additional renovation costs).

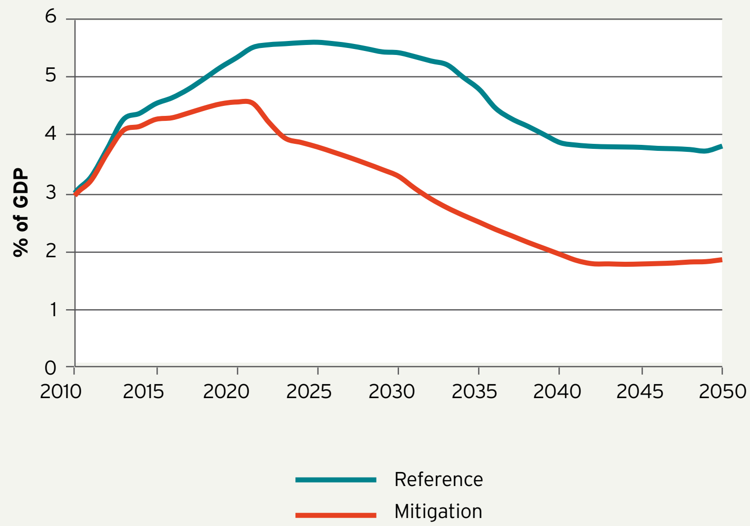
* For services industries that are not energy-intensive, which furthermore reinforces the international competition of French goods.

2. Energy efficiency, imports dependency and the energy bill

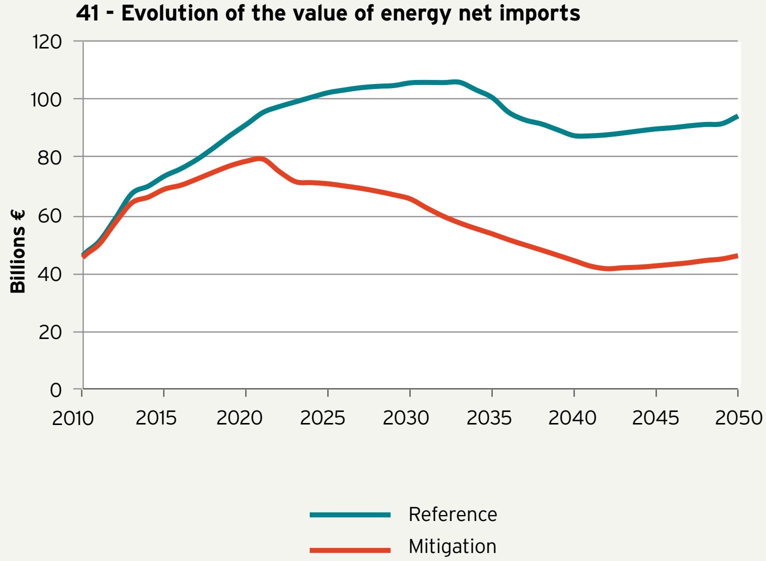
The development of non-fossil energies in conjunction with energy efficiency measures constitutes a protection against the negative impacts of the increase in energy prices and of the French import dependency. In the reference scenario, the energy import values represent more than 5% of GDP between 2019 and 2035. In the mitigation scenario, the energy import intensity of the GDP peaks in 2020 at 4.7% and gradually declines to a stable level 1.7% after 2040.

An often-overlooked fact is the dependency to uranium imports for the French energy mix. Even if the impact on the energy bill is negligible, the uranium consumption for nuclear power plants creates a dependency and increase energy vulnerability for France.

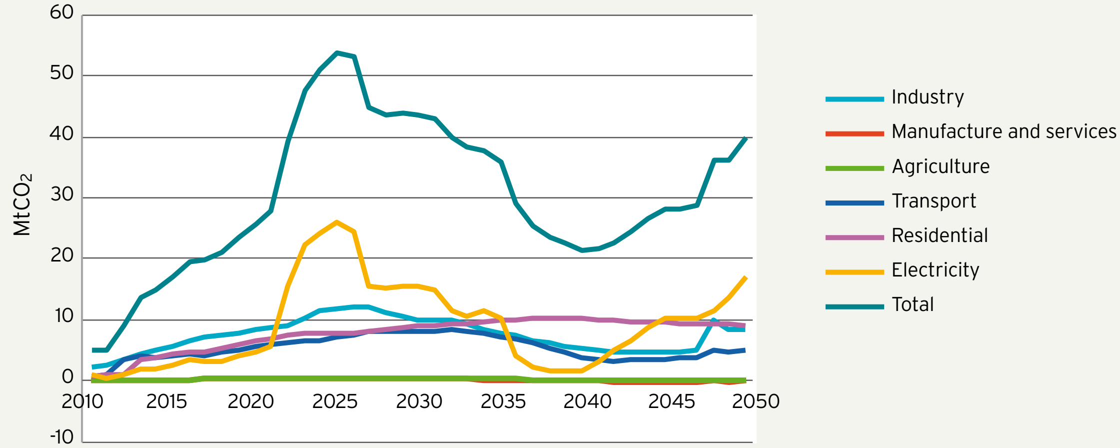
40 - Evolution of the net energy import intensity of the GDP



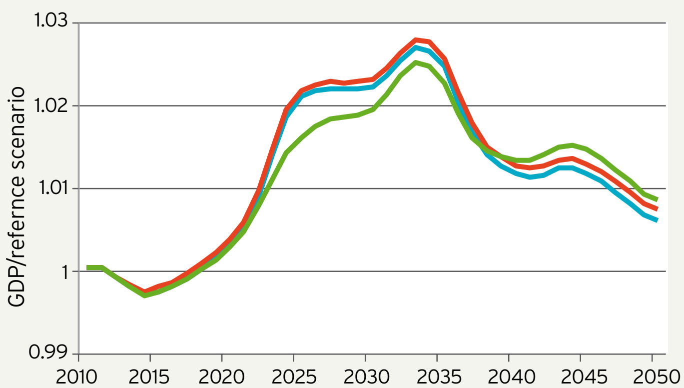
41 - Evolution of the value of energy net imports



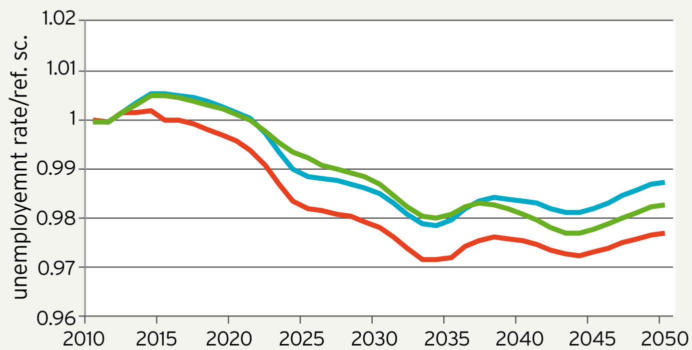
42 - CO_2 Emission reductions induced by the carbon tax



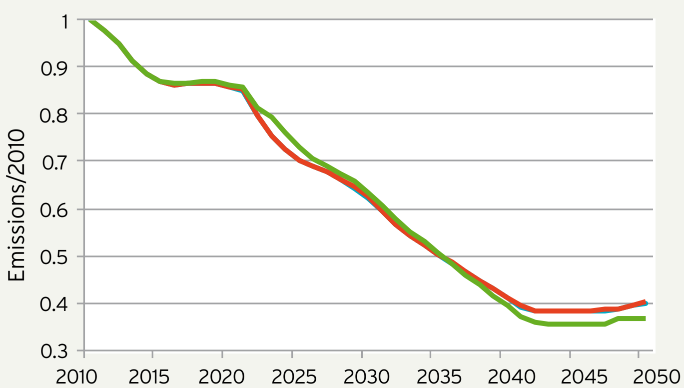
43 - GDP according to carbon tax recycling options



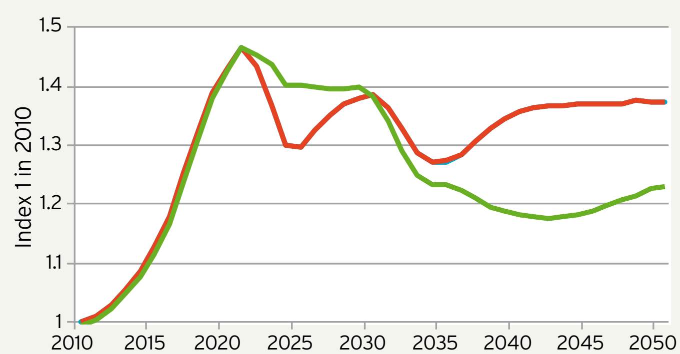
44 - Unemployment rate according to carbon tax recycling options

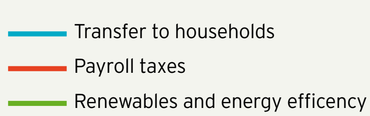


45 - Emissions according to carbon tax recycling options



46 - Consumer electricity price according to carbon tax recycling options





III. Carbon tax: a necessary measure?

1. The marginal impact on emissions reductions

One of the most emblematic measures of the scenario is the carbon tax. In order to disentangle its leverage power on emissions reductions, the marginal impact of the carbon tax on sectoral emissions reduction has been calculated. Thus, graph 42 illustrates the emissions reduction when the tax is implemented. As such, these emissions reductions are conditional to other policy measures implemented in the acceptable mitigation scenario. The emissions reductions would be much higher if the only policy measure were the tax.

The carbon tax is very efficient in decarbonizing the power sector particularly during the transition phase between 2020 and 2030 and at the end of the period when a large amount of nuclear plants are decommissioned. The carbon tax is also decisive in the renovation decisions in the residential sector during the whole period. Finally, the industrial emissions are much higher in the short term without a carbon tax serving as a signal for investments.

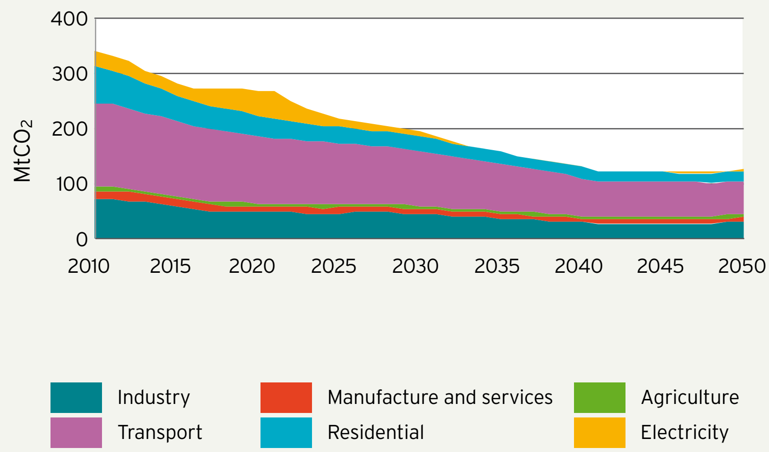
2. Carbon tax recycling options

The carbon tax is exogenously set in the scenario and follows the recommendations of the "Quinet" governmental report[28] until 2030 (32€/tCO_2 in 2012, 56€/tCO_2 in 2020, 100€/tCO_2 in 2030) and then extrapolated until 2050 (200€/tCO_2 in 2040 and 300€/tCO_2 in 2050). The carbon tax pathway is anticipated in the power sector but in other sectors and households form myopic expectations, based on the yearly tax.

The recycling of the tax was a lump sum transfer to households by default in the description of the mitigation scenario in the previous sections. Two other options were investigated to take into consideration stakeholder contributions: i) recycling towards subsidies for renewable energy development and energy efficiency improvements, and ii) a recycling towards lowering salary taxes.

In graphs 43 to 46, the economic impacts of the three variants are given. In the long term, the recycling towards subsidies for renewable development and energy efficiency improvements have the most positive impact on the GDP development. In addition, these variant leads to the most ambitious emissions reduction. On the other hand, the variant with a recycling towards lower payroll taxes has the most positive influence on the employment situation. The consumer electricity price varies widely depending on the chosen recycling option after 2035: the lowest price appears in the variant with a recycling towards subsidies for renewable development and energy efficiency and leads to an improved economic growth compared to other options.*

47 - Sectoral CO_2 emissions



28- *Alain Quinet (2009) : "La valeur tutélaire du carbone", Centre d'analyse stratégique.*

IV. CO_2 emissions reductions of the mitigation scenario

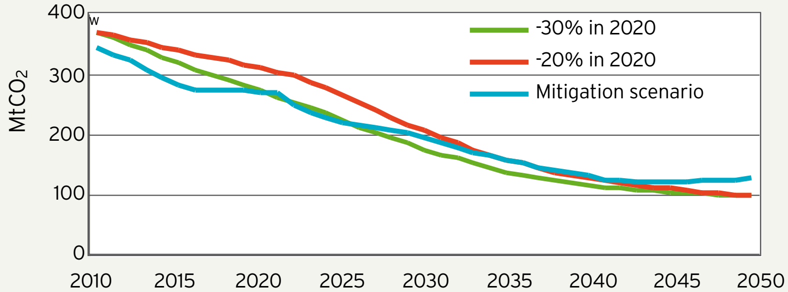
At the end of the period, the integration of all measures considered acceptable by stakeholders lead to CO_2-related energy emissions equal to 126 Mt CO_2. The following graph describes the sectoral contributions leading to this 60% decrease in emissions compared to 2010 and -68% compared to 1990.

The decarbonization of the electricity sector is difficult between 2015 and 2025 with the first wave of nuclear plants decommissioning. During this transition period, gas plants are built which

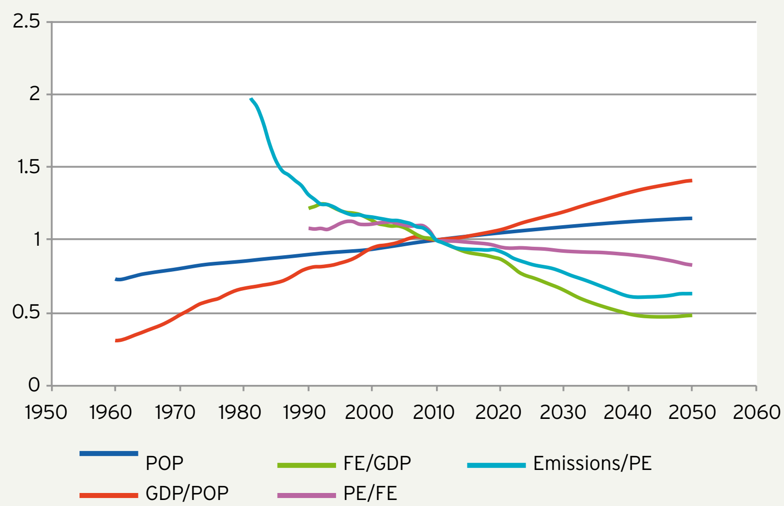
CO_2 sectoral emissions compared to 2010 (mitigation scenario)

	2020	2030	2040	2050
Industry	-33%	-37%	-59%	-57%
Manufacture and services	-36%	-39%	-49%	-49%
Agriculture	-24%	-30%	-42%	-40%
Transport	-19%	-35%	-55%	-60%
Residential	-44%	-62%	-72%	-75%
Electricity	49%	-68%	-100%	-86%
Total	-15%	-39%	-59%	-60%
Total (compared to 1990)	-31%	-50%	-67%	-68%

48 - Comparison of the mitigation scenario emission trajectory to Factor Four trajectories



49 - Evolution of the CO_2 emissions drivers (index 1 in 2010)



induces new emissions for the electricity sector. To limit these "transition emissions", priority has to be given to very ambitious energy efficiency measures to decrease electricity demand during this transition period and to the development of renewable energies on the short term. The main difficulty for decarbonization is the transport sector, where emissions still represent 60 $MtCO_2$, i.e. half of 2050 total CO_2 emissions.

The CO_2 emissions gap in 2050 between reaching a Factor Four and this mitigation scenario represents 28 $MtCO_2$. This still represents 25% of remaining emissions in the mitigation scenario at the end of the period. Until 2042, the CO_2 emissions trajectory of the mitigation scenario is consistent with a Factor Four trajectory. The trajectory even achieves a 31% CO_2 reduction in 2020 (compared to 1990). However, emissions reductions decelerate at the end of the period and the emissions level plateaus at 126 $MtCO_2$. ★

V. Drivers of CO_2 emissions reductions

The "Kaya identity" breaks down the emissions evolution into several drivers as follows:

$$CO_2 = POP \times \frac{GDP}{POP} \times \frac{FE}{GDP} \times \frac{PE}{FE} \times \frac{CO_2}{PE}$$

It states that total emissions levels can be expressed as the product of five inputs: population (POP), per capita income ($\frac{GDP}{POP}$), final energy intensity of GDP ($\frac{FE}{GDP}$), efficiency of the transformation of primary energy into final energy ($\frac{PE}{FE}$) which refers to the efficiency of the French energy system, carbon content of primary energy ($\frac{CO_2}{PE}$).

In the graph, the evolution of each of these drivers is given between 2010 and 2050. It shows that during the period:

* population increases by 15%,
* the per capita income increases by 41%,
* the final energy intensity of the GDP decreases by 51%,
* the primary energy needed per unit of final energy consumption reduces by 18%
* the CO_2 content of the primary energy reduces by 38%.

Globally, energy efficiency and structural changes represents two thirds of the emissions reductions and the penetration of decarbonized energy represents one third of the emissions reductions.

Against historic trends, population keeps increasing, albeit with a decreasing growth rate (from more than 1.5% per year in the 1960 until a predicted 0.2% in 2050). The GDP per capita growth was at a very high level (more than 4%) until the end of the 1970s, remained just below 2% until the 2000 and remains on average just below 1% over the simulated period. Final energy intensity of the GDP decrease, with a steadily growing speed (from -0.3% a year in the 1990s until -3% a year at the end of the 2020s), continuing the historic trend. After 2035, a shift in the simulated trend can be observed, no further reduction can be observed. The same analysis can be applied to the energy efficiency of the French energy transformation system. The carbon intensity of primary energy sharply decreases, continuing the trend set after the construction of nuclear power generation capacities in the 1990s. After 2040, the carbon intensity remains stable, thus preventing the scenario from reaching a Factor Four. The end of the period is the second wave of nuclear plants decommissioning. In the scenario, new gas plants are introduced at this time to bridge the gap between EPR and renewable production on the one hand and electricity demand on the other hand. ★

Emissions reductions and emissions scope

It has to be notified that an important share of greenhouse gases emissions is not considered in the project scope. The scenario is only focusing on energy-related domestic CO_2 emissions. All agricultural emissions, except energy-related CO_2 emissions, were not taken into account, thus overlooking the issue of land-use change. Upstream and downstream emissions outside the domestic perimeter were not covered by the present study either. This last point refers to the difference between accounting emissions in terms of production on a territory or in terms of consumption (which means accounting for imports and excluding exports). Finally, international transport was not listed in the French emissions. Besides, other greenhouse gases are outside the scope of this study.

This scenario therefore focuses on only 69%[29] of the overall French domestic emissions (share of CO_2 within the total French production related emissions). If consumption-related emissions from production outside the French borders are added, the scenario presented here only accounts for 44% of the French emissions.

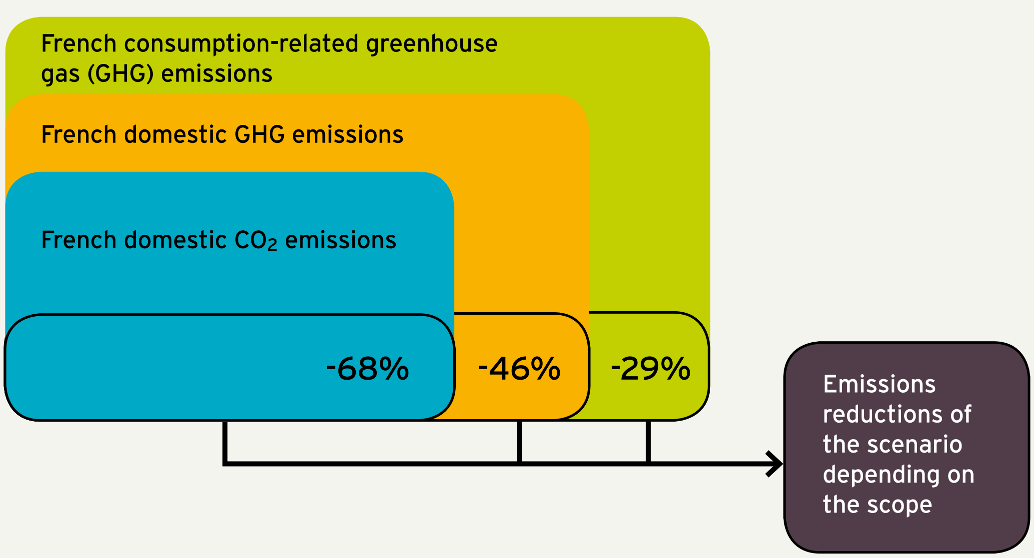
A 68% emissions reduction in 2050 represents a 46% reduction of the total French GHG emissions and of only 29% of the total consumption-related French GHG emissions[30]. In conjunction with the uncertainties surrounding the energy transition, this prospect emphasizes the importance of at least insuring a Factor Four in France to fight climate change.

As a result, the following section first delves into uncertainties. Then, it presents additional measures and their impact on the energy consumption, emissions reduction, investment and price development. These measures were not considered to be acceptable by at least half of the stakeholders. Finally, a combination of measures reaching the Factor Four is explored.*

29- *CITEPA (2011) "Inventaire des émissions en France".*

30- *Edgar G. Hertwich / Glen P. Peters (2009) "Carbon Footprint of Nations: A Global, Trade-Linked Analysis", Environmental science & technology, 43 (16).*

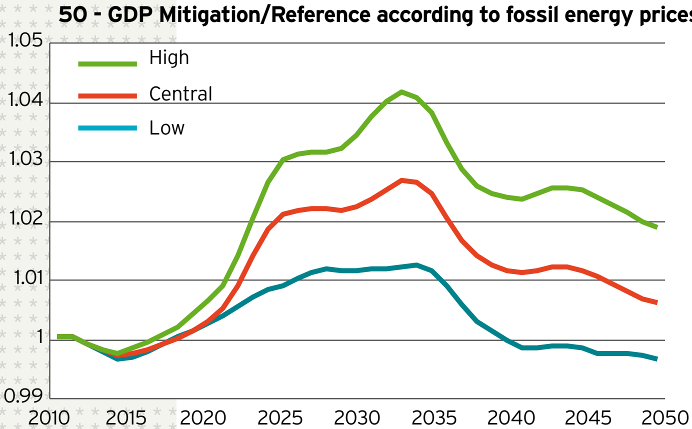
Emissions reduction scope (compared to 1990)



4 Reconciling
stakeholders' acceptance and ambitious climate objectives

After studying the acceptability of policy measures in the previous section, we now focus on other types of determinants which could significantly impact the CO_2 emissions trajectory, namely the uncertainties around fossil energy prices, a border tax adjustment and a change of the development styles. The uncertainty surrounding these scenario variants is of a completely different nature compared to the issue of stakeholders' acceptability.

50 - GDP Mitigation/Reference according to fossil energy prices



I. The role of fossil energy prices

In the previous section, the mitigation scenario was based on fossil energy prices from the World Energy Outlook (IEA, 2011). To show the impact of energy prices assumptions on mitigation scenarios, we investigate two other scenarios: one with fossil energy prices 30% less expensive, and one with fossil energy prices 30% more expensive.

Unsurprisingly, higher (respectively lower) energy prices lead to higher (respectively lower) emission reductions. Nevertheless, emission reductions in 2020, compared to 1990 are always higher than 25%. In the long term, only high energy prices are consistent with a Factor Four. In the low prices scenario, emissions increase in the short term, because relative energy prices between 2010 and 2020 favor a substitution from oil, coal and electricity towards gas. In the long term, total CO_2 emissions only decrease by 57% compared to 2010.

The main sectoral impact compared to the central energy prices scenario is on the renovation of the existing buildings stock. With low energy prices, economic incentives for refurbishment are not high enough to induce a significant transition to lower energy classes.

In the scenario with lower fossil fuel prices, the decarbonization of the power sector is complete because electricity prices remain higher than gas prices during the whole period, therefore electricity demand is reduced compared to other scenarios. With a lower demand it is less challenging to decarbonize the power production.

The scenario with higher energy prices has a higher decarbonization rate on the long term but for other reasons: as the overall costs are higher, the CCS technology becomes competitive and reduces the emissions of the fossil power production.

Whatever the assumptions with regards to fossil energy prices, GDP growth in mitigation scenarios is always higher than in the corresponding reference scenario. This result underlines the importance of the implementation of mitigation policies to reduce the vulnerability regarding the evolution of fossil energy prices.*

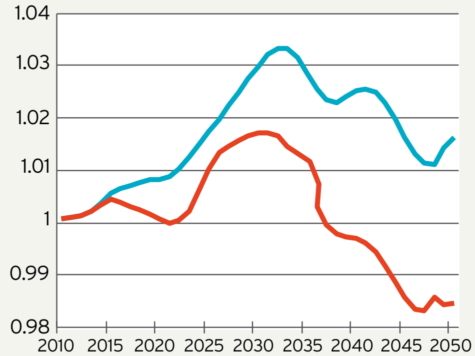
31- The "industry" denomination refers to energy-intensive industry.

32- The "tertiary" aggregates services and the manufacture that is not intensive in energy.

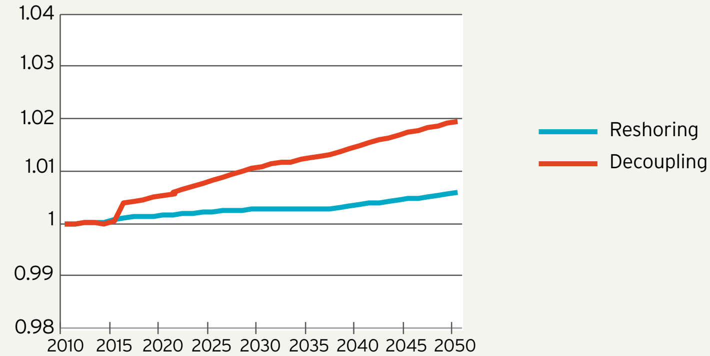
Total and sectoral emissions reduction compared to 2010 according to the fossil energy prices

	2020			2030			2040			2050		
	Low	Central	High	Low	Central	High	Low	Central	High	Low	Central	High
Industry[31]	-33%	-33%	-33%	-38%	-37%	-53%	-48%	-59%	-67%	-57%	-57%	-77%
Tertiary[32]	-34%	-36%	-38%	-40%	-39%	-59%	-44%	-49%	-64%	-47%	-49%	-67%
Agriculture	-19%	-24%	-20%	-26%	-30%	-48%	-30%	-42%	-58%	-33%	-40%	-61%
Transport	-8%	-19%	-19%	-22%	-35%	-37%	-38%	-55%	-57%	-54%	-60%	-65%
Residential	-28%	-44%	-37%	-43%	-62%	-61%	-54%	-72%	-74%	-65%	-75%	-79%
Electricity	-61%	49%	-53%	-34%	-68%	-43%	-99%	-100%	-100%	-100%	-86%	-99%
Total	-18%	-15%	-24%	-26%	-39%	-43%	-45%	-59%	-64%	-57%	-60%	-71%
Total /1990	-25%	-31%	-31%	-33%	-50%	-48%	-50%	-67%	-67%	-60%	-68%	-74%

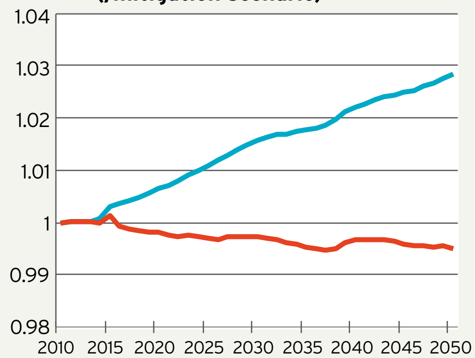
51 - CO_2 emissions (/mitigation scenario)



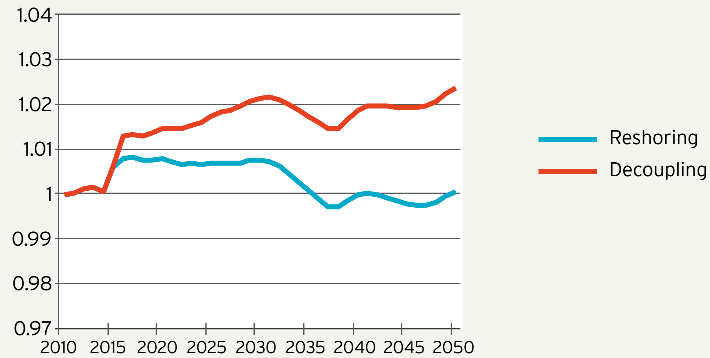
52 - GDP (/mitigation scenario)



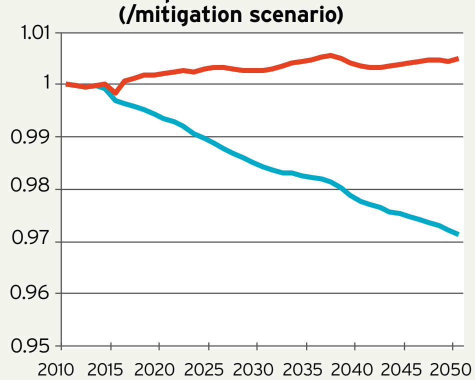
53 - Consumption price index (/mitigation scenario)



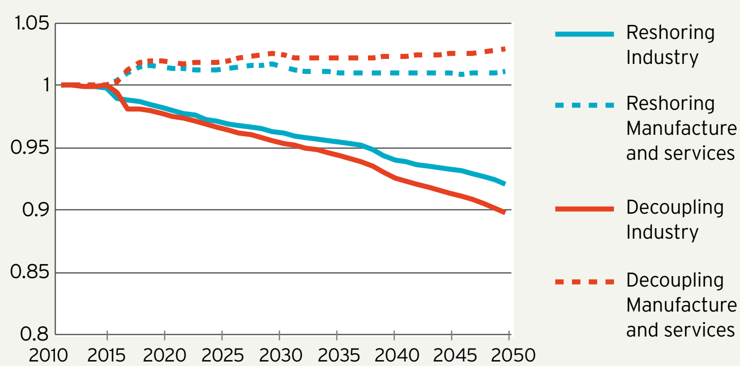
54 - Final consumption (/mitigation scenario)



55 - Competitiveness index (/mitigation scenario)



56 - Production index (/mitigation scenario)



II. The impact of the development style

Two variants refer to the evolution of values and standards:

* The decoupling[33] of consumption styles: French households are considered to change their consumption patterns and to consume less material goods and more services.
* The reshoring[34] of production capacities back to France: French consumers and producers prefer to consume French products instead of importing.

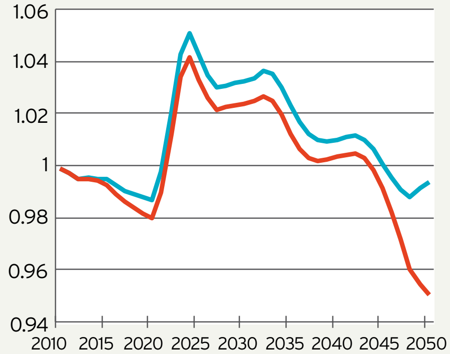
In the reshoring scenario, households agree to pay higher prices for goods if these goods are produced in France. Logically, this raises consumption prices (+3% in 2050). The combined effect of higher prices and reshoring on final consumption levels is almost neutral. On the one hand, industrial production decreases, and the other hand, services and manufacture production increases. GDP is 0.6% higher in 2050, and CO_2 emissions are between 1 and 3% higher compared to the acceptable scenario in 2050. Overall competitiveness decreases, but more of the French consumption is produced in France.

In the decoupling scenario, policies and measures are implemented in a French economic context with a 30% decrease of the industrial and material content of consumption in 2050. The decrease

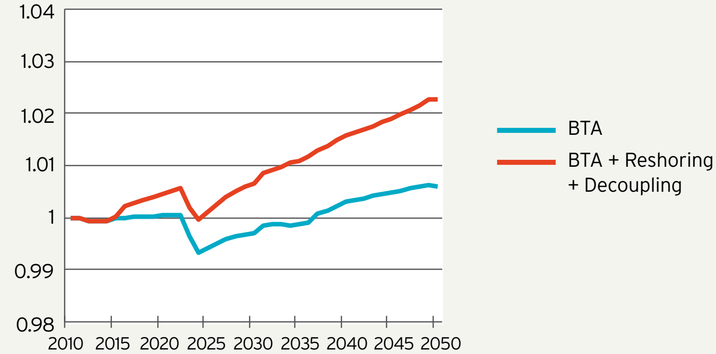
33- *The ability of an economy to grow without corresponding increases in environmental pressure, particularly in terms of the use of natural resources, is referred to as decoupling or eco-economic decoupling.*

34- *Reshoring is defined as the relocation of activities from foreign countries back to France, as opposed to offshoring. For instance, relocation of activities from France to China is called offshoring whereas bringing back the activities in France is called reshoring.*

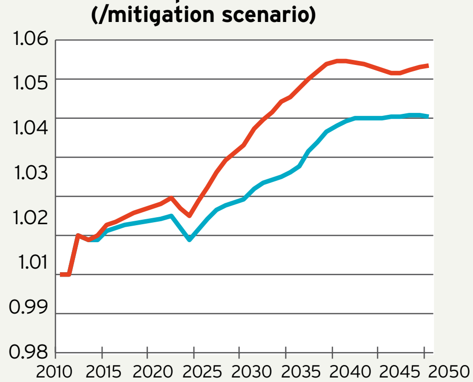
57 - CO_2 emissions (/mitigation scenario)



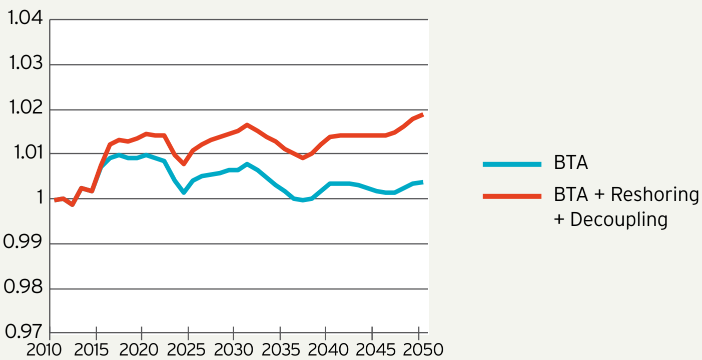
58 - GDP (/mitigation scenario)



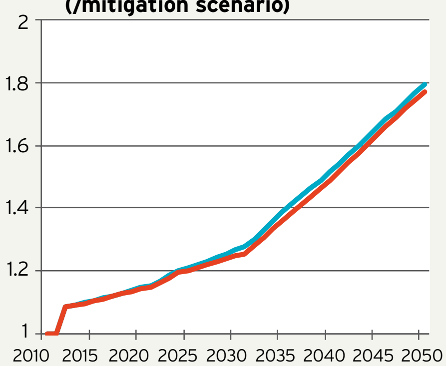
59 - Consumption Price index (/mitigation scenario)



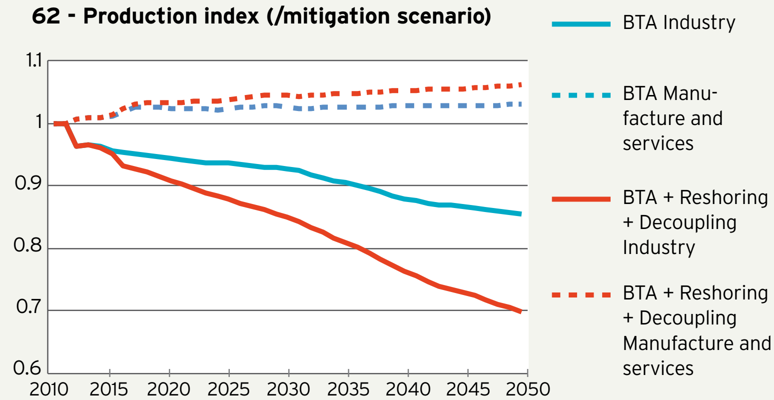
60 - Final consumption (/mitigation scenario)



61 - Competitiveness index (/mitigation scenario)



62 - Production index (/mitigation scenario)



of the material consumption is partly compensated by more consumption of services. Overall final consumption is higher by 2.5% in 2050. The consequence on the economy is a 2% GDP increase compared to the acceptable scenario in 2050, and a nearly 2% decrease in CO_2 emissions. The consumption price index slightly decreases because of the diminution of the weight of energy expenditures on the economy. For the same reason, the price competitiveness index mildly increases.

If both these variant exhibit an increased GDP, the results in terms of emissions and economic activity are different. Relocation increases CO_2 emissions as well as the consumer price index. However, the economic decoupling allows a higher level of activity without a raise in CO_2 emissions.*

III. Do we need a border tax adjustment?

A number of policies have been suggested to address concerns over competitive losses due to one country introducing a carbon tax while another country does not. In this variant, the impact of the implementation of a border tax adjustment (BTA) at the EU27 level was analyzed. The role of a BTA is to address the competitiveness losses which stems from the price distortion induced by the carbon taxation. This BTA taxes imported goods in the manufacturing sector. Highly energy-intensive industrial goods are not subject to the BTA, as we consider that European imports mainly consist of manufactured goods. The level of taxation is subject to the additional carbon content compared to EU average carbon content. This additional measure is computed alone in a first scenario, and a second scenario gathers the BTA and previous assumptions related to decoupling and reshoring.

Logically, the direct impacts of the BTA are a reinforced international competitiveness, but also an increase of consumer prices. As the BTA is applied only for the manufactured goods (and not on industry), manufacturing increases, but the energy-intensive industry production decreases. Due to the relative weights of these sectors in the French economy, the global outcome on the longer term is a slightly increased economic growth, with a more significant emissions decrease.

If assumptions related to reshoring and decoupling are added, economic and environmental outcomes of the implementation of the BTA are significantly improved. In this variant, CO_2 emissions drop by an additional 5% in 2050, GDP and final consumption levels increase by 2%, while competitiveness increases. The only drawback would be the 5% increase of the consumer price index.*

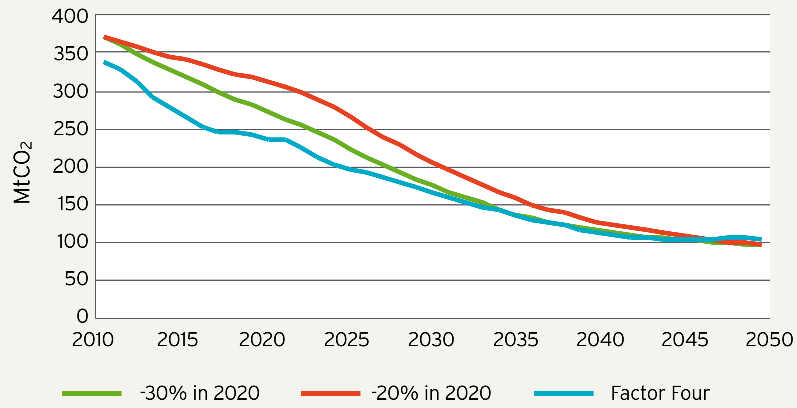
IV. How to reach the Factor Four?

Additional measures that were considered as acceptable by about 50% of stakeholders are implemented to further CO_2 emissions reductions:

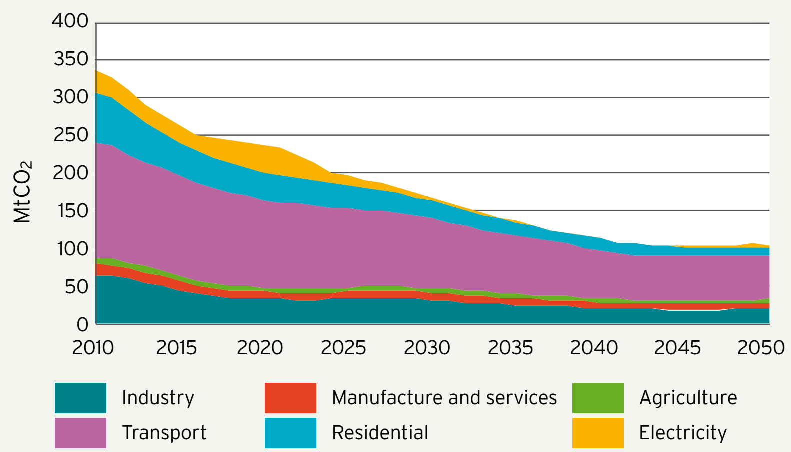
A carbon-energy tax (CET): the carbon tax is replaced by a carbon-energy tax to give a further incentive to reduce energy consumption. It taxes the energy content and the carbon content of the energy and is applied to all the forms of energy (coal, gas, oil, nuclear) except renewable energies. So electricity is also taxed. The tax rate corresponding to the carbon content is still the same as in section 3. The tax rate concerning the energy content is calibrated in 2012 in order the total income from the energy part of the CET equals the total income from the carbon content.

This CET is calibrated in order to align the energy part of the tax with the amount of the carbon part of the tax on average. The CET induces a tax level corresponding to a doubling on average of the previous carbon tax for fossil fuels. For carbon-free energy, the CET adds a tax valued as the energy part of the CET on fossil fuels. The CET aims at introducing more sufficiency in households' behaviors, particularly concerning specific electricity consumption, and more energy efficiency in industry and in the tertiary sector.

63 - Comparison of the Additional Measures Scenario emission trajectory to Scenario with additional measures trajectories



64 - Sectoral CO_2 emissions in the Additional Measure Scenario



A refurbishment obligation is applied to the building stock. The planning of the obligation is organized following the type of building (individual houses, collective dwellings and social houses) and the energy label of the building, beginning with the less energy-efficient classes. The refurbishment aims at reaching label B (80 kWh/m^2/year). The obligation is first applied to social houses because this type of housing is best suited to implement such a measure and because of fuel poverty considerations, due to its existing centralized ownership structure. Implementation dates are given in the following table. Refurbishments are calibrated in

Sectoral emissions reductions / 2010				
	2020	**2030**	**2040**	**2050**
Industry	-41%	-43%	-57%	-63%
Manufacture and services	-51%	-55%	-70%	-75%
Agriculture	-32%	-37%	-52%	-58%
Transport	-23%	-40%	-57%	-63%
Residential	-48%	-67%	-81%	-85%
Electricity	-20%	-90%	-100%	-85%
Total	-43%	-48%	-65%	-69%
Total compared to 1990	-36%	-59%	-73%	-75%

order to leave enough time for the firms in the construction sector for restructuring and training to be able to face this vast national action plan.

Dates for the refurbishment obligation

	G	F	E	D	C
Social housing	2016	2016	2016	2020	2020
Collective dwellings	2020	2024	2024	2028	2032
Individual houses	2018	2022	2026	2030	2034

The total number of refurbishments remains below 200.000 until 2020. After 2020, this number gradually increases until 2040 with 900.000 renovations a year. Thereafter, the number of annual renovations declines. At the end of the period, 16.1 million of buildings are retrofitted.

With these additional measures, emissions reductions reach the Factor Four.

With the additional measures, the emissions reduction pathway is lower than both Factor Four pathways (-20% in 2020 or -30% in 2020). This precocious abatement to achieve Factor Four pleads for early action as way to ensure that emissions reductions at the end of the period follow the prescribed pathway. In addition, this leads to lower cumulated emissions, which results in a slightly lighter environmental impact.

Sectoral emissions reach a very low level. The residential sector reaches a division by 6.6, thanks to the refurbishment obligation. Transport and production sectors reduce their emissions by two thirds. The power sector is totally decarbonized in 2040, but emissions increase again until 2050 because gas is used to fill the gap between the electricity demand and the development of renewable energies and residual nuclear production. We find results similar to those of chapter 3 with respect to the sectors with the highest emission reductions and the sector that represent challenges to decarbonize.

From a macroeconomic point of view, the average economic growth in the Additional Measures Scenario (AMS) is slightly inferior to the reference scenario whatever the option for the CET recycling. Nevertheless, until 2030, additional measures have positive economic impacts particularly because of energy efficiency measures which reduce the necessary energy expenditures of households.

These GDP trends are directly linked to the evolution of the unemployment rate (compared to the reference scenario). Whatever the tax recycling option, the impact on unemployment is positive compared to the reference scenario. The maximum reduction of the unemployment rate occurs around 2030, but the unemployment rate decreases as soon as 2020. The recycling of the CET for lowering payroll taxes has the most positive impact on employment over the whole period.

In this AMS scenario, the analysis of the households' energy expenditures can prove very interesting. Overall households' energy expenditures decrease slightly (-1%) as soon as 2020 compared to the reference scenario. The decrease reaches 5% in 2030 and the households' energy expenditures display a very important decrease between 2030 and 2050, stabilizing at a level 28% inferior to the reference. The share of the mentioned costs (total energy budget share for households) is 18.4% in 2010, 15.8% in 2050 in the reference and 11.3% in 2050 in the Factor Four scenario.

Conflicting trends are hidden behind this apparent regular decrease in expenditures. Gasoline expenditures decrease throughout the period, accounting for improvements in cars energy efficiency and modal switch towards public transportation, with a transition speed much faster than in the reference. The share of other transport modes in the energy expenditures increases by 20% in 2030 to fall back to an identical level in 2050. Regarding residential energy, most of the effort is done between 2020 and 2030 where the share drops much faster than in the reference. As a result of the refurbishment obligation the share of construction and refurbishment in 2030 soars compared to the reference, as to be multiplied by 2.7. As said previously, these opposing tendencies still result in a very important decrease, which seems to be a precondition to a very ambitious mitigation plan.*

		Average annual GDP growth rate			
		2010-2020	2020-2030	2030-2050	2010-2050
Reference scenario		**1.19**	**1.29**	**1.23**	**1.24**
Additional measures scenario	Transfer to households	1.27	1.41	1.06	1.20
	Payroll taxes	1.29	1.41	1.06	1.21
	Energy Efficiency And renewables	1.27	1.41	1.06	1.20

		Unemployment rate/Ref. Sc.		
		2020	2030	2040
Additional measures scenario	Transfer to households	-0.2%	-1.9%	-1.0%
	Payroll taxes	-1.3%	-3.1%	-2.4%
	Energy Efficiency And renewables	-0.2%	-1.9%	-1.0%

Expenditure share / Reference scenario	2020	2030	2050
Construction and refurbishment	156%	262%	67%
Gasoline	-17%	-32%	-49%
Residential energy	-15%	-32%	-36%
Other transports	10%	19%	1%
Total energy budget share	-1%	-5%	-28%

Sensitivity analysis

5

1 - Sensitivity analysis parameters and nomenclature

	Scenario name	CCS in the power sector	Nuclear (EPR) investment cost (€/kW)	Cost of nuclear plant lifetime extension (€/kW)	Biofuels - 1st and 2nd generation	Renewables cost decrease between 2010 and 2050
Default settings	Acceptable scenario	available	2900	700	available	- X%
	AMS scenario	available	2900	700	available	- X%
Alternatives	No CCS	unavailable	2900	700	available	- X%
	Expensive nuke	available	**4500**	700	available	- X%
	Expensive extension	available	2900	**1400**	available	- X%
	No biofuels	available	2900	700	**unavailable**	- X%
	Expensive RNE	available	2900	700	available	**- X/2%**
	Adverse scenario	**unavailable**	**4500**	**1400**	**unavailable**	**- X/2%**

I. Sensitivity analysis description

Emission reductions in the scenario implementing the measures considered as acceptable by stakeholders depend on many assumptions, particularly concerning technological change as well as the availability and acceptance of technologies.

Therefore, we undertake a sensitivity analysis on several parameters. We tested several parameters as described in table 1, namely the availability of carbon capture and storage, investment costs of new nuclear plants, the extension of existing nuclear plants lifetime, investment costs of renewable electricity plants, and the availability of biofuels. We considered here a "no biofuels" alternative scenario in which second generation biofuels never achieve economic and technical viability and first generation biofuels are banned because of their weak environmental performances and their impact on land use change. We considered here the "expensive RNE" alternative scenario where the pace of cost decrease for renewables is half the pace of cost decrease assumed in chapter 3 (meaning that it takes twice as long in the "expensive RNE" scenario to reach the same cost as in the original scenario).

For each of these five parameters, we tested the acceptable scenario with the most pessimistic option for that parameter. Moreover, an adverse scenario was tested where all the five parameters are set to the pessimistic case at the same time. In addition, an adverse scenario was tested based on the "Additional Measures Scenario" from the previous section.

Table 1 presents the content of the modified parameters for the seven resulting scenarios, as well as the scenario nomenclature used in this section.*

II. Sensitivity analysis for the "acceptable scenario"

Table 2 presents the emissions impacts for the sensitivity analysis. The impossibility to rely on biofuels is the variant with the largest impact on emission reductions in the short-term as well as in the long-term. Other parameters taken one by one have only a limited impact on emission reductions.

Nevertheless, when these parameters are combined all together, long-term emissions reductions are significantly reduced as they reach only -53% in 2050 compared to 1990, thus exceeding the aimed "Factor Four". It is noteworthy that short-term reductions (i.e. in 2020) do not fall below the "No Biofuels" scenario. Indeed, all the other parameters of the "Adverse Scenario" mainly

2 - Sensitivity analysis for the "acceptable scenario" described in chapter 3
Emissions, electricity prices and macroeconomics impacts

	Emission reductions compared to 1990		Electricity price (€/MWh)		GDP (/Mitigation)		Unemployment rate (/Mitigation)		Household energy related expenditures (/Mitigation)	
	2020	2050	2030	2050	2020	2050	2020	2050	2020	2050
Acceptable scenario	-31%	-68%	1081	1100	-	-	-	-	-	-
No CCS	-32%	-67%	1110	1077	0.0%	0.2%	0.0%	-0.1%	0.0%	-0.3%
Expensive Nuke	-33%	-65%	1151	1217	0.1%	-1.1%	-0.1%	0.8%	-0.4%	2.7%
Expensive Extension	-31%	-67%	1090	1153	0.0%	-0.2%	0.0%	0.2%	0.0%	0.6%
No Biofuels	-28%	-61%	1109	1087	-0.2%	-1.2%	0.3%	1.2%	0.3%	0.4%
Expensive RNE	-31%	-66%	1085	1163	0.0%	-0.2%	0.0%	0.3%	0.0%	0.9%
Adverse scenario	-28%	-53%	1169	1332	-0.2%	-2.3%	0.2%	2.4%	0.4%	4.3%

impact the power sector, where the transition really starts after 2020 when the first nuclear reactors are decommissioned and the share of intermittent renewables becomes significant. In this case, the measures considered as acceptable by stakeholders are not ambitious enough, even if emission reductions are significant in 2020.

Electricity prices increase in the short-term in all scenarios. The most influential parameter is the cost of new nuclear power plants. Indeed, increasing the investment costs by 55% leads to a 6% increase of electricity prices in the short term and to an increase of 11% in the long term compared to the "acceptable scenario". The unavailability of CCS, as well as the unavailability of biofuels, induces a 3% increase in prices in the short term because these technologies reduce emissions, but slightly decrease the price in the long-run as they avoid a lock-in in carbon-emitting technologies. The pessimistic case for renewables investment cost (respectively the extension of nuclear power plants) has no effect in the short run and induce a 5% (respectively 6%) price increase in the long run. Finally, the "Adverse Scenario" leads to an increase of the electricity prices 8% in the short term and 21% in the long run, compared to the acceptable scenario presented in section 3.

Macroeconomic impacts such as economic growth, unemployment and energy related expenditures for households are limited, but negative (see table 2) . The most influential parameters are the unavailability of biofuels and the increase in investment costs for new nuclear power plants. However, short-term impacts are very limited in the "Adverse Scenario" which is the most pessimistic one (inferior to 1% in 2020 compared to the acceptable scenario). In the long run, the increase in the electricity price leads to a 4.3% increase in energy-related expenditures for households in the "Adverse Scenario".

The impact on investments in the power sector is however very contrasted. Higher costs of new nuclear plants are considerably decreasing their share in the energy mix. They are being replaced mainly by gas power plants. With the low level of carbon tax at the beginning of the period, only half of the additional investment is with CCS. On the contrary, the unavailability of CCS technologies induces a shift towards new nuclear and gas without CCS. It is interesting to note that most scenarios rely on gas without CCS to a certain extent, at least as a transition technology.

The impacts of the other investigated sources of uncertainties are much more limited. The total amount of capacity is almost stable, showing that electricity becomes increasingly important as an energy carrier. However, any of the pessimistic assumptions leads to an increase in price (at least temporary) compared to the acceptable scenario, inducing a lower demand for electricity, which decreases the profitability of investment, hence reducing actual investments (even if by a small amount).

In the "Adverse Scenario", the high cost of nuclear and the unavailability of CCS induce a massive shift toward gas power plants without CCS. However, only 10.4 GW of gas power plants are built against the missing 18.6 GW of nuclear

3 - Sensitivity analysis for the "acceptable scenario" on investment in the power sector Cumulated investment between 2010 and 2050 (GW)

	Emission reductions compared to 1990		Electricity price (€/MWh)		GDP (/Mitigation)		Unemployment rate (/Mitigation)		Household energy related expenditures (/Mitigation)	
	2020	2050	2030	2050	2020	2050	2020	2050	2020	2050
Acceptable scenario	-31%	-68%	1081	1100	-	-	-	-	-	-
No CCS	-32%	-67%	1110	1077	0.0%	0.2%	0.0%	-0.1%	0.0%	-0.3%
Expensive Nuke	-33%	-65%	1151	1217	0.1%	-1.1%	-0.1%	0.8%	-0.4%	2.7%
Expensive Extension	-31%	-67%	1090	1153	0.0%	-0.2%	0.0%	0.2%	0.0%	0.6%
No Biofuels	-28%	-61%	1109	1087	-0.2%	-1.2%	0.3%	1.2%	0.3%	0.4%
Expensive RNE	-31%	-66%	1085	1163	0.0%	-0.2%	0.0%	0.3%	0.0%	0.9%
Adverse scenario	-28%	-53%	1169	1332	-0.2%	-2.3%	0.2%	2.4%	0.4%	4.3%

4 - Sensitivity analysis for the « additional measures scenario » - Emissions, electricity prices and macroeconomics impacts

	Emission reductions compared to 1990		Electricity price (€/MWh)		GDP (/AMS)		Unemployment rate (/AMS)		Household energy related expenditures (/AMS)	
	2020	2050	2030	2050	2020	2050	2020	2050	2020	2050
AMS	-44%	-75%	1179	1600	-	-	-	-	-	-
Adverse AMS scenario	-40%	-68%	1192	1503	-0.2%	-1.6%	0.3%	1.5%	0.3%	-0.1%

5 - Sensitivity analysis for the "additional measures scenario" on investment in the power sector – cumulated investment between 2010 and 2050 (GW)

	Gas without CCS	Gas with CCS	New Nuclear	Coal	Oil	Total
AMS	14.4	2.4	0	0	2.4	**19.2**
Adverse AMS scenario	14.4	2.4	0	0	4.8	**21.6**

and gas with CCS. Indeed, another impact is the decrease in cumulated investments in the power sector (-16%) because of the electricity price increase in this scenario.

III. Sensitivity analysis for the Additional Measures Scenario

We also explore the aggregated impact of these parameters on the additional measures scenario (described in section 4).

The impact on emissions reductions is significant but smaller compared to the impact on the "acceptable" scenario (7 points of emissions reductions compared to 13 points in the previous sensitivity analysis). It is thus important to keep in mind that the implementation of additional measures leads to reduce by 50% the impact of uncertainties surrounding technology development and their impact on emissions reductions. Macroeconomic impacts linked to unemployment, GDP growth and to household energy related expenditures are also smaller than for the "acceptable" scenario. This is partly explained by the smaller impact of uncertainties on investments in the power sector in the Additional Measures Scenario due to the reduced need for additional investments in electricity production capacities, with the exception of renewable energy.

The Additional Measure Scenario is thus more robust to uncertainties. ★

6 Conclusion

The outcome of this collaborative scenario creation attempt is threefold. First, we designed and introduced a methodology for collaborative scenario creation. Second, we successfully applied this methodology to design a scenario which integrates the visions and contributions of a variety of stakeholders. Finally, the analysis of the energy scenario resulting from this process opened up a fruitful discussion on the transition and necessary steps to face the urging climate challenge.

The emissions reductions following the implementation of all the measures that were judged acceptable by at least half of the stakeholders come close but fail in reaching the Factor Four target. In 2020, the mitigation scenario leads to CO_2 emissions 33% lower than 1990, which is more ambitious than the 20% European objective. However, the package of measures leads to a 68% CO_2 emissions reduction only in 2050 compared to 1990. Nonetheless, the Factor Four is reached in the residential sector as well as the power sector. The crucial issues lie with the contributions of the transport sector and the productive sectors to tackle emissions. In the transport sector, the evolution of emissions will heavily depend on mobility, strongly driven by urban sprawl. The predominance of road for transportation and the yearning for more mobility, intertwined with the transformation of urban patterns in France will determine the shape of the energy transition. Besides, the emissions level in the productive sectors will be contingent upon the relative prices of gas and electricity and the speed of technical change. This mutation might significantly affect economic performance, calling for a national debate on the role of globalization.

This scenario does not represent a paradigm shift in the development pattern. Indeed, GDP per capita is projected to increase by 41% between 2010 and 2050, and consumption is not reduced but redirected towards less energy-intensive products and services. Climate policy measures, especially through higher fossil energy prices, promote the development of low-carbon technologies and energy demand reduction, which contribute to reducing the overall energy bill and the energy budget of households. In addition, these policy measures alleviate the economic detrimental consequences of the rise of fossil fuels prices. Also investing in energy efficiency drives GDP growth and reduces unemployment. The trigger for this evolution is the implementation of a carbon tax to redirect investments towards less carbon-intensive options by increasing the cost of fossil fuels. A low carbon transition cannot be initiated without this crucial leverage, which is supported by a majority of the contributing stakeholders.

This project has revealed elements of consensus regarding climate mitigation policies but also some cleavages. Two measures that were not consensual among stakeholders appear crucial in actually reaching the Factor Four objective: the refurbishment obligation for the existing building stock and the energy-carbon tax (instead of a carbon tax only). This report reveals the need for a strong political commitment to leverage the decarbonization of the energy system. The responsibility lies with the stakeholders and the government to decide on a hierarchy of values and actions fed by scientific evidence and public concerns. The question of the precedence of long-term interests (e.g. protecting the needs of future generations) over short-term considerations is an ethical issue, which should be subjected to public scrutiny. In any case, scientific evidence shows today that urgent and far-reaching action is necessary. This project shows that a consensus about the acceptability of ambitious measures cannot be easily found among stakeholders, especially if their activity is directly impacted. However, it is the responsibility of the government to act as a mediator to implement the measures that are needed to achieve climate objectives and to define the required compensations to overcome the identified cleavages. *

Summary tables
of the acceptable mitigation scenario

Policies and measures financial balance (mitigation scenario) in bn €

	2010	2020	2030	2040	2050
TRANSPORT					
Heavy trucks eco-tax	0	1.3	1.1	1.1	1.2
Kerosene tax	0	1.6	1.1	1.4	1.3
Impact on domestic consumption tax on petroleum products	23.8	21.4	17.9	13.4	12.9
INFRASTRUCTURE INVESTMENTS					
Urban transports	+3 billion € each year from 2012 until 2030			-	-
Railways	+3 billion € each year from 2012 until 2030			-	-
Road transports	-6 billion € each year from 2012 until 2030			-	-
ELECTRICITY					
CSPE Income = feed-in tariffs expense	2.9	1.9	7.2	17.8	12.7
RESIDENTIAL SECTOR					
Tax credit	-	-3.3	-2.5	-0.8	-0.5
Eco-loan	-	-3.3	-1.9	-0.6	-0.4
Construction	-	-9.5	-9.4	-7.7	-6.3
Refurbishment	-	-14.9	-10.3	-3	-1.8
OVERALL MEASURES					
Carbon tax	0	13.7	18.1	23.9	34.8
BILAN	**26,7**	**8,9**	**21,3**	**45,5**	**53,9**

CO_2 sectoral emissions compared to 2010 (mitigation scenario)

	2020	2030	2040	2050
Industry	-33%	-37%	-59%	-57%
Manufacture and services	-36%	-39%	-49%	-49%
Agriculture	-24%	-30%	-42%	-40%
Transport	-19%	-35%	-55%	-60%
Residential	-44%	-62%	-72%	-75%
Electricity	49%	-68%	-100%	-86%
Total	-15%	-39%	-59%	-60%
Total (compared to 1990)	-31%	-50%	-67%	-68%

Acceptable policy measures in the mitigation scenario

Residential sector	**Tax credits:** The purchase of refurbishment elements is eligible to income tax credits. Increased rates and an extended eligibility base are modeled from 2009 until 2050 through a uniform tax rebate of 30% of the investment.
	Zero-interest loans for retrofitting actions: 0% interest rates apply for retrofit packages with a maximum amount at 30,000€ per dwelling. The credit duration period is about 10 -15 years.
	Thermal regulation for new buildings: From 2012 maximum primary energy consumption level: 50 kWh/m^2/year of primary energy. After 2020: new buildings have to be net producers of energy.
	Implicit representation of **obligatory renovation funds for jointly-owned buildings availability of third-party financing** which reduces the risk aversion of the agents.
	Biogas: The biogas penetrates gradually between 2012 and 2050. Its share reaches 17% in the gas in 2050.
	Urban planning: Economic incentives and regulations slow down urban sprawl until 2030. After 2030 urban density increases again.
	Urban transports investment program: Investments in urban transports (buses, tramways) are doubled during 15 years from 2012.
	Teleworking: one day of work out of ten.
	Vehicles occupation rate: increase of the cars occupation rate for urban transport from 1.25 to 1.5.
	Kerosene tax: A tax on kerosene consumption for air transport is introduced in 2012. It represents 400€/toe.
	Heavy truck environmental tax: an eco-tax on the liquid fuel consumption of heavy trucks is introduced in 2012. It is calibrated to bring in 1.2 billion € in 2012.
	Rail investment program: Investments in road infrastructures are limited to maintenance of infrastructures. Investments are shifted from road to rail for 20 years.
	All **collective transports investments** are deducted to the **road infrastructures investments.**
	Bonus-malus: is extended until 2050. A positive annual financial balance for the government budget or at least close to 0 is obtained.
	Logistics: annual decoupling of freight transport needs of 1% for all sectors.
	Infrastructures: the modal share of rail transport in freight reaches only 20% in 2030 (exogenous assumption).
	Biofuels: Biofuels penetrate following the biofuel development scenario in the "World Energy Outlook 2006". Production is about 5 Mtoe in 2020 and 16 Mtoe in 2050 (respectively 9% and 39% of total refined petroleum products).
Electricity	**Expectations:** The electricity sector is assumed to receive clear carbon tax signals and expects the exact value of the carbon tax for the whole period.
	Existing nuclear plants lifetime extensions: 40 GW out of 63 GW have their lifetime extended for 0.7 bn€/GW.
	Feed-in tariffs: Feed-in tariffs for renewable energies are economic incentives to facilitate the market penetration of these technologies to accelerate the learning effect. Feed-in tariffs are normally decreasing over time and end when the technologies achieve price competitiveness with other technologies.
	Demand side management: implicit measures (interruptible contracts, smart metering) are used to flatten the load demand curve.
	Interdiction of electric heating: Electric heating is not globally banned but the implementation of the thermal regulation up from 2012 is de facto excluding electric heating (exception heat pumps).
	Grid construction: The construction of renewables triggers additional grid investments, thus increasing the electricity price for 3€/MWh in the mitigation scenario.
Overall policy measures	**Carbon tax:** 32€/tCO_2 in 2012, 56€/tCO_2 in 2020, 100€/tCO_2 in 2030, to 200€/tCO_2 in 2040 and to 300€/tCO_2 in 2050.
	Progressive tariff: For all households, any consumption above 60 kWh/m^2 is more expensive: 5% after 2014 and of 10% after 2030.
	Carbon tax recycling: The carbon tax income is recycled in a lump sum towards households (each person receives an equal share of the total perceived amount).

Primary and final energy in the mitigation scenario (Mtoe)

	2010	2030	2050
PRIMARY ENERGY MIX			
Total primary energy	234	178	166
Biogas	-	2	3
Biofuel	-	8	16
Coal	11	6	6
Electricity - nuclear	91	71	58
Electricity - renewables	10	18	28
Gas	40	23	15
Oil	82	50	40
Wood	-	3	3
FINAL ENERGY MIX			
Final energy	152	130	126
Biogas	-	2	3
Biofuel	-	8	16
Coal	6	4	3
Electricity	46	46	52
Gas	34	15	11
Oil	66	50	39
Wood	-	3	3

Note: in this table, primary energy for biomass (biogas, biofuels and wood) equals final energy since the Imaclim-R model does not represent the energy transformation for these energies (but only the economic flows).

Chapter 5

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