Policy scenarios and recommendations on nZEB, deep renovation and RES-H/C diffusion : the case of France

D4.3and D5.6 from Entranze Project

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ENTRANZE Project

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Project consortium:

	EEG	Energy Economics Group Institute of Power Systems and Energy Economics Vienna University of Technology
	NCRC	National Consumer Research Centre
	Fraunhofer	Fraunhofer Society for the advancement of applied research
	CENER	National Renewable Energy Centre
	eERG	end use Efficiency Research Group, Politecnico di Milano
	Oeko	Öko-Institut
	SOFENA	Sofia Energy Agency
	BPIE	Buildings Performance Institute Europe
	Enerdata	Enerdata
	SEVEn	SEVEn, The Energy Efficiency Center

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The ENTRANZE project

The objective of the ENTRANZE project is to actively support policy making by providing the required data, analysis and guidelines to achieve a fast and strong penetration of nZEB and RES-H/C within the existing national building stocks. The project intends to connect building experts from European research and academia to national decision makers and key stakeholders with a view to build ambitious, but reality proof, policies and roadmaps.

The core part of the project is the dialogue with policy makers and experts and will focus on nine countries, covering >60% of the EU-27 building stock. Data, scenarios and recommendations will also be provided for EU-27 (+ Croatia and Serbia).

This report provides model based policy scenarios and related recommendations for France. The input data and results were discussed intensively with policy makers and stakeholders. Similar reports are available for all target countries of the project ENTRANZE, which are Austria, Bulgaria, Czech Republic, Germany, Spain, Finland, France, Italy and Romania.

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Executive Summary

This paper describes the methodology and results of policy scenario simulations for France and recommendations prepared within the ENTRANZE project.

In a first step policy scenarios have been developed, based on discussions with ADEME and the Ministries in charge of Energy and Housing, referred here as “policy group”. This work took into account the results of other studies carried out in the course of the project, especially the analyses of barriers for investors and cost optimality calculations for renovations. The policy sets have been discussed and revised several times during policy group meetings. The impacts of the policy scenario have then been simulated with the Invert/EE-Lab model. Finally, recommendations have been derived from the results of the calculation and discussed by the policy group.

In France the following three policy scenarios have been analysed:

1. Business as usual, corresponding to the implementation of policy measures decided until beginning of 2013;
2. CO2/energy tax scenario, implying the implementation of a progressive CO2/energy tax with reallocation of the tax revenue for the renovation of social dwellings as a priority;
3. Proactive scenario enforcing to least efficient dwellings obligation of thermal renovation during real estate transactions and major transformations.

The following main findings have been obtained:

- The energy demand for space and water heating is expected to decrease by up to 32% in 2030 compared to 2008 level in the proactive scenario, which is close to the official Grenelle target. In the business as usual scenario (BAU), demand would be reduced by 18%in 2030. The CO2/energy tax scenario would allow an intermediate reduction of 20%.
- There is an increasing role of renewables in building heating energy demand.
- As the proactive scenario implements more stringent measures on existing buildings, the dynamics of renovations is significantly higher: in 2030 around 30% of the stock would be renovated with a strong share of deep renovation (15%). Dynamics of renovation are similar in BAU and CO2/energy tax scenario, with around 15% of the stock renovated in 2030.
- As a direct consequence of renovation activities, investments are significantly higher in the proactive scenario (around €18 bn in 2030). As the CO2/energy tax scenario aims at redistributing the tax revenue towards renovation activities of social dwellings, the amount of subsidies is higher (and represent 13% of total investments) than in the proactive scenario (for which almost all of investments would be private). However, as these subsidies would be financed by the tax, the public cost is limited.

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The following recommendations have been derived from these results:

1. Coaching is a key measure to boost renovation activities. It should be addressed to several actors in order to increase i) household information and ii) professional training and financial engineering.
2. The impact of the tax on energy consumption is really effective above a certain threshold.
3. Any tax should be accompanied by complementary measures to alleviate the immediate effect on low income households.
4. “Mandatory" renovations (when economically feasible) are an effective measure to boost renovations in badly insulated dwellings. To be acceptable different way of implementation can be envisaged.

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1. Introduction

A key element for investigating the potential future impact of policy instruments and for deriving policy recommendations in ENTRANZE is the development of policy scenarios. These scenarios have been simulated so as to project the development of the building stock and its energy demand in the EU-27 (+Croatia and Serbia) up to 2030, with a specific focus on 9 countries, referred later as "target countries"[1]. In particular, the future deployment of Nearly Zero Energy Buildings and RES-H/C in the EU building stock is investigated and corresponding cost, expenditures and benefits are assessed. The impacts of different policy instruments on the diffusion process and the building related energy demand are investigated, considering economic, technical, non-technical and institutional barriers and rebound-effects. The impact of the scenarios has been simulated until the year 2030, with a particular focus on the year 2020, according to the target setting of the EPBD and the RED.

For each target country, a set of at least three different policy scenarios has been developed. These policy scenarios have been defined according to the specific needs, ideas and suggestions of the policy makers and stakeholders involved in the national discussion processes, the so called "policy group". These policy scenarios have been then been simulated with the Invert/EE-Lab model and associated to 2 scenarios of international prices

In total, 16 members participated to the policy group. Most of them participated to all meetings, implying a continuity in the discussions. Members came from ADEME[2], the French Energy and Environment Agency, the Ministry in charge of Energy[3]and the Ministry of Housing[4]. ADEME experts were specialised both in energy efficiency and building policy design and evaluation[5].

First of all, each policy group meeting was the occasion to inform regularly the participants about the recent developments, results and publications of Entranze. The second part of the meeting aimed at defining policy sets for France and to benchmark with the other target country policy sets. It was also an opportunity for ADEME and Ministries representatives to discuss about current building policy implementation in France.

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[1]Austria, Bulgaria, Czech Republic, Germany, Spain, Finland, France, Italy and Romania.
[2]http://www2.ademe.fr/servlet/getDoc?id=38480&m=3&cid=96
[3]Ministry of Ecology, Sustainable Development and Energy (http://www.developpement-durable.gouv.fr/).
[4]http://www.territoires.gouv.fr/
[5]Didier Bosseboeuf, from ADEME, was the chairman and participated as well to the project meetings; hence he was really aware and involved in the policy set process

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This report provides a summary of these national policy scenarios as well as corresponding conclusions and recommendations.

The report starts with a documentation of the methodology in chapter 2. Chapter 3 provides the policy sets which were defined in the policy group meetings. Chapter 4 presents the resulting scenarios in terms of energy demand projections and related renovation activities in the building stock. Finally, chapter 5 includes the recommendations.

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2. Methodology

The methodology of the Entranze project is based on three pillars:

1. The selection and description of policy scenarios based on a participatory stakeholder process;
2. The modelling of the impact of these policy sets with the Invert/EE-Lab model;
3. Preparation of recommendations

In the following chapters the methodology behind the three pillars will be explained in more detail.

2.1 Pillar 1: Methodology for selection and description of policy sets

The selection of policy sets for the scenario calculation relied on the results of the previous activities in the project, especially the study on public and socialacceptance and perception of nearly zero-energy buildings and RES-H/C, the cost optimality calculation and the analysis of specific barriers for different types of buildings and ownership groups (Table 1). The policies were selected so as to most effectively address and overcome these barriers. All results of the previous work have been discussed with the policy group members in policy group meetings and bilateral discussions. Additionally expert interviews have been carried out. Finally, the current policy measures have been considered, and the policy scenarios have been set up following discussions in the policy group.

Table 1: Barriers for different types of buildings and ownership groups

Building type, target group respectively	Barriers
Owner-occupied single-family homes	Financial barriers: high initial investment costs for refurbishment measures at the building structure or for improving or replacing the heating system as well as the access to capital or the cost of capital. long payback times.
Owner-occupied multi-family buildings	Financial barriers: high initial costs and long payback periods Difficulty of taking decisions about refurbishment measures due to the different nature of owners in such buildings
Rental buildings owned by private or social companies	Financial barriers do still apply: mainly the long payback times and the access to capital.

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Other general barriers, concerning all target groups, include[6]

- information deficits about the economic benefits from refurbishment measures, and the availability of support schemes;
- legal and technical barriers, such as the low value of some buildings, the uncertainty of the long-term value of a property, and sometimes the poor quality of refurbishment measures.

2.2 Pillar 2: Methodology for modelling policy impact in Invert/EE-Lab

Invert/EE-Lab is a dynamic bottom-up simulation tool that evaluates the effects of different settings of economic and regulatory incentives and consumer and behaviours on the total energy demand, energy mix, CO2 reductions and costs for space heating, cooling and hot water in buildings. More information is available on www.invert.at or e.g. in (Kranzl et al., 2013) or (Müller, 2012).

2.2.1 General approach of modelling policy instruments in Invert/EE-Lab

Invert/EE-Lab models the decision making process of agents (i.e. building owner types) regarding building renovation and heating, hot water and cooling systems[7]. Policy instruments may affect these decisions (in reality and in Invert/EE-Lab) in the following ways:

- Economic incentives change the economic effectiveness of different options and thus affect investment decisions. This change leads to higher market share of the supported technology in Invert/EE-Lab (via the nested logit approach).
- Regulatory instruments (e.g. building codes or renewable heat obligations) restrict the technological options that decision makers have: limited compliance with these measures can be taken into account by limiting the information level of different agents regarding this measure (see next bullet point).
- Information, advice, etc: agents have different levels of information; lack of information may lead to neglecting innovative technologies or to a lack of awareness regarding subsidies or other support policies. Information campaigns and advice can increase this level of information. Thus, the consideration of innova-

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[6]For more explanation see deliverable D2.4 (Heiskanen et al., 2012) and Deliverable D5.4 (Bürger, V., 2013).
[7]The approach is described in annex of a separate report: “Integrating user and investment behaviour in bottom-up Energy-economic simulation models” (http://www.entranze.eu/pub/pub-scenario)

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tive technologies, knowledge about support programmes and compliance with regulatory standards increases.
- R&D can push technological progress. The progress in terms of efficiency increase or cost reduction of technologies can be implemented in Invert/EE-Lab.

More specific examples of modelling policy instruments in Invert/EE-Lab are described in the annex of this report.

2.2.2 Key input data to the model

The Invert/EE-Lab model requires the following main categories of input data:

- **Disaggregated description of the building stock**: The scenarios presented in this report are based on the building stock data as described in the report “Building sector and energy demand in target countries” for France (http://www.entranze.eu/pub/pub-data) and the corresponding online data tool (http://www.entranze.eu/tools/interactive-data-tool).
- **Cost data of heating, hot water and cooling systems as well as of renovation options**: These data have been collected and checked with national experts and literature in the frame of the cost-optimality calculations. The background data and results of these techno-economic analyses are documented in the report on “Cost of energy efficiency measures in buildings refurbishment: a summary report on target countries” (Fernandez-Boneta, 2013) and the report on cost/energy curves (Pietrobon et al., 2013),both available at http://www.entranze.eu/pub/pub-optimality.
- **Definition of renovation packages:** As described above, for those measures leading to a reduction of the energy need (e.g. renovation of building envelope or heat recovery systems) Invert/EE-Lab requires a set of pre-defined renovation packages from which consumers or other investors, called “agents” may select. The selection and definition of these renovation packages was done based on the cost-optimality calculations in this project (Pietrobon et al., 2013) and the derived energy-cost matrices (Fernandez-Boneta, 2014). Based on these calculations, three packages have been selected:
    - The standard renovation package more or less reflects the current practice of thermal building renovation,
    - the “good” renovation package reflects a set of measures near the cost-optimality point
    - the “ambitious” renovation package refers to a level of renovation which is near the “minimum primary energy” level as indicated in Pietrobon et al., (2013).

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Annex A.2lists the main characteristic of these three renovation packages taken into account for the modelling and scenario development for France.

2.2.3 Energy price scenarios and the link to the model POLES

Energy price scenarios are a highly relevant and sensitive input data for the Invert/EE-Lab model. The POLES has been used to project the energy prices relying on two scenarios for the overall development of the global energy system that led to projections of international fuel prices:

- The **"Reference"** scenario assumes that only on-going and already planned climate policies are taken into account and that no consensus is reached at international level. Sustained growth of China and other emerging countries is a powerful driver of energy demand at world level leading to high international oil and gas prices but to lower domestic prices. Energy prices for end-users at country level were then projected, taking into account changes in international prices and taxes (excise tax[8], VAT) and a carbon price[9].
- The **"Ambitious Climate"** scenario explores the implications of more stringent climate policies and reinforced support for renewables at world level driven by successful. negotiations between advanced and emerging economies on climate change. International fossil fuel prices are lower as a result of a lower demand but domestic prices are higher due to higher taxes and the cost of policies to reach the emissions abatement targets.

The resulting two energy price scenarios were then used in Invert/EE-Lab as an input, as well as the corresponding primary energy factors and CO2-emission factors of electricity, based on POLES projections of the power mix and CO2 emissions by country. The consistency of the results of the Invert/EE-Lab model were checked with POLES regarding the potential feedback loop on energy prices.

International prices

Over the 2010-2030 period, prices are expected to increase for oil, gas and coal. Trends are significantly stronger in the reference scenario, as in the ambitious scenario the demand for oil and gas is growing less rapidly resulting in lower tensions on the international markets. More details are available below by type of fuel for both scenarios.

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[8]Including existing energy & environmental taxes.
[9]Carbon prices are different from EU ETS prices and refer to an aggregate metric in POLES used to characterise the effort necessary to reach climate objectives: they might be seen as "shadow prices" for policies stimulating low-carbon technologies.

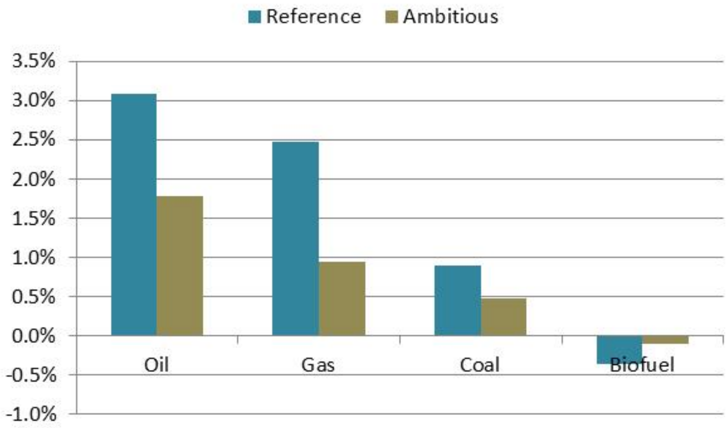

Figure 1: Annual growth rate of international energy price over 2010-2030

Source: POLES-Enerdata

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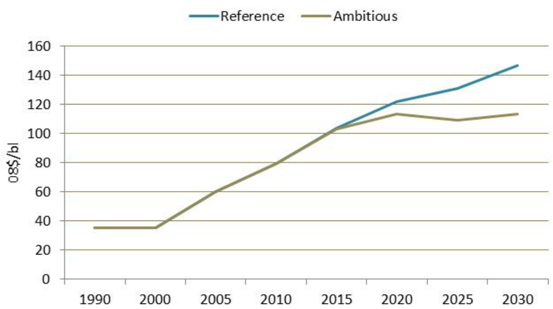
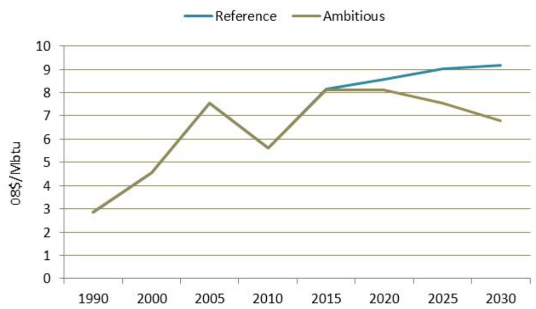
Oil



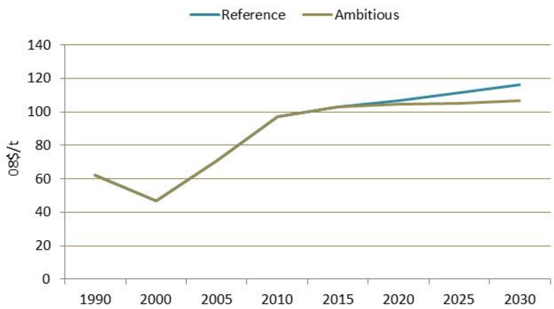
In the reference scenario, oil price is expected to increase at a rapid pace of 6.5%/year from 2000 to 2020, which will then slow down to 2%/year. In the ambitious scenario, it increases less rapidly until 2020 (3.6%/year), and remains almost steady reaching 100$/bl in 2030. This lower price is explained by the decreasing oil demand.

Gas



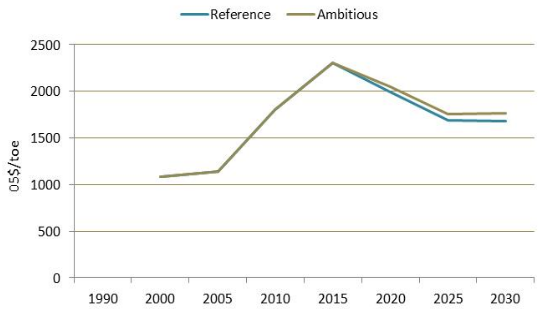
Gas price in Europe is expected to increase by 7.6%/year for both scenarios until 2015 (Figure 8). Then it will continue to increase by 0.8%/year on average until 2030 in the reference scenario whilst it is decreasing in the ambitious scenario by 1.2%/year because of decreasing demand.

Coal



Coal prices are expected to increase steadily, with a slightly less rapid trend concerning the ambitious scenario, i.e. 0.5%/year compared to 0.9%/year for the reference scenario. This price increases in both scenario is due the fact that production costs will increase with income in producing regions.

Biomass



After a short-term increase due to the strong dynamics in biofuel demand in all sectors, the biomass price[10] will decrease by roughly 2%/year until 2025 thanks to market regulation. It will again slightly increase because of a strong penetration of biofuels, the high mitigation option.

Figure 2: European energy price forecasts until 2030

[10] Prices for biomass refer to modern biomass (i.e. pellets or wood chips).Prices are based on simulation of land use and international biomass trade, and unlike for other fuels they do not take into account historical prices

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Residential domestic prices[11]

Excise taxes and VAT have been assumed constant in these projections. Price of heating oil and gas for households consumers are projected to increase in France by respectively 5.9% and 5.4%/year in the ambitious scenario over the period 2010-2030, which will be later referred to the “high price” scenario. In the reference scenario the progression is lower because of lower carbon tax (2.9% and 1.6%/year respectively for oil and gas) (Figure 12). This scenario will later be referred to as the “low price” scenario. The coal price increases rapidly as well in the ambitious scenario, by up to 5.3%/year, and to a lesser extent in the reference scenario by 1.3%/year.

The electricity price is modelled on the basis of the cost of generation of electricity that results from changes in the price of fossil fuels and in the power mix[12] and it also includes taxes. The average price increases by 2.6%/year in the ambitious/high price scenario and by 1.5%/year in the reference/low price scenario. The electricity price is expected to peak in 2030 at around 2 800 $/toe (33 $c/kWh)[13] in the ambitious/high price scenario and at 2 300 $/toe (27 $c/kWh) in the reference/low price scenario.

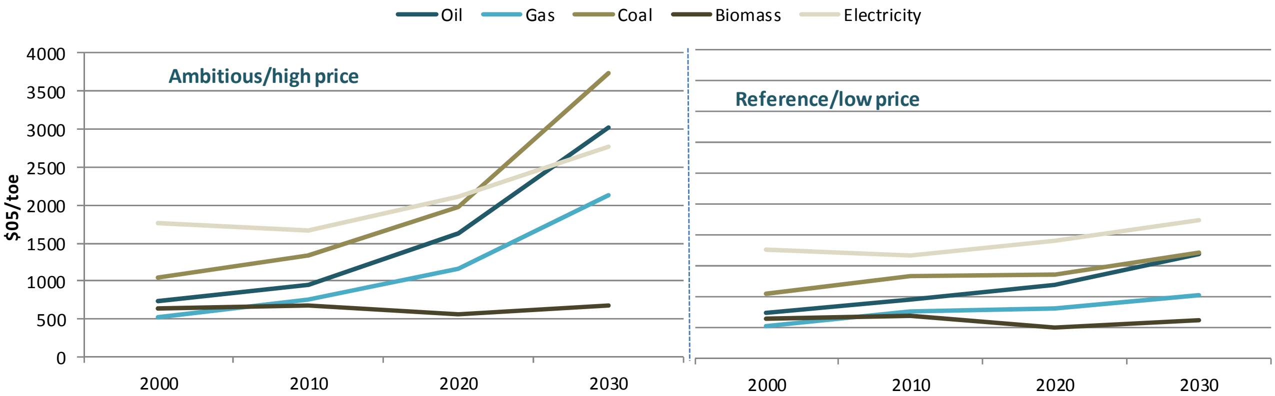

Figure 3: French residential domestic prices forecasts by type of energy

Source: POLES-Enerdata

[11] Domestic prices are in constant euros (i.e. without inflation), from which you can derive an average variation by period.

[12] In 2030 the electricity mix, as modelled by POLES, is expected to be the following: 11% from fossil fuels, 60% from nuclear and 29% from renewables in the reference scenario; and 8% from fossil fuels, 62% from nuclear and 30% from renewables in the ambitious scenario (“high electricity prices). These projections did not include the objectives under discussion in the French energy transition law.

[13] In 2005 prices and exchange rates.

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2.3 Pillar 3: Methodology for deriving recommendations

The recommendations have been derived in close interaction with the stakeholders based on the results of the scenario calculation. Recommendations for other Member States were also considered.

The developed recommendations have been evaluated on the basis of the criteria listed in Table 2.

Table 2: Selection of qualitative assessment criteria

Criteria	Key questions
Target achievement	To which extent is an instrument appropriate to achieve a quantifiable target (e.g. renovation rate, annual final/primary energy savings, GHG reduction)? For instance does BAU reach 30% of energy savings in 2030? Or the proactive scenario or CO2/energy tax can reduce 2008 consumption level by 40% in 2030?
Target compatibility	Can the instrument be designed as to incorporate incentives to steer investments into deep renovation measures that are compatible with the long-term needs? The BAU includes a bunch of incentive measures to boost renovation while the proactive scenario is going a step further by enforcing renovation concerning certain type of dwellings. What are the impact and the acceptability of these measures?
Type and strength of steering effects	Which steering effects are applied (e.g. steering effect by putting a financial burden or substantive duty on building owners or energy consumers; steering effect through the support regime) and how strong are they? Who is targeted by the instrument in the proactive scenario for instance? Who benefit the tax revenue in CO2/energy tax scenario?
Cost allocation	In case of financial support programs, e.g. CO2/energy tax scenario, who is finally providing the counter-financing (e.g. tax payer, energy consumers, building owners)? How does this relate to important environmental economic principles such as the polluters pays principle or generally the ability-to-pay principle? Does the instrument allow for avoiding asymmetric allocation burdens (e.g. allocating all costs to e.g. private households due to their generally low price elasticity of demand)? What is the rate of tax revenue distributed to target (e.g. social dwellings in the case of CO2/energy tax scenario)?

Source: Bürger/Klinski 2013 and Bürger/Varga 2009

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3. Policy set description

In this part of the report we describe the policy sets that will be simulated with the Invert model. We start with an overview of existing policy measures in France, and provide some general considerations for the selection before we define the policy sets as discussed process in the policy group meetings.

3.1 Overview of policy instruments for improving energy performance of buildings

Figure 5 give an overview about the categories of existing policy instruments for the improvement of the energy conditions of buildings. For more detailed information see the report “Overview and assessment of new and innovative integrated policy sets that aim at the nZEB standard” of the ENTRANZE-project (Bürger, 2013).

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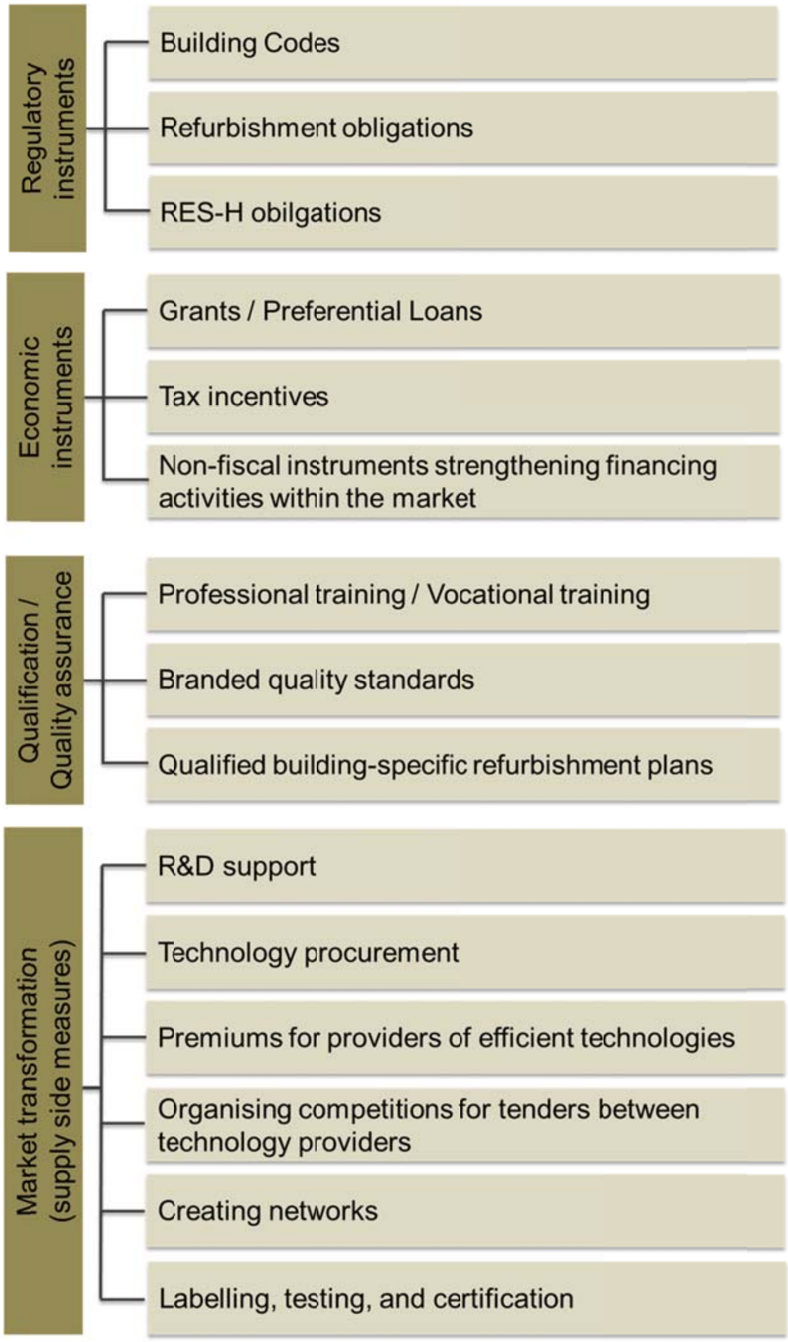

Figure 4: Categories of policy instruments (part 1)

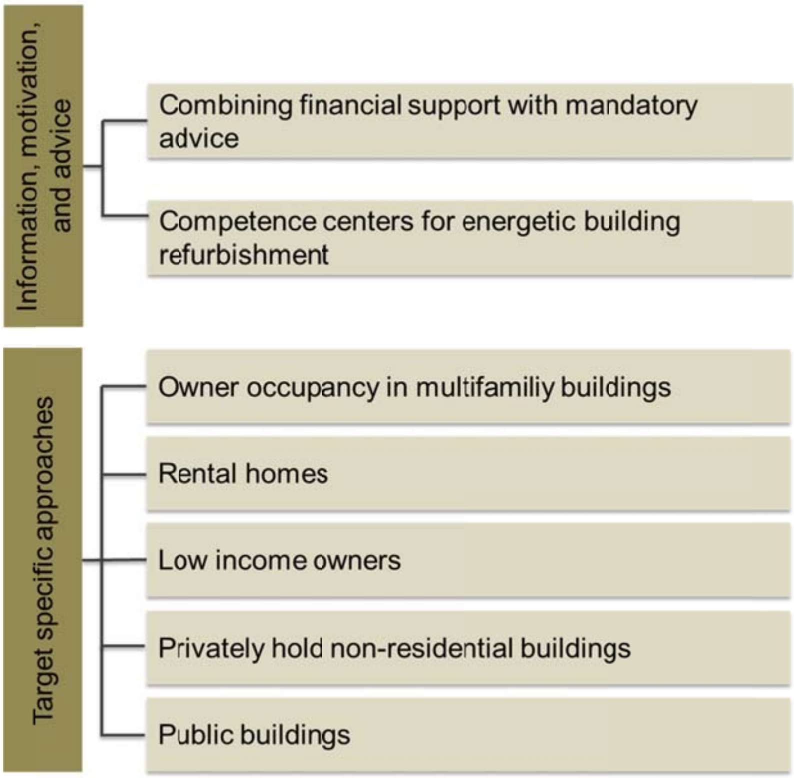

Figure 5: Categories of policy instruments (part 2)

For the combination of different instruments in a policy set some considerations should be taken into account:

- Instruments should be designed as to address the main barriers that hamper investments in the efficiency of buildings. In addition the policy package should include elements that enable to target the needs of the major target groups and should also reflect the market maturity of the different technologies.
- If a certain barrier (e.g. a financial barrier) is addressed by two or more instruments at the same time, this should be adequately justified (e.g. by the fact, that the instruments offer different access to financial support according to different target groups). Redundant instruments should be avoided to limit administrative costs.
- In general administrative costs of a policy package should be kept as low as possible. This includes the transaction costs for the state but also all other system participants. For that reason it should be assessed to which extent synergies could be exploited when administering several instruments at the same time.

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- In order to increase public acceptance for the communicative perspective the policy package should be kept as simple as possible. The main elements of a package should be easy to communicate.

3.2 Policy sets defined for the scenario calculation

Based on the portfolio of policy instruments and the considerations regarding the selection of policy packages, the policy group decided to analyse the following policy sets:

- The BAU scenario simulates the building stock evolution and retrofitting rates obtained thanks to the existing package of policy measures for buildings at the end of 2012. Therefore, this scenario does not integrate the measures or reforms announced in 2013.
- The CO2/energy tax scenario simulates, in addition to the BAU measures, the impact of a progressive CO2/energy tax[14] reaching 100€/tCO2 (or 2.1 c€/kWh) in 2030. The tax is accompanied by complementary measures for low income households.
- The proactive scenario enforces to least efficient dwellings obligation of thermal renovation during real estate transactions and major transformations. It includes all BAU measures and an intensive coaching for building renovations.

[14] 7€/tCO2 for gas and coal in 2014; +7,5€/tCO2 in 2015 for other fossil fuels (implementation of an equivalent energy tax-expressed for instance in €/kWh-to avoid unbalanced energy prices, in particular gas versus electricity in France);+7, 5€/tCO2 in 2016 to reach progressively, with an intermediate threshold of 50- 60€/tCO2 in 2020.

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	Policy set 1 BAU	Policy set2 CO2/energy tax[15]	Policy set 3 Proactive
Expected Savings			
Measures on new dwellings	**Overall objective:** 350 000 new dwellings/year + 35 000 deconstruction/year in residential; 17 Mm²/y? new construction for services **Building codes**: • Implementation of 2012 Building code (RT 2012~max consumption of 50 kWh/m²/year in residential and non-residential) • Implementation of 2020 building code: New buildings should be energy positive (BEPOS, primary energy average consumption lower or equal to 0 kWhep/m2/year[16]), or 12 kWhep/m²/year of space heating consumption. **Labels** for new dwellings more efficient than RT 2012, i.e. HPE (10% more efficient than RT) and THPE (20% more efficient than RT). Assumption: 30% of residential construction get labels/year, and 15% per year in non-residential.		
Measures on existing dwellings	**Overall objective**: 130 000 renovation/year, among which 25 000 social dwellings renovated per year **Building code:** For major renovation[17]of buildings > 1000 m², RT 2012 sets a global energy performance target for renovated buildings, built after 1948. **Label:** marginal impact of labelling program (10 000 labialised renovation/year). **Financial and fiscal measures**: Eco PTZ, CIDD, ANAH, white certificate **Other**: information centre, white certificate, etc.	**Overall Objective**: Target in priority low income and social dwellings In addition to BAU measures, the tax is accompanied by complementary measures for low income households, such as a dedicated fund to help them investing at attractive conditions in renovation (via existing measures such as ANAH).	**Overall objective**: 500 000 renovation/year among which 120 000 social dwellings. In addition to BAU measures: --**Mandatory renovation** enforced at the occasion of real estate transaction of dwellings with energy performance certificate above D[18] with a temporary tax[19].Two additional obligation of thermal renovation (when economically feasible) are taken into account:1) in case of maintenance works on the buildings- for instance wall insulation in case of facades cleaning (mandatory in France every 20 years), insulation of attic or roof during repair or change of roof or an insulation obligation, during the transformation of attic or garage in living space in the dwelling; 2)Increase the requirement levels of the element by element stated in the French building code in case of renovations; - **Information and awareness** One stop shops and training for professionals

[15]Implementation of a progressive energy/CO2 tax
[16]kWep= primary equivalent of 1 kWh of electricity; 1 kWhep=2,58 kWh
[17] Only apply torenovation that costs more than 25% of the value of the building, excluding land cost, ie322 €/m² for dwellings and 275 €/m² for non-residential buildings (cost without taxes).
[18]For the other dwellings (EPC below D), we assume an increase the requirement levels of the element by element stated in the RT2012 in case of renovation.
[19] The revenue of which would be stored on an account and released to the buyer once the renovation has been done (under presentation of the new energy certificate).

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4. Model results

The models results are illustrated with graphics taken directly from the on line Entranze scenario result tool (http://www.entranze.eu/scenario-results/online-scenario-results). This tool provides the results of alternative policy scenarios in terms of development of the building stock and its energy demand in France, at EU level and for 8 other target countries[20] up to 2030. The results can be displayed for 2 variants of domestic prices, as explained above.

4.1 Energy demand, energy mix and renewables

In the case of the low price scenario, the energy demand for space and water heating is expected to decrease by 26% between 2008 and 2030 in the proactive scenario (equivalent to -1.4%/year, Figure 6). In the business as usual scenario (BAU), the reduction is around twice less (12% in 2030). The CO2/energy tax scenario would allow an intermediate reduction of 15% in 2020.

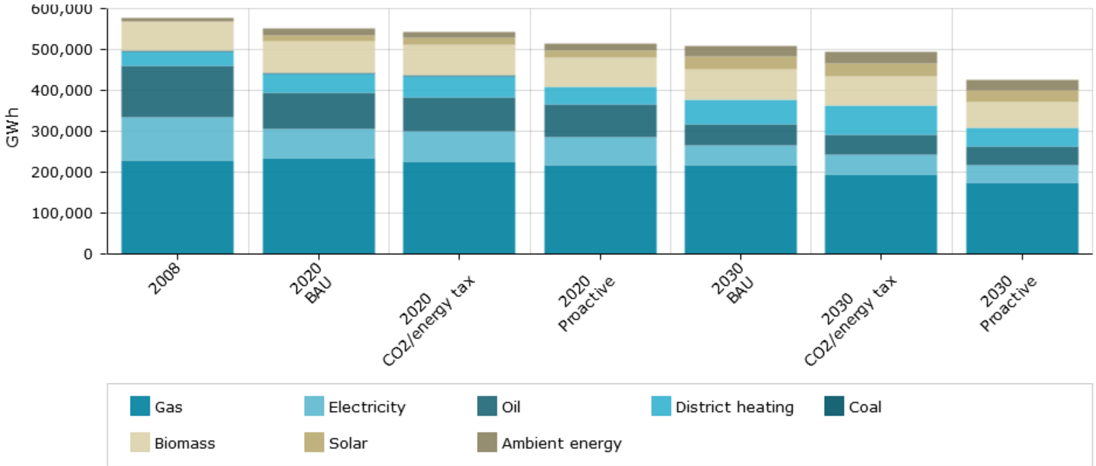

Figure 6: French building energy demand for space & water heating-Low price

Source: Entranze

In the high price scenario, the energy consumption for space and water heating is decreasing more rapidly: by 32% between 2008 and 2030 in the proactive scenario, by 20% in the CO2/energy tax scenario and by 18% in BAU (Figure 7).

[20]Austria, Bulgaria, Czech Republic, Germany, Spain, Finland, Italy and Romania

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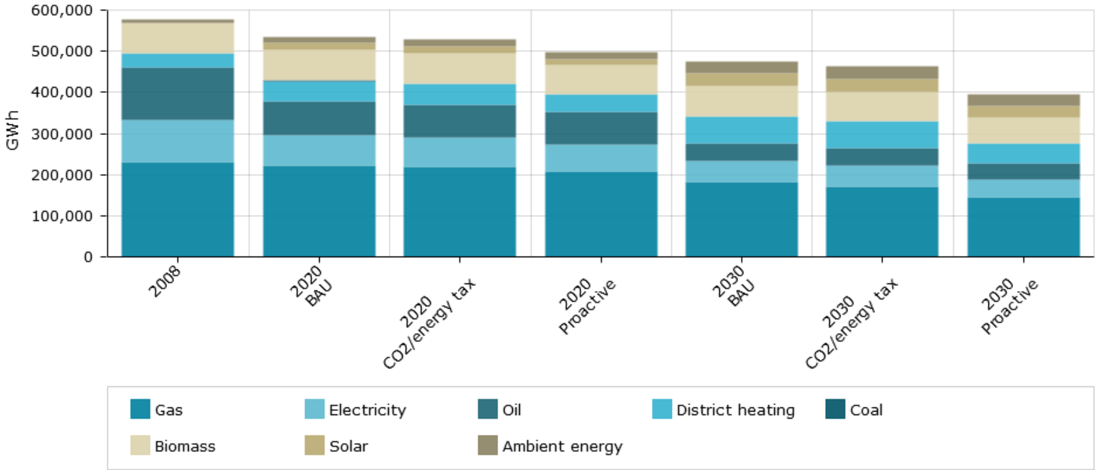

Figure 7: French building energy demand for space & water heating-High price

Source: Entranze

The impact of the 100€ tax was not as high as expected given its level. A first reason is that it is progressive and is only reaching 100€ at the end of the period. Secondly, as energy prices are already high, the impact of the tax on the consumer price is limited: (1.5 c€/kWh in 2020 and 2.1 c€/kWh in 2030). To see the impact of a higher tax level, a sensitivity analysis has been simulated with a doubling of the tax level (200€ /tCO2 in 2030). In addition, as the model simulates the choices of investment of the different type of actors by balancing economic and extra economic criteria, a sensitivity analysis has also been done by eliminating the effect of the extra- economic parameters.

The main results of this sensitivity analysis are the following:

- The increase in the tax to 200€/t has a significant impact on the consumption level: indeed consumption is reduced by at least additional 20% compared to the tax set at 100€ /t (Figure 8). As a conclusion the implementation of a 200€/t tax is expecting to have a strong impact on energy consumption in 2030, larger than the 32% observed in the proactive scenario.
- The removal of the non economic decision factors (aversion to risk, etc), which are likely to modulate the impact of the tax, shows that these non economic factors have some effect, corresponding to an additional reduction of 4% on average of final consumption in 2030.

The combination of the two effects, i.e. a tax set at 200€ and the only accounting of economic criteria, shows a strong deviation of the results compared to the tax scenario at 100€/t, that is to say a 25% additional demand reduction.

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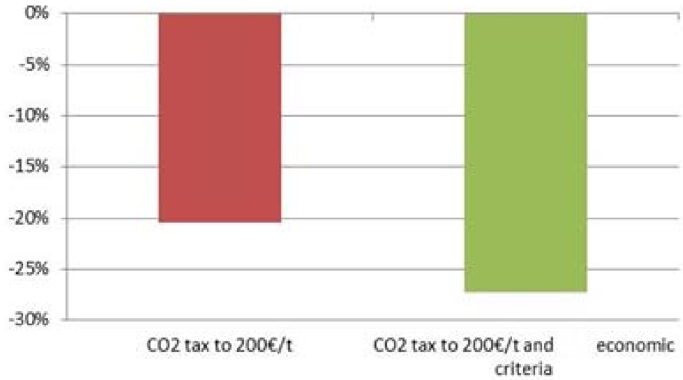

Figure 8: Sensitivity analysis variation of result between 100€/t and 200€/t

Source: Entranze

The energy market shares have roughly the same trends in both high and low price scenario, with the following common observations: until 2030, the share of gas in total space and water heating[21] demand is steady across time (slight fluctuations around 40% according to scenario); electricity will play a decreasing role in heating demand around 10% in 2030 (compared to 18% in 2008); oil market share is collapsing from 22% in 2008 to 10% in 2030 while heat is increasing (from 6% in 2008 to 12%-14% depending on scenario). There is an increasing role of renewables in the heating energy demand in building: biomass will represent 15% of demand. And the share of non-delivered[22] energy (i.e. solar and ambient energy) is increasing over time from around 2% of final energy use in 2008 to around 12%-14% in 2030 (Figure 9).

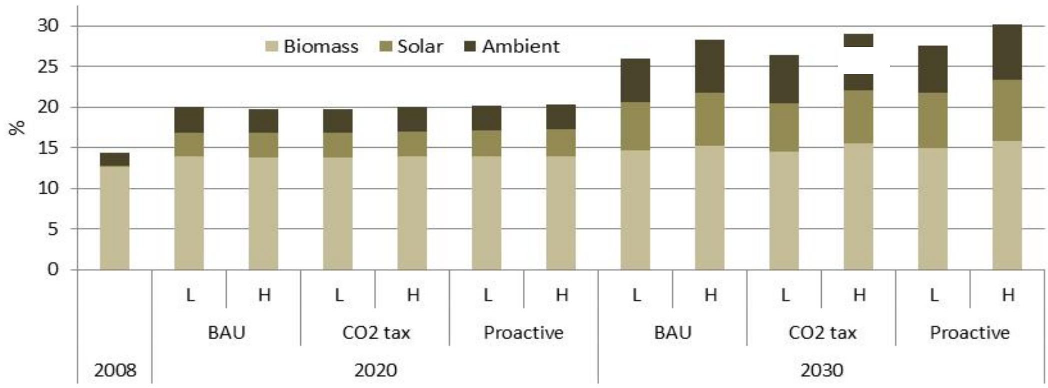

Figure 9: Renewables market share in heating demand in France

Source: Entranze

[21]All along the report, heating always refers to both space and water heating.
[22] The delivered heating demand excludes solar and ambient energy.

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Heating energy demand is decreasing over time by 0.6% and 0.9%/year in BAU (according to price variant) between 2008 and in 2030, by 1%/year or 1.4%/year in the CO2/energy tax scenario and up to 1.4 to 1.7%/year (Figure 10) in the proactive scenario.

Consumption for air cooling is increasing (by 2.7%/year on average over the period 2008-2030) with the diffusion of this end-use (the share of building with air cooling systems is growing from 6% in 2008 to 23% in 2030).

Consumption for lighting is decreasing by 1.5%/year in the BAU, 1.7%/year in the CO2/energy tax scenario and up to 2.9%/year in the proactive scenario. These different trends are due to different level of technology diffusion (LEDs, halogen lamps, etc.).

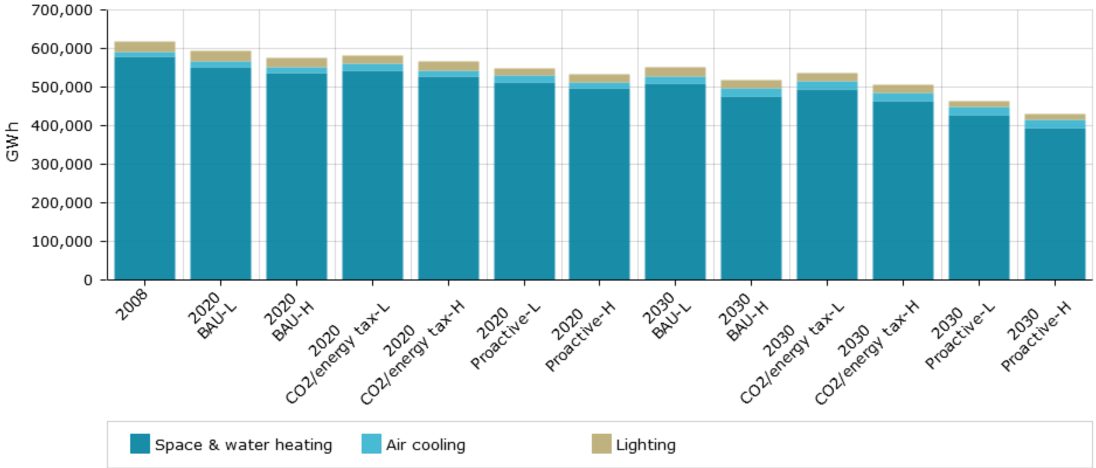

Figure 10: Final energy demand for heating, cooling and lighting in France

Source: Entranze

Heating consumption per m² is decreasing in a range of 0.9% to 1.2%/year in the BAU scenario according to price variant (Figure 11). The decrease is expected to be around 1%/year or 1.3%/year (according to price variant) in the CO2/energy tax scenario and in a range of 1.7 to 2.1%/year in the proactive scenario according to price variant. Air cooling consumption per m² is expected to decrease as well by 1.4%/year (same results across scenarios). Specific consumption of lighting is decreasing over 2008-2030: by 1.8%/year in the BAU, -2%/year in CO2/energy tax scenario and by up to 3.3%/year in the proactive scenario.

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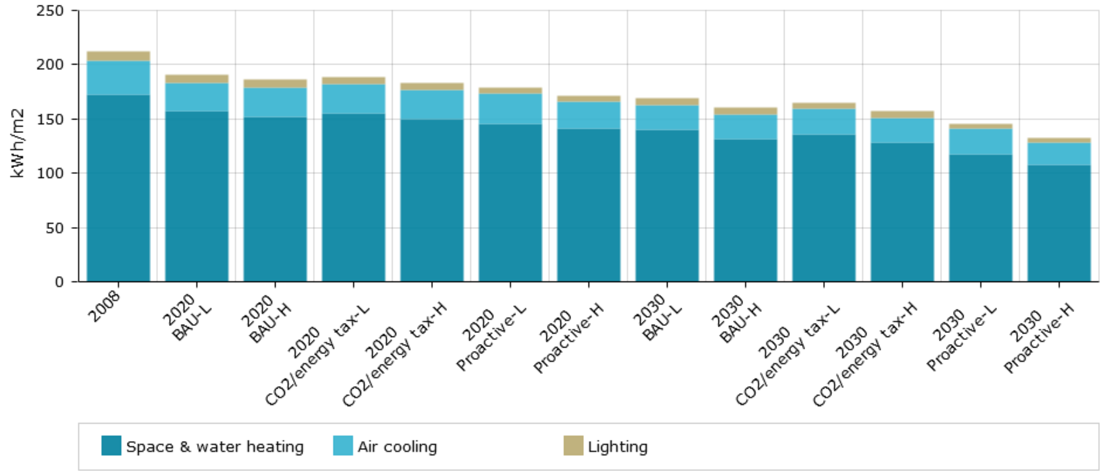

Figure 11: Specific consumption per m² in buildings for heating and cooling in France

Source: Entranze

Energy savings are expected to be more important in non-residential buildings. Indeed in the proactive scenario, demand will decrease by 1.8%/year in non-residential buildings over 2008-2030, while in the residential sector it is expected to decrease by 1.2% to 1.6%/year according to price variant.

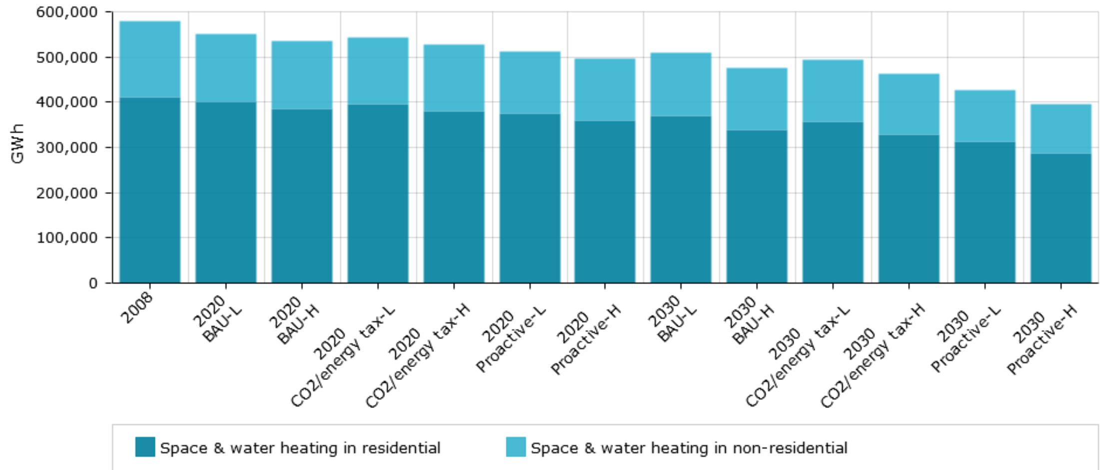

Figure 12: Final heating demand by type of building in France

Source: Entranze

In 2030 the average surface area of installed photovoltaic in residential and non residential buildings is expected to reach 6%. As a consequence the photovoltaic generation is increasing across time to reach around 28 TWh in 2030 (Figure 13).

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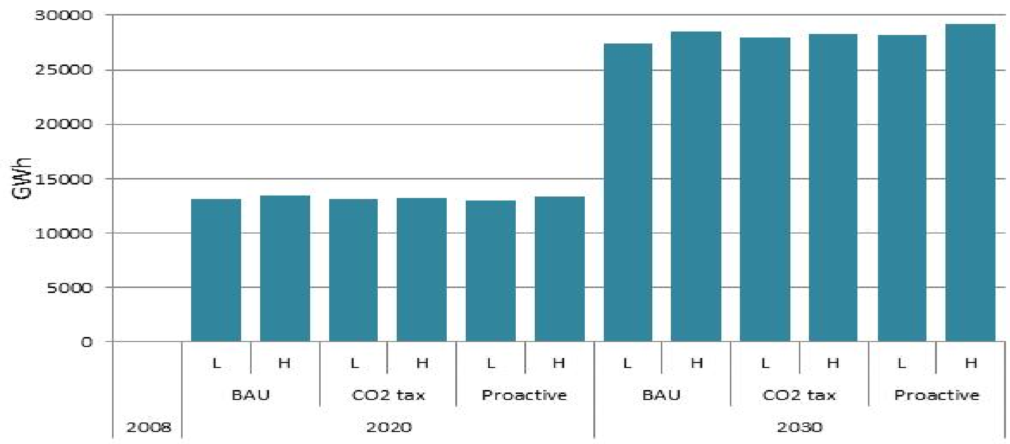

Figure 13: Photovoltaic generation in buildings in France

Source: Entranze

4.2 Renovation activities

As the proactive scenario implements stringent measures on existing buildings, the dynamics of renovation is significantly higher[23]: in 2030 around 30% of the 2008 stock will be renovated with a strong share of deep[24] (10%) and medium renovation (15%), resulting in higher energy savings (Figure 14). Dynamics of renovation are similar in BAU and CO2/energy tax scenario: around 15% of the stock will be renovated in 2030, but the share of deep and medium renovation is higher in the energy tax scenario, resulting in higher energy savings compared to BAU. However, the CO2/energy tax scenario is not leveraging renovation activities as much as the proactive scenario.

[23]More than 500,000 dwellings are retrofitted by year in the proactive scenario, while itwiil reach 360,000 dwellings per year retrofitted in 2030 in the CO2/energy tax scenario (and 300,000 retrofit per year in the BAU scenario by 2030).

[24] The renovation packages for France are defined in A.2.

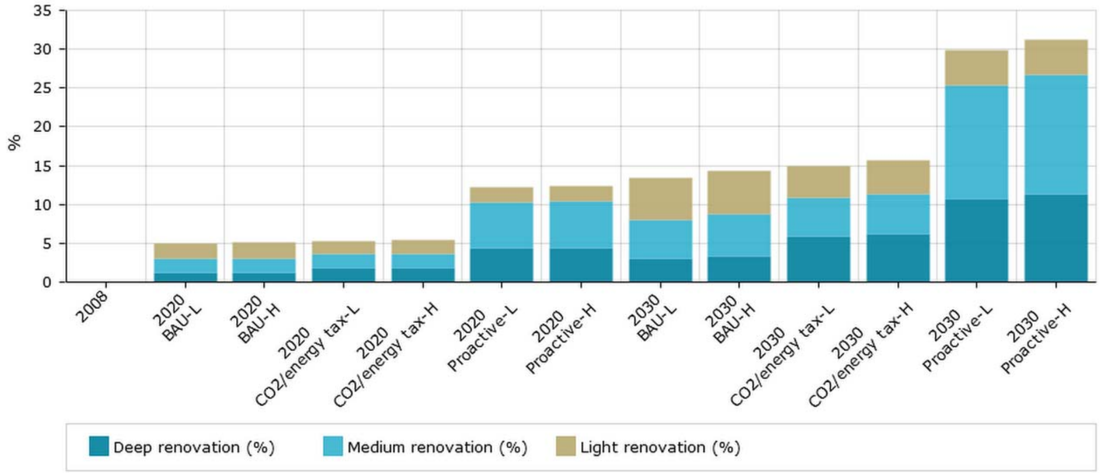

Figure 14: Share of building stock renovated since 2008 in France

Source: Entranze

4.3 Economic indicators, investments and public expenditures

A direct consequence of the renovation activities is that the investments are significantly higher in the proactive scenario (between €17 bn and €19 bn in 2030 according to price variant) compared to CO2/energy tax scenario (€12 bn) or BAU in 2030 (€11 bn/year, Figure 15).

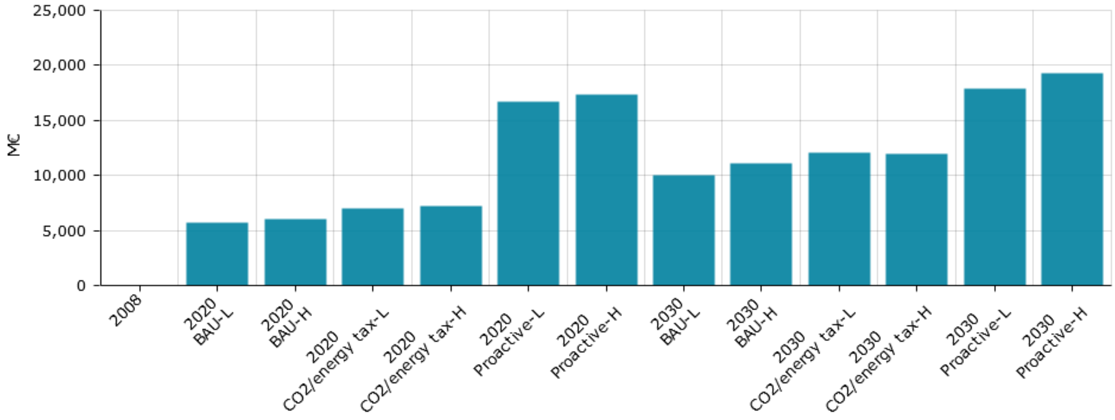

Figure 15: Annual investment dedicated to thermal renovation in France

Source: Entranze

As the CO2/energy tax scenario aims at redistributing the tax revenue (equivalent to €1.3bn in 2030 or 80% of total subsidies of the C2/energy tax scenario) toward renovation activities (in priority to social dwellings) the amount of subsidies is higher than in the proactive or BAU scenario that have similar subsidy levels as they integrate the same package of incentive measures.

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However, even if the amount of subsidies is higher in the CO2/energy tax scenario it only represents 13% of the total investment in 2030, compared to 3% in BAU and 2% in the proactive scenario (Figure 16). In the CO2/ energy tax scenario, the cost will not be directly supported by the public budget as it will rely on the revenue of the tax.

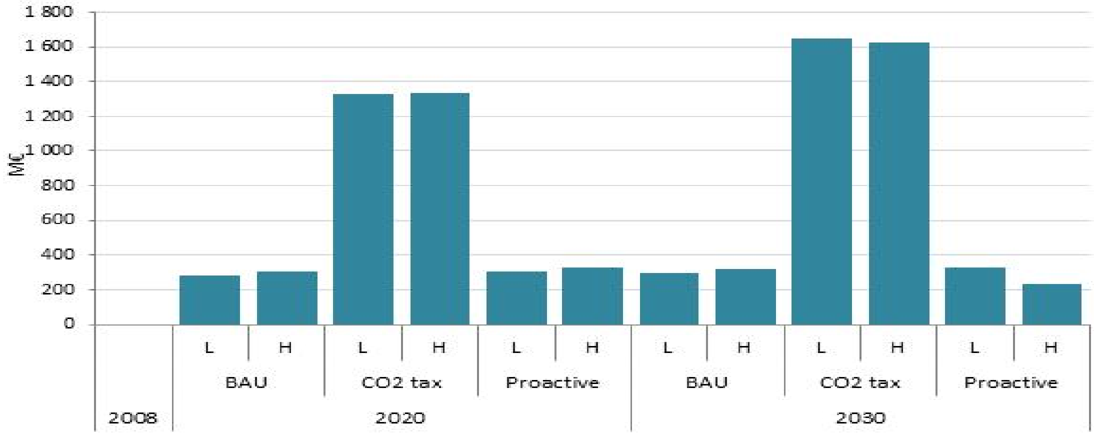

Figure 16: Annual subsidies dedicated to thermal renovation in France

Source: Entranze

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5. Recommendationsto national policy makers

This chapter describes the instruments that are recommended for implementation as a result of the ENTRANZE-project. We present recommendations for national policy makers.

The recommendations described below were derived from the results of the work packages of the ENTRANZE-project, especially from the simulation of the policy scenarios and the discussion within the policy group.

Based on the scenario simulations, recommendations regarding a package of new and adapted instruments have been developed. The main instruments should always be accompanied by supporting instruments: measures for buildings always need to involve a set of measures and go beyond the consideration of single policy instruments. The main pillars of additional elements in the policy bundle are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.Due to the discussions with experts and policy makers, there seems to be a higher need for intensifying and improving building renovation activities. Therefore, the recommendations and main pillars of policy instruments focus on efficiency improvement and thermal renovation.

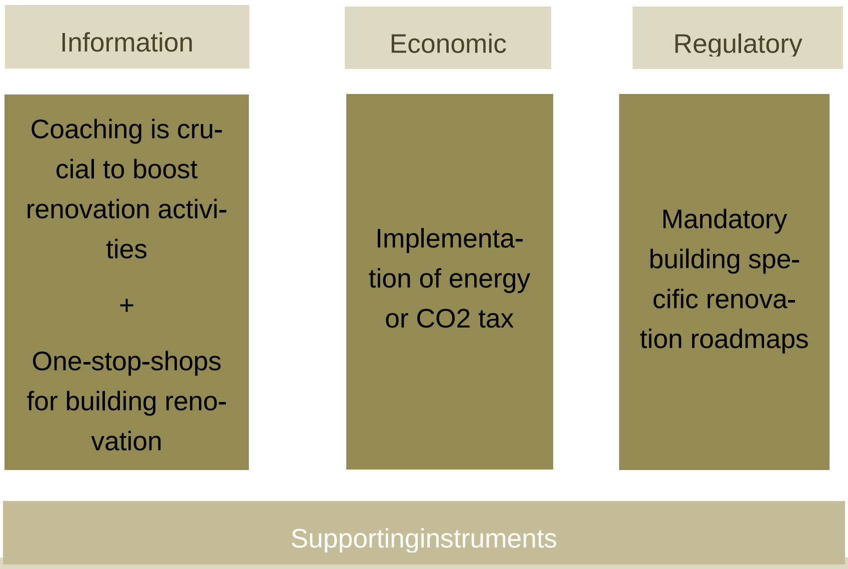

Figure 17: Bundle of new, additional instruments recommended

In France many economic incentives for building renovation, such as subsidies or tax credit,have been implemented, and still the renovation rate remains very low.

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A main barrier for building renovation that has been identified during the discussion process is a lack of information and motivation of building owners. The improvement of information and motivation could be an approach to increase renovation activities.

With an overall objective of 500,000 dwellings retrofitted per year, the policy group wanted to know what type of instrument(s) should be implemented to increase investments in deep retrofitting (especially investments targeting low-income owners of single-family dwellings). They assumed the implementation of an energy/CO2 tax to reach that objective, under the condition that revenues from tax would be redistributed in priority to low income owner through grants or other forms of financial support to boost deep renovations in that group of population (specific conditions to be defined according to income, housing type, year of construction, etc.).Simulation results shows that the energy/CO2 tax scenario is not leveraging renovation activities as much as the proactive scenario: even if the tax revue is allocated in priority to low income dwellings, annual renovation are increasing over time but reach only 360,000 dwellings per year (far from the expected 5000,000 annual dwellings retrofitted). Policy group members also underlined the immediate negative effect of a tax on low income households that should be addressed in the short term with appropriate measures.

The actual French law enforces mandatory retrofitting concerning only service buildings; policy group discussed how to extend this regulation to residential buildings: the implementation of mandatory building renovation roadmaps can, depending on the design, be an effective instrument as well. All recommended instruments are described below.

5.1 Coaching is crucial to boost renovation activities

Coaching is a key measure to boost renovation activities. It should be addressed to several actors in order to increase i) household information and ii) professional training and financial engineering.

Strengthen advice to private consumers thanks to information centres or local platforms dedicated on retrofitting.
The objective is also to centralize all advice as well as financial support (single point of entry for financial aids).In France Energy Information Centres launched in 2001 by ADEME inform on energy efficiency solutions (particularly on efficient space heating

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solutions, retrofitting options and renewable energies)[25]. These information centres have been recently extended in 2014 to information centres dedicated to renovation activities ("point rénovation info service" or "one stop shop" in English, measure included in the proactive scenario and implying a higher dynamics in terms of (deep) renovations). This should be accompanied with the implementation of financial incentives targeting retrofitting activities promoted in the one-stop shops (propose complete services: audit, financial opportunities, professional, etc.). One-stop shop could as well increase energy saving certificates towards global rehabilitation (deep retrofitting).

The coaching of private consumers should be available at low costs or even at no charge. If the coaching would address the needs of building owners, it can be expected that this coaching would be well accepted by the public, as far as total public expenditures for the programme would be acceptable. As shown in the scenario calculation the effects of such an instrument would be significant, although there are uncertainties regarding the modelling of this type of instruments. If the reached renovation standard is very high, this instrument is compatible to long term-energy efficiency-targets. The compatibility with long-term efficiency targets depends on how the coaching process is exactly implemented and how effective it is. If the process only leads to higher renovation rate without increasing the quality of renovation and the depth of the renovation activities, it might not contribute to the long-term target. If the coaching process also takes into account a long-term strategy of the building renovation which is in line with overall, aggregate long-term energy efficiency targets, the instrument contributes also to a large extent to long-term compatibility. Thus, it is important to integrate intensified coaching with accompanying elements of the policy bundle.

5.2 Implementation of a CO2/energy tax

The implementation of energy or CO2 tax with reallocation of the revenue of the tax in priority to low income household to support energy efficiency investment is an attractive measure as it provides additional resources to subsidize investments reduce fuel poverty and increase the cost effectiveness of the investments.

Based on the model simulation, it turns out that the impact of this tax on energy consumption is really effective above a certain threshold. Energy or CO2 tax in the range

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[25]These information centres gather 500 consultants throughout 259 centres all over France. More than 8 million people have consulted these centres since 2003. In 2011, out of the 650 000 people advised, 45% had implemented an action

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of 100€/t CO2 in 2030 (with a linear increase starting in 2015) show only very limited impact whereas a tax in the range of 200€/t CO2 in 2030 has a stronger impact.

However, even if on a longer period it should improve the situation of low income households, it will penalize them on the short term by increasing their energy bills, thus leading to fuel poverty and increased restrictions. Therefore, **any tax should be accompanied by complementary measures to alleviate the effect on low income households**, such as a dedicated fund to help them investing at attractive conditions.

CO2-taxes incentivize both RES-H and thermal building renovation. The split between these measures depends on the CO2-tax level as well as on the barriers for different measures. RES-H installations typically are easier to install and may achieve a faster market penetration than thermal building renovation. Thus, it might be necessary to implement complementary support instruments that are technology specific in order to achieve a certain technology mix or a minimum or renovation measures.
The public acceptance for an energy or CO2might be low. That is why social impacts of this instrument, not only for low income households, should be explored. So at least accompanying instruments to inform about the tax are necessary.

A CO2-tax would also provide an incentive for RES-H.

5.3 “Mandatory” renovations

“Mandatory" renovations (when economically feasible) are an effective measure to boost renovations in badly insulated dwellings.

It can be enforced at the occasion of real estate transaction and heavy non-energy renovations (e.g. obligation of thermal renovation in case of roof renovation, wall or roof insulation with the transformation of attic or garage in living space in the dwelling, etc.) concerning dwellings with energy performance certificate above D[26].

In case of problem of acceptability and instead of having a real obligation, it may be more efficient to set a temporary tax, the revenue of which would be stored on an account and released to the buyer once the renovation has been done (under presentation of the new energy certificate).

[26]For the other dwellings (EPC below D), we assume an increase the requirement levels of the element by element stated in the French building code in case of renovation.

However, this type of measure has many drawbacks: on the one hand, it might be un-constitutional to enforce an obligation only on the most energy consuming dwelling; on the other hand it may have a significant impact on the real estate market by limiting the sales of dwellings. Finally, the idea of an obligation may not be well accepted by stake-holders, representatives of building professionals or individuals.
Renovation can be as well enforced (still when economically feasible)in case of maintenance works on the buildings: for instance wall insulation in case of facades cleaning (mandatory in France every 20 years),insulation of attic or roof during repair or change of roof or an insulation obligation, during the transformation of attic or garage in living space in the dwelling.

It should be enforced that the renovations target high energy efficiency standards up to the nZEB-standard to ensure that ambitious long-term energy efficiency targets can be met. To avoid negative social impacts to private building owners this instrument should be accompanied by supporting instruments.

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A Annex

A.1 : Specific examples of modelling policy instruments in Invert/EE-lab

In the following, we will give some examples how policy instruments can be modelled and which level of detail we can cover. However, in most cases I would try not to overwhelm policy makers with details. For the policy group meeting it might be absolute sufficient to decide on the principle design of the instrument. The specific design will be suggested (and simulated) by us and can be discussed in a further step with policy makers (during the summer/autumn), if required.

- Investment subsidies for renovation measures

For simulating the impact of investment subsidies for renovation measures, the following parameters have to be defined:

- The standard of renovation measures being supported (e.g. in terms of U-values for building components; may differ between building categories; three different levels of renovation packages can be defined for each building category).
- The percentage of overall investment costs being granted by the scheme (may differ between building categories).
- Optional: maximum support level in €/m² floor area and/or €/building (Investment subsidies)
- Optional: Total support budget (M€ on an annual basis, can change from year to year)

The agents in Invert/EE-Lab decide among the options “no thermal renovation measure” and several different renovation measures including policy measures, as defined above, targeting on them individually. The policy instrument will increase the market uptake of this specific type of renovation measure addressed in the policy instrument depending on the agents awareness of the instrument and the relevance of economic aspects in the decision making process of different agents.

- Investment subsidies for renewable heating

For simulating the impact of investment subsidies for renovation measures, the following parameters need to be defined:

- The percentage of overall investment costs being granted by the scheme for different heating technologies.

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- Optional: maximum support level €/building and/or dwelling (Investment subsidies)
- Optional: Total support budget (M€ on an annual basis, can change from year to year)

The agents in Invert/EE-Lab decide among the different heating and hot water options. The instrument will increase the market uptake of the specific type of (renewable) heating system addressed in the policy instrument depending on the agents awareness of the instrument and the relevance of economic aspects in the decision making process of different agents.

- Investment subsidies for renewable heating independent on public budget

Similar to the conventional investment subsidies financed by the public budget we are able to simulate the impact of instruments financed e.g. on a levy on fossil fuels. (see. e.g. Bürger, 2013) There are different specific options for adapting the levy automatically on the support level of renewable heating systems. In case that you select such a system, we will decide together with you on the detailed setting of these systems.

- Building codes for new buildings

Minimum standards for new buildings are defined exogenously in Invert/EE-Lab. All new buildings will have at least this minimum standard. So, the definition of this standard is a relevant regulatory instrument. For this definition, we need the U-values of relevant building components (if there are performance based criteria in kWh/m²/a, we will have to convert this value into typical U-values consistent with this performance based criteria).

(Optional, also geometry data of new buildings may be changed. As a default, we will use the geometry data from the last building construction period, e.g. 2000-2008.)

- Building codes for renovation of buildings

As a default, in Invert/EE-Lab building owners are free to select either “no thermal renovation measure” or some level of renovation measures. However, Invert/EE-Lab can introduce an obligation to carry out at least a minimum set of thermal renovation measures in case that a building is being refurbished.

- RES-H obligations

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For an obligation to use renewable heating, there are the following options to be defined in Invert/EE-Lab:

- When will the obligation come into force? (a) in case of new building construction, (b) in case of renovation of buildings or (c) in case of each change of heating systems
- Which share of renewable heating is obligatory for this specific building? (e.g. 25%, 50%, 75%?)
- Are there penalties in case that the obligation is not being fulfilled? How high are they (€/m² floor area).
- Optional: the penalty may also be linked to increasing the thermal efficiency of the building
- Optional: there might be a weighting between different renewable energy carriers, i.e. solar thermal might be weighted higher than biomass.

- Information, training, advice

Information, training advice may lead to higher awareness level of different type of agents. Invert/EE-Lab is able to model the impact of a higher level of awareness from different type of agents. However, Invert/EE-Lab is not able to model the link between information campaigns and the increase of the awareness level.

- R&D

For each technology implemented in Invert/EE-Lab, cost reduction (or increase) or efficiency development over time up to 2030/2050 can be defined. This changes the attractiveness of the different options and subsequently (according to the logit-approach) the market share of different measures, energy carriers and technology options.

Invert/EE-Lab is not able to model the link between R&D-expenses and the cost reductions. So, there is the need to make own assumptions based on expert guess to which extent R&D policies might lead to technological progress.

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A.2 Definition of renovation packages

Table 3: Definition of renovation packages (FRA)

	Roof	Wall	Base	Windows	Nightcooling	Solar shading	He-atrecovery
Residen-tial							
Standard	15 cm of thermal insulati-on	5 cm of thermal insulati-on	5 cm of thermal insulati-on	Double glass with air cavity (16mm), thermal transmit-tance value of glazing Ug= 2,7 W/m²K; g= 0,78; Tvis= 0,82,	no	no	no
Good	20 cm of thermal insulati-on	15 cm of thermal insulati-on	10 cm of thermal insulati-on	Double glass with air cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,7 W/m²K; g= 0,72; Tvis= 0,82,	Automatise-dnaturalven-tilation	Automa-tion of solar shading devices	no
Ambiti-ous	30 cm of thermal insulati-on	20 cm of thermal insulati-on	15 cm of thermal insulati-on	Triple glass with argon cavity (16mm) and a low-e glass, thermal transmit-tance value of glazing Ug= 1,0 W/m²K; g= 0,64; Tvis= 0,74	Automatise-dnaturalven-tilation	Automa-tion of solar shading devices	yes
Non-residen-tial							
Standard	15 cm of thermal insulati-on	5 cm of thermal insulati-on	5 cm of thermal insulati-on	Double glass with air cavity (16mm), thermal transmit-tance value of glazing Ug= 2,7 W/m²K; g= 0,78; Tvis= 0,82,	no	no	no
Good	20 cm of thermal insulati-on	10 cm of thermal insulati-on	10 cm of thermal insulati-on	Double glass with air cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,7 W/m²K; g= 0,72; Tvis= 0,82,	Automatise-dnaturalven-tilation	Automa-tion of solar shading devices	no
Ambiti-ous	30 cm of thermal insulati-on	25 cm of thermal insulati-on	15 cm of thermal insulati-on	Triple glass with argon cavity (16mm) and a low-e glass, thermal transmit-tance value of glazing Ug= 1,0 W/m²K; g= 0,64; Tvis= 0,74,	Automatise-dnaturalven-tilation	Automa-tion of solar shading devices	yes

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A.3 Documentation of the model Invert/EE-Lab

In addition to the short overview of the model Invert/EE-Lab in chapter 2, this annex provides a few more information.

Invert/EE-Lab is a dynamic bottom-up simulation tool that evaluates the effects of different promotion schemes (in particular different settings of economic and regulatory incentives) on the total energy demand, energy carrier mix, CO2 reductions and costs for space heating, cooling and hot water preparations in buildings. Furthermore, Invert/EE-Lab is designed to simulate different scenarios (price scenarios, insulation scenarios, different consumer behaviours, etc.) and their respective impact on future trends of energy demand and mix of renewable as well as conventional energy sources on a national and regional level. More information is available on www.invert.at or e.g. in (Kranzl et al., 2013) or (Müller, 2012).

The basic structure and concept is described in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

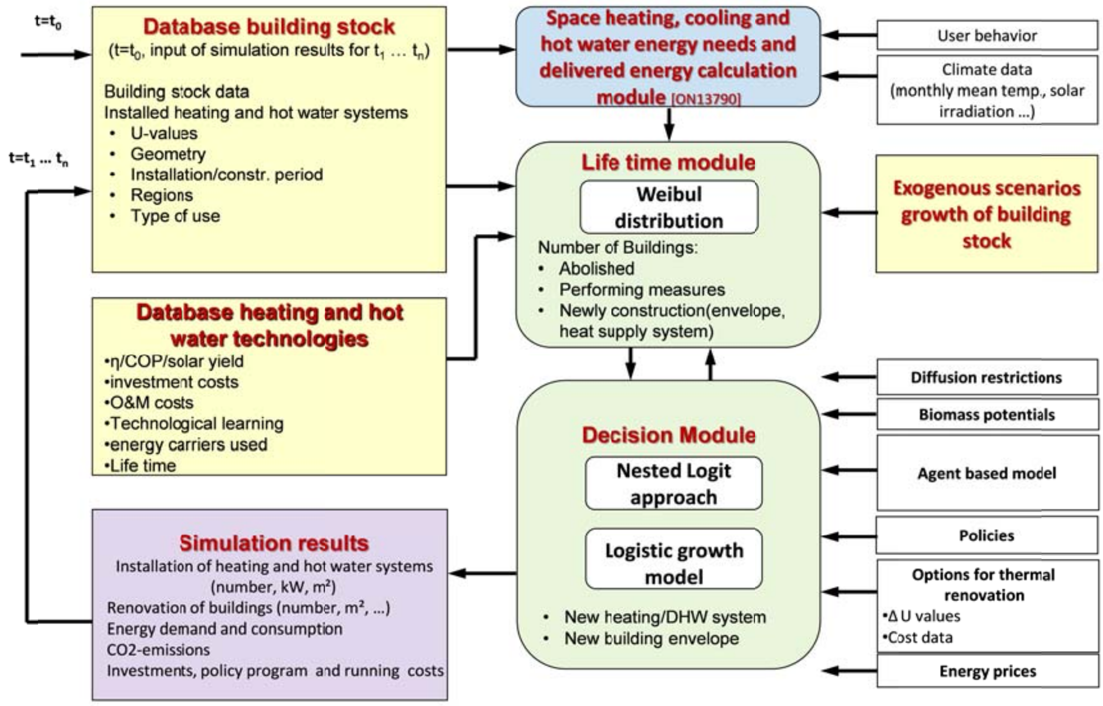

Figure 18: Overview structure of Simulation-Tool Invert/EE-Lab

Invert simulation tool originally has been developed by Vienna University of Technology/EEG in the frame of the Altener project Invert (Investing in RES&RUE technologies:

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models for saving public money). In more than 30 projects and studies for more than 15 countries, the model has been extended and applied to different regions within Europe, see e.g. (Kranzl et al., 2012), (Kranzl et al., 2013), (Biermayr et al., 2007), (Haas et al., 2009), (Kranzl et al., 2006), (Kranzl et al., 2007), (Nast et al., 2006), (Schriefl, 2007), (Stadler et al., 2007). The last modification of the model in the year 2010 included a re-programming process and accommodation of the tool, in particular taking into account the inhomogeneous structure of decision makers in the building sector and corresponding distributions (Müller, 2010). The current state of the model relies on this new calculation-core (called EE-Lab) leading to the current version of the model Invert/EE-Lab.

The basic idea of the model is to describe the building stock, heating, cooling and hot water systems on highly disaggregated level, calculate related energy needs and delivered energy, determine reinvestment cycles and new investment of building components and technologies and simulate the decisions of various agents (i.e. owner types) in case that an investment decision is due for a specific building segment.The core of the tool is a myopical, multinominal logit approach, which optimizes objectives of "agents" under imperfect information conditions and by that represents the decisions maker concerning building related decisions.

The model enables the definition of a various number of different owner types as instances of predefined investor classes: owner occupier, private landlords, community of owners (joint-ownership), and housing association. The structure is motivated by the different perspectives regarding building related investments. For instance, energy cost savings are only relevant for those owners which occupy the building. The corresponding variable relevant to landlords is a refinancing of energy savings measures through additional rental income (investor-tenant dilemma). Owner types are differentiated by their investment decision behaviour and the perception of the environment. The former is captured by investor-specific weights of economic and non-economic attributes of alternatives. The perception relevant variables – in-formation awareness, energy price calculation, risk aversion – influence the attribute values. More details regarding the integration of stakeholder specific investment behavior in the model Invert/EE-Lab is documented in Steinbach, (2013).

Coverage and data structure

The model Invert/EE-Lab up to now has been applied in all countries of **EU-28 (+ Serbia)**. A representation of the implemented data of the building stock is given at www.entranze.eu.

Invert/EE-Lab covers **residential and non-residential buildings**. Industrial buildings are excluded (as far as they are not included in the official statistics of office or other non-residential buildings).

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The following figure shows the disaggregated modeling of the building stock within each country. The level of detail, the number of construction periods etc. depend on the data availability and structure of national statistics. We take into account data from Eurostat, national building statistics, national statistics on various economic sectors for non-residential buildings, BPIE data hub, Odyssee, which are finally summarized in the ENTRANZE database (www.entranze.eu).

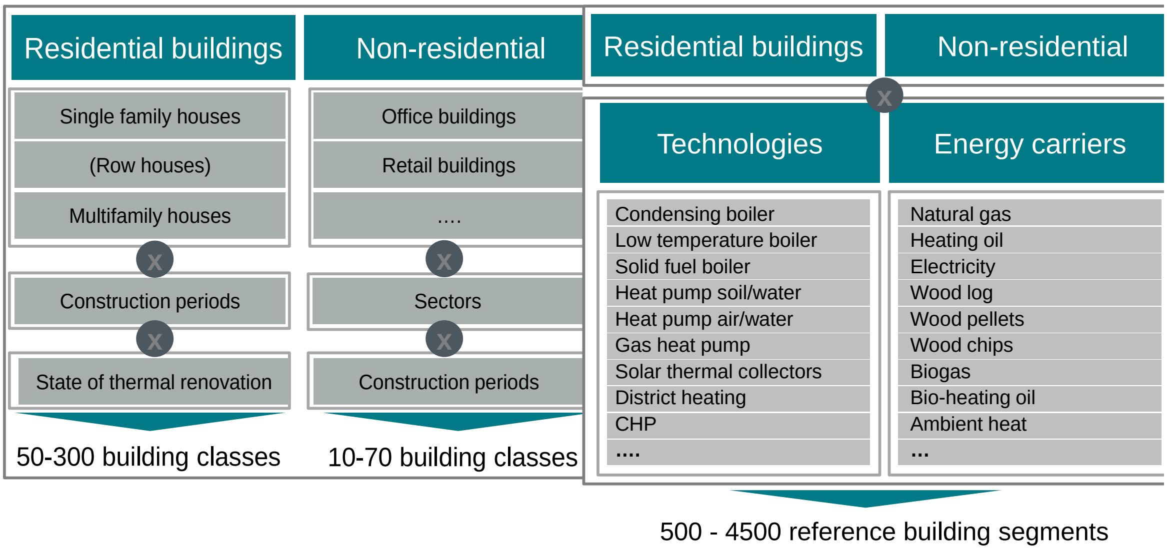

Figure 19: Disaggregated modeling of the building stock within each country. Where relevant climatic zones are taken into account within a country.

Outputs from Invert/EE-Lab

Standard outputs from the Invert/EE-Lab on an annual basis are:

- Installation of heating and hot water systems by energy carrier and technology (number of buildings, number of dwellings supplied)
- Refurbishment measures by level of refurbishment (number of buildings, number of dwellings)
- Total delivered energy by energy carriers and building categories (GWh)
- Total energy need by building categories (GWh)
- Policy programme costs, e.g. support volume for investment subsidies (M€)
- Total investment (M€)

Moreover, Invert/EE-Lab offers the possibility to derive more detailed and other type of result evaluations as well. Based on the needs of the policy processes we will have to discuss which other type of evaluations of the result data set might be required.

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