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

## D4.3 and D5.6 from Entranze Project


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**September 2014**


Co-funded by the Intelligent Energy Europe
Programme of the European Union

## ENTRANZE Project

**Year of implementation:** April 2012 – September 2014

**Client:** EACI

**Web:** http://www.entranze.eu

**Project consortium:**

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|---|---|
| **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 Spain. 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.

### Acknowledgement:

The authors and the whole project consortium gratefully acknowledge the financial and intellectual support of this work provided by the Intelligent Energy for Europe – Programme.

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Programme of the European Union

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## Executive Summary

In this paper the methodology and the results of the creation of the policy scenario calculations and the policy recommendations within the ENTRANZE project are described. These are the main results of the work packages 4 and 5 of this Intelligent Energies Europe (IEE) - project.

In a first step policy sets have been developed, basing on the findings of the previous work within the project, e.g. data collection about the building sector, analyses of barriers for investors, and cost optimality calculations for renovations. The policy sets have been discussed and revised within the policy group meetings. Eventually the impact of the policy sets has been calculated with the model Invert/EE-Lab, and the recommendations have been derived from the results of the calculation. Again the recommendations have been discussed and revised by the policy group.

In Spain the following policy sets have been chosen and their impact calculated with Invert/EE-Lab:

- Policy set 1 (low): business as usual (current Technical Building Code + current financial and tax incentives)
- Policy set 2 (medium): focus on regulatory measures (policy set 1 + tightening mandatory energy requirements + training/advice)
- Policy set 3 (ambitious): policy set 2 + increase the amount available from the State budget for subsidies + energy efficiency obligations

The following main findings have been identified:

- It is estimated that the current policies regarding energy efficiency of buildings implemented in Spain will result in an energy saving (for heating and hot water) between 2% and 4% in 2020 compared to 2008 (see sections 3.3 and 4.1).
- Achieving more ambitious savings (e.g. 15% -25%) in 2020 and 2030 necessarily requires the implementation of more ambitious policy instruments. In some cases the currently implemented policy instruments can be strengthened or improved, in other cases new and innovative instruments are needed (see sections 3.3 and 4.1).
- A market transformation is needed in order to meet quality assurance requirements of the implemented energy efficiency measures. Several experts point at the development of an effective surveillance system which will ensure the quality of the whole process (from the project design to implementation and maintenance) in order to ensure the compliance of the TBC[1] requirements (see section 5.1).

[1] Technical Building Code (updated in 2013)



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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. Policy scenarios are derived for the development of the building stock and its energy demand in the EU-27 (+Croatia and Serbia) up to 2030. In particular, the future deployment of Nearly Zero Energy Buildings and RES-H/C in the EU building stock is investigated and corresponding costs, 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 scenarios are developed 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 for two energy price scenarios has been developed. The national 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.

In Spain, three policy group meetings have been taken place in Madrid with representatives of Directorate-General of Architecture and Housing and Land (Ministry of Public Works), Ministry of Industry, Energy and Tourism and IDAE (Institute for Energy Diversification and Savings) in order to discuss about the policy process to enforce the transition to nZEB of existing buildings.

The meetings were held in June 2012, July 2013 and March 2014. They have allowed the definition and revision of policy sets in order to provide national policy scenarios. At the same time, the discussion with the policy makers about each particular instrument involved, has allowed the trend identification about the policy process in Spain in order to take feasible instruments into account.

This report provides a summary of these national policy scenarios as well as corresponding conclusions and recommendations. It starts with a documentation of the methodology in chapter 2. Chapter 3 provides the policy sets which were defined in policy group meetings together with relevant national stakeholders. Chapter 4 presents the resulting scenarios for the energy demand in the building stock and related renovation activities. Finally, chapter 5 includes the recommendations.



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## 2. Methodology

The methodology of this report is based on three pillars:

1. Selection and description of policy sets based on a participatory stakeholder process
2. Modelling the potential impact of these policy sets with Invert/EE-Lab
3. Deriving 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 bases on the results of the previous work. These are especially the collected data of the building stock, the study on public and social acceptance and perception of nearly zero-energy buildings and RES-H/C in the target countries, and the cost optimality calculation. Another focus was put on specific barriers for different types of buildings and ownership groups (compare Table 1). Generally the policies should be designed in a way that they most effectively address these barriers and help to overcome them. 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 current political processes have been considered, and the policy sets have been created in a common process of discussion 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 and cooling system as well as the access to capital or the cost of capital. long payback times for the respective investments |
| | Information deficit with high information search costs |
| **Owner-occupied multi-family buildings** | Financial barriers: high initial costs and long payback periods |
| | Difficulties with taking a collective loan for the investment in a refurbishment measure (in several countries all dwelling owners of a multi-family building must mortgage their apartment) |



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| | Decisions about refurbishment measures must be more or less taken collectively: 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 in some countries the access to and cost of capital. |
| | The landlord-tenant dilemma |
| **Public building sector** | Public budgeting practises: different budget lines distinguishing between investment and operation costs |
| | Financial barriers: High initial cost for refurbishment measures and poor financial state of public finance |

Other barriers, concerning all target groups, include

- information deficits; there often is a low level of information and awareness concerning economic benefits from refurbishment measures, benefits with regard to comfort, the availability of support schemes;
- the lack of technical/administrative advice (e.g. due to the absence of energy agencies on the local, regional or even national level).
- psychosocial factors such as preferences and attitudes,
- administrative barriers, such as low reliability and continuity of public support programs, and the sometimes complex and complicated administrative procedures (multi-stakeholders decision chain) for undertaking refurbishment measures or for applying for support.
- legal and technical barriers, such as the low value of some buildings, the uncertainty of the long-term value of a property, and the sometimes poor quality of refurbishment measures (In many countries the quality of modernisation measures was identified as a common problem, however the severity varies by countries. Poor quality might derive from inadequately qualified workforce lacking the competence to properly conduct such measures, or from do-it-yourself type of renovations carried out by the homeowners themselves. Lacking measures to substantially improve the renovation competence, the problem will even increase as soon as more ambitious refurbishment levels need to be met. Particularly in the case of deep renovations special attention has to be paid to a sound installation of the different components as well as coordination between the different structural elements (e.g. wall – window, roof – wall).

For more explanation compare deliverable D2.4 (Heiskanen et al., 2012) and Deliverable D5.4 (Bürger, V., 2013).



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## 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 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).

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

Invert/EE-Lab models the decision making of agents (i.e. building owner types) regarding building renovation and heating, hot water and cooling systems. 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 lead to other investment decisions. This change leads to a higher market share of the supported technology in the 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 of innovative technologies in the decision making process 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 innovative 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 model Invert/EE-Lab 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 reports "Building sector and energy demand in target countries" and the corresponding online data tool, both available at www.entranze.eu.

- **Cost data of heating, hot water and cooling systems as well as of renovation options**: These data have been collected, 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).

- **Definition of renovation packages and the link to the cost-optimality calculations:** 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 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 whereas 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). Annex A.2 lists the main indicators for the renovation packages taken into account for the modelling and scenario development.

### 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. POLES has been established. POLES developed 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[2], VAT) and a carbon price[3].

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. On the other hand, the results of the model Invert/EE-Lab 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.

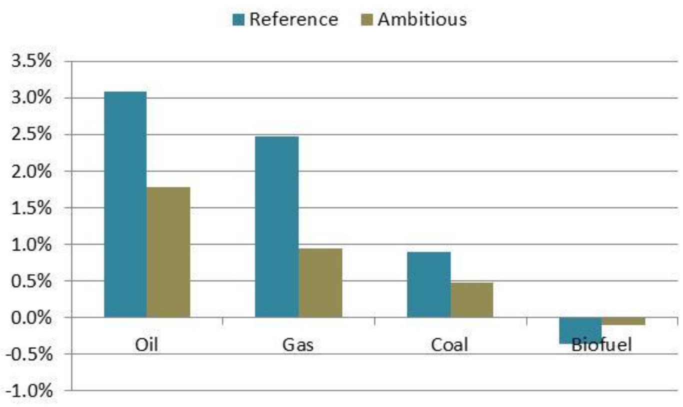


**Figure 1: Annual growth rate of international energy price over 2010-2030**

Source: POLES-Enerdata

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2 Including existing energy & environmental taxes.

3 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.



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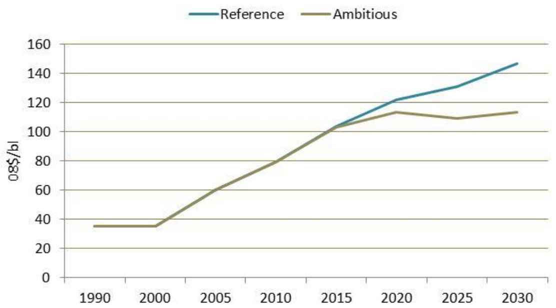
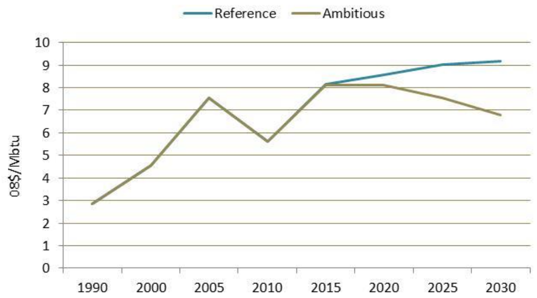
## Oil



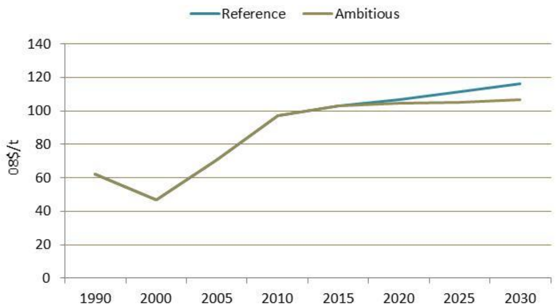

In the reference scenario, oil price is expected to increase at a rapid pace of 6.5%/year from 2000 until 2020, which will then slow down to 2%/year until 2030. In the ambitious scenario, it increases less rapidly until 2020 (3.6%/year), and remains almost steady reaching 100$/bl in 2030. This lower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

## Gas



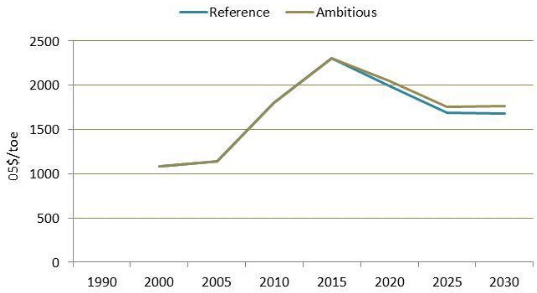

Gas price in Europe is expected to increase by 7.6%/year for both scenarios until 2015. Then it will continue to increase on average until 2030 by 0.8%/year in the reference scenario whilst it is decreasing in the ambitious scenario by 1.2%/year because of decreasing demand.

## Coal




Coal prices are expected to increase steadily across time in Europe, 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: the fact that production costs will increase with income in producing regions.

## Biomass




After a short-term to increase due to the strong dynamic in biofuel demand in all sectors, the biomass price[4] will decrease by roughly 2%/year until 2025 thanks to market autoregulation. It will again slightly increase (until 2050) because of a strong penetration of biofuels, the high mitigation option.

**Figure 2: European energy price forecasts until 2030**

[4] 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[5]

Excise taxes and VAT have been assumed constant in these projections. Price of heating oil and gas for households consumers are projected to increase by respectively 6.1% and 5.6%/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 (3.0% and 1.9%/year respectively for oil and gas) (Figure 3). 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 1.2%/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 and. It also includes taxes. The average price increases by 1.9%/year in the ambitious/high price scenario and by 0.7%/year in the reference/low price scenario. The electricity price is expected to peak in 2030 at around 3 149 $05/toe (27 $c/kWh)[6] in the ambitious/high price scenario and at 2 490 $05/toe (21 $c/kWh) in the reference/low price scenario.

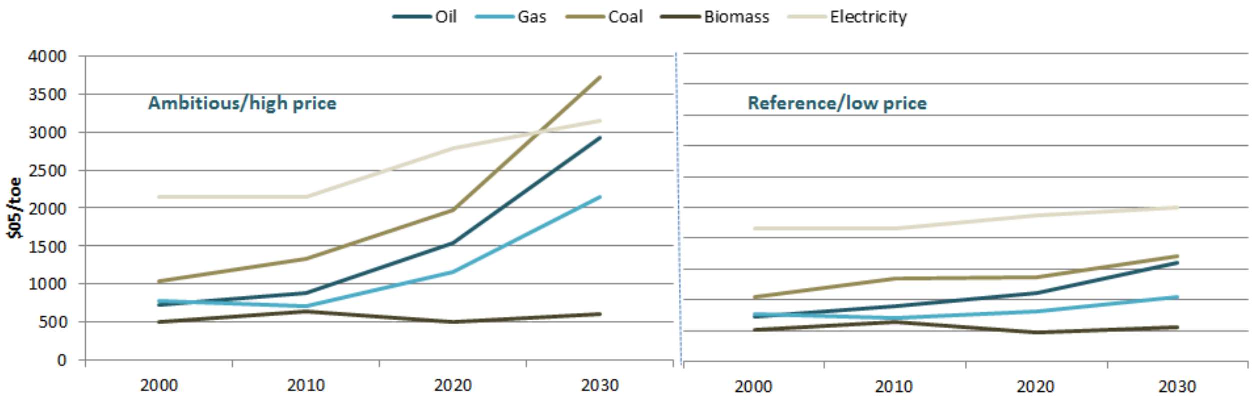


**Figure 3: Spanish residential domestic prices forecasts by type of energy**

Source: POLES-Enerdata

[5] Domestic prices are in constant euros (i.e. without inflation), from which you can derive an average variation by period.
[6] 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 basing on the results of the scenario calculation. Again the results of all previous works have been considered. The results of the national policy process have also been evaluated as to whether recommendations for other Member States can be derived.


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# 3. Policy set description

In this part of the report we describe the policy sets which will be further investigated regarding their potential impact. We start with an overview of existing instruments, and provide some general considerations for the selection before we define the policy sets according to the discussion process in the policy group meetings.

## 3.1 Overview of policy instruments for improving energy performance of buildings

Figures 4 and 5 give an overview about the categories of existing policy instruments for the improvement of the energetic condition of buildings. For more detailed information compare the report "Overview and assessment of new and innovative integrated policy sets that aim at the nZEB standard" of the ENTRANZE-project (Bürger, 2013).


**Figure 4: Categories of policy instruments (part 1)**



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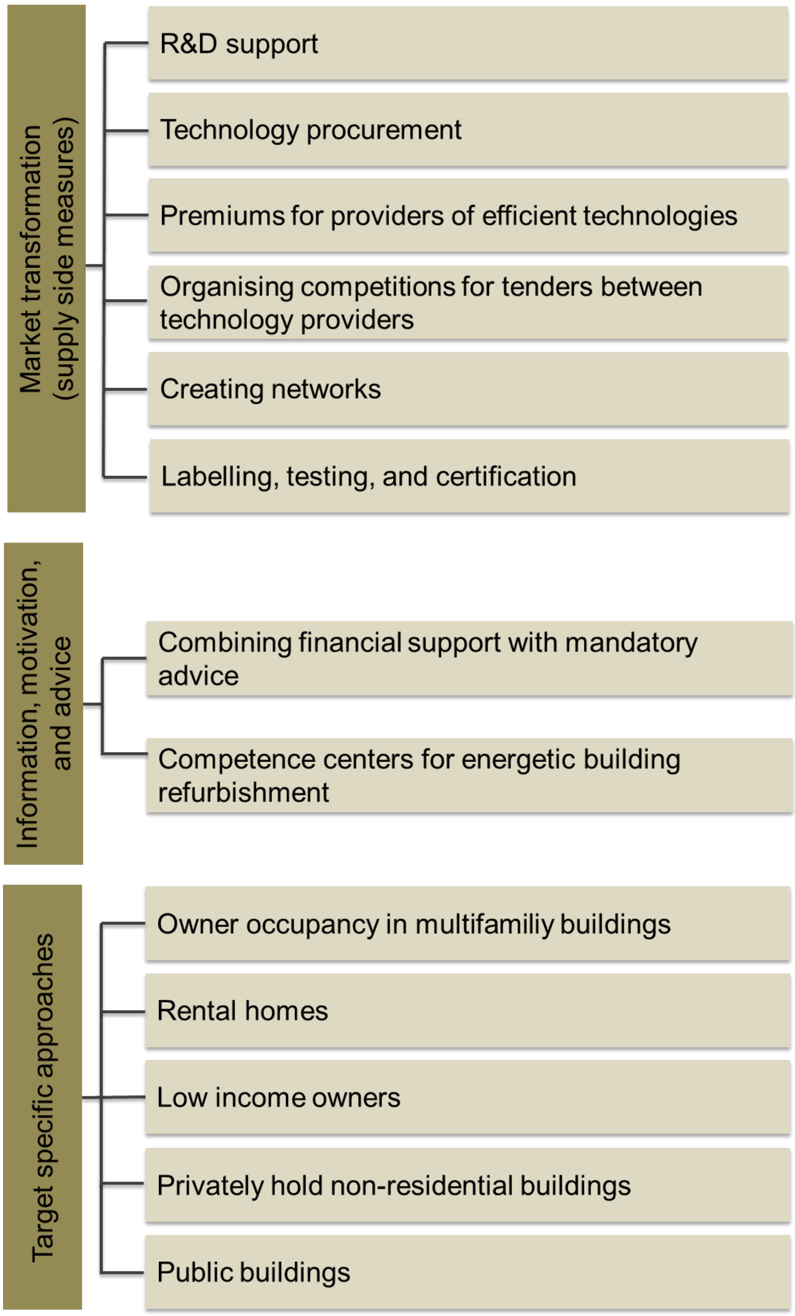


**Figure 5: Categories of policy instruments (part 2)**

## 3.2 Key considerations for defining policy sets

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


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- 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 as to target the needs of the major target groups. The instruments in the policy package should 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 accesses to financial support which might aim at different target groups). It should be avoided that instruments are simply redundant (which might only lead to higher 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.
- 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.

One option to define the policy packages would be to choose policy sets according to distinct “policy lines”. For instance a policy package could lay a focus on regulatory measures. Such a package could involve tightening the building code, implementing replacement obligations (e.g. for boilers) and/or unconditional refurbishment obligations (e.g. for the structural components of a building) as well as implementing a use obligation for RES-H. Another policy line would focus on financial support that is offered by state-financed support programs. The core of such a policy package would be grant programs, soft loans, tax incentives that could incentivise building owners to make investments in refurbishment measures.

A third potential policy line could strengthen support and financing activities within the market. Under such a policy line the state would create the framework conditions and support would be given independent from public budgets. Typical instruments within such a policy package would be energy saving obligations under which obliged market actors would start to establish support pro-grams for refurbishment measures. Also typical price-based (e.g. premium schemes) or quantity-based (e.g. quota schemes) approaches could be taken up as long as it is ensured that the support costs are covered by the market participants (finally ending with the end consumer).

The strategy of a policy set should include a long-term goal (expressed in form of a set of indicators) but also milestones that should be met during the sector transformation from the status quo today towards the long-term goal. Another important question is how the different instruments are designed in detail. Often the impact of a political in-



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tervention is more dependent on the core design parameters of an instrument than on the question which instrument is applied. For a grant program important design parameters are the grant level(s), potentially tiered according to the efficiency level of a measure, the eligibility to the program etc. For the quantitative impact assessment these parameters must be set. Another dimension is the time. Policy sets might change over time. This applies to the selection of instruments within a package but also to the evolution of the specific instrument designs. The time dimension needs to be taken into account as well when the policy sets are set up. For more information please compare the report "Overview and assessment of new and innovative integrated policy sets that aim at the nZEB standard" of the ENTRANZE Project (Bürger, 2013).

## 3.3 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:

**Table 2: Policy sets definition for Spain**

| Policy set 1<br>Business as usual | Policy set 2<br>Focus on regulatory measures | Policy set 3<br>Ambitious scenario |
|---|---|---|
| 1-a) Frozen regulatory scenario (CTE DB-HE 2013)<br>+<br>2-a) Frozen scenario of financial instrument financed from the state budget (grants and preferential loans)<br>+<br>3) Reduction VAT to 10% for residential building sector (only *"major"* refurbishment) | 1-b) "Moderate" scenario of regulatory requirements<br>+<br>2-a) Frozen scenario of financial instrument financed from the state budget (grants and preferential loans)<br>+<br>3) Reduction VAT to 10% for residential building sector (only *"major"* refurbishment)<br>+<br>6-a) Capacity building, qualification and quality assurance<br>+<br>7) Competence centres for energetic building refurbish- | 1-b) "Moderate" scenario of regulatory requirements<br>+<br>2-b) Increase amount of financial instrument financed from the state budget (grants and preferential loans)<br>+<br>3) Reduction VAT to 10% for residential building sector (only *"major"* refurbishment)<br>+<br>4) Energy efficiency obligations<br>+<br>5) Energy refurbishment obligation |



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| | | |
|---|---|---|
| | ment | +<br><br>6-b) Capacity building, qualification and quality assurance<br><br>+<br><br>7) Competence centres for energetic building refurbishment |

According to the previous table, each particular instrument is described next.

### 3.3.1 Description of the instruments

*1)* Regulatory measure: tightening the minimum standards (CTE DB HE 2013), mainly *for new buildings and major renovations of existing buildings.*

The new CTE DB-HE 2013 establishes minimum mandatory requirements based on energy need and energy use.

*Energy saving document of Technical Building Code 2013 (CTE DB-HE), including:*

- *HE 0 – Minimum energy requirements for energy use*
  Only for new buildings and enlargements of existing buildings.
- *HE 1 – Minimum energy requirements for energy need*
  For new buildings and refurbishment and/or enlargement of existing buildings.
  However, the requirements are different for new and existing buildings.

- *HE 2 – Minimum requirement for H/C systems*
  For new buildings and existing buildings when the H/C system is renovated.
- *HE 3 – Minimum requirements for lighting efficiency*
  For new buildings and existing buildings when the lighting system is renovated.
- *HE 4 – Minimum contribution of solar thermal for DHW*
  For new buildings and existing buildings when major renovation occurs or a renovation of heating system is carried out.
- *HE 5 – Minimum PV installation*
  Only tertiary sector. For new buildings and existing buildings when major renovation is carried out. Moreover, only when the area is more than 5.000m$^2$ and the building use is one of the following:
    - ✓ Hypermarket

- ✓ Leisure centre
- ✓ Storage and distribution building
- ✓ Sport building
- ✓ Hospitals
- ✓ Fairgrounds pavilion

**Variants:**

a) Frozen energy efficiency requirements of the CTE DB-HE 2013:

b) Moderate tightening of energy efficiency requirements of the CTE DB-HE 2013:

2) Financial instrument:

Establishing a financial support programme which is financed through the state budget (support is provided by grants and preferential loans). It is based on the Royal Decree 233/2013, April 5th (State Plan to rental housing development, building and urban renovation, 2013-2016.

The programme only covers residential buildings but it is not restricted to any specific agents, but also covers all residential buildings owners.

The technologies subsided are:

**Envelope:** Thermal insulation improvement, windows replacement and any other bioclimatic device.

**H/C, ventilation and DHW systems:** New implementation and/or efficiency improvement of existing installations.

- Boiler replacements
- Heat pumps replacement
- Control and regulation devices
- Metering
- Insulation of distribution systems (pipes and/or ducts)
- Efficiency improvement of auxiliary systems (pumps and/or fans)
- Heat recovery systems
- Free cooling implementation

**RES:** Renewable energy implementation for reducing fossil energy use (heat and/or electricity).

- Solar thermal panels
- Biomass
- GSHP – Ground source heat pump
- PV



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**Table 3: Subsidies included in the programme**

| | Maximum level of subsidies [€/dwelling] | Obligation to reach a specific reduction of final energy demand [%] |
|---|---|---|
| Level 1 | 2.000€ | 30% |
| Level 2 | 5.000€ | 50% |

The programme is financed from the state budget annually, punctually contribution of ERDF funds and each region could contribute, too.

*The Energy Savings and Efficiency Action Plan 2011-2020 mentions an average budget of 288M€.*

**Variants:**

a) Frozen scenario

b) Static up to 2017. Increase by 15% up to 2019. Increase by 15% up to 2030.

3) Tax incentives: Reduced VAT value for major renovations in residential sector (from 21% to 10%).

4) Energy saving obligations according to Art.7 of EED 2012

5) Refurbishment obligation

In Spain, the law 8/2013 on urban rehabilitation, regeneration and renovation, which was passed in June 2013, includes, among others, the following novelty: residential buildings that are more than fifty years old must have a Building Assessment Report, which in addition to evaluating the state of conservation and accessibility includes an energy efficiency certificate.
Around 55% of Spanish building stock (13 million of dwellings) was built before 1980 (without any Building Code) and around 21%, 5 million dwellings are more than fifty years old. However, the law does not involve clear criteria for a refurbishment obligation.
In order to achieve an ambitious target for penetration of nZEB in the current building stock, an annual rate of the building stock that is **in poor or very poor condition** should be fixed for a refurbishment obligation after the assessment report (e.g. based on age of components or **low energy performance rates**).



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6) Qualification and quality assurance

a) Professional training:

- the systematic integration of topics related to refurbishment measures in the curriculum of universities and professional training of architects, construction engineers, engineers for supply technologies, expert planners and other occupational categories with strong links to the renovation of buildings (such as plasterer, window fitters, roofers, heating installers);
- the further development of teaching modules and their integration in the vocational education of all refurbishment related occupations requiring formal training;
- where appropriate: development of a trade-integrative occupation combining competences of all different trades that are relevant for major refurbishment projects

**b)** Professional training + **qualified building specific refurbishment plans:**

Introduction of a qualified long-term building specific refurbishment plan; this plan would outline a strategy how a building could be refurbished over time to finally (in the long-term) achieve an energy standard (1) that is compatible with the long-term goals. The strategy could a staged approach where measures are taken step by step e.g. according to the availability of finance. For the step-by-step approach the plan would outline different alternatives how to proceed. The plan would include both, refurbishment measures at the envelope as well as efficiency measures concerning the heating and/or cooling system, including the use of renewables.

This plan would allow buildings owners to have access to grants or preferential loans (economic instruments (2)), although they are not able to make a complete deep renovation.

7) Information, motivation and advice

### Competence centres for energetic building refurbishment

Establishment of local competence centres that are specialised in all topics concerning the energetic refurbishment of buildings; This would include technological measures, legal, economical and financing issues. The centre would provide an overview of support programs available for the specific refurbishment projects, in addition a positive list of local companies conducting such measures.

# 4. Model results

The main results of the policy scenarios modelled with Invert are shown in the following graphs. All data are also shown in an online tool included on the project website (www.entranze.eu).

## 4.1 Energy demand, energy mix and renewables

The following graphs show the projections of energy demand for heating and domestic hot water in Spain up to 2030 under three different scenarios (policy sets 1, 2 and 3 as are described in the previous paragraph). The energy demand has been split into the different energy carriers. The results are shown for both, low and high energy price scenarios.

In the low energy price scenario the reduction in 2020 compared to 2008 for the policy set 1 (described as business as usual) is around 2%. Hence, if it is necessary to achive a more ambitous target, it will be necessary to implement additional policy instruments. In the graph can be seen that the most ambitious policy set (3) leads to the highest energy saving (around 25% in 2030 compared to 2008).

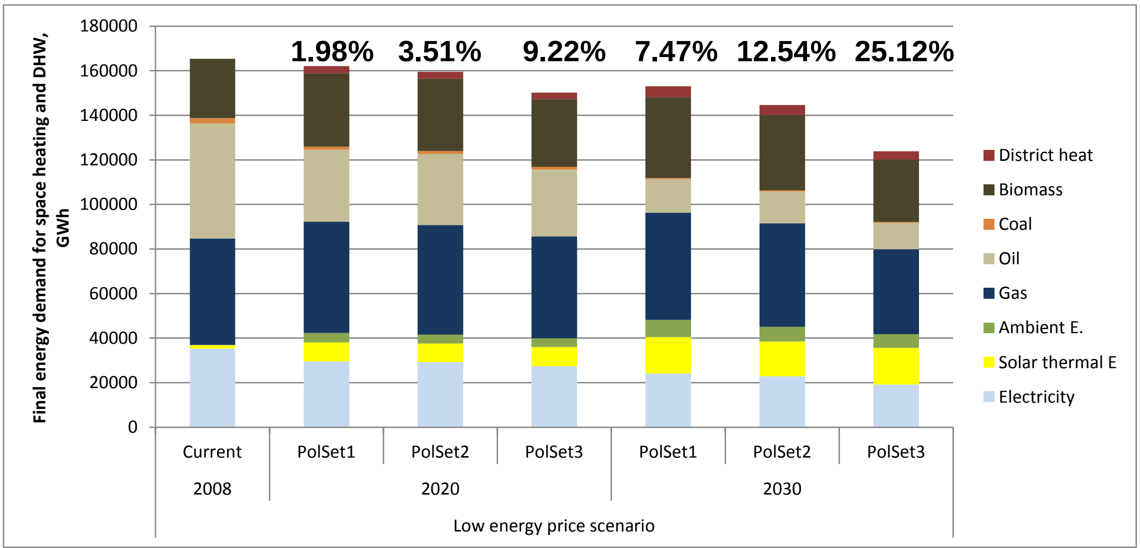


**Figure 6: Final energy demand for space heating and DHW, GWh**

The results of the same analysis can be seen in the following graph regarding the high energy price scenario. It can be shown that at higher energy prices the considered policy instruments lead to higher energy savings up to 2030. Policy set 2 shows the biggest difference between low and high energy price scenario, with an energy reduction in 2030 of 15.06% (high price scenario) versus 12.54% (low price scenario).



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The results show that the implementation of more ambitious policy instruments is needed in order to achieve ambitious targets in terms of energy saving. The height of the energy savings achieved is also determined by the development of the energy prices.

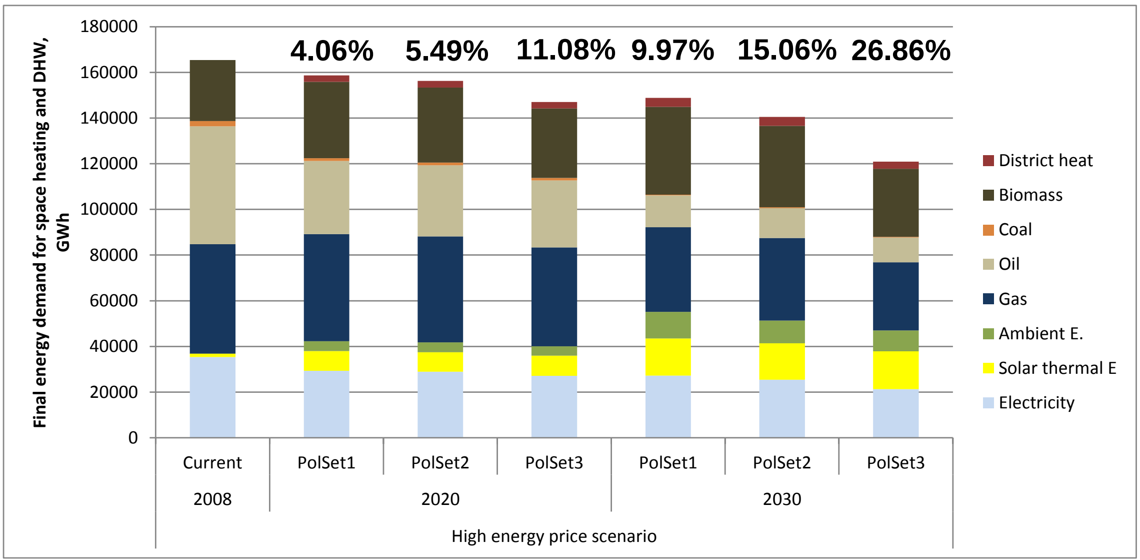


**Figure 7: Final energy demand for space heating and DHW, GWh**

The annual energy demand of the different energy carriers shown in the previous graphs can be translated into annual costs for the needed energy carriers as it is shown in the following two graphs:

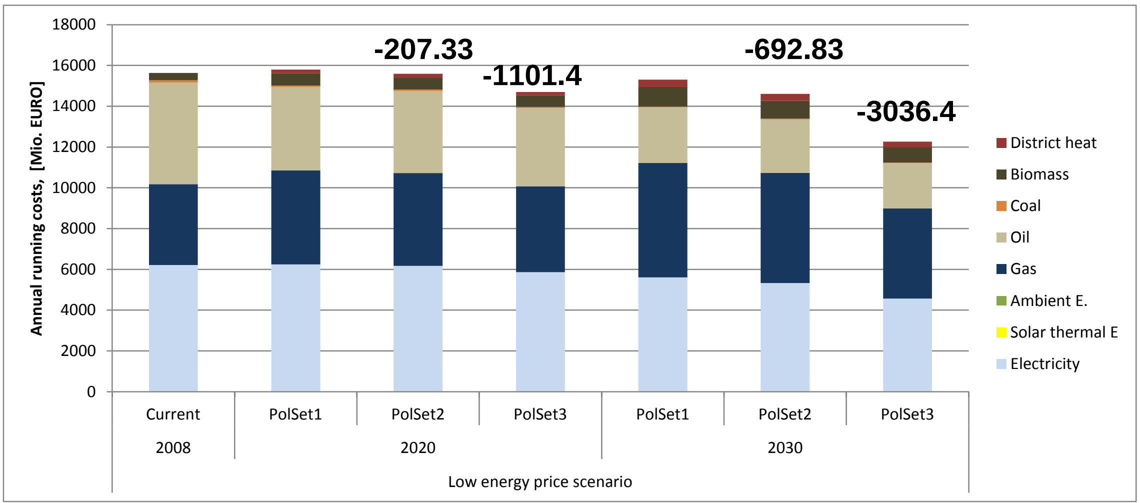


**Figure 8: Annual running costs, [Mio. EURO] (low energy price scenario)**



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As can be seen in the previous graph a reduction of the annual costs of around 3.000 Mio EURO has been calculated for policy set 3 compared to policy set 1 in 2030 in the low price scenario. Figure 9 shows that in the high energy price scenario: the reduction of the costs for the used energy carriers is 4.500 Mio EURO in policy set 3.

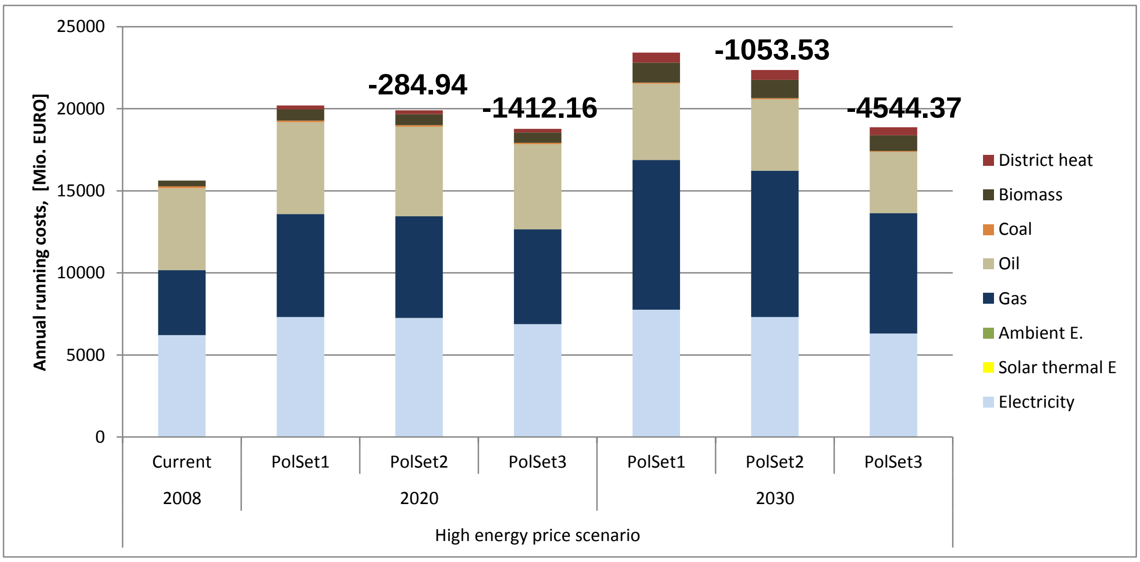


**Figure 9: Annual running costs, [Mio. EURO] (high energy price scenario)**

## 4.2 Renovation activities

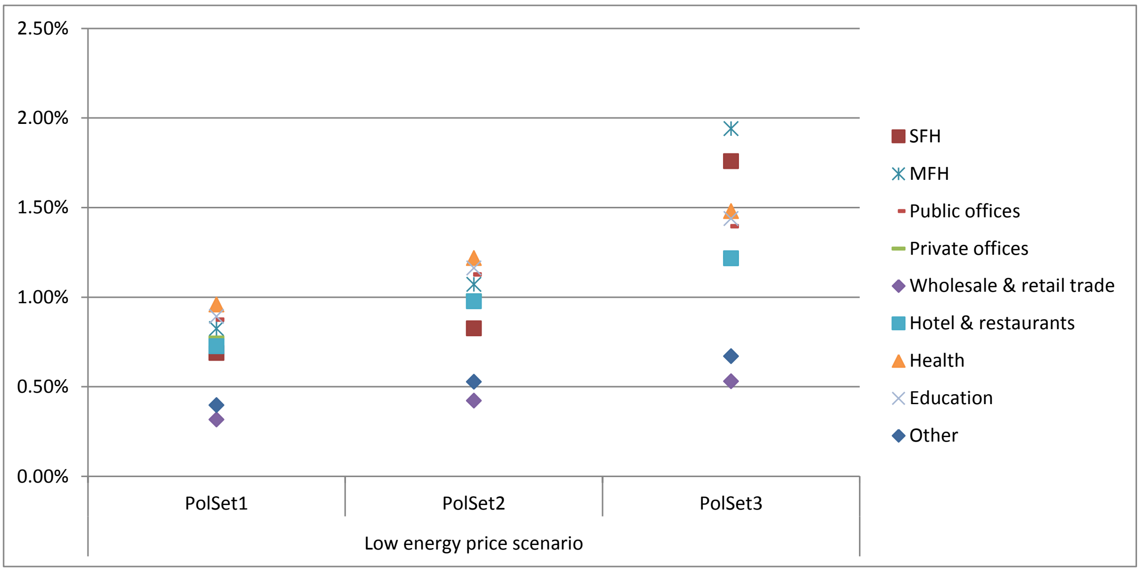


**Figure 10: Renovation rates under low energy price scenario**



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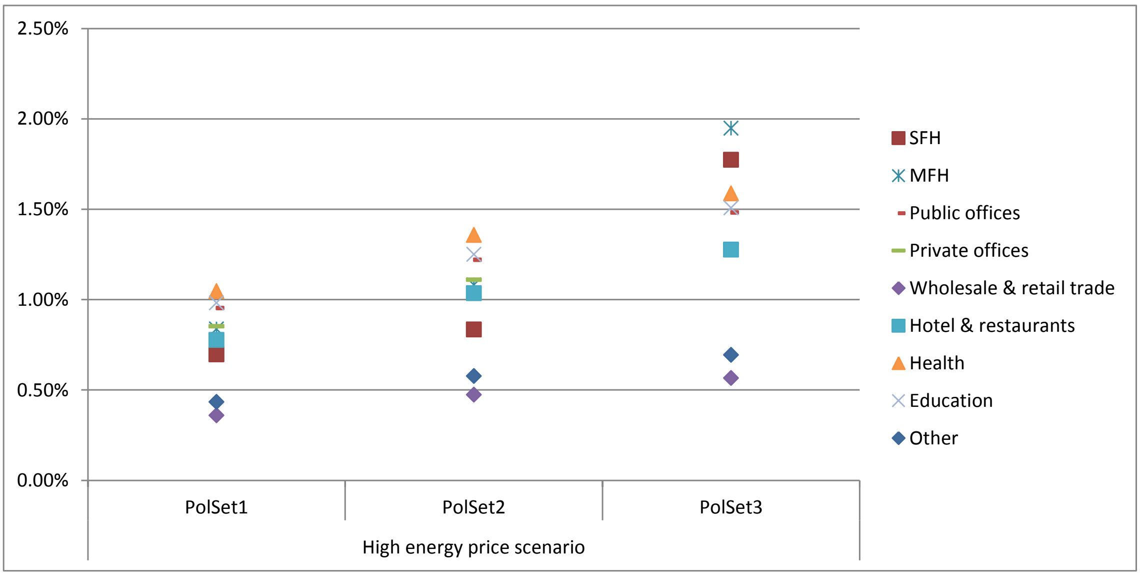


**Figure 11: Renovation rates under high energy price scenario**

Figure 10 and Figure 11 show the renovation rates considered for modelling for each type of building. It can be seen that more ambitious policy sets involve higher renovation rates in all categories. The differences between low and high energy price scenarios are small.

The renovation activities of the thermal envelope have been divided into three categories within the Invert model: standard, good and ambitious. The specific characteristics of these three renovation packages are shown in the annex 2 (A.2). As can be seen in the following four graphs, more ambitious policy instruments involve or lead to a higher share of buildings renovated according to the most ambitious renovation package. Thus, the energy saving will be higher. The least ambitious policy set (business as usual) involves a higher share of standard renovation for both, residential and non-residential buildings.

The high energy price scenario mainly shows the same trends than the low energy price scenarios. However, they involve a slightly stronger effect, which means slightly higher renovation rates.



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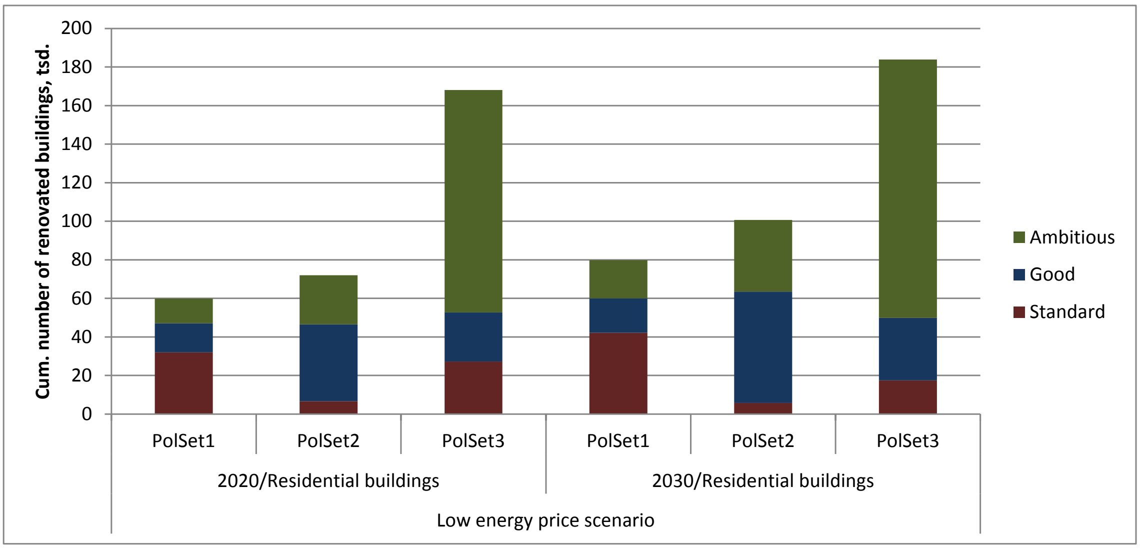


**Figure 12: Cumulative number of renovated residential buildings (low)**

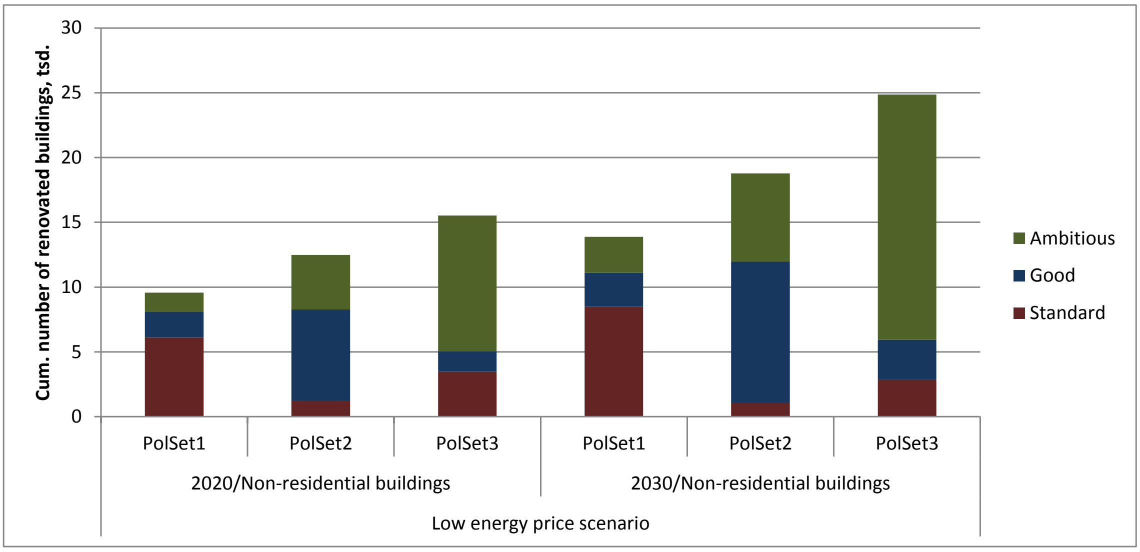


**Figure 13: Cumulative number of renovated non-residential buildings (low)**



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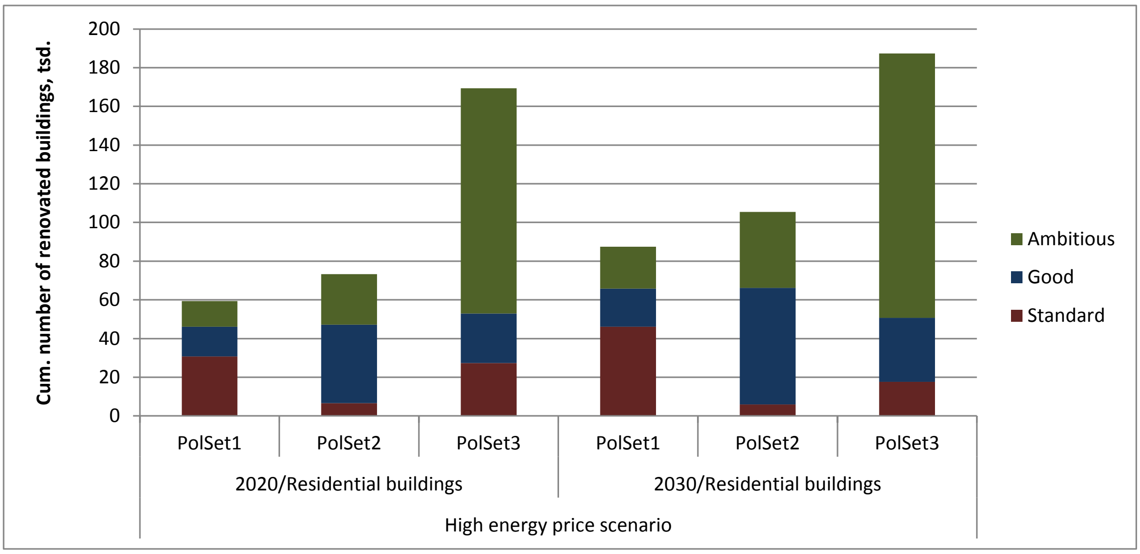


**Figure 14: Cumulative number of renovated residential buildings (high)**

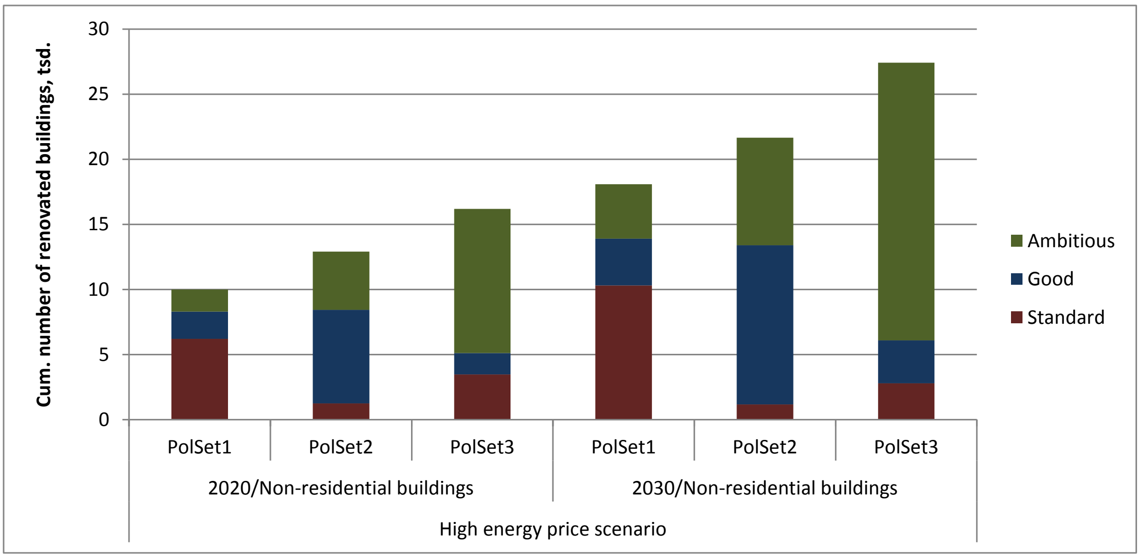


**Figure 15: Cumulative number of renovated non-residential buildings (high)**

## 4.3 Economic indicators, investments and public expenditures

The annual investment costs and public expenditures needed for the renovation of existing buildings will vary according to the energy reduction target fixed for Spain, which will involve more or less exigent policy instruments (see policy sets 1, 2 or 3).



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The following graphs show the investment costs and public expenditures needed for high energy price scenario. The investment costs and public expenditures have been divided into thermal/envelope renovation and RES-H systems.

As can be seen, the total investment carried out within the ambitious scenario represent a 60% higher regarding to policy set 2, however the energy saving involves an increase of 330% of annual running cost reduction (see figure 9).

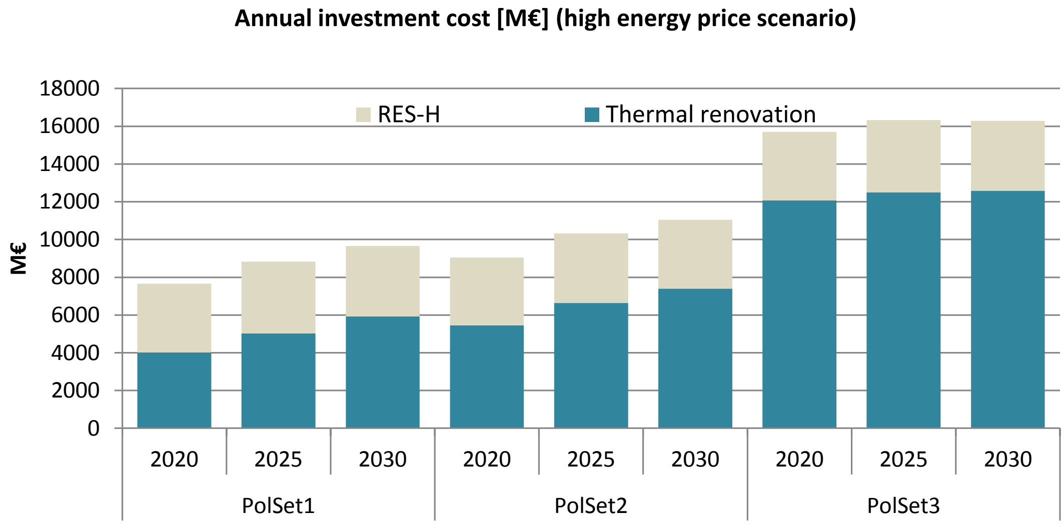


**Figure 16: Yearly investment (high energy price scenario)**

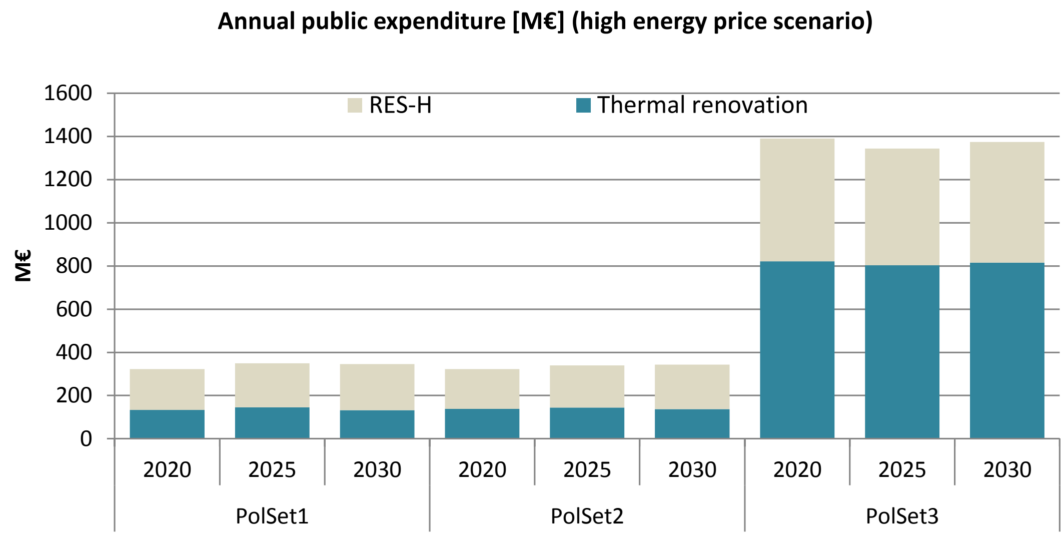


**Figure 17: Yearly public expenditure (high energy price scenario)**



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## 5. Recommendations to national policy makers

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

Based on the scenario calculations recommendations regarding a bundle of new and adapted instruments have been developed. The main instruments should always be accompanied by supporting instruments. Thus, the building related energy sector always needs policy bundles which 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 Figure 18. Due to the discussions with experts and policy makers, there seems to be a higher need for intensifying and improving building renovation activities.

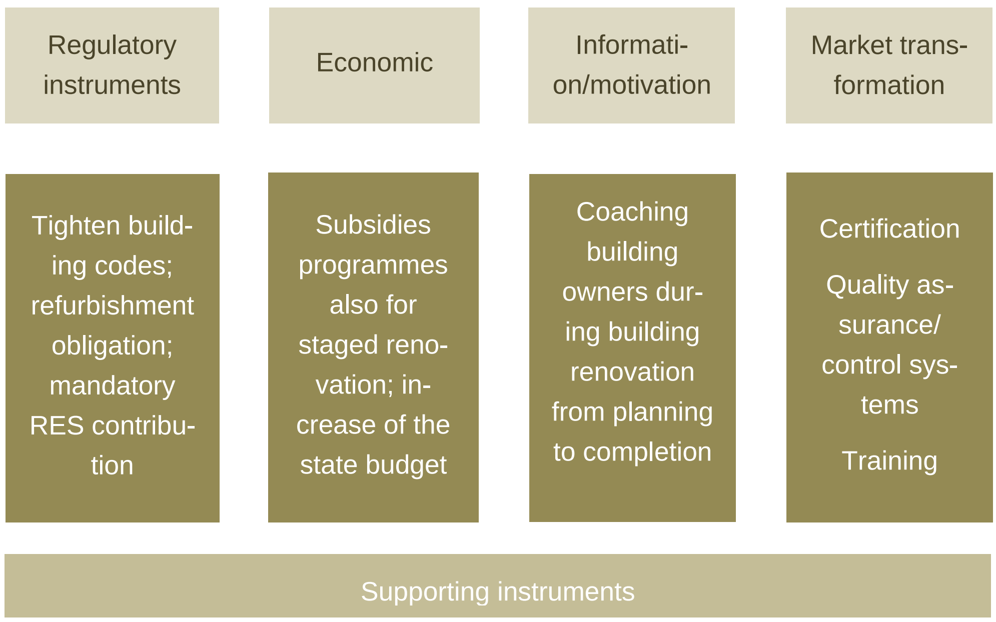


**Figure 18: Bundle of new, additional instruments recommended**



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In Spain there already are quite attractive subsidies for building renovation, still the major renovation rate remains very low. Additional financial incentives could help to trigger building renovation. Here it would be important to support not only major renovations but also staged renovations, as long as they reach ambitious energy efficiency standards.

The tightening of building codes, the implementation of refurbishment obligations and mandatory RES contribution can be effective instruments as well. The same is true for one-stop-shops for building renovation.

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 another approach to increase renovation activities. Another important field of action is quality assurance and compliance of existing regulatory instruments.

Additionally to the main instruments there are some supporting instruments. All recommended instruments are described below.

## 5.1 Regulatory instruments

**Building codes**

The current CTE HE-2013 is in line with the minimum requirement of energy efficiency associated to the cost-optimal analysis that has been submitted to the Commission by Spain. The purpose of this updating[7] has been to define the scenario which will form the basis for strengthening demands in a future version of the CTE up to the specific definition of nZEB for Spain.

CTE DB HE-2013 sets the minimum mandatory requirements according to tabulated values of energy need (heating and cooling) and primary energy consumption (kWh/m2year) for new residential buildings or building enlargements, maximizing the importance of building design as well as of the constructive elements used. However, in the case of major refurbishments the HE-2013 does not provide tabulated values about energy need and primary energy consumption. Thus, regarding existing buildings the minimum requirement is fixed according to a reference building which meets the minimum requirements of DB HE 2006. It means that the maximum energy need of the renovated building will be set by the energy need calculated for that reference building.

[7] The previous version of the Technical Building Code is Spain is from 2006

Besides, it is important to clarify that the requirement about refurbishment in existing buildings is only based on energy need, not on primary energy consumption as happens also for new buildings and enlargements.

The impact of this regulatory instrument has been modelled up to 2030 (policy set 1) and the final results are not too optimistic. An important conclusion from the results of the scenarios is that a more ambitious regulatory instrument is needed in order to achieve an ambitious target (policy set 3). The focus of future updating of CTE HE should be in tightening the requirements especially for existing buildings, since the current requirements for existing buildings are much more relaxed.

The main recommendation regarding Buildings Codes based on the scenarios and cost-optimal results is to tighten the minimum requirement for existing buildings in line with the cost-optimal analysis.

**Refurbishment obligation**

In Spain, the law 8/2013 on urban rehabilitation, regeneration and renovation, which was passed in June 2013, includes among others the following novelty: residential buildings older than fifty years must have a Building Assessment Report, which in addition to evaluating the state of conservation and accessibility includes an energy efficiency certificate.

Around 55% of Spanish building stock (13 million of dwellings) was built before 1980 (without any Building Code) and around 21%, 5 million dwellings are over fifty years. However, the law does not involve clear criteria for refurbishment obligation.

In order to achieve an ambitious target (policy set 3) of penetration of nZEB in the current building stock, an annual rate of building stock in poor conditions should be fixed for refurbishment obligation after the assessment report (e.g. based on age of components or low energy performance rates). The specific instrument is described in the following table:

**Table 4: Refurbishment obligations**

| **Refurbishment obligations** | |
|---|---|
| **Description** | Imposing a legal obligation to take a certain refurbishment or retrofitting measure, different situations may trigger the measures; triggers could be that a component has reached a particular age, that the building as a whole, a specific building component or element of the thermal supply systems does not meet a legally fixed minimum standard (which could e.g. be a minimum efficiency standard in the case of a whole building or a boiler or a maximum U-value that must not be exceeded) or the change of ownership of a building. |



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| | |
|---|---|
| | Additional design parameters of the instrument involve the development of the trigger or the minimum standards over the time (e.g. the U-value or efficiency level that trigger the obligation) but also potential compensatory measures, e.g. the possibility to pay a compensation charge in order to avoid the refurbishment obligation. |
| **Discussion** | In principle refurbishment obligations are highly effective in terms of achieving a specific target (e.g. a specific refurbishment rate). However, any form of refurbishment obligation interacts with principle ownership rights that are generally protected by the Member States' constitutions. The "harder" the obligation (especially in terms of the financial impact on the obliged home owner) the more extensive is the intervention with these ownership rights. There are at least four options to alleviate the effective burden from such regulations:<br>• the creation of exemption rules for cases of hardship;<br>• the introduction of the optional payment of a compensatory fee (which of course could also impose a high financial burden depending on the level of the fee);<br>• the establishment of sufficiently long periods in which building owners would have to comply with the requirements (which would allow them to identify the cost-optimal point in time to conduct the measure, e.g. by synchronising the measure with the renovation cycles of the building components);<br>• the establishment of a support program to which house-owners would have access when conducting measures that are triggered by the obligation (while the support program could partly be fed by the compensatory fee).<br>If the obligation is linked to the efficiency standard of the whole building, another drawback is the necessity to classify all buildings according to their status quo efficiency. This would require collecting a set of data on each existing building. Whereas the huge burden associated with this initial classification could be alleviated by grouping buildings into typical efficiency categories according to building type and age[8], there would be a trade-off with regard to the accuracy of the scheme.<br>Similar to building codes, enforcement would go along with a considerable administrative burden. |

8 Such classification has for instance been developed within the IEE Tabula project (http://www.building-typology.eu/).



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| | |
|---|---|
| **Example** | Some countries have adopted modest refurbishment requirements. For instance in Germany building owners must ensure that heat distribution and hot water pipes as well as fittings that are not situated in heated spaces are insulated; or that non-insulated top floor ceilings of heated spaces will be insulated. However we are not aware of any country that has implemented wide ranging unconditional refurbishment obligations especially affecting the larger structural elements of a building such as the outer wall or the roof. |

Source: D5.4

**Mandatory RES contribution**

Regarding RES mandatory contribution, the cost-optimal analysis for Spain shows a strong impact of PV installation in both, residential and tertiary sector (see D3.3 and D3.2). Thus, the nZEB definition for existing buildings should involve the integration of PV systems. In this way, the Spanish regulation should support this technology or at least, not penalize it.

## 5.2 Economic instruments

In Spain 1.600.000 dwellings are in poor or very poor condition and the present state budget for the refurbishment of existing buildings only allows the support of the renovation of 100.000 dwellings per year. This means that it will take 16 years to cover 1.600.000 dwellings. Hence, Spain needs other instruments that allow this transition.

In Spain there already are quite attractive subsidies for building renovation, still the renovation rate remains very low because the programmes involve major renovations, what involves an important initial investment. Thus, the low-rent sectors have difficulties to have access to subsidies anyway.

For this reason it would be recommended to adapt these programmes of subsidies and/or preferential loans for actions to be carried out in stages. In this way, the energy saving requirements to have access to economic incentives could be achieved in stages according to an agreed time schedule.

In Spain, the current tax incentive is based on a VAT reduction (from 21% to 10%) for residential buildings owners. However, this tax incentive is only linked to major renovations. That means it is anyway difficult for buildings owners (with low rents) to have access to the subsidies due to the high initial investment cost for the refurbishment.

Hence, for a stronger impact of this instrument in the projections up to 2030, it could be to allow stage refurbishment with meeting specific rates of energy saving.



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Policy set 3, which achieves the highest renovation rate, involves an increase (without limit) of the state budget for renovation subsidies. Hence, it can be taken into account in order to achieve ambitious targets.

## 5.3 Information, motivation and advice

Building owners are still very much uninformed on refurbishment issues. Although in recent years, caused by the economic crisis that involves an increasing fuel poverty rate, more social conscience in the heat supply sector has been developed.

Programs that aim at informing and motivating building owners to invest in refurbishment measures are important flanking measures. They are necessary to strengthen the impact in particular of financial support programs.

Advice programs are necessary to enable building owners to make well informed decisions about which measures to go for.

More projects or training/coaching campaigns with citizen's collaboration should be developed (e.g. RENOVE[9] project in Madrid).

There should be created more effective information campaigns about the plans for rehabilitation aid to the building's owners. It should be interesting also to simplify the access to funds and unify criteria between regional governments (CCAA).

Two interesting instruments which could be useful in Spain are described in the following table:

**Table 5: Instruments recommended within information/motivation context**

| **Combining financial support with mandatory advice** | |
|---|---|
| **Description** | The eligibility to a financial support program could be linked to the requirement to get energy advice. The idea behind this combination is to ensure that a) building owners select reasonable refurbishment measures and b) to ensure high quality measures. |
| **Discussion** | Combing financial support with advice is especially important in the case of buildings that are refurbished step by step. In this case advice is necessary to ensure that the different measures are coordinated even if |

[9] http://www.coam.org/portal/page?_pageid=33,54943,33_54980&_dad=portal&_schema=PORTAL&p_id=423)



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| | |
|---|---|
| | they are spread over a longer period (e.g. insulation of the roof in year 1, insulation of the outer wall in year 10). Furthermore in the case of deep renovations high quality is a key to ensure that the calculated savings can be achieved and no damage on the building (e.g. in form of moisture, mould) will occur. Also here linking support to advice should be a fundamental prerequisite. |
| **Example** | Within the German KfW support scheme investors have to provide evidence that in case of deep renovations planning work and supervision of the measure is carried out by an independent expert. |
| **Competence centres for energetic building refurbishment** | |
| **Description** | Establishment of local competence centres that are specialised in all topics concerning the energetic refurbishment of buildings. This would include technological measures, legal, economical and financing issues. The centre would provide an overview of support programs available for the specific refurbishment projects, in addition a positive list of local companies conducting such measures. |
| **Discussion** | The competence centres would ensure that the various stakeholders involved in refurbishment projects (e.g. investors, installers, refurbishment companies) would have one central contact and meeting point. The establishment of such centres could be supported by national, regional or local governments by a start-up funding. In the mid-term financing could come from those business sectors that benefit from increasing refurbishment activities. |
| **Example** | In many countries energy agencies take a rather similar role as described for the competence centres. However only few countries have a network of local energy agencies that operate all over the country. Often energy agencies cover a much broader spectrum of topics than just the refurbishment of the building stock. |

Source: D5.4

## 5.4 Capacity building, qualification and quality assurance

Badly performed refurbishment measures hamper the achievement of the expected energy savings and are thus having a negative impact on the economics of such projects. In addition this damages the confidence of home owners, which is a problem especially for those who are already hesitant to decide in favour of a building renovation. Moreover, assessors need to be trained and certified to enable them to conduct building energy efficiency audits to a high standard in terms of accuracy. Audits need to



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provide accurate and credible results, especially when they are used as a basis for financial support or loan applications.

The proper design of constructive and HVAC elements is highly important, as well as the proper implementation phase.

Several Spanish experts have agreed with establishing an effective control system in order to ensure the right implementation of the Technical Building Code, what is as important as the content of the Building Code itself. So far the Spanish control mechanisms are not sufficient enough to ensure the compliance of the TBC. It would be really interesting to create an effective surveillance system that allows control to all stakeholders (project designer, housing developer, builder and so on) in order to ensure the correct use of the TBC and the successful of energy efficiency measures implementation.



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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:



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



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- RES-H obligations

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 6: Definition of renovation packages (ESP)**

| | Roof | Wall | Base | Windows | Night cooling | Solar shading | Heat recovery |
|---|---|---|---|---|---|---|---|
| Residential | | | | | | | |
| Standard | 10 cm of thermal insulation | 10 cm of thermal insulation | 5 cm of thermal insulation | Double glass with air cavity (16mm), thermal transmittance value of glazing Ug= 2,7 W/m²K; g= 0,78; Tvis= 0,82, | no | yes | no |
| Good | 20 cm of thermal insulation | 15 cm of thermal insulation | 10 cm of thermal insulation | Double glass with air cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 2,7 W/m²K; g= 0,72; Tvis= 0,82, | no | yes | no |
| Ambitious | 30 cm of thermal insulation | 20 cm of thermal insulation | 15 cm of thermal insulation | Triple glass with argon cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,7 W/m²K; g= 0,72; Tvis= 0,82 | Automatised natural ventilation | Automation of solar shading devices | no |
| Non-residential | | | | | | | |
| Standard | 10 cm of thermal insulation | 10 cm of thermal insulation | 5 cm of thermal insulation | Double glass with air cavity (16mm), thermal transmittance value of glazing Ug= 2,7 W/m²K; g= 0,78; Tvis= 0,82, | no | no | no |
| Good | 20 cm of thermal insulation | 15 cm of thermal insulation | 10 cm of thermal insulation | 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, | no | Automation of solar shading devices | no |
| Ambitious | 30 cm of thermal insulation | 20 cm of thermal insulation | 15 cm of thermal insulation | Triple glass with argon cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,7 W/m²K; g= 0,72; Tvis= 0,82 | Automatised natural ventilation | Automation of solar shading devices | no |



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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](http://www.invert.at) or e.g. in (Kranzl et al., 2013) or (Müller, 2012).

The basic structure and concept is described in figure 19.

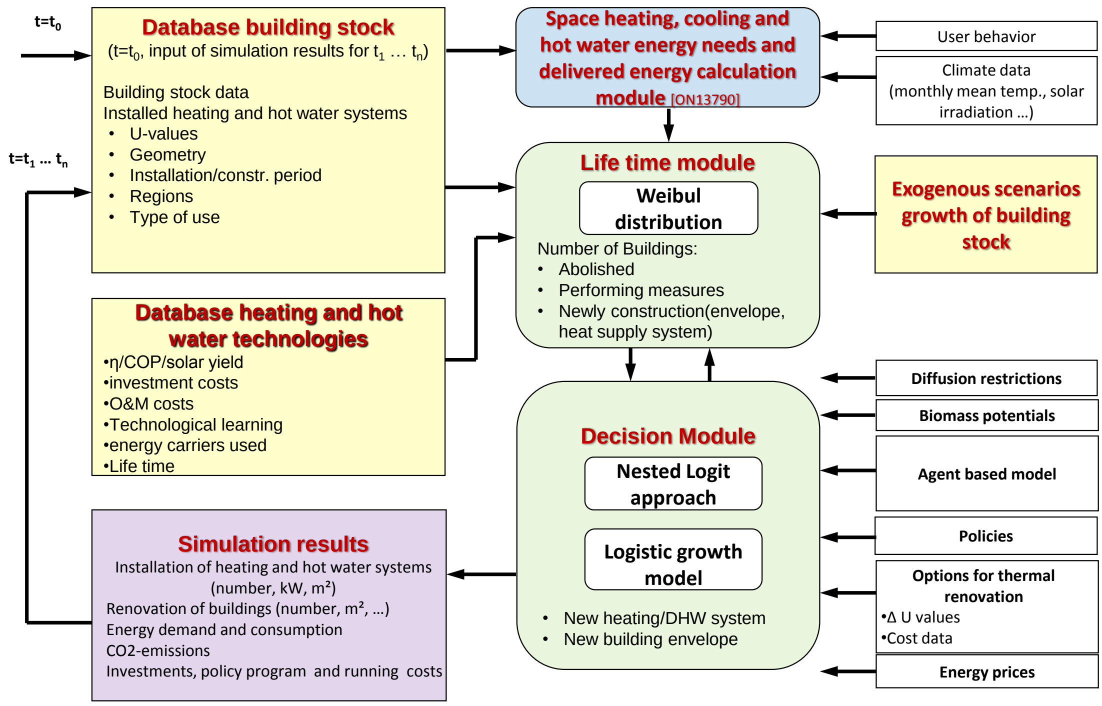


**Figure 19: Overview structure of Simulation-Tool Invert/EE-Lab**

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: models for saving public money). In more than 30 projects and studies for more than



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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 modelling 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](http://www.entranze.eu)).

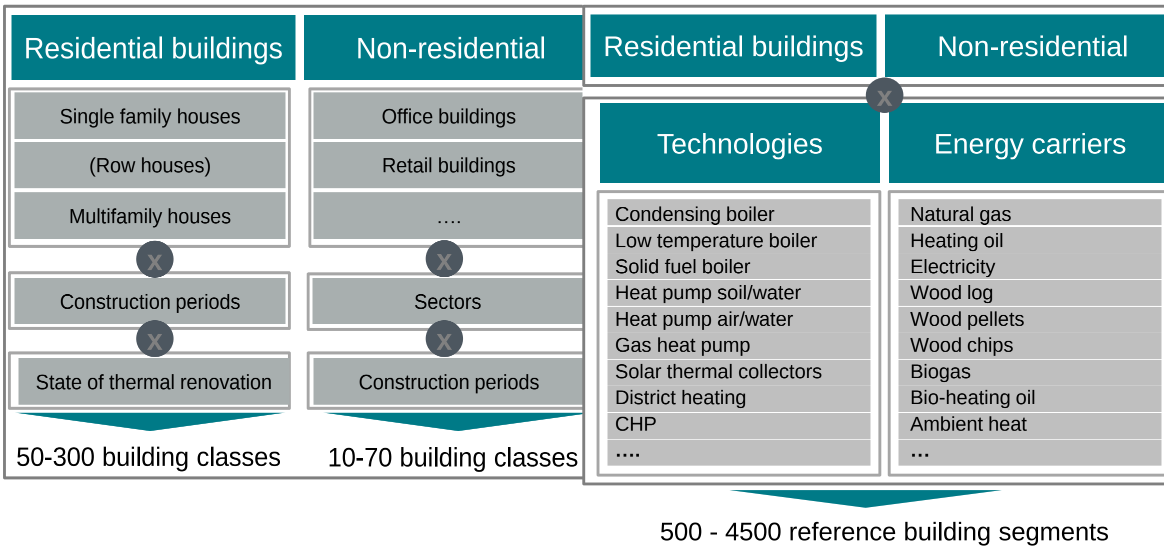


**Figure 20: Disaggregated modelling of the building stock within each country. Where relevant climatic zones are taken into account within a country.**

### 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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