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

D4.3 and D5.6 from Entranze Project

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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 Finland. 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

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

- Frozen scenario = currently agreed measures such as the Building Code, Ministry of Environment Decree 4/13) with the financial instrument financed from the state budget (including tax deductions) and informative measures and voluntary agreements
- Target-group specific policy package

The policy set focuses on two kinds of buildings: 1. single-family buildings with no district heat: shift from oil and electricity to ground-source heat and wood-based heating via new finance scheme and technology (cost) development (technology procurement). 2. apartment buildings: renovation to reduce energy demand by 50% for all buildings that are 35 years of age via tailored advice and new finance scheme. Technology procurement is also added here for heat recovery. Solar heat and power promotion by investment subsidy (15% of equipment cost). These policy measures have been added “on top of” the currently agreed measures.

- Economic instruments scenario

Energy taxation: price of energy (electricity, heat and fossil fuels) raised by 50 %

The following main findings have been identified: Finland has a slightly different situation than other European countries because the building stock is newer, the standard levels of insulation are higher and building automation is widespread. There is also a long history of systematic building maintenance even though the renovation culture is rather new. Therefore, cost and resource effective cheap solutions are more difficult to find for the Finnish situation than in other countries. However, the Finnish building stock is also getting older and measures need to be taken in Finland as well. Good opportunities can be found in the replacement of old oil and resistance electric heating with renewable energy sources, which is often cost and resource efficient. Finland does

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not have a practice of having renovation funds and the public sector should make sure that regulation or tax rules are not forming a barrier to anticipatory saving for renovations.

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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 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 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 Finland the policy group has met five times during the project. The meetings were held at the Ministry of the Environment in Helsinki in July and September 2012, in May 2013 and in May and September in 2014. The experts in the policy group meetings come from the environmental administration in Finland such as the Ministry of Environment: Juha-Pekka Maijala, Erkki Laitinen and Harri Hakaste, and the Finnish Environment Institute Pasi Tainio and Maija Mattinen, from the universities such as the University of Tampere, Juhani Heljo and Aalto University in Helsinki, Kai Siren. From RAKLI,the Finnish Association of Building Owners and Construction Clients Erkki Aalto and Petri Pylsy from the Finnish Real Estate Federation. The policy group was very interested in the project and the members shared the view that it was very good that Finland took part in the project. Similar modelling has been executed in Finland by one of the policy group members, which gave good comparison for the results of the ENTRANZE project.

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 policy group meetings together with relevant national stakeholders. Chapter 4 presents the resulting scenarios for the energy

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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). All results of the previous work have been discussed with the policy group members in up to four policy group meetings. 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)
	Decisions about refurbishment measures must be more or less

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	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 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:

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- **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 **Fehler! Verweisquelle konnte nicht gefunden werden.** lists the main indicators for the renovation packages taken into account for the modelling and scenario development.

Table 2: Definition of renovation packages

	Roof	Wall	Base	Windows	Night cooling	Solar shading	Heat recovery
Residen-tial							
Standard	15 cm of thermal insula-tion	10 cm of thermal insula-tion	5 cm of thermal insula-tion	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	no	no
Good	20 cm of thermal insula-tion	15 cm of thermal insula-tion	10 cm of thermal insula-tion	Triple glass with argon cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,0 W/m²K; g= 0,64; Tvis= 0,74, t	no	no	yes
Ambiti-ous	30 cm of thermal insula-tion	20 cm of thermal insula-tion	15 cm of thermal insula-tion	Triple glass with argon cavity (16mm) and a low-e glass, thermal transmittance value of glazing Ug= 1,0 W/m²K; g= 0,64; Tvis= 0,74,	no	yes	yes
Non-residen-tial							
Standard	10 cm of thermal insulati-on	10 cm of thermal insulati-on	5 cm of thermal insulati-on	Double glass with air cavity (16mm), thermal transmit-tance value of glazing Ug= 1,7 W/m²K; g= 0,78; Tvis= 0,82,	no	no	no
Good	15 cm of thermal insulati-on	10 cm of thermal insulati-on	5 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,	no	yes	yes
Ambiti-ous	20 cm of thermal insulati-on	15 cm of thermal insulati-on	10 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,	yes	yes	yes

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 model Invert/EE-Lab. In order to build on sound scenarios which are consistent with overall energy scenarios, a soft link to the model POLES has been established. POLES developed scenarios for the overall development of the global energy system. The energy price scenarios which are an endogenous result from POLES are used in Invert/EE-Lab as an input, as well as the corresponding primary energy factors and CO2-emission factors of electricity. On the other hand, the results of the model Invert/EE-Lab are checked with POLES regarding the potential feedback loop on energy prices. Two energy price scenarios are applied in the Invert/EE-Lab simulations: (1) a reference price scenario and (2) a price scenario based on an ambitious CO2-mitigation pathway.

All prices of fossil fuels (oil, gas and coal[1]) indicated in this chapter are final consumer prices (tax included[2]). In Poles, prices are modelled on the basis of changes in international prices and taking into account taxes (excise tax[3], VAT) and a carbon price.

2.3.1 International prices

Over the period 2010-2030, prices are expected to increase for oil, gas and coal, by up to at least 1.7%/year for oil (Figure 6). Trend variations are significantly stronger in the reference scenario compared to the ambitious one. More details are available below by type of fuel for both scenarios.

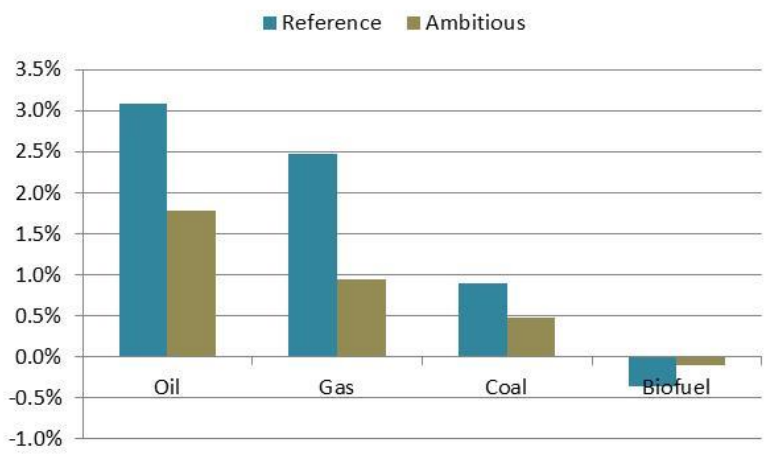

Figure 1: Annual growth rate of international energy price over 2010-2030

Source: POLES-Enerdata

[1] The district heating price is not considered in the POLES model. .

[2] Including VAT.

[3] Including existing energy & environmental taxes.

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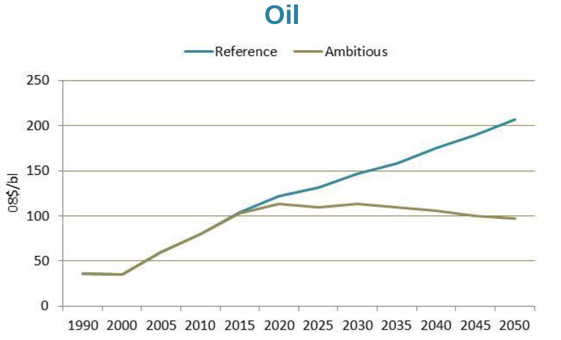
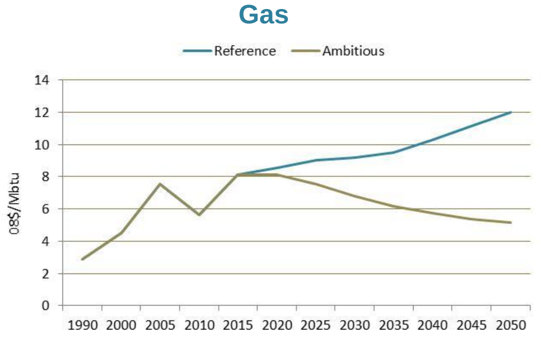
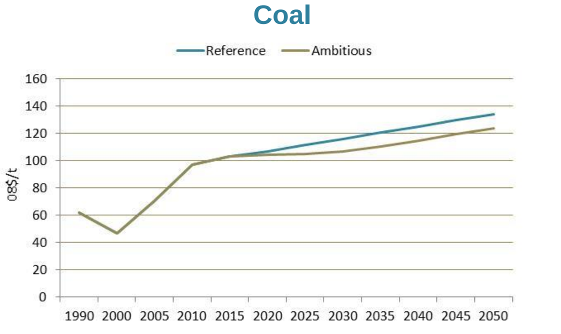


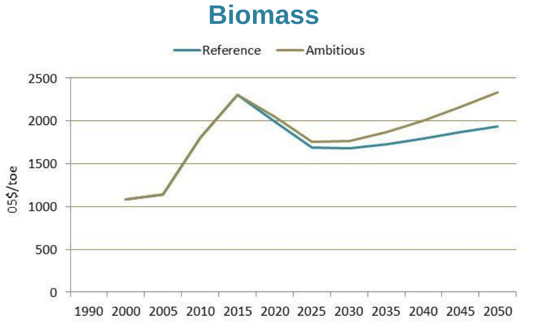
In the reference scenario, from 2000 until 2020, oil price is expected to increase at a strong steady pace of 6.5%/year (Figure 7). Then from 2025, oil price will increase less rapidly by 2%/year on average until 2050. In the ambitious scenario, oil price is following a different trend: until 2020, it increases by 3.6%/year and remains quite steady until 2030, at a price level of around 115$/bl, to fall down below 100$/bl in 2050. As the oil demand is decreasing in the ambitious scenario, and as at the same time the resource is becoming less abundant, oil price is maintained at a steady level from 2020.



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 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 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 (Figure 9). The price is expected to increase in both scenario: the decreasing price effect due to the decrease of demand is counter balanced by the fact that production costs will increase with income in producing regions.



Until 2015, i.e. in the short-term, the biomass price is expected to increase significantly by 5%/year for both scenarios: there is indeed a strong dynamic in the first coming years in biofuel demand (emerging market in all sectors (energy, transport and domestic uses), Figure 10). Then, thanks to market autoregulation, the price will decrease by roughly 2%/year until 2025. It will remain steady until 2030, and will again increase steadily until 2050 because of a strong substitution towards biofuels that will become the high mitigation option, i.e. low carbon emission.

Figure 2: European energy price forecasts until 2050

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2.3.2 Residential domestic prices[4]

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 5.9% and 7.9%/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 (3.1% and 3.3%/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 10.6%/year, and to a lesser extent in the reference scenario by 3.8%/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 2.5%/year in the ambitious/high price scenario and by 1.4%/year in the reference/low price scenario. The electricity price is expected to peak in 2030 at around 2 800 $05/toe (33 $/kWh)[5] in the ambitious/high price scenario and at 2 200 $5/toe (27 $05/kWh) in the reference/low price scenario.

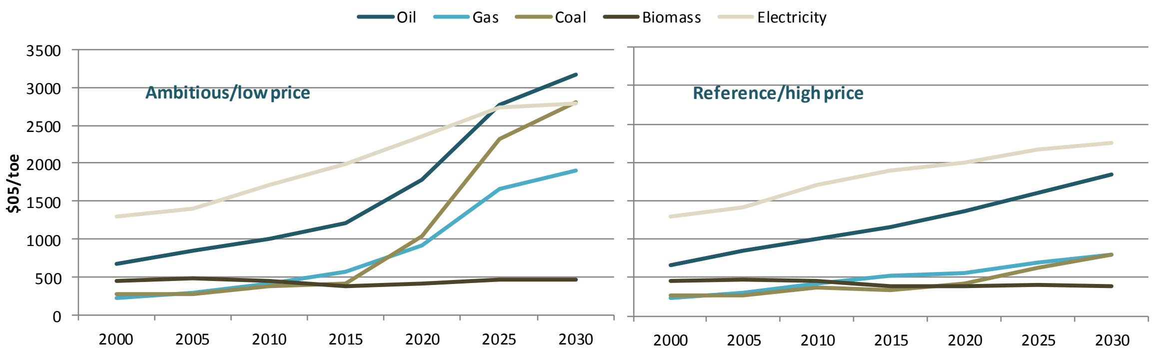

Figure 3: Finnish residential energy price scenarios by energy carrier

Source: POLES-Enerdata

2.4 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

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

5 In 2005 prices and exchange rates.

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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.

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

Figure 5 gives 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).

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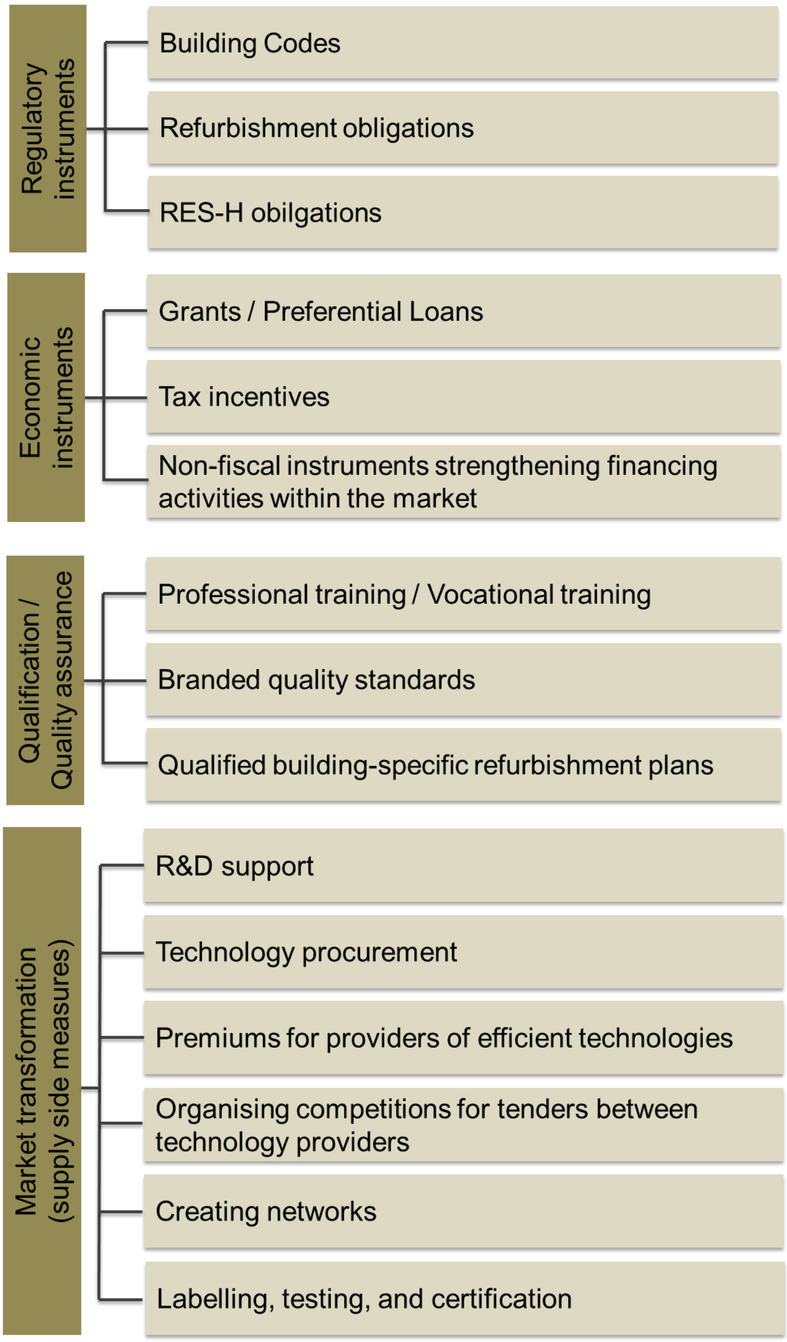

Figure 4: Categories of policy instruments (part 1)

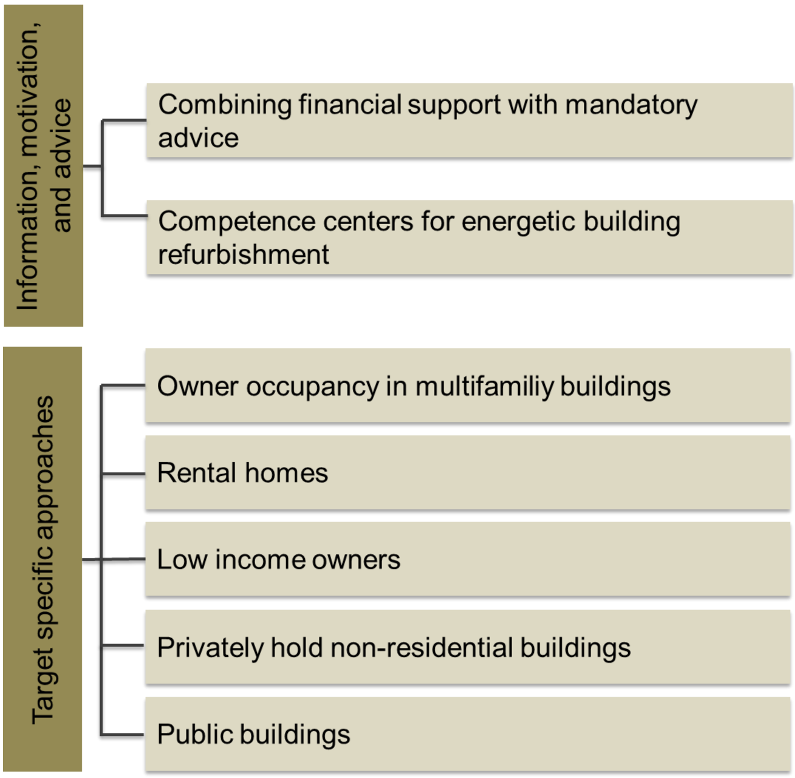

Figure 5: Categories of policy instruments (part 2)

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:

- 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 sys-

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tem 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 intervention 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).

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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:

Policy set 1 Frozen scenario	**Policy set 2** Target group specific policy package	**Policy set 3** Energy taxation
Frozen regulatory scenario (Building Code, Ministry of Environment Decree 4/13) + Frozen scenario of financial instrument financed from the state budget (including tax deductions) + Frozen scenario for informative measures and voluntary agreements	Frozen regulatory scenario (Building Code, Ministry of Environment Decree 4/13) + Frozen scenario of financial instrument financed from the state budget (including tax deductions) + Frozen scenario for informative measures and voluntary agreements + Single-family homes: shift from oil and electricity to ground-source heat and wood-based heating via new finance scheme and technology (cost) development (technology procurement) + Apartment buildings (and service buildings): renovation to reduce energy demand by 50% for all buildings that are 35 years of age via tailored advice and new finance scheme. Technology procurement is also added here for heat recovery	Frozen regulatory scenario (Building Code, Ministry of Environment Decree 4/13) + Frozen scenario of financial instrument financed from the state budget (including tax deductions) + Frozen scenario for informative measures and voluntary agreements + Energy taxation: price of energy (electricity, heat and fossil fuels) raised by 20,50 & 100%

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	+ Solar heat and power promotion by investment subsidy (15% of equipment cost)	

The policy sets for Finland were initially agreed on at the Policy Group meeting on May 14th, 2013 and subsequently modified somewhat on the basis of the Interim Workshop organized on Oct 1st, 2013. The justifications for these scenarios are as follows:

Regulatory energy efficiency requirements for renovations have been just recently introduced in the Building Code (2012), and there is as yet limited experience of how they work. Policy makers and stakeholders would like to obtain more experience before exploring regulatory instruments further. Moreover, there is an overall need to investigate and revise the legal basis of ordinances in the Building Code, which is a broader legislative issue pertaining to the competences of the Ministry of Environment.

The notion of target group–specific instruments introduced in D5.4 is the starting point for scenario 2, which focuses on two core target groups in Finland: single-family home owners and owners of apartment buildings. These entail different cost-effective opportunities and have different cost implications for policy implementation. Several studies have indicated that heating system changes are cost-effective where oil or electricity are used for heating, which is still the case in majority of single-family homes. This is hence a starting point that offers significant CO_2 emission reductions at low life-cycle costs for the owner. A particular problem is the large share of buildings lacking a (water-based) central heating system, where there is a need to bring down the costs (and ease and risks) of installing e.g. radiator or radiant floor heating.

In the case of apartment buildings and service buildings, most of these are connected to district heat (which is relatively cheap/kWh, due to widespread use of combined heat and power production). On the other hand, due to the smaller number and larger size of such buildings, there are more opportunities for tailored advice. The original suggestion was to have building inspectors offer this advice, but the MoE said this would not be possible since these people are overloaded as it is and municipal budgets are heavily strained (due to the financial crisis, state contributions to municipal budgets are e.g. this year cut by one-fifth).

In contrast, direct financial support for building owners has traditionally been low and it is perceived to involve significant administrative cost and feared to potentially distort the market. Moreover, there is simply no possibility to increase state contributions to households since state budgets are currently heavily constrained. Thus, there is a

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preference for private finance-based support from outside the state budget, e.g. along the lines suggested in D5.4[6].

There has traditionally been a high preference for financial instruments which are believed to be cost-effective. Finland has applied energy and CO_2 taxes for decades, and the trend has been to increase such taxes and to reduce income tax in order to support employment. Hence, tax increases for energy are suggested in scenario 3.

4. Model results

Figure 7 below shows the modelling results for the scenarios 2 and 3 in a low energy price scenario as well as in a high energy price scenario in 2020 and 2030. Scenario 2 was identified as leading to reduced energy consumption vis-à-vis existing policy development. This scenario included (a) timely and personal advice for multifamily buildings from the age of 35 years, (b) finance covering the costs of the renovations so that annual costs after the renovation do not increase, (c) R&D programmes to overcome the most pressing cost barriers and (d) a small subsidy for solar power and solar thermal systems installation.

By 2030, Scenario 2 is the most effective scenario for reducing total energy demand and increasing RES H/C (see Figure 7 below). Scenario 3, focusing on financial measures – i.e., a tax that raises the price of electricity, heating oil and district heat by 50% by 2030 – is relatively effective, but it is unrealistic to implement. The modelling reveals that this kind of tax might lead to a significant increase in biomass heating in single-family homes (see Figure 7), which is not considered desirable in urban areas in Finland. Hence, such a measure needs to be accompanied by other measures to ensure that unwanted side-effects are avoided.

The reduction in the consumption of oil and coal is the most dramatic: the reduction of oil with the policy set 2 by 2030 compared with scenario 1 (BAU) is over 90 % in both low and high energy price scenario, of coal over 60 %. The highest increase takes place in solar thermal energy (>300%) and in ambient energy (>150%).

[6] e.g. Energy saving obligation, quota system for RES-H, bonus/premium scheme, contracting type of instruments, bank obligation to grant interest reduced loans; for details see D5.4

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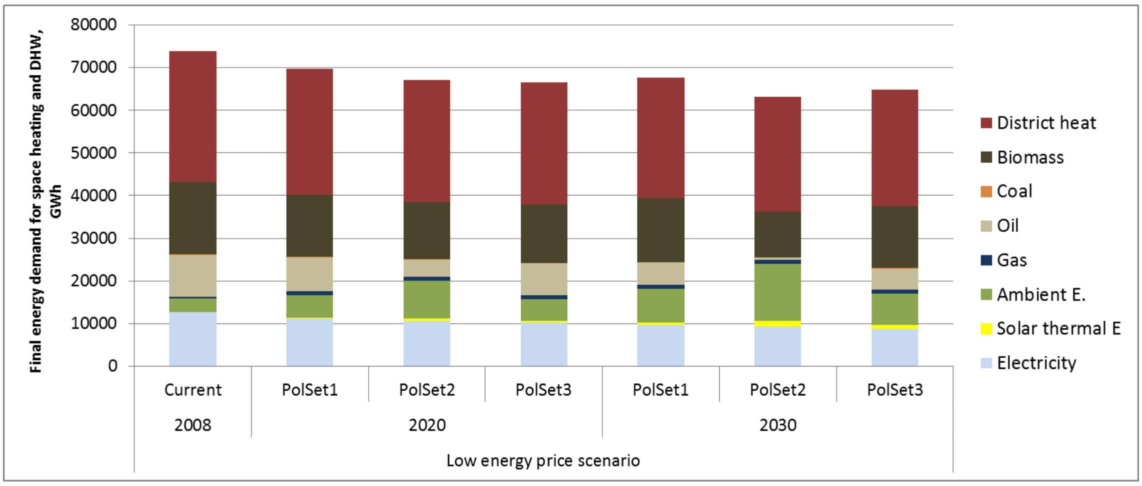

Figure 7: Categories of policy instruments (part 2)

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5. Recommendations to national policy makers

While Finland has many of the same barriers to renovation as other European countries, there are some differences that can be relevant. The building stock is newer than in most other European countries. Moreover, Finland was among the first countries introducing stricter building codes with respect to required U-values and energy performance of buildings. Because of this, standard levels of insulation are higher, and especially the U-values of windows are on average significantly higher than in the European building stock. Moreover, building automation such as thermostatic radiator valves are widespread, as are energy efficient systems for domestic hot water distribution.

Moreover, some cheap, cost effective and resource efficient heating systems are more widespread than elsewhere in Europe. These include district heating, which for example in the metropolitan area only costs 6 cents/kWh in the winter due to the use of combined heat and power production. Outside the district heating network, heat pumps have been rapidly spreading in recent years.

Systematic building maintenance (including advanced controls) and renovation has been on the agenda for decades, promoted by tools and voluntary standards such as those distributed by the Building Information Foundation, RTS (RT cards and the KIPI cards). There are also some benefits in the way Finnish condominiums (housing companies) are organized, which make decision-making and the financing of renovations easier. Moreover, the landlord-tenant dilemma is – as a rule – not present in Finland, since landlords cover the heating costs. Because of this, and the more professional approach to life-cycle costing of large landlords, experts agree that rental housing is actually more regularly renovated than owner-occupied housing (which is in contrast to the situation in many other European countries).

Due to these Finnish idiosyncratic features, there are as a rule fewer cost-effective options for energy renovations than in other countries. However, there are also some specific barriers and opportunities with regard to policy intervention:

- Resistance electric heating and oil heating are still widespread in single-family homes, whereas the replacement of these heating systems with renewable energy sources is usually cost-effective. However, for resistance electric heating, there is a considerable economic and non-economic barrier to switch to central heating systems, which is more or less a precondition for modern renewable and efficient heating systems.
- Renovation costs are normally higher in Finland than in other countries, what suggests the need to develop cost-effective solutions for particular circumstances, such as the installation of water-based central heating in single-family homes without one, or the need to develop cost-effective solutions for exhaust

air heat recovery for buildings connected to the district heating system. The renovation culture is fairly new (since the building stock is relatively new), and there is a need to develop the operating procedures and productivity of the sector.

- There are good tools for systematic maintenance and renovation, but there is still a need to ensure that they are adopted. Small scale building owners (housing companies, owner-occupants of single-family homes) do not have the resources or competencies to use them. Moreover, in some housing companies, residents might not be able to afford the loan repayments after a renovation, and may even have to move out, in the worst case. Moreover, while renovation funds are possible, they are not so widely used as in e.g. Germany and Austria. The public sector should make sure that regulation or tax rules are at least not forming a barrier to anticipatory saving for renovations via renovation funds.
- Specific barriers are present in areas with declining populations. Here, the value of the building might be too low to merit the costs of renovation. Specific strategies should be drawn up for such buildings and areas, and the problem could be also to some extent mitigated through better information systems in the real estate market. Issues pertaining to demographic change and the ageing population need to be taken into consideration when devising policies to promote near-zero energy renovations.
- The overall policy strategy is to link energy renovations and heating system renewal to systematic renovation planning. Policy makers do not want to promote the hasty adoption of solutions without careful consideration of what is sensible in the long term. However, there is still room for innovation, and this has been taken into account by moving to performance-based energy standards in the Building Code.

The Finnish recommendations have been developed with consideration for these particular circumstances outlined above. They also take into account the overall Finnish policy of downsizing public budgets on the state and municipal level, as well as an overall drive for deregulation and reduced state intervention. Hence, no new regulation has been proposed, since the energy standards for existing buildings were only just recently published, and the relevant authorities want to gain some experience of them before any new reforms.

The recommendations have also been developed with consideration for the results of the scenario modelling. Here, scenario 2 was identified as leading to reduced energy consumption vis-à-vis existing policy development. This scenario included the following additional measures vis-à-vis the existing policies (a) timely and personal advice for owners of multifamily buildings when they reach the age of 35 years, (b) finance that covers the costs of the renovations so that annual costs after the renovation do not

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increase and (c) R&D programmes to overcome the most pressing cost barriers, as well as (d) a small subsidy for solar power and solar thermal systems installation.

By 2030, Scenario 2 was identified as the most effective scenario for reducing total energy demand and increasing RES H/C in accordance with Finland's Renewable Energy Action Plan. It was also identified as having the potential to contribute to reducing carbon dioxide emissions in sectors outside the EU ETS (oil heating), as well as to the National Climate and Energy Strategy (2013) programme to reduce the use of mineral oil.

Scenario 3, which focused on financial measures – i.e., a tax that raises the price of electricity, heating oil and district heat by 50% by 2030 – was also found to be relatively effective according to the scenario modelling, but unrealistic to implement. The modelling also revealed that this kind of tax might lead to a significant increase in biomass heating in single-family homes (especially homes with direct electric heating and room-based wood heating systems), which is not considered desirable in urban areas in Finland. Hence, such a measure should be accompanied by other measures to ensure that unwanted side-effects are avoided. On the other hand, if the same measure would be implemented with a lower tax level, it would strongly reduce the effect, since relatively strong energy price signals are necessary in the building sector to incentivize effective renovation measures. This has been shown for other countries (in particular for France) in the project ENTRANZE.

The lack of timely knowledge about appropriate solutions is a barrier for residential buildings. Many Finnish multifamily buildings are now approaching the age for major renovations. This is an opportunity to integrate ambitious measures to cut energy consumption and increase renewable heating and cooling, where appropriate. Owner-occupied multifamily buildings are seen as being in greater need of advice than professionally owned rental residential buildings, commercial buildings and public buildings, which are already today more likely to apply systematic renovation planning and budgeting. For single-family buildings, knowledge and advice need to be delivered via mass communications, but awareness can be enhanced via personal networks:

- **It is recommended that owner-occupied multifamily apartment buildings that are due for major renovations are identified in each municipality (e.g., buildings that are 35 years of age), using the building registry, and tailored on-site advice is provided to them.** The board of the housing company owning the building should receive a personal letter offering expert advice free of charge, for example to be presented at the annual resident's meeting ("yhtiökokous"). It would be ideal if this advice could be offered by the municipal building inspectors, but the view of the Ministry of Environment is that they are under such severe strain already with current tasks, so they cannot be given any new responsibilities. However, Motiva is coordinating a nation-wide programme for local energy advice, and this could be an opportunity to pilot and potentially upscale such tailored “opportunistic” advice services (see Darby 2006) that address building owners at the exact right time.

- **It is recommended that local energy advice services target heating systems replacements as a special topic for single-family homes and make use of best practices and local networks to reach greater numbers of homeowners with tailored and personal advice.** In the case of single-family homes, personal advice is more expensive to deliver, and hence the provision of unsolicited (“opportunistic”) advice at a particular time is not likely to be feasible. Moreover, as was found in Heiskanen et al. (2012), single-family homeowners tend to conduct renovations in a more piecemeal fashion, and there is less likely to be a “moment” for major renovation. However, there are particular times when advice can be effective. One such time is when a single-family house is sold.
- **It is recommended that real-estate agents or banks offering credit consider their role as transforming more into door-openers for energy advice services.** They also play an important role in identifying how particular heating systems influence the value and sales time of a building. Online advice can also be made more usable for single-family homeowners, and for example, the Finnish House Owners’ Association can help to upscale the “Open Homes” peer-to-peer activities which are already ongoing among their local member associations in the Carbon-Neutral Municipalities. Local banks can also be a place to offer personal advice, as has been the case in some instances in the Carbon-Neutral Municipalities.

Finance is a barrier, since many measures related to the building envelope have long payback periods. Finance can also be a problem for measures like heating system replacements, with shorter payback periods but greater perceived relative transaction costs for single-family homeowners.

- **Hence, it is recommended that systems of private finance are developed where building owners can make energy renovations and obtain new heating systems without increasing their cost of living.** This requires long loan periods, which match the lifetime of the building systems being replaced. It is also recommended to negotiate with banks to bring to the market unsecured loans for new heating systems for single-family homes (such loans are already provided by one local bank). The availability of such finance could be promoted by systems for the verification of savings, which should be developed.

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Costs are a barrier, partly because Finland is a small and sparsely populated country, but also because so many buildings are only now approaching their first major renovation. Enhanced information systems, such as open data on building properties and blueprints, as well as the Energy Label registry, could be used to develop tools for building owners and service providers to find each other more easily.

- **It is recommended to start development projects to leverage the possibilities of open building data to reduce the costs of renovation planning.** The cost of renovations can also be reduced via R&D programmes and e.g. procurement competitions like such as the EEMontti competition organized by Sitra (see http://www.greennetfinland.fi/en/index.php/EEMontti).
- **It is recommended to make a careful survey of all specific areas where cost-effective solutions are needed and launch relevant R&D programmes and/or procurement competitions to find such solutions.** Examples of solutions needed include low-cost solutions for installing ground-source heat pumps, or in general central heating systems in single-family homes. The scenario modelling indicates that Finland's REAP target of producing 8 TWh of renewable energy with heat pumps by 2020 might not be reached unless such solutions are developed. Finnish experts have also identified the need to develop cost-effective solutions for exhaust air heat recovery for buildings heated with district heat. There are likely to be other similar special cases where targeted R&D could reduce costs.

Solar heat and power are less widespread in Finland than in other countries, including countries that have comparable temperatures and insolation levels. Because of this, it is recommended that short-term investment subsidies for building owners are directed toward these technologies in order to open up the market, give their diffusion a boost, and start the learning process in installation services which will eventually bring down installation costs.

Some other recommendations arose from the discussions in the Finnish Policy Group. Energy renovation should be considered in the context of overall renovation. Hence, a broader vision of the future of the building stock (and the individual building types and locations) is needed. This is relevant both on the national and regional level and for individual buildings. Energy renovation is one part of good management of the building stock.

Future policies concerning energy efficiency in buildings should also take into account maintenance, operations and use of the building. Examples of measures that can have large effects are regular balancing of the heat distribution system and control of ventilation. Moreover, use of the building can also pertain to intensity of use. When only the specific energy efficiency (per m^2) is considered, issues pertaining to square meters per person are not taken into account, although these might have a large impact, and

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could be improved e.g. in office buildings or public buildings. This should be taken into account in future research and policy development.

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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 Documentation of the model Invert/EE-Lab

In addition to the short overview of the model Invert/EE-Lab in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**, 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.**.

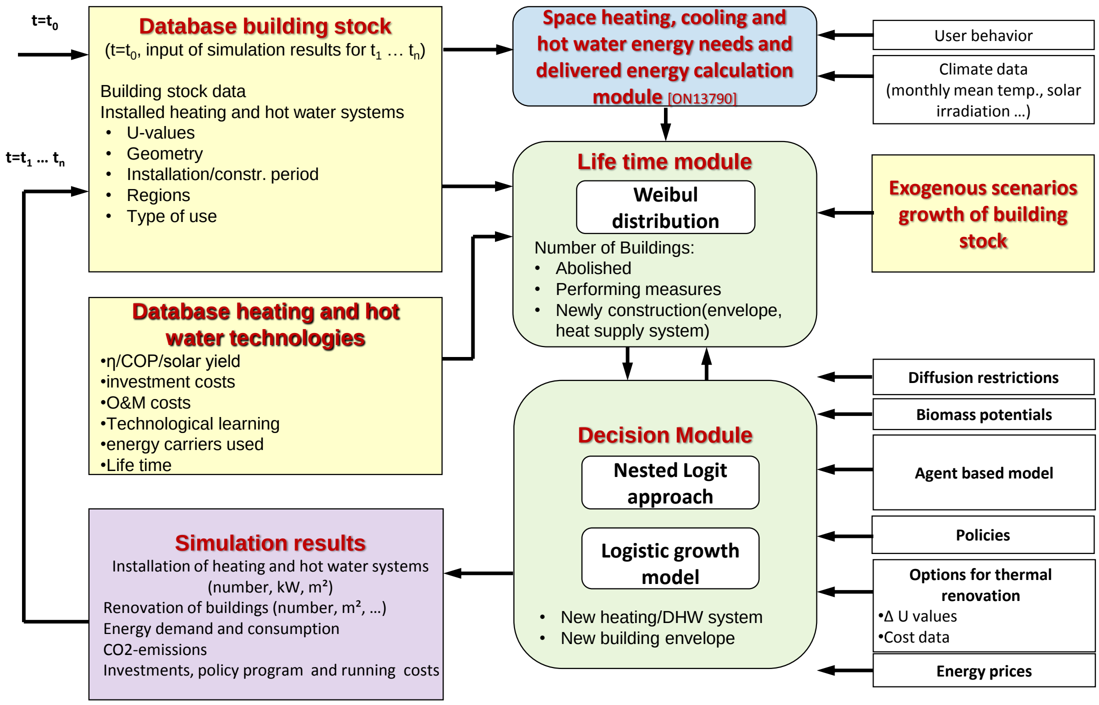

Figure 6: Overview structure of Simulation-Tool Invert/EE-Lab

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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 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).

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).

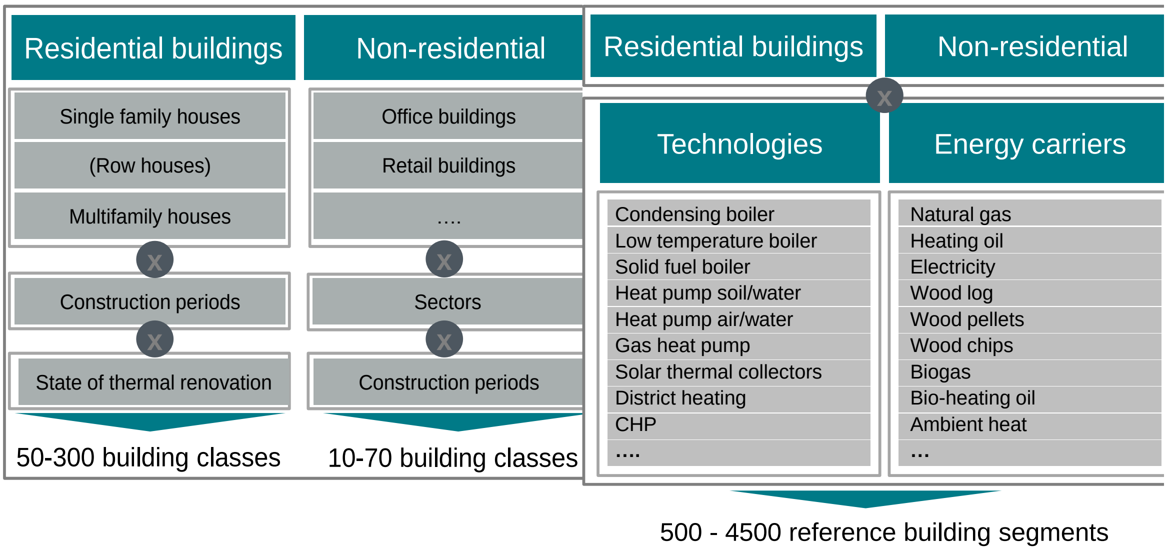

Figure 7: Disaggregated modeling of the building stock within each country. Where relevant climatic zones are taken into account within a country.

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€)

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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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