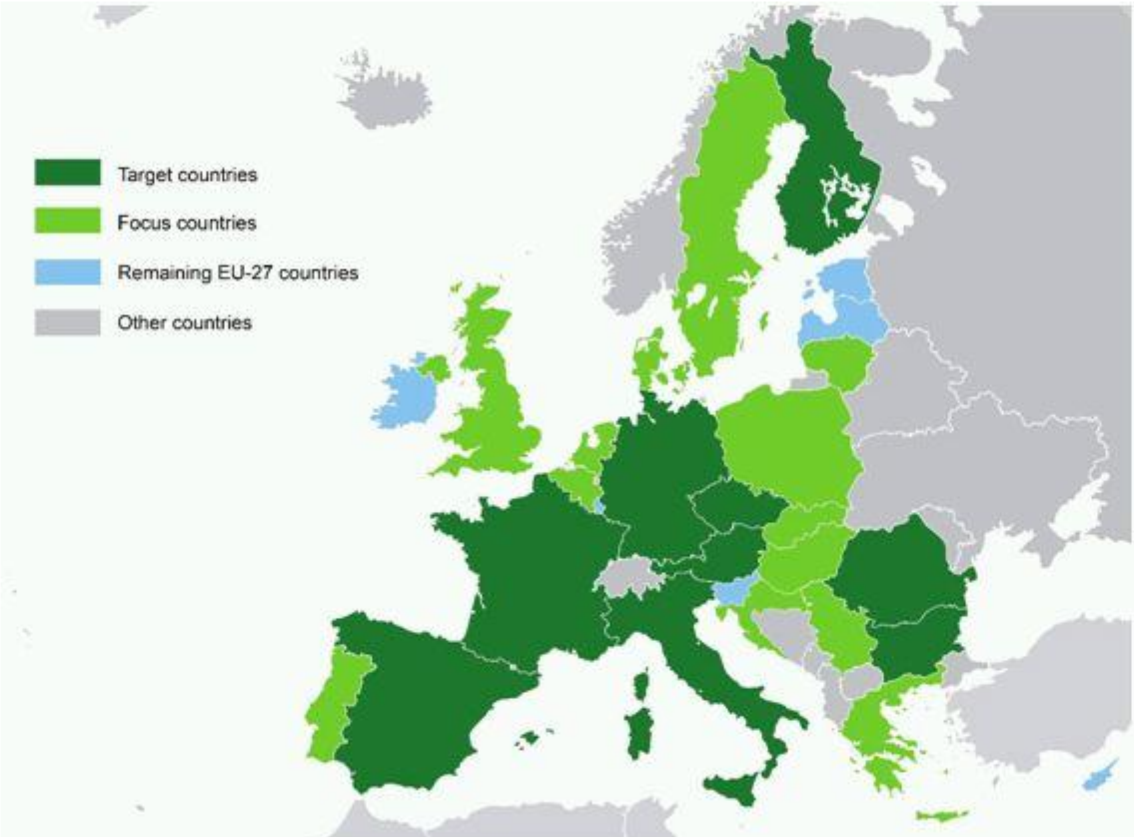
Report on specific features of public and social acceptance and perception of nearly zero-energy buildings and renewable heating and cooling in Europe with a specific focus on the target countries

D2.6. of WP2 of the Entranze Project



Written by:

Eva Heiskanen, Kaisa Matschoss, Helka Kuusi, National Consumer Research Centre

With contributions from:

Lukas Kranzl, Energy Economics Group, Institute of Energy Systems and Electrical Drives at Vienna University of Technology

Bruno Lapillone, Carine Sebi, Nicolas Mairet, Enerdata

Petr Zahradník, SEVEn, The Energy Efficiency Center

Bogdan Atanasiu, Buildings Performance Institue Europe, BPIE

Paolo Zangheri, end use Efficiency Research Group, Politecnico di Milano

Zravko Georgiev, Sofena, Sofia Energy Agency

Ines Diaz Regodon, Maria Fernandez Boneta CENER, National Renewable Energy Centre

Veit Bürger, Öko-Institut

Jan Steinbach, Judit Kockat, Clemens Rohde, Frauenhofer ISI

Reviewed by:
Bogdan Atanasiu, Buildings Performance Institue Europe, BPIE

Supported by INTELLIGENT ENERGY EUROPE

Part of INTELLIGENT ENERGY EUROPE

ENTRANZE Project

Year of implementation:	April 2012 – September 2014
Client:	EACI
Web:	http://www.entranze.eu

Project consortium:

EEG	Energy Economics Group, Institute of Energy Systems and Electrical Drives at 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

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 working paper constitutes Deliverable 2.6 of the ENTRANZE project and presents the main results of Task 2.5 (Public and social acceptance and perception of RES-H/C and energy efficiency in the building sector).

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.

Supported by INTELLIGENT ENERGY EUROPE

with the support of the EUROPEAN COMMISSION

Executive Agency for Competitiveness and Innovation Intelligent Energy for Europe

Contents

Executive summary

This report explores the factors influencing public acceptance of nearly-zero energy building solutions and renewable heating and cooling in the building sector. It contributes to the ENTRANZE project. ENTRANZE is funded by the Intelligent Energy Europe programme and aims to actively support policy making by providing data, analysis and guidelines to achieve a fast and strong penetration of nearly-zero-energy buildings (nZEB) and renewable heating and cooling (RESH/C) in the existing building stock.

Building owners and users are critical in determining the share of the energy efficiency and RES potential in buildings, because most of the renovations are ultimately made at their costs. There are several types and combinations of solutions for reducing the external primary energy demand of existing buildings, and their current level of public acceptance in different European countries varies. The aim of this report is to:

a) Identify the current status of public perception and social acceptance of energy efficiency and renewable energy solutions in buildings in participating countries and
b) Identify key factors underlying social acceptance, such as risks, initial costs, visibility, types of organizations promoting the technology, and barriers to acceptance.

The level of public acceptance – in terms of actual adoption of technologies – also depends on the situation of the building owners and on the way in which they make decisions. Concerning this question, the current report draws on work reported in ENTRANZE D2.4 (Literature review of key stakeholders, users and investors, Heiskanen et al. 2012). This previous report built on literature, the ENTRANZE partners' experience, as well as on 29 expert interviews (usually 3 per target country) with public authorities, building owners' associations and experienced consultants, as well as some representative building owners (see Annex 2). The current report combines findings from the previous report with a more detailed analysis of particular nearly-zero energy building and renewable heating solutions. Moreover, the current report extends the analysis from the ENTRANZE target countries (Austria, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Romania and Spain) to provide a more aggregated assessment for the focus countries and a rough assessment for these issues concerning all EU-27 countries. For this, we have drawn on several data sources:

- Research reports and industry association statistics on market developments and major drivers and barriers for particular nZEB and RES-H/C solutions
- Research reports and academic studies on consumer and investor acceptance of particular nZEB and RES-H/C solutions, where available
- Project partners' summaries of the situation in ENTRANZE target countries, focusing on the main drivers and barriers for particular solutions at the present moment, as well as on the identification of the most and least promising building owner types for each solution.
- Research reports on the situation in other than ENTRANZE focus countries, i.e., the rest of EU-27

While our primary data pertain to the nine ENTRANZE target countries (Austria, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Romania and Spain), the analysis of barriers and decision criteria conducted in Heiskanen et al. (2012) indicated that differences in barriers and drivers are in many cases greater among building owner groups than among countries. We were also able to identify certain other indicators that are closely connected to drivers and barriers, including geography, energy costs, policy developments, heating sources, income and debt levels, etc. These are used here to group countries and to identify where countries in a certain group are similar or different from each other. There are, however, several limitations to the quality of the data reported here. The available research reports only cover certain geographical areas and investor types. The country reports on the driving factors and barriers of particular solutions are mainly based on our consortium partners' experience, though this is corroborated with research literature where available. The assessment concerning other than ENTRANZE target countries is much more aggregated and is presented here to support the modeling in WP4.

Existing knowledge base on public acceptance of nearly-zero energy and renewable heating and cooling solutions in existing building

Public acceptance of nearly-zero-energy solutions

Public or social acceptance is a major concern in energy policy and in the marketing of new innovative solutions, yet the concept can refer to many different types of "publics". Acceptance by several different groups in society is relevant for nearly-zero energy buildings and renewable heating and cooling. These include the expert community, national and local policy makers, the media, building professionals and craftsmen, building owners and users, owner associations, user communities and other NGOs. Moreover, we can identify two kinds of acceptance – acceptance in principle and actual adoption and use. They are not unrelated, but acceptance in principle does not necessarily mean that stakeholders are willing to, capable of, or used to investing in or using a particular solution. A positive attitude toward certain solutions is usually a necessary condition for voluntary actions to adopt that solution, but it is not a sufficient one.

Certain factors intervening between "acceptance in principle" and "acceptance in practice" are widely recognized: (1) *Various constraints:* In the case of building renovation, these can relate to the owners' wealth and access to capital, to the costs and risks of the renovation (including potential costs of relocation), to access to suitable services, as well as to whether owner can make the decision alone or depend on agreement with other building owners or users; (2) *Conventions and routines*: Solutions related to energy renovations are usually "high involvement decisions", i.e., not habitual behaviours. They do involve information processing and a distinct 'moment' of decision, but lay people still do not make decisions in the same way as energy experts. Ordinary investors usually expect relatively short payback times from their investments; partly because of their particular circumstances, but also due to cultural conventions that people learn from each other. Conversely, some solutions can start to become so 'normal' that they are adopted without much calculation or consideration of alternatives; (3) *Particular issues relating to particular types of actions*: In the case of durable goods like renovations or HVAC installations, one such issue is investment cycles and the related timing of decisions.

One of the problems with the concept of 'energy renovation' is that it does not have a widely recognized and stabilized content. It consists of various measures applied to the building façade, HVAC and other systems, which are deemed sensible ways of saving energy in a certain geographical context and at a certain period of time. In a study of energy-related renovation practices and their variability in four European countries, Bartiaux et al. (2011) conclude that 'energy renovating' is not yet an integrated practice. Knowhow is fragmented among several groups of professionals (e.g., carpenters, installers) and these professionals do not share a common goal or recognize themselves as 'energy-saving practitioners'. Nor do most homeowners recognize a unified practice of energy renovation, but rather individual measures, usually aimed at increasing the comfort and livability of their homes.

Hence, while it is recognized that nearly-zero energy buildings always are a well-designed combination and integration of several solutions, we focus here on separate solutions. This is because the focus in ENTRANZE is on existing buildings. Nearly-zero building renovations are still at a pilot phase and the term itself is not likely to be recognized by building owners. Instead, building owners can occasionally face the decisions of implementing several different kinds of upgrades and improvements in their building. The following solutions are considered relevant: thermal renovation (high standard of insulation), efficient and renewable energy supply and minimized ventilation losses.

Several authors have conceptualized public acceptance of nearly-zero energy building or particular renewable heating/cooling solutions in terms of innovation diffusion theory. This theory, which builds on work by Rogers (1995), focuses on the life cycle of innovative products and the different drivers and barriers for diffusion at different stages of the life cycle, including processes of communication among different categories of users (innovators, early adopters, early majority, late majority, and laggards). Social networks and communication among different types of users are central in the diffusion of innovations from the more to the less innovative users. For example, most people are unlikely to invest in a new technology that they have never seen in operation in real life. During the process of adoption, there is a point at which an innovation reaches critical mass, and adoption becomes self-sustaining.

Not all innovations manage to progress to the mass market; some die out or remain in a small niche market. Some might not even aim to capture the entire market. There is still no reliable and widely accepted way of predicting the diffusion patterns of particular solutions. Hence, for contemporary innovations, we cannot reliably distinguish between an introduction phase and a niche innovation. Innovation diffusion models are also highly simplified, as solutions develop as they diffuse. However, for the current purpose, this model can serve as a heuristic to characterize the level of public and market acceptance of particular nearly-zero energy building solutions in particular markets. In the following, we hence adapt the typology used by Prendergast et al. (2010) and try to identify whether particular solutions are in: (1) an introductory or niche phase, (2) a growth phase or (3) a mature market phase.

Drivers and barriers on the macro and micro levels

Drivers and barriers to the adoption of nZEB and RES-H/C solutions can be examined on different levels. On a *macro level*, we can focus on the role of policy, markets and other institutions in pushing, pulling or obstructing certain solutions over several years or decades. The following factors are highlighted in the literature.

Geography: Heating solutions are naturally of greater interest in countries with cold climates and cooling solutions in countries with hot climates. Countries also have different endowments of natural resources, which still today influence the relative prices of energy sources, the existence of domestic industrial competencies, and the development effort devoted to related solutions. However, the objective availability of energy sources does not completely explain the amount of (e.g. policy or industry) effort devoted to certain solutions, as evidenced by the uneven historical development of e.g. solar energy in Europe.

Infrastructure: Examples of infrastructures influencing the feasibility of nearly-zero-energy solutions include the natural gas grid, district heating systems, and the state of the electricity grid(?). Other relevant existing infrastructures relate to the age, size, structure and current condition of the building stock, or to the availability of central heating. Energy infrastructures exhibit a high level of path dependency, which is not only due to cumulative investments in certain physical infrastructures, but also to related investments in knowledge, production skills and capacity, political power, market expectations, network effects, etc. Hence, it is difficult for new technologies to compete with the dominant technology, even if they hold large future potential or even once they become cost-effective. However, problems with existing technologies (such as sharp rises in fuel prices or declining legitimacy) can also offer opportunities for new solutions.

History and culture: It is well-established that expectations toward energy provision and use in buildings vary both historically and across cultures, even within Europe, as is shown, for example, in literature on the variability of thermal comfort expectations in different countries. These differences are due to historical experiences, building traditions and building usage practices. Historical and cultural traditions can also influence how buildings and their renovations are typically governed and managed. West European countries have a long legacy of energy efficiency policy, which started during the first oil crisis in 1973. In contrast, the countries that were closely linked to the former Soviet Union did not suffer from a similar fuel shortage. There are also diverse historical experiences of particular nZEB solutions. The existing share of (mainly new) nearly-zero energy, zero-carbon or passive houses in a country can be one such factor influencing overall awareness and acceptance.

Policy is clearly a driver for the adoption of nearly-zero-energy solutions. According to literature, this is the case both for insulation and for various heating and micro-generation solutions. Recent commentators have discussed the possibilities for market transformation (i.e., simultaneous shaping of both supply and demand) in nZEB building renovation. This would involve the widespread provision of well-coordinated training and quality control mechanisms, and a continual revision of energy standards, which could involve an ongoing upscaling of best practices from demonstration projects. These factors could serve as indicators of countries that are on a growth path, where acceptance is spreading to early mainstream markets. An additional factor relates to the *political* aspects of policy making. It is likely that nearly-zero energy solutions gain more consistent political support if they can convincingly offer other benefits than climate change mitigation, such as fuel poverty and job creation can serve as arguments and issues that maintain consistent political support for the necessary policy measures.

Markets and companies are important drivers of new solutions, since solutions cannot be(?) adopted unless they are readily available in the market. Most of the solutions discussed above are in principle available throughout Europe but the practical feasibility of selecting them varies from one country to another. Technological learning is an important factor that influences the development of the availability and cost of various nZEB solutions. For mainstream construction companies, solutions need to be simple and quick to implement, replicable, affordable, reliable, cost-effective, readily available and profitable before mainstream companies are willing to consider them. The existence of well-established large companies offering certain solutions can be relevant indicators for their entry into the mainstream market. The competitiveness of new solutions is also naturally influenced by the price of energy. The variation in consumer prices of electricity and fuels in Europe is quite significant, with natural gas prices ranging from 3 to almost 12 cents/kWh and electricity prices ranging from about 9 to 30 cents/kWh.

Expert and professional communities, such as universities, consultants and professional associations have an important role in introducing and mediating new ideas such as those represented by nZEB and RES-H/C However, these same expert groups may also be major reproducers of old ideas, which maintain the existing structures. A lack of consensus on what is best practice in nZEB and RES-H/C (especially in refurbishment) can be a factor obstructing public acceptance and creating uncertainty and confusion also among the general public. Such issues like the longstanding existence of voluntary but widely accepted standards or certification schemes might serve as one possible indicator of the level of consensus on appropriate nZEB and RES-H/C solutions in a country.

Citizen and social movements: Apart from formal policies – and usually, before such formal policies mature – various types of social and entrepreneurial movements have put their stamp on national perceptions of sustainable energy solutions. Examples include the role of citizen movements for solar water heaters in Austria and Barcelona, Spain and the importance of the construction of networks among proponents of the new solutions in the development of the solar PV. Such movements create legitimacy for the new solutions before and while they are promoted by public policy. This type of legitimacy may be one of the reasons why similar policies might have uneven effects in different European countries.

Media: The role of the media has not been examined in many studies yet; however our experience and the evidence collected for D2.4 suggest that the media has an important role not only in raising awareness of energy issues and the need for renovation, but also in highlighting particular issues. In this respect, studies show that the media do not always promote acceptance, but can also fuel controversies.

The factors operating on a more macro level naturally also have their influence on the micro level, but they combine in different ways in the different particular circumstances of specific renovation projects. In practice, this difference can be seen in the differences between the barriers experienced by different kinds of building owner groups:

- For owner-occupied single-family homes, the decision to adopt energy efficient or renewable energy solutions is in principle simple, as the owner makes decisions on their own. However, the notion of a 'comprehensive renovation' is not familiar to single-family homeowners in many countries; in contrast, renovation is an ongoing and largely do-it-yourself process. The small scale rarely enables the contracting of outside planning professionals. High initial costs and lack of access to capital are widespread barriers, whereas improved comfort, energy cost savings and the availability of widely used solutions are common drivers for renovations. This segment, however, is highly heterogeneous, including both the richest urban and often the poorest rural households. It is hence probably likely to host the most innovative pioneers but also the buildings that will never be completely renovated.
- For owner-occupied multifamily buildings, decisions about energy renovations are greatly hampered by organizational difficulties of reaching agreement on the need to take measures and on the type of measures to be taken. The share of owner-occupancy among multifamily buildings varies greatly, with the lowest rates in Germany (24%) and the highest in Spain (94%) and Romania (96%). The more widespread owner-occupied multifamily dwellings are, the more diverse the socioeconomic background of the inhabitants. When this is coupled with high majorities for reaching decisions concerning renovations and difficulties in raising collective finance, the barriers to energy renovations are extremely severe.
- Rental dwellings are extremely diverse in Europe. In many countries, a large share of the entire rental stock is owned by private, individual landlords owning one or two properties. Conversely, the share of professionally owned rental apartments (including social housing) varies greatly by country. In countries where social housing is very rare (Central and Eastern Europe and South Europe), these buildings are particularly problematic, as they only house the poorest people, and there are legal and practical constraints on adding any of the renovation costs to the rent. However, in countries where there is a large and well-established professional rental sector, social housing providers can be the forerunners in solutions for multifamily buildings.
- Public buildings are very diverse. Common barriers throughout Europe and across public building types are the existence of separate budget lines for investments and running costs. Another particular set of problems relates to public procurement rules. However, public buildings are also expected to serve as an example, and individual public buildings do serve as visible demonstrations of exemplary solutions.
- Office buildings appear to be more similar to one another across countries. They differ from the other building types discussed here insofar as space and water heating are relatively less important than in other building types, and cooling, ventilation and lighting are more important. Office building owners usually apply sophisticated investment calculus methods and energy efficiency or RES solutions have to compete with other, more productive uses of capital. This said, office buildings can be important and visible sites for nZEB renovation demonstrations.

The barriers and decision criteria are not necessarily the same for different solutions. Comfort, timing, aesthetic factors, investment costs and cost savings are important determinants for investments in the building envelope, whereas investments in HVAC equipment are more related to capital cost and technical performance and branding. Particular technologies can also have particular problems, at least in some markets. For example, biomass boilers have a somewhat ambiguous image in several countries.

The report includes a review of existing consumer acceptance studies, especially of new and renewable-based heating and micro-generation solutions. There are several limitations to the existing research knowledge: there is much more research from Germany, Sweden and the UK than from other countries. There is also more research on single-family home owners than on other types of building owners. However, the few existing studies suggest that multifamily homeowners and tenants might be less likely to accept new solutions; partly because they are less involved in the choice and design of such systems.

The existing studies suggest that the drivers for people choosing "innovative" systems are different than for ones that have become conventional. However, what is an innovative system depends on the country context. People choosing innovative systems are driven by environmental considerations and interests in the technology and its particular benefits. They are usually younger, more educated and wealthier than the population at large (but this could depend on the purchasing price of the innovative system, which is usually high at this stage). Costs, convenience, perceived risks and peer influence play a larger role for the mass market. There is also data suggesting that initial costs are particularly important for low-income households, whereas middle-income households usually consider the heating cost savings as well, and the wealthiest are not sensitive to costs. Social influences (media, advice, recommendations by installers or friends) appear to be important for the majority of owners.

The studies (which reflect prosperous West and North European contexts) indicate that single-family home owners' required rates of return for heating systems vary from 12% (heating systems in general), to 16% (for groundsource heat) and 22% (for wood pellets) to 34% for diverse renewable solutions in the UK. There are differences both between countries and among the different solutions. It seems that when the solutions are perceived of as innovative and risky, mainstream consumers require higher rates of return than for more conventional and packaged systems.

Certain technologies involve particular risks, concerns or constraints. These include e.g. fuel storage and availability for all kinds of fuels (especially biomass), disruption of the property and garden (groundsource heat, district heat connections), and concerns about dependency on a single provider (district heat). Moreover, concerns may be quite different in different countries and survey studies do not always reveal all constraints or concerns related to particular technologies. Additional concerns raised in other types of studies relate to e.g. permitting problems and time-lags, concerns about indoor air or mould in low-energy buildings, or historical experiences of quality problems in certain heat pump markets.

Several studies suggest that novel solutions, especially heating systems, also have different regional diffusion patterns within countries. There are even quantitative estimates on how much installations in the neighbourhood increase the likeliness of further installations. Many studies stress the importance of social influence, in terms of recommendations from friends, neighbours or installers, at least for the less innovative consumers. However, the strength of the regional effect seems to suggest a broader 'network effect', which is not only due to direct recommendations or imitation, but also to the development of local visibility, competences and service markets.

Studies also reveal the crucial role of various stakeholders in influencing building owners. It is likely that the role of service providers grows when innovative solutions start to enter the mass market. The early adopters are more likely to make efforts to find new solutions, but latecomers are more likely to rely on solutions that are readily available. Hence, the knowledge level and awareness of e.g. engineers or architects, craftsmen, installers, as well as real estate agents, house managers and maintenance service providers can influence the acceptability and actual adoption of new solutions. Another factor that is likely to gain importance is quality assurance, monitoring and verification of savings, which was also highlighted in some of our expert interviews. There is a much discussion on whether technically possible savings are actually realized due to execution of the renovation, maintenance and use, and user behavior. Guarantees and insurance products may also be important. Mainstream consumers are not likely to accept even unlikely risks, and the risks of new solutions usually gain much more attention than the risks of old ones.

Table 1 presents a summary of the literature review. In the first rows, the most important barriers and drivers of energy renovation in general are summarized, which vary in weight by building owner group and country. The first column below summarizes the 'macro' factors discussed above, which pertain to the country and regional context and might vary systematically among countries. The second column below highlights some of the technology-specific factors identified above as factors influencing owners' decision making on the micro level of individual renovation or renewal projects.

Table 1. General, context specific and technology specific factors influencing public acceptance and adoption

General factors	
Initial cost, cost-effectiveness	Organizational barriers
Energy cost savings	Access to capital
Improved comfort	Availability of widely used and recommended solutions
Occasions for renovation	Availability of quality service
Context specific factors	**Technology specific factors**
Geography: climate, natural resources, industries	Different decision criteria for early adopters of innovative technologies (environment, technology attraction) than for latercomers (more cost and convenience driven)
Infrastructure: building stock, energy systems, compatibility of new solutions	Different financial valuation for technologies, with higher payback expectations for technologies perceived of as riskier
History and culture: Traditions of building governance, institutionalization of energy efficiency policy, good and bad experiences of solutions	Social and regional influence strong in growth phase: adoption by neighbours increases likelihood to adopt
Policy: legislation & financial support, effectiveness of policy, political support (other than climate benefits)	Particular concerns and constraints related to particular technologies (e.g. inconvenience, space requirements, perceived performance risks, permitting issues)
Markets and companies: availability and cost of solutions vs. cost of energy; established large companies offering solutions	Role of stakeholders e.g. installers for windows and HVAC, financial institutions for expensive solutions
Expert and professional communities: level of integration and consensus	Importance of auxiliary services like finance and guarantees for mass market adoption
Citizen and social movements: legitimacy and public support	
Media: public information and contoversies	

Source: Own compilation

Particular features of public acceptance and adoption of nZEB and RES-H/C solutions in ENTRANZE target countries

The extent to which knowledge, support and exemplars are available for particular solutions depends on the maturity of the market. On the basis of our analysis, we attempt to characterize the level of maturity of markets for various nearly-zero-energy and renewable heating solutions (see table 1). This is relevant because the maturity of the market relates to:

- The type and quality of services and commercial solutions available: these can range from quite exceptional and niche market services at premium price, to widely available services. At one extreme, finding and applying a solution requires extensive Internet searches and consulting with several experts. At the final stage, solutions are be routinely included in a service package (e.g. windows are sold with frames today).
- The evaluation criteria used by building owners. Most building owners are unlikely to invest in solutions that they have never seen. If solutions are perceived of as innovative, they will only be chosen by a certain segment of pioneering users. Other users are not likely to choose them unless they fulfill a very specific need.

Table 2 offers a characterization of the ENTRANZE target countries in terms of the market maturity for some nZEB and renewable heating solutions. The maturity of the market is assessed mainly from the end-users' perspective (not that of companies offering these systems, or the total market size). The rationale for this is that acceptance, adoption and growth may be constrained in very small markets, where less than 1% of buildings have applied the solution. In this case, it is likely that many building owners have never seen the system or are at least not familiar with it. It may be difficult for many of the less active building owners also to find appropriate products and services in such markets. In table 1, such markets are characterized as "initial". Markets where less than 5% of the relevant buildings have applied the system are characterized as "small" – products and services are more likely to be available, but the solution might not be familiar to all building owners. Markets in which more than 5% of the relevant buildings have applied the system are characterized as "established"[1].

In addition, an arrow depicting the annual growth rate of installations (calculate as an average of 4-5 years, 2006-2010, depending on data availability) has been added to each cell, where available. A horizontal arrow denotes a sales growth of less than 20%, a 45 degrees arrow a sales growth of more than 20% but less than 100%, and a vertical arrow denotes an average annual sales growth of more than 100% (i.e., installations have on average doubled each year). The strong growth rates for solar PV suggest that in some cases, new installations can indeed double on average each year over a period of several years even with a low installed base. Hence, the maximum adoption growth rate can be dependent on technology.

Renovations are made in all countries. Advanced thermal renovations are a novelty in all countries: however, there are clear differences among the ENTRANZE countries in how well established near-zero energy solutions are in new or existing buildings. In this respect, Austria, Germany and France are likely to represent more advanced or rapidly moving markets in this respect, whereas the other ENTRANZE countries are in a very initial phase.

Table 2. Assessment of the maturity of the market for various nZEB and RES-H/C solutions in ENTRANZE target countries

	AT	BG	CZ	DE	ES	FI	FR	IT	RO
Compre-hensive nZEB solutions	Initial ↗	Initial	Initial	Initial ↗	Initial	Initial	Initial ↗	Initial	Initial
Pellet boilers	Small ↗	Initial	Small →	Small ↗	Initial	Initial →	Initial ↗	Established ↗	Initial
Ground-source heat pumps	Small →	Initial	Initial ↗	Small ↗	Initial	Small →	Initial →	Initial →	Initial
Airsource heat pumps	Small ↗	Initial	Small ↗	Initial ↗	Established	Established ↗	Small ↗	Initial	Initial
Solar thermal systems	Established →	Initial ↗	Small →	Small →	Small ↗	Initial →	Small ↗	Small ↗	Initial ↑
Solar PV	Initial ↗	Initial ↑	Established ↑	Established ↗	Small ↑	Initial ↗	Initial ↑	Small ↑	Initial ↗

Legend: Initial = diffusion < 1% of the dwelling stock; Small = diffusion < 5% of the dwelling stock; Established = diffusion > 5% of the dwelling stock. (For solar PV, initial = <20W_c/capita; small < 100 W_c/capita; established> 100W_c/capita). Sources: see chapter 3

The main **drivers** for nZEB solutions in ENTRANZE target countries are fairly similar in all countries, although the emphasis varies somewhat from one country to another. Regulations (existing or pending), subsidies and finance schemes, as well as especially local advice agencies are the main drivers in most countries. The state of the existing housing stock is another major driver, more so in some countries than others, as well as the arguments that thermal renovations are cost-effective. The rising price of energy was also mentioned frequently as a driver for energy renovations. Voluntary initiatives, regional energy agencies,

[1] Solar PV has been calculated somewhat differently due to data availability issues, with "established" referring to markets where there is more than 100 W capacity installed per person, "small" referring to markets with 20-99 W capacity per person, and the rest as "initial". Not all of the PV installations included here are necessary building-applied, as no statistics were available on this.

existing good examples and individual champions were also mentioned in some countries as important drivers.

Subsidies and finance schemes are important drivers for renewable heating and cooling solutions in many countries. There are also mandatory requirements in several countries, e.g. the Renewable Heat Act in Germany and building regulations in Spain and France. Companies were also often mentioned as promoters of these solutions, especially installers in Austria. In particular, heat pumps have been promoted by energy utilities in Austria, France and Germany. Promotion, marketing and good examples are mentioned as important; this applies especially in the initial market introduction stage of a solution.

Certain solutions have an overall positive image: this is the case for solar energy in most countries (irrespective of whether it is widespread or not). However, biomass is perhaps a solution that has a more positive image in German-speaking countries than outside them. There are also practical arguments for some of the solutions. Cheap fuels are a widely acknowledged argument for biomass, convenience and low maintenance costs for groundsource heat. Ease of use and ease of installation are also important arguments for relatively independent systems like solar water heaters or airsource heat pumps.

Mechanical supply and exhaust ventilation is quite rare; hence the possible scope for ventilation heat recovery systems is limited. On the other hand, there are also countries in which air conditioning (i.e., cooling) is extremely rare as well. Ventilation heat recovery and energy efficient air conditioning are more expert-driven systems, which are usually promoted by standards, requirements and labelling or experts and designers rather than public demand. There are also subsidies and finance schemes in Austria and Germany. However, motivated building owners can also be drivers, as in the case of the Czech Republic. In countries where air conditioning is only just being introduced (e.g. Czech Republic, Finland), reversible air conditioning/heat pumps present an attractive prospect.

Solar PV panels are mainly driven by subsidies, finance schemes and feed-in-tariffs, as well as the overall positive image of solar energy, and the attraction of independent energy production (for some building owners). There are also legal requirements in some countries, and the growing market and rising energy prices increase its attraction in others.

High initial investment costs are a common **barrier** to all solutions, except for air-source heat pumps in most countries. There are also particular barriers related to particular technologies such as space demand and urban air quality issues for biomass heating. Some of these are quite definite technical constraints, such as the low airtightness of existing buildings in the case of ventilation heat recovery. Some barriers, however, relate to the type and development stage of the market. These are, for example, lack of knowledge and dedicated finance for e.g. biomass heating systems, or uncertainties about fuel prices and availability. There is also a competition among many of these systems, and while our experts and the national or local advice schemes referenced above can recommend some solutions for particular buildings or locations, this might not be obvious to building owners. There are also some quality and performance issues related to particular technologies. Especially, the variable quality of airsource heat pumps was mentioned in several countries. Electricity micro-generation (solar PVs) suffers from high investment costs, high seasonal (and daily) variation and lack of storage solutions, as well as unstable feed-in-tariff schemes and practical problems in grid connections in several countries.

In general, different **building owner types** have specific needs as concerns the identification and promotion of suitable solutions. It was noted in D2.4 that single-family homes in many countries often engage in piecemeal and step-by-step renovation. They often save money and repair or replace building components over the years, rather than starting a comprehensive renovation with external capital. Our analysis here has shown that single-family homes are also often the most likely to install various kinds of renewable heating systems and more recently, also, PV panels. This piecemeal progress toward less energy use and more renewable energy is an opportunity but also a challenge for those wishing to promote nZEB and RES-H/C in the existing building stock. It is an opportunity because there are existing examples and accumulated experience, and developed service structures for the installation of components. It is a challenge because piecemeal replacement and installation of various solutions might not represent an optimal combination. It is thus worth considering whether we need a (partly) step-by-step and do-it-yourself track toward nZEB in existing buildings, alongside the prevailing notion of a comprehensive renovation, if a wide segment of European single-family homeowners is to be engaged.

Multifamily buildings have quite different challenges. Especially in multifamily buildings, all kinds of renovations cause difficulties in making decisions, but innovative solutions may be particularly challenging in a collective decision context. All kinds of multifamily buildings experience difficulties of fitting most renewable heating solutions into an urban structure and the management practices of urban buildings. Planning, permitting, decision making and financing issues can cause significant delays and time-lags in implementation. Moreover, for technical building systems, issues of the training of maintenance staff and users can be quite important for both the acceptance and the performance of the systems.

Service buildings and public buildings can serve as important exemplars of new solutions. This can serve a very important purpose not only in educating other owners of public or service buildings, but also other building users. People are extremely unlikely to invest their own money in solutions that they have never seen or experienced themselves. Hence, implementation of these solutions in buildings that are open to the general public (and visited regularly by people also long before their own renovation decision is at hand) can be a very important aspect of creating public and social acceptance of nearly-zero energy buildings and renewable heating and cooling solutions.

As concerns **public acceptance in general**, the overall perception of the need to save energy is relatively widespread in Europe. However, levels of public understanding are low – especially compared to the relatively complex and ambitious systems connected to nearly-zero energy renovations and renewable heating and cooling systems. Moreover, different solutions are more relevant and/or familiar and institutionalized in some countries than others. nZEB or even energy renovation is not a concept that is understood or applied similarly throughout Europe, or even within countries.

These issues give rise to some recommendations concerning the future public acceptance of nearly-zero energy renovations and renewable heating and cooling solutions. Quality issues and e.g. training and certification of installers and construction workers are currently topical in Europe. Out study indicates that there is an urgent need for such training. Concerns over the quality of thermal renovation and the performance of various new heating and cooling equipment need to be rapidly resolved. Installers are also important promoters or obstructers of new solutions. Alongside the development of certification schemes, also marketing and general awareness-raising concerning such schemes are very important.

Renovation in itself is not desirable or fun for building owners, nor is experimenting with new technical systems an interesting prospect in itself for other than a small minority of pioneering building owners. Most mainstream building owners see the renovation as an ordeal and the ensuing building condition as the reward. As of yet, there is still quite a lot of uncertainty about the achievement of this reward among many building owners, especially in cases where the existing condition of the building is experienced as bearable. Hence, promotion of nearly-zero energy buildings should focus on investigating and disseminating results on user satisfaction and real-life experiences of renovated nearly-zero energy buildings and renewable heating and cooling systems in a variety of building contexts.

1 Introduction

This report constitutes Deliverable 2.6 of the ENTRANZE project and presents the main results of Task 2.5 (Public and social acceptance and perception of RES-H/C and energy efficiency in the building sector). ENTRANZE is funded by the Intelligent Energy Europe programme and aims to actively support policy making by providing data, analysis and guidelines to achieve a fast and strong penetration of nearly-zero-energy buildings (NZEB) and renewable heating and cooling (RES H/C) within the existing national building stocks.

ENTRANZE is coordinated by the Energy Economics Group from the Vienna University of Technology. Project partners include the National Consumer Research Centre (FI), Fraunhofer Society for the advancement of applied research (DE), National Renewable Energy Certre (ES), end use Efficiency Research Group, Politecnico di Milano (IT), Öko-Institut e.V. (DE), Sofia Energy Agency (BG), Buildings Performance Institute Europe (BE), Enerdata (FR), SEVEn, The Energy Efficiency Center (CZ). All partners have contributed to Task 2.5.

Building owners and users are critical in determining the share of the energy efficiency and RES potential in buildings, because most of the renovations are ultimately made at their costs. There are several types and combinations of solutions for reducing the external primary energy demand of existing buildings, and their current level of public acceptance in different European countries varies. The aim of this report is to:

c) Identify the current status of public perception and social acceptance of energy efficiency and renewable energy solutions in buildings in participating countries and
d) identify key factors underlying social acceptance, such as risks, initial costs, visibility, types of organizations promoting the technology, and barriers to acceptance.

The level of public acceptance and actual adoption of technologies also depends on the situation of the building owners and on the way in which they make decisions. Concerning this question, the current report draws on work reported in ENTRANZE D2.4 (Literature review of key stakeholders, users and investors). ENTRANZE D2.4 has drawn on statistics, literature and expert interviews to (1) Make a classification of the relevant stakeholders with regard to investment decision making and user behavior and (2) Identify the stakeholder-specific barriers to the application of energy efficient technologies and describe the causal relationships between certain constraints and investment decision making and (3) Identify similarities and differences in investment decisions among the ENTRANZE target countries.

The D2.4 report is available online at http://www.entranze.eu/files/downloads/D2_4/D2_4_Complete_FINAL3.pdf. The present report also integrates findings from D2.4 in database format (D2.5: Database on stakeholders, investors and user types and their interests for each target country) as an electronic annex (online at: http://www.entranze.eu/annex/electronic-annex).

The current report combines findings from ENTRANZE D2.4 with a more detailed analysis of particular nearly-zero energy building and renewable heating and cooling solutions. Moreover, the current report extends the analysis from the ENTRANZE target countries (Austria, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Romania and Spain) to provide a more aggregated assessment for the focus countries and a rough assessment for these issues concerning all EU-27 countries. This report aims to provide input data for ENTRANZE WP4, which deals with modeling of the impacts of policy scenarios.

The report is structured as follows: The data and methods used in this report are presented in Chapter 2. Chapter 3 presents an overview of existing research on public acceptance of nearly zero-energy buildings and renewable heating and cooling solutions. Chapters 4-7 present country-specific findings in more detail for the ENTRANZE target countries, and on a more aggregated level for other countries. Chapter 8 examines similarities and differences among countries and owner groups and chapter 9 presents conclusions.

2 Data and methods

This report draws partly on data collected for D2.4 of the ENTRANZE project Working paper: Literature review of key stakeholders, users and investors (Heiskanen et al. 2012). The D2.4 report built on literature, the ENTRANZE partners' experience, as well as on 29 expert interviews (usually 3 per target country) with public authorities, building owners' associations and experienced consultants, as well as some representative building owners (see Annex 2). The parts of D2.4 that summarize the overall policy context and the building owners' barriers and drivers for energy renovations have been used as such for this report and the underlying data sources and analysis are presented in D2.4.

The data from D2.4 have been complemented with a more detailed analysis of particular solutions for nearly-zero energy buildings (NZEB) and renewable heating and cooling (RES H/C). For this, we have drawn on several data sources:

- Research reports and industry association statistics on market developments and major drivers and barriers for particular NZEB and RES H/C solutions
- Research reports and academic studies on consumer and investor acceptance of particular NZEB and RES H/C solutions, where available
- Project partners' summaries of the situation in ENTRANZE target countries, focusing on the main drivers and barriers for particular solutions at the present moment, as well as on the identification of the most and least promising building owner types for each solution.
- Research reports on the situation in other than ENTRANZE focus countries, i.e., the rest of EU-27

While our primary data pertain to the nine ENTRANZE target countries (Austria, Bulgaria, Czech Republic, Finland, France, Germany, Italy, Romania and Spain), the analysis of barriers and decision criteria conducted for ENTRANZE D2.4 indicated that differences in barriers and drivers are in many cases greater among building owner groups than among countries. We were also able to identify certain other indicators that are closely connected to drivers and barriers, including geography, energy costs, policy developments, heating sources, income and debt levels, etc. These are used here to group countries and to identify where countries in a certain group are similar or different from each other. This is important because D2.6 is expected to produce input data for WP4, where policy scenarios are modeled across the EU-27.

There are, thus, several limitations to the quality of the data reported here. The available research reports only cover certain geographical areas and investor types. The country reports on the driving factors and barriers of particular solutions are mainly based on our consortium partners' experience, though this is corroborated with research literature where available. The assessment concerning other than ENTRANZE target countries is much more aggregated and is introduced here mainly to support the modeling to be conducted in WP4.

3 Existing knowledge base on public acceptance of nearly-zero energy and renewable heating and cooling solutions in existing building

This section aims to outline some of the key concepts of this report and offer a European overview of the current status and factors influencing it. We first define public acceptance, then nearly-zero and renewable solutions for existing buildings. A brief overview is also given of the variable level of market diffusion among the EU-27. Then, an analysis is presented of the macro and micro level factors influencing public acceptance on the basis of the available research literature.

3.1 What is public acceptance?

Public or social acceptance is a major concern in energy policy and in the marketing of new innovative solutions, yet the concept can refer to many different types of "publics" (Heiskanen et al. 2008). For example, Wüstenhagen et al. (2007) distinguish between socio-political acceptance, community acceptance and market acceptance of renewable energy solutions. Acceptance by several different groups in society is relevant for nearly-zero energy buildings and renewable heating and cooling. These include the expert community, national and local policy makers, the media, building professionals and craftsmen, building owners and users, owner associations, user communities and other NGOs.

Moreover, we can identify two kinds of acceptance – acceptance in principal and actual adoption and use. They are not unrelated, but acceptance in principle does not necessarily mean that stakeholders are willing to, capable of, or used to investing in or using a particular solution (Heiskanen et al. 2007; Wüstenhagen et al. 2007; Sauter and Watson 2007; Claudy et al. 2011).

Acceptance "in principle" can be illustrated by some recent surveys of European citizens. The most recent Eurobarometer study that directly asks respondents about the importance of energy efficiency is from 2006 (EB 2006). It shows that more than half of all Europeans considered energy efficiency to be "very important" (EB 2006). The top five countries in this respect were Cyprus, Malta, Ireland, Germany and Portugal, whereas the least concerned were Estonia, Czech Republic, Lithuania, Sweden and Latvia.

Some more recent surveys, however, put these findings into perspective. In the second-to-previous Eurobarometer survey on public opinion on climate change (EB 2009), energy conservation at home was the second-most popular action taken to combat climate change.[2] It was less popular than waste recycling, but still mentioned by 64% of Europeans as something they do to fight climate change. This same question was also asked in a more recent survey on public opinion concerning climate change (EB 2011b) but with different alternative responses. This more recent study on public opinion on climate change suggests that a relative large share of Europeans report that they are "insulating their homes" in response to climate change. It also shows large variations among countries, which may relate to different interpretations of what home insulation means (i.e., e.g., window insulation strips). However, the study suggests that overall responsiveness to the notion of home insulation has grown, at least in countries where the issue has been widely communicated (e.g. Hamilton 2011). Nonetheless, waste recycling was still the most commonly reported action taken in response to climate change (EB 2011b).

A recent study on citizens' priorities for energy co-operation (EB 2011a) indicated that the stability of energy prices was the first priority, the development of renewable energy sources was second, and guaranteeing energy supplies was third. Energy efficiency was only at fourth place: 16% considered it the most important priority for European co-operation[3]. These findings suggest that Europeans are increasingly aware of the importance of energy efficiency, but citizens' awareness levels are perhaps not quite as high as those of policy makers. One can thus say that energy efficiency is widely accepted, but often not a top priority in any respect for European citizens.

Overall energy awareness is a certain kind of indicator, but not a very good predictor of what exactly (if anything) people actually do to conserve energy in their homes. A positive attitude toward certain solutions is (usually) a necessary condition for voluntary actions to adopt that solution, but it is not a sufficient one (e.g. Diekmann & Preisendorfer 1998; Olli et al. 2001; Abrahamse et al. 2005). Moreover, people might have somewhat different motives than those expected for certain kinds of actions such as insulating homes (EB 2006). There are tens of different ways of conceptualizing the relations between people's thoughts and

[2]

[3] Interestingly; with the greatest shares from Finland, Sweden and Latvia, two of which were the least concerned about energy conservation in EB 2006.

their behaviours[4], yet certain factors intervening between "acceptance in principle" and "acceptance in practice" are widely recognized:

- Various constraints: not all lines of action are equally available to all people. For example, in the case of building renovation, the possibilities depend on the owners' wealth and access to capital, on the costs and risks of the renovation (including potential costs of relocation), on access to suitable services, as well as on whether they can make the decision alone or depend on agreement with other building owners or users (see Heiskanen et al. 2012). In social psychological models, such factors are captured in concepts like "perceived behavioural control" (Kaiser et al. 1999) or "ability" (Ölander and Thøgersen 1995).
- Conventions and routines: Solutions related to energy renovations are usually "high involvement decisions", i.e., not habitual behaviours like turning off lights. While they are usually preceded by significant information processing and a distinct 'moment' of decision, it is still not obvious that lay people make decisions in the same way as energy experts. Ordinary investors usually expect relatively short payback times from their investments; such calculation rules may relate to the particular circumstances of the decision maker (Golove and Eto 1996), but are also cultural conventions that people learn from each other (Breukers et al. 2009). To the opposite effect, but following a similar pattern of conventional behavior, some solutions (e.g. heat pumps, solar heaters) can start to become 'normal' solutions in a certain environment, and they can be adopted without significant thought or consideration of alternatives.
- Particular issues relating to particular types of actions: In the case of durable goods like renovations or HVAC or other such installations, one such issue is investment cycles and the related timing of decisions. If we consider the example presented above, both appliance purchasing and insulation are likely to occur in a cyclical manner: people rarely would replace a new appliance or building component. In the case of home renovation, certain occasions have been found to be particularly important, such as change of ownership of a property and technical wear of building components (e.g. Stiess et al. 2009b; Beillan et al. 2011; Bartiaux et al. 2011; Nair 2012).

One of the problems with the concept of 'energy renovation' is that it does not have a widely recognized and stabilized content. It consists of various measures applied to the building façade, HVAC and other systems, which are deemed sensible ways of saving energy in a certain geographical context and at a certain period of time. In a study of energy-related renovation practices and their variability in four European countries, Bartiaux et al. (2011) concluded that 'energy renovating' is not yet an integrated practice. Knowhow is fragmented among several groups of professionals (e.g., carpenters, heating installers, windows installers) and these professionals do not share a common goal or recognize themselves as 'energy-saving practitioners'. Nor do most homeowners recognize a unified practice of energy renovation, but rather individual measures, usually aimed at increasing the comfort and livability of their homes.

3.2 Acceptance and adoption of nearly-zero energy innovations

Several authors have conceptualized public acceptance of nearly-zero energy building or particular renewable heating/cooling solutions in terms of innovation diffusion theory (Heimdahl and Bjørstrand 2009; Prendergast et al. 2010; Tapaninen 2010; Woersdorfer & Kaus 2011). This theory, which builds on work by Everett Rogers (1995), focuses on the life cycle of innovative products and the different drivers and barriers for diffusion at different stages of the life cycle, including processes of communication among different categories of users (innovators, early adopters, early majority, late majority, and laggards). Social

[4] For more details see e.g. Breukers et al. (2009), pp. 42-48.

networks and communication among different types of users are central in the diffusion of innovations from the more to the less innovative users. As an example: most people are unlikely to invest in a new technology that they have never seen in operation under real-life conditions. During the process of adoption, there is a point at which an innovation reaches critical mass, and adoption becomes self-sustaining.

Drawing on this model, Prendergast et al. (2010), in a report for IEA Task 37, characterize the contemporary diffusion of advanced (nearly zero-energy) housing renovation into three stages, a demonstration and introduction phase, a growth phase and a volume phase (mature markets). Here, the introductory phase is characterized by pilot projects, innovative companies and innovative and idealistic users. The growth phase, which has not yet been reached in any country for nearly-zero energy renovations as a whole, would include cost-effective demonstration projects, adoption by quality leaders, public sector demand, and marketing campaigns by renovation service providers. Prendergast et al. (2010) also note the important role of passive (or nearly-zero-energy) new buildings as examples, which can start the diffusion of acceptance through social networks.

However, Rogers (1995) himself notes that one of the major drawbacks of the diffusion of innovation literature is its pro-innovation bias. Not all innovations manage to progress to the mass market; some die out or remain in a small niche market (Moore 2002). Some might not even aim to capture the entire market. While Rogers (1995) suggested several factors that determine how rapidly and fully technologies diffuse, there is still no reliable and widely accepted way of predicting the diffusion patterns of particular solutions. Hence, for contemporary innovations, we cannot reliably distinguish between an introduction phase and a niche innovation.

Innovation diffusion models are highly simplified and there are many more sophisticated models. For example, innovations rarely remain the same throughout the diffusion process, but are changed and improved due to feedback from users and the market (e.g. Fleck 1993). However, for the current purpose, this model can serve as a heuristic to characterize the level of public acceptance, especially market acceptance, of particular nearly-zero energy building solutions in particular markets. In the following, we will hence adapt the typology used by Prendergast et al. (2010) and try to identify whether particular solutions are in:

1. an introductory or niche phase
2. a growth phase
3. a mature market phase

Prendergast et al. (201) conceptualize ‘advanced housing renovation’ as a particular type of service offering. However, we saw before that this is not the case in most markets (Bartiaux et al. 2011). In reality, there are several products and services that are of interest, and they are today rarely integrated by either companies in the market or by users. Moreover, the most appropriate combination of products and services varies by building and building type, the available energy infrastructure, as well as by the geographical location of the building.

Considering that public acceptance is not a unified concept and energy efficiency and renewable energy solutions are not a unified practice, the most commonly proposed solutions for nearly-zero energy buildings and renewable heating and cooling and their market developments are first briefly outlined below together with some data on their market status and development in different parts of Europe.

3.3 Conventional and nZEB technologies and their market developments

While it is recognized that nearly-zero energy buildings always are a well-designed combination and integration of several solutions, we focus here on separate solutions. This is because the focus in ENTRANZE is on existing buildings, where owners (at least at present) do not usually face the decision of ‘buying a nearly-zero energy building' or renovating their building to 'nearly-zero energy status'. Nearly-zero building renovations are still at a relatively early stage of market introduction (Prendergast et al. 2010) and the term itself is not likely to be recognized by building owners. Instead, building owners can occasionally face the decisions of implementing several different kinds of upgrades and improvements in their building. The following solutions are mentioned in Prendergast et al. (2010) as being part of an advanced (or nearly-zero energy) renovation concept: thermal renovation (high standard of insulation), efficient energy supply (heat pumps, high efficiency gas boilers, wood pellet furnaces), minimized ventilation losses, overheating control, and passive and active solar energy.

Thermal renovation[5] typically relates to measures for the insulation of roof, walls and/or base of the building as well as to the repair or replacement of windows, as well as other measures to improve airtightness. According to BPIE (2011), most estimates of renovation rates are mainly between around 0.5% and 2.5% of the building stock per year, and can be highly influenced by topical factors such are renovation programmes. It is also influenced by the average age, construction type and materials, and renovation history of the building stock. BPIE (2011) estimates that the average annual renovation rate in Europe is about 1%.

Policy has been found to be one of the major drivers for the insulation market, along with energy prices and the overall volume of construction and renovation (Kiss et al. 2010). However, according to IEA (2010), while advanced housing renovations, or comprehensive renovations, have shown good results in demonstration projects, it has turned out to be difficult to increase the volumes to full-scale market deployment. The main demand-side drivers for such renovations are attractiveness (i.e., promotion of the solutions), competitiveness (increased energy prices), affordability (e.g. grants or tax subsidies) and market infrastructure, such as the existence of active networks of clients and professionals stimulating demand. On the supply side, similarly, expectations about growing markets, cost reductions due to industrial learning, incentives to companies and active networks are important (Prendergast et al. 2010).

Heating and domestic hot water can be provided by several possible solutions. Compared to several other building components, such as roofs and windows, heating systems typically have a somewhat shorter lifespans and are thus more frequently replaced (Kemna et al. 2007a). However, this needs to be considered in the light of the market development and public acceptance of the most usual alternatives. Increased uptake of a new system may be the result of the increased acceptance of these new systems or the decreased acceptance of fossil-based systems. We consider here both factors influencing the following 'conventional systems' as well as ones influencing the diffusion of systems that reduce the amount of energy delivered (e.g. condensing gas boilers), the amount of primary energy demand (district heat based on CHP), or the amount of fossil fuels needed (biomass-based systems):

- Conventional/new: Fossil-based central heating systems refer to central heating systems[6] that are heated with gas, oil or coal. There are several more efficient alternatives here, such as condensing gas boilers. Fossil-based room heating systems include room-based gas, oil and coal burners.
- Conventional: Resistance electric heating refers to heat radiating from an electric coil within an electric radiator.
- Conventional/new: District heat[7] refers to heat produced at a central location and delivered from there to local customers. It can be produced with fossil fuels, from waste heat or waste

[5] Thermal renovation refers to measures taken on the building envelope, i.e., the integrated elements of a building which separate its interior from the outdoor environment (EPBD 2010).
[6] Concerning non-electrical heating, central heating refers to a system for heating a building from one source, which then sends the hot water or hot air around the building through pipes (Oxford Advanced Learner's Dictionary).
[7] District heat refers to the distribution of thermal energy in the form of steam, hot water or chilled liquids, from a central source of production through a network to multiple buildings or sites, for the use of space or process heating (EPBD, 2010/31/EC)

incineration, or directly from geothermal heat sources. However, the current interest in district heat relates to the possibility to use waste heat from electricity production (combined heat and power production), as well as to the possibility to integrate renewable energy sources.

- Coventional/new: Biomass-based room heating systems are usually wooden stoves, which are conventional in several regions. Biomass-based central heating systems are a newer alternative, which can use e.g. wood logs, pellets or wood chips.
- New: Heat pumps[8]: the most commonly used heat pump types used today are ground-source heat pumps, air-source heat pumps (including exhaust air heat pumps) and water-source heat pumps (EHPA 2011). These can be connected to a water-based central heating system (groundsource, air-to-water) or the heat can be delivered directly to each room (air-to-air heat pumps).
- New: Solar thermal systems refer to solar water heaters, which can also be connected to a central heating system if available.

In general, “alternative” systems such as district heat, biomass, solar thermal and heat pumps have seen positive market developments in recent years. These are due to the rising prices of conventional fuels and electricity, but also to policy support and the maturation of markets and technology. There are, however, also variations in adoption levels among countries that cannot be straightforwardly explained by policy support or technology cost developments (e.g., Weiss et al. 2009; Karteris and Papadopoulos 2012). A brief review of the heating systems examined and their recent market development is given below.

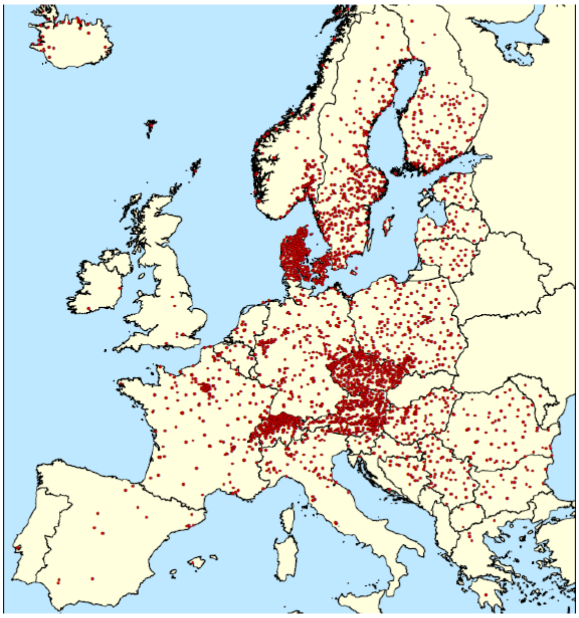
District heat is very recently highlighted in the Energy Efficiency Directive (Directive 2012/27/EU)[9], due to the possibilities to reduce the demand for primary energy by using combined heat and power production (CHP) and to introduce renewable fuels. District heating can thus reduce primary energy demand. On the other hand, very low energy buildings (e.g. nearly-zero energy buildings) might have such a low heat demand that the high investment required by the district heating system is not merited. Vice versa, in a renovation context, cheap district heat from CHP may reduce the cost-effectiveness of investments in thermal insulation.

District heating systems can to be found all over Europe today, but levels of expansion differ significantly between EU27 Member States (Figure 3.2). While district heat has national heat market share of between 40-60% in some Scandinavian and Baltic Member States, district heating systems are rare or almost non-existent in some of the larger European countries such as Germany and the UK. District heat currently covers 12% of the European heat market for buildings in the residential and service sector and is only available in about 6000 European cities or districts (Dalenbäck and Werner 2011). Unlike some of the other heating systems discussed here, the choice of district heat is not only the owners’ decision, but also depends on the availability of such a service.

[8] Heat pumps refer to installations that transfer heat from natural surroundings such as air, water or ground to buildings or industrial applications by reversing the natural flow of heat such that it flows from a lower to a higher temperature (EPBD 2010).

[9] The EED (2012) defines ‘efficient district heating and cooling’ as a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat; Member states are required to make a comprehensive assessment of the potential for district heat, and require accost benefit analysis of possibilities for combined heat and power production for all new or refurbished electricity installations.

Figure 3.2. Map of district heating systems (red points) in Europe.



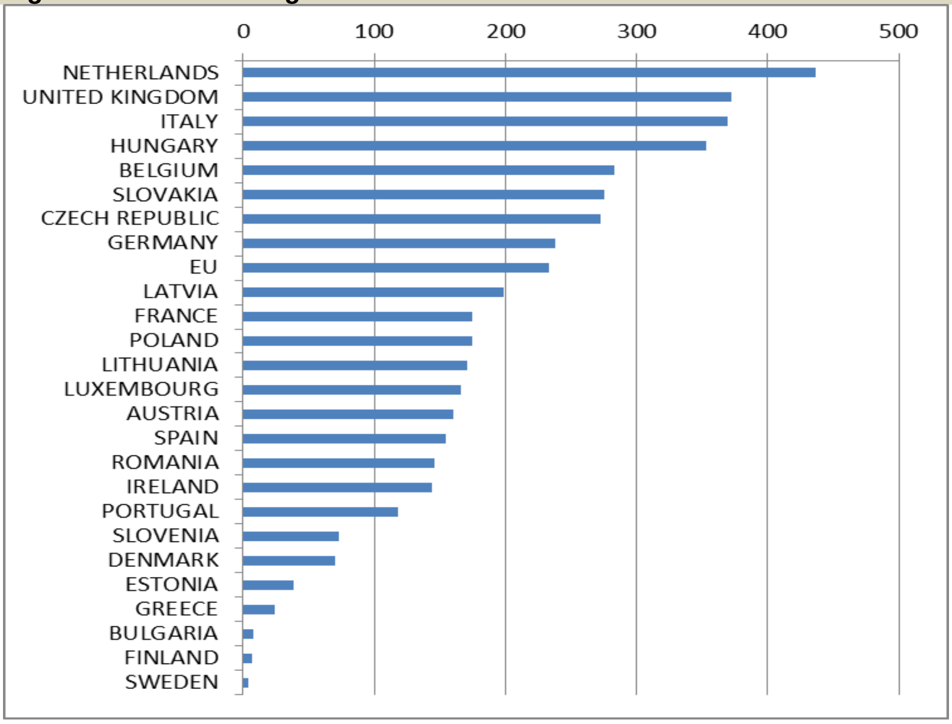
Source: Dalenbäck and Werner 2011. Data for Slovakia are missing.

Among **fossil fuels for heating**, natural gas is of greatest interest. However, similarly to district heat, the feasibility of natural gas solutions depends to a large extent on access to the gas distribution grid. There are great differences in the extent of this distribution grid in the EU-27. It is best developed in the Netherlands, Belgium, Italy, France, Germany and the UK, and has developed rapidly also in Spain, Portugal, Greece and Ireland (Griffin 2000). However, there are countries where the gas distribution grid for household heating is almost non-existent due to low population density or other geographical factors, or to competing investments in the district heating network (Griffin 2000). Figure 3.3 shows the number of gas customers/1000 inhabitants in the EU-27, which offers an indicative figure for the number of building owners using gas for heating[10]. Similarly to district heat, if gas is not readily available, heating solutions based on gas are not a very feasible option for the building owner (although liquid natural gas is fairly widely used in e.g. Spain and Italy and some other countries) (Kemna et al. 2007a).

Condensing gas boilers are a significantly more efficient type of gas boiler invented in the Netherlands in the 1970s, which are able to use the latent heat in of evaporation contained in the water vapour of flue gases (Weiss et al. 2009). After a slow start since their introduction in the late 1970s, their cost-effectiveness grew rapidly from 1999 onwards (Weiss et al. 2009). Their growth in market share is a continued trend (Kemna et al. 2007a), especially in the category of wall-hung boilers that do not require a separate boiler room. There have been several policy measures in the UK, the Netherlands, Denmark, Belgium, Italy, France and Germany to support or even prescribe the shift to condensing gas boilers.

[10] Natural gas can of course be used for industrial solutions such as a paper mill or a bakery, but in the countries with hundreds of gas customers, the large majority are domestic heating customers.

Figure 3.3. Number of gas consumers/1000 inhabitants in the EU-27.

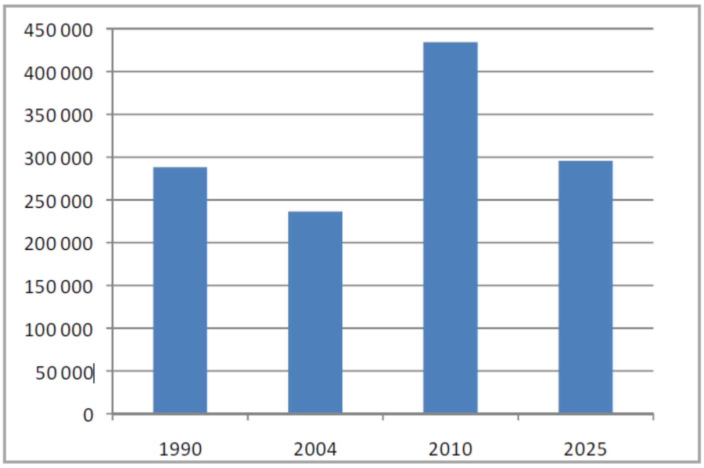


Source: Calculated on the basis of Eurogas (2012).

According to AEBIOM (2012), the most common **biomass fuels** for domestic heating are wood logs, wood chips and wood pellets. Wood pellets are gaining a rapidly rising share in many Member States e.g. Austria, Germany, Italy and France. This has reflected in the sales of solid fuel boilers (Figure 3.4), which was at its lowest in 1999 at about 160 000 pieces due to the fall in demand in countries of the former Eastern Block, but recovered to more than 300 000 pieces in 2007 (Bio Intelligence Service 2009). However, small-scale use of wood fuels in heating systems in Europe is currently concentrated in a small number of member states (predominantly Austria and Germany and, to a lesser extent, Italy, Finland, Belgium and France) (AEBIOM 2012).

Moreover, while growth has been significant from 2004 to 2010, market saturation is expected fairly soon, as only a proportion of homes can handle solid fuel (Bio Intelligence Service 2009). Until now, factors influencing the popularity of solid fuel boilers have been the price of fossil fuels, government policies such as subsidy schemes, fuel availability, environmental concerns and the functionality of the products.

Figure 3.4. Past and forecasted solid fuel boiler sales in Europe, pieces

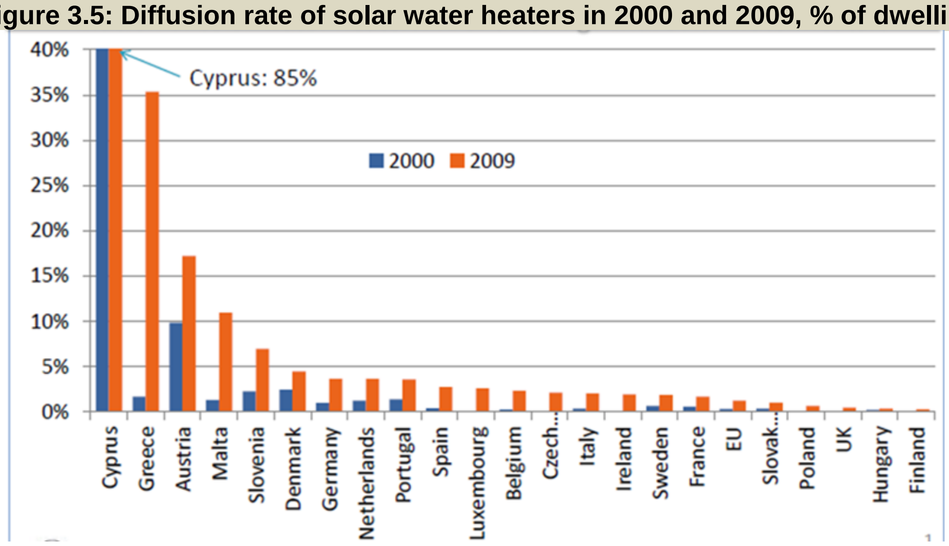


Source: Bio Intelligence Service 2009

The solar thermal market has grown by about a factor of three since 2000 (ESTIF 2012). The leading country is Germany, which amounts for slightly less than 1/3 of the installed capacity, whereas the subsequent top six countries, Austria, Spain, France, Greece, Italy and Poland, account for slight more than 1/3 of the market together, with the remaining 1/3 left to remaining 20 EU countries. The traditional market has been domestic hot water and heating for single-family homes. This has suffered from the economic downturn; however, large systems have seen continued positive development (ESTIF 2012).

Figure 3.5 shows that the diffusion rate vary greatly among countries. It grew significantly in many countries during the 2000s, but was still well below 5% in most countries. Policy support measures have always been important for the solar thermal market, although collective action by citizens has also played a major role in some countries (Ornetzeder 2001; Schaefer 2006). For example, ESTIF (2012) argues that political indecision has adversely influenced the market growth in 2011 in countries with low penetration rates of solar thermal, such as Portugal, the Czech Republic, Poland and the UK. On the other hand, reductions in subsidies in Germany since 2012 caused a significant market upsurge in investments in 2011.

Figure 3.5: Diffusion rate of solar water heaters in 2000 and 2009, % of dwellings with solar heaters

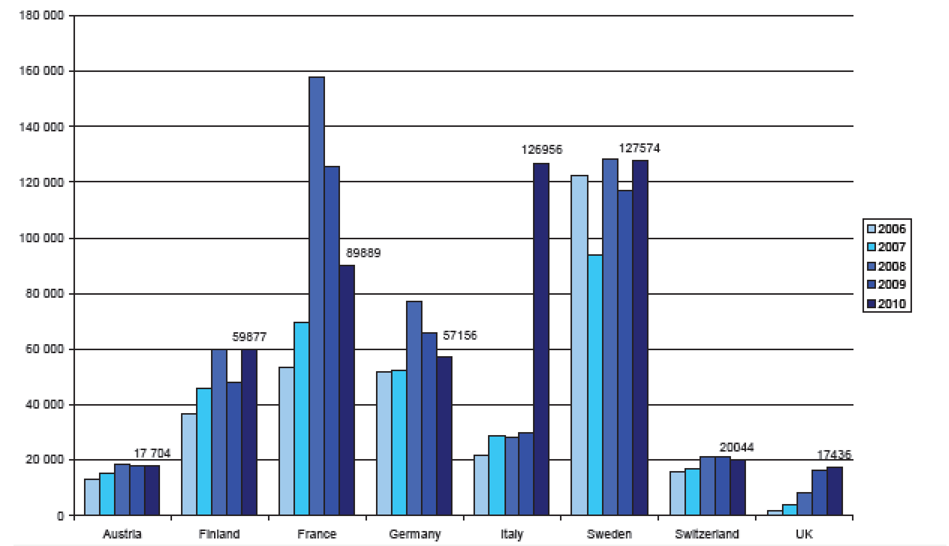


Source: Odyssee 2010

The installed capacity of heat pumps has increased rapidly since 2000 in several countries. In 2010, more than 750 000 units were sold in Europe (EHPA 2011). Internationally leading countries in Europe, apart from Sweden, are France, Germany, Italy and Finland (Figure 3.6). On a per capita basis, the largest numbers of heat pumps are sold annually in the Nordic Countries (European Heat Pump Statistics, Outlook 2011). However, this has been the result of a slow, but accelerating development. There has been a continued trend towards a shift from ground source to air source heat pumps in most markets, largely driven by the low and declining costs of air-to-air units. With the current slowdown in new build activity, the markets have shifted to the renovation sector (EHPA 2011).

According to EHPA (2011), the rapid expansion of the European heat pump sector in recent years has brought with it the typical changes and challenges of a growing market. The market, previously characterized by a large number of small manufacturers, it is now being integrated into the mainstream European heating, ventilation and air-conditioning market. A notable development in the European heat pump sector is the growing presence and expansion of the air conditioning manufacturers. The large oil and gas boiler manufacturers have also gradually established a position in the heat pump sector, leading to the emergence of a number of larger European 'Heating and Cooling Groups'. Increased competition has brought intense price competition, especially in the lower cost segments (EHPA 2011).

Figure 3.6. Heat pump sales (pieces, all kinds combined) in selected European countries, 2006-2010. .



Source EHPA (2011b) Heat Pump Statistics 2010 preview. Includes reversible air conditioners

Energy-efficient air conditioning and ventilation heat recovery: Air-conditioning systems refer to a combination of the components required to provide a form of indoor air treatment, by which temperature is controlled or can be lowered (EPBD 2010). Ventilation refers to the process of replacing air in any space to provide high indoor air quality. Often, air conditioning and ventilation are considered together: together, cooling and ventilation account for about 10% of energy end-user in an office building (Breligh et al. 2012). Examples of energy efficient systems include air handling units with low face velocity, energy efficient fans, good energy class filters, air-to-air heat recovery systems, demand controlled ventilation, well designed and balanced ductwork, variable load chillers, well dimensioned pumps, the use of variable speed drives for the motors of the above-mentioned equipment, as well as the effective use of solar shading (Brelight et al. 2012).

As concerns market development, natural ventilation is still dominant in the existing building stock, but various types of mechanical (exhaust or supply and exhaust) ventilation systems are now predominant in new buildings in most European countries (Litiu 2012). Industrial innovation and policy appear to be the main market drivers of ventilation heat recovery and energy efficient air conditioning (Kurnitski et al. xx; Seppänen 2012).

In general, the diffusion of air conditioning equipment is very different across Europe. The picture is further confounded by the fact that reversible heat pumps are included in statistics as air conditioning devices in some countries but not others (Pout and Hitchin 2008; EHPA 2009). Even though air conditioning represents only 10% of total electricity consumption even in the countries that consume the most, the average consumption per dwelling for this end-use is increasing (Lapillone et al. 2012a). However, the residential sector only represents about one-third of the air conditioning consumption by cooling capacity, whereas services are still a larger share (Pout and Hitchin 2008). While new air conditioners in 2009 were 30% more efficient than in 2002 in the EU (Lapillone et al. 2012a), there is still significant scope for improvement (Pout and Hitchin 2008).

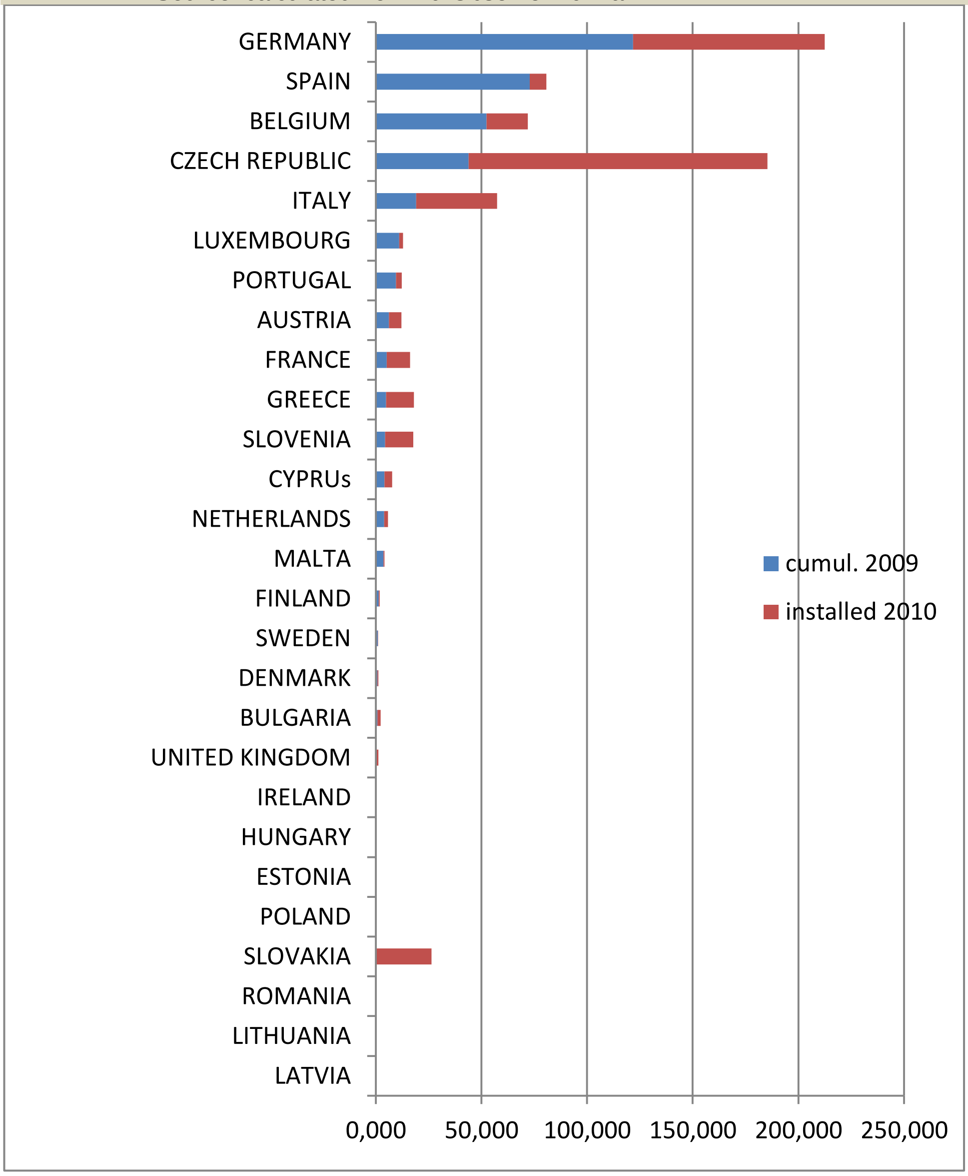
Electricity micro-generation[11], especially solar power production in buildings, has become an important element in nearly zero energy building designs, because modern low-energy buildings have a low heat demand and hence the share of electricity use becomes more important. This is a promising solution also because solar power microgeneration is increasingly popular. The total installed capacity of solar power has grown very rapidly in Europe (EurObserver 2011a), but still was not more than about 52 GWh, almost half of which was in Germany and one-fourth in Italy (EPIA 2012).

The development is strongly connected to government promotion schemes via favourable feed-in-tariffs, as well as to sharp declines in production and installation costs (EurObserver 2011a; Karteris and Papadopoulos 2012). While there are most likely relatively few barriers to acceptance in principle, as solar energy is European's favourite energy source (see Heiskanen et al. 2007), there are certainly several practical barriers – especially related to cost effectiveness and highly variable costs of installation – in several countries (Karteris and Papadopoulos 2012). There are also drivers that are country specific, such as incentive schemes (EurObserver 2011a), which have a significant influence on annual sales (see Figure 3.7).

[11] Electricity micro-generation refers to the small-scale generation of heat and electric power by individuals, small businesses and communities to meet their own needs, as alternatives or supplements to traditional centralized grid-connected power. In the following, building-applied solar PV is used to denote solutions that are connected to or integrate in buildings (rooftop systems, but also systems applied to building facades).

Figure 3.7. Cumulative capacity installed in 2009 and sales of solar PV panels (Wp) per 1 000 inhabitants

Source: calculated from EurObserver 2011a.



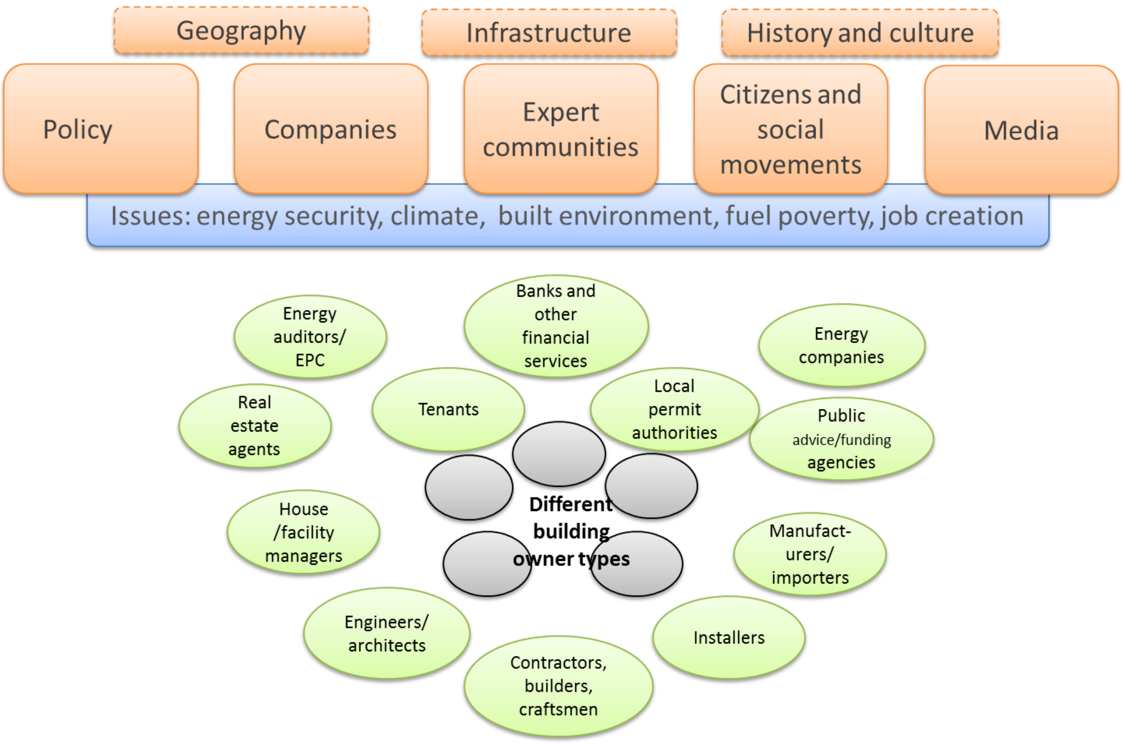
In conclusion, it is clearly visible that the level of acceptance and market adoption of various RES-H/C solutions varies greatly in different countries. This is partly explained by geographical, cost-effectiveness and policy factors, but not completely. The following sections focus on examining factors underlying these differences.

3.4 Public acceptance of energy efficient and renewable energy solutions in existing buildings: Drivers and barriers on the macro and micro levels

The drivers and barriers to the adoption of NZEB and RES-H/C solutions can be understood on different levels (Figure 3.8). On a *macro level*, we can focus on the role of policy, markets and other institutions like universities, expert communities, social movements and the media in pushing, pulling or obstructing certain technical solutions over the course of several years or decades. Moreover, we can look at various issues or concerns that drive (or obstruct) adoption, such as energy security, climate or preservation of the built environment.

On a more *micro level* of individual building renovation projects, these broader factors have their influence on the background; however, they combine in a particular way and are represented by particular stakeholders at a certain time and place to influence adoption of lack of it. Such micro-level factors can be particularly relevant when considering differences between different building and owner types. For example, even though a certain technology has made great progress in a country among a particular segment of the building stock, it may encounter severe difficulties when trying to enter another segment. Building owners are, moreover, influenced by different combinations of external stakeholders such as service providers, local authorities or tenants.

Figure 3.8. Macro and micro level factors influencing acceptance and adoption of nearly-zero energy and renewable heating and cooling solutions



Source: own compilation

Driving forces and barriers can also be different at different stages of the diffusion of innovative solutions (Prendergast et al. 2010). At the very early, demonstration stage, government support and subsidies are an important driving force, alongside innovative companies and building owners. Knowledge and competencies need to be developed, and high initial costs are major barriers. Experiences gained from early demonstration projects are important in the move from the demonstration to the growth stage: negative experiences can stop the diffusion process. In the growth stage, a larger number of players must be involved, including public sector building owners and mainstream construction companies, and a larger number of issues such as job creation and fuel poverty are salient. The availability and cost of easy-to-access and comprehensive services gains importance as the group of potential building owners grows. Moreover, not only specialist NZEB providers need to have knowledge and capacities, but also a large group of customers and suppliers.

In the following, drivers of and barriers to public acceptance of NZEB solutions are first briefly overviewed on the macro level. We then turn to a closer analysis of micro-level factors that influence acceptance by individual building owners.

3.3.1 Macro-level drivers and barriers to public acceptance of NZEB and RES-H/C solutions

Geography is naturally a macro-level factor influencing the practical feasibility and related market interest in particular solutions. It is self-evident that, for example, heating solutions are of greater interest in countries with cold climates and cooling solutions in countries with hot climates. Countries also have different endowments of natural resources like wood, hydroelectricity and various kinds of wastes like sawdust, which still today to some extent influence the relative prices of energy sources, the existence of domestic industrial competencies, and the amount of development effort devoted to related solutions. However, the objective availability of energy sources does not completely explain the amount of (e.g. policy or industry) effort devoted to certain solutions, as evidenced by the uneven historical development of e.g. solar energy in Europe (Heiskanen et al. 2007; Karteris and Papadopoulos 2012).

Infrastructure: The existing infrastructure influences the opportunities for applying NZEB and RES-H/C solutions. The most extreme example is, naturally, district heat, which building owners cannot adopt unless such a system is available. Moreover, the level of urban density, among other things, greatly influences whether it is profitable to build a heat distribution network. The availability of CHP-based district heat at low market prices also influences the cost-effectiveness of energy demand reducing measures to the building façade. Other major infrastructures influencing the possibility to install certain systems include the natural gas grid, which influences the convenience and cost of natural gas as a heating source, and the state of the electricity distribution grid, which influences the possibilities to deploy e.g. heat pumps (Singh et al. 2010) or grid-connected solar power systems.

Other relevant existing infrastructures relate to the age, size, structure and current condition of the building stock, or to the availability of central heating. In general, energy infrastructures exhibit a high level of path dependency (Lovio et al. 2011), which is not only due to cumulative investments in certain physical infrastructures, but also to related investments in knowledge, production skills and capacity, political power, market expectations, network effects[12], etc. Hence, it is difficult for new technologies to compete with the dominant technology, even if they hold large future potential or even once they become cost-effective (e.g., Weiss et al. 2009). However, problems with existing technologies (such as sharp rises in fuel prices or declining legitimacy) can also offer important opportunities for newcomers. From this perspective, problems in existing heating systems, such as rising or volatile fuel prices and overall decrease of legitimacy, can also boost the search for alternatives.

History and culture: It is well-established that expectations toward energy provision and use in buildings vary both historically and across cultures, even within Europe (Wilhite et al. 2000), as is shown, for example, in the variability of thermal comfort expectations in different countries (Chappels and Shove 2005). These differences are due to historical experiences, building traditions and building usage practices. Historical and cultural traditions can also influence how buildings and their renovations are typically governed and managed (e.g. traditions of co-ownership, traditions of self-renovation) (see Heiskanen et al. 2012).

West European countries have a long legacy of energy efficiency policy, which started during the first oil crisis in 1973. Starting in this period, most countries adopted RD&D policies, information and education, financial incentives and energy efficiency standards for buildings. In contrast, the countries that were closely linked to the former Soviet Union did not suffer from a similar fuel shortage. Hence, energy efficiency policy is more institutionalized in the west. Energy awareness and concerns over e.g. fuel poverty have, however, emerged strongly over the recent years (Tirrado-Herrer and Ürge-Vorsatz 2011).

[12] network benefits grow as increasing numbers of users adopt the technology.

There are also diverse historical experiences of particular NZEB solutions. These can be positive and self-reinforcing, such as the recent history of bioenergy in Austria (Späth and Rohracher 2010) or negative, such as poor historical experiences of early heat pumps (Jakobs and Laue 2010) and solar thermal installations (Philibert 2006) in the pioneering countries. Such experiences can influence which solutions are considered feasible (what is included in the decision set) or which solutions are 'officially endorsed'.

The existing share of (mainly new) nearly-zero energy, zero-carbon or passive houses in a country can be one such factor influencing overall awareness and acceptance (Prendergast et al. 2010). Elswijk and Kaan (2008) examined the market penetration of passive houses in Europe in 2005. They noted that passive houses have a wider (though still very initial) market penetration in Germany and Austria, followed by Belgium, Sweden, Switzerland and France. Other countries were at that time at a very initial 'preparation' stage, at best.

Policy is clearly a driver for the adoption of particular solutions. For example, Kiss et al. (2010) identify interventions to address energy saving potentials in the building sector as one of the three main factors influencing the demand for insulation materials over the past decades in Germany, the UK and Sweden. This includes legislation – which in the case of insulation and most other solutions has until now mostly pertained to new buildings – but also various kinds of financial support and incentives (Kiss et al. 2010). The crucial role of policy measures is visible in the discussion above concerning particular technologies (such as pellet boilers or solar power), where support schemes have had a crucial role in opening up markets.

Financial incentives and informative policy measures can be particularly important at the early stage where technologies and markets are immature. For example, Heimdal and Bjørstad (2009) stress the importance of demonstration and technology procurement projects to highlight innovations at the stage when technologies are immature. Immature *markets,* in turn, can be developed by support schemes, whereas e.g. recommendations lists and labeling schemes are relevant for mature markets. From a European perspective, this is an interesting notion since the level of maturity of both combinations of technologies represented by NZEB and the level of maturity of markets even for mature technologies like solar heaters vary greatly between different countries.

Until now, policy efforts to promote comprehensive NZEB renovations including a combination of technologies have mainly been limited to demonstration projects. Recent commentators (e.g. Prendergast et al. 2010; Killip 2011) have discussed the possibilities for market transformation (i.e., simultaneous shaping of both supply and demand) in advanced building renovation. However, the starting points for such proposals are diverse. Common points include the widespread provision of well-coordinated training and quality control mechanisms, and a continual revision of energy standards, which could involve an ongoing upscaling of best practices from demonstration projects (Prendergast et al. 2010; Killip 2011). These factors (quality labels, existence of new nearly-zero energy buildings or passive houses) could serve as indicators of countries that are on a clear growth path, where acceptance is spreading from innovative pioneers to early mainstream markets.

An important aspect of policies to promote nearly-zero-energy and renewable heating and cooling solutions are their consistency. This depends on the *political* aspects of policy making. It is likely that nearly-zero energy solutions gain more political support if they can convincingly offer other benefits than "merely" climate change mitigation, since politicians might not seriously believe that they can solve the problem of climate change (see Heiskanen et al. 2009). Smaller, more local and more 'solvable' problems like fuel poverty and job creation can serve as arguments and issues that maintain consistent political support for the necessary policy measures (Prendergast et al. 2010).

Markets and companies are naturally important drivers of new solutions, since solutions cannot adopted unless they are readily available in the market. Most of the solutions discussed above are indeed in principle available throughout Europe. However, the relative availability of different solutions, and the practical feasibility of selecting them, is perhaps the more important factor from most building owners' perspectives. This is less critical and variable for components like insulation materials or solar panels, but the differences in the cost and quality of design, planning and installation services can vary quite significantly from one country to another (Palm and Neij 2012).

Standard economic theory suggests that investments are made in energy efficiency when the marginal benefits of the investment exceed the marginal costs of the investment. While this is usually not the case due to the "energy efficiency gap" (see Heiskanen et al. 2012), the price of energy naturally influences both the level of policy concern and the private profitability of energy efficiency investments in buildings. The variation in consumer prices of electricity and fuels in Europe is quite significant, with e.g. natural gas prices ranging for 3 to almost 12 cents/kWh and electricity prices ranging from about 9 to about 30 cents/kWh (see Annex 2).

Technological learning is an important factor that influences the development of the availability and cost of various NZEB solutions (Kiss et al. 2010; Weiss et al. 2009; Prendergast et al. 2010). As a result of technological learning, the prices of various solutions decline over several decades and new technologies become competitive with old ones – one example is the declining installation cost of solar photovoltaic power as market volumes grow (Eurobserver 2011a). Because technological learning takes time, subsidies might be necessary over several year, even a decade or more (Weiss et al. 2009).

Many authors, however, stress the fact that the competencies of the construction industry are fragmented (Nösperger et al. 2011). Construction companies are often claimed to be conservative; there are self-reinforcing tendencies to use familiar products and familiar technologies (Killip 2011). This is because solutions usually need to be fairly simple and quick to implement, replicable, affordable, reliable, cost-effective, readily available, guaranteeable and profitable before mainstream companies are willing to consider them. The existence of well-established large companies that are market leaders offering certain solutions can be relevant indicators for their entry into the mainstream market (Moore 2002).

Expert and professional communities, such as universities, consultants and professional associations have an important role in introducing and mediating new ideas such as those represented by NZEB and RES-H/C (Raven et al. 2007; Geels and Raven 2006; Ornetzeder and Rohracher 2009). However, these same expert groups may also be major reproducers of old ideas which maintain the existing structures (Janda 1999). According to Nösperger et al. (2011), today's system of building professionals fails to address the issues of low-carbon (or nearly-zero energy) refurbishment, since it does not fall within the domain of any existing profession and requires co-operation among several professions.

There are not many studies of how expert communities in general perceive issues related to NZEB and RES-H/C, but where they have been investigated, quite large controversies or at least differences in views have been documented, at least in some countries (Stenberg and Räisänen 2006; Koch and Buser 2012; Mlenick et al. 2012). Hence, a lack of consensus on what is best practice in NZEB and RES-H/C (especially in a refurbishement context) can be a factor obstructing public acceptance and creating uncertainty and confusion also among the general public (Heiskanen and Lovio 2010; Killip 2011). Such issues like the longstanding existence of voluntary but widely accepted standards or certification schemes might serve as one possible indicator of the level of consensus on appropriate NZEB and RES-H/C solutions in a country (see e.g. Bullier et al. 2011; Wahlström et al. 2011; Kientzel and Kok 2011).

Citizen and social movements: Apart from formal policies – and usually, before such formal policies mature – various types of social and entrepreneurial movements have put their stamp on national perceptions of sustainable energy solutions. Examples include the role of citizen movements for solar water heaters in Austria (Ornetzeder 2001) and Barcelona, Spain (Schaefer 2006), and the importance of the construction of networks among proponents of the new solutions in the development of the solar PV and wind tubine industries (Jacobsson and Bergek 2004; Jacobsson and Lauber, 2006; Karnøe and Buchhorn, 2008). Such movements create legitimacy for the new solutions before and while they are promoted by public policy. This type of legitimacy may be one of the reasons why similar policies might have uneven effects in different European countries.

Media: The role of the media has not been examined in many studies yet; however our experience and the evidence collected for D2.4 (see Heiskanen et al. 2012) suggest that the media has an important role not only in raising awareness of energy issues and the need for renovation, but also in highlighting particular issues. In this respect, the media do not always promote acceptance, but can also fuel controversies, as shown in studies concerning the image of green buildings in the trade press of Swedish building professionals (Glutch and Stenberg 2006), as well as the image of solar power in the Spanish daily press (Heras-Saizarbitoria et al. 2011). Since there is very limited research in this area and media coverage can be either positive or negative or both (see Sengers et al. 2010; Skjølsvold 2012), the amount of media coverage itself cannot be used as an indicator of public acceptance, but such indicators could be developed in the future.

3.3.2 Drivers and barriers on a micro level

As described above, the factors operating on a more macro level naturally also have their influence on the micro level, but they combine in different ways in the different particular circumstances of specific renovation projects. In practice, this difference can be seen in the differences between the barriers experienced by different kinds of building owner groups, as shown in Heiskanen et al. (2012):

- For owner-occupied single-family homes, the decision to adopt energy efficient or renewable energy solutions is in principle simple, as the owner makes decisions on their own. However, the notion of a 'comprehensive renovation' is not familiar to single-family homeowners in most countries; in contrast, renovation is an ongoing and largely do-it-yourself process. The small scale rarely enables the contracting of outside planning professionals. High initial costs and lack of access to capital are widespread barriers, whereas improved comfort, energy cost savings and the availability of widely used solutions are common drivers for renovations. It is worth noting, however, that this segment is highly heterogeneous in most countries, including both the richest urban and often the poorest rural households. It is hence probably likely to host the most innovative pioneers but also the buildings that will never be renovated.
- For owner-occupied multifamily buildings, decisions about energy renovations are greatly hampered by organizational difficulties of reaching agreement on the need to take measures and on the type of measures to be taken. The share of owner-occupancy among multifamily buildings varies greatly, with the lowest rates in Germany (24%) and the highest in Spain (94%) and Romania (96%). The more widespread owner-occupied multifamily dwellings are, the more diverse the socioeconomic background of the inhabitants. When this is coupled with high majorities for reaching decisions concerning renovations and difficulties in raising collective finance, the barriers to energy renovations are extremely severe.
- Rental dwellings are extremely diverse in Europe. Some countries have a relatively large share of rental single-family homes while this segment is extremely small in other countries. In many countries, a large share of the entire rental stock is owned by private, individual landlords owning one or two properties. Conversely, the share of professionally owned rental apartments (including social housing) varies greatly by country. In countries where social housing is very rare (Central and Eastern Europe and South Europe), these buildings are particularly problematic, as they only house the poorest people, and there are legal and practical constraints on adding any of the renovation

costs to the rent. However, in countries where there is a large and well-established professional rental sector, social housing providers can be the forerunners in solutions for multifamily buildings.

- Public buildings are very diverse. Common barriers throughout Europe and across public building types are the existence of separate budget lines for investments and running costs. Another particular set of problems relates to public procurement rules. However, public buildings are also expected to serve as an example, and individual public buildings do serve as visible demonstrations of exemplary solutions.
- Office buildings appear to be more similar to one another across countries. They differ from the other building types discussed here insofar as space and water heating are relatively less important than in other building types, and cooling, ventilation and lighting are more important. Office building owners usually apply sophisticated investment calculus methods and energy efficiency or RES solutions have to compete with other, more productive uses of capital. This said, office buildings have often been pioneers in new technologies and can be important and visible sites for NZEB renovation demonstrations.

It is also important to recognize that barriers and decision criteria are not necessarily the same for different solutions. For example, a review by Neij et al. (2009) suggests that comfort, timing, aesthetic factors and investment costs and cost savings are important determinants for investments in the building envelope, whereas investments in HVAC equipment are more related to capital cost and technical performance, comfort and branding. Particular technologies can also have particular problems, at least in some markets. For example, biomass boilers have a somewhat ambiguous image in several countries (Rohracher et al. 2004; Heiskanen et al. 2007; Alasti 2011), partly because of contradictory messages on environmental impacts and partly also because the term “biomass” does not convey a clear message of the fuel used (Alasti 2011).

In order to illustrate some of the factors influencing customer acceptance of diverse NZEB and RES-H/C solutions identified in previous research across Europe, a selection of studies is presented in Table 3.1. This table focuses on studies conducted in the EU-27 and preferably fairly recently (some early 2000s studies are included where none others were available on the particular topic). General studies focusing on thermal insulation in general or unspecified ‘energy renovation’ are not discussed here. They are reported in great detail in D2.4, and discussed briefly below in Table 3.2.

Table 3.2. Studies on factors influencing the adoption of various NZEB and RES-H/C solutions

Type of solution	Country	Type of owner	Factors identified as influencing acceptance and adoption	Reference
Low-U-windows	SE	single-family homeowners	need to replace windows, recommendations by external experts, especially window sellers/installers (often did not want to recommend low-energy windows due to condensation concerns)	Nair et al. 2011
Renewable heating systems	DE	diverse residential	lifestyle: high-income, young, educated and unconventional "modern performers" were more likely to prefer renewables (especially solar heat and district heat) than the middle class	Gröger et al. 2011
Renewable vs. fossil heating systems	DE	single-family home owners	Factors influencing choice: environmentalism (pellet boiler), economic aspects, practical issues (availability, storage, etc.)	Decker et al. 2009
Renewable vs. fossil heating systems	SI	diverse residential	Rural households more likely to use solid fuels or oil; urban households gas. Socio-economic and demographic variables do not explain choice of green heating system (solar or heat pumps), but region does to an extent	Zoric and Hrovatin 2012
Renewable vs. fossil heating systems	FI	detached homeowners	Overall preference for groundsource heat and district heat. Loyalty to existing heating system creates choice inertia. Criteria depend on system, but initial cost, operating cost, reliability, fuel price stability and environment important.	Rouvinen and Matero 2012
Renewable heating systems	SE	single-family homeowners	Price of electricity, investment subsidies and personal recommendations main motivator; cost of heating, investment costs and functional reliability main concerns	Mahapatra et al. 2009
Renewable heating systems	DE	diverse residential	Costs aspect, attitude toward heating system, government grant, independence, environmental concern, comfort, peer influence (some of these differently for different systems)	Michelsen & Madlener 2011
Renewable heat & power	UK	diverse residential	Choice experiment/WTP: initial cost dominant (payback time of 3-5 years), recommendations by engineers and friends would influence choice, concerns: disruption, storage space	Scarpa & Willis 2010
Renewable heat & power	IE	home owners	Stated preference/WTP: payback time acceptance varies by technology (pellet boilers 7 yrs, solar PV 8.5 yrs, micro wind 10 yrs., solar thermal 13 yrs.) Energy cost savings, independence and environment most important benefits	Claudy et al. 2011
Heat pumps	UK	social & owner-occupied	Role of surveyor, installers, availability of alternatives, availability of sufficient electric power, installation and maintenance issues, affordability, comfort	Owen et al. 2012
Ground source heat pumps	UK	mostly single-family home owners	Drivers: carbon dioxide emissions, fuel bills, lack of access to gas grid, compatibility with existing building systems, well informed; Concerns: Initial cost, performance, reliability, disruption to garden	Roy et al. 2008
Air-source heat pumps	DK	single-family home owners	Drivers: Electric resistance heating as original heating system, financial savings, energy savings, improve comfort, reduce pollution	Christensen et al. 2011a
Solar thermal	UK	mostly single-family home owners	Drivers: carbon dioxide emissions, fuel bills, low risk, affordability; Concerns: Initial cost, payback, relative advantage, reliability, incompatibility with building systems	Roy et al. 2008
Solar thermal	DE	solar owners and non-owners	Different drivers along the diffusion curve: Owners wealthier and more ecologically motivated, peer example important for those 'planning' to adopt, knowledge and environmental concern important for those 'interested'	Woersdorfer & Kaus 2011
District heat	UK	diverse, mostly residential	Reliability of heat supply, cost, contract flexibility, environmental impact; concerns about lock-in	Upham & Jones 2012
District heat	SE	detached home owners	Criteria: cost of heating, investment cost, reliability, indoor air, secure fuel supply, automation, environment, value of property. Change in perception of DH on these criteria achieved via regional marketing combined with national investment subsidy	Mahapatra & Gustavsson 2009
Wood boilers	UK	mostly single-family home owners	Drivers: carbon dioxide emissions, fuel bills, lack of access to gas grid, own wood available. Concerns: purchase price, effort to source and use fuel, incompatibility with building system, lack of space, reliability	Roy et al. 2008
Small self-assembly microgen (solar, wind)	SE	single-family homeowners	Environmental consciousness, set an example to others, or to protest against "the system" and achieve a degree of self-sufficiency.	Palm & Tengvard 2011
Solar power	UK	single-family homeowners	Different for 'early adopters' (environmentally driven) and 'early majority': for the latter, costs, cost effectiveness and aesthetics limit adoption	Faiers, Neame 2006
Own power (unspecified)	NL	diverse residential	Environmental concern, affinity with technology, affinity with energy and poor perceived reputation of energy companies main drivers for intention to produce own power. Older households less likely to want own power.	Leenheera et al. 2011
Mechanical ventilation	AT	single-family and multifamily buildings	Multifamily building dwellers more negative (lack of involvement in design), problems with noise, opening of windows, air heating systems, dry air, constant and even room temperatures	Rohracher & Ornetzeder 2002

Considering the existing body of research, it is noteworthy that there is much more research on building users' acceptance of particular RES-H/C solutions, especially heating systems, from Germany, Sweden and the UK than from other countries. Another noteworthy factor is that there is more research on single-family home owners than on other types of building owners. This is fairly natural from a marketing perspective (single-family homeowners are certainly the largest group purchasing new heating systems), but data on acceptance of mechanical ventilation in Austria (Rohracher and Ornetzeder 2002) suggest that multifamily homeowners and tenants might be less likely to accept new solutions; partly because they usually are less involved in the choice and design of such systems.

Another factor worth noting is the great diversity in the research designs. There are two basic approaches: one is to explain the existing heating system choice via various factors (i.e., why people chose the system that they have), the other is to ask people what they would choose or prefer or how much they would be willing to pay for particular systems. Considering that most studies are quantitative, the design of the study defines which results can be obtained. For example, some questionnaires included a large number of questions concerning environmental drivers (and usually found this then to be relatively important), whereas other studies asked more about other factors such as costs and convenience, and hence obtained more results concerning them.

Some general tentative conclusions, however, which can be drawn from the studies are that:

- Drivers for people choosing "innovative" systems are different than for ones that have become conventional. However, what is an innovative system depends on the country context. Heat pumps are not innovative in Sweden but are in innovative in Germany, whereas the situation is probably vice versa for solar power. People choosing innovative systems are driven by environmental considerations and interests in the technology and its particular benefits (Faiers and Neame 2006; Woersdorfer & Kaus 2011; Leenheera et al. 2012). They are usually younger, more educated and wealthier than the population at large (but this could depend on the purchasing price of the innovative system, which is usually high at this stage).
- Costs, convenience, perceived risks and peer influence play a larger role for the mass market. There is also data suggesting that initial costs are particularly important for low-income households, whereas middle-income households would usually consider the heating cost savings as well, and the wealthiest are not sensitive to costs. Social influences (media, advice, recommendations by installers or friends) appear to be important for the majority of owners.
- The studies (which reflect prosperous West and North European contexts) indicate that single-family home owners' required rates of return for heating systems vary from 12% (Cayla et al. 2011, heating systems in general), to 16% (for groundsource heat) and 22% (for wood pellets) (Rouvinen and Matero 2012) to 34% for diverse renewable solutions in the UK (Scarpa and Willis 2006). There are differences both between countries and among the different solutions. It seems that when the solutions are perceived of as innovative and risky, mainstream consumers require higher rates of return than for more conventional and packaged systems.

Certain technologies involve particular risks, concerns or constraints (e.g. Roy et al. 2008). These include e.g. fuel storage for all kinds of fuels (especially biomass), disruption of the property and garden (groundsource heat, district heat connections), and concerns about dependency on a single provider (district heat). Moreover, concerns may be quite different in different countries. For example, Austrian households were unhappy because air heating systems offer an even heating level throughout the home (Rohracher and Ornetzeder 2002), whereas in some other countries, even indoor temperatures are a desirable characteristic. Moreover, survey studies do not always reveal all constraints or concerns related to particular technologies. Additional constraints or concerns raised in other types of studies relate to e.g.

permitting problems and time-lags (ECORYS 2010), concerns about indoor air or mould in low-energy buildings (Heiskanen and Lovio 2010), or historical experiences of quality problems in certain heat pump markets (Jakobs and Laue 2010).

Several studies suggest that novel solutions, especially heating systems, also have different regional diffusion patterns within a country. These patterns cannot be explained merely in terms of climate but also through history and industrial structure, and perhaps the influence of neighbouring countries as well. Many studies stress the importance of social influence, in terms of recommendations from friends, neighbours or installers having an influence on (at least some households') decisions (Woersdorfer & Kaus 2011; Sopha et al. 2010; Schelly 2010). For example, the most detailed quantitative estimate available from California, suggests that an additional solar PV panel installation increases the probability of an adoption in the area code by 0.78 percentage points (Bollinger and Gillingham 2012)[13]. However, the strength of the regional effect seems to suggest a broader 'network effect', which is not only mediated by direct recommendations or imitation, but also through the development of local visibility and competences and local service markets (Ornetzeder 2001; Rohracher 2001).

The emerging evidence concerning the role of the 'neighbour effect' can be due to several different factors (Axsen et al. 2012). However, one important aspect is the concept of triability, which is one of Rogers' (1995) factors influencing the diffusion of innovations. Investments are usually not triable (reversible). Hence, few people are likely to invest in systems that they have never seen and experienced themselves. Most people also understand that systems do not necessarily work in real life in the same way as they do in labs or showrooms; hence, the critical importance of real-life examples (e.g. Hamilton 2011).

Some of the more thoughtful qualitative studies take into account that the choice of a heating system is not made in a void, but in relation to the current situation of the building owner, the condition of the building and the available alternatives[14]. For example, Owens et al. (2012) have examined the special needs of elderly people (this particular aspect is highlighted in some other studies, as well). Elderly people are usually not particularly innovative. However, they may benefit greatly from the replacement of boilers and burners with other systems that do not require cleaning (Mahapatra et al. 2009; Owens et al. 2012). Hence, their needs may be an important factor in the mainstream market (Prendergast et al. 2010).

Studies also reveal the crucial role of various stakeholders in influencing building owners:

- **Installers** are often the main source of information for building owners, and their recommendations have significant weight in the choice of several building systems or components (e.g. Kemna et al. 2007; Nair et al. 2011; Scarpa and Willis 2010; Owen et al. 2012). However, the role of installers does not appear very positively in studies on the replacement of building components or systems. For example Nair et al. (2011) found that installers often discouraged their customers from installing windows with a low U value, whereas Kemna et al. (2007b) report that installers of replacement boilers (at least previously) tended to be conservative and harbored myths and misperceptions about condensing gas boilers.
- Energy Performance Certificates (EPCs) have been expected to make a large difference, e.g. by influencing consumers' renting or purchasing decisions, which would suggest a large role for **certificate providers and e.g. real estate agents**. However, a recent European study (TIghelaar et al. 2011) suggests that the current impact of EPCs during home purchasing is low, partly because EPCs have not until recently been required in several contexts. Real estate agents play a crucial role

[13] Nolan et al. (2011) have another example from the US of advanced HVAC systems, in which adoption in a neighbouring block increased the likeliness of adoption (all other things being equal) by 3,4%.
[14] Psychological studies and choice experiments rarely take into account such contextual issues but treat all kinds of choices (e.g. purchase of heating system vs. washing machine vs. car) as if they were the same.

in presenting the EPC, but not always a positive one (e.g. playing down its accuracy). However, while home improvements are usually motivated by other factors, recommendations in the EPC seem to help in raising awareness of some energy efficiency options. We were not, however, able to find research on the extent to which EPC recommendations help in selecting e.g. heating systems.

- Several studies have examined the role of various kinds of **advice, technical support or funding** programmes (e.g. Michelsen and Madlener 2011; Mahapatra et al. 2011; Steinestel et al. 2009). These can be particularly important when building owners are aware of the need to renovate or replace building components, but there is significant uncertainty of what are the best solutions for each site, which leads to delays and inertia (Heiskanen and Lovio 2010). It is worth noting that there are large differences in the availability of unbiased, third-party advice in Europe (Serenade 2007), which may result in different capacities to identify, compare and select solutions.
- **Energy companies** can have a role in mainstreaming NZEB and RES-H/C solutions, e.g. via energy efficiency obligation schemes and feed-in-tariff schemes. For example, alongside insulation, also heating systems (boiler replacement) and other renewable energy technologies are offered in the energy efficiency obligation schemes of several countries (IEA DSM 2012).
- **House managers** or residents' boards might have a significant role in multifamily buildings, but especially heating system or other renewable energy choices have not been studied much in this type of context. Nor does there seem to be much research on the choices of rental housing providers or public building owners, which could play an important role in mainstreaming advanced renovation solutions (Prendergast et al. 2010).
- **Banks** are an important source of finance even for conventional renovations and improvements such as heating system replacements. Private finance is absolutely critical for mainstreaming energy efficient and renewable heating/cooling solutions (T'Serclaes 2007). Endorsement by retail banks could also be an important way to create public acceptance of NZEB and RES-H/C solutions among more conservative building owners (Prendergast et al. 2010). Several countries offer dedicated credit lines for e.g. energy renovations and renewable energy investments (see Heiskanen et al. 2012; Atanasiu et al. 2013). However, it is important to recognize that such credit lines are not available in all countries, and that the cost and availability of capital for different types of building owners varies greatly among European countries, especially in the current economic crisis.

It is likely that the role of service providers grows when innovative solutions start to enter the mass market. The innovators and early adopters are more likely to make efforts to find new solutions, but latecomers are more likely to rely on solutions that are readily available (Prendergast et al. 2010). Hence, the knowledge level and awareness of e.g. engineers or architects, craftsmen, installers, etc., as well as real estate agents, house managers and maintenance service providers can influence the acceptability and actual adoption of new solutions.

Another factor that is likely to gain importance is quality assurance, monitoring and verification of savings, which was also highlighted in some of our expert interviews (see Heiskanen et al. 2012). There is a great deal of discussion on whether technically possible promised savings are realized due to execution of the renovation, due to maintenance and use, and due to user behavior (e.g. Killip 2011; Mlecnik et al. 2012). Guarantees and insurance products may also be important for individual appliances, such as new heating systems. Mainstream consumers are not likely to accept even unlikely risks, and the risks of new solutions usually gain much more attention than the risks of old ones (Jakob 2006).

3.3.3 Summary

Table 3.2 presents a summary of the previous chapter. In the first column, the most important barriers and drivers of energy renovation in general are summarized, based on Heiskanen et al. (2012). It is important to note that, as stated above, these barriers and drivers vary by building owner group and country. Table 3.2 is thus a gross simplification. The second column summarizes the 'macro' factors discussed above, which pertain to the country and regional context and might vary systematically among countries. The second column below highlights some of the technology-specific factors identified above in section 3.3.2 as factors influencing owners' decision making on the micro level of individual renovation or renewal projects.

Table 3.2. General, context specific and technology specific factors influencing public acceptance and adoption of nearly-zero energy and renewable heating and cooling solutions

General factors	
Initial cost, cost-effectiveness	Organizational barriers
Energy cost savings	Access to capital
Improved comfort	Availability of widely used and recommended solutions
Occasions for renovation	Availability of quality service
Context specific factors	**Technology specific factors**
Geography: climate, natural resources, industries	Different decision criteria for early adopters of innovative technologies (environment, technology attraction) than for latercomers (more cost and convenience driven)
Infrastructure: building stock, energy systems, compatibility of new solutions	Different financial valuation for technologies, with higher payback expectations for technologies perceived of as riskier
History and culture: Traditions of building governance, institutionalization of energy efficiency policy, good and bad experiences of solutions	Social and regional influence strong in growth phase: adoption by neighbours increases likelihood to adopt
Policy: legislation & financial support, effectiveness of policy, political support (other than climate arguments)	Particular concerns and constraints related to particular technologies (e.g. inconvenience, space requirements, perceived performance risks, permitting issues)
Markets and companies: availability and cost of solutions vs. cost of energy; established large companies offering solutions	Role of stakeholders e.g. installers for windows and HVAC, financial institutions for expensive solutions
Expert and professional communities: level of integration and consensus	Importance of auxiliary services like finance and guarantees for mass market adoption
Citizen and social movements: legitimacy and public support	
Media: public information and contoversies	

Source: Own compilation

The following section turns to a more detailed analysis of public acceptance and adoption of nearly-zero energy and renewable heating and cooling solutions in four parts of Europe. We place a special focus on the ENTRANZE target countries, but offer some information also on other countries for the purpose of the modeling to be conducted in ENTRANZE WP4.

4 Trends, drivers and barriers in Western Europe

This large group of countries accounts for 50 % of EU-27 population and spans in the area of more than 1 331 190 km^2 (31% of EU-27) from the west coast of Ireland to the eastern border of Austria. However, a chacteristic that is common to many countries in this group is the historical presence of relatively forceful energy policies, many of which have been in place more or less since the energy crises in the late 1970s. In particular, support for renewable heating and cooling has a relatively long tradition among this group of countries, though some countries have been more consistent and successful than others in their efforts.

The Western European countries show important differences in the structure of dwelling type and in the structure of tenure type, however (Table 4.1). In Ireland, United Kingdom and in the Netherlands, almost 90 % of all dwellings are single-family dwellings. In France, Belgium, Austria and Luxemburg, on the other hand, circa one third of all dwellings are multi-family dwellings.

Tab. 4.1: Dwelling stock by dwelling type in West European countries

	AT	FR	DE	BE	NL	UK	IE	LU
Single-family dwellings	63	69	60	64	89	88	93	64
Multi-family dwellings	37	31	40	36	11	12	7	36
Total	100	100	100	100	100	100	100	100

Source: ENTRANZE database www.entranze.eu

A consideration of the dwelling stock by tenure type in Western European countries reveals quite large differences between countries (Table 4.2). In all of these countries at least a half of the dwellings are owner-occupied. Only in Germany the share is 46 %. In Belgium, Luxemburg, United Kingdom and Ireland about three out of four dwellings are owner-occupied. In Germany, the most dominant type of tenure is private rental dwellings by a share of 54 %, which differs a great deal from the other Western European countries. In other countries the share is less than one third. In the Netherlands, the share of social rental dwellings is the highest of these countries. In other countries the share is less than 20 %. Hence, the landlord-tenant dilemma is likely to have a quite different level of relevance in the different countries[15].

Tab. 4.2: Dwelling stock by tenure type in West European countries

	AT	FR	DE	BE	NL	UK	IE	LU
Owner-occupied	49	58	46	73	52	73	70	74
Private rental	31	23	54	19	12	9	18	19
Social rental / other	20	19	0	9	36	18	12	7
Total	100	100	100	100	100	100	100	100

Source: ENTRANZE database www.entranze.eu

[15] These considerations are quite interesting in the light of an empirical study conducted in Germany in 2006. According to the study (Rehdanz 2006) household expenditure for heating and hot water is significantly lower for owner occupied accommodation. At least in Germany, those households have suffered less from increases in energy prices compared to those in rented accommodation. This result was explained by the suggestion that home owners are more likely to have invested in energy-efficient heating and hot water supply systems.

Contrary to the previous aspects, there are not very large differences between the Western European countries when it comes to socio-economic characteristics of the building owners. The average income PPS/capita in relation to EU-27 average (=100%) is in all of these countries well above the average, only in Ireland around the average (see Table 4.3). The richest country is Luxemburg followed by Germany, France and Austria. When considering the share of low income households among owner-occupants, there are some differences among the Western European countries: they are more common in the UK and Ireland than in the other Western European countries. This has significant implications to citizens' financial ability to engage in refurbishment activities of their homes.

Tab. 4.3: Socio-economic characteristics of building owners in West European countries

	AT	FR	DE	BE	NL	UK	IE	LU
Average income PPS/capita in relation to EU-27 average (=100%)	119	120	121	114	109	115	103	147
Share of low-income households among owner-occupants, %	9	9	8	10	6	14	13	9
Gross household savings rate 2010, %*	13.5	15.6	17.1	16.2	10.9	7.5	13.4	-

* NB: includes savings for fixed capital, including mortgage repayments (hence, these savings are not all available for new investments)

Source: Eurostat, Dol and Hafner (2010)

A consideration of the gross household savings rate reveals large differences between Western European countries. The country where the savings are the largest, i.e. where the households would be most able to invest in refurbishments even without state subsidies, is Germany followed by Belgium and France. The country where savings are the lowest is the UK. Thus, among the West European countries, the building owners in the UK and Ireland would need the most financial support to be able to engage in energy efficiency retrofits. Germany and France appear to have the building owners that are the most well-off.

In Western European countries natural gas as a source for heating is very popular (Table 4.4). The feasibility of natural gas solutions depends to a large extent on access to the gas distribution grid, and it is best developed in Western European countries, especially the UK and the Netherlands.

Tab. 4.4: Share of various energy sources in building energy use in West European countries

	AT	FR	DE	BE	NL	UK	IE	LU
District heat	16	5	8	1	5	1	0	2
Oil	20	18	24	33	2	7	35	30
Coal/lignite	1	0	1	1	0	1	11	0
Gas	19	33	38	37	65	59	21	38
Biomass	18	10	7	2	2	1	1	2
Electricity	27	34	23	26	26	32	32	27
Total	100	100	100	100	100	100	100	100

Source: ENTRANZE database www.entranze.eu

The most common source of energy for building energy use in France and Austria is electricity. In France, it is produced by nuclear power, but in Austria, mainly by hydro power. Electricity is the second largest energy source for building energy use in the Netherlands, UK and Ireland. In the Netherlands it is produced mainly by coal, in UK mainly by coal and nuclear energy and in Ireland mainly by coal. For Ireland the largest share of energy use for buildings is oil (a share of almost one third). It forms the second largest share of all energy use for buildings also in Belgium, Luxembourg, Germany and Austria. There are also significant differences among some of these countries in terms of prices for gas and other fuels (see Annex 2).

In the following, we first provide a more detailed description of the trends, drivers and barriers of nZEB and renewable heating solutions in the ENTRANZE target countries in this group, Austria, Germany and France. Here, we draw on the expert interviews (Annex 2), literature and our project partners' experience. Then, a more aggregated analysis, based on literature alone, is provided for the other countries in this group.

4.1 Austria

4.1.1. General policy context and major investor categories

In Austria, the number of dwellings was 3.6 million in 2009. Some 45 % are single-family houses, the rest are dwellings in apartment buildings. Approximately, 11 % are owner-occupied apartments, 40 % are rental apartments and the rest other forms of tenure. 28 % of the final energy is used for space heating and cooling as well as water heating, mostly in private households. A refurbishment rate of 1 % is supposed to be increased into 3 % by structuring of the regional housing subsidies. (Amann et al. 2012.)

The Austrian market is characterised by different federal, regional and private subsidy schemes. 80 % of housing starts receive some kind of subsidy. Especially owner-occupied houses and LPHA-built owner-occupied apartments have received large amounts of subsidies (Amann et al. 2012.) Subsidy schemes for renovation of old buildings differ depending on the part of country, the building type (apartment, single family house, multi-family building) and kind of renovation (small or total renovation). Mainly measures to improve energy efficiency, heating system or materials used in buildings are subsidised. There are several approaches used for subsidies: definition of minimum heat insulation standards, subsidy depending on achieved U-values, and subsidy scheme depending on total space heating energy system. (Streicher et al. 2004.)

Buildings that were built in the 60ies and 70ies form one third of the residential building stock. These buildinings are also considered to be those that are the easyest to refurbish to the passive house standard, due to their compactness and easily insulatable outer walls. In addition, they need to be renovated anyway due to their age. (Elswijk and Kaan 2008.) The highest potential for sustainable refurbishment is within the sector of single-family houses now reaching an age of 30 years or older. Two-thirds of all possible investments are estimated to be assignable to this category of buildings. (Ornetzeder & Suschek-Berger 2008.)

Austria belongs to those countries where the passive house market is most developed in Europe. Since 1999, the Austrian Federal Ministry of Transport, Innovation and Technology promotes the development of innovative solutions for building components and systems for residential, office and other buildings based on low-energy and passive house standards within its "Haus der Zukunft" –initiative (Building of the Future). Another initiative, Klima:aktiv programm of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management supports the dissemination and implementation of minimum criteria concerning the energy performance and the ecological quality of new build residential buildings. Depending on the level of the fulfilled criteria the assessed buildings are classified in Klima:aktiv houses and Klima:aktiv passive houses. In 2006, there were 1660 passive houses built in Austria. The passive house standard is expected to be obligatory in the housing grant schemes by 2015. (Elswijk and Kaan 2008.)

When considering traditional heating systems in Austria, direct electric space heating and hot water system are supported by the low investment costs and easy installation. However, there are no other major drivers and not major diffusion of new direct electric heating. Hindering factors are the high electricity costs. These systems continue to exist in old buildings without central heating system but almost no direct electric heating systems are built in new buildings or in buildings with existing central heat distribution within the buildings. Fossil-based room heating systems are also loosing their relevance because almost no new systems are currently installed in Austria. These systems are only installed in old buildings without existing central heating system. Major drivers promoting the take-up of fossil based central heating systems are low investment costs. Also fossil fuel companies promote the take up of these systems and support the new oil boilers related to fossil based central heating system and to some extent also the system installers. The availability of natural gas grid acts as a significant driver as well as the promised comfort and the reward of doing the same as the neighbour. The major barriers hindering the take-up of this system are costs of the system and its installation as well as high oil prices. Oil boilers are installed mainly in buildings that already had an old oil boiler (and oil storage tank). The take-up is most problematic for new buildings, in particular in rural regions without access to natural gas grid.

Small-scale use of wood fuels in heating systems are gaining importance in Austria. The final heat consumption of biomass for heat in Austria in 2010 was circa 26 % of all fuels and almost 90 % of renewable energy sources. The total final energy consumption from biomass in heating and cooling sector is expected to grow from 2015 to 2020 by circa 4 %. The amount of annually installed small-scale pellet boilers has grown by 50 % between 2005 and 2012 and the wood pellet heating demand is expected to grow by 400 % by 2020. (AEBIOM 2012).

The solar thermal market in Austria can be considered to be the most mature in Europe. A large spectrum of solar thermal application are available ranging from domestic hot water systems, combisystems, district heating and systems in hotels and even the industrial sector. The market has kept growing steadily until quite recently (ESTIF 2012.) For PV, the market grew to 80 MW in 2011 due to improved policy framework. The yearly budget to support PV deployment has quadrupled, being 8 million euros. However, EPIA (2012) evaluates that the market still is capped and is not allowed to grow at its full potential. EPIA estimates that the potential for PV deployment could be at nearly 500 MW on average per year until 2020.

4.1.2 General drivers and barriers for energy renovations among different owner groups

A multitude of factors influence the investment decision on energy efficiency simultaneously. In the Austrian context to reach an efficiency improvement that is sustainable and cost efficient, all elements must be available on a regional context and they have to fit together, not as a step by step support programme, but as a comprehensive policy programme with enough financial support and skilled people to realise initiatives in local context.

In Austria, a general barrier to energy efficiency refurbishments is that a holistic view in policy making is missing and therefore the target of nZEB has not been pushed efficiently. The move into nZEB calls for major changes in the structure of the construction sector i.e. a restructuring of the construction sector towards renovation. This would influence project management, know-how, other type of hard ware etc. There is a genuine lack of quality of renovation measures and the missing know-how is a true problem.

Financial barriers form the most important barriers for most owner types. In general, it can be stated, that financial subsidies help to remove important barriers but subsidies should be linked with energy efficiency improvements. In addition, investment subsidies are especially suitable for supporting specific RES-H/C technologies (Kranzl 2010). In Austria, a lot of attention has been paid to help overcome financial barriers. The state and regional authorities offer a number of refurbishment subsidies for households although the experts have suggested that the subsidies system should be renewed. In spite of subsidies, the high initial costs and long payback times are critical barriers for most owner types. There are groups among homeowners for which access to or cost of capital are critical barriers. In particular, these are the low-income and over 65 years aged persons among the "owner-occupied single or two-family homes”.

Other very important barriers are the transaction costs. Switching costs and concerns over disruption and risks of failures in renovation form critical barriers to all owners. There are also informational barriers: people are focused rather on the investment costs but not on the life cycle cost analysis.

The most complicated case is the group of owners are the one that live in their own apartments in multi-family buildings. These people face many of the barriers that are considered as most critical. As this group also forms 16 % of all buildings measured by the floor area, much focus should be directed to removing the barriers that they are subject to. They face genuine uncertainties regarding cost effectiveness, lack of information and skills, transaction costs and financial barriers, which are made more critical through the collective decision problems. Owner-occupied single- and two-family homes face transaction costs and lack of information and skills. A special barrier to them is their unwillingness to incur debt. Generally, it can be concluded that our study of Austria has revealed that alongside financial barriers the most critical barriers are transaction costs and lack of information and skills.

One of the most important drivers in Austria would be to build new networks of good builders/craftsmen. A trained energy expert should always be involved in the renovation planning/process. Competencies of the renovation craftsmen should be increased through education and enabling them to gain more experience in supervised practical work. A closer look at the most important decision criteria for different owner groups shows that the single most important decision criteria for all owner groups is the timing vis-à-vis previous renovations. This means that policy programmes should be planned in such a way that the “windows of opportunity” could be reached in an efficient way.

In general, there has happened a change in the awareness and attitudes of the people. For example, in Vienna, a competition was lauched for housing developers, where 1700 housing units in 20 large volume passive houses were built. In Vienna, the goal was to reach the percentage of passive houses of new buildings from 3 % to 20 % by 2008. In Innsbruck, a housing company was implementing a settlement of passive-multi-family-buildings of 354 housing units. In Salzburg, 300 housing units was planned to be erected in passive-multi-jousing-buildings and in Linz 4 high-rise-residential-buildings in passive house standard was supposed to be implemented. In Niederösterreich all new built buildings must be passive houses. However, information about refurbishment solutions is needed. Although in Austria, the government is taking some measures to encourage passive house building, the main driving forces are the syndicate of passive houses (IG Passivhaus Österreich) and the community of the insulation material industry (GDI). They require passive house standards for all public buildings, for multi-family-houses amd for one-family-houses. (Elswijk and Kaan 2008.)

4.1.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 4.5 presents an overview of major drivers, barriers and the most and least promising building and owner types.

Thermal renovation

The major drivers that promote the investments in thermal renovation are financial incentives (Wohnbauförderung - support of residential building construction). In addition, very important are also best case examples (and their promotion) as well as information and assistance offered by regional and local energy agencies.

In Austria, there are several initiatives launched to promote energy issues. An Austrian climate protection initiative (Klima:aktiv-Program[16]) is one of the initiatives that acts as a driver for thermal renovation. The primary objective of the klima:aktiv is to introduce and promote climate friendly technologies and services. The initiative offers advice and a high quality guarantee for renovation projects.

Research program Haus der Zukunft[17] is one of the Federal Ministry of Transport, Innovation and Technology's research and technology programs. Starting from the low-energy solar building approach and the concept of the passive building, and incorporating ways of using environmentally friendly and renewable materials in construction, new designs with great promise for the future have been developed and implemented. Research and development work has provided a firm basis for innovative, sustainable concepts both for new buildings and for renovating existing ones.

e5 is an Austrian energy efficiency and climate protection programme[18] acting on local level. e5 supports communities that want to contribute to a sustainable energy policy and urban development through the rational use of energy and an increased use of renewable energy. It is a certification and quality management system for communities enabling participants to improve their communal energy efficiency and to increase the utilisation of renewable energy. e5 consists of a quality management system for communal energy-related services and activities as well as certification and award for energy-related achievements. In addition, in some regions of Austria (Bundesländer) there are very ambitious persons (energy commissioners, representatives from regional governments etc.) actively promoting renovation activities (and efficient new buildings).

The major barriers hindering the take-up of this system are the high investment costs. People often use short-term calculations and considerations, which prevents them to engage in a longer term relatively large infrastructure project. An important barrier is the lack of know-how as well as technological challenges with renovation of old buildings. People are also faced with uncertainty and high search costs to get good advice.

The take up of thermal renovation activities is particularly positive in case of social housing and cooperatives. There is also some progress in case of owner occupied single dwellings. The most problematic owner/building type are owner-occupied multiple dwellings due to difficult collective decision making. For public buildings there is little data available, but it appears that the uptake of renovation measures is quite slow in public buildings. Old buildings (protection of historical monuments) are also a difficult building type to address (challenges with indoor insulation etc.).

Heating and hot water systems

The following will list some features of different technologies use for heating and hot water systems in Austria.

- District heating utilities are the major actors promoting the take-up of this system. Also regional, urban (and to some extent federal) government and administration are engaged in efforts to increase the share of CHP in Austria. The major barrier hindering the take-up of this system is the competition with natural gas (partly within the same companies selling gas and district heating). Another barrier is formed by old buildings that do not have a collective central heating system for the whole building. The building types, in which the take-up is more positive, are in urban regions the multifamily houses, especially newer buildings. The take-up is more problematic in rural regions and in single family houses. Unlikely adopters are owners of buildings with no central heating system. Usually the heating system in such buildings is gas one floor heating. Also the very efficient

[16] http://www.klimaaktiv.at/article/archive/29292
[17] http://www.hausderzukunft.at/english.htm.
[18] http://www.e5-salzburg.at/service/english.php

new buildings and settlements are not likely to take-up district heating because the new efficient areas have a low heat density from the beginning.

- Biomass central heating systems are promoted by subsidies for biomass heating systems. There is also promotion in most programmes of residential building construction and renovation (Wohnbauförderung). The Austrian Biomass association and to some extent also installers are active in promoting biomass heating systems. Chamber of agriculture and economics support these systems. Klima:aktiv –programme has its own "holzwärme" (i.e. wood heat) initiative. There are also special support programmes for biomass district heating in Austria. The major barriers hindering the take-up of biomass central heating system are high investment costs. A major problem is formed by the space requirement for the fuel storage. Another problem is the higher effort for operation (in particular for wood log) as well as emission control (CO, dust, CxHy, …) in particular in urban regions. The take up of biomass central heating systems is most promising in single dwellings and in rural regions. The take-uf this system is most problematic in multiple dwellings and in urban regions due to problems with space requirement of the fuel storage.
- Groundsource heat pump systems are also mainly promoted by subsidies. There is promotion for groundsource heat pump systems in most programmes of residential building construction and renovation. Also electricity utilities and installers promote groundsource heat pump systems in Austria. High investment costs hinder the take-up of this system. Installation is difficult in existing buildings with high inflow temperature. There might also be difficulties in existing buildings with ground source collectors or drilling. There is also competition with air-source heat pumps and other heating systems. New buildings and single dwellings are most promising building types but these systems are slowly increasing also in multiple dwelling buildings and in office buildings. Especially problematic these systems are in urban regions and in existing buildings due to the switching costs from existing heating systems to groundsource heat pumps. In Austria, there is permanent discussion on what would be the achievable seasonal cooling output of groundsource heat pumps.
- Biomass-based room heating systems are mainly driven by subsidies, but in rural regions there still are a significant number of old systems. To some extent they are replaced after they have reached the end of their lifetime. New biomass-based room heating systems are gaining relevance in particular for low-energy single family houses. Major barriers hindering the take-up of this system are comfort reason, due to the difficult handling with biomass fuel. Also there might not be suitable chimneys in existing building. In urban regions emission regulations may pose a barrier to the take-up of biomass-based room heating systems. Most promising buildings for these systems are efficient new low energy and passive house buildings as well as single family houses mainly in rural areas. Take-up is more problematic in urban areas and in multiple dwelling buildings.
- Airsource heat pumps are mainly promoted by subsidies, although subsidies are mostly connected to minimum cooling output (COP) values. Electricity utilities and installers promote these systems. They are also promoted by the fact that they are easy to install and have therefore lower investment costs. A barrier to some extent is the minimum COP value, although in practice it does not really have a high impact. Most promising users are owners living in new single family houses and passive houses, increasingly also in existing buildings with correspondingly low COP values. Existing multiple dwelling buildings are the most problematic group of buildings. In Austria, there is a lot of discussion on minimum COP values and much criticism on airsource heat pumps. However, the market data shows that the take up of airsource heat pumps has significantly risen being about the same or somewhat higher than for groundsource heat pumps.
- Solar thermal. The major drivers promoting the take-up of solar thermal heating systems are subsidies although there are many initiatives promoting for solar heating. Most programmes of residential building construction and renovation promote these systems. Installers as well as regional energy agencies are the main actors promoting solar thermal systems. In the Klima:aktiv –programme there is "solarwärme" (=solar heat) –initiative. There are also a lot of promotion activities of different kinds, like competitions and awards between communities, based on who has

the highest share of solar thermal systems installed. High investment costs hinder the take up of this system as well as technological barriers in existing buildings, like the need of space for storage instead of heating system. There might also be problems in the availability of roof space. In multiple dwelling buildings, collective decision making poses a major barrier for the take up of solar thermal systems. These systems also face competition with district heating. The take-up is more positive in case of single family houses, in particular new ones, and the most problematic in multiple dwelling buildingss (in particular existing buildings with multiple owners).

Ventilation heat recovery

In the take-up of ventilation heat recovery, there is a general trend to application in passive houses. Also the producers of prefabricated houses promote ventilation heat recovery. There are support mechanisms like subsidies, promotion in the frame of the support of residential building construction (Wohnbauförderung) that encourages the application of these systems. Also some installers promote these systems pleading to comfort reasons and to higher social status of "high-tech" buildings. There are also a lot of research programmes and promotion of best practice examples, also in office buildings and in public buildings like schools etc. The major barriers hindering the take-up of this system are high investment costs, considerations regarding air quality and sound disturbance. They are also difficult to install in existing buildings. Most promising building types are new single dwellings, especially passive houses, but these systems are slowly increasing also in new public buildings and in new multiple dwelling buildings. Ventilation heat recovery systems are problematic in existing buildings due to the high renovation effort necessary.

Energy efficient air conditioning

The take-up of this system is promoted only by a few support mechanisms (in building codes, Wohnbauförderung) but they are not significant. Major barriers hindering the take-up of this system are high investment costs, low awareness, low know-how and low building codes. In general, there are almost no air conditioning systems in residential buildings in Austria, only partly in non-residential buildings, and mainly only experience of these systems on a pilot/demonstration scale. There are just a few examples of solar cooling, offices with ground cooling and just a few public buildings. This is one of the newer topics in Austria.

Electricity micro-generation

Electricity micro-generation is promoted by Klien[19]-subsidies and partly by additional subsidies from the regional governments. Environmental considerations and enhanced social status act as promoters. Also cost decline of the systems and expectations of high energy prices promote these systems. Own electricity generation gives a feeling of security. High investment costs are the main barriers as well as the lack of awareness. In multiple dwelling buildings, the collective decision making process is difficult. In some cases, the investment is still not considered to be economical, even with subsidies. The design of the support system is not optimal for these systems: the total support budget is limited and the demand of subsidies is higher than their supply: interested investors will not invest in cases where they do not get a subsidy. Lower subsidies might lead to more investments because with the limited subsidy budget more PV-systems could be subsidised. In addition, Klien-subsidies can be applied for only once a year, which might be a barrier in the planning phase of new buildings. Single dwellings are the most promising target group and multiple dwelling buildings and non-residential buildings are the most problematic. Also historic buildings face difficulties, due to preservation rules. Especially in Vienna, the approval procedure can be time-consuming because of building standards. Larger systems (over 5 kWp) get subsidised through feed in tariffs but there is a long waiting list for those subsidised and it is not very likely that a subsidy will be

[19] Klien-subsidies are Klima- und Energieförderung i.e. climate and energy subsidies.

granted within 2 years. It is also very likely that high subsidies together with a limited budget lead to higher system prices, which is a barrier for the evolution of functioning markets for PV-systems.

Table 4.5: Overview of drivers, barriers and the most and least promising building and ownertypes for major categories of NZEB and RES H/C solutions

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	financial incentives, promotion of positive case examples, energy agencies, climate and research programs, locally active and ambitious persons	investment costs, owners short-term considerations, owners uncertainty and lack of knowledge and good advice, renovation of old buildings	social housing and co-operatives, owners of single-family houses	owner-occupied multi-apartment buildings, (difficulties in collective decision-making), public buildings, old historical buildings
District heating	district heating utilities, governments and administrations efforts to increase the share of CHP	competition with natural gas, old buildings without a collective central heating	multifamily houses (particular new buildings) in urban regions	buildings with no central heating system, single-family houses, rural regions, efficient new buildings and
Biomass central heating systems	subsidies, promoting programs, Biomass association, installers	investment costs, space for fuel, emission control (urban areas), inconvenience	single-family homes, rural areas	urban multi-apartment buildings
Groundsource heat pump systems	subsidies, programs promoting ground source heat, utilities, installers	investment costs, installation to some existing buildings, competition with air-source heat pumps	new buildings, single-family homes, slow increase also in multi-apartment and office buildings	existing buildings in urban regions
Biomass-based room heating systems	old systems exists in rural areas, subsidies, relevant in low-energy single-family homes	inconvenience, suitability to existing buildings, emission regulations(urban area)	single family houses (rural areas), new efficient systems (low energy, passive houses)	multiple dwellings in urban areas
Airsource heat pumps	lower investment cost, easy to install, electricity utilities	some extent the minimum COP values	new single-family houses, passive houses, also existing buildings	existing multiple dwellings
Solar thermal	subsidies, programs promoting, installers, energy agencies, promotion activities	investment costs, technological barriers, roof space, collective decision making, competition with district heat	especially new single-family homes	multiple dwellings, existing buildings with multiple owners
Heat recovery	prefab home companies, subsidies, promoting programs, installers, convenience, positive image	investment costs, considerations of air quality, installation to existing buildings, sound disturbance	new single dwellings (passive houses), new multiple dwellings	renovations in existing buildings
Energy efficient air-conditioning	few support mechanisms	investment costs, lack of awareness and knowledge	only on a demonstration scale, offices, public buildings	
Electricity micro-generation	environment, subsidies, image, costs, independence	investment costs, lack of awareness, collective decisions	single dwellings	non-residential buildings, historic buildings

4.2 France

4.2.1. General policy context and major investor categories

Buildings are responsible for 44% of total energy use in France, and constitute a major challenge for energy efficiency policies (NEEAP2 2011). While there has been a decline of specific energy consumption for space heating of about 20% since 1997, the energy efficiency of space heat use per m^2 is still lower than in several other European countries (Lapillonne 2011; Lapillonne et al. 2012).

France has a long history of energy efficiency policy, which has been significantly reinforced in recent years. The Grenelle de l'Environnement, a collective consultation between the state, the regional authorities and civil society representatives, defined a roadmap for ecology and sustainable development. This resulted in several mid-term and long term objectives; among others, the goal of reducing total energy use by 75% by 2050 and the goal of reducing energy use in existing buildings by 38% between 2008 and 2020 (Giraudet et al. 2011; NEEAP2 2011).

There are also efficiency standards for existing buildings (NEEAP2 2011). For major renovation of buildings larger than 1000 m² and built after 1948, the global Thermal Regulation sets a global energy performance target. For smaller buildings or minor renovations, the element-by-element Thermal Regulation sets a minimum performance level for elements replaced or installed, especially concerning insulation, heating, hot-water production, cooling and ventilation equipment. Labelling of energy efficient renovations has also been introduced: a 'high energy performance renovation, HPE 2009' label for buildings achieving primary energy consumption below 150 kWhep/m2/year and a 'low energy consumption building renovation, BBC 2009' label for buildings achieving primary energy consumption below 80 kWhep/m2/year (NEEAP2 2011).

Several measures to promote energy renovations and energy efficiency improvements have been available for years; however with several changes over the years. The current measures include (Commissioner-General for Sustainable Development 2009, Laurent et al. 2011; Economidou et al. 2011; EuroAce 2010; Baudry and Osso 2011):

- Several subsidies from national agencies such as the national energy efficiency agency, ADEME, and the housing agency, ANAH
- A tax credit of up to 16 000 € over 5 years for various energy efficiency measures
- Since 2009, a zero-interest loan for combinations of energy efficiency measures (that can be combined with the above-mentioned tax credit, provided that total annual household income is lower than 30000€)
- An energy saving obligation scheme for energy suppliers, in which several standardized actions in customers' premises pertaining to improved heating systems, ventilation and thermal renovation are eligible for energy saving certificates
- For social housing organizations: a low-interest loan linked to energy renovations
- Several programmes by local and regional governments
- Training of construction professionals: a training programme in energy saving for construction firms to recognise overall building energy performance and energy efficient techniques

Until recently, while the retrofit market has grown, it has grown no faster than GDP and the costs of renovations are rising (Laurent et al. 2011). The number of energy efficiency improvements has grown since 2002, but still only represent 15% of all renovations conducted (Economidou et al. 2011). Achievement of the ambitious government targets is thus expected to require further efforts.

There are additional measures in place to support renewable heat. Renewable heat in France has been supported by tax credits for renewable heating, reduction in VAT, and direct subsidies (IEA 2007). Additionally, France introduced in November 2008 a development plan for renewable energy in the Grenelle Environment. This program aims to bring at least 23% share of renewables in energy consumption by 2020. With more than 1,2 € each year, a Heat Fund (Fonds Chaleure) administered by ADEME aims to finance projects for the production of heat from renewable energy sources (biomass, geothermal, solar ...), while ensuring a lower price than the heat generated from conventional energy. Eligible projects include solar thermal, geothermal (including groundsource heat pumps), energy recovery and district heating networks. Both large and small-scale projects (e.g. multifamily buildings) are funded (ADEME 2012).

4.2.2 General drivers and barriers for energy renovations among different owner groups

There has been a rapid growth in awareness of the importance of energy renovations in France during the past few years, largely due to determined campaigns by the state and agencies like ADEME. This is more visible among professional property owners than residential owner-occupiers, but awareness seems to be fairly widespread (TNS-SOFRES/ADEME 2012).

However, there are several barriers to translating the awareness into action. Financial barriers are predominant. They influence different owner groups somewhat differently, but high initial costs, long payback times and access to capital are widespread problems. Another common barrier type is organizational. This is particularly severe for owner-occupied apartments, where reaching an agreement among condominium co-owners is difficult, which also intensifies the influence of other barriers. As concerns rental housing owners, measures have been taken to reduce the landlord-tenant dilemma through legislation enabling a sharing of costs among landlords and tenants, but this requires quite careful planning and the meeting of certain criteria by owners. In public and office buildings, competition among different types of investments and at different levels of the organization slows down the pace of energy renovations. There are also groups where attention to energy issues is still not so strong: these include condominium owners as well as public and office buildings, where energy costs are still only a minor part of total costs. High information search costs are a problem for private households, which still struggle to figure out how to best finance their renovation and to find good quality service providers.

In spite of these barriers, there are also several drivers for energy renovations. Whereas cost savings are an important driver, more societal and long-term concerns appear to have more influence in France in this area than in some other countries. Overall awareness has risen and there are several policy measures in place to promote renovations thanks to the Grenelle de l'Environnement agreement. Several parties are actively involved in promoting energy renovations:

- **Public bodies:** Compared to many other countries, the role of the state and the mobilization of the main national bodies seems to be a more visible influence. Ambitious targets set in the Grenelle agreement have served to create awareness and grants, tax incentives, training programmes, labels and advice networks are serving to facilitate renovations.
- **Companies offering solutions:** The construction industry in France consists of several small companies. There are hence not so many companies yet actively promoting a holistic view of the building or actively offering comprehensive energy refurbishments. However, there is a large nation-wide training programme working to improve this situation.
- **Associations:** One of the active players in the field has been the Plan Bâtiment Grenelle, a collaboration of a large chain of actors in construction and real estate aiming to implement the targets of the Grenelle de l'Environnement. Twenty working groups under this umbrella are working to implement and improve various measures such as the zero-interest loan or energy performance guarantees. The participating organizations also offer support for their own constituencies, e.g., the association for condominium owners, ARC, offers support for condominiums and promotes long-term maintenance plans and a renovation funds.
- **Banks** are central in distributing the zero-interest loans and dealing with the related documentation (eligibility criteria, evidence of works conducted). However, according to our interviewees, they are not particularly interested in energy renovations today.
- **Energy companies** participate in energy renovations via the energy obligations scheme. Several of the measures that are eligible for certificates pertain to energy renovations.As concerns decision criteria, there are a few criteria that are highly important for all owner groups (Table 8.4.2). Initial costs are important for all building owner groups, albeit for somewhat different reasons. Quick

installation and timing vis-à-vis previous renovations are also important criteria for all groups. The availability of quality services is important for residential building owners, with less market power.

Renovations are usually made when building components need to be replaced, and this is the main opportunity for integrating energy saving solutions. As one of our interviewees pointed out (see also Beillan et al. 2011), the change of ownership is another occasion for renovation and the integration of energy improvements. The availability of widely used solutions is also an important criterion for several groups, as is expected future regulation.

Some additional criteria were proposed by our interviewees. The expected amount of energy cost savings are important for many groups of owners: for owner-occupiers they are one of the keys motivation for engaging in an energy renovation. They are particularly important for rental housing providers, which need to be able to show that cost savings will be achieved in order to include the costs of the renovation in the rent, and they are particularly important for social housing providers, which have targets to reduce energy use. One of our interviewees also suggested that aesthetic aspects can be an important criterion for some homeowners.

4.2.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 4.6 presents an overview of major drivers, barriers and the most and least promising building and owner types

Thermal renovation

Major drivers for thermal renovation are the enegy efficiency standards for all buildings (including service buildings) in the Thermal Regulation (NEEAP2 2011). Moreover, the financial incentives and support measures such as the tax credit and low interest loans for first time buyer households have played an important role. Other drivers include the energy performance certificate for buildings and the thermal renovation measures taken by energy service companies as part of the energy efficiency obligation scheme. These have been accompanied by exemplary and informative measures implemented by the state, local governments, utilities, local and regional energy agencies and associations, including a nation-wide network of energy information centers (of which 50% of all renovators had made use of, TNS/ADEME 2012). The supply of services is also improving, as there has been a long-standing programme for training building professionals in France.The importance of national or local incentive schemes and government support programmes as triggers for more comprehensive energy renovations was stressed by our interviewees and Beillan et al. (2011).

Alphéeis (2012) notes that single-family homes are the group with the greatest uptake of these support instruments. TNS /ADEME (2012) report that in 2011, 17.5% of all homeowners planned to conduct energy renovations and this figure has been fairly stable for several years, albeit recently somewhat reduced by the economic crisis. The most common types of renovations in 2011 were improvements to the building envelope (2/3 of the works), especially window and door replacements, followed by heating system upgrades (TNS /ADEME 2012). According to TNS/ADEME (2012), financial support instruments are the greatest trigger for energy renovations, followed by expert advice.

The greatest barriers are initial costs, payback times and limited access to credit for households. Lack of information is also a barrier, including information on who to access funding schemes. The most problematic owner types are multifamily dwellings, especially ones with a mix of occupants and tenants. Here, organizational barriers and difficulties in decision-making are the greatest barrier.

Heating and hot water systems

According to Lapillone et al. (2012b), natural gas is the main fuel for space heating: 42% of residential dwelling and 40% of service dwellings. Electricity accounts for 31% of space heating needs in the residential sector and 24% in the service sector. About 20% of buildings are heated with oil, while other energy sources such as biomass and district heating are marginal (4% each). While gas heating systems are dominant in multifamily dwellings, oil heating and biomass are more important in single family dwellings (27% and 7% respectively).

The most important instrument supporting the change of heating systems is the tax credit, which can be used for the purchase of efficient heating systems such as condensing boilers or heat pumps. It has also been supported over the years with intensive guidance, including public information campaigns and training for installers, and quality certification schemes (IEA 2010; Eurobserver 2011b).

According to a TNS/ADEME (2012) survey of households that had renovated their homes, most households that replaced their heating systems installed a gas boiler (14% of all renovation measures taken). Many also took measures to improve their heating systems, such as replaced radiators, installed closed fireplaces or improved the regulation of the heating system. More efficient gas boilers are promoted by tax credit for condensing boilers and through the energy savings obligation for utilities. Annual sales of condensing boilers have increased from about 2000 units to more than 200 000 units during the 2000s (ENTRANZE database). They are most popular in single family dwellings and owner-occupied multi family dwellings. According to the TNS/ADEME (2012) survey, fewer of the households that had conducted some kind of renovation had installed renewable systems such as heat pumps (3%), wood pellet boilers (2%) or solar water heaters (1%). However, a slightly larger number (8%) were planning to install pellet boilers in 2011.

Some specific issues for particular renewable heating and cooling technologies are highlighted below:

- **District heating** is not widespread in France. However, the National Heat Plan supports the development of district heating using biomass and geothermal for multi-family dwellings, service sector, agriculture and industry. The most promising customer types are large buildings in service sector (eg hospitals, public buildings), and especially in densely populated areas (Paulus 2012). Major barriers are the complexity of installations and cost of connection, which limits the applicability of district heating to multifamily dwellings and to buildings with collective systems.
- **Biomass central heating and room heating systems:** Biomass boilers have seen only relatively moderate sales in recent years, in spite of good efforts to promote biomass in the early 2000s, which resulted in significant growth at that time (IEA 2007). Major drivers are the tax credit for wood and pellet boilers. The most promising type of customer is a single-family dwelling.
- **Heat pumps:** The groundsource heat pump market grew similarly to the solar thermal market up until 2008, but has slowed down due to the recession. Sales have been promoted via a tax credit, as well as the availability of soft loans and support by the energy efficiency obligation scheme. The most promising customers are still single family dwellings. Major barriers are the high initial investment cost. Eurobserver (2011b) also reports an overheated market in 2008, when some installers had insufficient training and some installed systems underperformed. Airsource heat pump sales are reported to have survived the recession fairly well (Eurobserver 2011b). They have been widely installed in the energy savings obligation scheme, representing 10% of total savings achieved (Bodineau & Bodiguel 2011).
- **Solar thermal:** Solar thermal systems sales grew nicely until about 2008, peaking at annual sales of about 350 000 m2 (ENTRANZE database). This was supported by support programmes including e.g. quality training, which increased awareness and market confidence (IEA 2007). There are national targets for more than one million m^2 installed in 2012, but current annual installations are only one-fourth of (ESTIF 2012). The main barrier is a lack of cost-effectiveness (Sia Partners 2013). The traditional market has been single-family homes, but the growth of this segment slowed down at the end of the 2000s, whereas larger installations (multifamily and service building) grew by 30% thanks to the Fonds Chaleur funding (ESTIF 2012) and building regulations (Epp 2012).

Ventilation heat recovery and energy efficient air conditioning

Mechanical ventilation is relatively widespread in France, especially in residential buildings (whereas e.g. 60% of educational institutions have no ventilation system) (Durier 2008). However, balanced (exhaust and supply) ventilation is not widespread, and hence ventilation heat recovery is not widespread either, or even considered relevant, compared to e.g. demand-controlled ventilation (Savin and Bernard 2011). One major driver of energy efficient ventilation is the availability of low interest rate for loans for improvements to ventilation systems, which has been used annually by 1-2% of households making energy renovations (TNS/ADEME 2012).

The share of air-conditioned floor-area is about 5% in residential buildings and somewhat below 30% in service sector buildings (ENTRANZE database). Energy efficient air conditioning is promoted by periodic inspection of AC systems.

Electricity micro-generation

France is one of the countries with the most developed PV sector (5th in EU in 2010) with over 1000 MWp installed grid-connected systems (Eurobserver, 2011). Still, in terms of PVs per capita, the country falls to the 10th place (Karteris and Papadopoulos 2012). The incentive scheme for PVs consists of common feed-in-tariff support, but also of tax credits, and PV investments are also eligible for low-interest loans.

The most positive take-up has been in single-family dwellings, which also receive the most generous support and have the best situation in terms of quick access to the grid. Large systems struggle more with permitting issues (Roland and Elamine 2011). The application of building-applied PV is also more problematic in existing multifamily dwellings due to difficulties in reaching decisions among owners.

Table 4.6 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions.

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	Thermal regulations for all buildings tax credit State, local governments, utilities Local & regional energy agencies and associations (energy information centers)	Credit access for households Imperfect information	Single-family dwellings	Multi-family dwellings especially with a mix of occupants and tenants
District heating	Heat plan supporting the development of district heating using biomass and geothermal	high installation costs, complexity of installations	Large buildings in service sector (hospitals), public buildings	Buildings without central heating
Biomass central and room heating systems	Tax credit for wood boilers	-	Single-family dwellings	-
Heat pumps	Tax credit, soft loans, energy obligations scheme	Some examples of underperformance	Single-family dwellings	Urban areas
Solar thermal	Tax credits Fonds Chaleur Building regulations	Lack of cost-effectiveness	Single-family dwellings (traditional) Multifamily buildings (growing) Service buildings (growing)	Less cost-effective without support in multifamily buildings
Heat recovery	Low interest loans	Low airtightness	-	-
Energy efficient air-conditioning	Periodical inspection of AC systems	-	-	-
Electricity micro-generation	Feed-in –tariffs, low interest loans, tax credit		Single-family dwellings	Existing multi-family dwellings (decision making)

References and data sources: National Energy Efficiency Action Plan; ADEME

4.3 Germany

4.3.1. General policy context and major investor categories

In Germany, there are 17.8 million buildings. 40 % of them were built between 1948 and 1978. There are 14 million single- or two-family houses. The new building rate is less than one per cent per year and the renovation rate of the existing building stock is one per cent. (Kraus 2011.) About 80 % of today's building stock will remain in place beyond 2050 and new buildings that will be built in the coming 40 years will constitute 20-30 % of the building stock in 2050 (Neuhoff 2011).

The largest potential for saving energy in Germany is in the housing stock. About three times as much energy is required for heating in the existing building stock as in new buildings. About 85 % of total energy demand is used for heating rooms and for hot water in private households. (dena 2012). The German government has committed to reducing the heat demand in the building sector by 20 % by 2020 and the primary energy demand by 80 % by 2050. The government aims that new buildings built after 2020 will be climate neutral. The reduction of energy demand will require efficiency improvements and therefore a thermal retrofit of the existing building stock is essential. (Neuhoff et al. 2011.) There are, however, results that show that the refurbishment activities of homeowners in Germany are far below what is needed to meet these ambitious goals (Stiess and Dunkelberg 2012, Bürger 2012).

In the EnEV, the goal was to reduce the energy, heating and warm water demand by 30 % for old and new buildings. A new reduction of further 15 % has been introduced in 2012 (Bundesministerium für Justiz 2012) however being limited to new buildings. The government target for annual thermal retrofit rate is 2 %. (Neuhoff et al.2011.) Governmental buildings are set under stricter requirements than other buildings. For example, the buildings of the federal government in Berlin have to fulfil the requirement to perform 30 % to 40 % better than stipulated by the EnEV requirements. This applies for both new and existing buildings (decision of the Bundeskabinett/ Federal Cabinet as of 11/12/1991).

In Germany, the main financial mechanism to get a loan for energy renovation is the financing through the Kreditanstalt für Wiederaufbau (KfW). It is a public bank that is jointly owned by the Federal State and the Bundesländer. In Germany, the financial incentives of the KfW are targeting the overall energy performance.

Until 2006, approximately 8000 passive house dwellings had been built in Germany. However, passive houses have still a very small market share of about 1 % in Germany. Regions where there are active policies supporting passive houses achieve higher market shares. In Germany, the rate of new construction is very low. Therefore, for passive house solutions the most promising market is the retrofit market.

Nearly 87 % of all residential households have installed their own heating system (Decker et al. 2009). In Germany, the most often used energy source for space heating was gas in 2010 with a share of almost 50 %. It is often used in central heating or in relatively common heating systems covering one floor. The next most common energy source for heating is heating oil with a share of circa 28 %. District heating as next source for heat has a share of circa 13 %. District heating is much more common in the new federal states (NFS) than in the old federal states (OFS) whereas heating oil is used much more in the OFS than in the NFS. Heating oil is used especially in large owner-occupied single- or two-family homes where there is much need for refurbishment because the most of these homes were built prior to 1978. (Statistisches Bundesamt 2012.) This would mean a good opportunity to shift from a fossil fuel based heating to RES-H/C system.

Renewable energy and heating system upgrades are of major interest in reducing the energy use of buildings in Germany. The policy framework for building-level renewable energy use is much supported and for example there is a minimum standard for new buildings of RES-H. Germany has a long tradition in renewable energy support. For example, electricity generated with renewable energies (RE) is supported by a feed in tariff (FIT), which sets a fixed price for the electricity produced by RE, and by an obligation for the grid operators to connect the RE-producer to the grid and buy the produced electricity. This support has led to a fast diffusion of e.g. photovoltaic technologies to private homes. Germany is also the market leader for the European solar thermal markets.

4.3.2 General drivers and barriers for energy renovations among different owner groups

The awareness for the passive house concept has grown in Germany e.g. due to the promotional activities of the proKlima initiative in the region of Hanover and the organisation of the international Passivhaus Tagungs (seminars) by the Passivhaus Institute. There is still a high information need. For example, refurbishment projects with passive house components should be evaluated especially concerning the influence of the existing heat distribution system and recommendations based on the produced results should be given. (Elswijk and Kaan 2008.)

In general, the refurbishment measures are usually quite complex, which might prevent owners from starting a retrofit process. Also the circumstances, in which people are, vary. Therefore, the investment decision is rather a combination of many factors than a single motivation. Still, there are barriers and decision criteria that emerge more often than others.

Lack of knowledge on available technical solutions and their saving potential still seems to prevail among the population (Huber et al. 2011). The uncertainty concerning the results is closely linked to the complexity of renovation and circumstances as well as lack of trust in involved parties or experts. When it comes to architects or craftsmen, there is sometimes lack of skills or qualification, which might lead to a failure of the refurbishment. The market is not transparent, which means for the building owner that there is lack of actual and up-to-date information. (Kraus 2011.)

Lack of information and skills forms thus another general barrier for energy refurbishments. Many studies suggest that building networks of different stakeholders, like energy advisers, craftsmen, authorities etc. is essential in giving more people an incentive to start refurbishment (see i.e. Kesternich 2010, Stiess and Dunkelberg 2012). Households trust information more if it is provided by experts rather than by internet platforms (Novikova et al. 2011).

Specific problems considering lack of skills of the craftsmen recognised in Germany is that they may not be installing the equipment like the producers require, which might lead to wrong installation or even damage to building. Craftsmen may not work with each other in good understanding and therefore they do not understand the work of the others and the relevance of the solutions, which might lead to energy efficiency losses or even damage. This is a quite important matter when considering the RES-H/C-technologies and their large scale acceptance among home owners. Support programs to educate the craftsmen work better if the geographical area is not too large. There are problems in bigger areas, because the political unity is missing, the critical size is exceeded or the mechanism becomes too big.

A common barrier is that the building owners face difficulties in financing refurbishment measures. This can be tackled with subsidies, grants or taxation. In Germany, also the landlord-tenant dilemma is a critical barrier because the landlord can transfer only 11 % of the investment costs to rent in the first year and later the rent must be harmonised to the general rent level, and only the tenant gets the benefits for reduced energy bill. According to Huber et al. (2011) the public support schemes play a crucial role in making refurbishments affordable for the building owners. Local embedding of projects seems to be important as well as regulation stimulating comprehensive retrofitting projects.

The owner groups that experience the most barriers are the indifferent and passive single-family home-owner/occupants and the private owners of rental multi-family buildings. They face financial barriers, organisational problems and genuine uncertainties regarding cost effectiveness. There are also a lot of barriers in the way of energy refurbishments in case of rental single-family owners and the associations of owners.

When considering decision criteria encouraging to refurbishments, the single most important decision criterion is the timing vis-à-vis previous renovations or necessary maintenance. This is also linked with the question: how to reach potential customers? Some people are searching for information themselves or some can be reached in connection with other offerings. There is an opportunity factor here that is the most important: in what shape is the house of the person in question at that moment. The influence of advice is smaller among people that are reached through other channels than though their own active searching. Home-owners who are not under pressure to renovate take more time to start renovation.

4.3.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

Decker et al. (2009, 2010) have studied the purchase behaviour related to heating systems in Germany with special consideration of consumers' ecological attitudes. Based on literature, they have recognised four parameters that influence the purchase of a heating system: characteristics of the combustible, socio-demographic characteristics of the consumer, individual conditions and individual attitudes. In the empirical research of Decker et al. (2009, 2010) it was found out that mainly the membership to different ecological clusters (like e.g. ecological minded, active altruists or environmental nihilist consumers) influences the choice of a certain heating system. Also the assessment of different combustibles plays a major role for the decision. In addition, they found out that different information sites have no influence on the purchase of a heating system i.e. it does not matter where and how often the consumer gets information about a heating system. In addition, respondents' monthly income has no influence on the choice of the heating system.

Also Braun (2010) has studied what determines households' space heating type in Germany for owner-occupied or rental dwellings. According to the empirical study, similar influences of socio-economic factors could be found on the heating technology between the sample of owners and the sample with all households. The construction period of a dwelling and its location in East Germany showed less influence on house owners than on the sample as a whole implying than for the rental dwellings these factors play a much larger role in the decision making. The study identifies a shift in space heating from oil-fired to gas-fired appliances, especially in newly erected buildings. The main conclusion of the study is that there are large differences between the rural and urban areas of Germany as well as between East and West. A meaningful strategy would be for Germany to design and implement the policies and instruments to the level of federal states, because the local level can take more carefully into account the specific situations. (Braun 2010.)

Homeowners' preferences for adopting residential heating systems in Germany were also studied by Michelsen and Madlener (2012). They found out that the choice of a residential heating system (RHS) is a complex process because the preferences about RHS-specific attributes are found to be significant determinants of the decisions and the importance of key drivers differs across RHS and groups of homeowners. The study found out that there are important differences between new and existing homes. For both types of homes spatial aspects are relevant. For newly built homes the choice of RHS seems to be highly influenced by preferences about certain characteristics of the home, like its size or the energy standard. Thus, home-owners make a decision based on a bundle of attributes related to home rather than making an isolated decision about the RHS. For existing homes, the owners focus their decision mainly on the RHS itself. The choice seems to be much more influenced by given individual framework conditions on the level of the building owner. In this case, the attributes that cannot be easily altered, like the age of the home, homeowner's age or income, do impact the adoption decision.

According to the study of Michelsen and Madlener (2012), adopters of a gas- and oil-fired condensing boilers with solar thermal support have a strong preference for energy savings, while adopters of a heat pump or wood pellet-fired boiler prefer being more independent from fossil fuels. They also found out that a grant is important for the choice of a wood pellet-fired boiler in both existing and newly built homes, i.e. the availability and amount of grant has a direct impact on the adoption decision. On the other hand, for certain RHS a BAFA-grant did not play any role in decision-making process. Thus, for some cases the grant is not economically efficient since the homeowners would by the RHS anyway. Therefore, this instrument should focus only on RHS where it has an influence on the decision, like wood pellets. (Michelsen and Madlener 2012.)

Small-scale use of wood fuels in heating systems are gaining importance also in Germany. The final heat consumption of biomass for heat in Germany in 2010 was circa 10 % of all fuels and almost 92 % of renewable energy sources. The total final energy consumption from biomass in heating and cooling sector is expected to grow from 2015 to 2020 by circa 9 %. The amount of annually installed small-scale pellet boilers has grown by 47 % between 2005 and 2012 and the wood pellet heating demand is expected to grow by 150 % by 2020. (AEBIOM 2012).

In the following, table 4.7 presents an overview of major drivers, barriers and the most and least promising building and owner types the following categories of NZEB solutions thermal renovation, heating and hot water systems, heat recovery, and on-site electricity production. Energy efficient air conditioning is practically non-existing for private homes in Germany and electricity as a primary source for heating is also rare (Rehdanz 2006).

As a general comment, it is worth noting that in Germany the energy sector is supposed to go through a significant structural change during the coming decades. This structural change is called the Energiewende and it is based on a decision of the German government to give up nuclear energy altogether by 2022. Because of the country’s climate goals, the long-term future energy system must be based on mainly renewable energy production and energy efficiency improvements. In Germany, the public in general agrees with the realisation of the Energiewende. A recent poll by TNS Infratest shows that the public broadly supports the idea and is even willing to pay for it. 94 % of the respondents are in favour of an accelerated development of renewable energy and 80 % thinks the costs are adequate or even too low (Bosman 2012).

Thermal renovation

The main driver for the thermal renovation investments is the main financial support scheme by the Federal Development Bank (KfW), which provides softs loans and investment subsidies. As drivers also function the increasing awareness of the economic efficiency of energy saving measures and the importance of energy efficiency on general for climate protection.

The most important barriers that hinder building owners in starting thermal renovation are the financial barriers. Especially important are uncertainties. There is uncertainty about 1) own and overall economic situation and economy, 2) the development of energy prices and 3) about social and political reforms. Owners are also reluctant to engage in energy retrofits because of the long amortisation times of energy saving measures. Furthermore, accepted amortisation time differs among the different investor types. Lack of equity and missing access to capital is an important barrier for thermal renovation. Certain groups of owners are more affected by this than others. For example some owners have a hard time getting a credit due to their age. People usually tend to be risk averse and therefore they are reluctant to take a credit to finance thermal renovation. For some building owner types, the investor-user dilemma poses a barrier. The investor must invest the finances but sometimes other parties get the benefit. This is a typical landlord-tenant dilemma. Finally, there are costs involved in getting the energy advice and this may be a barrier to some investors.

A recent study (IWU 2010) showed that thermal renovation is significant less in buildings with owner association or in multi-family houses with heterogeneous owner structure. There, renovation is hindered by collective decision making. Some decisions require a unanimous resolution and then even one vote can stop the renovation. In these cases, the role of building management companies becomes quite decisive. Another group of building owners, where thermal renovation may prove to be quite difficult, are buildings owned by private landlords. Private landlords may suffer from missing knowledge about their legal situation. For example, they may not know about tenants' obligation to tolerate some renovation measures. The landlords are sometimes claimed for rent reduction because of the discomfort of the tenants due to renovation measures.

Finally, regional aspects play a role in Germany. In total there are less thermal renovation activities in the north of Germany than in the south, which reflects to a certain extent also differences in incomes or in the economic situation between the regions.

Heating and hot water systems

In general, for all RES-H technologies applies that the major driver promoting the take-up of these systems is the market incentive program (MAP) as main financial support scheme providing investment subsidies and soft loans. Another important driver is the renewable heat act introducing an obligation to use RES in newly constructed buildings. A somewhat surprising driver is also the attitudes of people. There is a certain willingness to pay for renewable energy systems. This applies especially for solar thermal systems, which is a lifestyle and an image question.

- District heating in Germany is hindered by the availability of gas grids. Fossil-based central heating systems are supported by the fact that condensing gas boilers as standard technology are offered and advertised by installers and manufactures. In Germany, there is a large gas supply network and the majority of buildings are connected to the gas grid.
- Biomass central heating systems are promoted by local availability of cheap biomass especially in rural areas. The main hindering factor is the lack of storage facilities, especially in urban areas. Owner occupied single family houses are expected to be the buildings that would experience the most positive effects of investing in a biomass central heating systems.
- Groundsource and airsource heat pump systems are advertised and supported by utility companies with investment subsidies and discounted electricity tariffs (demand side management), which function as main drivers for these systems in Germany. The main barriers that hinder investment into these systems are technical barriers, an energy efficient operation requires renovated and new buildings. Geothermal drilling is not feasible at every location. Single family houses, new buildings and owner occupier are most promising investors due to technical reasons.
- Solar thermal systems. The major drivers promoting the take-up of solar thermal systems are financial support provided by the MAP since 2000 and renewable heat act for new buildings. Also the positive image of these systems acts as a driver, because building owners have a higher willingness to pay for solar thermal systems. These systems are quite visible and therefore they show the greenness of the building owner. The neighbourhood effect is quite strong when it comes to solar thermal systems. The major barrier hindering the take-up of this system is the competition with photovoltaic regarding available roof area. Also the integration in existing heating systems in existing buildings is complex. The installers' missing knowledge and skills in some cases acts as a barrier. The take-up of these systems is more positive in single family houses and in new buildings due to technical reasons. Also owner occupiers are a promising owner type for these systems. The most problematic is the take-up in multi-family and non-residential buildings. The take-up is also problematic in case of private landlords or housing associations.

Ventilation heat recovery

The major drivers promoting the take-up of ventilation heat recovery are the building codes that set these systems as a standard in high energy efficient new buildings, which are supported by the Federal Development Bank (kfW). New buildings require automatic ventilation systems due to the manner of how they are constructed. Renewable Heat Act also acts as a driver, because it allows for heat recovery use as an option to comply with the RES-H obligation. The major barriers hindering the take-up of this system are technical issues in existing buildings. A subsequent instalment is difficult. Consequently, the take up is most positive in new buildings and most problematic in existing buildings.

Electricity micro-generation, PV

Electricity micro-generation, especially photovoltaics in buildings, has become an important element in NZEB designs, because modern low-energy buildings have a low heat demand and hence the share of electricity use becomes more important. This is a promising solution also because solar power micro-generation is increasingly popular. The total installed capacity of solar power has grown very rapidly in Europe, but still was not more than about 52 GWh, almost half of which was in Germany. In 2011, 7485 MW new capacity of PV was installed in Germany (EPIA 2012).

Table 4.7 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	financial support by the Federal development bank (soft loans and invest subsidies), environment and climate protection, economic efficiency of energy saving measures	financial barriers, lack of information, general attitudes, fears and preferences, technical barriers		buildings owned by private landlords, multi-family houses with heterogenous owner structure, buldings with owner association and collective decision making
District heating	general drivers for all RES-H technologies	availability of gas grids		
Biomass central heating systems	availability of cheap biomass (rural areas), , positive image, Market incentive program MAP (subsidies, soft loans), renewable heat act (new buildings)	lack of storage facilities especially in urban areas	single family houses owner-occupiers	
Groundsource heat pump systems	advertised and supported by utility companies (subsidies, discounted electricity tariffs), MAP, positive image renewable heat act (new buildings)	technical barriers, operation is only feasible in renovated and new buildings geothermal drilling is not feasible at every location	single-family homes new buildings owner-occupier	
Biomass-based room heating systems	convenience, positive image, renewable heat act (new buildings), MAP		single-family houses	
Airsource heat pumps	advertised and supported by utility companies (investment subsidies, discounted electricity tariffs)	technical barriers, operation is only feasible in renovated and new buildings	single-family homes new buildings owner-occupier	
Solar thermal	MAP, renewable heat act (new buildings), positive image: owners willingness to pay for solar thermal	competition with photovoltaics (roof space), integration in existing heating systems, knowledge of installers	single-family houses, new buildings, owner-occupiers	multifamily buildings, non-residental buildings, private landlords, housing association
Heat recovery	standard in new high energy efficient buildings, financial support by the Federal development bank, renewable heat act	technical barriers in existing buildings	new buildings	existing buildings

Source: Bürger et al. (2011), Diefenbach et al. (2010). Ecofys et al. (2012), Stieß et al. (2010)

4.4. Other West European countries

4.4.1 Belgium

The Belgian housing stock is characterised by a high proportion of old buildings, especially in the larger cities (EEA 2010). According to EEA (2010), the presence of central heating in Belgian housing has risen in the past decades. Natural gas has now surpassed fuel oil as the main source of heat. Coal has also shown a marked decline. Major progress has been made in insulating buildings (dual-glazed windows, insulated roofs, outer walls and heating pipes).

Mlecnik (2010) reports that there are several innovations available for advanced (low-energy) renovation in Belgium, due to financial support offered for such solutions in several regions and municipalities. However, a qualitative study by Bartiaux (2011) of Belgian homeowners in the Walloon region suggests that mainstream renovation practices are less advanced. Many of her informants made do-it-yourself renovations (which are common in single-family homes), and were disappointed with the attitude of craftsmen and contractors to both insulation and energy regulations in general.

There is no large scale policy on the federal level for RES-H&C. For households, tax reductions of 40% are in place for the installation of RES-H production units, such as solar thermal systems, efficient heat pumps and wood stoves, as well as thermal insulation (Teckenburg et al. 2011). There have been several regional and technology-specific promotion schemes, as well. As a result, for example the biomass heating market in Wallonia has grown exponentially (Verma et al. 2009). There is also a fairly generous green certificate scheme for solar PV in Belgium, which has brought the country to 6th place in terms of total installed PV capacity in Europe (Karteris and Papadopoulos 2012).

1.4.2 The Netherlands

Itard et al. (2008) report that social rental housing providers have a better capacity to invest in renovatios than private owners. Of the single-family houses, Itard et al. (2008) report that 66% are owner-occupied and 26% social rented, which is quite an unusual situation in Europe. Half the social rented single-family dwellings are post-war and were built before the first oil crisis in the 1970s. Half the owner-occupied single-family dwellings were built before the oil crisis. More than half the multi-family building stock is social rented, whereas owner-occupancy and private rented have an equal share (21%). One third of the multi-family building stock was built between the war and the oil crisis, and another third between 1970 and 1990. According to Itard et al. (2008), renewal of the post-war housing stock is a major challenge in the coming years in the Netherlands.

According to Itard et al. (2008), the Dutch have a long tradition of promoting energy efficiency in buildings. Dutch policy is largely made via sector-wide voluntary agreements called covenants. Concerning the existing building stock more generally, an agreement called More with Less aims to save 78 PJ (21.7 TWh) by 2020 (Meijer et al. 2012), which translates into the annual improvement of 300 000 dwellings annually by at least two energy label (EPC) increments. The Dutch housing associations and the government have made an agreement that housing associations are going to invest in improving the energy efficiency of existing homes. The goal is to save 20% on the energy use in the existing social housing stock by 2018 (Itard et al. 2008. Recently, goals have also been added for the private rental sector (Meijer et al. 2012). These goals are supported by financial instruments on the national, provincial and municipal level (Meijer et al 2012).

Meijer et al. (2012) report that there has been some progress toward these goals in recent years, e.g., 20% additional energy savings were achieved in 2008-2010. However, they also report that the energy saving measures in the social housing sector are lagging behind targets.

The Netherlands also has as target to increase renewable energy use to 14% of the total by 2020. However, Meijer et al. (2012) report that this target is not likely to be met. According to Menkveld and Beurskens (2009), renewable heating options only serve a small segment of the market and installers often advise against them because they have little or no experience with them. Itard et al. (2008) report that 82% of all dwellings had central heating, mostly gas-driven, in the mid-2000s. Of these, 12% had a conventional boiler, 49% have an increased efficiency boiler and 39% a high efficiency condensing boiler. In addition to this, more than 30 000 heat pumps have been installed, which is less than 0.5% of all central heating systems. Biomass local heating accounts for 6.5% of the renewable energy use in the Netherlands and district heating is used in 4% of dwellings.

Itard et al. (2008) report that in buildings equipped with mechanical supply and exhaust heat recovery ventilation systems, several studies show a correlation with health problems (allergy and respiratory problems). A possible cause of this is the poor design of the ventilation system, poor maintenance, and the occupants lack of knowledge and capacity to use the system.

The Netherlands has a long history of variable support for solar PV in buildings (Verhees et al. 2013). At present, since 2011, there are no subsidies or feed-in-tariff for small-scale building-applied PV. However, since there is a lot of interest and a long history of building-integrated PV projects and capacities, other models for making PV affordable have been developed, e.g. co-operatives and leasing (Verhees et al. 2013).

4.4.3 United Kingdom

In the UK, there is significant potential for cost-effective investment in energy efficiency. Almost 60 % of homes were built prior to 1964 and almost 80 % prior to 1980. There are barriers that mean that the full potential is not been realised. These barriers relate to a market that is still small and just at the beginning of its development, lack of trusted and appropriate information, misalignment of financial incentives and behavioural barriers. (Department of Energy and Climate Change 2012.)

The UK has a very ambitious policy to promote zero-carbon homes – a term which is similar to NZEB. The Climate Change Act established a legally binding target to reduce the UK's greenhouse gas emissions by at least 80 % below base year levels by 2050, with several intermediate targets as well. So far (DECC 2011), emissions in buildings have fallen by 18 %, despite the growth in population and housing, largely due to regulation requiring the introduction of new, more efficient condensing boilers and through measures to fit 11 million homes, i.e., 60 % of all homes with cavity walls, have been fitted with cavity wall insulation. Through the Renewable Heat Incentive (RHI) and Renewable Heat Premium Payment, over 130 000 low carbon heat installations are expected to be carried out by 2020.

Itard (2008) note that the UK is one of the few European countries with a longstanding policy concerning housing renovation (partly due, perhaps, to the historically poor state of the housing stock). There are several measures in place to promote energy renovations and renewable heating and cooling, but they are fragmented (Karvonen 2012): Building regulation only pertain to the existing housing stock in the case of building extensions, windows, conservatories, and major renovations, but there are also requirements for thermal comfort in health and safety regulations. There are several grant programmes available such as the Warm Front, providing energy renovation grants of up to £3500 for low-income households (to date, almost 2.3 million households have received funding), and a Landlords' Energy Saving Allowance. The UK also has a longstanding energy efficiency obligation scheme, currently called the Green Deal, which enables owners and occupants to install energy-efficiency measures up to £6500 while paying for the investment over several years in their energy bill. On-site electricity production is promoted by a feed-in-tariff scheme, which was, however, recently cut by half.

However, the Royal Academy of Engineering (2012) comments that the 80 % CO2 reduction targets cannot be met via more efficient gas boilers or improved insulation. Renewable heating is a necessary part of the solution, as domestic heating accounts for one-fourth of total energy demand. However, building-applied renewable energy production has not progressed as expected in the UK. At present, 85 % of homes in the UK are heated by natural gas. Of the remainder, some in rural areas are heated by oil and others, particularly in tower blocks where gas may be banned for safety reasons, by electricity. According to Kelly (2010), there were 120 000 solar thermal installations, 25 000 PV installations, 28 MWe capacity of CHP (<100kWe), 14 000 small wind installations and 8 000 ground source heat pumps installed (among a population of more than 60 million).

Several studies (Hamilton 2011; Loveday 2011; Karvonen 2012) show that the barriers to thermal insulation and building-applied renewable energy production are similar to those in other countries. In fact, while thermal insulation has enjoyed a wave of popularity due to large-scale campaigns, several support measures and some affordable commercial solutions, studies suggest that British households might be less eager to invest in renewable heating options than e.g. German households.

4.4.4 Ireland

The housing stock in Ireland is relatively new, with approximately 40 % having been constructed since 1990, during the great economic boom (Meijer et al. 2012). More than 90 % of all dwellings consist of single-family homes and 70 % of the dwelling stock is owner-occupied.

A major retrofit programme, currently called Better Energy, has been running since 2009. According to Sustainable Energy Ireland (2013), almost 500 000 measures (in a population of less than 5 million) have been funded through this scheme, which offers homeowners a fixed cash grant of 200-3600 € for measures ranging from attic insulation to external wall insulation, heating controls and installation of solar heating, as well as a small grant for a Better Energy Rating, which is mandatory for all beneficiaries.

Claudy et al. (2011) have estimated Irish homeowners' willingness to pay for such renewable energy solutions as wood pellet boilers, solar water heaters, small wind turbines and solar PV panels. In almost all cases, the homeowners on average were willing to pay less than the current cost of these technologies, although for solar water heaters the WTP was closest to the market price. The willingness to invest in these technologies was influenced by such factors as a desire for independence and an appreciation for the environmental friendliness of solar energy. The barriers indentified in this study were fairly similar to those identified for single-family home owners in other countries for energy renovation in general (Heiskanen et al. 2012); however, issues like uncertainty about performance, incompatibility with habits (disruption) and e.g. social risk appear to be heightened in the case of novel renewable energy technologies.

4.4.5 Luxembourg

Luxembourg has a population of 0.5 million, with the highest per-capita income in Europe. The building stock consists of 64 % single-family homes and 74 % owner-occupied. Oil and gas are the main heating sources.

The government offers subsidies to support homeowners' investments in thermal renovation and renewable energy. These measures include insulation of the building envelope, energy efficient windows and condensing boilers, as well as renewable technologies such as solar and biomass heating systems, heatpumps and micro co-generation (Eischen 2010). On a per capita basis, Luxembourg ranked 6th in terms of installed PV capacity, largely building-applied, thanks to very generous support measues (Karteris and Papadopoulos 2012).

4.5 Similarities and differences among West European countries

This large group of countries accounts for 50 % of EU-27 population and spans in the area of more than 1 331 190 km^2 (31% of EU-27) from the west coast of Ireland to the eastern border of Austria. Hence, it is fairly diverse both geographically and culturally. However, a chacteristic that is common to many countries in this group is the historical presence of relatively forceful energy policies, many of which have been in place since the energy crises in the late 1970s. In particular, support for renewable heating and cooling has a relatively long tradition among this group of countries, though some countries have been more consistent and successful than others in their efforts.

This has relevance for the kind of market offerings available for building owners. The more mature the market, the more likely it is that relatively good quality services are available. It also seems that some of the countries in this group have learned from previous decades and years of policy and have improved the effectiveness and user-friendliness of the renovation policy measures and schemes.

The building stock and its age, however, are quite diverse. This has a great influence on suitable policy measures for encouraging energy efficiency retrofits in individual countries. Our ENTRANZE target countries are somewhat different from other countries in this group insofar as they have a relatively large share of multifamily dwellings. In contrast, e.g., Belgium, the Netherlands, Ireland and the UK all have more than 80% of single-family dwellings. The UK, Belgium, Ireland and Luxembourg also have a relatively large share of owner-occupancy. However, the barriers and drivers to energy renovations have been investigated quite closely in these countries. They are fairly similar, at least as concerns owner-occupied single-family homes.

Most countries in this group have fairly ambitious targets for improving energy efficiency in buildings and in promoting renewable heating and cooling. Some of these, such as thermal insulation in the UK, are making good progress. However, Meijer et al. (2012) argue that all of the expected and needed renovations are not likely to be realized, due to market failures, financial barriers and inefficient regulations. Moreover, they argue that all renovations are not likely to have the expected effects on energy use. For example, findings from the UK, where lacking thermal comfort levels have been one of the reasons for a forceful policy, suggest that part of the benefits of thermal insulation are realized in the form of improved thermal comfort. In terms of ventilation heat recovery and energy efficient air conditioning diffusion, however, the countries in this group present a variable picture.

In terms of renewable heating and cooling diffusion, some of these other countries represent less mature markets than e.g. Austria and Germany. This is probably at least partly due to the large share of natural gas in some countries. The largest shares of gas in building energy use are in the Netherlands and in the UK, because they produce natural gas themselves. The other Benelux countries and Germany have a share of approximately 38 % and France 33 %. In Ireland and Austria the share is circa one fifth of the building energy use. The growth of the market share of condensing gas boilers is a continued trend (Kemna et al. 2007a), especially in the category of wall-hung boilers that do not require a separate boiler room. There have been several policy measures in the UK, the Netherlands, Belgium, France and Germany to support or even prescribe the shift to condensing gas boilers.

District heating systems are rare in the UK, like in Germany, and heat pumps in Western Europe are most sold in Austria, Germany and France. Wood pellets are gaining a rapidly rising share in Austria, Germany and France. However, small-scale use of wood fuels in heating systems in Western Europe is currently concentrated predominantly in Austria and Germany and, to a lesser extent Belgium and France. (AEBIOM 2012). According to statistics by ESTIF (2012), the solar thermal market has grown by about a factor of three since 2000. On a per capita basis, Austria has the widest diffusion of solar heaters in this group (>15%), whereas Germany, Netherlands, Luxembourg and Belgium have a less than 5% diffusion, and Ireland, France and the UK even less.

In terms of market maturity for building-applied solar PV, this group is quite diverse. Germany and Belgium are clearly the leaders, France and Austria are medium-level countries, and the rest of the countries in this group are clearly at a more initial stage.

5 Trends, drivers and barriers in Southern Europe

We have categorized in the Southern European group the following EU-27 countries: Italy, Spain, Greece, Portugal, Cyprus and Malta. These countries share a Mediterranean climate. Some of them also host the first cities in Europe, and hence millennia of urban history and existing urban structure.

The three largest countries in this group, Italy, Spain and Greece, have a building stock that is dominated by multifamily dwellings (Table 5.1). Most of these are owner-occupied and governed in condomium form (Table 5.2). However, the smaller countries in this group have a large share of single-family dwellings.

Tab. 5.1: Dwelling stock by dwelling type in South European countries

	IT	ES	GR	PT	CY	MT
Single-family dwellings	29	35	35	63	72	78
Multi-family dwellings	71	65	65	37	28	22

Source: ENTRANZE database www.entranze.eu

Tab. 5.2: Dwelling stock by tenure type in South European countries

	IT	ES	GR	PT	CY	MT
Owner-occupied	61	83	77	75	68	80
Private rental	17	8	18	11	14	2
Social rental / other	22	9	5	14	18	18

Source: ENTRANZE database www.entranze.eu

In terms of socio-economic characteristics, these counties have been fairly close to the EU-27 average (Table 5.3), however, the most recently available Eurostat data from 2010 do not reflect the current situation of the economic crisis, with e.g. negative GDP growth in 2012 (-6.4% fo Greece) as well as unemployment rates of more than 20% in Greece and Spain. Moreover, the financial stability pact has forced the public sector in these countries to cut spending sharply, which influences the prospects for investments in both public and residential buildings.

Tab. 5.3: Socio-economic characteristics of building owners in South European countries

	IT	ES	GR	PT	CY	MT
Average income PPS/capita in relation to EU-27 average (=100%)	102	97	93	81	104	-
Share of low-income households among owner-occupants, %	16	18	19	17	15	13
Gross household savings rate, 2010, %*	12.5	13.9	5**	10.1	11.6	-

* NB: includes savings for fixed capital, including mortgage repayments (hence, these savings are not all available for new investments)
** From World Bank online statistics, http://data.worldbank.org/indicator/NY.GNS.ICTR.ZS

Source: Eurostat; Dol and Hafner 2010

Most countries in this group rely on energy imports, and have few domestic energy sources. Gas and oil are important fuels used in households (Table 5.4). The relatively large share of electricity use (apart from Italy) is due to the relatively low share of heating energy demand compared to other parts of Europe,as well as to the relatively large share of cooling in some countries in this group.

Tab. 5.4: Share of various energy sources in building energy use in South European countries

	IT	ES	GR	PT	CY	MT
District heat	0	0	1	0	0	1
Oil	10	28	40	19	34	22
Coal/lignite	0	0	0	0	0	0
Gas	55	17	5	8	0	0
Biomass	4	9	11	27	11	0
Electricity	30	46	44	46	56	78

Source: ENTRANZE database www.entranze.eu

In the following, we first provide a more detailed analysis of the factors influencing public acceptance and adoption of various NZEB and RES-H/C solutions in the two ENTRANZE target countries in this group: Italy and Spain. Here, we draw on the expert interviews (Annex 2), literature and our project partners' experience. Then a more aggregated and rougher assessment is made of other countries in this group, and the most important similarities and differences are highlighted.

5.1. Italy

5.1.1 General policy context and major investor categories

In Italy, the building stock is fairly old. According to Ruggieri et al. (2007), about 75% of the buildings were built before the introduction of any kinds of energy performance standards. A significant portion of the buildings are more than 50 years old. There is a wealth of historical buildings that are widely appreciated and protected (Nigro and Nigro 2011). Hence, renovation is a growing business in Italy.

In recent years Italian national and regional governments have been active in promoting energy efficiency and renewable energy (Zabot et al. 2011). Significant measures are focused on the residential sector: feed-in tariffs are offered for photovoltaic systems and 55% tax credits are available for energy efficiency investments (windows or boilers substitutions, walls and roof insulations or even complete building refurbishments). In some individual provinces, also low-interest loans are provided (Zabot et al. 2011).

Energy performance standards in the national building code apply to new buildings and the renovation of buildings with an area of more than 1000 m^2 (ENEA 2009). New buildings have an energy performance index threshold, and must have external shielding systems, 50% of primary energy consumption for water heating from renewable sources, PV panels to produce electricity, and connection to district heat if available (ENEA 2009).

The main mechanisms in operation at national level to promote the use of renewable resources for heating and cooling, including indirectly, are the energy efficiency obligation schme and tax deductions (NREAP Italy 2009). Promotion of the use of renewable energy sources in heating and cooling through technologies such as solar thermal, high-efficiency heat pumps, low-temperature geothermal systems and biomass heaters is also achieved as part of the wider 55% tax deduction to incentivize energy saving in the building sector. This has been a very popular scheme (ENEA 2010), which is today somewhat less generous than before because the deduction is split over 10 years (EurObserver 2011b).

Moreover, the governance system in Italy is highly decentralized. Regional and local authorities have significant responsibilities for urban, energy and even climate policy. Some regions and municipalities have implemented their own building codes, energy standards and energy performance certification schemes, which are more ambitious than the national standards, and several regions and municipalities have introduced ambitious promotion and incentive schemes for energy investments in buildings (Ruggieri et al. 2011; Zabot et al. 2011).

Italy also has a system of energy saving obligations for major energy providers. According to ENEA (2009), the white certificates are released by GME (Getore dei Mercati Energetica), after authorization of Regulatory Authority for Electricity and Gas, which verifies the achievement of energy savings. Energy efficiency projects can (and often are) also carried out by ESCos (ENEA 2009).

Energy performance certificates (EPCs) are mandatory for new buildings, sale and rent of a home or dwelling (advertising of real estate ads), total renovation of a home, request for the 55% tax deduction and incentives for PV systems, signing of a new energy supply contract (Bevini 2010). However, the legislation allows for some loopholes, especially concerning the use of certified experts (EC 2012), and the application of the national principles is referred to the regional authorities. In this context, several Regions (e.g. Trento e Bolzano, Lombardia, Piemonte) have issued their own EPC requirements, which are more demanding than the national ones (Bevini 2010), and other Regions have not yet implemented its own EPC scheme.

Italy is the least energy-intensive economy in Europe, but a large weight is placed on energy efficiency policy due to the large share of import of energy and the ensuing high cost per energy unit (ENEA 2007a). Renovation of buildings is also a major industry (ENEA 2007b; Ruggieri et al. 2007). However, there are still several challenges ahead for comprehensive renovations to become widespread throughout the country (Ruggeri et al.2007).

5.1.2 General drivers and barriers for energy renovations among different owner groups

Italy has traditionally had a fairly forceful energy efficiency policy, considering the low energy intensity of the economy. However, this has been hampered by various types of market failures, including the lack of capital, as well as organizational and informational barriers (Ministry of Economic Development 2012). These are today intensified by the current financial crisis.

Table 10.2 presents an overview of the main barriers to energy investments for various building owner groups, on the basis of our review and expert interviews. Genuine uncertainties play a certain role for several owner groups, especially concerning verification of energy savings. Financial barriers are also widespread concerns, especially initial costs, long payback times and access to capital. The current financial situation also intensifies the overall unwillingness to incur debt. Collective decision problems, however, are the most severe barriers for multifamily housing, which constitutes a relatively large of the total housing stock. Lack of customer knowledge and lack of reliable advice are also widespread barriers in the residential sector, as is the difficulty in finding skilled service providers. According to our interview data, the public sector is struggling with a different and even more severe problem, i.e., the inability to make any new investments in the face of the internal stability pact.

Several parties influence, or can influence the situation, and support the process of energy renovations by building owners:

- **Regional and local governments** have been particularly active in Italy. Some have implemented their own ambitious energy standards, energy performance certification schemes, as well as ambitious promotion and incentive schemes for energy investments in buildings (Ruggieri et al. 2011; Zabot et al. 2011).
- **The national government and the national energy agency ENEA:** The government has a central role in setting the overall targets and framework (e.g. EPBD2 implementation), and ENEA has a central role in planning and providing advice for building owners, as well as in stimulating the development of new solutions.
- **NGOs** are playing a growingly active role in promoting energy efficiency, as reflected e.g. in a WWF contracted study on barriers to energy efficiency in condominiums (Ruggieri et al 2007).

- **Companies offering solutions:** Renovation is a major industry in Italy, and contractors are active in promoting solutions. However, Ruggieri et al. (2007) suggest that qualifications for professionals should be strengthened, that also building administrators and heating system managers could take a more active role in energy management, the role of energy performance certificates should be strengthened by including advice on measures to be taken, and that ESCOs could be supported by organizing regional certification.
- **Financial institutions:** There are successful local examples where bank financing has been mobilized by public sector guarantees and incentives (Ruggieri et al. 2011). Ruggieri et al. (2007) suggest that such public-private partnerships should be further developed, dedicated funds be established, and also insurance products be developed to support ESCO expension.
- **Energy utilities** play a central role via the white certificates scheme. The government expects to further strengthen this scheme in the new national energy strategy (Ministry of Economic Development 2012).

There are several drivers for energy efficiency improvements in existing buildings. Economic benefits are widely recognized, as energy is relatively expensive in Italy. However, for residential customers, issues of comfort are the most important driver, and the perceived technical need to renovate is important for all types of building owners. Table 10.3 provides an overview of the most important decision criteria for each owner group, as identified in our study. Economic criteria are among the most important for all groups, and the emphasis on initial costs cuts across all owner groups. Timing is also a widespread concern, as is improved comfort for all kinds of residential building owners. For the public sector, there are many criteria that were deemed as having medium value (e.g. environmental and societal concerns), however, they cannot compete with the cost criterion under the current financial austerity regime. They could probably gain importance if financing can be organized via third parties.

5.1.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 5.5 presents an overview of major drivers, barriers and the most and least promising building and owner types.

Thermal renovation

In Italy, a strong driving force for energy efficiency in buildings is the awareness of final users; in this sense the media have an important role (television, newspapers, dedicated magazines): they incentivate the renovations and suggest solutions toward efficient buildings. Moreover, the government allocates economic support (incentives) for renovating residential existing buildings, and some municipalities have introduced regulations that facilitate the construction or renovation in an efficient manner (such as volume addition or economic remission costs). At the national (and in some case, also at the regional) level, laws drive towards buildings characterized by low energy need.

The major barriers are different depending on who has to invest in renovation:

- Private: lack of knowledge about efficient buildings, high initial costs, long payback time, too much bureaucracy to obtain incentives, difficult to obtain economic funding from the banks, overestimation of initial costs;
- Business Office: in general the energy consumptions are secondary respect to the company's core business; often the company rents the space for the office and the owner is not interested to invest money in renovation;
- Public administration: cannot obtain national incentives and moreover the municipalities cannot spend more money in pubblic renovation due to the national law "stability act".

In addition, there are two other common big problems: the professional inertia of technicians (engineers, architects, etc.) toward new technologies: innovation, because unknown, is seen as a possible complication. Morever, the building amministrators in multifamily housing do not want to assume more responsibilities and take on more things that they "have to do".

Thermal renovation is easiest in single-family homes, which have easier access to national incentives. Public building (such as schools) have a big interest in renovation, but currently it is difficult for them to find funding. Thermal renovation is particularly problematic in existing buildings that are under environmental protection or constrained for historical reasons. Office and public buildings are also less likely to conduct thermal renovation due to constraints on capital expenditure.

Heating and hot water systems

Existing heating systems are dominated by gas (49%), oil (29%) and biomass (13%), with very small shares of electric heating and district heating. Oil-based heating systems are on the decline, due to the high cost and poor, polluting image of oil. Electric heating is not widespread or regarded well, either.

For all new buildings and in case of large renovations, the current energy efficiency standards in the building code require a minimum percentage of energy for heating and hot water from renewable sources. The government is also discussing the possibility to introduce a mechanism of public support for thermal renewable energy.

The main barriers (see De Felice and Forni 2011) include high initial costs. For some solutions, space availability is a barrier in urban contexts (e.g. solar panels or ground source heat pump). Some technologies have a large impact on the visual landscape. Hence, new renewable solutions are more easily installed in single-family homes and larger standalone buildings outside the urban centres, whereas they are more problematic in urban areas.

Some specific issues for particular renewable heating and cooling technologies are highlighted below:

- **District heating** is prompted by private or pubblic companies that deliver energy. These companies are more interested in apartment blocks or office buildings. Hence, district heat is most likely applied in large apartment buildings (which will always use district heat when available), public buildings, and even most offices. Single-family homes are not so eager to connect to district heating.
- **Biomass-based central heating systems:** Marketing by companies is the main driver for this solution. There are, however, several barriers (Caserta 2007), which include lack of customer knowledge, the fluctuating price of pellets as well as the absence of a financial framework to encourage stable and dedicated investments. Moreover, confidence and market development is hindered by the fact that the market is dominated small companies with small markets. Biomass use is perceived of as being complex. Especially older people are concerned about the annoyance of cleaning the boiler. Biomass can be problematic especially in an urban context, where it is difficult to find space for fuel storage. However, buildings in rural areas are a promising group of customers for this technology.
- **Biomass based room heating systems** are driven mainly by marketing by companies. They are most widely adopted by single-family houses and individual flats, where they are then usually used as the primary heating system (the existing plant became auxiliary). Major barriers are the inconvenience and effort of charging and the cleaning system, which can be a deterrent for older people and in urban areas.
- **Groundsource heat pump systems** are mainly driven by marketing by companies and real-life examples. However, in Italy groundsource heat is still a niche product with variable solutions offered (Maritan and Panizzolo 2008) The most promising customer types are new single-family homes, existing single-family homes with central heating, and also some apartment and commercial buildings. The major barrier is the cost of installation. This is likely to deter buildings which lack central heating or buildings with low-income residents. Space can also be a problem in urban areas (Maritan and Panizzolo 2008). ¨

- **Airsource heat pumps** are promoted by companies marketing them and real-life examples. However, there have been problems with the poor quality of some of the cheapest models, and airsource heat pumps are not actively promoted by the authorities. They can also be difficult to integrate with typical heat distribution systems in buildings from the 1950s-1980s, which are heated with radiators with high temperatures.
- **Solar thermal systems** are an easy system to reach the energy performance standards of the Building Code, especially for hot water, which require that at least 50% of hot water, and as of January 1, 2012, also 20% of heat (Eurobserver 2012) are produced with renewables in new buildings or buildings undergoing major renovations. They are most popular in single-family homes and small multi-family or office buildings. Wider takeup is hindered by a lack of knowledge and concerns about the seasonal variation in heat production. The can be difficult to integrate with the heating and hot water sysems in apartament blocks and office buildings, and it can be difficult to find space for a sufficiently large hot water tank. They are not suitable for buildings connected to district heat, and may be difficult to apply in buildings with limited free surface on the roof.

Ventilation heat recovery

Ventilation in existing buildings in Italy is performed mainly through local ventilation by fans and airing (Ringer 2011; Litiu 2012). Ventilation heat recovery is closely connected to the installation of mechanical ventilation for improving indoor air quality and comfort levels. It is usually promoted by associations or entities that promote building energy efficiency, often linked to low-energy building certification schemes (Passivhaus, CasaClima, BestClass, etc.). Hence, ventilation heat recovery is for the moment more likely to be applied in new rather than existing buildings. Major barriers are a lack of knowledge and familiarity with ventilation systems, i.e., a lack of professional training and customer information.

Energy efficient air conditioning

Unlike other Euopean countries, Italy represents are long-established market for air conditioning, which is showing signs of market maturation and declining sales (Adnot et al. 2011). Parties promoting energy efficient air conditioning are often linked to low-energy building certification schemes (Passivhaus, CasaClima, BestClass, etc.). They are mainly used in new buildings. Major barriers are high initial costs and long payback times. There are also technical difficulties in installing efficient systems for air conditioning in existing buildings.

Electricity micro-generation

For all new buildings and in case of large renovations, the law requires a minimum electric power deriving from renewable sources. There is a strong public support in term of incentives for the production of electric energy from renewable sources (PV, biomass, wind, etc). For example, there is a generous feed-in-tariff of 0,32€/Wh for small roof-mounted PV system (Karteris and Papadopoulos 2012).

However, wider diffusion is hindered by the lack of cost-effectiveness without public support. There are also large seasonal variations (for solar panels and wind turbines), as well as a low efficiency for some systems and difficulties to store the generated energy when it is not directly consumed. Moreover, there is significant bureaucracy required in order to obtain public incentives. It is also not easy to obtain funding for investments in electricity micro-generation rom the banks. There can also be constraints on visual impact, especially in urban areas.

Building-applied PV is most readily applied in single-family houses, industrial buildings, agricultural buildings and unused farms. It is less easy to apply in apartment buildings, and particularly buildings with historical constraints.

Table 5.5 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions.

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	Overall energy awareness, incentives, laws at national and regional level	Lack of qualified technicians Lack of knowledge High initial costs,long pay-back times, access to capital	Single-family houses	Office buildings Public buildings
District heating	Private and public energy companies	Single family homes are left aside	Large apartment buildings Public buildings Most office buildings	Single-family homes
Biomass central heating systems	Companies	Lack of knowledge Lack of dedicated finance Inconvenience Fluctuating fuel costs Small markets Space (urban buildings)	Buildings in rural areas	Buildings in urban areas Older people
Biomass-based room heating systems	Companies	Inconvenience, charging and cleaning	Single-family houses Individual flats	Urban areas Older people
Groundsource heat pump systems	Companies, real life examples	Investment costs Difficult to install in existing buildings in urban areas	Single-family homes with central heating, new homes Some apartment and commercial buildings	Lack of central heating Low-income households
Airsource heat pumps	Companies, real life examples	Quality problems of some products Difficult to integrate with 50s–80s buildings	All buildings	None
Solar thermal	Easy system	Lack of knowledge Seasonal variation, difficult to integrate in larger buildings Space for water tank	Single-family homes Small multi-family or office buildings	Buildings connected to district heat Buildings lacking free surface on the roof
Heat recovery	Associations that promote energy efficiency Convenience	Lack of knowledge	All new buildings	Existing buildings
Energy efficient air-conditioning	Associations that promote energy efficiency Convenience	Long payback time, initial cost Difficult to install in existing buildings	New buildings Buildings with need for high indoor air quality	Existing buildings
Electricity micro-generation	Legal requirements Positive image, strong public support	Seasonal variation Costs, low efficiency Energy storage problems Landscape constrains Financing	Single houses Industrial buildings Agricultural buildings	Historical apartment buildings

Sources: National strategic plan for energy; http://www.canaleenergia.com; Cariani and Disi (2012)

5.2 Spain

5.2.1 General policy context and major investor categories

The building stock consists of an estimated 10.2 million buildings, nearly 9.5 million of which are residential buildings. Spanish homes consume 17% of Spain's final energy.

The housing stock includes approximately 25 million dwellings (Cuchi & Sweatman 2011). More than 60% of these were built before 1980, when there were no technical standards or codes to regulate the quality of buildings: 44% of buildings were built between 1960–1980, 41% between 1900–1960 and 15% before 1900. More than 1.2 million primary dwellings built between 1960–1980 have deficiencies in their conservation and service status, which makes them especially interesting in terms of upgrading their technical systems (Cuchi & Sweatman 2011).

A special feature of the housing stock in Spain is the large share of secondary residences. There are about 8 million secondary residences, which are unused or empty some part of the year (Tragopoulos & Sweatman 2012). Primary residences accounted for 65% of the built housing stock (Cuchi & Sweatman 2011), and these constitute a more promising potential in terms of energy savings and renovations (Tragopoulos & Sweatman 2012).

In Spain, the Ministry of Industry, Tourism and Commerce (MITyC) manages overall energy policy. Energy efficiency policy is coordinated and guided by the resources and technical leadership of the Energy Diversification and Savings Institute (IDAE, Instituto para la Diversificacion y Ahorro de la Energia,) in conjunction with the autonomous regions (Sweatman & Managan 2010).

The energy efficiency policies are defined in the Strategy for Energy Savings and Efficiency 2004–2012 (E4), Energy Efficiency Action Plans (PAEE 2008–2011; PAEE 2011–2020) and the Plan to Activate Energy Savings 2008–2011 (Tragopoulos & Sweatman 2012; Sweatman & Managan 2010). The building policies for energy efficiency mainly draw on regulatory and legislative measures such as Building Technical Code 2006, Regulation for Buildings' Thermal Installations 2007, Regulation for Buildings Energy Efficiency Certification 2007, State Plan for Housing and Renovation 2009–2012 and Plan 2000ESE concerning Energy Service Companies (Tragopoulos & Sweatman 2012, 11). One of the success stories was the adoption of mandatory solar thermal installation as part of the building code. There have also been several campaigns to promote building insulation the replacement of boilers (Sweatman & Managan 2010).

As a part of Spains's Energy Efficiency Action Plan, provincial governments allocate grants or preferential loans to support the energy efficiency in buildings. Four types of measures have been implemented in the existing residential and public building sector (EURACE 2010):

- Grants or preferential loans have been granted for rehabilitation of the thermal envelope of existing buildings. The objective is to reduce the energy demand of heating and cooling by means of application of energy-efficiency criteria in the rehabilitations of buildings thermal envelope.
- Energy rating enables owners to compare energy-efficiency of buildings, which aims to encourage investments in energy efficiency.
- Measures have focused on improving the energy efficiency of existing thermal installations. Public support is given to energy actions that allow reduction in the consumption of conventional energy.
- Measures have been taken for improving the energy efficiency of existing lighting equipment.

Our interviewees stressed that an overriding issue currently influencing is the financial crisis, which has made banks very cautious in their lending. This has greatly reduced all construction activity, including renovations. Moreover, energy use has declined sharply due to overall declines in income and consumption levels. Fuel poverty is an increasing problem in Spain in the current situation.

5.2.2 General drivers and barriers for energy renovations among different owner groups

The current situation in Spain does not appear to be encouraging for the promotion of energy renovations. While the government has taken several measures and NGOs have been actively advocating for a more forceful renovation policy, current investment levels are low and there are many severe barriers. Among these, our interviewees and several commentators (e.g. Travezán 2012; Tragopoulos and Sweatman 2012) have emphasized the administrative complexities and delays and the poor organization of condominium owners' access to finance (i.e, the need for mortgages by all owners) as the most significant ones. These are very important issues because owner-occupied apartments constitute almost half of the entire building stock considered here (and also many of the rental apartments are located in condominium buildings).

Across all building owner types, financial barriers are the most widespread, including high initial costs, long payback times, access to capital and the cost of capital, as well as the unwillingness to incur debt under conditions of financial uncertainty (Table 12.2). The organizational problems of condominium owners were already mentioned above: in addition to difficulties in accessing finance, there are also conflicts of interest and renovation projects often require professional mediation and the help of external parties. Moreover, our experts were of the view that secondary buildings face similar barriers as the others but to a greater extent: moreover, the absence of any current drivers makes this segment of the building stock very unlikely to undertake major renovations under any foreseeable circumstances.

Nonetheless, most authors argue that a concerted chain of stakeholders supporting renovations could help to make a breakthrough in energy renovations. The following stakeholders have been identified as important (Cuchi & Sweatman 2011; Tragopoulos and Sweatman 2012; Travezán 2012; MARIE 2012):

- **Public bodies:** Many instruments are in place to promote energy renovations but they do not seem to be reaching their goals under current circumstances. Several innovative policy instruments have been recently suggested. These include for example fiscal instruments such as tax deductions for energy investments, as well as the provision of upfront finance via ESCO-type solution. There also seems to be a need for more convincing and tailored communication on the benefits and procedures of energy renovations.
- **Companies offering solutions:** Several commentators suggest that training and certification measures are needed to offer an appropriate package of services. On the other hand, because building owners face difficulties in raising finance, also contractors can face risks in offering comprehensive services.
- **Banks:** Banks might play an important role under different circumstances. There is a clear need for long-term low-cost loan products that could lever public funding.
- **Energy companies:** There is no energy efficiency obligations scheme in Spain. However, several commentators have suggested that such a scheme would be necessary in order to raise the necessary capital, and it could also provide a way to recover upfront finance via energy bills.

As concerns the most important decision criteria for the major building owner groups, initial costs are likely to be relevant criteria for all groups of building owners, and many would also examine payback times. Timing is likely to be important for all larger building types, as renovations are usually made in response to the technical need to renovate the building or its parts. Improved value of property is also relatively relevant for several building owner types, as there is a surplus of property for sale in Spain. In other respects, the criteria reflect the specific situations of particular owners, including their knowledge levels and the average condition of different types of buildings.

5.2.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 5.6 presents an overview of major drivers, barriers and the most and least promising building and owner types.

Thermal renovation

A large number of apartment buildings were built between 1970 and 2006. These dwellings were built without adequate energy efficiency criteria and thermal protection. Energy costs have increased in recent years, so the private sector is promoting energy saving initiatives without diminishing users comfort.

There is currently no legislation that requires owners to conduct renovations in existing buildings, but there is a plan of action that includes strategic measures aimed at these buildings (Plan de Acción de Ahorro y Eficiencia Energética 2011-2020 and Plan Estatal de Vivienda y Rehabilitación 2009-2012), in terms of thermal rehabilitation or financial assistance for rehabilitation involving a reduction of building energy consumption. So the principal drivers promoting insulation and thermal renovation are national incentives and subsidies, mainly based on plans for replacement of windows, insulation on façades, and tax deductions and VAT reductions for renewal and repair work for residence housing. However, they are currently being reduced because of the financial crisis.

The main barriers to thermal renovation are costs and lack of skills and awareness. Renovations are expensive and residents have not saved enough even for things that must necessarily be done. There is a lack of awareness and capacity among owners and tenants. There is also a lack of technical skills and awareness of architects, because traditionally insulation was not a priority in buildings .

Owner-occupied single family homes and social housing estates are renovated more regularly. Also state-owned and local government buildings conduct major renovations because they are expected to be energy eficiency models. However, thermal renovations are problematic in owner-occupied apartment buildings, because residents have difficulties in reaching agreement. They are also rare in older single-family homes, especially in rural areas. Sometimes demolition might be an alternative to renovation if the resale possibilities are uncertain.

Heating and hot water systems

Space heating in Spain is mostly based on gas (45%), electricity (34%), oil (16%), and biomass (4%) (ENTRANZE database). Fossil fuel-based systems represent mature markets, in which designers, installers and developers have a great deal of experience. System reliability and security of energy supply are the main factors maintaining these systems, as well as the relatively low investment cost. In Spain, there is a preference for individual heating systems even in apartment buildings, due to low initial cost and greater individual control. Central heating systems are more typical in high-rise and other large buildings, whereas smaller apartment buildings tend to have individual heating systems. Electric heating is also popular due to the low initial investment cost and ease of installation. However, the running costs are relatively high, as are CO_2 emissions.

Some specific issues for particular renewable heating and cooling technologies are highlighted below, based on CENER projects[20] and several literature sources (Communidad de Madrid 2008; González et al. 2012):

- **District heating** is virtually non-existent in Spain. There are several technical, regulatory, political and economic barriers to district heat, including a lack of culture and political will as well as very high investments and uncertain returns. District heat is most feasible in concentrated residential areas, prefereably new ones, concentrated industrial areas, preferably with similar uses, and in general, types of buildings with high and continual (more or less) heating demands. It is particularly problematic in neighborhoods with low population density, and urban – especially historic - city centers, where the construction of the pipeline network involves many difficulties and high costs.

[20] NIRSEPES project (New Integreted Renovation Strategy to Improve Energy Performance of Social Housing), ENERGY-TOOLSET for improving the energy performance of existing buildings, Renewable energy acting in sustainable and novel community enterprises a Concerto coordinated initiative, Joint eco–city developments in Scandinavia and Spain

- **Biomass central heating systems** are highly valued by the Spanish regulation on energy certification of buildings; i.e., the use of biomass helps to obtain a good rating. They also offer a good combination with solar water heaters. Moreover, biomass prices are very stable because they are not linked to fossil fuel prices. The use of forest residues revalues the value of forests and prevents forest fires. So far, the state has partially funded biomass facilities. However, the initial investments are high compared to central fossil heating systems, and space requirements and fuel supply logistics can prove problematic. Moreover, Spanish people are not familiar with bionenergy hence biomass solutions are often rejected by users and designers. Biomass price is not regulated and the maintenance of the facilities of biomass is more expensive than a central fossil heating system. Due to the intrinsic characteristics of the biomass combustion, the ignition system, regulation and control of these devices is more complex. For central heating systems, the most promising types of customers are large multifamily dwellings and other buildings with high heating demands, whereas low-rise residential buildings and other buildings with low heating demands (office buildings, comercial buildings, museums...) are less promising.
- **Biomass-based room heating systems** are partly subsidized (IDAE 2013). Potential problems are smoke evacuation and fuel storage and management. It is most likely to be used in small housing with the possibility to store sufficient biomass
- **Groundsource heat pump systems**: One of the main drivers is that groundsource heat pumps can help to provide for heating and cooling needs with a single system. Compared to airsource heat pumps, groundsource heat pump sytems have a high performance and low noise levels. They require minimal maintenance and have low operating costs. So far, the geothermal facilities to heating and cooling have been funded partially, and they offer one way to obtain a good rating in the energy certification of buildings. However, the initial investments are high compared to other heating systems (especially if domestic hot water is also required). From a technical point of view, facilities with horizontal coils need large areas of land, while facilities with vertical coils are very expensive. Proper sizing of geothermal facilities requires exhaustive studies of thermal behavior of the soil, which expensive and complex. Soil conductivity is a determining factor for its viability. There can also be difficulties in predicting the behavior of the ground (subsidence, differential settlement) in massive actuations. There are also potential environmental risks. In buildings with unbalanced demand, the soil may be saturated thermally. Groundsource heat pumps are well suited for types of buildings where the heating and cooling demands are balanced, i.e., suitable for buildings where outside temperatures in winter and summer are extreme (i.e., areas of Spain with continental climate). However, it is not recommended for buildings where there is demand for heating only or cooling only, and not suitable for buildings where outside temperatures in winter and summer are smooth (litoral areas of Spain).
- **Airsource heat pumps:** A main driver is the possibility to provide for heating and cooling needs with a single system. The performance of airsource heat pumps is, however, lower than that of groundsource heat pumps. Airsource heat pumps are relatively cheap to purchase, relatively easy to install, require little maintenance and cost little to operate. However, a major concern is that the price of electricity is likely to increase in the future. In Spain, it is deemed particularly suitable for properties without connection to the gas grid or with limited access road. It is considered particularly suitable for when retrofitting buildings. From a cost-effectiveness perspective, it is considered suitable for buildings where outside temperatures in winter and summer are smooth (litoral areas of Spain). It is not recommended in residential buildings that only have heating (and no cooling) demands, and it is not considred suitable for buildings where outside temperatures in the winter and summer are extreme (some areas of Spain with continental climate).
- **Solar thermal:** The mandatory requirements of the Technical Building Code (TBC 2006) is believed to be a major driver to solar thermal technology in Spain. The HE4 Section of the Code imposes a minium share of domestic hot water that must be produced with solar energy, depending on consumption, climate zone and technology system. In the same way, it imposes the minimum annual contribution for heating indoor pools. Solar thermal has been taken up most readily in single-family homes, because owners can decide on their own and the system is easy to implement. In the tertiary sector this technology is interesting for hotels and indoor pools due to the huge quantity of hot water that they

consume. However, apartment building owners are problematic because this technology requires a centralized system with storage rooms in the building and the roof needs to be accessible. Hence, it is so complicated and expensive to install in existing buildings. Moreover, it is complicated or unlikely that owners mange to reach an agreement. Moreover, the the huge investment cost and long payback are barriers, as are the high maintenance costs.

Ventilation heat recovery

For non residential buildings heat recovery of ventilating air exchange is mandatory when that flow exceeds 0,5m3/s (IT 1.2.4.5.2 RD 1027/2007). For residential housing, the building code CTE (CODIGO TÉCNICO DE LA CONSTRUCCIÓN RD314/2006) sets a high minimum ventilating air flow compared with other European countries. That makes heat recovery more attractive.

However, a major barrier is that heat recovery is not cost effective in soft climates (A, B and C). The poor air- tightness in buildings lowers the effectiveness of heat recovery systems. Before planning the installation, the airtightness of the building envelope needs to be tested (blower door test). Heat recovery also doubles the number of air pipes in the building, thus reducing useful space. Moreover, there is a lack of technical skills in implementing this type of system.

There are several heat recovery companies active in Spain, such as SOLER&PALAU, SIBER, ALDER, ZHENDER, SALVADOR SCODA. The most promising customer types include the tertiary sector and single houses, especially in cold climates (E & D). The least promising buildings are blocks of flats and buildings in soft climates (A, B & C).

Energy efficient air conditioning

High efficient air condition systems improve energy performance certification of buildings (RD47/2007). Air conditioning equipment is also easy to install, which makes replacement fairly straightforward. The most promising customers can be found in the tertiary sector, especially among hotels.

Several schemes promote energy efficient air conditioning. Energy labelling of air conditioning systems according to Directive 2010/30/EU is mandatory for equipment under 12Kw. The national Plan RENOVE promotes the replacement of air conditioning systems by newer and more efficient equipment, but depends on regional governments (see IDAE 2012).

Major barriers that hinder the take-up of mor efficient air conditioning equipment include the still relatively low cost of electricity, as well as the reltatively high noise levels of some models. More efficient equipment have a relatively high initial investment cost compared with less efficient ones.

Electricity micro-generation

Marjor drivers at the building code CTE-HE5 (RD 314/2006), which requires PV installations in large tertiary buildings. The installation cost of this technology is decliding very quickly. Moreover, the energy performance certification of buildings takes into account the reduction of CO_2 thanks to on-site electricity generation of using PV panels or wind turbines.

Major barriers are changes in the feed-in-tariff system and bureaucracy. RD-Ley 1/2012 cancelled Feed In Tariffs in 2012; the current price does not exceed 8 c€/kWh, compared with old 39c€/kWh (for PV). However, there is a draft regulation (Draft RD 1699/2011), which would pay building owners the same price for on-site production as they pay for purchased electricity (nearly 17c€ for housing) if local production is smaller than the consumption.

Buildings with large and well oriented roofs, especially in zones III, IV,V in Spain, are the most promising customer types. In contrast, historical buildings and shadowed roofs are more problematic.

Table 5.6 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	incentives and subsidies, tax credits (now reduced due to financial crisis)	costs, lack of technical skills and awareness of insulation (architects), lack of awareness of programs for owners and tenants	owner-occupied single family homes, social housing, government buildings (energy efficiency model buildings)	owner-occupied apartment buildings (collective decision making), old single-family homes especially in rural areas
District heating	none	No existing culture (low demand, lack of experts and technical skills), high investment costs, no political support	New concentrated residential and industrial areas, buildings with high and continual heating demands	Areas with low population density, urban and historic city centers
Biomass central heating systems	Low running costs, so far partially funded, technical drivers, benefits forests	Competition with fossil-based central heating, lack of awareness and intrest, investment costs, maintenance costs, space limitations	High-rise apartment buildings, buildings with high heat demand (residential, hospitals)	Low-rise residential buildings, buildings with low heat demand (office and commercial buildings etc.)
Groundsource heat pump systems	Convenience, low maintenance cost, so far subsidies	Initial cost, technical barriers, system is not feasible for every building or location	Buildings where heating and cooling demands are balanced, buildings in continental Spain	Buildings where is only need for heating or cooling, buildings in litoral spain
Biomass-based room heating systems	So far subsidies	iInconvenience (smoke evacuation)	Single-family homes (space for storage)	
Airsource heat pumps	Investment cost, easy to install, technical merits	Needs other systems for domestic hot water	Suitable for quite isolated areas without gas connection, existing buildings, litoral areas of Spain	Buildings with only heating demand, buildings in continental areas of Spain
Solar thermal	Mandatory requirements (Technical building Code, TBC 2006)	Investment costs, long payback time, high maintenance costs	Single-family homes, buildings with large hot water demand (hotels)	Buildings lacking storage room or roof space, apartment buildings (collective decision making)
Heat recovery	Mandatory minimum reguirements for residential buildings and some non-residental buldings, companies	Cost effectiveness in soft climate areas, effectiveness in buildings with bad air tightness, space limitations, lack of technical skills	Single-family houses Tertiary sector buildings in cold climate zones	Multi-appartment buildings Buildings in soft climate zones
Energy efficient air-conditioning	Availability, easy to install, mandatory requirements for more effient equipments	Electricity costs, inconvenience (noise), competition with less efficient equipment	Tertiary sector buildings (specially hotels)	
Electricity micro-generation	Required PV installations in big tertiary buildings (CTE-HE-5), tax credits from installation costs	Bureaucracy, cancelled feed in tariffs for green kWh (PV)	Buildings with big and well oriented roofs, buildings in specific climate zones in Spain	Historical buildings, buildings with shadowed roofs

Sources: Communidad de Madrid, CENER's IEE projects, IDAE manuals, Technical Building Code www.codigotecnico.org

5.3 Other South European countries

5.3.1 Greece

In terms of building stock and dwelling tenure, Greece is fairly similar to the larger two countries in this group. It was also fairly similar in terms of socio-economic characteristics, until recently. Oil is more widely used in buildings compared to the other countries in this group, as gas grid connections are limited (and will probably be so in the future in many regions).

State support for energy renovations and renewable heating and cooling systems appears to be somewhat less than e.g. in Italy. According to Giakoumi and Iatridis (2009), Greek households are offered a tax deduction of 20% of the cost for applications like building insulation, natural gas, district heating, solar thermal and central air-conditioning units using solar energy, as well as other energy production from renewable sources. The tax deduction is mainly used for solar thermal applications (Giakoumi and Iatridis 2009).

The solar thermal market is well developed and has been active for almost 30 years (Giakoumi and Iatridis 2009). In the history of the Greek solar thermal market, the main solar thermal product was, and still is, the thermosiphonic water heater. In 2009, 35% of Greek households had a solar thermal system in use (ODYSSEE 2010). Biomass-based heating systems are the main contributor to renewable heating in the residential sector; however, biomass-based central heating was banned for several years the largest cities (Giakoumi and Iatridis 2009).

As regards solar PV, Kartesis and Papadopoulos (2009) note that residential building-applied PVs gained significant momentum after 2009, when a national development programme started providing potential investors with a very high tax-free tariff as well as determining clarified and simplified grid-connection procedures. Since then, the development of PV installations was immediate, representing a cumulative capacity of 46 MWp in 2011.

The DEMOHOUSE (2007) project analysed the barriers to energy renovations in Greece, among other countries. The barriers identified are fairly similar to those in other countries, and relate to finance, awareness, the availability of quality services, and in the case of multifamily buildings, especially organizational barriers.

5.3.2 Portugal

Compared to the other countries in this group, Portugal has a much larger share of single-family homes, but similar high owner-occupancy rates. Average per capita income is clearly lower than in the other countries. With a relatively large share of the population living in rural areas, Portugal also has a relatively large existing share of biomass in building energy use.

The available incentives to improve the energy performance of existing buildings are low and, for a long period of time, were specific to renewable energy (Tuominen and Kolbut 2011). Quite recently, incentive schemes for thermal renovation were introduced, which offer tax deductions, efficiency cheques and low-interest credit lines, with the aim to retrofit 100 000 dwellings and 200 000 windows (Fonesca et al. 2011).

New investments are likely hampered by the current financial crisis. For example, according to Karteris and Papadopoulos (2012), despite the attractiveness of Portugal's current FiT system, investors are discouraged and the country's PV market is far from mature. The tariff is particularly favourable to small-scale residential systems that are combined with renewable heating systems.

A study of barriers to energy efficiency investments in Portugal (Tuominen and Kolbut 2011; Fonseca et al. 2011) reveals fairly similar barriers to those identified in Heiskanen et al. (2012) pertaining to Spain. Long payback periods, lack of access to capital, lack of awareness and easy-to-use solutions, lack of technical skills and good quality services were mentioned by experts from Portugal. There is a lack of information on how and where to apply for the incentives. The bureaucratic process and or the restrictive requirements to apply are so cumbersome that people do not feel motivated to apply. In addition, a particular problem related to solar thermal installations was past poor experiences with cheap equipment and poor installation, which have created a bad image of solar water heaters among consumers.

5.3.3 Cyprus and Malta

The total population of Cyprus in Government-controlled areas is 0,8 million, and the total population of Malta is 0,4 million. While there are likely many differences compared with other countries of South Europe (e.g. very limited domestic energy sources), for the purposes of the ENTRANZE project these countries can be assumed to have similar features as Greece. It is, however, worth noting that Cyprus has Europe's widest diffusion of solar thermal systems (0,6 kWh_{th}/capita).

5. 4 Similarities and differences among South European countries

In terms of building stock, there are some important differences among countries in this group. Italy, Spain and Greece have a relatively large share of multifamily dwellings, most of which are owner-occupied. They are thus greatly influenced by the organizational problems that are inherent to this type of buildings. In contrast, the smaller countries, Portugal, Cyprus and Malta have a larger share of single-family dwellings. Due to the high share of owner-occupancy, the share of low-income owner occupants ranges from 13 to 19%. There are also some quite large differences in the energy sources used in buildings.

A recent study (MARIE 2012) of demand-side barriers to energy efficiency in the Mediterranean region (including Italy, Spain, Greece, Portugal, Southern France, Slovenia and Malta) identified similar barriers in all countries. The study mentions several financial barriers, which are similar across Europe, as well as technical and knowledge barriers, which relate to service provide and user skills and capacities. These findings are supported by the studies reviewed in the sections above.

However, the MARIE (2012) study also highlights some barriers that seem to be typical to South Europe. These include structural barriers such as unstable legislative frameworks, gaps between objectives and implementation, complex administrative procedures, and complex decisions for multi-owner buildings, which are widespread in the region. The study also mentions a mismatch between the highly technocratic approach of the administration to energy renovations, and the attitude of residents, which is more geared to aesthetics, well-being and a "Mediterranean lifestyle". Users are thus reluctant to accept refurbishment works as they are perceived as intrusive, complex, bureaucractic and annoying, rather than helpful and user friendly.

In terms of renewable energy, it is worth noting that many countries in this group are highly advantageous for solar thermal and building-applied solar PV. However, for example as concerns solar PV, the installed capacity does not reflect the current profitability of installations in terms of solar potential and returns offered by local financial incentives, due to "social and administrative conditions" (Karteris and Papadopoulos 2012). Similarly, on a per capita basis, solar thermal installations are below European average in Spain (where they are mandatory for major renovations), Italy (where they have been supported by the 55% tax incentive) and Portugal (where they have been supported by a 50% grant, albeit one that is very complex to obtain).

6 Trends, drivers and barriers in Central and Eastern Europe

The countries of Central and Eastern Europe share some common features that merit their being grouped together, even though the geographic distance from the Baltics to Bulgaria is very long. The countries are all post-communist states, most of which where within the sphere of influence of the former Soviet Union (and the Baltic countries actually part of it) until 1989. This resulted in a certain structure of the building stock and certain patterns of energy use that have their influence even today.

Compared to Western Europe and the EU-27 average, countries in Central and Eastern Europe have a relatively high share of owner occupied housing stock (Table 6.2). The lowest share is in Poland, 52%, and the highest is in Bulgaria, 97% of the housing stock. This is also the case in multifamily buildings, which constitute 24-63 % of the total housing stock (Table 6.1). Apart from Hungary and Romania, most countries of Central and Eastern Europe have more multifamily dwellings than do countries in Western Europe.

Tab. 6.1: Dwelling stock by dwelling type in Central and East European countries

	BG	CZ	RO	HU	LT	PL	SK	EE	LV	SI
Single-family dwellings	55	55	67	76	50	55	60	37	45	51
Multi-family dwellings	45	45	33	24	50	45	40	63	55	49

Source: ENTRANZE database www.entranze.eu

Tab. 6.2: Dwelling stock by tenure type in Central and East European countries

	BG	CZ*	RO	HU	LT	PL	SK	EE	LV	SI
Owner-occupied	97	77	96	89	92	66	89	89	86	81
Private rental	0	10	3	3	1	2	9	3	7	5
Social rental / other	3	10	1	8	7	32	2	8	7	14

Source: ENTRANZE database www.entranze.eu

Another common feature of the countries in this group is the relatively low income level (Table 6.3). Per capita purchasing power corrected incomes are at their lowest about half of the EU-27 average. Income inequalities are also high in some (but not all) countries. Combined with the prevalence of owner-occupancy, this means that many building co-owners are extremely poor and simply cannot afford to invest in renovations. For example, in Romania and Latvia, one-fourth of the owner-occupants are low-income households, i.e., earn less than 60% of the median income (which in itself is very low).

Tab. 6.3: Socio-economic characteristics of building owners in Central and East European countries

	BG	CZ	RO	HU	LT	PL	SK	EE	LV	SI
Average income PPS/capita in relation to EU-27 average (=100%)	-	69	-	57	57	65	70	56	47	83
Share of low-income households among owner-occupants, %	21	7	24	12	19	17	10	19	24	11
Gross household savings rate, 2010, %*	-	10.3	-	8.2	1.2	8.5	11.3	9.6	4.2	15.7

* NB: includes savings for fixed capital, including mortgage repayments (hence, these savings are not all available for new investments)

Source: Eurostat, Dol and Hafner 2010

In terms of energy sources used in buildings (Table 6.4), there are some commonalities but also significant differences. District heat is available in all countries, but its share in total energy use in buildings (including lighting and appliances) varies greatly, with 7% at the lowest in Slovenia and 37% at the highest in Lithuania. The most common energy source in some countries is natural gas (Hungary, Slovakia, Czech Republic), whereas biomas is widely used in Romania, Latvia, Estonia and Lithuania.

Tab. 6.4: Share of various energy sources in building energy use in Central and East European countries

	BG	CZ	RO	HU	LT	PL	SK	EE	LV	SI
District heat	15	17	14	9	37	19	16	32	25	7
Oil	3	0	6	1	2	5	1	3	3	32
Coal/lignite	7	6	0	2	6	25	7	1	2	0
Gas	4	37	30	57	8	19	51	7	11	8
Biomass	23	12	35	8	22	10	1	29	39	20
Electricity	48	27	14	23	25	23	24	27	19	33

Source: ENTRANZE database www.entranze.eu

In the following, we first provide a more detailed analysis of the factors influencing public acceptance and adoption of various NZEB and RES-H/C solutions in the three ENTRANZE target countries in this group: Bulgaria, Czech Republic and Romania. Here, we draw on the expert interviews (Annex 2), literature and our project partners' experience. Then a rougher assessment is made of other countries in this group, and the most important similarities and differences are highlighted.

6.1 Bulgaria

6.1.1 General policy context and major investor categories

The housing stock in Bulgaria is comparatively new: about half of it was constructed during the last 40 years and only 4% was built before 1919. However, it is not in good condition and is constantly degrading, mainly due to insufficient maintenance and inadequate management (UNDP 2007).

There is now a widespread recognition in Bulgaria that the process of deterioration of the housing stock must be stopped. The government has over the last few years taken a number of steps to address the problem, including: 1) adoption of a National Housing Strategy and a National Program for the Renovation of Residential Buildings (NPRRB); 2) adoption of an Energy Efficiency Act and establishment of an Energy Efficiency Fund; 3) adoption of a set of technical standards and energy efficiency norms; 4) ongoing preparation of enabling legislative measures 5) inclusion of an Action 1.2 Housing in the Regional Development Operational Program (RDOP).(UNDP 2007).

Practically all the housing stock is considered to need renovation, except for the newest buildings, because it does not meet present-day technical standards and energy consumption requirements (UNDP 2007). Nevertheless, the national strategic documents prioritize the industrially constructed residential buildings built in the period 1960 – 1990. Since 2005, energy standards for new and refurbished buildings have been significantly tightened (Todorova 2008). The newest norms are from 2009 and currently the new amendments of the Energy Efficiency Acts are under discussions in the Bulgarian Parliament for the transposition of the EPBD Recast directive and are to be adopted in September 2012.

Practical measures to promote energy renovation include (Kostadinov 2009; Rezessy and Bertoldi 2010; Trainrebuild 2011):

- Under the National Strategy for financing the building insulation for energy efficiency (2006-2020) the state grants a subsidy for measure implementation, audits and certification to state owned buildings, municipal owned buildings and private multi-family residential panel buildings.

- The National Programme for the Renovation of Residential Buildings (2006-2020) has multi-family panel buildings as a priority. The state supports the panel dwelling owners by means of direct subsidy of 20% from the renovation total.
- The Bulgarian Energy Efficiency Fund (BEEF) provides loans, partial credit guarantees as well as portfolio guarantees for ESCOs and for the residential sector. This instrument aims to provide an ESCO-type finance solution for multi-family buildings.
- The Residential Energy Efficiency Credit Line (REECL) was developed by the EBRD and the EC and offers loans for renovations, as well as an incentive depending on the energy savings achieved.
- A requirement of buildings with more than 1000 m2 of space to undergo an energy audit. This was applied to public buildings and the thresholds are to be strengthen gradually to 500 m^2 from 2013 and to 250 m^2 from 2015.
- Renovation under Operational Programme "Regional Development" – EU grants up to 85% are provided for energy renovation of municipal and state buildings and up to 50% for multifamily residential buildings. The cost of energy audit and project management are also included into the scheme in order to facilitate the process. Several banks are involved in order to ensure pre-financing and financing of the own contribution of the flat owners. This new scheme aims to remove the main obstacles for owners of multi-family residential buildings.

During the past decades, the energy sector has gone through a major restructuring involving significant tariff increases. This has had a large impact on private households, as large parts of the country are not served by district heat or gas, and use electricity for heating (Draganinska 2004). In this environment, cost increases and the introduction of individual billing in multi-family houses with district heating have led to a decline in energy use in households, which is still nonetheless significantly higher than in Western Europe (Kostadinov 2009).

6.1.2 General drivers and barriers for energy renovations among different owner groups

The Bulgarian situation is changing very rapidly in terms of general awareness and interest in energy issues, also as a result of rising energy prices. According to our interviewees, there were no discussions and no instruments 5-10 years ago, and now there are several measures in place to stimulate renovations.

However, there are still several barriers to more comprehensive energy renovations, which are summarized in Table 5.2. Two financial barriers are critical for all owner groups: high initial costs and access to capital and/or the cost of capital. A particular problem in Bulgaria are the owner-occupied apartment buildings, most of which still lack any capacity for common, comprehensive renovations because they are rarely organized as legal entities. This is important because they constitute a fairly large share of the total building stock. Moreover, while attention to and interest in energy issues has increased significantly, this is from a very low initial level and in a context where people have several other issues and concerns. Hence, lack of attention and interest is still considered a critical barrier for most owner groups, and lack of customer knowledge is critical for residential building owners.

In spite of these barriers, there are also several drivers for energy renovations. The rising price of energy, increasing awareness and public discussion, and several government, municipal programmes and NGO programmes were mentioned as important factors by our interviewees. On the basis of this review (see also Adjarova et al. 2010), the main parties influencing renovations are:

- **The state** has placed a special focus on panel buildings, for example in the National Programme for the Renovation of Residential Buildings. It also supports municipalities.
- **Municipalities** have been particularly active in Bulgaria. They have common networks of experts and provide information to other building owner groups. For example, the municipalities have the responsibility to support homeowners' associations in relation to the National Programme for Renovation of Multifamily Buildings (Trainrebuild 2011).
- **NGOs**, such as the Bulgarian Housing Association and EnEffect, are working to get building owner organized and to offer information and technical support for building owners.

- **Banks** could play an important role in financing energy renovations. However, as noted above, they have difficulties in dealing with unorganized multifamily housing owners, and commercial interest rates are high due to a high level of uncertainty in the market. This is why other dedicated finance instruments such as Bulgarian Energy Efficiency Fund and the Residential Energy Efficiency Credit Line (REECL) are very important.
- **Companies offering solutions:** Designers, architects and engineers working with energy efficient solutions can play an important role, as can construction companies and **i**nstallers. Other relevant companies include e.g. auditors issuing energy performance certificates.
- **Educational institutions** play an important role in education a new generation of professionals and introducing new solutions.

Table 5.3 presents a summary of the decision criteria identified in our study as important for different building owner groups in the Bulgaria. Two criteria stand out as being important for all groups: initial cost and improved comfort. The availability of good services and especially turnkey solutions for renovation and also priorities for several groups, as are the examples of widely used standard solutions, which are still lacking for many types of buildings in Bulgaria. However, energy efficiency seems to be rising on the agenda, as public sector organizations and office buildings are deemed to gain social approval through well-renovated buildings.

6.1.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 6.5 presents an overview of major drivers, barriers and the most and least promising building and owner types.

Thermal renovation

The main drivers for thermal insulation of buildings in Bulgaria are economic, and result from the increasing price of energy. Most of the building stock was constructed before 1990, when the fuel price was more affordable. With the increasing age of buildings, the issue of thermal comfort also arises. the old wooden-framed windows are replaced mainly with PVC and with double/triple glazing, thermal insulation of walls has also become a popular and effective measure. Regulations for new buildings and building renovations have strenghtened the requirements for heat retention and energy savings. There are also some examples of low energy and passive houses promoted in Bulgaria (LEED certification, passive house standard and other approaches).

However, the initial investment cost is high and some people cannot afford it. Loans are expensive (high interest rate) and the payback period is relatively long. Lack of knowledge and bad quality of services (installers) are also problematic for energy renovation technologies.

The first fully renovated buildings were public buildings – e.g. schools and kindergartens – as they received support from EU projects and other initiatives. These buildings serve as shining examples for the up-take of the process for private buildings. With the increasing competetiveness of office buildings, most of the new buildings in this market segment are incorporating new energy efficient technologies. On the other hand, office buildings and multifamily buildings are less eager to invest in thermal renovation as they distribute the heating cost between the tentants or co-owners.

Heating and hot water systems

The existing heating systems are based on biomass, coal and district heat, with a growing share of gas heating (ENTRANZE database). Other fossil fuel systems are on the decline, especially oil heating due to the rising and high cost. While coal is fairly cheap, it is inconvenient and also understood as polluting. Electric heating is mainly used in buildings in which only a few rooms are heated.

Heating and domestic hot water systems are important issues for all type of building owners. There are discussions on the replacement of the district heating substations in buildings (more effective heat exchangers, insulations), fuel change (from oil to natural gas, propane gas, biomass), integration of renewables (solar thermal, biomass), and more effective boilers and heating systems.

The investment cost is the major issue. Heating systems are major investments in themselves, and some new technologies also require major changes in the whole system (e.g., replacement of the radiators with convectors, installation of floor heating, etc.). BPIE (2012c) also mentions a shortage of trained installers for renewable energy supply equipment on a building scale.

The extension of gas network is normally viewed positively and most of the buildings connect to the new system (Kostadinov 2009). Single-family homeowners, but also owners of apartments that are not connected to the district heating are more flexible in their choice and they are generally more active in changing their heating systems. On the other hand, the penetration of new heating systems is not recommended for buildings connected to district heating. Additionally, tenants rarely invest in new heating systems as later they will remain the property of the landlords when the tenants move.

Some specific issues for particular technologies are highlighted below:

- **District heat:** According to BPIE (2012c), district heat could provide cheap NZEB solutions especially for multifamily and office buildings; hence promising owner types include apartment buildings, large office buildings and shoping centers. However, BPIE (2012c) estimates the current share of renewable energy in district heating plants to be about 1%; hence radical changes are needed in order to transform district heat into an effective NZEB solution. The main drivers for district heat expansion today are the district heat utility companies, which are extending their network. However, due to the monopoly position enjoyed by district heat companies, there is a great deal of negative public opinion (e.g. IRG 2007; BPIE 2012c) due to problems with heat losses and increases in the price of heat energy.
- **Biomass-based systems**: Biomass is still the dominant heating system in Bulgaria; however, the traditional systems based on wood stoves are not very efficient, and have also recently been replaced by gas-fired systems (Kostadinov 2009). Bulgaria also has a fairly large pellet industry, but has until recently exported most of its production (Steiner et al. 2009) Efficient heating appliances have entered the market, and the share of high-efficiency pellet and briquette boiler-based technologies is growing.However, such advanced technologies are mainly used by a small part of the population with high incomes, and the total domestic consumption of pellets is estimated at about 10 % of the production (Steiner et al. 2009).
- **Groundsource heat pumps** are today actively promoted in Bulgaria via marketing and good examples. A major barrier to widespread installation, however, is the high initial cost. Slow permitting procedures are also mentioned as a barrier (Dobrich Local Agency for Energy Management 2009). The most promising customer types are large installations like offices and public buildings, whereas apartment building are deemed the least promising.
- **Airsource heat pumps** have experienced increasing popularity because they are widely promoted and easy to install. Increased uptake is however somewhat hindered by quality issues: some models are not as effective as expected. All types of buildings are deemed promising customers for airsource heat pumps.
- **Solar thermal systems:** The solar thermal is fairly established in Bulgaria (BPIE 2012). Major drivers include the fact that solar thermal is a well promoted technology, especially in some regions in Bulgaria, as well as a proven one. However, in some cases there have been problems with the quality and efficiency of the systems. Single-family homes are deemed by our experts to be the most promising systems, whereas apartment buildings are considered the least promising due to complicated procedures.

Ventilation heat recovery and energy efficient air conditioning

Heat recovery is well promoted for mechanical ventilation systems in Bulgaria. Designers are aware of the benefits and include it into their projects. However, the existing market is very small (BPIE 2012), and investments are hampered by additional initial costs. The most promisting customer groups include large office buildings and hotels. However, mechanical ventilation is not common in residential buildings (BPIE 2012) and hence heat recovery is only likely to be implemented in connection with mechanical ventilation installed together with improvements to the airtightness of the building envelope (and this has not always been the case, according to our interviewees).

All new public buildings are designed with air conditioning. New technologies and effective systems are promoted by designers and experts in larger installations such as new office buildings pr shopping centers. Cooling systems are not generally installed in residential buildings; according to the ENTRANZE database, the rate of air-conditioning equipment ownership is only 15%.

Electricity micro-generation

Until recently, the construction of small rooftop PV systems on residential buildings in Bulgaria has been hampered by the requirement for a building permit, which has required fairly complex supervision procedures and delays in grid connection permits (PV Grid 2013). However, the procedures for installation of roof top systems have recently been facilitaded. Due to fairly generous feed-in-tariffs offered until recently, companies have been intensive marketing rooftop PV applications. However, feed-in tariffs have been recently cut from about 0.3 €/kWh to about 0,17 €/kWh (Beetz 2012).

The most promising types of customers include owners of office and industrial buildings. In contrast, building-integrated PV installations are difficult to organize and invest in in existing apartment buildings.

Table 6.5 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	Increasing energy cost Thermal comfort Regulations and voluntary initiatives	Initial costs, long paybac times Cost of capital Lack of knowledge Poor quality of services	Public buildings (renovations) New office buildings as exemplars	Old office buildings Existing multifamily buildings
District heating	District heat utility companies expanding network	Negative public image of companies	Appartment buildings, big office buildings and shopping centers	Single family homes
Biomass-based systems	Market promotion Cheap fuel: pellets, fire-woods	Manual operation	Single-family homes	Apartment buildings
Groundsource heat pump systems	Marketing activities, good examples	High investment cost	Offices and public buildings	None
Airsource heat pumps	Easy to install, well promoted	Some quality issues (not so effective models)	All types of buildings	None
Solar thermal	Well promoted, proven technology	Some cases with quality and efficiency issues	Single-family homes	Apartment buildings
Heat recovery	Well promoted for mechanical ventilation systems	Additional initial cost	Big office buildings, hotels	-
Energy efficient air-conditioning	Promoted by designers and experts	High initial cost	New office buildings, shopping centers	-
Electricity micro-generation	Marketing FIT and facilitation of permitting procedures	Reduction of FIT in 2012	Office and industrial buildings	Apartment buildings

6.2 Czech Republic

6.2.1 General policy context and major investor categories

In the Czech Republic, the average age of the building stock is relatively high (about 50 years). Several authors report a neglect of maintenance and renovation, which has resulted in poor conditions of buildings (Pejter and Gebauer 2010; Galda and Kubenkova 2007; Temelova et al. 2011). A particular feature of the residential building stock is a large share of panel buildings, i.e., large apartment blocks constructed of pre-fabricated, pre-stressed concrete. Panel buildings, constructed since the 1950s, make up the largest share of individual building types, and house almost one-third of the population (Galda and Kubenkova 2007 ; Temelova et al. 2011).

The Ministry for Regional Development is in charge of housing policy in the Czech Republic. Energy policy, and e.g., the Energy Performance Certificate, is the responsibility of the Ministry of Industry and Trade. Mandatory energy efficiency standards exist for new buildings and also for buildings undergoing deep renovation (Regulation No. 148/2007). However, the energy efficiency standards in the 1960s and 1970s, when a large share of the current buildings were built, were not very stringent (Pejter and Gebauer 2010).

Several programmes have been launched to support modernization (including energy efficiency improvements) of housing in the Czech Republic.

- The PANEL programme (2001-) supports the renovation of prefabricated panel buildings through an interest subsidy, a bank guarantee for credit and specialized technical assistance (Galda and Kubenkova 2007).There is a specified list of efficiency improvements that applicants must make, including insulation, improved heating systems, and use of renewable energy; however, there are no strict energy performance criteria for the basic level of support (UK Green Building Council 2011). About one-third of the panel houses have been renovated by now (Karasek and Ubralova 2012). The NEW PANEL programme subsidizes also apartment buildings constructed by "non-panel" technology.
- The Green Light for Savings Scheme (2009-2012) was administered by the Ministry of Environment and has provided generous (>50%) subsidies for thermal insulation and heating sources based on renewable energy (Zámečník and Hlaváč 2011). The precondition for the subsidy is the commitment to reduce the need of energy for heating below 55 kWh/m2/a, and at the same time to reduce the consumption of the heat by at least 40% after the completion of the reconstruction (Vanicek 2011). The scheme also provided a subsidy bonus for selected combinations of measures. Only accredited suppliers and products listed by the Ministry of Environment are eligible for the programme subsidy. The Czech Republic has raised funds for this programme from the sale of emission credits under the Kyoto Protocol on greenhouse gas emissions (UK Green Building Council 2011). The programme has been very successful in promoting ambitious energy renovations (Zámečník and Hlaváč 2011).
- Operational Programme Environment (OPE) offers more than 5 billion EUR from various European and national funds for ecological projects, including sustainable use of energy, renewable heat and electricity and the use of waste hear. This fund has, e.g., successfully supported energy renovations in public buildings in about 1500 projects (UK Green Building Council 2011).
- There are several energy service companies (ESCOs) in the Czech Republic providing energy performance contracting. The energy performance contracting market is increasing, but there are many administrative barriers to its rapid development. Usually the administration takes more time then is expected.

Energy performance certificates (EPCs) are mandatory for new buildings with more than 50m^2 of floor area (except industrial and agricultural buildings) and for major renovations of building with more than 1000m^2 of floor area. The EPCs are required in building permitting phase. Further, EPCs have to be displayed in public buildings with more than 1000m2 of floor area. EPCs are not required in case of selling or renting a building or its part (this obligation should start in January 2013 with relevant law recast, implementing

EPBD 2 as well. After this recast comes into force (should start on 1.January 2013), the EPC obligation should be broaden to more renovations (not only major ones) and to selling and renting buildings or parts of buildings. The EPC itself as well as some details of calculation methodology will be changed. A recommendations chapter is a part of the EPC, but it is usually filled in only in case of EPCs for renovations or public buildings.

New buildings and buildings over 1,000 m² undergoing a major refurbishment are required to undertake a renewable energy use assessment (Act No. 406/2000 Coll.; Regulation No. 148/2007 on energy performance of buildings). The amendment of Act No. 406/2000 Coll. envisages that if renewable energy sources are technically, economically and environmentally feasible, they will have to be incorporated in all new or refurbished buildings - starting from 2015 this will apply to all other buildings (RES Legal 2012).

6.2.2 General drivers and barriers for energy renovations among different owner groups

There has been an increasing emphasis on energy renovations in the Czech Republic in recent years. This is due to increasing awareness created by European directives and financial instruments, as well as to activity by energy auditors, architects, engineers, state institutions, universities and civil society. However, since the building stock is old and still largely in a poor condition, there is much work ahead.

Barriers shared by all owner groups in the Czech Republic seem to be problems with conflicting information and mistrust of information. This appears to be a situation typical in situations where markets for energy efficient solutions are rapidly expanding, and there are many players offering their own solutions. Other widely shared barriers are the high initial cost of energy efficient solutions and limited access to capital or the high cost of capital.

Where there are several owners, organizational problems are also widespread. These include especially collective decision problems: while the owner-occupied sector is not so large, the co-operative rental apartments in the Czech Republic are similar to owner-occupied ones as the owner-occupants have the final say on energy investments. Collective decision problems are also perceived to be widespread in public sector organizations, where there are several decision makers at various levels. Lack of customer knowledge – especially knowledge about solutions that are appropriate to their situation - was also deemed a widespread problem by all our interviewees. Transaction costs influence different building owners differently: they are most severe for the owner-occupied apartment buildings which are relatively small contracting units. Disruption in general seems to be a larger problem in apartment buildings than in single-family homes. This is probably because individual residents can block decisions, and e.g. elderly people are often more affected by disruption.

Our interviewees have several suggestions for how to overcome these barriers and further stimulate energy renovations. While there is information available, it requires some expertise to use: hence, an intelligible information campaign and public support for gaining high-quality energy performance certificates were suggested as useful informative instruments. Subsidized energy audits with expert recommendations were suggested as a way to overcome informational barriers. It was also suggested that loan subsidies should be offered for renovations that make a significant impact on energy for better renovations. In the public sector, a revision of public procurement rules was considered important in order to focus attention on lifetime costs rather than the companies offering the lowest initial cost.

In spite of these barriers, there are several drivers for energy renovations. Especially, the success of the recent Green Light for Savings programme, also in creating awareness, has been emphasized (Zámečník & Hlaváč 2012). Several parties have an influence on building owners' propensity to make energy renovations:

- **The state and local government:** The two major subsidy programmes have had a large influence on renovations: The Panel program resulted in more than 300 000 renovations of flats and the Green Light for Savings programme raised significant interest (Zámečník & Hlaváč 2012). Moreover, the ongoing EPBD2 developments have attracted a lot of interest.

- **Energy auditors:** Audits are mandatory for all buildings receiving a state subsidy within the National Panel Programme, as well as for buildings owned by the public sector if their energy consumption is more than 1500 GJ/a (MURE database 2012).
- **Architects and engineers:** There is an increasing emphasis on training architects and engineers in energy efficiency (Hajek and Tywoniak 2007). Universities, in general, have had an important role.
- **Banks:** Banks have had a central role, e.g., in administering the Green Light for Savings programme (Zámečník & Hlaváč 2012).
- **Civil society:** In the Czech context, **i**ndividual citizens are often highlighted as forerunners, and examples from neighbouring Austria are presented as inspiration.
- **Companies offering solutions:** It seems that different players in the renovation industry have somewhat different views on what are sensible solutions. Some new companies are eager to offer comprehensive packages of solutions, whereas traditional players in the industry are more conservative.

As concerns decision criteria, initial cost was the one criterion that all owner groups commonly considered to be important, according to our data and the views expressed by the interviewees. There is less emphasis on other financial criteria, except for among office building owners.

In contrast to many other countries, the timing vis-à-vis previous renovations did not seem to play a big role among building owners in the Czech Republic. In other respects, there are differences among owner groups. Our interviewees did not place much emphasis on the importance of widely used solutions; however, the availability of standard solutions was stressed in the literature, especially for the panel buildings. Hence, this criterion might have an important role in some cases.

Owner-occupants and rental co-operative owner-occupants appear to value improved comfort highly (though there is some ambiguity here concerning owner-occupied apartments). For larger building stock owners, such as rental housing, public buildings and office buildings, the availability of turnkey solutions seems to be an important criterion for larger building stock owners. Unlike many other countries, expert recommendations also appear to play a fairly important role in the public sector in the Czech Republic.

6.3.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following four categories of NZEB and RES-H/C solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery and energy efficient air conditioning and (4) On-site electricity production. Table 6.6 presents an overview of major drivers, barriers and the most and least promising building and owner types. The data are based on our project partners' experience and expert evaluations, and where available, existing literature and statistical sources.

Thermal renovation

Thermal renovation is highly topical in the Czech Republic due to the current state of building stock. Buildings dating from 1960 to 1980 are in need of refurbishement of the building envelope (Panel Scan 2009; Karasek and Ubralova 2010; Karasek and Ubralova 2012). Other major drivers are the increasing prices of energy. In this area, the key actors are the building owners and state institutions (laws and regulations). The most important barriers are the complicated process of the whole investment project, the financing of projects and legal issues. Another major barrier is the poor quality of construction works, which creates bad publicity for new projects (see e.g. Hazucha 2009).

Thermal renovation is easiest in single-family homes, where the administration and decision making are fairly straightforward. However, better results in terms of energy performance parameters are achieved in apartment buildings. Problematic builing and owner types include historical buildings, of which there are many in the Czech Republic, where the costs are higher, and also administration and technical aspects of insulation are difficult. In this context, windows and walls are the most problematic.

Heating and hot water systems

Space heating is usually provided by district heat or gas in multifamily buildings; in single-family buildings it is provided by gas, coal or biomass. The share of fossil-fuel based heating systems is decreasing. Changing of the energy source from fossil fuels to environmental friendly fuels is typical, although coal is the cheapest fuel. This is because of the inconvenience of coal heating systems for small installations; another one is the negative environmental impact. The switch from fossil to renewable heating sources is promoted by specific programmes such as the Green Investment Scheme and national programmes. Electric heating is also not typical, except as a temporary solution.

Strong drivers for heating system upgrades are renovations of the building envelope, which result in lower energy requirements for heating and in needs for changes in the heat regulation. However, heating system upgrades are often complex. A major barrier is a need for changes of current structures inside the house (walls, floors), as the impact of the construction works is on the whole interior.

Some systems heating system changes are less complicated for apartment buildings, because heating is typically outside the building or in a specific room. Also the cores for heat pipes are usually available. Some heating system changes are more complex for single-family homes, where heat pipes are often beneath the floor, so partial demolishing of the floor is needed. Moreover, in single-family homes, costs per unit for heating are also higher.

Some specific issues for particular renewable technologies are highlighted below:

- **District heating** is the simplest choice for the building owner, where available. About 38% of the population are served by district heat (Ecoheat4eu 2012), so it is not available for all buildings. Moreover, there are large differences in the prices for district heat in different regions, and in general the heat price is increasing. A further concern in the dependence on the district heat supplier. Some parts of the network are old and poorly insulated, and leakages of old pipelines in the streets are not uncommon. Its popularity has not increased increased in the past few years (Ecoheat4eu 2012). However, district heating is useful for and popular among apartment buildings, but it is not generally cost-effective for single-family homes.
- **Biomass-based systems:** Biomass-based systems are usually central heating systems; room-based systems are only used in small houses and cottages. A strong driver for increased use of biomass is the Green Investment Scheme, as well as the positive environmental impact and acceptable price of bioenergy fuels. There has been positive uptake especially in single-family homes, but systems are also available for apartment buildings. In the future, a major concern is the availability of biomass for specific regions. Fining space for biomass storage can also be problematic, especially considering the humidity of the energy source.
- **Groundsource heat pump systems:** Strong drivers are the Green Investment Scheme, as well as the positive environmental impact. The most important barrier is the initial cost of this type of heat pump, typically for family houses and small scale installations. It is considered a suitable solution for single-family homes, but because groundosource heat is so expensive to install, most of projects have been subsidized. There are only a few apartment buildings installations in the Czech Republic. If the solution becomes more popular in the future, there might be difficulty in finding suitable places for boreholes.
- **Airsource heat pumps:** Strong drivers are the Green Investment Scheme, as well as the positive environmental impact. The initial cost is the largest barrier, considering that the solution is typically used for single-family houses and small scale installations. The overall (system-level) efficiency of airsource heat pumps also depends on the primary production factor for electricity. Larger installations can be problematic, as space needs to be found for outdoor units in the façade.

- **Solar thermal installations** have also been driven by the Green Investment Scheme and the positive environmental impact. For apartment buildings, the investment also delivers a good return on investment (better then in single-family homes). The most important barrier is initial cost. Without subsidies, the number of installations would be significantly smaller than they are today. This subsidy was recently discontinued, which caused a significant downturn in annual investments (ESTIF 2012).

Ventilation heat recovery and energy efficient air conditioning

Ventilation heat recovery is not widely measure in the Czech Republic. It is the last in a list of recommended measures including walls insulation, windows replacement, roof insulation and installation of an efficient heat source. Mechanical supply ventilation is usually not provided in poorly insulated apartment buildings, but in some new projects with higher living standards it is installed. Hence, there is limited user experience in the Czech Republic mechanical supply ventilation or heat recovery.

A major driver for ventilation heat recovery is higher standard requirements in particular for office buildings and energy savings. The key actors are owners motivated by the lower energy consumption of their building typically in passive energy standard. Heat recovery is positive in well-insulated houses; typically when used by the owner. In these cases, the owner also has a stronger motivation to use the system correctly. The major barriers are costs for the installation and a poor return on investment. Typical problems are deemed to be condensation of moisture.

The major driver for air conditioning installation is higher standard requirements, in particular for office buildings. Also the combination with heat pumps (reversible air-conditioning appliances) drives demand. The key actors are firms motivated by the higher performance of employees working in air conditioned spaces. Air conditioning helps in poorly designed buildings, such as buildings with glassed façade and a strong risk of space overheating from the sun. However, air conditioning is not typically used in private flats, but in some new projects with higher living standards it is installed. There is thus not much experience with energy efficient solutions.

Electricity micro-generation

Solar photovoltaic panels are usually installed in off-grid applications under specific conditions, such as mountains. There are not so many other cost-effective possibilities. The key drivers for solar PV installation are the owners. Their motivations are environmental and economic, as electricity from renewable energy source receives a green bonus. This feed-in-tariff was quite generous for some years. Due to the green bonus/feed-in-tariff, supplying electricity to grid is economically attractive. However, for on-site use, the major barriers are electricity storage, proper dimensioning and overall cost-efficiency.

Solar PV panels are applicable in all types of buildings, especially ones with saddle roofs and a low share of shading. However, installation on roofs with small different oriented areas can be problematic, involving complicated installation and lower energy gains.

Table 6.6 Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	The current state of housing Rising cost of energy Building owners, state institutions (law and regulations)	Financial and legal difficulties in investment project Poor quality of construction works	Single-family houses Multi-apartment buildings	Historical buildings
District heating	Simplest choice for the building owner (if available)	Not always available Prices rising and variable Dependence on supplier	Apartment buildings	Single-family homes
Biomass central heating systems	Environment, national green investment scheme, acceptable price	Availability of biomass for specific regions	Family houses, multi-apartment buildings	Buildings with not enough space for biomass storages
Biomass-based room heating systems	Small house installation	Efficiency, regulation	Simple solution for small cottages	Larger family houses, apartment buildings
Groundsource heat pump systems	Green Investment Scheme, environment	Initial cost	Single-family houses (subsidies)	Apartment buildings (only few installations in Czech Rebuplic)
Airsource heat pumps	Green Investment Scheme, environment	Initial cost	Single-family homes (subsidies)	Space for units in façade of building (larger installations)
Solar thermal	Green Investment Scheme, environment, return on investment (apartment buildings)	Initial cost, subsidies recently discontinued	Apartment buildings (higher cost efficiency)	Buildings shadowed by other buildings or greenery
Heat recovery	Higher requirements for air recovery and energy savings in office buildings Motivated owners of buildings	Costs of installation, cost-effectiveness	Owner-occupied buildings, well insulated houses	Typically private flats
Energy efficient air-conditioning	Higher requirements for air conditioning installation in office buildings Combination with heat pumps Air conditioned spaces for employees	Costs of installation, maintenance and operational costs Space conditions for installations in buildings	Badly designed buildings with risk of overheating	Typically private flats
Electricity micro-generation	Off-grid areas Environmental concern Subsidies	Electricity storage Overall efficiency	All types of buildings especially with saddle roofs and low share of shading	Buildings with roofs with small different oriented areas

References and data sources: National web for heating and ventilation http://www.tzb-info.cz/, Green investment scheme in the Czech Republic http://www.zelenausporam.cz/, Energy regulation office http://www.eru.cz/?bl=y

6.3 Romania

6.3.1 General policy context and major investor categories

The building stock in Romania is newer than in most countries of Central Europe: the largest share of current buildings was built in the post-war period (1945-1970). However, there are significant problems in the condition of buildings due to neglect of repairs, in particular, in urban high-rise apartment buildings and in part of the rural single-family homes (UN ECE 2001; Trainrebuild 2011). A noteworthy factor concerning residential housing is the large share of owner-occupancy: more than 90% of dwellings are owner-occupied (Housing Statistics 2010); another is the relatively large share of rural population; about half of all Romanians live in rural areas.

The Ministry for Development, Public Works and Housing is in charge of energy efficiency policy in buildings. Romania has made progress in the development and implementation of policies and laws to address the energy efficiency of buildings as part of European policy implementation. Minimum requirements for the energy performance of building components used in new buildings and buildings subject to major renovation have been set (BPIE 2012a). Energy performance certification of buildings when they are sold or rented is also required by legislation (BPIE 2012a), though Prada (2011) and R0BGC (2009) report on some enforcement problems in this area.

Several support programmes target the thermal renovation of existing buildings, as this is not only an energy, but also a housing quality issue. There are programmes dedicated to public buildings, to the rehabilitation of residential high-rise panel buildings built by 1990, a loan scheme for residential buildings built by 2000, and financing schemes for introducing renewable energy in buildings (BPIE 2012a) (for more details see following section). There are also several support programmes for the renovation of public buildings, and also international funds available for co-funding the renovation of commercial buildings.

In general, the country report for MURE (Rugina 2009) shows a significant decrease in energy consumption in the residential sector. This is estimated as being due to price increases in energy, to an overall increase in energy efficiency, as well as to the rapid rate of new construction until recently.

However, there are several challenges remaining in the improvement of energy efficiency in the existing building stock. These relate to the severe financial situation and the high interest rates in the country. While awareness among residential building owners has grown, this is from a low level and a situation where energy prices were heavily subsidized. Due to the limited experience with renovation and a general shortage of skilled labour, building owners have difficulties in finding good-quality services. This problem is currently being addressed in an Intelligent Energy Europe programme under Build-Up Skills Romania, which aims to develop a national qualification roadmap for the construction industry.

6.3.2 General drivers and barriers for energy renovations among different owner groups

Awareness and interest in energy renovations appear to be growing rapidly in Romania – albeit from a low starting level and under severely difficult conditions. Because of the poor initial condition of most buildings, there are many opportunities for improvement.

The financial barriers to large-scale renovation activity are difficult, but there are also other barriers. Apart from initial costs and payback times, also the cost of capital is a problem as interest rates are generally high – these are barriers shared by all owner groups. Owner-occupied apartment buildings also have great difficulties in reaching decisions, as the decision making in condominiums is poorly organized: all owners need to sign a mortgage in order to get funding for renovating the building as a whole. Because of this, renovations require significant external funds. Organizational barriers are also widespread in the public administration.

Our experts also highlighted lack of reliable advice and unsophisticated financial analysis as widespread barriers. One suggestion for improving this situation was to monitor the newly renovated buildings and thus offer real-life examples of the costs and benefits of accomplished renovations. The lack of skilled service providers was also brought up as a widespread barrier. There are efforts underway to start a broad training programme under the IEE-funded BUILDUP skills programme, but several issues remain to be solved. An additional barrier mentioned as important for residential customers is the (still) low price of energy, which detracts from the financial attractiveness of energy renovations.

In spite of these barriers, there are also several drivers for energy renovations. These include the rising price of energy, increasing awareness and public discussion, and the ongoing national renovation programmes.

In addition to these drivers, there are local initiatives aiming for more ambitious results. Our interviewees mentioned as a good practice the comprehensive agenda announced the current administration of Bucharest Sector 1. This agenda aims to complement the existing thermo-rehabilitation program for multi-family buildings with another local program for housing renovation, sustainable regeneration of the Sector as well as to upgrade the public buildings towards low-energy/nZEB levels.

On the basis of this review, the main parties influencing renovations are the following:

- **Public authorities** play a key role in promoting renovations. The available funding schemes are very generous and this aim to surmount the lack of funding by building owners and the high interest rates and stringent loan requirements of banks. Municipalities also often offer technical support for multifamily apartments, which are not usually capable of organizing renovations on their own. Public authorities also have an important role in renovating public buildings and thus accumulating experience and competence in the sector.
- **International financial institutions** and the EU have played a large role in raising the issue and launching programmes and funding schemes for energy renovations. Examples include the programmes run by the UNDP/GEF Energy Efficiency Financing Team and growing role of European structural funds in financing the Multiannual National Programme for the Thermal Rehabilitation of Blocks of Flats.
- **Companies offering solutions:** Until now, the domestic building industry has not been well developed and there have been quality problems, which are gaining increasing attention in the media as experiences from renovations accumulate. Training and development programmes like BUILDUP skills can play an important role in the future.
- **The media** has an important role in awareness raising and e.g. reporting on new funding opportunities and experiences in renovation.
- **Associations:** Industry associations and associations of cities as well as NGOs were also mentioned as parties influencing the conditions for energy renovations. One example is the Romanian Green Building Council, which has been active in e.g. promoting building certification and the property tax deduction, as well as in showcasing successful examples.

As concerns decision criteria, there are a few criteria that are highly important for all owner groups. These are the financial criteria of initial cost and payback times, whereas mainly owners of larger buildings or building stocks use sophisticated measures such as return on investment. For them also, criteria like quick installation are important to avoid interruptions in building use. Smaller building owners place more value on aspects like widely used solutions. Their main interest is to gain a comfortable living environment, hence improved comfort is an important decision criterion.

6.3.3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following four categories of NZEB and RES-H/C solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery and energy efficient air conditioning and (4) On-site electricity production. Table 6.7 presents an overview of major drivers, barriers and the most and least promising building and owner types. The data are based on our project partners' experience and expert evaluations, and where available, existing literature and statistical sources.

Thermal renovation

The major drivers are the National Programme for Thermal Rehabilitation of multi-family blocks of flats built between 1950-1990 (last reinforced by Government Ordinance OUG 18/2009) and the Ministry for Regional Development and Tourism, which coordinates this programme. In addition, the continuous energy price increase, together with the example of the above-mentioned programme, encourages some building owners to proceed to thermal insulation for their homes. However, this multiplier effect is not monitored and no figures are available. In November 2012, OUG no 18/2009 was modified by OUG 63/2012 and the scheme had been modified for using EU Structural Funds (under the Regional OP, Priority 1: Sustainable development of cities). Therefore, the new financing scheme has an overall budget of 304 MEUR where 150 MEUR come from the EU and the other from national sources. The projects have to be committed in 2013, while the execution of the works may continue afterwards.

Lesser drivers are a financing scheme for suporting the thermal rehabilitation of SFH and MFH built before 2000 (OUG 69/2010) by state guarantee credits and 'Casa Verde'(Green House) Programme which offers subsidies for renewable energy in buildings. The first financing scheme offers subsidised interest with 5 yrs maturity (Government of Romania 2011), supporting also the replacement of existing heating systems. However, this scheme is much less attractive than the above mentioned one and only up to 100 credits had been signed in 2 yrs.

The Casa verde Programme subsidises renewable energy technology in two disting financing lines, one dedicated to the housing sector and the other to the public sector buildings. For public buildings, there is also a national program for the increase of the energy efficiency and utilization of renewable energy sources in the public sector. While some activities have been implemented between 2009-2010, the budget of this program (annual based) was significantly affected by the crisis and budgetary cuts or reallocations. This program includes also works on district heat.

Other major drivers are the rising energy prices: liberalisation of the energy market is expected by 2018 in the residential sector and by 2015 for industry/commercial customers. A related development is the phase-out of heating subsidies of district heat in some cities.

Major barriers to thermal renovation include the following:

1. The purchase power of people which is much lower than the EU average, which is relevant when dealing with high upfront capital requirements and long payback times.
2. Lack of a proper awareness of the benefits of improving thermal insulation and of prioritising energy efficiency above other perceived needs.
3. Energy prices are still subsidised, mainly for the residential sector and especially for district heating at the level of several municipalities, including Bucharest (to be gradually liberalised by 2015/2018). This significantly increases the payback period of energy efficiency measures.
4. Insufficient popular awareness of the ongoing public support schemes.
5. People's general reluctance to take loans, also influenced negatively by the economic crisis.
6. The lack of other financing options excepting the above mentioned programmes which have a limited budget, defined on annual basis, entirely supported only from public budget (fund is recently diversified by using EU Structural Funds).
7. Collective decision problems in the case of multifamily homes, where in practice the agreement of 90%-100% of owners is required.
8. Public sector: energy efficient public procurement rules are not yet in place.
9. Public sector: no incentive to save energy, still need to improve the rules for public budgeting (energy efficiency should be treated as an investment paying back in time and not as any other

expenditure, no reward for savings: if a local authority saves costs by implementing energy savings they may receive less money from the budget), EPCs/ESCOs for buildings still in pilot phase (an EBRD project)

10. Romania has a flat tax of 16%, the local taxes are quite low and this make the introduction of fiscal measures almost impossible.

Adoption of thermal renovation is more widespread in apartment buildings. This is due to measures supported by the above-mentioned National Programme. As a result, around 80.000-90.000 apartments were renovated between 2008 and today, representing about 2.5% of the entire building stock of this type (86.100 MFH in total in Romania). In contrast, the single-family homes are probably the most problematic, because they represent by far the largest part of the residential building stock, most of them in rural areas (5,017 mn detached or semi-detached SFH our of which 3,17 mn in rural area). The biggest problem is the purchase power (which is much lower in rural areas), followed by other barriers mentioned above.

However, the national renovation programmes shown the benefits of increasing the energy performance of buildings and over the last years many energy renovation activities are undertaken by private owners on their own expenses. However, these renovation measures are not often based on detailed calculations aiming to maximise the energy and costs savings (e.g. not adding the right insulation thickness on building's envelope).

Heating and hot water systems

The existing heating systems are very different in single-family and multifamily dwellings (ENTRANZE database). More than half of multifamily dwellings are heated with district heat, with gas and biomass accounting for most of the remainder. Single-family dwellings are mostly heated with biomass, with gas accounting for the small remainder.

The existing systems are thus the district heating, individual gas and biomass systems, the latter often still based on wooden stoves. Natural gas is the most common fossil fuel system for individual heating systems, whereas oil and coal are almost non-existent. Electric heating is rare, though electric heaters may be used in some cases where owners have disconnected from district heat, or for domestic hot water in some single-family houses, and electric floor heating seems to become more and more popular in single-family homes.

District heat has been increasingly replaced with gas. Most of the fules used in district heat production are fossil fuels[21]. Many district heating plants are CHPs, but represent old technology from 30-40 years ago. The district heat companies are subsidized, mainly by local authorities (about 40% of the costs).

Renewable heating systems are mainly promoted by the national programme 'Casa verde' (Green House), coordinated by the Ministry of Environment, with financial schemes subsidising heating RES (solar thermal, heat pumps, biomass systems). This programme has two lines: one for residential and the other for public buildings. The main barriers are the purchasing power of citizens, limited awareness and information on energy efficiency, RES and support programmes, as well as the other barriers mentioned in connection with thermal renovation.

Some specific issues for particular renewable technologies are highlighted below:

- **District heating:** District heat is mainly promoted by local authorities and the autonomous district heat companies[22]. Customers have continually disconnected from district heat over the last years and and building owners are attracted by independent heating systems. Despite constant investments in plants and networks, the district heat systems are in a poor condition

[21] 54.1% natural gas; 25.8% oil products; 20.1% coal. However, there are some renewable district heating systems in a few small cities (geothermal, biomass and to a much smaller extent solar-thermal).

[22] mainly public owned but in few cities also with private management or under BOOT schemes

with low efficiency (PWC 2011). Due to this, the average losses are about 30% and the costs are 20% more than in efficient systems from other countries. The thermal rehabilitation of apartment buildings will put additional pressure for improving the efficiency of district heat. The district heating companies are unprofitable and many are even in debt; hence, budgets for improving systems are limited.

- **Biomass-based systems:** There are still many biomass (and mostly forest wood) heating systems in single-family homes in rural areas. Many of these are still inefficient stoves, but also new heating systems are appearing (See NREAP Romania 2010)[23]. There is limited use of pellets, mainly due to the lack of a local market and local pellet production (while natural resources are abundant). This is probably a growing market as well, though still hindered by high upfront capital, low incentives for fuel shift, low energy prices etc. like the other renewable systems.
- **Groundsource heat pump systems:** to a very limited extend, but supported from 2008 by 'Casa Verde' Programme. However, geothermal eneryg is used in some cities/districts (e.g. in Oradea city, North-Western Romania, Calimanesti town, South Romania etc.). The major barriers are high upfront capital requirements, low incentives, lack of awareness, low offer on the market. While the budget is very small, the Casa Verde Program may stimulate the fuel shift from fossil based to renewables.
- **Airsource heat pumps:** Adoption until now is very, very limited, supported more recently (but not very much) by Casa Verde program. The main barriers are high upfront investment, low incentives, lack of awareness, low offer on the market.
- **Solar thermal:** [24]Now there is a growing market, and more and more contractors providing solar-thermal, which is further supported by the good solar resources in some parts of the country. Solar thermal systems are by far the most popular renewable technologies currently used in Romanian buildings. According Eurobserver (2012), the total installed solar-thermal collectors area in 2010 in Romania was approx. 144.000 m2 with a thermal capacity of around 101MWhth. The Romanian solar thermal industry reported for 2010 a turnover of 20 million Euro and 250 direct and indirect jobs BPIE (2012b).

Ventilation heat recovery

Mechanical supply ventilation is not yet very common in Romania. E.g. BPIE (2012b) estimate that less of half of commercial office space has (any kind of) mechanical ventilation and 20% of new buildings are equipped with mechanical exhaust ventilation. However, as thermal renovations proceed, also the demand for mechanical ventilation is expected to increase. Other major drivers are market actors, i.e. companies seling these systems, short payback periods, growing energy prices (faster than in Western Europe) and phase-out of heating subsidies of DH in some cities. It seems that the market uptake can be vigurous over the following years. Some best expert's estimations indicate a 25%-100% market uptake in new buildings by 2020. The most promising customer types for this technology are most probably commercial buildings and SFH, but there are not official statistics on this (BPIE 2012b).

Major barriers are a lack of stimulus to change the existing inefficient systems, rather high upfront investment compared to less efficient systems on the market, lack of customer awareness, as well as the still low energy prices. Less awareness of consumers about energy and cost savings in time, decision based rather on investment cost than on overall costs including operation and maintenance ones.

[23] NREAP Romania (2010) states that the share of renewable energy in buildings is 93.1% (p. 48). A potential problem is that not all wood consumption for heating is officially registered and the true figures are much larger than in offical statistics (?)

[24] After the oil crises in the 1970s, Romania launched a very strong renewable program and solar thermal flat plate collectors were produced and installed on a large scale. In 1989, Romania was the 5th worlwide in terms of installed capacity. However, the lack of technicians and of policies to develop simultaneously maintenance services as well as a bad resource efficiency national policy (e.g. which led to the replacement of copper with iron pipes in solar collectors) led to a big failure of the installed systems. This created a negative image to renewable energy which lasted until 2000 when they gradually regained a certain popularity on the market.

Energy efficient air conditioning

Due to increased number of hot days over the summer time registered over the last decades, air conditioning is used increasingly in Romania. According to the ENTRANZE database, it is estimated that only 5% of the residential floor area is air conditioned, although the share of air-conditioned space has increased and is estimated to increase in the future (Pout and Hitchin 2008). Market actors, i.e. companies seling these systems, short payback periods, and growing energy prices (faster than in Western Europe) are major drivers of energy efficient air conditioning systems. A vigourous market uptake is expected over the coming years and the less efficient systems on the market will be gradually phased out (also Ecodesign regulations will contribute to this).

Major barriers to energy efficient air conditioning systems are similar to those hindering other energy efficiency investments. Higher prices for high efficient air-conditionning, less awareness of consumers about energy and cost savings in time, decision based rather on investment cost than on overall costs including operation and maintenance ones.

Electricity micro-generation

The market for rooftop PV systems is still very small In Romania (BPIE 2012b). Photovoltaic systems (PV) are currently used at a very small scale in buildings (less than 1%). The cumulative installed PV power capacity in 2010 was approx. 1.9MWp. out of which 1.3MWp represents grid-connected capacity and 0.6MWp off-grid. 1.3MWp were installed in 2010. According to BPIE (2012b), this may be a promising sign indicating that the PV market could have a fast uptake in the coming years.

The major drivers are a growing market, higher offer, and more contractors providing solar PV. Good solar resources in some regions of the country (south-eastern region near the Black Sea Coast, almost all southern regions of Romania and the Western Field on the western side of the country. This is supported by declining of PV systems and growing electricity prices. The Casa verde program stimulates the uptake of solar systems. At the supply side, the Green certificates scheme, reinforced recently, may stimulate a more consistent market uptake of renewables, inclduing PV power plants. Major barriers are a lack of awareness, lack of consumer confidence, lack of feed-in-tariffs, and also still a lack of clear legislation that allow small producers to feed electricity to the grid. High upfront costs are also still a major barrier.

While still at very small scale, PV is more popular in single-family homes. Some programs anounced by few local authorities may stimulate the deployment of renewables (including PV) in public buildings. For example, the mayor of District 1 of Bucharest is very dedicated to thermal rehabilitation. He built his entire re-election campaign in June 2012 on completing the thermal rehabilitation of all blocks of flats and on starting to heavly introduce RES in public buildings. However, less promising customer types include multifamily apartment buildings and office buildings, where there are rooftop limitations and shading effects due to a high density of blocks (in urban areas). Similar problems may occur for single-family homes in rural areas near natural obstacles.

Table 6.7: Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions.

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	National Program for Thermal Rehabilitation, other programs Rising energy prices, subsidies	Costs, long payback time, subsidised energy price (residential) Lack of awareness, owners unwillingness to take loan, collective decion-making (multi-family houses)	Multi-apartment buildings of 1950s-1090s (related program)	Single-family homes (especially rural areas) with low purchasing power
District heating	Local authorities, district heating companies, national authorities	Cost-effectiveness Inefficiency and poor image of district heating systems	Multi-family houses	Single-family homes in rural areas, owners with low income (rural areas)
Biomass-based heating systems	Limited support from Casa Verde program	Inefficient stoves, limited use of pellets Lack of incentives, lack of awareness, lack of investment capital	Single-family homes especially in rural areas	-
Groundsource heat pump systems	Limited support from Casa Verde program, some cities or discticts	High initial costs, low incentives, lack of awareness, markets	-	-
Airsource heat pumps	Limited support from Casa Verde program	High initial costs, lack of awareness, markets, low incentives	-	-
Solar thermal	Growing market, good solar resources, Casa Verde program, active promoters	Initial cost, lack of consumer confidence	Buildings in areas with good solar resources	Multi-family houses and office buildings, some single-family houses (shading)
Heat recovery	Companies, cost-effectiveness, rising energy prices, growing market Cut of district heating subsidies (some cities)	Lack of awareness (residential buildings), initial costs, energy prices are still quite low	New buildings Commercial buildings Single-family homes	-
Energy efficient air-conditioning	Companies, cost-effectiveness, rising energy prices, growing market	High prices, lack of awareness about energy and cost savings	Offices and other non-residential buildings, multifamily and single-family buildings	-
Electricity micro-generation	Growing market, good solar resources in some regions, rising electricity prices, Casa Verde program	Initial costs, lack of awareness and consumer confidence No feed-in tariffs, no proper legislation for grid connection	Single-family homes, some public and commercial buildings	Multi-family houses and office buildings, some single-family houses (shading)

References and data sources: NEEAP2, NREAP Romania, BPIE 2012b, other BPIE studies and surveys

6.4 Other Central and East European countries

6.4.3 Hungary

The dwelling stock in Hungary consists largely of single-family dwellings, and with a high rate of owner-occupancy also among the multifamily dwellings (ENTRANZE database). The average age of residential buildings is fairly young, with only 25% dating back to the pre-1960s (BPIE 2011).

According to Ürge-Vorsatz et al. (2010), buildings are responsible for approximately 50% of energy-related CO_2 emissions in Hungary. As in many other countries in the group, the high energy consumption of the average residential unit is a consequence of the historically subsidized energy prices and the deterioration of the residential stock. Major drivers for improvements are concerns about energy dependency and a high incidence of fuel poverty: 15% of Hungarian citizens declared to be unable to afford to keep their homes adequately warm (Tirado Herrero and Ürge-Vorsatz, 2010).

Energy efficiency is seen as an important contributor to energy security, given the steadily rising demand for imported natural gas and oil (Eurostat 2009). A number of national policies and programmes promoting energy efficiency and and renewable energy in buildings – such as the ÖKO-programme and the Grants for Renovation of Prefabricated-Panel Residences (the so-called "Panel" programme) – are currently in place. However, available data indicate that conventional retrofitting programmes funded by the government achieve a maximum reduction of 6% to 36% in the energy demand for heating (Ürge-Vorsatz et al. 2010). Based on the Kyoto Protocol the state proceeds from the sale of CO_2 emission rights can be used to finance Green Investments. Most of these funding have been used for housing renovation projects mostly for energy efficiency improvements but also including some renewable energy at limited scales (Teckenburg et al. 2011). However, all incentive programmes were recently suspended for one year because of the financial situation. The new Hungarian roadmap - the Széchenyi Plan – focuses on renewable energies and promotes, among others, the installation of solar thermal systems.

Natural gas is an important energy source for buildings in Hungary (ENTRANZE database). Biomass is not used widely in buildings. Support for renewable heating is limited to investment grants; another driver is the expected increase in natural gas price (Teckenburg et al. 2011). Solar PV is supported by a relatively low standard tariff (about 0,1 €), which is why the market has developed slowly (Karteris and Papadopoulos 2012).

Farsang and Watt (2010) have examined the barriers to energy efficient refurbishment and solar PV installations in Hungary and found them quite similar to those reported for other countries in this group (see above and Heiskanen et al. 2012). Among others, the difficulty in agreeing on investments in multifamily buildings was mentioned. Barenergy (2010) also analysed consumer awareness of renewable energy sources, showing that Hungarian consumers know and would like to have solar water heaters, but are not yet familiar with e.g. heat pumps[25].

6.4.4 Poland

Single family dwellings represent around 55% of the residential building floor area, and apartment buildings 45% (ENTRANZE database). About 66% of all dwellings are owner-ocuppied. In this respect, Poland is clearly different from the other countries of Central and Eastern Europe. According to CECODHAS (2012), social housing in the form of municipal housing is still an important part of the Polish housing stock (about 8% in

---

[25] However, large-scale high-temperature geothermal energy is used for district heat and is planned to be exploited more in the future (NREAP Hungary 2010). Online: http://www.kormany.hu/download/6/b9/30000/RENEWABLE%20ENERGY_REPUBLIC%20OF%20HUNGARY%20NATIONAL%20RENEWABLE%20ENERGY%20ACTION%20PLAN%202010_2020.pdf

2009) but recently production of new municipal housing has almost stopped. Co-operatives still administer 19.4% (2009) of the total housing stock in Poland. BPIE (2012d) notes that housing co-operatives have been recently recognized as the most significant player in the residential sector.

Poland has several instruments for the promotion of energy renovations. These include a Thermo-Modernization and Renovation Fund, which offers loans (combined with a small grant) for renovations that deliver at least 25% energy savings (based on energy audits and plans), mainly in apartment and public buildings (NEEAP Poland 2012). There are also other funding schemes, including a Green Investment Scheme, as well as some national and local grants for renewable energy. However, these are not sufficient, according to BPIE (2012d).

BPIE (2012d) has estimated the current status of markets for particular NZEB and RES-H/C technologies:

- There is a current market existing for insulation, but for example the market for triple-glazed windows is small.
- The current market for ventilation systems with heat recovery is very small. Even among new buildings, only 5% have mechanical ventilation installed, and the current trend is not to install effective heat recovery even in new buildings.
- There is an existing market for pellet boilers and solar thermal panels. They are used in current construction practice for supplying domestic hot water in single family houses and in regions where no district gas is available and when the investor decides to not use coal, or is not allowed to use it, which is the case in some in regions. Solar thermal systems are also relatively popular, and Poland ranks
- The current market for heat pumps is very small. Less than 20 000 heat pump were installed in 2010, and there are significant barriers to adoption, including lack of cost-effectiveness, legal obstacles, lack of information, lack of guidelines and standards, and only local subsidies. Moreover, quality problems have been reported, which may undermine market confidence.
- Similarly, the market for rooftop PV is very small. Existing PV installations are mostly small off-grid installations or installed in buildings subsidised by EU funds. PV technology is not usually currently considered for single family, multi-family or public buildings.

6.4.5 Slovakia

The energy system in Slovakia is characterised by an extensive natural gas distribution system, a high dependence on fossil fuels, and a significant share of nuclear in the electricity mix (Eurostat 2009). Natural gas has the largest share of all energy sources used in buildings, followed by electricity and district heat (ENTRANZE database).

The building stock is dominated by owner-occupied single-family dwellings. The age distribution of the housing stock is fairly average for this group of countries: about half of all dwellings were constructed between 1961-1990.

According to Teckenburg et al. (2011), the generation of RES-H is supported by investment subsidies under the Governmental Programme for Promotion of Biomass and Solar Energy Use in Households. Based on this programme, households that install a biomass boiler or solar panels are eligible for a subsidy under specified criteria. According to BPIE (2011), the government and the EBRD have financed a programme for local banks to provide loans between 20,000 EUR and 2,500,000 EUR (as well as grants of 7.5-15% of the loan amounts), together with free technical assistance, for private companies and housing associations implementing energy efficiency and renewable energy projects.

Bioenergy does not traditionally have a large share, though there have been recent developments to manufacture and use wood pellets (BIOMASA 2011). The solar thermal market is also growing (11% in 2010); the installed capacity per capita is small but growing. Slovakia is also one of the countries in this group with a large growth in solar PV; however, a large share of this is not from buildings but from ground-mounted systems (Karteris and Papadopoulos 2012).

6.4.6 Slovenia

The housing stock in Slovenia is relatively new: more than 40% were built between 1960-1990, and about 20% after 1991. Single-family homes account for about 64% of all dwellings (ENTRANZE database). Natural gas is not widely used, and there are only about 50 gas connections per 1000 inhabitants (Eurogas 2012). Because of this, oil is widely relied on for heating (ENTRANZE database; Eurostat 2009).

According to BPIE (2011), the barriers to energy renovations in multifamily buildings are similar to those observed in other countries in this group (see Heiskanen et al. 2012 and descriptions above). Decision making is particularly difficult in multifamily buildings, where a majority of 75% is required for decisions.

As in other countries in this group, public support schemes for renewable energy and energy efficiency include both loans and grants (Rezessy and Bertoldi 2010). The latter are exclusively addressed to individuals and households. The public sector is also offering two loan schemes targeting individuals, households, companies and public administration. There is a program for sustainable energy in the framework of the Structural Funds programme which is expected to trigger investments in energy efficiency and renewable energy by subsidizing investments with 15-40 % of the total. In the period 2002-2009 thermal solar systems, heat pumps combined with solar systems, biomass heating boilers and PV systems were eligible for subsidy. In the period 2008-2016 grants and preferential loans are available for e.g. energy efficiency renovation and sustainable building of new buildings and for energy efficiency heating systems. Grants are also available for service and public buildings (Bertoldi and Rezessy 2010).

Solar thermal systems have a long tradition in Slovenia, where several large solar thermal systems were constructed in the tourist regions in the 1980s and a domestic industry emerged (Solarge 2006). The market crashed after 1989, but has slowly recovered to some extent. Today, the installed capacity is about 60 kW_{th} per capita, i.e., twice that in Italy but only one fifth of that in Austria (ESTIF 2012). According to Šubic and Staničic (2005), 28% of households in Slovenia used wood as their only heating source. The use of wood in traditional stoves is declining, however, whereas the use of biomass in modern boilers has increased. According to Karteris and Papadopoulos (2012), Slovenia has a similar PV market to Slovakia's. Although the country was in the 13th place in EU in cumulative capacities in 2010, the development of its PV sector took place mainly in 2010, due to the feed-in-tariff introduced in 2009. The share of building-applied PVs is not known, but they receive a higher feed-in-tariff than ground-mounted systems (0.33 - 0.38 €/kWh for 15 years).

6.4.7 Lithuania, Latvia and Estonia

Lithuania, Latvia and Estonia are in many ways different from the other Central and East European countries. Firstly, they are all fairly small countries, with populations ranging from 1.3 million in Estonia to 3 million (Lithuania). They also have a relatively larger share of multifamily dwellings (50-60 %), even compared with the other countries of Central and Eastern Europe. Almost all of these dwellings are owner-occupied.

Most of these dwellings date from the Soviet period and are badly depreciated. This is made worse by the fact that the climate is very cold, and hence thermal comfort is a major driver for thermal renovations (Ozoliņa and Garā 2011). However, these countries have lower average incomes than others in this group; moreover, the share of low-income owner-occupiers is relatively high (19-24%).

Biomass is the main renewable energy source, accounting for as much as 39% of the energy use in builings in Latvia. District heat is also widespread in these three countries with a share of 25-37%, but not commonly produced with renewable energy yet. Other renewable heating sources are still not commonly used, although heat pump sales have been quite significant in Estonia in 2011, with more than 12 000 units sold/1.4 million inhabitants (Nowak 2012).

Several studies (Ozoliņa and Garā 2011; Kallaste 2009; Kamenders 2009; Valuntiene 2009) show that residents and other buildings owners are very motivated to conduct thermal insulation. The main barriers are similar to those that are generally common among owner-occupied multifamily buildings (see Heiskanen et al. 2012), i.e., organizational difficulties in reaching a decision and financial difficulties in raising funds, which are further aggrevated by the low value of the properties.

6.5 Similarities and differences among the countries in this group

Large prefabricated concrete apartment buildings, often called panel buildings, are characteristic of urban areas in Central and Eastern Europe, although they also exist elsewhere. However, it is important to understand that these buildings, which look fairly similar, have somewhat different ownership structures.

On the basis of the analysis conducted in ENTRANZE D2.4 (Heiskanen et al. 2012), it is likely that owner-occupied apartment buildings are the most problematic building type, whereas for example the rental housing co-operatives that are more typical in Poland and the Czech Republic are better organized. Among owner-occupied apartment buildings, there are also differences in how well the ownership structure facilitates decision making on energy renovations, with Bulgaria as an extreme case where many buildings completely lack a body capable of making decisions concerning the entire building (see Heiskanen et al. 2012 for details).

The need to renovate especially the housing stock of the 1960s-1980s has been recognized in all countries of Central and Eastern Europe. Many countries offer a relatively high share public funding for thermal renovation; however, in several countries the programmes are focused on multifamily buildings and some commentators argue that they are not sufficiently ambitious. Public buildings are another major focus for economic and financial incentives, at least in Bulgaria, the Czech Republic, Poland and Romania.

As concerns particular technologies, the situation concerning thermal insulation is fairly similar in all these countries, although some have more advanced policies than others. Existing programmes are mainly targeted at multifamily dwellings (especially the prefabricated apartment buildings), whereas there are fewer measures in place for single-family homes.

The barriers to energy renovations, especially in multifamily dwellings, appear to be fairly similar across this group of countries. Building owners in Central and Eastern Europe struggle with financial and organizational difficulties. This is a severe constraint on the speed of renovating the existing building stock. However, the overall impression is that thermal renovations are viewed more positively than negatively by citizens because of the poor original condition of the buildings and because of the improved comfort and appearance gained, e.g., via renovation of building facades.

District heat accounts for a relatively large share of the heating in this group. Whereas district heating is usually viewed positively in North and West Europe, there is much criticism voiced about district heat in Central and Eastern Europe, both by citizens and by experts (e.g. Tirado Herrero and Ürge-Vorsatz 2011). So it is not self-evidently part of the solution. There might be differences among countries in this respect, but we were not able to identify them in the present analysis.

Biomass and solar thermal are the most popular and established RES-H/C technologies in Central and Eastern Europe. The existing share of biomass use in buildings varies, however, from 1% (Slovakia) to 35% (Romania), partly depending on the level of urbanization of the countries and the availability of biomass and other fuels. Some of the biomass use, however, is due to economic necessity rather than a systematic public policy, and occurs in inefficient wooden stoves. Moreover, the opportunities for increasing the share of biomass are likely to depend on the level of urbanization and the share and location of multifamily buildings (if not for other reasons, at least due to fuel logistics).

Heat pumps and solar PV are at a very initial stage of market introduction in most of these countries. However, the Czech Republic and Slovakia are exceptions here, as the Czech Republic had the largest per capita PV capacity added in 2010, and Slovakia was in 8th place in Europe in this respect (Eurobserver 2011a). These developments are thanks to a generous feed-in-tariff, which also brought Slovenia to 13th place in Europe in terms of per-capita growth in 2010 (Karteris and Papadopoulos 2012). Additionally, the heat pump market has recently taken off at speed in Estonia.

The public acceptance and especially market adoption of many of these solutions is also likely to be influenced by income levels, and especially the current economic prospects in the countries in this group. There are relatively large differences in the current economic situation among countries in this group. In 2012, Estonia, Latvia, Lithuania and Poland had positive GDP growth rates of 2-5%, wheras e.g. Bulgaria and Romania had about zero growth, and Czech Republic, Hungary and Slovenia had negative GDP growth (-1 to -3%)(Eurostat 2013).

7 Trends, drivers and barriers in Northern Europe

The three North European countries discussed in this report are Finland (ENTRANZE target country), Sweden and Denmark (ENTRANZE focus countries). These countries share some similar characteristics: they all have a wide district heat network and a cold climate. All have small populations. They also have historically had a high level of social policy and also of policy co-operation, e.g. via the Nordic Council of Ministers. The countries are also all part of the Nordic electricity system, Nordpool. They are thus fairly similar to each other in some respects, especially when compared to other European countries. There are, however, some significant differences, which are discussed in the following.

Single-family dwellings are predominant in the Nordic landscape, but multifamily dwelling are more common in Sweden than in the other countries (Table 7.1). The majority of dwellings are owner-occupied: however, significantly more so in Finland than in the other Nordic countries, which both have a sizable public/co-operative housing sector (Table 7.2).

Tab. 7.1: Dwelling stock by dwelling type in North European countries

	DK	FI	SE
Single-family dwellings	71	68	57
Multi-family dwellings	29	32	43

Source: ENTRANZE database www.entranze.eu

Tab. 7.2: Dwelling stock by tenure type in North European countries

	DK	FI	SE
Owner-occupied	58	80	55
Private rental	16	10	19
Social/co-operative/other rental	26	10	24

Source: ENTRANZE database www.entranze.eu

The Nordic countries have slightly higher income per capita than the European average (Table 7.3), and in this respect the countries are fairly similar. The share of low-income households among owner-occupants is close to the West European average. Savings rates are somewhat lower than in West European countries.

Tab. 7.3: Socio-economic characteristics of building owners in North European countries

	DK	FI	SE
Average income PPS/capita in relation to EU-27 average (=100%)	102	109	113
Share of low-income households among owner-occupants, %	8	9	7
Gross household savings rate, 2010, %*	8	11.3	13.3

* NB: includes savings for fixed capital, including mortgage repayments (hence, these savings are not all available for new investments)

Source: Eurostat; Dol and Hafner (2010)

All countries in this group have a very high share of district heat in building energy use (Table 7.4). They also have a relatively (Denmark) or extremely low (Finland and Sweden) share of natural gas use in buildings. Biomass use is also relatively high. Finland and especially Sweden have significant hydropower and nuclear energy resources, and hence a relatively widespread (though declining) legacy of electric heating, especially in single-family homes.

Tab. 7.4: Share of various energy sources in building energy use in North European countries

	DK	FI	SE
District heat	34	31	33
Oil	9	12	4
Coal/lignite	0	0	0
Gas	13	1	1
Biomass	16	14	10
Electricity	28	42	52

Source: ENTRANZE database www.entranze.eu

In the following, we focus on the ENTRANZE target country, Finland. Here, we draw on the expert interviews (Annex 2), literature and our project partners' experience. This is followed by a discussion on the two other North European ENTRANZE focus countries, Denmark and Sweden. The summary then concentrates on highlighting major differences vis-à-vis the other countries in this group.

7. 1 Finland

7. 1.1 General policy context and major investor categories

The Finnish building stock is relatively new. More than 40% of all buildings in Finland were built after 1980 (Ministry of Environment 2007). Hence, many of the current buildings have been influenced by the energy performance standards introduced during the energy crises. Energy performance standards for major building components (U values) were significantly tightened in 1976 and requirements for airtightness (n-

50 specification) were introduced, and the U values were tightened in 1978 and 1985[26]. Small revisions were made again in 2003 and 2007 and major revisions in 2010. The same standards apply to all building types.

Since 1983, the energy efficiency of buildings has been the responsibility of the Ministry of Environment, which gives detailed regulations and instructions in the National Building Code. The Building Code sets a minimum level for energy efficiency for *new* buildings and building permits are awarded by the municipal building supervision authority. Recently, a draft decree on energy efficiency standards for *existing* buildings has been sent out for comments. The plan is to approve the decree in early 2013.

A large share of the building stock is approaching the age for major renovations. However, markets for renovation services have only recently started to develop to meet this need. There are also several other targets than energy efficiency in the national renovation strategy (Ministry of Environment 2007): mould and indoor air quality problems need to be solved and buildings need to be made more accessible for an ageing population.

Moreover, problems and opportunities are very different in different parts of the country. People continue to move to growing regions, mainly in the south of Finland, whereas especially apartments and public buildings in other parts of the country are becoming redundant (Ministry of Environment 2007; 2009). This large mobility is also reflected in the value of buildings. For example, in summer 2012 the cost/m2 for apartments was double in the metropolitan area compared to other parts of the country. This can be a challenge for making renovations outside the metropolitan area: the cost of renovating is approximately the same, but the value of housing is determined according to location.

Several measures to stimulate energy renovations have been introduced during the past decades. These include financial incentives and the provision of training and advice. The national strategy for renovation (Ministry of the Environment 2007) has launched initiatives to improve competencies and markets for renovations (Ministry of the Environment 2009). The Energy Performance Certificate also seems to be gaining importance in stimulating renovations. Until now, they have been voluntary for old single-family houses and houses with less than six dwellings. They are to become compulsory when these buildings are sold and certificates will be required to include recommendations. According to a survey to facilities professionals by Motiva (2009), two-thirds of the energy performance certificates in the study had included recommendations, and 17% of these had already been implemented.

Renewable energy and heating system upgrades are of major interest in reducing the external energy use of buildings. This is particularly the case for single-family homes, most of which are not connected to the district heating network. A major change from electricity and oil to heat pumps and other renewable energy sources is underway (Vihola and Heljo 2012). This is mainly market-driven, but there has been a small government grant (15% of investment cost) available for home owners. Similarly, renewable energy (solar heat and power combined with low-energy solutions) is central in demonstration projects for NZEB (Heiskanen and Lovio *forthcoming*). Apart from these developments, however, the policy framework for building-level renewable energy use has not been particularly ambitious, compared to several other countries.

7.1.2 General drivers and barriers for energy renovations among different owner groups

Certain features are common to all or most Finnish building owners. Since the building stock is fairly new and as a rule relatively well-insulated, there are not so many obvious cost-effective opportunities for energy investments in buildings. This is especially the case for buildings that are connected to district

[26] For example, the Building Code of 1978 requires the following U-values: exterior walls 0.29, roof 0.23, base floor 0.40, windows 2.1, doors 0.7. The airtightness requirement (n50) was 6.

heating (most apartment buildings, most public buildings, almost all office buildings), which is relatively cheap due to the widespread use of combined heat and power production.

It is conventional among Finnish building owners – apart from very few exceptional single-family home owners – to always evaluate cost-effectiveness in some way. It is considered the only sensible approach to energy investments (even when other decisions like comfort-improving ones can be made without a cost-benefit analysis). Collective decisions, as in owner-occupied apartment buildings, also require some kind of formal analysis and decision process, which can take several years. While several criteria and issues can be discussed, the final decision is almost always made on financial grounds. The larger and more professional the unit making decisions, the more sophisticated the financial analysis is.

Following from these conditions framing the decision to renovate or invest, the most widely shared barrier is long payback times (see Heiskanen et al. 2012). The importance of other barriers, in contrast, depends on the situation of each owner type. Single-family homes are most concerned about high initial costs, access to capital and incurring debt – especially vis-à-vis the value of their property, which may be relatively low outside the metropolitan area. In contrast, collective decision problems are the most severe barrier for owner-occupied apartment buildings. For public buildings and offices, there are major issues related to the financial costs and benefits of competing investments, since capital is scarce and there are several projects competing for it.

There are, of course, differences also within owner groups. Especially for residential buildings, the following issues stand out:

- People are still moving to larger cities and rural areas are declining. The value (indeed the future) of properties in such areas is uncertain at best, and does not easily merit major investments.
- Elderly property owners are not eager to incur debt and especially in case the value of their property is low, they might not be able to get credit even if they want to.
- Some small municipalities are struggling to meet their legal responsibilities. They are not likely to invest in renovations, especially when the future is uncertain.

In spite of these barriers, there are also several drivers for energy renovations. The overall discussion on energy issues has gained significant momentum in the past few years. This has been spurred by rising energy prices (including energy tax increases) and intensified discussion in the media. Several parties can and do influence building owners, including the following:

- **Public bodies:** The state is currently introducing energy performance requirements for renovations, and also offers advice on the korjaustieto.fi portal and on the website of Motiva. Municipalities (building inspectors) also provide advice, though resources are limited. In some parts of the country, local energy agencies have also offered advice and a nation-wide network is currently being established. Grants and tax deductions have a role in stimulating energy investments, especially among single-family home owners.
- **Companies offering solutions:** Facility management companies are important influencers for owner-occupied apartment buildings. Moreover, marketing of energy efficient solutions such as new heating systems has intensified significantly. There are also more and more companies offering comprehensive service packages (e.g. hardware stores offering energy audits, advice and planning), but this is a relatively new development in Finland.
- **Associations of building owners:** There are nation-wide associations for each group of owners: the Finnish Homeowner's Association offers advice for single-family homes, the Finnish Real Estate Federation for owner-occupied apartment buildings, RAKLI for professional building owners and the Association of Finnish Regional and Federal Authorities for municipalities. All of these are active in promoting energy efficient solutions and offering advice. The Building Information Foundation publishes guides and standards (e.g. on renovation cycles), which are widely used at least by managers of larger building stocks.

- **Banks** could play an important role, but do not necessarily actively promote energy efficiency or renewable energy investments today. In autumn 2012, there are only two banks in the country offering a dedicated loan package for energy investments in buildings. Especially concerning comprehensive renovations, our interviewees raised the issue of e.g. short loan periods (10 years) for housing companies, which are not comparable to the payback time of larger renovations.
- **Energy companies** are not yet very active in the field of energy renovations. There is no energy efficiency obligation scheme in Finland, but a voluntary agreement that focuses on informative measures such as electricity consumption reports. A few companies have recently experimented with renewable energy service packages (heat pump leasing, solar PV service).
- **Online user communities** are quite active in certain areas. For example, the builders' portal Rakentaja.fi has more than 400 000 members and the heat pump user community Lämpöpumput.info has been visited more than 6 million times (Hyysalo et al. 2013).

As concerns decision criteria, there are a few criteria that are highly important for all owner groups (see Heiskanen et al. 2012). Payback time is a critical issue for all owner types. The more professional building owners of large building stocks also pay attention to the return on investment. Timing is also very important, although the reasons vary slightly. The norm in Finnish building management is to have a maintenance and upgrading plan. Single-family homes usually do not have such a plan, but financial reasons lead to a certain investment cycle. Widely used solutions are also popular: if they are readily available, the decision-making is significantly easier. Recommendations by experts can also be influential, especially if certain solutions are widely endorsed.

7.1. 3 Trends, drivers and barriers for particular NZEB and RES H/C solutions

In the following, the following five categories of NZEB solutions are considered: (1) Thermal renovation, (2) Heating and hot water systems, (3) Heat recovery, (4) Energy efficient air conditioning and (5) On-site electricity production. Table 7.5 presents an overview of major drivers, barriers and the most and least promising building and owner types.

As a general comment, it is worth noting that due to the relatively new and insulated building stock, heating system upgrades are relatively more interesting in Finland than thermal renovation. For example, Häkkinen et al. (2012) have analysed the opportunities for reducing energy demand and CO_2 emissions in the Finnish dwelling stock. They found that heating systems changes in detached houses (which are not usually connected to district heat) could amount to a savings potential of 7 TWh delivered energy (compared to 15 TWh of other types of energy renovations in the entire dwelling stock), and could provide 4,3 Mt of greenhouse gas savings (compared to 3,1 Mt from other energy renovations).

Thermal renovation

Considering that the building stock is fairly new and relatively well-insulated, the opportunities for thermal renovation are not as large as in many other countries. Insulation of the building façade or roof is only cost-effective (from a private cost perspective) when included as part of a comprehensive renovation (Häkkinen et al. 2012, Heljo and Vihola 2012). Certain types of energy renovations have already been done. For example, Heljo and Vihola (2012) have estimated that about 15% of all building types have replaced old windows with new, more energy efficient ones. About 8-15% of all building types are estimated to have added wall insulation, and as many as 30% of single-family homes are estimated as having added roof insulation.

Major drivers for thermal renovations are an overall increase in energy awareness, which is due to the rise of energy prices, overall environmental awareness, and in particular, rising awareness of a variety of solutions and their combinations. In particular, Sitra, the Finnish Innovation Fund, has stimulated public and professional debate on energy efficiency in buildings via the ERA-17 programme, seminars and demonstration projects. It was for long believed that Finland is greatly ahead of other countries in energy efficiency, but recently, awareness has grown of the need to take action to regain this position (McKormick & Neij 2009).

A large share of the existing building stock is approaching the age for major structural renovations. Since especially larger buildings are renovated according to a pre-set schedule for major building parts, this is an important opportunity for integrating energy efficiency measures into major renovations. Successful renovation concepts can lead to increased market value, especially when the building is located in a relatively valuable neighbourhood and the whole neighbourhood is renovated at the same time. Moreover, the upcoming draft decree on energy efficiency standards for *existing* buildings will require that when major renovations are made, the energy efficiency of the entire building or the components replaced must be significantly improved.

As stated above, the age of the building stock is a major driver, but it also limits the cost-effective opportunities for thermal renovation. More than 40% of the building stock was built after 1980. Another aspect that limits cost-effective opportunities is the large share of buildings connected to district heat, which costs less than 7 cents/kWh due to the widespread use of combined heat and power production, which covers about ¾ of the total district heat production (Pöyry 2012). As a result, thermal renovations usually have relatively long payback times. Initial costs and uncertainty about property values are major barriers for large-scale renovations for properties in declining areas, and collective decision problems and concerns over disruption are barriers for owner-occupied apartment buildings.

Public opinon concerning high insulation levels can also be a concern. Mould is a widespread problem in buildings, and the popular press sometimes attributes mould problems to the high levels of insulation applied after the energy crises. Also some experts appear in the media arguing against high levels of insulation. There is a lack of consensus in the expert community, which is also quite visible to the general public.

There are different views on what are the most promising owner and building types. The Ministry of Environment has focused largely on multifamily buildings that are approaching the age of major renovations, partly because of the need to preserve and maintain this large part of the national built environment. On the other hand, from a pure cost-effectiveness perspective, the most promising owner types for thermal renovation are buildings that are not connected to district heat – i.e., single-family homes, which pay about 13 cents/kWh for heating electricity costs or about 11 cents/kWh for oil (Statistics Finland 2012). In general, it seems that thermal insulation has been more widely done by single-family homes (Heljo and Vihola 2012), and the cost factor is the likely explanation for this, although organizational simplicity may be relevant as well.

Service and office buildings are likely to be the least promising types of buildings for thermal renovation, as the relative share of heating energy is the lowest in this type of building, and ventilation, lighting, operation and maintenance are seen as more promising ways to improve energy efficiency.

Heating and hot water systems

The major heating and hot water system in Finland is district heat, which serves about half of the building stock (Pöyry 2012). District heat has grown steadily since the early 1970s, and its current growth rate is expected to continue at least until 2020 (Pöyry 2012). One of the major growth factors has been the concentration of the population in densely populated areas. Since district heat has been developed purely on a market basis in Finland, population density is also a major limiting factor, as some buildings simply cannot be served competitively by traditional large district heating systems due to their location. District heat is the defining factor also for other energy sources, as can be seen in Table X.X. Other solutions are not feasible for buildings that are connected to district heat, whereas buildings that are not connected are actively searching for other solutions. For example, fossil-based central heating systems (oil heating) are clearly declining, as owners are shifting mainly to ground source heat pumps (and to some extent, wood-based systems in rural areas).

The relative decline of fossil-based heating systems and electric heating are the main drivers for new heating systems, especially heat pumps, but also some biomass-based systems in rural areas. The cost of energy, but also growing awareness and market offerings are driving these new solutions. As stated above, the growing awareness is reflected in the fact that the heat pump online user community has been visited more than 6 million times (Hyysalo et al. forthcoming).

- The diffusion or air-to-air heat pumps since 2000 has been phenomenal – almost 300 000 pieces have been installed[27]. Moreover, a recent study by Sitra (2011) indicates that Finnish homeowners are very interested in heat pumps, as more than 50% of detached home owner and 60% of attached home owners not yet having a heat pump were interested in obtaining one. This is mainly due to their low price, ease of purchasing and heavy marketing, as well as to word-of-mouth and promotion by citizens (Heiskanen et al. 2011). Moreover, since many single-family homes do not have central heating, air-to-air heat pumps are often believed to be the only feasible option for heating.
- Groundsource heat pumps have also experienced steady growth: according to the Finnish Heat Pump Association (SULPU 2012), there are more than 74 000 pieces installed. These are mainly installed in single-family homes that were previously heated with oil (Vihola and Heljo 2012).
- Advanced biomass-based systems such as wood log central heating, pellets and woodchips have seen some growth, but this has been somewhat sporadic (Vihola and Heljo 2012). Woodchips and pellets for larger installations (farms, public buildings) are however growing especially in rural areas. There has also been a rapid growth in “heat entrepreneur services” in rural areas, where local farmers offer both the wood and the heating service for e.g. schools or small district heating systems (Motiva 2012).
- Solar thermal systems in Finland are mainly for heating hot water for about half of the year. There seems to be a steady but slow growth. On the basis of annual sales figures from the ENTRANZE database), we estimate about 5 000- 6 000 units currently installed in Finland (less than 1% of the detached housing stock).

The main barriers to new heating and hot water systems are the initial costs. Especially the change from oil to groundsource heat is constrained by the higher investment cost. Also, a general uncertainty and competition between several solutions has to some extent slowed down the changeover (Heiskanen et al. 2011; Sitra 2012). For some systems (such as solar water heaters), the overall lack of awareness and services seems to be a limiting factor, as well (see Jalas et al. *forthcoming*). For all kinds of new systems, concerns about cost-effectiveness, limited experience and concerns over reliability are also major concerns (Sitra 2012).

Buildings heated with oil and electricity are the most promising building types for new renewable heating systems. This includes mainly single-family homes, but also other buildings such as public buildings in rural areas or outside the district heating system. The buildings with central heating installed have the largest number of options, whereas buildings that lack central heating are mainly likely to choose air-source heat pumps (and perhaps solar water heaters, if they are very innovative).

District heating does not combine well with any of the new heating systems from a cost-benefit perspective (Pöyry 2012). Hence, no existing buildings served by district heat are likely to install e.g. groundsource heat, biomass based systems or solar water heaters.

[27] They are not, however, always used optimally, and studies indicate that energy savings are far below the marketing claims (Heiskanen et al. forthcoming).

Ventilation heat recovery

Ventilation systems vary greatly by building age. Because so many buildings are fairly new, Finland has the highest penetration of mechanical supply and exhaust ventilation in the EU (Kurnitski and Seppänen 2008). Older residential buildings have natural of mechanical exhaust ventilation, whereas since 2003 the building code requirements of 30% heat recovery replaced mechanical exhaust air ventilation almost completely in new buildings. However, public and commercial buildings started to use mechanical supply and exhaust ventilation as early as in the 1960s, and school buildings since the 1980s (Kurnitski and Seppänen 2008). However, demand-controlled ventilation is still not commonly used even in office or public buildings.

According to Kurnitski and Seppänen (2008), the major drivers for current developments have been indoor climate concerns, industry initiatives and regulations; performance-based energy standards have recently started to drive the development in new buildings. However, indoor air requirements also mean that when ventilation systems are renewed, airflows are increased, which detracts from the nominal energy efficiency improvements (Heljo and Vihola 2012).

According to Heljo and Vihola (2012), major barriers to ventilation heat recovery in existing buildings are the building owners' and users' lack of awareness, as well as problems in old ventilation systems and airtightness. In older buildings, supply air intake is not controlled; hence installing an efficient heat recovery system may require several measures to improve airtightness. In old apartment buildings, centralized new ventilation systems are quite expensive to install; cheaper and more controllable room-based systems are not always deemed acceptable (Heljo and Vihola 2012).

According to Heljo and Vihola (2012), most large service buildings already have heat recovery installed. The most promising building and owner types are apartment buildings that are undergoing major renovations, as well as post-1980s single-family homes (with mechanical supply ventilation) that are renewing their ventilation systems. In service buildings, demand-based control is the most promising option for saving energy, according to Heljo and Vihola (2012). Buildings that lack mechanical supply ventilation, buildings with low airtightness, and old apartment buildings that are not due for major renovations are the least promising buildings.

Energy efficient AC

Air conditioning (i.e., mechanical cooling of ventilation air, AC) is not widespread in Finland due to the cold climate and the low angle of the sun. According to a working group report (MoE and MTI 2005), AC is typically used in commercial and service buildings, of which about half are believed to have air conditioning[28]. It is estimated that on average, 4% of all electricity use in cooled commercial space is used for cooling. It is also believed that cooling is currently not as efficient as it could be, due to oversized equipment.

However, AC is installed in almost all new commercial and office facilities, and it is believed to be becoming more widespread also in health and educational buildings (Moe and MTI 2005). AC is still extremely rare in households, but air-to-air heat pumps are very popular and are also used for cooling. While the demand for cooling is expected to grow due to global warming and better insulated buildings, there are also several more efficient alternatives available. Chilled beams have been a standard solution in new office and public buildings for the last ten years (Kurnitski and Seppänen 2008). New options include district cooling, which is available in certain larger cities and used mainly by larger facilities, and bedrock cooling. However, external shading is not commonly used. District cooling has a very positive image, and is claimed to consume only 1/5 of the energy consumed by mechanical cooling. It has been adopted by many large and visible facilities,

[28] Small AC equipment (12-70 kW) are typically used in small offices and businesses (about 19 000 pieces installed). Medium-sized equipment (70-300 kW) are typically used in large IT facilities and large office and retail outlets (about 10 000 pieces installed). Large AC equipment are typically used in large office and commercial facilities (about 3500 pieces installed) (MoE and MTI 2005).

such as popular department stores. There are today products available also for smaller consumers, at least in Helsinki.

Air conditioning is a fairly new phenomenon in Finland. It has been mainly used in larger commercial facilities and most of the more efficient solutions are developed for this purpose. The total energy consumption is still low; hence, overall awareness is also low. Large facilities are the most promising customers, whereas e.g. single-family homes are likely to use air-to-air heat pumps or small appliances like fans for cooling. However, air conditioning in general is still quite rare and is not expected to grow very rapidly in existing residential buildings.

Electricity micro-generation

Micro-generation of electricity is still extremely rare in Finland and mainly limited to off-grid summer cottage solutions or new demonstration buildings. Quite recently, there has been increased interest in solar power, at least in the public discussion. This is partly due to media reports and people's personal observations in e.g. Germany (Heiskanen et al. 2012). A recent survey (Sitra 2012) indicates that about 55% of apartment owners and 60% of (attached and detached) single-family homeowners are interested in PV panels. Sitra, the Finnish Innovation Fund, has been actively promoting solar power during the past few years. Visible demonstrations of NZEB buildings have also prominently featured solar power solutions, serving to counteract the old belief that Finland has little sun (Heiskanen et al. *forthcoming*). Two leading energy companies have recently started to offer solar power packages (including equipment, installation and purchase of surplus power) to their own electricity customers.

Cost effectiveness is still a major barrier, as solar power is still far from grid parity and there is no feed-in tariff for small power producers in Finland. Sitra (2012) also mentions difficulties in connecting equipment to the grid (technical standards), complex bureaucracy and difficulties in selling surplus energy, as well as the low electricity price offered to small producers. Sitra (2012) is also critical of the definitions used in the current Building Code, which do not take into account energy produced in and exported from the building. Because the seasonal variation of solar power production is so large, this would be necessary for solar power to contribute to NZEB.

Among existing buildings, very environmentally aware and innovative single-family home owners are the most promising customers for solar power. New apartment buildings and office buildings are experimenting with solar power, and there are some experimental new urban developments that include solar power production (Tekes 2012), but it is not likely to be a major option for existing buildings for some time. At the moment, few existing building owners are particularly promising for solar power or other forms of micro-generation, unless major market drivers such as incentives or legislation emerge, and major barriers are reduced.

Table 7.5: Overview of drivers, barriers and the most and least promising building and owner types for major categories of NZEB and RES H/C solutions.

	Major drivers	Major barriers	Promising owner & building types	Problematic owner & building types
Thermal renovation	overall energy awareness upcoming regulations combined with large share of building stock approaching age of major renovations	relatively new building stock relatively high level of insulation large share of buildings served by district heat lack of consensus on appropriate levels of insulation	buildings that are outside the district heating system buildings built in the 1960s-1970s	buildings that are connected to district heat buildings outside growing cities
District heating	concentration of buildings in densely populated areas	some buildings are not feasible to connect to district heat due to location some competition with groundsource heat	all large building types all buildings located in densely populated areas	small buildings located in sparsely populated areas single-family homes have more cost-competitive options
Biomass central heating systems	costs, environment, local energy	inconvenience	rural households some small public buildings in rural areas	urban households
Groundsource heat pump systems	costs, environment, convenience	investment costs	all single-family homes with central heating system and not connected to district heat some outlying larger buildings	buildings connected to district heat
Biomass-based room heating systems	widespread as auxiliary system	rarely standalone today (inconvenience)	all single-family homes (as auxiliary system)	all other buildings
Airsource heat pumps	low investment cost, ease of purchase	none	single-family homes without central heating	buildings connected to district heating
Solar thermal	overall image, “free energy”, hot water in summer	cost-benefit ratio (short summer season)	single-family homes, buildings outside district heat, buildings with large hot water demand in summer	buildings connected to district heat
Heat recovery	energy and cost savings	lack of awareness (residential buildings), lack of controlled air supply (old buildings)	newer buildings with controlled air supply	old buildings with dispersed air supply, lacking airtightness
Energy efficient air-conditioning	general interest in cooling, market supply	limited experience in cooling	service and public buildings	residential buildings
Electricity micro-generation	environmental concerns, “free energy”	costs, standards, complexity, lack of incentives	very environmentally conscious single-family homes	all owner and building types

7.2 Other North European countries

7.2.1 Sweden

As concerns policy, Sweden’s energy efficiency standards for new buildings have developed fairly similarly as those in Finland over the years. One difference was an earlier emphasis on resistance electric heating, which has had more stringent requirements than other heating types since 1988 (McCormick and Neij 2009). Furthermore, there is a longer history of subsidies for insulation and heating systems conversion, and there has been a nation-wide network for local energy advice since 1998.

As concerns building owner types, the structure of ownership and building types is fairly similar to that in Finland, although the share of multifamily buildings and public rented dwellings is somewhat larger (ENTRANZE database). As in Finland and the other Nordic countries, municipalities own a large share of the service buildings. The age structure of the buildings is also fairly similar; there are large numbers of large apartment buildings from the 1960s that are coming up for major renovations (Wahlström et al. 2011).

The heating systems used in Sweden are also fairly similar to those in Finland (ENTRANZE database). However, due to the early start with an intensive market transformation process including domestic R&D, technology procurement, special loan instruments and later, investment subsidies and other forms of support, heat pumps have a wider penetration, especially groundsource heat pumps (Neij et al. 2008). Moreover, solar thermal systems are sold at about a five-fold rate to Finland, per capita (ENTRANZE database).

A great deal of research has been conducted in Sweden on building owners' propensity to renovate and change heating systems. Mahapatra et al. (2009) have conducted several surveys during the previous decade. They found that most oil heating system owners have replaced their systems with another heating system: the remaining 10% are not eager to change. Homeowners with resistance electric heaters were eager to change, motivated by the rising price of electricity, investment subsidies and personal recommendations, which were found to be the most important source of knowledge (similarly, installers and personal sources were the most important information source for low-energy windows, according to Nair et al 2011). The annual cost of heating, investment costs and functional reliability were the major decision criteria for these homeowners. However, for more innovative systems, the situation is different. Palm and Tengvard (2011) examined the motives for the adoption of small-scale self-assembly microgeneration equipment. They found that some households did this to reduce fossil fuels use, others to display environmental consciousness or set an example to others, and yet others to protest against "the system" and achieve a degree of self-sufficiency.

7.2.2 Denmark

Denmark has had a very active energy efficiency policy, which has continued at a fairly strong pace ever since the energy crises. For example, mandatory energy labelling for buildings was introduced as early as in 1979, an electricity saving trust was introduced in 1996 and energy efficiency obligations for energy companies were introduced in 2006 (McKormick and Neij 2009). Moreover, the Heat Supply Act from 1976 introduced local least-cost energy planning (Dyrelund and Lund 2009). A special characteristic of the Danish energy system is the large and growing share of intermittent power production, which Denmark aims to accommodate through widespread use of flexible cogeneration plants, heat pumps with heat storage and electric cars (Hvelplund 2012). Thus, the capacity to use electricity when it is cheap is an important feature of desirable home heating systems in Denmark.

As concerns building owner types, Denmark is more similar to many continental European countries than the other Nordic countries. Single-family homes, most of which are owner-occupied, constitute half of the total building stock. Multifamily homes are more often rented than owner-occupied, and they have a smaller share of the total stock than in Sweden or Finland.

As concerns heating systems, district heat has a very large share of the total heat supply (46%), and 60% of the heat supply for dwellings, with about 80% of the heat produced as combined heat and power (CHP) plants, almost half of which run on renewable fuels (Dyrelund and Lund 2009). As a result these forceful policies, CO_2 emissions of heating have decreased from 25 kg/m^2 in 1980 to 10 kg/m^2 (Dyrelund and Lund

2009). The policy is to promote a continued expansion of district heat, combined with the use of heat pumps for sparsely populated areas. This is especially at the cost of oil and gas heating. From 2010-2011, Denmark had a special funding scheme for scrapping oil heaters, in which solar thermal, air-to-water and groundsource heat pumps, and district heat were promoted. A special Danish feature is the (relatively) large share of district solar heat, which accounts for about 30% of the total area of installed solar thermal systems (Dalenbäck and Werner 2012).

These differences partly reflect, and are partly reflected in, large differences in the prices of the most common energy sources (Annex 2). For example, Denmark has one of Europe's highest electricity prices for small consumers, whereas Finland has one of Europe's lowest prices for electricity.

According to a survey on homeowners' reasons to conduct renovations (Christensen et al. 2011b; Gram-Hanssen 2011), comfort was very important for half of the respondents, but also reducing the energy bill and making the property more energy efficient figure were common motives. Reducing environmental impacts and increasing the value of property were very low by the homeowners. On the basis of related qualitative research, Gram-Hanssen (2011) has pointed out that policy instruments focus too much on rational economic motives: lifestyle issues and the process of renovation (i.e., desire to personally take care of one's home) were as important as the technical need to renovate and the outcomes of the renovation.

7.4 Similarities and differences among North European countries

There are certain similarities among the countries, and they share a historical co-operation in many areas. One of these areas is energy, in which respect the countries however have quite different endowments and current concerns. The energy efficiency policy in Denmark is more forceful and applies a larger number of instruments than in the other two countries (McCormick and Neij 2009). In several issues (such as the energy performance certification of buildings, energy efficiency obligation scheme for energy companies, passive and sustainable building construction), Denmark has been a forerunner in Europe. Denmark is hence to be considered an 'early adopter' of most building energy efficiency and renewable energy solutions.

Sweden has disbursed a larger number of subsidies for heating system renewals to its citizens than Finland, and has also actively participated in market transformation for the heat pump sector (McCormick and Neij 2009). However, because of the vicinity of Finland to Sweden and because of the integration of the two markets, Finland has benefited from much of this market transformation activity and largely managed to catch up in this particular technology. However, Finland's groundsource heat pump market is still growing, whereas the Swedish market is already mature (EREC 2011). Significant growth is expected in Denmark, where heat pumps are seen as one option for storage of excess heat from peak electricity production.

All of the Nordic countries are quite advanced in the use of modern biomass heating systems. Solar water heaters are more widespread in Denmark and Sweden than in Finland, possibly because they have received extremely limited public support in Finland. None of the Nordic countries are particularly advanced in terms of building-applied solar PV. All can be characterized as being at a very initial stage, although Denmark saw significant growth in 2012 thanks to electricity tax exemption (0,27 €/kWh) scheme for self-produced electricity.

8 Summary: similarities and differences among countries by building type, stakeholder group, trends and solutions

As stated in chapter 3, there are several common features that apply to all kinds of energy investments in buildings, and which are widely shared among countries and owner groups. These are the facts that most building owners are constrained by the high initial costs of energy investments, due to short time horizons and unsophisticated financial analysis, but also because of other priorities, uncertainties about the risks of these investments, and because of difficulties in raising capital for investments. Many building owners in the EU-27 simply do not have the money to make these investments. Short payback expectations are not the result of an individual calculus, but rather the result of social structures that do not prioritize energy saving and CO_2 emission reductions.

Nonetheless, there are occasions for making improvements in existing buildings, which relate to the technical need to replace building components, changes of ownership, the possibility improve comfort and the possibility to cut energy costs. Apart from these general factors, the extent to which certain solutions are applied depends largely on public knowledge and awareness, and whether the solutions are endorsed by experts, widely used and whether good quality services (including financial services) are available. If these factors are largely missing, we cannot speak of public acceptance by the majority of citizens, even in principle.

The extent to which knowledge, support and exemplars are available for particular solutions depends on the maturity of the market. On the basis of our analysis, we attempt to characterize the level of maturity of markets for various nearly-zero-energy and renewable heating solutions (see table 1). This is relevant because the maturity of the market relates to:

- The type and quality of services and commercial solutions available: these can range from quite exceptional and niche market services at premium price, to widely available services. At one extreme, finding and applying a solution requires extensive Internet searches and consulting with several experts. At the final stage, solutions are be routinely included in a service package (e.g. windows are sold with frames today).
- The evaluation criteria used by building owners. Most building owners are unlikely to invest in solutions that they have never seen. If solutions are perceived of as innovative, they will only be chosen by a certain segment of pioneering users. Other users are not likely to choose them unless they fulfill a very specific need.

Table 2 offers a characterization of the ENTRANZE target countries in terms of the market maturity for some nZEB and renewable heating solutions. The maturity of the market is assessed mainly from the end-users' perspective (not that of companies offering these systems, or the total market size). The rationale for this is that acceptance, adoption and growth may be constrained in very small markets, where less than 1% of buildings have applied the solution. In this case, it is likely that many building owners have never seen the system or are at least not familiar with it. It may be difficult for many of the less active building owners also to find appropriate products and services in such markets. In table 1, such markets are characterized as "initial". Markets where less than 5% of the relevant buildings have applied the system are characterized as "small" – products and services are more likely to be available, but the solution might not be familiar to all building owners. Markets in which more than 5% of the relevant buildings have applied the system are characterized as "established"[29].

[29] Solar PV has been calculated somewhat differently due to data availability issues, with "established" referring to markets where there is more than 100 W capacity installed per person, "small" referring to markets with 20-99 W capacity per person, and the rest as "initial". Not all of the PV installations included here are necessary building-applied, as no statistics were available on this.

In addition, an arrow depicting the annual growth rate of installations (calculate as an average of 4-5 years, 2006-2010, depending on data availability) has been added to each cell, where available. A horizontal arrow denotes a sales growth of less than 20%, a 45 degrees arrow a sales growth of more than 20% but less than 100%, and a vertical arrow denotes an average annual sales growth of more than 100% (i.e., installations have on average doubled each year). The strong growth rates for solar PV suggest that in some cases, new installations can indeed double on average each year over a period of several years even with a low installed base. Hence, the maximum adoption growth rate can be dependent on technology.

Renovations are made in all countries. Advanced thermal renovations are a novelty in all countries: however, there are clear differences among the ENTRANZE countries in how well established near-zero energy solutions are in new or existing buildings. In this respect, Austria, Germany and France are likely to represent more advanced or rapidly moving markets in this respect, whereas the other ENTRANZE countries are in a very initial phase.

Table 1. Assessment of the maturity of the market for various nZEB and RES-H/C solutions in ENTRANZE target countries

	AT	BG	CZ	DE	ES	FI	FR	IT	RO
Comprehensive nZEB solutions	Initial ↗	Initial	Initial	Initial ↗	Initial	Initial	Initial ↗	Initial	Initial
Pellet boilers	Small ↗	Initial	Small →	Small ↗	Initial	Initial →	Initial ↗	Established ↗	Initial
Ground-source heat pumps	Small →	Initial	Initial ↗	Small ↗	Initial	Small →	Initial →	Initial →	Initial
Airsource heat pumps	Small ↗	Initial	Small ↗	Initial ↗	Established	Established ↗	Small ↗	Initial	Initial
Solar thermal systems	Established →	Initial ↗	Small →	Small →	Small ↗	Initial →	Small ↗	Small ↗	Initial ↑
Electricity micro-generation	Initial ↗	Initial ↑	Established ↑	Established ↗	Small ↑	Initial ↗	Initial ↑	Small ↑	Initial ↗

Legend: Initial = diffusion < 1% of the dwelling stock; Small = diffusion < 5% of the dwelling stock; Established = diffusion > 5% of the dwelling stock. (For solar PV, initial = <20W_c/capita; small < 100 W_c/capita; establishe> 100W_c/capita. Sources: see chapter 3

The main drivers for nZEB solutions in ENTRANZE target countries are presented in table 8.2. The main drivers for thermal renovation are fairly similar in all countries, although the emphasis varies somewhat from one country to another. Regulations (existing or pending), subsidies and finance schemes, as well as especially local advice agencies are the main drivers in most countries. The state of the existing housing stock is another major driver, more so in some countries than others, as well as the arguments that thermal renovations are cost-effective. The rising price of energy was also mentioned frequently as a driver for energy renovations. Voluntary initiatives, regional energy agencies, existing good examples and individual champions were also mentioned in some countries as important drivers.

Subsidies and finance schemes are important drivers for renewable heating and cooling solutions in many countries. There are also mandatory requirements in several countries, e.g. the Renewable Heat Act in Germany and building regulations in Spain and France. Companies were also often mentioned as promoters of these solutions, especially installers in Austria. In particular, heat pumps have been promoted by energy utilities in Austria, France and Germany. Promotion, marketing and good examples are mentioned as important; this applies especially in the initial market introduction stage of a solution.

Table 8.2: Drivers for NZEB and RES-H/C solutions in ENTRANZE target countries

	Commonly mentioned drivers	Drivers for particular countries
Thermal renovation	Subsidies and finance schemes Regulations (existing or pending) Research programmes, expert advice Overall energy awareness	State of housing stock, large share of buildings up for renovation Rising price of energy Regional and local energy agencies Voluntary initiatives and individual champions Positive real-life examples Energy and climate protection, cost effective measures
District heating	DH utilities, authorities	Convenience Increased urban density
Biomass central heating systems	Subsidies and finance schemes (in most countries) Companies	Reasonably cheap fuel, low operating cost Positive image, environmental concerns Rewable heat act (DE) Market promotion Biomass associations, installers (AT)
Groundsource heat pump systems	Subsidies and finance schemes (in most countries) Marketing and real-life examples	Utilities (AT, DE, FR) Installers (AT) Convenience, low maintenance cost Renewabe heat act (DE) Positive image (DE)
Airsource heat pumps	Market promotion Low investment cost (most countries) Ease of installation, wide applicability Combination of heating and cooling	Subsidies and finance schemes (some countries) Utilities (AT, DE, FR)
Solar thermal	Subsidies and finance schemes (in most countries) Promotion Positive image (most countries), environmental concern	Building regulations (ES, FR) Proven, easy to use technology (IT, BG) Owners' willingness to pay for solar thermal (DE) Good return on investment in apartment buildings (CZ) Installers, energy agencies (AT)
Ventilation heat recovery	Companies Standards and requirements for new buildings	Subsidies and finance schemes (AT; DE) Renewable heat act (DE) Associations that promote energy efficiency (IT) Rising energy prices (RO) Motivated building owners (CZ) Well promoted for mechanical ventilation (BG)
Energy efficient air-conditioning (AC)	Promoted by designers and experts Mandatory requirements, labelling and inspections	Availability, easy to install Convenience Combine heating and cooling Requirements for AC in office buildings, air-conditioned space for employees
Electricity micro-generation	Subsidies and finance schemes, feed-in-tariffs (in most countries) Environmental concern, positive image, strong public support Independence	Legal requirements (IT, ES) Facilitation of permitting procedure (BU) Growing market, rising energy prices (RO)

Source: previous chapters

Certain solutions have an overall positive image: this is the case for solar energy in most countries (irrespective of whether it is widespread or not). However, biomass is perhaps a solution that has a more positive image in German-speaking countries than outside them. There are also practical arguments for some of the solutions. Cheap fuels are a widely acknowledged argument for biomass, convenience and low maintenance costs for groundsource heat. Ease of use and ease of installation are also important arguments for relatively independent systems like solar water heaters or airsource heat pumps.

Mechanical supply and exhaust ventilation is quite rare; hence the possible scope for ventilation heat recovery systems is limited. On the other hand, there are also countries in which air conditioning (i.e., cooling) is extremely rare as well. Ventilation heat recovery and energy efficient air conditioning are more expert-driven systems, which are usually promoted by standards, requirements and labelling or experts and designers rather than public demand. There are also subsidies and finance schemes in Austria and Germany. However, motivated building owners can also be drivers, as in the case of the Czech Republic. In countries where air conditioning is only just being introduced (e.g. Czech Republic, Finland), reversible air conditioning/heat pumps present an attractive prospect.

Solar PV panels are mainly driven by subsidies, finance schemes and feed-in-tariffs, as well as the overall positive image of solar energy, and the attraction of independent energy production (for some building owners). There are also legal requirements in some countries, and the growing market and rising energy prices increase its attraction in others.

The main barriers to nZEB solutions in ENTRANZE target countries are presented in Table 8.3. High initial investment costs are a common barrier to all solutions, except for air-source heat pumps in all but some countries.

There are also particular barriers related to particular technologies such as space demand and urban air quality issues for biomass heating. Some of these are quite definite technical constraints, such as the low airtightness of existing buildings in the case of ventilation heat recovery, which makes it pointless as a standalone solution in most cases.

Some barriers relate to the type ad development stage of the market. These are, for example, lack of knowledge and dedicated finance for e.g. biomass heating systems, or uncertainties about fuel prices and availability. There is also a competition among many of these systems, and while our experts and the national or local advice schemes referenced above can recommend some solutions for particular buildings or locations, this might not be obvious to building owners.

There are also some quality and performance issues related to particular technologies. Especially, the variable quality of airsource heat pumps was mentioned in several countries. Electricity micro-generation (solar PVs) suffers from high investment costs, high seasonal (and daily) variation and lack of storage solutions, as well as unstable feed-in-tariff schemes and practical problems in grid connections in several countries.

Table 8.3: Barriers NZEB and RES-H/C solutions in ENTRANZE target countries

	Commonly mentioned barriers	Barriers for particular countries
Thermal renovation	Financial barriers: initial cost, payback times, access to capital, unwillingness to incur debt Lack of information, general attitudes, uncertainty, fears, lack of knowledge and good advice Lack of technical skills, poor quality of services (most countries)	Collective decision problems (countries with large share of owner-occupied multifamily buildings) Legal difficulties Special needs of old buildings (AT) Lower cost-effectiveness due to higher initial insulation level and affordable district heat (FI)
District heating	High investment cost, not for every building or area Competition with natural gas (many countries) Old buildings without central heating	Dependence on supplier Rising and variable prices (CZ) Negative public image (BU, RO) Competition with groundsource heat (FI) No existing culture (technical or political) (ES)
Biomass central heating systems	Investment costs Inconvenience Space for fuel Emission control (urban areas)	Small markets, availability of fuel Maintenance and operation costs in apartment buildings (ES) Competition with gas central heating (ES) Fluctuation fuel costs (IT) Lack of knowledge (IT, RO) Lack of dedicated finance (IT)
Groundsource heat pump systems	High investment cost Not feasible for all buildings or locations Drilling of boreholes not possible in all areas, especially urban areas	Lack of awareness (some countries) Some examples of underperformance, quality problems Competition with airsource heat pumps
Airsource heat pumps	Some questions about performance and/or quality (several countries)	Lack of awareness (some countries) High initial cost (CZ, RO) Difficult to integrate in larger buildings (IT) Need for other system for domestic hot water (ES) Operation is only feasible in renovated or new buildings (DE)
Solar thermal	Initial cost (some countries) Cost-benefit ratio, payback time Seasonal variation	Roof space (AT), competition for space with PV (DE) Collective decision making (AT) Competition with district heating (AT) Integration in large buildings (IT), existing heating systems (DE) Lacking knowledge of installers (DE) Space for water tank (IT) High maintenance costs (ES) Some cases with quality and performance issues (BG)
Ventilation heat recovery	Investment costs Low airtightness of existing buildings	Cost-effectiveness Space limitations Lack of technical skills Air quality, noise (AT)
Energy efficient air-conditioning (AC)	Investment cost, payback time Lack of awareness and knowledge	Space Competition with less effective equipment Noise Difficult to install in existing buildings (IT)
Electricity micro-generation	Investment costs Seasonal variation, energy storage problems	Lack of awareness and consumer confidence Lack of finance Variable, reduced, cancelled FiT Bureaucracy, grid connections Visual impact (IT)

Source: previous chapters

The most promising customer type (Table 8.4) for several countries and several solutions is the single-family home. Exceptions include large and high-investment solutions like district heating in all countries and ground-source heating in countries in more temperate or warm climates. Moreover, there are solutions that are more suitable (and actually originally developed for) non-residential buildings, such as ventilation heat recovery (which requires supply and exhaust air ventilation, uncommon in residential buildings), and energy efficient air conditioning. Many of the solutions are perceived to be more suitable for new buildings. This is probably certainly true, but it also suggests that new solutions should be developed that are explicitly adapted to the diversity of existing buildings.

Table 8.4: Most promising owner types for NZEB and RES-H/C solutions in ENTRANZE target countries

	Commonly mentioned owner types	Owner types mentioned for particular countries
Thermal renovation	Single-family homes Buildings from the 1950s-1970s	Professionally managed rental housing (social housing, co-operatives) Public buildings Multifamily buildings (CZ, RO, FI) New office buildings as exemplars for innovative solutions (BG)
District heating	Apartment buildings Buildings in dense urban areas,	Big office buildings and shopping centers Large buildings in service sector (hospitals) Public buildings Most office buildings (IT)
Biomass central heating systems	Single-family homes, rural areas	Apartment buildings (CZ, ES)
Groundsource heat pump systems	Single-family homes (some countries) Buildings with central heating	Slow increase also in multifamily and office buildings (AT) Some apartment and service buildings (IT) Owner-occupied buildings (DE) Buildings with both heating and cooling demand
Airsource heat pumps	Single-family homes New buildings Owner-occupier	Isolated areas without gas connection, litoral areas of Spain (ES) All types of buildings (FR, IT)
Solar thermal systems	Single-family homes Buildings with large hot water demand	Apartment buildings (higher cost efficiency) (CZ) Small multifamily buildings, office buildings (IT) Multifamily and service buildings growing (FR) Buildings outside district heat (FI) Buildings in areas with good solar resources (RO)
Ventilation heat recovery	Newer buildings with controlled air supply	Big office buildings, hotels (BG) Owner-occupied buildings (CZ) Single-family buildings (ES, FI, RO)
Energy efficient air-conditioning	Offices, public buildings, new buildings	Badly designed buildings with risk of overheating (CZ) New buildings, buildings with high indoor air quality needs (IT)
Electricity micro-generation	Single-family homes	Office and industrial buildings (BG) All types of buildings, esp. with saddle roofs and low shading (CZ) Buildings with big and well oriented roofs, in specific climate zones (ES) Industrial and agricultural buildings (IT) Some public buildings (RO)

Source: previous chapters

Conversely, multifamily buildings were most frequently mentioned as a problematic customer type for several kinds of solutions (Table 8.5). Owner-occupied apartment buildings (and buildings owned by private landlords in Germany) are problematic for several different solutions, starting with but not limited to thermal renovation. This is clearly due to organizational problems in arriving at a common decision and raising funds for the investment, but also perhaps the available service offerings and support schemes. For example, multifamily buildings were mentioned as promising owner types for solar water heaters in the Czech Republic and they are a growing market in France. In some countries like Spain, the lack of central heating in many apartment buildings leads to a situation where particular solutions are suitable for a very particular set of buildings. The analysis thus suggests that there is an urgent need to renewable heating and cooling develop solutions for multifamily buildings, which are home to about 42% of all Europeans.

Some of the less promising building owner types are quite obvious and due to technical issues. These include issues like the problem of groundsource borehole drilling in urban areas, space demands for biomass storage or roof space demands for solar heat and power. Or they include particular constraints on the cost-effectiveness of particular solutions, like heavy-investment solutions for buildings with low heat demand. However, the diversity on "least promising customer types" also suggests that the adoption and adaptation of various solutions the needs of various building owners also depends on organizational, financial and cultural issues.

Table 8.4: Least promising owner types for NZEB and RES-H/C solutions in ENTRANZE target countries

	Commonly mentioned owner types	Owner types mentioned for particular countries
Thermal renovation	Owner-occupied apartment buildings Especially buildings with a mix of owners and tenants Old historical buildings	Public buildings (AT) Buildings with private landlords (DE) Office buildings (IT, BG) Public buildings (IT) Old single-family homes (ES) Buildings in rural areas (ES, FI, RO), with low purchasing power (RO)
District heating	Buildings with no central heating system Single-family homes Rural regions Efficient new buildings	Historic city centres (ES) Rural areas, low income households (RO)
Biomass central heating systems	Urban buildings Apartment buildings (most countries)	Buildings lacking storage space Older residents (IT) Low-rise residential buildings (ES) Buildings with low heat demand (office and commercial) (ES)
Groundsource heat pump systems	Existing buildings in urban regions Buildings with no central heating system	Low-income households Buildings with the need for only heating or cooling, litoral Spain (ES) Apartment buildings (CZ, FI)
Airsource heat pumps	-	Apartment buildings Buildings lacking space for units in façade (CZ) Buildings with only heating demand, buildings in continental Spain (ES)
Solar thermal systems	-	Apartment buildings Owner-occupied apartment buildings Office buildings Shadowed buildings Private landlords (DE) Less cost-effective without support in multifamily buildings (FR) Non-residential buildings (DE) Buildings connected to district heat (IT, FI) Buildings lacking free space on roof (IT, ES), space for water tank (ES)
Ventilation heat recovery	Existing buildings with low airtightness	Apartment buildings Buildings in soft climate zones
Energy efficient air-conditioning		Existing buildings Apartment building
Electricity micro-generation	Historical buildings Apartment buildings (decision making)	Buildings with shadowed roofs Non-residential buildings (AT) Buildings with roofs with small different-oriented areas (CZ) Office buildings (RO)

Source: previous chapters

Owner-occupied apartment buildings and low-income households are also mentioned in Table 8.5, and they might perhaps be even more important than the table suggests. If we consider the data presented before concerning home ownership, income levels and shares of low-income households among homeowners at the start of chapters 4-7, the issue of low incomes is likely to be more urgent than it seems. Apart from Austria, Germany and the Netherlands, home ownership is the predominant form of tenure in the EU-27. Owner-occupancy is also particularly widespread in the countries that have below-average income levels and high income differences, so it is obvious that new sources of finance will be needed to transform the existing European housing stock. There are also other financially problematic owner types, such as public buildings in countries and regions where public finance is severely constrained, and buildings in rural areas with low income levels and uncertain futures.

The observations presented here are focused on the ENTRANZE target countries, concerning which we have had access to expert views and detailed data. This report is also expected to produce a more aggregated or rough assessment of public acceptance of NZEB and RES-H/C solutions in the other EU-27 countries. This report has compiled the available data (considering time and resource constraints) and thus attempts to make an assessment of the extent to which data concerning ENTRANZE target countries can be extrapolated to the remaining EU-27 countries. Concerning this issue, the following comments and observations can be presented:

- On a very general level, the barriers and drivers for energy renovations appear to be quite similar across all countries in Europe, especially when considered by building owner type. However, particular circumstances influence their intensity. High initial costs are an issue for all but the wealthiest building owners. Income and savings levels (especially net savings, excluding fixed capital formation, if such data were available) provide a rough basis on which to assess the importance of initial costs, although the availability of generous grants and dedicated finance schemes can reduce the influence of income and savings levels to some extent.
- Apart from financial constraints, organizational barriers are widespread and similar across Europe. These relate to e.g. multifamily buildings (decision making in owner-occupied buildings, landlord-tenant dilemmas and rent control in rented buildings) as well as to public and some commercial buildings. However, the details of how co-ownership or rental arrangements are governed can make a relatively large difference. Apart from the governance of the building stock, there are also administrative issues related to permitting, disbursement of grants, etc. which can cause additional timelags after a decision has finally been reached. Hence, the time from initial idea to realization (and the probability of a renovation initiative to survive this period) can vary significantly by both ownership type and country or even region.
- We have tried here to group countries on a geographical basis and identify how similar or different they are in terms of (a) housing stock and tenure, (b) socio-economic characteristics, (c) energy sources used in buildings, (d) renewable energy growth rates, (e) policies to promote thermal insulation and renewable heating and cooling and (f) public opinion and acceptance of energy renovations (where available). Our country groups do indeed share some common features, and they can thus serve as an initial heuristic, taking into account the above-mentioned factors (a-f). However, there are also some important differences (especially in renewable heating and cooling solutions) that are not explained by these factors alone.

Hence, the observations concerning ENTRANZE target countries are not as such generalizable to EU-27 countries. However, this report has attempted to assemble some preliminary indicators and data that support further work towards a rough assessment of public acceptance and propensity to invest in energy renovations in the EU-27. More work is needed in this area, however.

9 Conclusions and recommendations

There are some differences in the trends concerning **thermal renovation** in Europe, which are largely due to the variable ownership structure, age and condition of the existing building stock, the relative cost of heating energy vs. efficiency investments, and the forcefulness of national policies and instruments. However, the barriers to energy renovation across Europe are fairly similar.

In contrast, **renewable heating and cooling**, as well as on-site electricity generation, are at quite different stages of market development in different European countries. They may also have quite different ultimate roles in the future building stock of different countries. For example, biomass is more likely to be relevant in certain countries and regions than others. The situation, with several competing solutions and combinations, is quite confusing for building owners.

In general, different **building owner types** have specific needs as concerns the identification and promotion of suitable solutions. It was noted in D2.4 (Heiskanen et al. 2012) that single-family homes in many countries usually engage in piecemeal and step-by-step renovation, which is partly do-it-yourself and partly contracted. They often save up money and repair or replace building components every few years, rather than starting a large and comprehensive renovation with external capital. Our analysis here has shown that single-family homes are also often the most likely to install various kinds of renewable heating systems and more recently, also, PV panels.

This piecemeal progress toward less energy use and more renewable energy is an opportunity but also a challenge for those wishing to promote NZEB and RES-H/C in the existing building stock. It is an opportunity because there are existing exemplars and accumulated experience, as well as developed service structures for the installation of components. It is a challenge because piecemeal replacement and installation of various solutions might not represent an optimal combination. We thus reiterate the suggestion made in Heiskanen et al. (2012), echoing calls by some of our expert interviewees, to develop a (partly) step-by-step and (partly) do-it-yourself track toward nearly-zero energy in existing buildings, alongside the prevailing notion of a comprehensive renovation, if a wide segment of European single-family homeowners is to be engaged.

Multifamily buildings have quite different challenges. Especially in multifamily buildings, all kinds of renovations cause difficulties in making decisions, but innovative solutions may be particularly challenging in a collective decision context. All kinds of multifamily buildings experience difficulties of fitting most renewable heating solutions into an urban structure and the management practices of urban buildings. Planning, permitting, decision making and financing issues can cause significant delays and time-lags in implementation. Moreover, for technical building systems, issues of the training of maintenance staff and users can be quite important for both the acceptance and the performance of the systems.

Service buildings and public buildings can serve as important exemplars of new solutions. This can serve a very important purpose not only in educating other owners of public or service buildings, but also other building users. People are extremely unlikely to invest their own money in solutions that they have never seen or experienced themselves. Hence, implementation of these solutions in buildings that are open to the general public (and visited regularly by people also long before their own renovation decision is at hand) can be a very important aspect of creating public and social acceptance of nearly-zero energy buildings and renewable heating and cooling solutions.

As concerns **public acceptance in general**, the overall perception of the need to save energy is relatively widespread in Europe. However, levels of public understanding are low – especially compared to the relatively complex and ambitious systems connected to nearly-zero energy renovations and renewable heating and cooling systems. Moreover, different solutions are more relevant and/or familiar and institutionalized in some countries than others. NZEB or even energy renovation is not a concept that is understood or applied similarly throughout Europe, or even within countries.

Although they do not dominate the public discussion, negative experiences were mentioned in all parts of Europe (though not in each country). Some of these are historical and fading, such as early not-so-convincing demonstrations of solar thermal systems and groundsource heat pumps. Others are more recent or more persistent, such as opposition to mechanical ventilation, especially mechanical supply and exhaust ventilation, which is a prerequisite for heat recovery, or quality problems in thermal renovations, or underperformance of airsource heat pumps or overblown marketing claims for solar thermal systems.

The way in which such 'growing pains' are managed can be quite important for public acceptance in the markets where many of these solutions are still at an initial stage and there is still a lack of good examples and widespread experiences.

These initial issues give rise to some recommendations concering the future public acceptance of nearly-zero energy renovations and renewable heating and cooling solutions. Quality issues and e.g. training and certification of installers and construction workers are currently very topical in Europe. Out study indicates that this is greatly needed and the current volume of efforts might not be sufficient. Concerns over the quality of thermal renovation and the performance of various new heating and cooling equipment are widespread, and need to be rapidly resolved. Installers are also important promoters or obstructers of new solutions. Moreover, alongside the development of certification schemes, also marketing and general awareness-raising concerning such schemes are very important in order for them to function in the market.

Renovation in itself is not desirable or fun for building owners, nor is experimenting with new technical systems an interesting prospect in itself for other than a small minority of pioneers. Most mainstream building owners see the renovation as an ordeal and the ensuing building condition as the reward. As of yet, there is still quite a lot of uncertainty about the achievement of this reward among many building owners, especially in cases where the existing condition of the building is experienced as bearable. Hence, promotion of nearly-zero energy buildings should focus on investigating and disseminating results on user satisfaction and real-life experiences of renovated nearly-zero energy buildings and renewable heating and cooling systems in a variety of building contexts.

References

Abrahamse, W., L. Steg, C. Vlek, and T. Rothengatter (2005): A review of intervention studies aimed at household energy conservation, Journal of Environmental Psychology 25:273-291.

Adjarova, L., Raicheva, N., Hiller, C., Serrasoles, J., Koschar, E., Knotzer, A., Palonen J. & Boonstra, C. (2010). SQUARE – A System for Quality Assurance When Retrofitting Existing Buildings to Energy-Efficient Buildings. Methods to break non-technical barriers in the energy saving retrofitting process. Intelligent Energy Europe: SQUARE Project.

Adnot, J., Greslou O., Riviere, P., Spadaro, J., Hitchin, R.,Pout, C., Kemna, R., van Elburg, M., van Holsteijn, R. (2011). Draft Report of Task 2 – Air-conditioning products. Service Contract to DG Enterprise, Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product. Group Analysis/2, Lot 6: Air-conditioning systems. Online: http://www.ecohvac.eu/downloads/Task%202%20Lot%206%20Air%20Conditioning%20Final%20report%20July%202012.pdf

AEBIOM (2012). European Bioenergy Outlook. AEBIOM Annual Statistical Report www.aebiom.org/wp-content/uploads/file/AEBIOM%20Statistical%20Report/AEBIOM_European%20Bioenergy%20Outlook%202012sv.pdf

Alasti, E. (2011). Social Acceptance of Bioenergy in Europe. IIIEE Theses 2011:13. Lund: IIIEE Lund.

Alphéeis (2011). Socio-economic barriers and drivers to energy efficient refurbishment in the private residential sector. A comparative survey in five European countries (2009-2011). ADEME, EDF, Efibau, EIFER, Nova Systeme En+, Pouget Consultants, Studio Cafiero & Transsolar.

Amann, W., Mundt, A. & Hüttler, W. (2012) Social housing providers at the forefront of energy efficiency in Energy Efficiency in Housing Management. Policies and practice in eleven countries. Nieboer, N., Tsenkova, S., Gruis, V. & van Hal, A. (eds.) Routledge . ISBN: 978-1-84971-454-9 (hbk)

Atanasiu, B., Maio, J., Staniaszeki, D., Koloumpi, I. (2013) Overview of the EU-27 building policies and programs. Factsheets on the nine Entranze target countries. D5.1 and D5.2 of WP5 from Entranze Project. Online: http://www.entranze.eu

Axsen, J. & Kurani, K.S. (2012) Social Influence, Consumer Behavior, and Low-Carbon Energy Transitions. Annual Review of Environment and Resources 37:311-340.

Barenergy (2010) WP 6: Focus Groups National report Hungary. BARENERGY project, Deliverable D 26. Funded by EC FP7 GA 213558). Online: http://www.barenergy.eu/uploads/media/D26_Hungary.pdf

Bartiaux, F. (2011). Homeowners and energy-related renovations in Belgium (Wallonia): An analysis of 23 interviews. In Bartiaux, F. (Ed.) Deliverable 2.4. A qualitative study of home energy-related renovation in five European countries: homeowners' practices and opinions. IDEAL EPBD project. Online: http://www.ideal-epbd.eu/index.php?option=com_content&view=article&id=12&Itemid=14&lang=en

Bartiaux, F., Gosselain, V., Vassileva, D., Ozolina, L. &Gara, E. (2011).Knowledge on Climate Change and Energy Saving Renovationsby Apartment Owners in Bulgaria and Latvia. A Qualitative Study.International review of Social Research, 1 (3), 133-154.

Bartiaux, F., Gram-Hanssen, K., Fonseca, P., Ozoliņa, L. & Christensen, T.H. (2011) A practice-theory based analysis of energy renovations in four European countries. Proceedings of ECEEE 2011 SUMMER STUDY • Energy efficiency first: The foundation of a low-carbon society 67-78.

Baudry, P & Osso, D (2011). Energy saving certificates in France: A new frame for the second period (2011-2013) and afterwards. eceee 2011 Summer Study. Online: http://proceedings.eceee.org/visabstrakt.php?doc=2-394-11

Beetz, B. (2012), Bulgaria unveils sharp PV cuts. PV Magazine July 2, 2012. Online: http://www.pv-magazine.com/news/details/beitrag/bulgaria-unveils-sharp-pv-cuts_100007578/#axzz2KaV6o4Te

Beillan V, Mayer H, Battaglini, Goater, A. (2011) Transforming existing buildings: barriers and drivers to energy efficient renovation in the residential sector. Empirical findings from five European countries. eceee 2011 Summer Study. Online: http://proceedings.eceee.org/visabstrakt.php?doc=5-072-11

Bevini, F (2010) The Green Building Market in Italy. Global Trade news site, January 8, 2010. Online: http://www.globaltrade.net/f/market-research/text/Italy/Building-Products-and-Construction-The-Green-Building-Market-in-Italy.html

Bio Intelligence Service (2009). Lot 15 Solid fuel small combustion installations, Task 2: Economic and Market Analysis. European Commission DG TREN, Preparatpry Studies for Eco-design Requirements of EuP (II).

BIOMASA (2011). Energy Globe 2011 Air. Change the thinking to stable effective domestic biomass/solar use. Presentation at award ceremony. Online: http://www.biomasa.sk/images/stories/biomasa/projekty/2011/BIOMASA__Energy_Globe_2011.pdf

Bodineau, L. & Bodiguel, A. (2011) Energy Savings Certifi cates (ESC) scheme in France: initial results.Proceedings of the eceee 2009 Summer Study. http://www.eceee.org/conference_proceedings/eceee/2009/Panel_3/3.274/paper

Bollinger, B. & Gillingham, K. (2012). Peer Effects in the Diffusion of Solar Photovoltaic Panels. Marketing Science 31: 900-912

Bosman, R. (2012) How Germany's powerful renewables advocacy coalition is transforming the German (and European) energy market. 27th February 2012. www.europeanenergyreview.eu/site/pagina.php?id=3552

BPIE (2011). Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings. Brussels: Buildings Performance Institute Europe (BPIE).

BPIE (2012a) Chairman's conclusions: How to make building retrofit happen in Romania? Kickoff workshop for BPIE taskforce in Bucharest. Building Performance Institute Europe.

BPIE (2012b) Implementing nearly zero-energy buildings (nZEB) in Romania – Toward a Definition and Roadmap. Building Performance Institute Europe.

BPIE (2012c) Implementing Nearly Zero-Energy Buildings (nZEB) in Bulgaria – Towards a Definition and a Roadmap. Brussels: Buildings Performance Institute Europe (BPIE).

BPIE (2012d) Implementing Nearly Zero-Energy Buildings (nZEB) in Poland – Towards a Definition and a Roadmap. Brussels: Buildings Performance Institute Europe (BPIE).

Braun, F.G. () What determines households' space heating type? A discrete choise analysis for German households.

Brelih, N., Seppänen, O., Bertilsson, T., Maripuu, M-L, Lamy, H. & Bore, A.V. (2012). Design of energy efficient ventilation and air-conditioning systems. REAHVA Guidenook no 17. REHVA: Federation of European Heating, Ventilation and Air-Conditioning Associations.

Breukers, S. Heiskanen, E., Mourik, R.M., Bauknecht, D., Hodson, M., Barabanova,, Y. Brohmann,, B. Bürger, V., Feenstra, C.F.J. Jalas, M., Johnson, M. ,Maier, P,. Marvin, S., Meinel, H., Pariag, J., Rask, M., Rinne, S., Robinson, S., Saastamoinen, M., Salminen, J., Valuntiené, I. & Vadovics E., 2009. Interaction schemes for successful energy demand side management : building blocks for a practicable and conceptual framework . Deliverable 5 of Changing Behaviour (GA 213217). Project co-funded by EC FP7. Online: http://www.energychange.info/deliverables.

Bullier, A., Sanchez, T., Le Teno, J.-F,. Caracassus, J., Ernest, D., Pancrazio, L. (2011). Assessing green value: A key to investment in sustainable buildings. Proceedings of ECEEE 2011 SUMMER STUDY • Energy efficiency first: The foundation of a low-carbon society 1061-1071. Online: http://proceedings.eceee.org/visabstrakt.php?doc=5-052-11

Bundesministerium für Justiz (2012) Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden http://www.gesetze-im-internet.de/enev_2007/index.html 27.8.2012

Bürger et al. (2011). Erarbeitung einer Intergriert Wärme- und Kältestrategie - Arbeitspaket 4 - Darstellung des Rechts- und Förderrahmes und dessen Wirkungen. Not published yet

Bürger, V. (2012) The assessment of the regulatory and support framework for domestic buidlings in Germany from the perspective of long-term climate protection targets. Energy Policy.

Cariani, W. & Disi, A. (2012). Stato e prospettive dell'efficienza energetica in Italia. Energia, Ambiente e Innovatione 1/2012: 30-37.

Caserta, G. (2007) Barrierre non technice della biomassa. Online: http://qualenergia.it/articoli/20071005-barriere-non-tecniche-la-biomassa-1

Cayla, J.-M., Maizi, N. & Marchand, C. (2011) The role of income in energy consumption behavior: Evidence from French housholds data. Energy Policy 39: 7874-7883.

CECODHAS (2012) Housing Review Europe. The nuts and bolts of European social housing systems. CECODHAS Housing Europe.

Chappells, H., and Shove, E. (2005) Debating the future of comfort: environmental sustainability, energy consumption and the indoor environment. Building Research and Information 33(1): 32-40.

Christensen, T.H., Gram-Hanssen, K., Petersen, P.E. , Larsen, T.F., Gudbjerg, E., Rasmussen, L.S. & Munter, P. (2011a). Air-to-air heat pumps: A wolf in sheep's clothing? Proceedings of the eceee 2011 Summer Study , Energy efficiency first : The foundation of a low-carbon society: 1963-1974.

Christensen, T. H., Gram-Hansen, K., Adjedi, A. & de Best-Waldhober, M. (2011b). Energy renovation practices in Danish homes: The influence of energy labels on home renovation practices. Paper presented at 10th Conference of the European Sociological Association (ESA2011) 7-10 September 2011, Geneva, Switzerland (slightly revised).Online: http://vbn.aau.dk/ws/files/58602742/Christensen_et_al._Energy_renovation_practices_in_Danish_homes_2.pdf

Claudy, M. , O'Driscoll, A. & Duffy, A. (2011) Home Owners' Attitudes, Perceptions and Willingness to Pay for Microgeneration Technologies. Energy Policy 39: 1459-1469.

Commissioner-General for Sustainable Development (2009) Annual report to Parliament on implementing France's Environment Round Table commitments. Online: www.developpement-durable.gouv.fr

Communidad de Madrid (2008). "Guía de la rehabilitación energética de edificios de viviendas" (Retrofitting guide for residential buildings) http://www.fenercom.com/pdf/publicaciones/guia-de-rehabilitacion-energetica-de-edificios-de-viviendas-fenercom.pdf

Cuchi, A. & Sweatman, P. (2011). A National Perspective on Spain's buildings Sector. A Roadmap for a New Housing Sector. The Rehabilitation Working Group (GTR) report. Online: http://www.encuentrolocal.vsf.es/download/bancorecursos/libro_GTR_engl_postimprenta.pdf

Dalenbäck, J.-O. & Werner, S. (2011). Solar District Heating: European Market Study. Deliverable D2.3 of SDHtake-off – Soar District Heating in Europe. Funded by Intelligent Energy Europe. http://www.solar-district-heating.eu/

Dalenbäck, J.-O. & Werner, S. (2012). Market for Solar District Heating. D2.3 of the SDH – Solar District Heating project. Intelligent Energy Europe.

De Felice, P. & Forni, A. (2011) Le barriere all'energia green. Energia Rinnovabili.it, Nov 14, 2011. Online: http://www.rinnovabili.it/energia/efficienza-energetica/le-barriere-allenergia-green3083/

de T'Serclaes, P. (2007) Financing energy efficient homes. Existing policy responses to financial barriers. Paris: IEA Information paper.

DECC (2011) The Carbon Plan: Delivering Our Low Carbon Future, Department of Energy and Climate Change, London.

Decker, T., Zapilko, M. & Menrad, K. (2009) Purchase behaviour related to heating systems in Germany with special consideration of consumers' ecological attitudes. Paper prepared for presentation a the Energy Engineering, Economics and Policy (EEEP) Conference Orlando (USA), 13th July 2009.

Decker, T., Zapilko, M. & Menrad, K. (2010) Buying behaviour related to heating systems in Germany, Conference Paper, http://ageconsearch.umn.edu/bitstream/137595/2/Conference%20Lyon-2010.pdf

DEMOHOUSE (2007) Deliverable 1 C: Barriers of sustainable and energy conscious renovation related to the pilot projects. DEMOHOUSE: Design and management options for improving the energy performance of housing. EC FP6 (contract FP6-503186).

dena (2012) Energieeffiziente Gebäude. http://www.dena.de/themen/energieeffiziente-gebaeude.html 27.8.2012

Department of Energy and Climate Change (2012) The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK. November 2012. http://www.decc.gov.uk/eedo

DG ENER (2007) Ecodesign preparatory study of Boilers (Lot 1), Task 2 - Market Analysis.In: http://ecoboiler.org

Di Santo D (2012) Efficiencia energetica: situazione, opportunita e sfide. Federazione Italiana per l'uso Razionale dell'Energia (FIRE).

Diefenbach et al. (2010). Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand

Diekmann, A. & Preisendorfer, P., 1998. Environmental behavior – discrepancies between aspirations and reality. Rationality and Society, 10: 79–102.

Dobrich Local Agency for Energy Management (2009) Deliverable 31. Round table about policy instruments to accomplish an increase in heat pump installations, Varna, 14th May 2009. Intelligent Energy Europe: ProHeatPump project. Online: http://www.proheatpump.eu/Downloads/Deliverables/ProHeatPump%20D%2031.pdf

Dol, K. & Haffner, M. (2010). Housing Statistics in the European Union. The Hague: Ministry of the Interior and Kingdom Relations. http://www.bmwfj.gv.at/Wirtschaftspolitik/Wohnungspolitik/Documents/housing_statistics_in_the_european_union_2010.pdf

Draganinska, T. (2004)Energy Efficiency in the Bulgarian Residential Sector.Technical, Legislative, and Socio-Economic Issues.Lund University Master's Programme in International Environmental Science.Online: http://www.lumes.lu.se/database/alumni/03.04/theses/draganinska_tanja.pdf

Durier, F. (2008) Trends in the French building ventilation market and drivers for change. AIVC Workshop Ghent 18-19 March 2008. Online: http://www.aivc.org/medias/pdf/14_France.pdf

Dyrelund, A. & Lund, H. (2009) Danish heating sector can be CO2 neutral before 2030. EuroHeat& Power 6 (11): 34-37.

EB (2006) Energy Technologies: Knowledge, Perception, Measures. European Commission, Directorate-General for Research:

EB (2009) Europeans' attitudes towards climate change. Special Eurobarometer 313. Online: http://ec.europa.eu/public_opinion/archives/ebs/ebs_313_en.pdf

EB (2011a) European Parliament Eurobarometer (Standard EB 74.3 on Energy). The Europeans and energy. Analytical synthesis. Online: http://ec.europa.eu/public_opinion/archives/ebs/ebs_pe_74-3_synth_en.pdf

EB (2011b). Climate change. Special Eurobarometer 372. Online: http://ec.europa.eu/public_opinion/archives/ebs/ebs_372_en.pdf

EC (2012). Press release: Energy performance of buildings: Commission refers Italy to Court. Online: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/12/411&format=HTML

Ecofys et al. (2012) Ecofys, Institut für ZukunftsEnergieSysteme (IZES), Fraunhofer-Institut für System- und Innovationsforschung (ISI), Öko-Institut e.V., Hochschule für Wirtschaft und Recht (HWR): Vorbereitung und Begleitung bei der Erstellung eines Erfahrungsberichtes gemäß § 18 Erneuerbare-Energien-Wärmegesetz, Dezember 2012, im Auftrag des BMU

Ecoheat4eu (2012) District Heating Barometer. Online at: http://ecoheat4.eu/en/District-Heating-Barometer

Economidou, M, Janssen, R & Constantinescu T (2011). Transforming Europe's buildings: A country-by-country review on the energy performance of buildings. eceee 2011 Summer Study http://proceedings.eceee.org/visabstrakt.php?doc=5-286-11

ECORYS (2010). Assessment of non-cost barriers to renewable energy growth in EU Member States – AEON. DG TREN no. TREN D1/48-2008. Final report. ECORYs Nederland BV. x

EEA (2010) The European environment – state and outlook 2010. European Environmental Agency. Online: http://www.eea.europa.eu/soer/countries/be/soertopic_view?topic=country%20introduction

EHPA (2011) Heat Pump Statistics 2010 preview. http://www.ehpa.org/fileadmin/red/EHPA_Activities/4th_Heat_Pump_Forum_2011/05_HPForum_Forsen.pdf

Eischen, T. (2010). Implementation of the EPBD in Luxembourg. Status in November 2010. Concerted Action: Energy Performance of Buildings. Online: http://www.epbd-ca.org/Medias/Pdf/country_reports_14-04-2011/Luxembourg.pdf

Elswijk, M. & Kaan, H. (2008) European Embedding of Passive Houses, May 2008, Intelligent Energy Europe. www.europeanpassivehouses.org.

ENEA (2007) Dall'Ecobuilding al Distretto Energetico: La Proposta ENEA pe un modello di sviluppo fondato su ecoedifici e generatione distributa. ENEA. Online: http://www.efficienzaenergetica.enea.it/doc/pubblicazioni/D13_DossierEcobuilding.pdf

ENEA (2007a) Solarbuild: Integration of solar technologies into buildings in Mediterranean communities. Local Italian Report. Online: http://www.cres.gr/solarbuild/project.htm

ENEA (2009) Energy Efficiency Policies and Measures in Italy. Monitoring of Energy Efficiency in EU 27, Norway and Croatia (ODYSSEE-MURE). Online: http://www.odyssee-indicators.org/publications/PDF/italy_nr.pdf

ENEA (2010). Economic analysis of energy efficiency programs in Italy. Online: http://www.enea.it/it/produzione-scientifica/energia-ambiente-e-innovazione-1/anno-2012/n.-2-marzo-aprile-2012/economic-analysis-of-energy-efficiency-programs-in-italy

EPBD (2010) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings.

EPIA (2012) Global Market Outlook for Photovoltaics until 2016. May 2012. European Photovoltaic Association. http://www.epia.org.

Epp, B. (2012). France: Influence of New Building Standards in 2013. Solar Thermal World, Dec. 19, 2012. Online: http://solarthermalworld.org/content/france-influence-new-building-standards-2013

EREC (2011) Mapping Renewable Energy Pathways towards 2020. European Renewable Energy Council. Online: www.erec.org

ESTIF (2012) Solar Thermal Markets in Europe. Trends and Market Statistics 2011. European Solar Thermal Industry Federation (ESTIF). Online: http://www.estif.org/statistics/st_markets_in_europe_2011/

EuroAce (2010) Making Money Work for Buildings: Financial and Fiscal Instruments for Energy Efficiency in Buildings. The European Alliance of Companies for Energy Efficiency in Buildings.

Eurobserver (2011a) Photovoltaic Barometer. Online: http://www.eurobserv-er.org/downloads.asp

Eurobserver (2011b) Ground Source Heat Pump Barometer. Online: http://www.eurobserv-er.org/downloads.asp

Eurobserver (2012) Solar Thermal and Concentrated Solar Power Barometer. Online: http://www.eurobserv-er.org/downloads.asp

EUROGAS (2012) Statistical Report 2012. Online: www.eurogas.org/uploaded/Statistical Report 2012_final_211112.pdf

Eurostat (2009) Household saving rate higher in the EU than in the USA despite lower income. Eurostat Statistics in Foucs 29/2009. Online: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-09-029/EN/KS-SF-09-029-EN.PDF

Faiers, A. &Neame, C. (2006) Consumer attitudes towards domestic solar power systems, Energy Policy 34: 1797-1806.

Farsang, A. & Watt, A. (2010) WP 4: Stakeholder interviews. National report Hungary. BARENERGY project, Deliverable D 19. Funded by EC FP7 GA 213558). Online: http://www.barenergy.eu/uploads/media/D19_Hungary.pdf

Fleck, J (1993) Innofusion: feedback in the innovation process. In Stowell, S.A., West, D. and Howell, J.G. (Eds.) Systems Science: addressing global issues. Kluwer Academic / Plenum Publishers, pp. 169-174.

Fonseca, P., de Almeida, A. & Nunes, U. (2011) Research results and policy recommendations of the IDEAL EPBD project addressing effective EPBD implementation and the Energy performance Certificate. National findings and policy recommendations of the EC FP7-funded IDEAL EPBD project. Online: http://www.ideal-epbd.eu/download/pap/PT_findings_recommendations.pdf

ftp://ftp.cordis.europa.eu/pub/fp7/energy/docs/energy_tech_eurobarometer_en.pdf

Galda, Z. & Kubenkova, K. (2007) Housing stock in the Czech Republic – Maintenance and Modernization. ENHR 2007, Rotterdam 25-28, 2007.

Garcia, N. P. Vatopoulos, K., Krook Riekkola, A., Perez Lopez, A., Olsen, L. (2012). Best available technologies for the heat and cooling market in the European Union. European Commission, Joint Research Centre, Institute for Energy and Transport.

Geels, F., Raven, R., 2006. Non-linearity and expectations in niche-development trajectories. Ups and Downs in Dutch Biogas Development. Technology Analysis & Strategic Management 18, 375-392.

Giakoumi, A. & Iatridis, M. (2009). Current state of heating and cooling markets in Greece. D3 of WP2 from the RES-H Policy project. A report prepared as part of the IEE project Policy development for improving RES-H/C penetration in European Member States (RES-H Policy). Online: http://www.res-h-policy.eu/RES-H_Policy_Market-Report-GR_%28D3%29_english.pdf

Giraudet L, Guivarch C and Quirion P (2011) Comparing and combining energy saving policies: will the proposed residential sector policies meet French official targets? Nogent sur Marne: CIRED Working Paper Series 34-2011.

Gluch, P. & Stenberg, A.-C. (2006) How do Trade Media Influence Green Building Practice? Building Research and Information, 34(2):104-117.

Golove, W.H. and J.H. Eto (1996) Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency. California: Lawrence Berkeley National Laboratory, LBL-38059.

González, F.M., Lumbreras, F. S. & de Garayo, S.D. (2012). Energías Renovables, objetivos europeos y situación en España En Portada 5/2012: 4-7. http://www.fevymar.com/cont/publis/boletines/166.pdf

Gram-Hanssen, K. Existing buildings – users, renovations and policy. Paper presented at WREC 2011, May 8-13,Linköping, Sweden.

Griffin, M. (2000). Annex F: The Development of the European Gas Distribution Network. Supporting document for Lower Carbon Futures. University of Oxford: Environmental Change Institute. Online: http://www.eci.ox.ac.uk/research/energy/lowercarbonfuturesreport.php

Gröger, M., Schid, V. & Bruckner, T. (2011). Lifestyles and Their Impact on Energy-Related Investment Decisions. Low Carbon Economy 2: 107-114.

Hajek, P. & Tywoniak, J. (2007). Sustainable Building in the Czech Republic – Challenge and Opportunity. CESB 07 Prague Conferenc, Session T1A: Keynote Addresses.

Häkkinen, T., Ruuska, A., Vares, S., Pulakka, S., Kouhia, I. & Holopainen, R. (2012). Methods and concepts for sustainable renovation of buildings. Espoo: VTT.

Hamilton, J. (2011) Keeping up with the Joneses in the Great British Refurb. In Whitmarsh, L., O'Neill, S., Lorenzoni, I. (eds) 2010 Engaging the Public with Climate Change: Behaviour Change and Communication. London: Earthscan.

Hazucha, J. (2009). Refurbishment of social housing – guidelines for implementing whole building energy efficiency measures. Bron: Centrum Passivniho Domu. Intelligent Energy Europe: Passnet Project.

Heimdal, S.I. & Bjørnstad, E. (2009). A policy model for diffusion of electricity saving technologies. Proceedings of the eceee 2009 Summer Study Act! Innovate! Deliver! Reducing Energy Demand Sustainably: 441-452.

Heiskanen, E. & Lovio, R. (2010) User−Producer Interaction in Housing Energy Innovations : Energy Innovation as a Communication Challenge. Journal of Industrial Ecology, 14: 91-102.

Heiskanen, E., Kivisaari, S., Lovio, R. & Mickwitz, P. (2009) Designed to travel? : Transition management encounters environmental and innovation policy histories in Finland. Policy Sciences 42 (3): 409-427.

Heiskanen, E., Johnson, M. & Vadovics, E. (2012). Learning about and Involving Users in Energy Saving on the Local Level. Forthcoming in *Journal of Cleaner Production*.

Heiskanen, E., Lovio, . & Nissilä, H. (forthcoming). The role of demonstrations in path creation - the case of solar building integration in Finland. Forthcoming in…

Heiskanen, E., Lovio, R. & Jalas, M. (2011) Path creation for sustainable consumption: promoting alternative heating systems in Finland. Journal of Cleaner Production, 19: 1892-1900.

Heiskanen, E., M. Hodson, R. Raven, Y. Feenstra, A. Alcantud, D. Bauknecht, B. Brohmann, U. Fritsche, J. Fucsko, E. Jolivet, M. Maack, R.M. Mourik, A. Onsizk-Poplawska, B.M. Poti and B. Schaefer (2007): Factors influencing the societal acceptance of new energy technologies: meta-analysis of recent European projects, Work Package 2 report of the Create Acceptance Project, FP6-2004-Energy-3, SUSTDEV-1.2.8. Online at http://www.createacceptance.net

Heiskanen, E., Matschoss, K. & Saastamoinen, M. (2012). Asiakkaan näkökulma älykkään sähköverkon lisäarvoon (Added value of the smart grid from the customer's perspective). National Consumer Research Centre Publications 2/2012.

Heiskanen, E., Matschoss, K., Kuusi, H. et al. (2012). Working paper: Literature review of key stakeholders, users and investors. D2.4. of WP2 of the ENTRANZE Project. Online: http://www.entranze.eu

Heljo, J. & Vihola, J. (2012). Energiansäästömahdollisuudet rakennuskannan korjaustoiminnassa (Energy saving opportunities in renovation of the building stock). Tampere University of Technology. Department of Civil Engineering, Construction Management and Economics. Report 8.

Heras-Saizarbitoria, I. Cilleruelo E. & Zamanillo, I. (2011) Public acceptance of renewables and the media: an analysis of the Spanish PV solar experience. Renewable and Sustainable Energy Reviews 15: 4685–4696.

Huber, A., Mayer, I., Beillan, V., Goater, A., Trotignon, R. & Battalgini E (2011) Refurbishing residential buildings. A socio-economic analysis of retrofitting projects in five countries. Online: http://fedarene.org/documents/projects/EEW2/WSED2011/Huber.pdf

Hvelplund, F. (2012) Innovative Democracy and Renewable Energy Strategies: A Full Scale Experiment in Denmark 1976-2010. In Järvelä, M. & Juhola, S. (Eds.) Energy, Policy, and the Environment, Modeling Sustainable Development for the North. New York etc. Springer.

Hyysalo, S., Juntunen, J.K., Freeman, S. (2013) User innovation in sustainable home energy technologies. Energy Policy 55: 490-500.

IDAE (2012) Information to the citizen. IDEA website: http://www.idae.es/index.php/relcategoria.1160/id.477/relmenu.377/mod.pags/mem.detalle (accessed Sept 19, 2009).

IDAE (2013). Plan Renove Aire Acondicionado. Eficiencia Energética. Online: http://www.idae.es/index.php/idpag.583/relcategoria.3799/mod.pags/mem.detalle. Easy to install.

IEA (2007) Renewables for Heating and Cooling. Untapped potential. Paris: IEA. Online: http://www.iea.org/publications/freepublications/publication/Renewable_Heating_Cooling_Final_WEB.pdf

IEA (2010). Best Practices in the Deployment of Renewable Energy for Heating and Cooling in the Residential Sector. IEA-RETD. Online: http://iea-retd.org/wp-content/uploads/2011/09/IREHC-Final-Report-20100726.pdf

IEA DSM (2012) Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes. Research Report Task XXII of the International Energy Agency Demand Side Management Programme. http://www.ieadsm.org/Content.aspx?ID=2

IRG (2007) Final Report TASK 4 South East Europe Regional Energy Market Support (SEE REMS)Project. USAID. Online: http://bulgaria.usaid.gov/cdir/bulgaria.usaid.gov/files/SEE-REMS-Task-4-Final-Report_FINAL.pdf

Itard, L., Meijer, M, Vrins, E & Hoiting, H. (2008) Building Renovation and Modernisation in Europe: State of the art review.ERABuild Final Report. Delft: TU Delft.

IWU (Institute für Wohnen und Umwelt) & bremer energie institute (BEI) (2010) Datenbasis Gebäudebestand, Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand.

Jacobsson, S. & Bergek, A. (2004) Transforming the Energy Sector: The evolution of technological systems in renewable energy technology, 2004, Industrial and Corporate Change 13: 815-849.

Jacobsson, S., Lauber, V., 2006. The politics and policy of energy system transformation – explaining the German diffusion of renewable energy technologies. Energy Policy 34, 256-276.

Jager, W. (2006). Stimulating the diffusion of photovoltaic systems: A behavioural perspective. Energy Policy 34: 1935-1943.

Jakob, M. (2006): Marginal costs and co-benefits of energy efficiency investments. The case of the Swiss residential sector. Energy Policy 34: 172-187.

Jakobs, R.M. & Laue,H.-J. (2010). Energy Efficiency and CO2 Reduction in the Building Stock – The Role of Heat Pumps. International High Performance Buildings Conference. Paper 19.

Janda, K. (1999). Re-Inscribing Design Work: Architects, Engineers, and Efficiency Advocates. In Proceedings of ECEEE Summer Study, June 1-6, 1999. Panel III. European Council for an Energy Efficient Economy. http://www.eceee.org/conference_proceedings/eceee/1999/Panel_3/p3_11/paper

Kaiser, F.G., S. Wölfing & Fuhrer, U. (1999) Environmental Attitude and Ecological Behaviour. Journal of Environmental Psychology 19: 1-19.

Kallaste, T. (2009) Case Study 23: KredEx. Energy Efficiency Competence Centre. EC FP7 funded CHANGING BEHAVIOUR project, WP2 case studies. Online: http://www.energychange.info/casestudies

Kamenders, A. (2009) Case Study 20: Building energy audits project, Latvia. EC FP7 funded CHANGING BEHAVIOUR project, WP2 case studies. Online: http://www.energychange.info/casestudies

Karasek, J. & Ubralova, E. (2010) Energetická účinnost obnovy panelových sídlišť. (Energy efficiency of panel buildings renewal) . In Beran, V., Kuda, F. et al. (Eds.) Bytové domy - moderní formy výstavby a revitalizace. Online: http://www.disparity.cz/data/usr_048_default/vsb_kniha_byt_domy.pdf

Karasek, J. & Ubralova, E. (2012) Czech Republic: energy efficiency increasing in the housing stock. In Nieboer, N., Tsenkova,S., Gruis, V. & van Hal, A. (Eds). Energy Efficiency in Housing Management. Policies and Practices in Eleven Countries. London: Routledge.

Karnøe, P., Buchorn, A., 2008. Denmark: path-creation dynamics and winds of change. In: Lafferty, W., Ruud,A. (Eds.), Promoting Sustainable Electricity in Europe: Challenging the Path Dependence of Dominant Energy Systems. Edward Elgar.

Karteris, M. & Papadopoulos, A.M. (2012). Residential photovoltaic systems in Greece and in other European countries: a comparison and an overview. Advances in Building Energy Research 6:141-158.

Karvonen, A. (2012). TOWARDS SYSTEMIC HOUSING RETROFIT Developing Local Cultures of Domestic Energy Conservation. Paper presented at the 2nd Aalto Event on Science and Technology Studies: Energy in Society. Helsinki, Nov 5-6, 2012.

Kelly, N. (2010). An overview of the state of microgeneration technologies in the UK. University of Strathclyde, Glasgow. Online: http://www.nist.gov/el/upload/2-1-Nick-Kelly-MicroGen-in-the-UK.pdf

Kemna, R., van Elburg, M., Li, W., van Holsteijn, R. (2007a). Preparatory Study on Eco-design of Boilers. Task 2 Report (Final). Market Analysis. Prepared by VHK for the European Commission DG TREN.

Kemna, R., van Elburg, M., Li, W., van Holsteijn, R. (2007b). Preparatory Study on Eco-design of Boilers. Task 3 Report (Final). Consumer Behaviour & Local Infrastructure. Prepared by VHK for the European Commission DG TREN.

Kesternich, M. (2010) What drives WTP for Energy Efficiency when Moving? Evidence from a Germany-wide Household Survey. Discussion Paper No. 11-004. ZEW. ftp://ftp.zew.de/pub/zew-docs/dp/dp11004.pdf

Kientzel, J. & Kok, G. (2011). Environmental Assessment Methodologies for Commercial Buildings: An Elicitiation Study of U.S. Building Professionals' Beliefs on Leadership in Energy and Environmental Design. Sustainability 3: 2392-2412.

Killip, G. (2011) Can market transformation approaches apply to service markets? An investigation of innovation, learning, risk and reward in the case of low-carbon housing refurbishment in the UK. Proceedings of ECEEE 2011 SUMMER STUDY • Energy efficiency first: The foundation of a low-carbon society 1185-1196.

Kiss, B., Manchon, C. G. & Neij, L. (2010). Insulation: The Importance of Learning in Supporting Energy Efficiency Technologies. A Case Study on Policy Intervention for Improved Insulation in Germany, the UK and Sweden. Paper presented at Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, The Netherlands, October 25-29, 2010.

Kiss, B., Neij, L. & M. Jakob (2012). Heat Pumps: A Comparative Assessment of Innovation and Diffusion Policies in Sweden and Switzerland. Historical Case Studies of Energy Technology Innovation. In Chapter 24, The Global Energy Assessment. Grubler A., Aguayo, F., Gallagher, K.S., Hekkert, M., Jiang, K., Mytelka, L., Neij, L., Nemet, G. & C. Wilson. Cambridge University Press: Cambridge, UK. Online: http://www.iiasa.ac.at/web/home/research/researchPrograms/TransitionstoNewTechnologies/04_Kiss_Heat_Pumps_WEB.pdf

Koch, C. & Buser, M. (2012). Multiple dynamics of sustainable housing concepts in Denmark – on the role of passive houses. In Proceedings of IST 2012 – Navigating Theories and Challenging Realities.Online: http://sts-conferences.dk/custom/files/ist2012/Fullpapers/Esessions-fullpapers.pdf

Kostadinov, L. (2009) Energy Efficiency Policies andMeasures in Bulgaria.Monitoring of Energy Efficiency in EU 27,Norway and Croatia (ODYSSEE-MURE). Online at: http://www.odyssee-indicators.org/

Kranzl, L. (2010) Description of selected RES-H/C support instrument options including their qualitative assessment for Austria. D9 of WP4 from the RES-H Policy project. A Working Document prepared as part of the IEE project “Policy development for improving RES-H/C penetration in European Member States (RES-H Policy) January 2010.

Kraus, F. (2011) Pilot project “Efficient Homes”. Presentation in Paris 2.2.2011. Dena.

Kurnitski, J. & Seppänen, O. (2008). Trends and drivers in the Finnish ventilation and AC market. Ventilation Information Paper no 20, May 2008. IEA Energy Conservation in Buildings and Community Systems Programme.

Lain, M., Drakl,F., Jensen, J.L.M.& Zrmhal, V. (2004). Low Energy Cooling Techniques For Retrofitted Office Buildings In Central Europe. 25th International Conference of Air Infiltration and Ventilation, September 5-17, 2004, Prague.

Lapillonne, B, Sebi, C, Pollier, K & Mairet N (2012a). Energy Efficiency Trends in Buildings in the EU. Lessons from the ODYSSEE/MURE project. ADEME, Supported by Intelligent Energy Europe. Online at: http://www.odyssee-indicators.org/publications/PDF/Buildings-brochure-2012.pdf

Lapillone, B.,Sebi, C. & Mairet, N. (2012b) The challenges, dynamics and activities in the building sector and its energy demand in France. D2.1 of WP2 from Entranze Project. Online: http://www.entranze.eu/files/downloads/D2_1/D2_1_Short_country_summary_report_-final-France.pdf

Laurent, M-H, Allibe, B & Osso, D (2011). Energy efficiency for all! How an innovative conditional subsidy on refurbishment could lead to enhanced access to efficient technologies. eceee 2011 Summer Study http://proceedings.eceee.org/visabstrakt.php?doc=2-231-11

Leenheera, J., de Nooijb, M. & Sheik, O. (2011). Own power: Motives of having electricity without the energy company Energy Policy 39: 5621–5629.

Litiu, A. (2012) Ventilation system types in some EU countries. REHVA Journal – January 2012: 18-23.

Loveday, D., Vadodaria, K., Haines, V., Hewitt, N, Hyde, T., Griffith, P., Critoph, B., Eames, P., Banfill, P., Gillot, M., Darlington, R., Hall, M. & Tsang, E. (2011). Refurbishing the UK’s ‘hard to treat’ dwelling stock: Understanding challenges and constraints – the work of Project CALEBRE. Paper presented at CIBSE Technical Symposium, DeMontfort University, Leicester UK – 6th and 7th September 2011. Online: http://www.calebre.org.uk/docs/output_CIBSE_Jul11.pdf

Lovio, R., Mickwitz, P. & Heiskanen, E. (2011). Path dependence, path creation and creative destruction in the evolution of energy systems. In: Rolf Wüstenhagen, Robert Wuebker (eds.): Handbook of Research on Energy Entrepreneurship. Cheltenham: Edward Elgar Publishing 2011.

Mahapatra, K. & Gustavsson, L. (2009) Influencing Swedish homeowners to adopt district heating system. Applied Energy 86: 144-154.

Mahapatra, K., Gustavsson, L. & Nair, G. (2009) Swedish homeowners’ perceptions of innovative heating systems – results from three surveys. Proceedings of the eceee 2009 Summer Study: 1665-1674.

Mahapatra, K., Nair, G. & Gustavsson, L. (2011). Energy advice service as perceived by Swedish homeowners. International Journal of Consumer Studies 35: 104–111.

Marie (2012). Regional Benchmarking Analysis of the Demand Side for Energy Efficiency in Buildings. WP4/Task 4.1. (Innovative Measures and Tools for Increasing Energy Efficiency in Buildings). MARIE: Mediterranean Building Rethinking for Energy Efficiency Improvement. http://www.marie-medstrategic.eu/uploads/media/MARIE_WP4_RBA_final_170412_1_.pdf

Maritan, D. & Panizzolo, R. (2008). Ground Source Heat Pumps Applications in Italy Proceedings, 33rd Workshop on Geothermal Reservoir Engineering, Stanford University, Jan 28-30, 2008. SGP-TR-185.

Mayer, A. & Ghiran, A. (2011). EU Public-Sector Experiences with Building Efficiency: Exploring Barriers to Performance Contracting and Deep Energy Retrofits. Institute for Building Efficiency.

McCormick, K. & Neij, L. (2009). Experience of Policy Instruments for Energy Efficiency in Buildings in the Nordic Countries. Lund: Lund University, IIIEE Lund.

Meijer, F., Itard, L. and Sunikka-Blank, M. (2010) Comparing European residential building stocks: performance, renovation and policy opportunities. Building Research & Information 37: 5-6.

Meijer, F., Visscher, H., Nieboer, N. & Kroese, R. (2012). Jobs creation through energy renovation of the housing stock. Neujobs working paper D14.2. Deliverable of the Neujobs project, Creating and adapting jobs in Europe in the context of a socio-ecological transition. Funded by EC FP7. Online: http://www.neujobs.eu

Menegaki, A. N. (2012). A social marketing mix for renewable energy in Europe based on consumer stated preference surveys. Renewable Energy, Volume 39, Issue 1, March 2012, Pages 30–39

Menkveld, M. & Beurskens, L. (2009). Renewable heating and cooling in the Netherlands. D3 of WP2 from the RES-H Policy project. Report prepared as part of the IEE project Policy development for improving RES-H/C penetration in European Member States (RES-H Policy). Online: http://www.res-h-policy.eu/RES-H_Policy_Market-Report-NL_%28D3%29_english.pdf

Michelsen, C.C. & Madlener, R. (2011). Homeowners' Motivation to Adopt a Residential Heating System: A Prinicipal-Component Analysis. Aachen: Institute for Future Energy Consumer Needs and Behavior (FCN): FCN Working Paper No. 17/2011.

Michelsen, C.C. & Madlener, R. (2012) Homeowners' Preferences for Adopting Residential Heating Systems: A Discrete Choice Analysis for Germany. FCN Working Paper No. 9/2011. Institute for Future Energy Consumer Needs and Behavior (FCN), RWTH Aachen University. Revised January 2012.

Ministry of Economic Development (2012) Italy's National Energy Strategy: for a more competitive and sustainable energy. A Public Consultation Document. Government of Italy, Ministry of Economic Development, Department of Energy. Online: http://www.sviluppoeconomico.gov.it/images/stories/documenti/20121115-SEN-EN.pdf

Ministry of the Environment (2009) Implementation plan for the Strategy for Renovation 2009–2017. Helsinki: Ministry of the Environment.

Ministry of the Environnment (2007). Korjausrakentamisen strategia 2007-2013 (Strategy for Renovation 2007-2013) Helsinki: Ministry of the Environment.

Mlecnik, E. (2010). The decision to adopt highly energy-efficient renovation Delft University of Technology, OTB Research Institute for the Built Environment. Online: http://c-p.bk.tudelft.nl/store/erwin_mlecnik.pdf

Mlecnik, E. (2012). Defining nearly zero-energy housing in Belgium and the Netherlands. Energy Efficiency 5: 411-431.

Mlecnik, E., Schütze, T., Jansen, S.J.T., de Vries, G., Visscher, H.J., van Hal, A. (2012). End-user experiences in nearly zero-energy houses. Energy and Buildings 49: 471–478.

MoE and MTI (2005). Energiatehokkuusdirektiivin edellyttämät toimenpiteet rakennusten lämmityskattiloiden ja ilmastointijärjestelmien energiatehokkuuden parantamiseksi - työryhmän ehdotukset (Measures required by the EPBD to improve the energy efficiency of heating boilers and air conditioning systems – working group recommendations). Ministry of Environment. Online: http://www.ymparisto.fi/download.asp?contentid=36674&lan=fi

Moore, G. (2002) Crossing the Chasm. New York: HarperBusiness.

Motiva (2009), Energiatodistuskyselyn tuloksia (Results from a survey on energy performance certificates). Online: http://energiatodistus.motiva.fi/mika-on-energiatodistus-/energiatodistuskyselyn-tuloksia.html.

Motiva (2012) Lämpöyrittäjyys (Heat entrepreneurship). Online: http://www.motiva.fi/toimialueet/uusiutuva_energia/lampoyrittajyys

Müller, A. and Kranzl L. (2012): Energieszenarien bis 2030: Wärmebedarf der Kleinverbraucher. Ein Projekt im Rahmen der Erstellung von energiewirtschaftlichen Inputparametern und Szenarien zur Erfüllung der Berichtspflichten des Monitoring Mechanisms. Unveröffentlichter Zwischenbericht.

Mure database (2012). Online: http://www.muredatabase.org/public/

Musatescu, V. & Comanescu, K. (2009) Energy – Climate Change Package: Impact on Romanian Urban Areas. Theoretical and Empirical Researches in Urban Management 4(13): 194-213.

Nair, G. (2012). Implementation of energy efficiency measures in Swedish single-family houses. Mid Sweden University Doctoral Thesis 120.

Nair, G., Gustavsson, L. & Mahapatra, K. (2010). Factors influencing energy efficiency investments in existing Swedish residential buildings. Energy Policy 38: 2956-2963.

Nair, G., Mahapatra, K. & Gustavsson, L. (2011). Influence of external actors in Swedish homeowners' adoption of energy efficient windows. Paper presented at WREC 2011, 8-13 May 2011, Linköping, Sweden.

NEEAP2 France (2011) Energy efficiency action plan for France. Ministry of Ecology, Sustainable Development, Transport and Housing and Ministry of the Economy, Finance and Industry. http://ec.europa.eu/energy/efficiency/end-use_en.htm

NEEAP2 Poland (2011) Second National Action Plan for Energy Efficiency. Online at: http://ec.europa.eu/energy/efficiency/end-use_en.htm

NEEAP2 Spain (2011) Spain's 2nd National Energy Efficiency Action Plan. Government of Spain. Online: http://ec.europa.eu/energy/efficiency/end-use_en.htm

NEEAP2 Italy (2011). Italian Energy Efficiency Action Plan. http://ec.europa.eu/energy/efficiency/end-use_en.htm

Neij L., Kiss B. and Jakob M, (2008) Market transformation for energy efficiency a case study of the introduction and diffusion of heat pumps in Sweden and Switzerland; Proceedings of DIME International Conference "Innovation, sustainability and policy. Bordeaux, September.

Neij, L., Muncada, L., Moukhametshina, E. (2009). Choice-decision determinants for the (non-) adoption of energy efficient technologies in households. Proceedings of the eceee 2009 Summer Study Act! Innovate! Deliver! Reducing Energy Demand Sustainably: 687-695.

Neuhoff, K., Amecke, H., Novikova A. & Stelmakh, K. (2011) Thermal Efficiency Retrofit of Residential Buildings: The German Experience. CPI Report. DIW Berlin.

Nigro G & Nigro F (2011). Energy management in cultural heritage sites, coastal landscapes and protected areas: opportunities and guidelines for sustainable local development. Association National Villes et Pays d'Art Histoire: Exchanges Internationales. Online: www.an-patrimoine-echanges.org

Nösperger, S., Killip, G. & Janda, K. (2011). Building expertise: A system of professions approach to low-carbon refurbishement in the UK and France. Proceedings of ECEEE 2011 SUMMER STUDY • Energy efficiency first: The foundation of a low-carbon society 1365-1375.

Novikova, A., Amecke, H., Neuhoff, K., Stelmakh, K., Kiss, b., Rohde, C., Dunkelberg, E., Matschoss, K. & Darby, S. (2011) Information tools for energy demand reduction in existing residential buildings. CPI report. June 27, 2011.

Nowak, T. (2012) European Heat Pump Association predicts market recovery in 2012. REHVA Journal – October 2012: 53-54.

NREAP Italy (2009). National Renewable Energy Action Plan. Online: http://ec.europa.eu/energy/renewables/action_plan_en.htm

NREAP Romania (2010) National Renewable Energy Action Plan. Online: http://www.ebb-eu.org/legis/ActionPlanDirective2009_28/national_renewable_energy_action_plan_romania_en.pdf

Odyssee (2010). Oline energy indicators. Households. Online: http://www.odyssee-indicators.org/reports/household/household30.pdf

Ölander, F. & Thøgersen, J. (1995) Understanding Consumer Behaviour asPrerequisite for Environmental Protection. Journal of Consumer Policy 18: 345-385.

Olli, E., Grendstad, G., and Wollebaak, D., 2001. Correlates of environmental behaviors: Bringing back social context. Environment and behavior, 33, 181–208.

Ornetzeder,M. (2001). Old technology and social innovations. Inside the Austrian success story on solar water heaters. Technology Analysis & Strategic Management 13: 105-115.

Ornetzeder, M. & Rohracher, H. (2009). Passive houses in Austria: the role of intermediary organisations for the successful transformation of a socio-technical system. Proceedings of the eceee 2009 Summer Study Act! Innovate! Deliver! Reducing Energy Demand Sustainably: 1521-1540.

Ornetzeder, M. & Suschek-Berger, J. (2008) 'Innovation networks in the refurbishment sector of Austria: promising approaches waiting for market success'. *Int. J. Innovation and Sustainable Development*, Vol. 3, Nos. 3/4, pp. 285-300.

Owen, A., Mitchell, G. & Unsworth, R. (2012) Reducing carbon, tackling fuel poverty: adoption and performance of air-source heat pumps in East Yorkshire, UK. Local Environment, Articles in Press, DOI:10.1080/13549839.2012.732050

Ozoliņa, L. & Garā, E. (2011) Homeowners and energy renovations in Latvia. An analysis of 24 homeowners. In Bartiaux, F. (Ed.) Deliverable 2.4. A qualitative study of home energy-related renovation in five European countries: homeowners' practices and opinions. IDEAL EPBD project. Online: http://www.ideal-epbd.eu/index.php?option=com_content&view=article&id=12&Itemid=14&lang=en

Palm, A. & Neij, L. (2012). A framework for analyzing deployment of solar photovoltaics. Paper presented at IST 2012 - International Conference on Sustainability Transitions.

Palm, J. & Tengvard, M. (2011) Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden. Sustainability: Science, Practice and Policy 7: 6-15.

Panel Scan (2009) Panel Scan http://www.casopisstavebnictvi.cz/panel-scan-2009-studie-stavu-bytoveho-fondu-v-bytovych-panelovych-i-nepanelovych-domech_N3736

Paulus, C. (2012) Solar District Heating in France: Developing and Innovating. DHC+, the Next DHC Generation Conference, Brussels 9-10 Oct 2012. Online: http://www.euroheat.org/Event-Presentations-147.aspx

Pejter, J. & Gebauer, P. (2010). Implementation of the EPBD in the Czech Republic. Status November 2010. Concerted Action: Energy Performance of Buildings. Online at: http://www.epbd-ca.org/Medias/Pdf/country_reports_14-04-2011/Czech_Republic.pdf

Philibert, C. (2006) Barriers to Technology Diffusion: The Case of Solar Thermal Technologies. Paris: OECD & IEA. Online: http://www.oecd.org/env/cc/37671704.pdf

Pout, C. & Hitchin, E.R, (2008). The future environmental impact of room air conditioners in Europe. Proceedings of Conference: Air Conditioning and the Low Carbon Cooling Challenge, Windsor, UK, 27-29 July 2008. London: Network for Comfort and Energy Use in Buildings, http://nceub.org.uk

Pöyry (2012) Kaukolämmön asema Suomen energiajärjestelmässä tulevaisuudessa (Role of district heat in the future Finnish energy system). Helsinki: Pöyry Management Consulting.

Prada, M.F. (2011). The Energy Auditing of Buildings in Romania. Paper at 17th Building Services, Mechanical and Building Industry Days, Urban Energy Conference, 13-14 October 2011, Debrecen, Hungary.

Prendergast, E., Mlecnik, E., Haavik, T., Rødsjø, A. & Parker, P. (2010). From demonstration projects to volume market. Market development for advanced housing renovation. International Energy Agency: IEA Task 37. Online: http://members.iea-shc.org/publications/downloads/Advanced_Housing_Renovation.pdf

PV GRID (2013). Projects database. Online: http://www.pvgrid.eu/database.html

PWC (2011). Provocări şi oportunităţi pentru sistemul de furnizare centralizată a energiei termice din România (Challenges and Opportunities for the Romanian district heating system) Online: http://media.hotnews.ro/media_server1/document-2011-06-15-8867155-0-raportul-pwc-privind-sistemul-termoficare.pdf

Raven, R. P. J. M., Heiskanen, E., Lovio, R., Hodson, M., Brohmann, B. 2008. The contribution of local experiments and negotiation processes to field-level learning in emerging (niche) technologies: meta-analysis of 27 new energy projects in Europe. Bulletin of Science Technology Society 28 (6), 464-477

Rehdanz, K. (2006) Determinants of Residential Space Heating Expenditures in Germany. Working Paper FNU-66 (revised). http://www.fnu.zmaw.de

RES Legal (2012). Legal sources on renewable energy. Online database at: http://www.res-legal.eu/home/

Rezessy, A. & Bertoldi, P. (2010). Financing Energy Efficiency: Forging the Link between Financing and Project Implementation. European Commission, Directorate General JRC, Joint Research Centre, Institute for Energy. Online: http://ec.europa.eu/energy/efficiency/doc/financing_energy_efficiency.pdf

Ringer, B. (2011). Deliverable 13/4: Heating and Ventilation Systems in Low Energy and Passive Houses in Europe. Radon Prevention and Remediation (RADPAR) project, with funding from the European Commission DG SANCO Second Public Health Programme. Online: http://web.jrc.ec.europa.eu/radpar/

RoGBC (2012). Property tax exemption for rehabilitated residential buildings in Romania. New release. Romanian Green Building Council, online at https://rogbc.wordpress.com

Rogers, E. (1995). Diffusion of Innovations. 4th edition. New York: The Free Press.

Rohracher, h. & Ornetzeder, M. (2002). Green Buildings in Context: Improving Social Learning Processes between Users and Producers. Built Environment 28: 73-84.

Rohracher, H., R. Bogner, P. Späth & F. Faber (2004): Improving the Public Perception of Bioenergy in the EU. Final Report. Available at: http://susproc.jrc.ec.europa.eu/heating/docs/ProductDefinition-Market-TechAnalysis.pdf

Roland, S. & Elamine, W. (2011) Overcoming the Administrative Obstacles Related to Photovoltaic Installations in Mainland France: Analysis and proposals. Report for the PV Legal project supported by Intelligent Energy Europe. Online: http://www.pvlegal.eu/en/results/advisory-papers/france.html?0=

Rouvinen, S. & Matero, J. (2012). Stated preferences of Finnish private homeowners for residential heating systems: A discrete choice experiment. Biomass and Bioenergy , In Press, Corrected Proof, Available online 10 November 2012. http://dx.doi.org/10.1016/j.biombioe.2012.10.010

Roy, R., Caird, S. & Abelman, J. (2008) YIMBY Generation – yes in my back yard! UK householders pioneering microgeneration heat. London: The Energy Saving Trust.

Royal Academy of Engineering (2012). Heat: Degrees of comfort? The Royal Academy of Engineering. Online: http://www.raeng.org.uk/news/publications/list/reports/RAE_Heat_Booklet.pdf

Ruggieri G, Galante A & Dall'Ò G (2011) Tackling the potential from below: Italian Municipal Building Codes as concrete implementation tools for the EPB Directive. Proceedings of the eceee 2009 Summer Study: 941-949.

Ruggieri, G, Dall'Ò, G & Galante, A (2007) Le barrier all'efficienza energetica nei condomini italiani. Report for WWF Italia. Online: http://www.wwf.it/UserFiles/File/News%20Dossier%20Appti/DOSSIER/dossier%20clima/dossierBarriere_WWF_DEF.pdf

Rugina, M. (2009). Energy Efficiency Policies and Measures in Romania. Monitoring of Energy Efficiency in EU27, Norway and Croatia (ODYSSEE-MURE). Energy Research and Modernizing Institute-ICEMENERG.

Sauter, R. & Watson, J. (2007). Strategies for the deployment of micro-generation: Implications for social acceptance. Energy Policy: 2770–2779

Savin, J.-L. & Bernard, A.-M. (2011) "Performance" Project: Large Scale Monitoring Of Occupied Dwellings Equipped With Dcv (demand Controlled Ventilation) In France. Roomvent 11 Conference. Online: http://www.tapironline.no/fil/vis/714

Scarpa, R. & Willis, K. (2010). Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies. Energy Economics 32: 129-136.

Schaefer, B. (2006) Case 16: Barcelona Solar Ordinance. Create Acceptance WP2 Historical and recent attitude of stakeholders. CREATE ACCEPTANCE, FP6. ECN-E--07-058. Online: http://www.esteem-tool.eu/fileadmin/esteem-tool/docs/CASE_16_def.pdf

Schelly, C. (2010). Testing Solar Thermal Adoption. Environment and Behaviour 42: 151-170.

Sengers, F., Raven, R., Van Venrooij, A. (2010). From riches to rags: Biofuels, media discourses, and resistance to sustainable energy technologies. Energy Policy 38: 5013–5027.

Seppänen, O. (2012). Effect of EPBD on future ventilation systems. REHVA Journal – February 2012: 34-38.

SErENADE (2007): Energy advice in Europe 2007. A review of current practice in advice on sustainable energy in the countries of the European Union. Available Online at: http://www.iee-library.eu/index.php?option=com_jombib&task=showbib&id=672

SIA Partners (2013) Tour d'horizon de l'énergie solaire thermique et de ses perspectives d'avenir en France. Energies & Environnement 30. Jan 2013. Online: http://energie.sia-partners.com/20130130/tour-dhorizon-de-lenergie-solaire-thermique-et-de-ses-perspectives-davenir-en-france/

Singh, H., Muetze, Annette and Eames, P. C.. (2010) Factors influencing the uptake of heat pump technology by the UK domestic sector. Renewable Energy, Vol.35: 873-878.

Sitra (2011). Saisiko olla lähienergiapalveluja? Kyselytutkimus: Omakotitalojen, taloyhtiöiden ja vapaa-ajan asunnon asukkaiden tarpeet energiaratkaisuja ja uusia lähienergiapalveluja kohtaan.

Sitra (2012) Aurinkosähkö ja muun uusiutuvan sähkön pientuotannon edistäminen Suomessa (Promotion of solar power and other renewable electricity micro-generation in Finland). Discussion paper, August 2012. http://www.sitra.fi/sites/default/files/u489/sahkon_pientuotanto_keskustelupaperi_2012-9-3.pdf

Skjølsvold, T. M. (2012) Curb Your Enthusiasm: On Media Communication of Bioenergy and the Role of the News Media in Technology Diffusion. Environmental Communication: A Journal of Nature and Culture, 6:4, 512-531.

Sochor, V.(2010) Energy Service Providing and ESCO activities in the Czech Republic. Presentation at Energy Community Conference, Vienna, March 18, 2010. Online at: http://www.energy-community.org/pls/portal/docs/562204.PDF

Solarge (2006) National market analysis for Enlarging Solar Thermal Systems in Multifamily Houses and Hotels in Europe: Slovenia. Report from the Solarge project funded by Intelligent Energy Europe. Online: http://www.solarge.org/uploads/media/NMA_Slovenia_en.pdf

Sopha, B.M., Klöckner, C.A., Skjevrak, G. & Hertwich, E. (2010). Norwegian households' perception of wood pellet stove compared to air-to-air heat pumps and electric heating. Energy Policy 38: 3744-3754.

Späth, P. & Rohracher, H. (2010) 'Energy Regions': The transformative power of regional discourses on socio-technical futures. Research Policy 39, pp. 449-458.

Späth, P. & Rohracher, H., 2010. 'Energy regions': The transformative power of regional discourses on socio-technical futres. Research Policy 39, 449-458.

Statistics Finland (2012). Building statistics. Suomen virallinen tilasto (SVT): Rakennukset ja kesämökit [verkkojulkaisu]. ISSN=1798-677X. Helsinki: Statistics Finland [referenced: 2.7.2012].Online: http://www.stat.fi/til/rakke/index.htm

Statistisches Bundesamt (2012) Bauen und Wohnen. Mikrozensus – Zusatzerhebung 2010. Bestand und Struktur der Wohneinheiten Wohnsituation der Haushalte. Fachserie 5, Heft 1. Wiesbaden 2012.

Steiner, M., Pichler, W. & Gosler, M. (2009) Pellet market country report BULGARIA. Pellets@las project (Development and promotion of a transparent European Pellets Market: Creation of a European real-time Pellets Atlas. Supported by Intelligent Energy Europe. Online: http://www.pelletsatlas.info/pelletsatlas_docs/showdoc.asp?id=091116171705&type=doc&pdf=true

Steinestel, M., Maier, P., Meinel, H. & Sieverding U. (2009) Changing behaviour of energy consumers and motivating private investments in energy efficiency by individual and neutral on site Energy consultancy for private house owners. Paper presented at First European Energy Efficiency and Behaviour Conference, Maastricht, October 19th-20th.

Stenberg, A.-C. and C. Räisänen (2006) The Social Construction of 'Green Building' in the Swedish context. Journal of Environmental Policy and Planning. 8(1):67-85.

Stieß et al. (2010). Handlungsmotive, -hemmnisse und Zielgruppen für eine energetische Gebäudesanierung.

Stiess I., van der Land, V., Birzle-Harder, B. & Deffner, J. (2010). Handlungsmotive, -hemmnisse und Zielgruppen für eine energetische Gebäudesanierung. Frankfurt am Main. http://www.enef-haus.de/fileadmin/ENEFH/redaktion/PDF/Befragung_EnefHaus.pdf, downloaded 26.11.2012.

Stiess, I. & Dunkelberg, E. (2012) Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. Journal of Cleaner Production XXX, article in press.

Stiess, I., Birzle-Harder, B. & Deffner, J. (2009a): „So ein Haus ist auch die Sparkasse von einem." Motive und Barrieren von Eigenheimbesitzerinnen und -besitzern gegen-über einer energieeffizienten Sanierung: Ergebnisse einer qualitativen Untersuchung Frankfurt am Main. http://xn--is-gka.net/ftp/publikationen/enef_haus_bericht09.pdf Downloaded 26.11.2012.

Stiess, I., Zundel, S. & Deffner, J. (2009b) Making the home consume less – putting energy efficiency on the refurbishment agenda. ECEEE 2009 Summer study. Act! Innovate! Deliver. Proceedings of the eceee 2009 Summer Study. Stockholm: European Council for an Energy Efficient Economy. pp. 1821-1827

Streicher et al. (2004) State of the art of energy efficiency of new and refurbished buildings. A comparative survey of the present situation in the Czech Republic and Austria.

Šubic, L. & Staničic, D. (2005) Bioenergy in Slovenia. Paper presented at the Conference Bioenergy in Eastern Europe, Leipzig, March 2005. Online: http://www.aure.si/knjiznica/BIOENERGY_IN_SLOVENIA_AURE_GEF.pdf

SULPU (2012). Lämpöpumppujen kokonaismäärän kehitys 1996-2012 (Development of total number of installed heat pumps, 18996-2012). Finnish Heat Pump Association. Online: http://www.sulpu.fi/tilastot

Sunega, P. & Bezovan, G. (2007). Regional differences in housing availability and affordability in the Czech Republic and in Croatia. ENHR 2007, Rotterdam 25-28, 2007.

Sustainable Energy Ireland (2013) Better Energy Home Statistics. Online at: http://www.seai.ie/Grants/Better_energy_homes/Better_Energy_Statistics/

Sweatman, P. & Managan, K. (2010). Financing Energy Efficiency Building Retrofits. International Policy and Business Model Review and Regulatory Alternatives for Spain. Climate stragy partners. Online: http://earthscience.bcsdk12.org/earthscienceiscool/media/climatechange/documents/2010%20Financing%20Energy%20Efficiency%20Building%20Retrofits.pdf

Sýkora, L. (2007). Office development and post-communist city formation: The case of Prague. In Stanilov, K. (Ed.) The Post-Socialist City 117-145. Berlin: Springer.

T'Serclaes, P. (2007) Financing Energy Efficient Homes: Existing Policy Responses to Financial Barriers. IEA Information Paper. Paris: International Energy Agency.

Talouselämä (2012). Kuntatalous rempallaan. (Municipal economy is a disaster). Talouselämä magazine 34/2012: 48-52.

Tapaninen, A. (2010). Adoption of Innovation: Wood Pellet Heating System in the Renewable Residential Energy Context. Tampere University of Technology. Publication 884.

Teckenburg, E., Rathmann, M., Winkel, T., Ragwitz, M., Steinhilber, S., Resch, G., Panzer, C. , Busch, S., Konstantinaviciute, I. (2011). Renewable Energy Policy Country Profiles. Prepared within the Intelligent Energy Europe project RE-Shaping supported by Intelligent Energy Europe. http://www.reshaping-res-policy.eu/downloads/RE-SHAPING_Renewable-Energy-Policy-Country-profiles-2011_FINAL_1.pdf

Tekes (2012). The Finnish Solar Energy Cluster. Helsinki: Pöyry Management Consulting and Tekes Groove and Sustainble Community programmes.

Temelova, J., Novak, J., Ourednicek, M.& Puldov, P. (2011). Housing Estates in the Czech Republic after Socialism: Various Trajectories and Inner Differentiation. Urban Studies 48: 1811-1834.

Tigchelaar, C., Backhaus, J. & de Best-Waldhober, M. (2011). Consumer response to energy labels in buildings. Recommendations to improve the Energy Performance Certificate and the Energy Performance of Buildings Directive based on research findings in 10 EU countries. Deliverable 6 of the IDEAL EPBD project. http://www.ideal-epbd.eu/download/pap/Final_WP6_report_findings_recommendations.pdf

Tirado Herrero, S. and Ürge-Vorsatz, D. (2010) Fuel poverty in Hungary. A first assessment. Center for Climate Change and Sustainable Energy Policy (3CSEP), Central European University, Budapest.

Tirado Herrero, S. and Ürge-Vorsatz, D. (2011) Investing in energy efficiency in buildings with district heating. Paper presented at Cohesion Policy Investing in Energy Efficiency in Buildings, Brussels, Nov 29-30, 2011.

TNS-SOFRES/ADEME (2012) Maîtrise de l'énergie – Bilan 2011. Survey by TNS-SOFRES for ADEME.

Todorova, S. (2008). Implementation of the EPBD in Bulgaria: Status March 2008. EPBD Buildings Platform, Country Review P76. Online: http://www.buildup.eu/publications/1401

Tragopoulos, G. & Sweatman, P. (2012). WWF Spain Report 2012: Challenges and Funding Opportunities for the Energy Efficient Renovation of Spain's Residental Building Stock. WWF / Adena 2012, Madrid.

Trainrebuild (2011).Training for Public Authority Civil Servants. Draft Toolkit for Local Authorities. Online at: http://trainrebuild.eu/wp-content/uploads/2011/07/Draft-Toolkit-for-Local-Authorities.pdf

Travezán, J. Y. (2012) Energy efficiency gap in Spain. A case study: Policy assessment for energy efficiency in residential buildings. Master's thesis, Utrecht University.

Tuominen, P. &Klobut, K. (2011).Deliverable 3.1.Country Specific Factors -Report of Findings in WP3.IDEAL EPBD. Online at: http://www.ideal-epbd.eu/download/D3-1_country_specific_factors.pdf

UK Green Building Council (2011) Existing Green Finance Structures in Europe. Online at: www.ukbc.org

UN ECE (2001). Country profiles on the Housing Sector. Romania: Summary and Recommendations. Online at

UNDP (2007) Demonstration Project for the Renovation of Multifamily Buildings, UNDP project http://www.undp.bg/uploads/images/1599_alt.pdf

Upham, P. & Jones, C. (2012) -Don't lock me in: Public opinion on the prospective use of waste process heat for district heating. Applied Energy, Volume 89, Issue 1, January 2012, Pages 21–29.

Ürge-Vorsatz D., Arena, D., Tirado Herrero, S., Butcher, A. (2010). Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary. Central European University: Center for Climate Change and Sustainable Energy Policy (3CSEP) and European Climate Foundation. Online: http://3csep.ceu.hu/sites/default/files/field_attachment/project/node-6234/employment-impactsofenergyefficiencyretrofits.pdf

Valuntiene, I. (2009). Case Study 12: Modernization Multi-apartment programme, Lithuania. EC FP7 funded CHANGING BEHAVIOUR project, WP2 case studies. Online: http://www.energychange.info/casestudies

Vanicek, V. (2011). Green Savings Programme. Using ETS (AAU in Czech Republic) funds for building renovation. Presentation at Financing Energy Efficiency in Romanian buildings (March 2011), Building Performance Institute. Online at: http://www.bpie.eu/event_proceedings.html

Verhees, B., Raven, R. , Veraart, F., Smith, A. & Kern, F. (2013). The development of solar PV in The Netherlands: A case of survival in unfriendly contexts. Renewable and Sustainable Energy Reviews 19: 275–289.

Verma, V.K., Bram, S. & De Ruyck, J. (2009). Small-scale biomass heating systems: Standards, quality labelling and market driving factors – An EU outlook. Biomass and Bioenergy 33: 1393-1402.

Vihola, J. & Heljo, J. (2012). Lämmitystapavalintojen kehitys 2000–2012 (Development of heating system choices 2000-2012). Tampere: Tampere University of Technology.

Wahlström, Å., Andresen, I. & Thomsen, K. E. (2011). The Nordic market for climate friendly buildings – status, barriers and opportunities. Proceedings of ECEEE 2011 SUMMER STUDY • Energy efficiency first: The foundation of a low-carbon society 1095-1140.

Weiss, M., Dittmar, L., Junginger, M., Patel, M.K. & Blok, K. (2009). Market diffusion, technological learning, and cost-benefit dynamics of condensing gas boilers in the Netherlands. Energy Policy 37: 2962-2976.

Wilhite, H., Shove, E., Lutzenhiser, L. & Kempton, W., 2000. The Legacy of Twenty Years of Energy Demand Management: We know more about Individual Behaviour but next to Nothing about Demand. pp. 109-126 in E. Jochem et al. (Eds.) Society, Behaviour, and Climate Change Mitigation. Dordrecht: Kluwer Academic Publishers.

Woersdorfer, J.. & Kaus, W. (2011). Will nonowners follow pioneer consumers in the adoption of solar thermal systems? Empirical evidence for northwestern Germany. Ecological Economics 70: 2282–2291.

Wüstenhagen, R., Wolsink, M. & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy 35: 2683-2691.

Zabot S, Monguzzi C & Ruggieri G (2011). Green loans experiences as investment multiplier schemes. Proceedings of the eceee 2011 Summer Study: 293-303.

Zámečník, M. & Hlaváč, J. (2011) Home is where the heat is: thermal insulation programs for buildings in the Czech Republicand its positive effect on job creation. EE Bankwatch Network and Hnuti DUHA. Online at: http://bankwatch.org/sites/default/files/Home-is-where-the-heat-is.pdf

Zoric, J.& Hrovatin, N. (2012). Determinants of residential heating preferences in Slovenia. International Journal of Sustainable Economy 4: 181-196.

Expert interviews

1. Pasi Tainio, Finnish Environment Institute, Finland, Sept 3 2012
2. Petri Pylsy, Kiinteistöliitto (Finnish Real Estate Federation), Sept 10, 2012
3. Erkki Aalto, Rakli (Property and Construction Industry), Finland, Sept 17, 2012
4. Louis-Gaëtan Giraudet, CIRED (International research center on environment and development), France, Sept 26, 2012
5. Jaroslav Suchánek, real estate agent, Czech Republic, Sept 26, 2012
6. Martin Tesař, Economist, apartment owner, Czech Republic, Sept 26, 2012
7. Alena Kliková, Lawyer, owner of a single family house, Czech Republic, Oct 12, 2012
8. Renata Uramová, Head of Department of Property, Housing and Investments of Municipality Prague 13, Czech Republic, Oct 16, 2012
9. Horia Petran, URBA-INCERC, Romania, Oct. 26, 2012
10. Régine Trotignon, ADEME (French Environment and Energy Management Agency), France, Oct 30, 2012
11. Mark Velody, Consultant for Tractabel and international organizations, Romania, Nov 1, 2012
12. Dr. Immanuel Stiess, ISOE (Institut für Sozial-ökologische Forschung), Germany, Nov 1st, 2012
13. Dr. Martin Pehnt, ifeu (Institut für Energie- und Umweltforschung Heidelberg GmbH), Germany, Nov 2nd, 2012
14. Prof. Dr. Harald Rohracher, Linköping University, Sweden (previously Graz University of Technology, Austria), Austria, Nov. 6th 2012.
15. DI. Armin Knotzer, Institut für Nachhaltige Technologien, Gleisdorf, Austria, Nov 7th 2012.
16. Martin Steinestel, Verbraucherzentrale Nordrhein-Westfalen, Germany, Nov 12th, 2012.
17. George Georgiev, Bulgarian Housing Association, Bulgaria, Nov 9, 2012
18. Julien Allix and Sylvaine Le Garrec, UNARC (Association of co-ownership responsible persons), France, Nov 11, 2012
19. Zdravko Genchev, Center for Energy Efficiency Eneffect, Bulgaria, Nov 11, 2012
20. Stevan Borcamp, Romanian Green Building Council, Romania, Nov 13, 2012
21. Xavier Carbonell, ARC Mediacion Ambiental, Nov 13, 2012
22. Dr. Michael Ornetzeder, Institute of Technology Assessment, Austrian Academy of Sciences, Austria, Nov 15th, 2012.
23. Paavo Kykkänen, Kotialue Oy (House Managing Agency), Nov 21, 2012
24. Carlos de Astorza, Spanish Association of Public Housing and Land Developers (AVS), Spain, Nov 22, 2012
25. Sergio Marta, Olano y Mendo Architects, Spain, Nov 22, 2012
26. Gianluca Ruggieri, Politecnico di Milano, Italy, Nov 22, 2012
27. Bettina Schaefer, Ecoinstitut Barcelona, Spain, Nov 23, 2012
28. Liyana Adjarova, Association of Bulgarian Energy Agencies, Bulgaria, Nov 28, 2012
29. Alain Lusardi, Federabitazione Europe – Confcooperative, Italy, Nov 30, 2012

Annex 1 Commonly used terms referring to building ownership and tenure used in this report

Different countries have different systems of building tenure. Hence, each chapter uses the national terminology as far as possible. The following are some terms referring to broadly similar (but not exactly the same) categories of building owners and users in different countries:

Single-family house (or home) as a generic term refers to both detached and attached (or semi-detached, or terraced, or row) houses. In some countries, detached and attached houses are discussed separately, because they have different ownership and tenure systems. In some countries, statistics refer to broadly the same group with the term "1-2 family houses"

Owner-occupied apartment building is here used as a generic term, along with owner-occupied multifamily building. These are also referred to in the following as condominiums when discussing the countries where this term is commonly used. They are governed by different bodies of owners in different countries: owners' assemblies, residents' associations, homeowners' associations, condominium (owners') associations, communities of property owners, or housing companies. Because the legal status of these bodies is not the same, different terms are used for different countries to refer to the decision-making body of these buildings.

Social housing: We use the term social housing here only for rental housing, even though in several countries there is also state support available for building owner-occupied housing that is sold on certain social criteria. Since there is not common European definition of social housing, different terms and definitions are used for different countries. This can be e.g. "municipally owned housing" or "public housing". Eligibility criteria (e.g. income thresholds) for social or public housing are different in different countries.

Private rental housing: This refers broadly to rental houses or apartments that are not distributed on social grounds, but available to anybody. They may be owned by private persons (owning one or several properties), professional real estate companies, or portfolio investors. Rental housing can also be owned by co-operatives or other non-profit bodies.

Public buildings: This term refers to buildings owned by public sector bodies such as the central government, states, provinces or regions, and municipalities or cities. The public sector is organised in different ways in different countries (e.g. healthcare or education can be provided by the central government, regions/provinces or the local government, or private companies or other organisations). We follow, as far as possible, the definitions used in each country.

(Commercial) office buildings: Where not specified, the term 'office buildings' refers here to commercial office buildings, whereas public sector office buildings are part of the category 'public buildings'. Commercial office buildings can be owned by the occupants or by private investors (professional real estate companies or portfolio investors).

Annex 2: Prices of gas, electricity and district heat in the EU-27, EUR/kWh, first half of year, 2009-2011

	Electricity prices						Gas prices						District heat price 2003
	Households (1)			Industry (2)			Households (3)			Industry (4)			
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	
EU-27	0,163	0,167	0,178	0,107	0,105	0,110	0,059	0,053	0,056	0,036	0,031	0,034	
Euro area (5)	0,171	0,176	0,187	0,111	0,109	0,116	0,066	0,058	0,062	0,038	0,032	0,036	
Austria													**0,057**
Belgium	0,192	0,196	0,214	0,111	0,106	0,110	0,061	0,053	0,057	0,033	0,029	0,032	
Bulgaria	0,082	0,081	0,083	0,065	0,065	0,065	0,047	0,037	0,043	0,031	0,024	0,029	0,022
Czech Republic	0,132	0,135	0,150	0,107	0,103	0,111	0,049	0,047	0,054	0,033	0,031	0,031	**0,062**
Denmark	0,270	0,267	0,291	0,086	0,094	0,099	0,092	0,107	0,116	0,056	0,057	0,067	**0,090**
Germany	0,228	0,238	0,253	0,113	0,112	0,125	0,065	0,057	0,059	0,043	0,036	0,046	**0,070**
Estonia	0,092	0,097	0,097	0,064	0,069	0,072	0,039	0,036	0,042	0,027	0,029	0,028	**0,045**
France													**0,060**
Ireland	0,203	0,180	0,190	0,121	0,112	0,116	0,064	0,050	0,051	0,033	0,028	0,038	
Greece	0,115	0,118	0,125	0,095	0,095	0,101	:	:	:	:	:	:	
Spain	0,158	0,173	0,195	0,115	0,117	0,114	0,061	0,053	0,054	0,031	0,028	0,029	
France	0,121	0,128	0,138	0,073	0,085	0,085	0,055	0,052	0,058	0,036	0,033	0,037	
Italy	0,210	0,197	0,201	0,153	0,139	0,153	0,076	0,062	0,069	0,040	0,030	0,031	
Cyprus	0,156	0,186	0,205	0,119	0,151	0,167	:	:	:	:	:	:	
Latvia	0,105	0,105	0,117	0,090	0,089	0,098	0,052	0,031	0,039	0,039	0,026	0,029	**0,050**
Lithuania	0,095	0,116	0,121	0,092	0,100	0,105	0,042	0,038	0,043	0,031	0,032	0,035	**0,063**
Luxembourg	0,188	0,173	0,168	0,116	0,102	0,100	0,049	0,043	0,051	0,040	0,037	0,042	
Hungary	0,148	0,170	0,168	0,124	0,106	0,095	0,048	0,054	0,056	0,037	0,030	0,033	
Malta	0,171	0,170	0,170	0,151	0,180	0,180	:	:	:	:	:	:	
Netherlands	0,190	0,170	0,174	0,113	0,104	0,103	0,083	0,070	0,072	0,038	0,032	0,033	
Austria	0,191	0,197	0,199	:	:	:	0,065	0,062	0,069	:	:	:	
Poland	0,113	0,134	0,147	0,090	0,098	0,101	0,039	0,043	0,046	0,028	0,030	0,033	
Portugal	0,151	0,158	0,165	0,094	0,094	0,099	0,060	0,059	0,061	0,035	0,027	0,034	**0,037**
Romania	0,098	0,103	0,108	0,081	0,085	0,080	0,029	0,027	0,028	0,023	0,022	0,023	**0,051**
Slovenia	0,135	0,140	0,144	0,103	0,099	0,099	0,066	0,058	0,067	0,044	0,042	0,045	**0,045**
Slovakia	0,154	0,152	0,168	0,142	0,117	0,128	0,046	0,044	0,047	0,041	0,033	0,035	**0,065**
Finland	0,130	0,133	0,154	0,069	0,069	0,076	:	:	:	0,031	0,030	0,042	**0,046**
Sweden	0,160	0,184	0,209	0,067	0,081	0,089	0,089	0,103	0,122	0,039	0,044	0,052	**0,060**
United Kingdom	0,147	0,139	0,143	0,112	0,099	0,098	0,043	0,041	0,042	0,029	0,023	0,025	

(1) Annual consumption: 2 500 kWh < consumption < 5 000 kWh.
(2) Annual consumption: 500 MWh < consumption < 2 000 MWh; excluding VAT
(3) Annual consumption: 5 600 kWh < consumption < 56 000 kWh (20-200 GJ).
(4) Annual consumption: 2 778 MWh < consumption < 27 778 MWh (10 000-100 000 GJ); excluding VAT.
(5) 2009 and 2010, EA-16.
Source: Eurostat (online data codes: nrg_pc_204, nrg_pc_205, nrg_pc_202 and nrg_pc_203), For district heat, Werner et al. 2003 and Euroheat and Power