Final Report

Building Renovation and Modernisation in Europe: State of the art review

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ERA BUILD

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Final Report

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ERABUILD

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ERABUILD

ERABUILD, is a strategic network for national R&D programmes from Austria, Denmark, Finland, France, Germany, the Netherlands, Sweden, United Kingdom, Switzerland and Norway, that started in 2004. The aim has been to influence the European Research Area (ERA) on sustainable development in the construction and operation of buildings by preparing frameworks for trans-national R&D co-operation and learning networks identifying best practices in programme management.

Two main topics are adressed in trans-national frameworks:

- value driven processes: aimed at increasing value for money for end users and clients through development of efficient processes. The programmes in the framework will support the development of a healthy business and innovation climate as well as to contribute to economic growth in society and a sustainable development.
- sustainable renovation: aimed at increasing both the quality and the quantity of renovation activities in Europe. The programmes in the framework will cover a broad scope including technological innovation, socio-economic concepts and supporting measures for sustainable renovation

EU funding for Erabuild ended december 2007, but the network and the two trans-national frameworks will continue in a subsequent project called ERACOBUILD.

ERACOBUILD, is organising a strengthened and enlarged continuation of ERABUILD, coordinating national RDI programmes in the field of "construction and operation of buildings". Besides the two trans-national frameworks of ERABUILD, identification of other RTD priorities and industry needs for pre/co-normative research and research facilities will have preliminary focus. ERACOBUILD is gathering 31 programme owners or managers from 16 EU Members States, 4 Associated Countries and 1 Western Balkan Country.

Contents

Summary

The final purpose of the project "State of the art review of building renovation and modernisation in Europe", launched by Erabuild, the European Research Area for the sustainable construction and operation of buildings, is to identify the most promising fields for future activities within the trans-national Erabuild research programme on Sustainable Renovation. To meet this final purpose, four work packages have been defined and are treated successively in the present report.

1. Mapping of building typologies and stakeholder interests (WP1).
2. Analysis of existing incentives and their impact on the renovation rate (WP2).
3. Mapping of modernisation and renovation research (WP3).
4. Recommendations about the most promising fields for future activities (WP4).

The countries covered in this study are Austria, Finland, France, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom. Residential and non-residential buildings are covered.

The information collected in this report is based on a literature review using scientific literature, and national and international reports and databases. When information was available from official European databases and statistics, it was used as the main source of information. In the absence of European data, national statistics, censuses and reports were used. When information was not directly available, other literature sources (research reports and papers) were used. In cases where no literature was found, the answers from a questionnaire, circulated in July and August 2007, were used. This questionnaire was sent to experts in ministries, government agencies, universities and consultancy firms. The aim of the project is not to make an exhaustive study of all possible sources but to identify needs and trends. Therefore, although the literature was gathered as thoroughly as possible, this study does not claim to be exhaustive. If information sources could not be found through international and national literature studies (including the internet) and was not known by the experts, the information was considered not operationally available.

The first conclusion of the present study is that - except for the International Energy Agency and Eurostat - data, definitions and methods used in national statistics for the residential sector differ in each country, which is not favourable for accurate comparisons between countries. There is much more official data available for the residential sector than for the non-residential sector. Data on the non-residential sector are scarce and scattered through a lot of private companies or sector organisations. Therefore, the development of consistent European statistics to assess the built environment should be considered. Although it is not necessary to centralise all statistics, it is important that at least a common basis is set up in all countries. This would allow better comparison and monitoring of the building stock and the effect of policies in the future. The implementation of the EPBD could be helpful to gather information. However, in the present state of affairs, the methods used and the data gathered in the framework of the EPBD differ greatly in the different countries. If the EPBD is to be used for monitoring and statistics as well, harmonisation between countries is considered necessary.

Second, although the residential sector accounts for about 70% of the total building stock, the non-residential sector is not negligible. In all the countries, office buildings have often already been renovated and the degree of penetration of sustainable renovation seems to be higher than in other sectors, not least because of image. The

shopping and leisure sector accounts for a large part of the non-residential sector, in terms of floor area and also in terms of energy use. This is also a complex sector because next to large chain stores, a large part of the market consists of small shops with a high diversity of activities. Introducing sustainable renovation in the shopping sector seems to be a challenge that requires standard solutions and specific incentives and policies for small and medium enterprises.

Third, educational buildings, although having a modest share of floor area and energy use in the non-residential sector could be considered as a sector of interest. Educational buildings are mostly owned by local, regional or national governments and their sustainable renovation could be seen as a standard bearer of political and social commitment. This also offers the opportunity to embed sustainability in education and to reach a large part of the population. Other good reasons to address the educational building stock are that the maintenance of schools is overdue in many countries and that many studies indicate large-scale problems with poor indoor air quality.

Fourth, the owner-occupied sector accounts for 35% to 70% of the residential building stock in the countries of interest in this study. This is also a sector where the penetration of sustainable renovation is low, in spite of the fact that a lot of renovation and modernisation activities are undertaken. Therefore, it seems to be an interesting sector to address. Owner-occupation accounts for 60% to 96% of single family dwellings and 20% to 60% of multi-family dwellings. Barriers to sustainable renovations in the owner-occupied market are the low investment capacity and the lack of knowledge about technical solutions. In owner-occupied multi-family dwellings, an additional barrier is the complex decision-making process related to the co-ownership of building parts.

Fifth, the other half of the residential sector consists of various shares of social rented and private rented dwellings. The social rented sector, very large in the Netherlands and Sweden, is strongly structured and easier to address than the private rented sector because the investment capacity and the structure are better. The private rented sector, very large in Germany and Switzerland, has to contend with a low investment capacity and a lack of knowledge about technical solutions. In both subsectors, the main barrier to sustainable renovation seems to be the return on investment; the one who invests is not the one who profits. This calls for specific financial and organisational solutions.

Sixth, in all countries except Finland and Sweden, a large part of the existing building stock, mainly with non-cavity external walls, still needs to be insulated and there seems to be a lack of practical technical solutions in this area. Although sustainable building services like heat pumps, solar heating or district heating have been demonstrated in many projects, the scaling-up of these projects seems a very difficult task. An exception to this is the large-scale implementation of district heating in Finland and Sweden. In addition to the activities aimed at the scaling-up process itself, there is a need for research on methods to achieve this. There is also an urgent need for the translation of solutions into practices through technical norms, education and knowledge sharing and for innovative solutions, like very thin insulation materials applicable indoors. The emergence of indoor air quality problems is also observed. Because natural ventilation by opening windows is still very common, but is insufficient in buildings that have been thermally renovated, integral renovation concepts should be developed, also taking into account the occupants' needs and behaviour.

Seventh, the monitoring of energy use and equipment is needed to really achieve energy savings and to evaluate the efficiency of measures.

Eighth, urban renewal, which is taking place on a large-scale in Germany, Austria and France, could be an opportunity for sustainable renovation, at least if decisions on asset management were related to the technical quality of the buildings, which is mostly not the case. Here, too, specific organisational and financial solutions are needed.

Ninth, most renovation activities in the residential sector are maintenance, repair and modernisation activities aimed at increasing the service life of components, increasing comfort or replacing components. The decision-makers in these renovation activities are owner-occupants and mostly small contractors. There is a need for the dissemination of knowledge and decision tools (for instance the "repair or replace" decision tool) to these small sized firms and non-professional actors. The consultancy process is also very unclear because the contractor acts as consultant too, but is not objective. There also seems to be a need here for specific organisations and processes.

Tenth, besides the implementation activities and practical research activities described above, more strategic research themes for the future were identified: research on life cycle costing and value-added chain of construction products; post-occupancy evaluations; research on sustainable urban communities and citizen participation; overall environmental impact of buildings (LCA); impact of renovation on indoor air quality; research on standard solutions for the implementation of renewable energy in buildings and neighbourhoods; use of 3D modelling GIS techniques for renovation; practical research on (new) insulation techniques for solid walls; practical research on new or better components; practical and cheap concepts for continuous monitoring and control of HVAC equipment; impact of occupant behaviour on energy conservation measures; sustainable financial constructions for renovation; demonstration and scaling-up projects; efficient building regulations and policies for renovation; and process and organisation models for different stakeholders.

1 Introduction

1.1 Context

Erabuild, the European Research Area for the sustainable construction and operation of buildings started in 2004 as a consortium of eight countries sharing the knowledge and resources of ten national construction research programmes. The aim of Erabuild is to build durable cooperation between European funding bodies in order to increase the impact of research in the sector, and to enhance the quality of research and performance of the construction industry. The trans-national programme Sustainable Renovation, launched through a pilot joint call, is one of the projects within Erabuild.

In this publication, we report the findings of the project "State of the art review of building renovation and modernisation in Europe". The main goal is to identify the most promising fields for future activities within the trans-national Erabuild research programme.
The countries covered in this study are Austria, Finland, France, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom. Both residential and non-residential buildings were objects of study. The project has been carried out by:

- OTB Research Institute for Urban Housing and Mobility Studies (The Netherlands; lead partner).
- W/E (The Netherlands, main partner).
- Cambridge Architectural Research Ltd (sub-contractor for the United Kingdom, Finland and Sweden).
- IIBW, Institute for Real Estate, Construction and Housing (sub-contractor for Austria and Switzerland).
- IWU, Institute for Housing and Environment (sub-contractor for Germany).
- CSTB (sub-contractor for France).

Considering the number of subjects and countries covered, the project has been carried out with relatively modest means. The information collected in this report is, as far as possible, based on a literature review using scientific literature and national and international reports and databases. In cases where no literature could be found, information provided by experts/subcontractors was used. You can find the names of the experts that have provided us with information in Appendix A. We would hereby like to thank them for their kind co-operation.

1.2 Scope and research questions

The final purpose of the project "State of the art review of building renovation and modernisation in Europe" is to identify the most promising fields for future activities within the trans-national Erabuild research programme on Sustainable Renovation. To meet this final purpose, two main questions must be answered.

- Which scientific practical research is needed to understand the barriers to sustainable renovation and to develop new technical and non-technical solutions?
- Which other activities, such as knowledge dissemination and ways of evening out practical barriers, are needed?

To meet this final purpose, four work packages have been defined:

1. Mapping of building typologies and stakeholder interests (WP1)
2. Analysis of existing incentives and their impact on the renovation rate (WP2)
3. Mapping of modernisation and renovation research (WP3)
4. Recommendations about the most promising fields for future activities (WP4)

The countries covered in this study are Austria, Finland, France, Germany, the Netherlands, Sweden, Switzerland and the United Kingdom. Residential and non-residential buildings were covered.

The research questions to be answered are summarised in Tables 1.1 to 1.4.

Table 1.1: Research questions for Work Package 1.

Work Package 1
• What is the share (m^2 or number of buildings) of the different building typologies (single-family houses, apartment buildings, office buildings, shopping and leisure buildings, schools and health care buildings)? • What are the main types of constructions in relation to building typology and year of build? • What are the main types of building services (space-heating, cooling and ventilation systems) in relation to building typology? • What is known about the share in energy use of these building typologies and how is it related to the total energy consumption of the country? • What is known about the quality of the building typologies in terms of construction, energy use, comfort and health, and market demand and how does it relate to the quality of the newly built? • What is the share of the different building typologies between urban and rural regions and is there a difference in quality of the building stock between urban and rural regions? • Are standard reference buildings provided for the building stock; which ones and by whom are they used? • For each building typology what are the main renovation activities (from simple refurbishment to complex transformations), how many buildings does it concern on a yearly basis and what are the main reasons for renovation? • What is the ownership structure (and in what proportion) of the different building typologies? For residential buildings, a distinction will be made between owner-occupied dwellings, social rented dwellings, dwellings rented by housing associations or municipalities, and private and corporate investors. For non-residential buildings, a distinction will be made between owner-occupied buildings, buildings rented from corporate investors and buildings in the ownership of municipalities or governments. If necessary, models specific to each country will be added. • Who are the current stakeholders of the renovation process in the different ownership structures, what responsibility do they usually bear and how is the renovation/building process organised?

Table 1.2: Research questions for Work Package 2.

Work Package 2, Part 1
• What are the current technical, financial, social and political reasons for renovation at the level of owner-occupants, private owners, housing associations, corporate investors and governments? • What are the reasons causing these actors to prefer demolition and building anew to renovation? • Which technical, financial and social barriers are experienced in renovation projects? What are "natural" renovation moments and how could they be used to improve the rate of sustainable renovation? • Are there specific barriers to sustainable renovation? • Is there any relationship between asset management and technical maintenance? • What is known about the effects of renovation on property values? • Is there any large-scale monitoring of the effects of renovation on energy use, comfort and

	health, and occupant satisfaction in general and what trends can then be identified?
Work Package 2, Part 2	
	• What are the current national and European policies that are believed to have an effect on renovation activities and rates? • What are the current technical, financial, social and political reasons for renovation at the level of governments? • What are the current local, national and European incentives for renovation; what is their aim and expected effects? • What are the national and European plans or studies for new incentives in the coming years? • Is there any monitoring of policies and incentives, and if there is, what are the registered effects and how do they relate to the expected effects? • Are there any kind of activities organised by institutions other than governments (for instance by associations or umbrella organisations) and demonstration projects (like the European DEMOHOUSE, SUREURO or SuRE-Fit) and what is their possible effect on sustainable renovation? • What is known in general about effective environmental and building policies?

Table 1.3: Research questions for Work Package 3.

Work Package 3
• Which institutes and universities conduct ongoing research on renovation? • Is it technical, economic, policy or social oriented research and what are the main objectives of the research? • Is there research in the fields of architecture, building physics and services, indoor climate, public health and sociology that could be of importance to research on sustainable renovation? • Who is funding this research? • Is there specific research conducted by other than universities and research institutes (for instance consultants and property developers); what are the aims of this research and how is it funded? • Have the parties involved a clear idea about the type of research that will be needed in the future, and of what it will consist?

Table 1.4: Research questions for Work Package 4.

Work Package 4
• How could renovation activities have a major impact on the sustainability of the building stock? • Which kind of incentives appear to be successful in which contexts? • What are the identified current barriers to sustainable renovations? • What are the identified current opportunities for sustainable renovations? • How is it possible to even out these barriers and make maximum use of the opportunities? • Which building segments should be addressed as a priority? • Which kind of scientific research is needed to understand better the barriers to sustainable renovation and to develop new technical and non-technical solutions? • Which kind of activities (i.e. tool development, knowledge dissemination, demonstration projects) are needed to even out practical barriers to sustainable renovation?

1.3 Research methods

The information collected in this report is based on a literature review using scientific literature and national and international reports and databases. When information

Table 1.5: Main sources of information

European sources	Austria	Finland
▪ Housing Statistics in the European Union 2004 ▪ Regular National Report on Housing Developments in European Countries 2004 ▪ EURIMA publications ▪ EuroACE reports ▪ UNECE (2002), Annual Bulletin of Housing and Building Statistics for Europe & North America ▪ Eurostat ▪ International Energy Agency	▪ Statistik Austria (2007): Statistische Jahrbuch (ISIS database) ▪ GWZ 2001: Gebäude- und Wohnungszählung 2001, Statistik Austria ▪ Bauen und Wohnen in Österreich van Kreuzer & Fischer und Partner (2004) ▪ Reports from IIBW	▪ Statistics Finland: Housing 2005 ▪ Statistics Finland: Building Stock 2006 ▪ Ekorem report ▪ Ministry of Trade and Industry: Energy Review 2006 ▪ Reports from VTT, Technical Research Centre of Finland and HUT.
France	**Germany**	**The Netherlands**
▪ General Census, 1999 ▪ Housing Inquiry, 2001-2002 ▪ Les Chiffres clés du batiment, 2006. ▪ Ministère de l'écologie, du developpement et de l'aménagement durables, Economie & Statistiques ▪ Reports from CSTB ▪ ENPER-EXIST project ▪ ADEME, French Environment and Energy Management Agency	▪ Statistisches Jahrbuch 2006 ▪ German Census 1994 ▪ Europarc: Der Gebäudebestand in Europa, 1999 ▪ Reports and data from IWU, Institut Wohnen und Umwelt GmbH	▪ CBS: Statistics Netherlands ▪ Qualitative Housing Registration (KWR 2000, 2002) ▪ Reports from Ministry of Housing, Spatial Planning and the Environment ▪ Reports from Delft University of Technology
Sweden	**Switzerland**	**United Kingdom**
▪ Statistics Sweden, Housing and Construction 2005 ▪ Publications from Chalmers University ▪ Publications from Royal Institute of Technology	▪ Bundesamt für Statistik, 2004 ▪ Bundesamt für Energie, 2002, 2006 ▪ BFE Schweizerische Energiestatistik 2006 ▪ BFS Wohnungzählung 2000 ▪ Bundesamt für Wohnungswesen (BWO)	▪ English House Condition Survey 2005 ▪ Technical report EHCS ▪ ACE Report ▪ CaRB Project ▪ Energy Consumption in the United Kingdom (DTI)

was available from official European databases and statistics, it was used as the main source of information. In the absence of European data, national statistics, censuses and reports were used. When information was not directly available, other literature sources (research reports and papers) were used. In cases where no literature was found, the answers from a questionnaire, circulated in July and August 2007, were

used. This questionnaire was sent to experts in ministries, government agencies, universities and consultancy firms. The aim of the project is not to make an exhaustive study of all possible sources but to identify needs and trends. Therefore, although the literature was gathered as thoroughly as possible, this study does not claim to be exhaustive. If information sources could not be found by international and national literature studies (including the internet) and was not known by the experts, the information was considered not operationally available.
Detailed information on the source used is given in each table of the report and in Appendix A, including the experts consulted. Table 1.5 gives a summary of the main sources of information.

1.4 Organisation of the report

Chapters 2 to 5 of this report deal with the mapping of building typologies and stakeholder interests (Work Package 1). Chapter 2 deals with basic data, Chapter 3 with the main characteristics of the residential sector, Chapter 4 with the quality of the residential building stock, and Chapter 5 with the non-residential sector. Chapters 6, 7 and 8 deal with Work Package 2. Chapter 6 is about the main features of the renovation market, Chapter 7 is about existing policies and incentives and Chapter 8 about barriers and opportunities. Chapter 9 relates to Work Package 3 and addresses modernisation and renovation research. In Chapter 10, recommendations are made about the most promising fields for future activities.

WORK PACKAGE I: BUILDING TYPOLOGIES AND STAKEHOLDER INTERESTS

2 Basic data on residential and non-residential building stocks

2.1 Introduction

In this chapter the residential and non-residential building stock are analysed in relation to building typology and stakeholder interest. The non-residential sector includes office buildings, educational buildings, health care buildings and shopping and leisure buildings.

2.2 Availability and quality of data

In general, there are much more data available on the residential stock than on the non-residential stock. This is because national statistical studies are carried out on a regular basis for the residential stock, whereas governments mostly do not arrange for systematic inventories of the non-residential stock because of the lack of homogeneity of the actors involved in this stock and also because the non-residential building stock is smaller than the residential one. In the non-residential private sector, data may exist in sector organisations or at a lower level, but in most cases, access to these data is not made public.

For the residential sector, the data used are based on the results of national censuses or various housing surveys. It is notable that even basic data are difficult to compare between countries because of the use of different units, different definitions, or different years of measure. Data are sometimes given in number of dwellings, number of buildings, square metres of useful area (U.A. as given in Table 2.1) or square metres of heated area. For instance the data for Finland from the Regular National Report on Housing Developments in European countries are consistent with the data from Housing Statistics in Europe 2004, but not with the data from Statistics Finland: Building Stock in 2006, which give a much lower number of dwellings (1 193 846 instead of 2 478 000). This is due to the type of dwellings accounted for differently in the different statistics – see also Chapter 3. In order to make comparison between countries possible, less recent but more harmonised data from European surveys were sometimes used. The source of the data is indicated under each table.

For the non-residential sector, the data are often older and derived from censuses or assembled from sector estimates and are therefore much less accurate than for the non-residential sector. The data are in general less comparable because different definitions may have been used in the different sectors and in the different countries. For instance, the definitions of useful area differ in each country and some of our data are based on useful floor area and others on heated area. In Housing Statistics in Europe, detailed definitions for each country are given (see Appendix I) However, the data presented hereafter are believed to give a reasonable estimate of the ratios between residential and non-residential building stock.

An additional remark is that in studies of housing statistics, there are no data available about energy use. Data on energy used are found in statistics from Eurostat or from the International Energy Agency. Therefore discrepancies between these sources may occur.

2.3 Size of the residential and non-residential building stocks

In Table 2.1, basic data about the building stock are presented. Figures 2.1 and 2.2 summarise these data.

Table 2.1: Basic data on the residential and non-residential building stocks

	Population[10]	Residential buildings			Non-residential buildings	
		m^2 U.A.	Number of dwellings	% m^2 U.A.	m^2 U.A.	Number of units
Austria[1]	8 206 500	300 x 10^6	3 863 000	n.a.	n.a	116 530
Finland[2]	5 236 600	212 x 10^6	2 478 000	43%	278 x 10^6	198 685
France[3]	60 561 200	2135 x 10^6	25 800 000	72%	850 x 10^6	n.a.
Germany[4]	82 500 800	3301 x 10^6	35 800 000	63%	1926 x 10^6	n.a
Netherlands[5]	16 305 500	724 x 10^6	6 969 931	81%	166 x 10^6	224 000
Sweden[6]	9 011 400	312 x 10^6	4 404 059	66%	158 x 10^6	n.a.
Switzerland[7]	7 418 400	330 x 10^6	3 581 000	96%	151 x 10^6	84 615
United Kingdom[8]	60 034 500	2236 x 10^6	26 200 000	71%	990 x 10^6	1 840 000
European stock[9]		9858 x 10^6	113 876 000	69%	4354 x 10^6	n.a.

[1] from Statistik Austria Jahrbuch 2007, statistics for 2001. Non-residential data from census 1997.
[2] from Statistics Finland: Building Stock in 2006 and from Housing Developments in European Countries 2004 (number of dwellings).
[3] from www.statistiques.equipement.gouv.fr, Residential: statistics for 2002 (m^2) and 2005 (number). The number of dwellings is the number of main homes. In addition to this, there are 3 x 10^6 secondary homes and 1.9 x 10^6 unoccupied houses. Non-residential: statistics for 2004 (heated area).
[4] from Statistisches Jahrbuch 2006, statistics for 2004 for residential and from Housing Developments in European Countries 2004. For non-residential, no official statistics; data from Europarc 1999 were extrapolated to 2004.
[5] from KWR 2002 for residential. For non-residential from final report ENPER-EXIST, Building stock knowledge, June 2007.
[6] from Statistics Sweden: Housing and Construction, with projection to 2006 and from Housing Developments in European Countries 2004. For non-residential, estimate of heated floor area for 2000 from [J. Nässen 2005].
[7] from BFS, Wohnungszählung 2000; for details see Chapter 5.
[8] from English House Condition Survey 2007, statistics from 2005 – residential data are for England only. Data scaled to the UK with population fraction 60.6/50.8, data for non-residential are for England and Wales, scaled as well.
[9] data are only for buildings in the cold and moderate climatic zones: sum of all eight countries of the present study, minus Switzerland, plus Belgium, Denmark, Ireland and Luxemburg. Data from EURIMA & EuroACE, Mitigation of CO_2 emissions from the building stock, Ecofys 2007, based on Housing Statistics in the European Union, 2001 and Eurostat Yearbook 2001.
[10] data from Eurostat 2004

The total non-residential building stock of the eight countries studied is 43% of the residential building stock in terms of floor area. The percentages differ by country, being from only 4% in Switzerland to 57% in Finland and 31% at the European level (at the European level, only the cold and moderate climate zones were taken into account, and Switzerland was not accounted for in the data).

Figure 2.1: Useful floor areas of residential and non-residential sectors: breakdown by country.

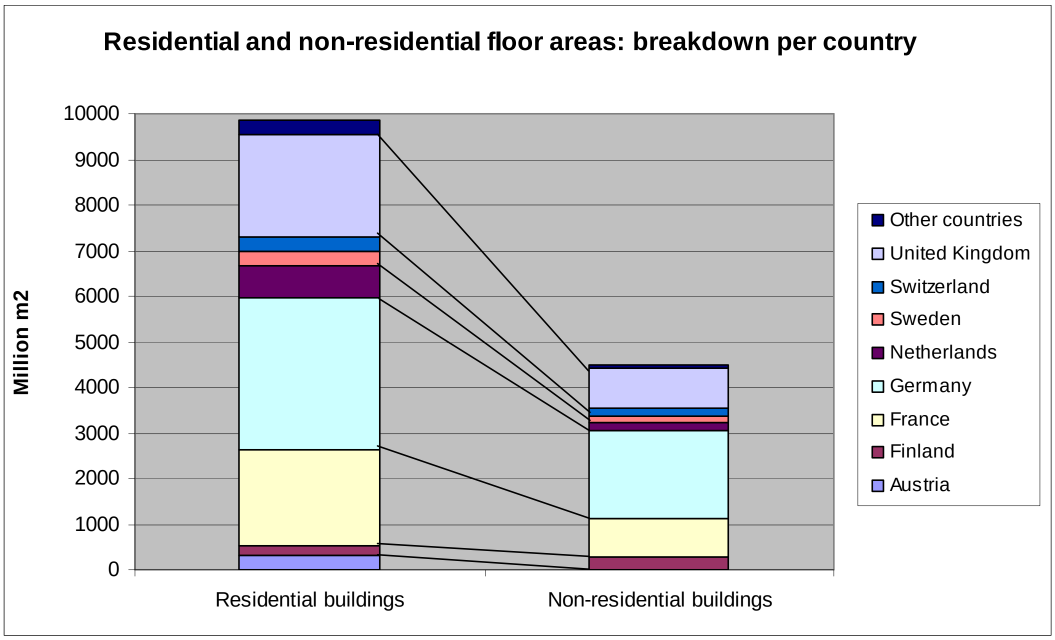
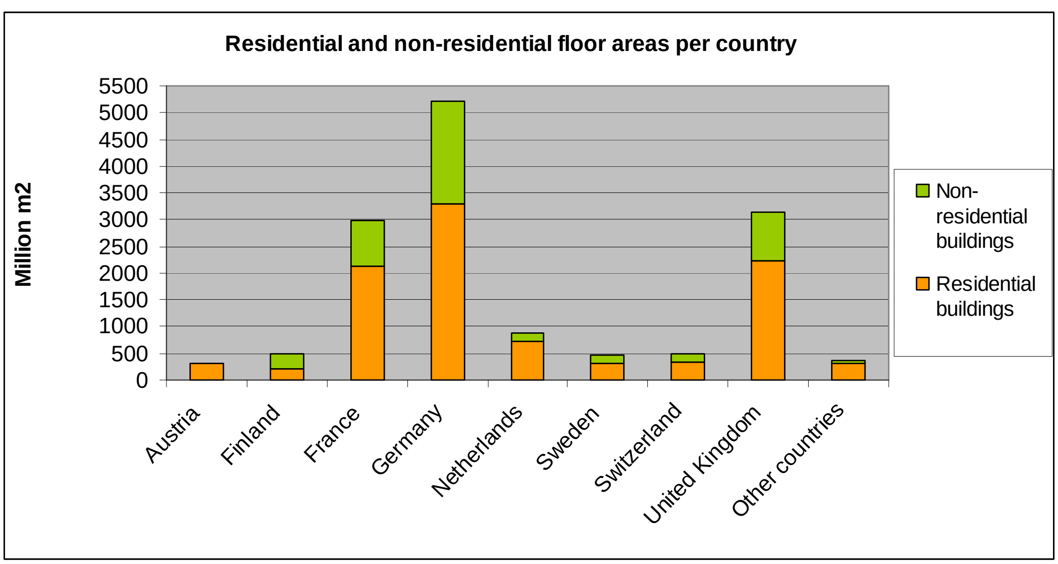


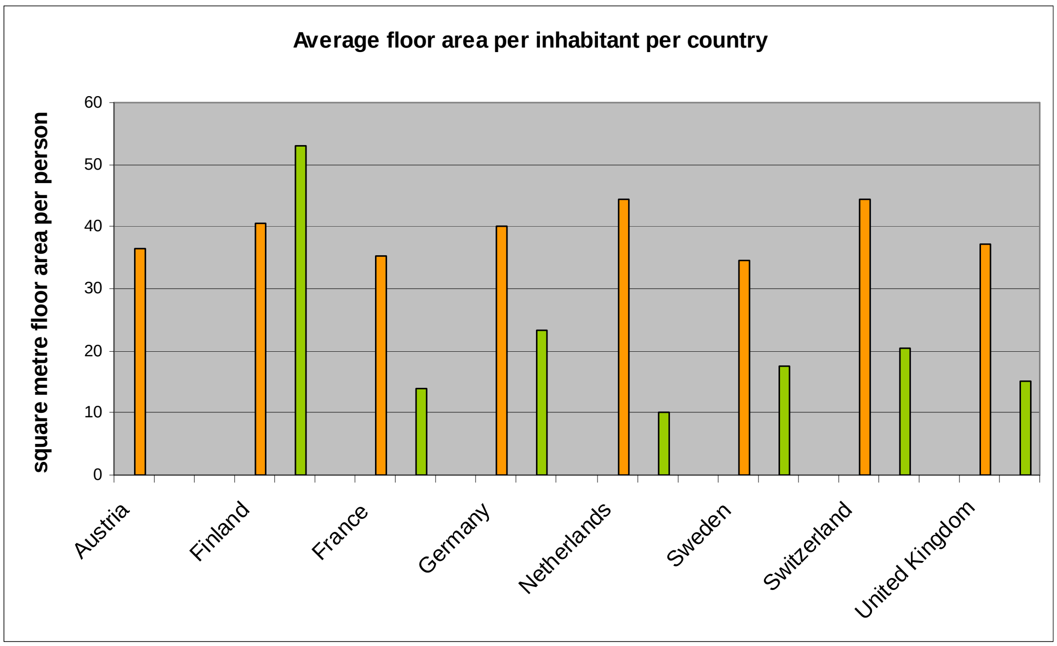
Figure 2.2: Residential and non-residential floor areas per country.



The large differences observed between countries are, however, directly related to the population of each country, at least for the residential sector. Figure 2.3 shows the average available floor area per inhabitant of the country. For the residential sector, the average useful floor area per inhabitant is 39 m^2, with Sweden at 35 m^2 having the lowest area, and Switzerland at 45 m^2 having the highest area.

For the non-residential sector, the data are less accurate and show large variations between countries (see also Chapter 5).

Figure 2.3: Useful floor area per person for residential buildings (orange/left) and non-residential buildings (green/right).

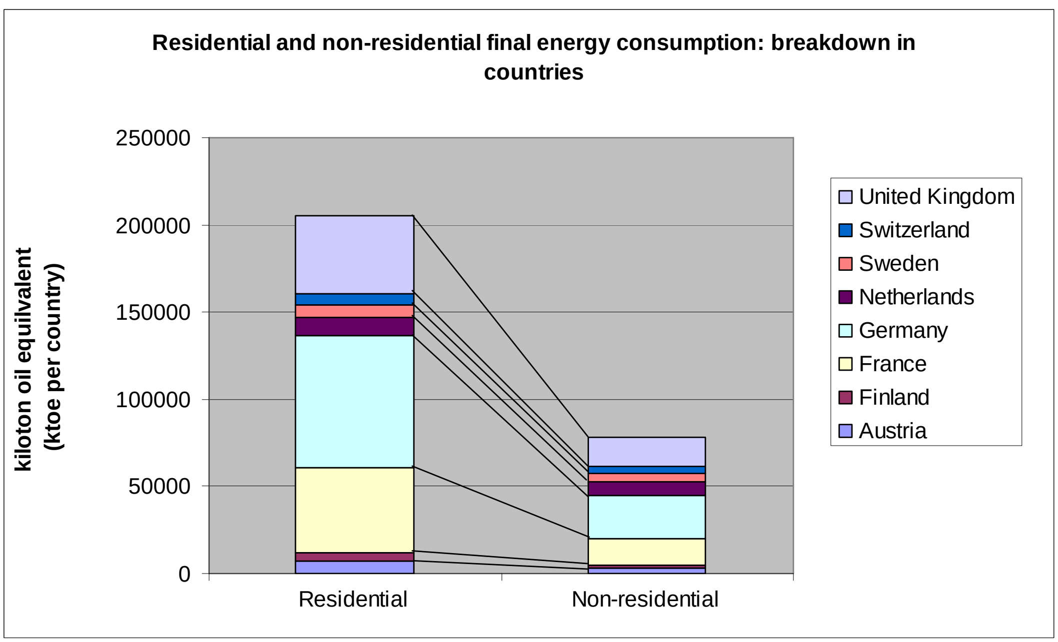


2.4 Compared final energy consumption in residential and non-residential sectors

In this chapter, the energy use of residential and non-residential building stocks are compared with each other and with the total energy use of the different countries. The basic data come from the energy balances for 2004 from the International Energy Agency (IEA, see references) and refer to the final energy consumption per country with the exclusion of primary energy sources for product manufacture (so called non-energy use). In the IEA statistics, the non-residential sector is defined as being the commercial and public services, which approximately corresponds to the definition of the non-residential sector used in the present report. The residential sector consists of households. The other sectors are shared by industry, transport, agriculture, forestry and fishing. The data for the construction industry, which are not specified in the IEA data, are taken from the energy balance for 2004 from Eurostat. In this European database, the construction industry, defined as the building materials industry, is aggregated with the glass and pottery industry, which introduces a small inaccuracy. The differences between data from Eurostat and the IEA are very small (< 2%). The detailed data can be found in Appendix B, Table B.1. Note that in this section geothermic and solar include wind energy. The final energy consumption includes all energy consumption of the residential and non-residential sectors, which means that the non-building related consumption, like electricity use for appliances, is also included.

The relative values of the total final energy use in the residential and non-residential sectors are given in kiloton oil equivalent (ktoe, 1 ktoe = 41 868 TJ) in Figure 2.4. The energy use of the non-residential sector is a little more than one third (37%) of the energy used by the residential sector. Because the floor area of the non-residential sector was about 43% of the floor area of the residential sector, it seems that the non-residential sector has a more efficient specific (per m^2) energy use. However, this efficiency could be very different in each sub-sector of the non-residential sector (see Chapter 4) and, as stated earlier in this chapter, there are a lot of uncertainties that make the comparability of the data questionable. Figure 2.4 shows the breakdown by country for the residential and non-residential total final energy consumption. Figure 2.5 shows the sources of energy used in the total final energy consumption of both sectors per inhabitant.

Figure 2.4: Total final energy consumption in residential and non-residential buildings: breakdown by country

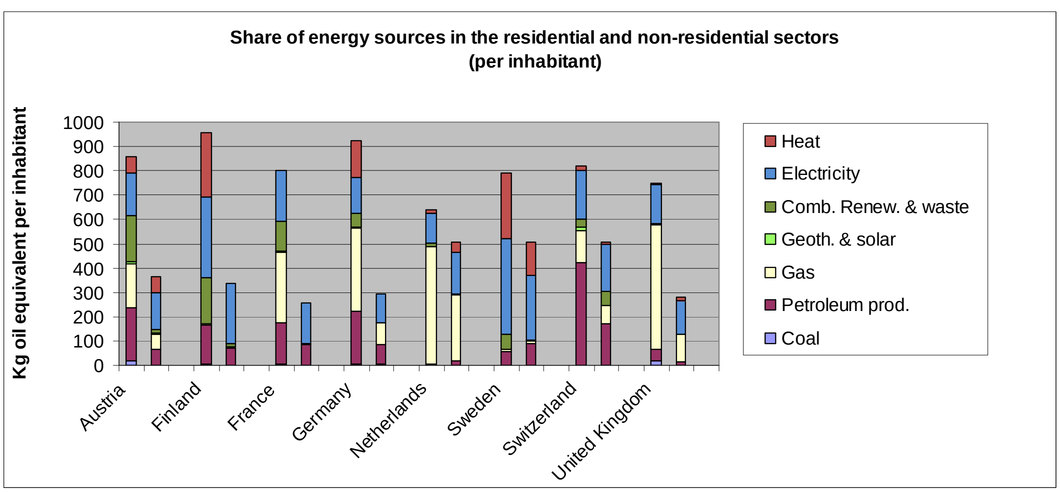


The magnitude of the energy use in each country is directly related to the number of inhabitants in the country (see Figure 2.4), although differences are observed between countries. Sweden, which has the lowest residential useful floor area per inhabitant, does not have the lowest residential energy consumption per inhabitant. The lowest energy consumption per inhabitant is found in the Netherlands, which has one of the highest useful floor areas per inhabitant. The highest energy consumption per inhabitant in the residential sector is found in Finland and Germany (see also Chapter 3.5).

The sources of energy used differ a lot in each country. Whereas the Netherlands and the United Kingdom use a large percentage of gas, this percentage is almost zero in Finland and Sweden. This is compensated for by a much larger use of electricity, heat and combustible renewables. The use of heat (district heating or cogeneration) has a very low penetration in France, the United Kingdom and the Netherlands, while its penetration is high in Finland, Sweden and Germany. Except for the Netherlands, all countries still use a non-negligible percentage of petroleum products. The degree of penetration of geothermy, solar and wind is very low in all countries, with Switzerland being a trendsetter in the field of geothermy and solar.
There are large differences between residential and non-residential energy consumption rates. In Austria, combustible renewables and waste account for 22% of the energy consumption in the residential sector, but they are negligible in the non-residential sector. In Finland, combustible renewables and waste account for 20% and heat for 28% in the residential sector, but they are negligible in the non-residential sector. In France, gas has a share of 36% in the residential sector and 0% in the non-residential sector. In general terms, it can be stated that the penetration of district heating is much higher in the residential sector than in the non-residential sector, as is the use of combustible renewables and waste. In this area, the residential sector acts as a pioneer.

The use of electricity is high in all countries, with an average share of 27% in the residential sector and 49% in the non-residential sector. Of all the countries, Sweden has the highest consumption of electricity for both sectors, followed by Finland, France and Switzerland. However, the primary energy sources for electricity production may differ a lot in each country; see Figures 2.6 and 2.7.

Figure 2.5: Share of energy sources for the residential (left) and non-residential (right) building stock per inhabitant (2004).



Energy production in France is mainly based (75%) on nuclear sources. In Sweden and Switzerland, there are almost equal shares of nuclear and hydropower (both around 50%). Austria is highly dependent on hydropower (60%) and the Netherlands on gas (60%). All countries except Sweden and Switzerland (and to a lesser

Figure 2.6: Energy sources for electricity production (2004).

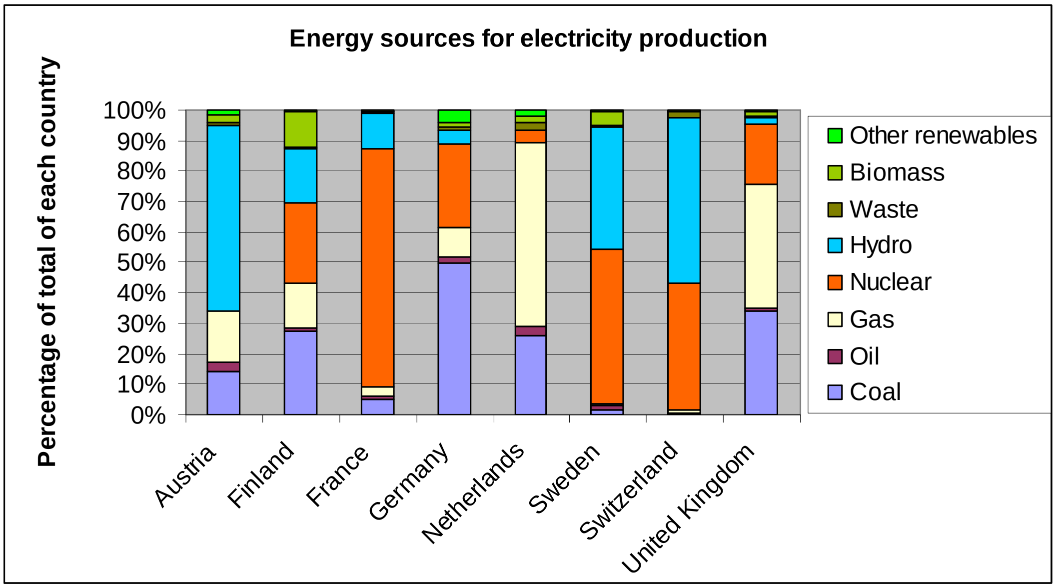
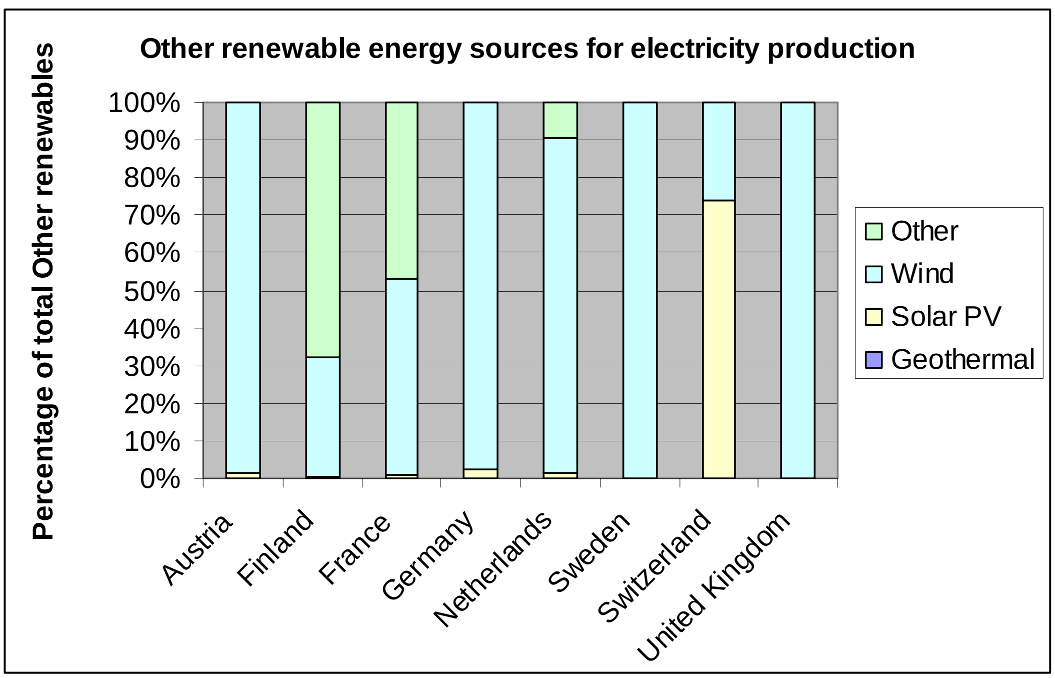


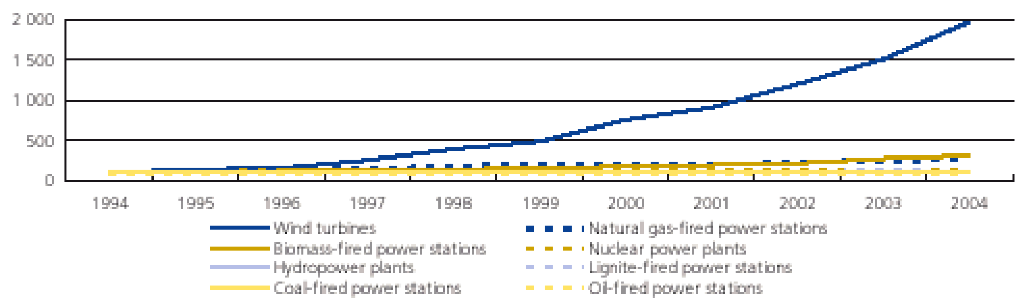
Figure 2.7: Renewable energy sources for electricity production (2004), other than biomass, waste and hydro. 100% corresponds to the series "other renewables" in Figure 2.6



extent France) still rely on coal for electricity production (share varying between 27 and almost 50%). Hydropower is the most widely used renewable source of electricity. Other renewable sources like waste, biomass and others that are described in Figure 2.7 have only a very limited share, with biomass and waste being the most utilised. Wind energy is predominant in the other renewable sources of electricity. The sustainability of the electricity production therefore differs greatly in each country. Austria, followed by Switzerland and Sweden, seem to have the most sustainable electricity production. Figure 2.8 gives the relative changes in fuel used for electricity generation in EU-25 since 1990. The increasing importance of wind power is visible.

However, it is important to keep in mind that the rational energy use of energy, also sometimes called the exergy approach, would imply that high quality energy sources like electricity, with which power can be generated, are not used for low quality applications like heating at low (near-environmental) temperatures. Therefore, in addition to the sustainability of the electricity production, it is important to determine to what extent the use of electricity is also sustainable. This will be dealt with in more detail in Section 3.8.

Figure 2.8: Relative changes (%) in electricity generation by primary energy source used (Eurostat, 2007) in EU-25



In Figure 2.9, the share of the final energy consumption per sector is given for each country as well as for the average of the eight countries. On average, the residential sector accounts for 30% of the total energy use, the non-residential for 12%, and the construction industry for 2%. The residential sector has the largest share in Germany with 34% and the lowest share Finland with 19%. The non-residential sector has the lowest share in Finland (7%) and the highest in Switzerland (18%). The construction sector accounts for no more than 2% of total energy use.

Figure 2.10 shows the same breakdown as Figure 2.9, but this time related to total electricity use. The electricity use for the residential and the non-residential sectors corresponds to the electricity consumption shown in Figure 2.5 for these sectors. In all countries, about 20% of the whole electricity production is used in the residential sector, and about 15% in the non-residential sector.

According to the EuroACE report "Towards Energy Efficient Buildings in Europe" and to Balaras (2007) more than half the final energy consumption of residential and non-residential buildings in the EU is used for space heating (see Figures 2.11 and 2.12). In the residential sector, water heating also plays a major role (25%). Lighting and major household electrical appliances account for more than 30% of the energy use of the non-residential buildings and remain limited to 11% for residential buildings. These figures differ from the data from the IEA and Eurostat (see Figure 2.5, 49% in the non-residential sector and 27% in the residential sector) because they do not account for the electricity use of small electrical appliances (brown goods). On average, for the EU-15, the electrical energy consumed by major electrical appliances and lighting in 2001 represents about 60% of the total electricity used by European households. In 1985, this was 53%. It can be stated from Balaras (2007) that in the EU-15, the share of space heating declined from 72.4% in 1985 to 69.6% in 2006, while it increased for lighting and major electrical appliances from 10.3% in 1985 to 12.3% in 2001.

Some specificities are mentioned hereafter and more detailed data are given, if available, in Chapter 3 (residential) and Chapter 4 (non-residential).

In Austria, 30% of all energy use is estimated to be for room heating and cooling. Of this, 42% comes from oil or gas, 22% from coal, 19% from renewable energy, 12% from district heating, and 5% from electricity (Statistik Austria 2005).

In Finland, the Ekorem report gives the main heat sources in the existing building stock in 2001 (in % volume.). Of the total energy use for heating, 10% comes from wood, 20% from light fuels, 1% from heavy fuels, 0.3% from gas, 0.4% from coals and turf, 20% from electricity, 46% from district heating, 0.4% from ground heat, and 2% from other sources. The trend in new construction (2002) is an increase in district heating (50% of the total new building stock) and electricity (27%) and a strong decrease in light fuels (9%) and wood (6%). Ground heat and others increased to 2.3% and 5%.

In France, the total production of renewable energy has been constant in recent years at about 3.5% of the total energy production. Renewable energy production is used for 86% of electricity generation and for 24% of thermal applications. 99.9% of renewable electricity production consists of hydraulic power plants. Some 86% of renewable thermal energy production is obtained from wood combustion. (Energy statistics from the Ministère de l'économie, des finances et de l'emploi).

Of the total solar domestic hot water systems installed in the Netherlands, 89% were installed in residential buildings and 11% in non-residential buildings. Altogether, 620 000 m^2 of solar collectors were installed, generating 0.18 GWh. Photovoltaic cells have been placed in 10 000 homes (new building stock) and generate 0.051 GWh electricity. Of all the photovoltaic cells in the Netherlands, 80% are in the residential sector and 20% in the non-residential sector. The use of heat pumps increased from 24 MW in 1995 to 376 MW in 2005. Long-term energy storage in aquifers (use of ground water heat) has also been used more often in recent years and increased from 25 MW in 1995 to 513 MW in 2005.

In Sweden, space heating and hot water contributed to about 60% of the total use of energy in the housing and service sectors in 2003. About 34% is used as household electricity and for appliances. Since 1973, the overall share of fossil fuels in Sweden has fallen by about 70%. District heating has been extended and above all replaced oil-fired boilers. District heating production has also undergone a changeover from fossil fuels to bio fuels, as well as to more waste heat and to heat recovery from waste. For all the renewable energy in Sweden, 92.2% comes from hydraulic plants, 6.9% from biomass and 0.9% from wind.

Figure 2.9: Final energy consumption persector in each country, 2004(IEA and Eurostat).

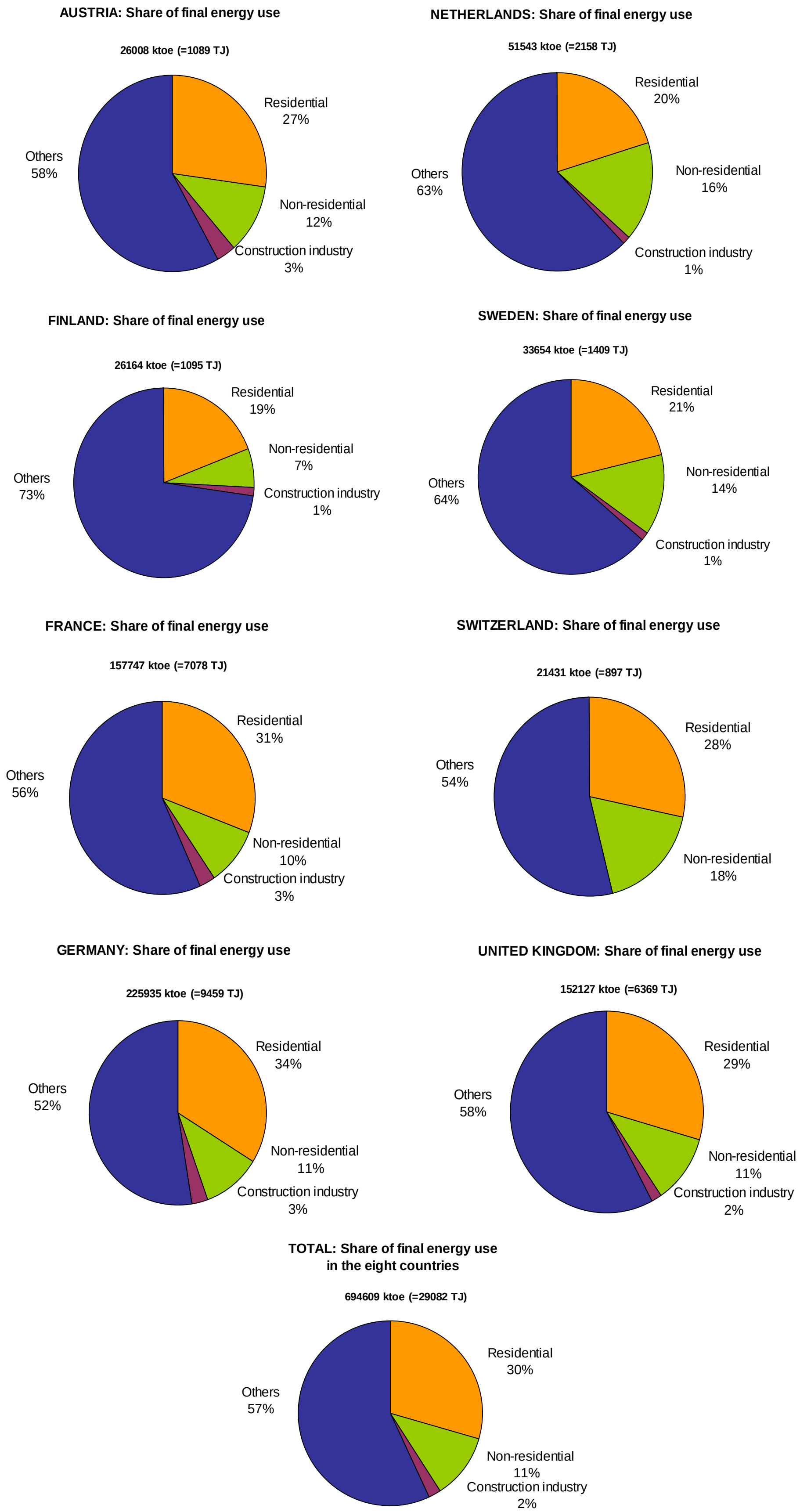


Figure 2.10: Final electricity consumption per sector in each country.

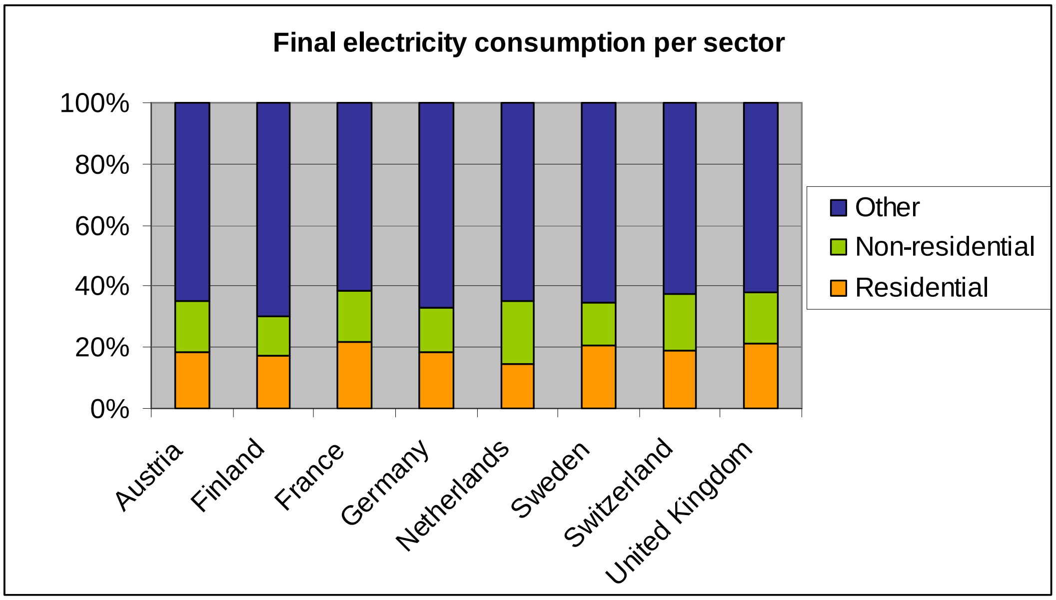


Figure 2.11: Final energy consumption in the residential sector in EU-countries: breakdown in end-use (EuroACE)

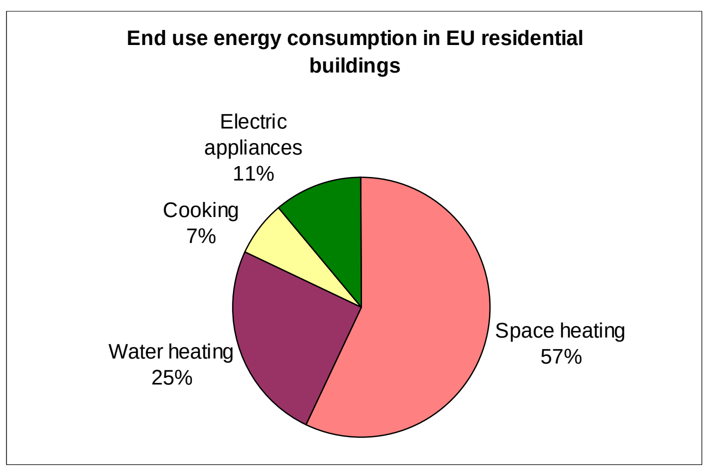
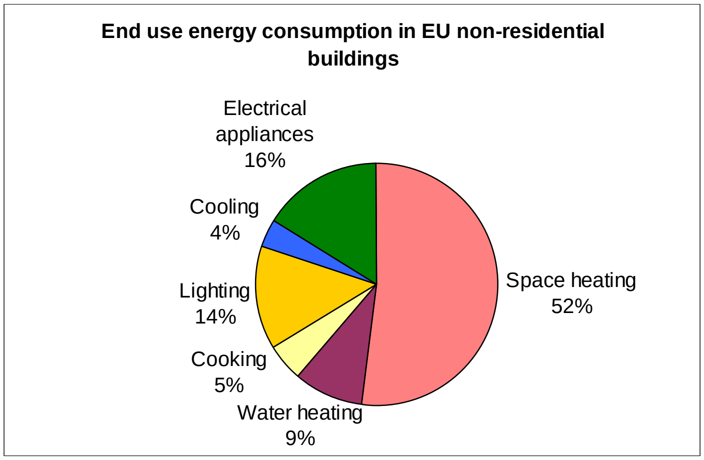


Figure 2.12: Final energy consumption in the non-residential sector in EU-countries: breakdown in end-use (EuroACE).



2.5 Summary and conclusions

The following conclusions may be drawn from the analysis of the basic data on the residential and non-residential buildings stocks:

Quality of data:

1. Except for data from the IEA and Eurostat, data, definitions and methods used in national statistics for the residential sector differ in each country, which is not favourable to accurate comparisons between countries.
2. There is much more official data available for the residential sector than for the non-residential sector. Data on the non-residential sector are scarce and scattered through a lot of private companies or sector organisations.

In the future, the development of consistent European statistics to assess the built environment should be considered. Such a statistics model could be based on the methods used for Eurostat or by the International Energy Agency. For instance recommendations are made for the harmonisation of statistical data for the residential sector in a working paper of UNECE (2004). Although it is not necessary to centralise all statistics, it is of importance that at least a common basis is set up in all countries. This would allow better comparison and monitoring of the building stock in the future.

Relative importance of the residential and non-residential building stocks

1. Although the residential building stock accounts for about 70% of the total building stock, the non-residential stock, with its share of 30% is far from negligible.
2. In the residential sector, there are no large differences between the useful floor areas per inhabitant of different countries. On average, this useful floor area is 39 m^2. In the non-residential sector, the comparability of the data is low.

A programme aimed at improving the sustainability of the building stock could take into account the residential as well as the non-residential stock. Of course, barriers, opportunities and technical solutions will be different in each sector, and the non-residential sector is not as large as the residential one, but it could be of major importance in making sustainability visible and increasing the consciousness of citizens.

Energy consumption in the residential and non-residential sectors

1. When taking into account all countries participating in this study, the final energy consumption in the residential and non-residential sectors is almost proportional to the useful floor areas in these sectors.
2. On average, the residential sector is responsible for 30% of the total final energy consumption, the non-residential sector for 11% and the construction industry for only 2%. There are large differences between countries, the lowest shares being observed in Finland for both the residential and the non-residential sector (19% and 7% respectively) and the highest shares being observed in Germany for the residential sector (34%) and in Switzerland for the non-residential sector (18%).
3. On average, water and space heating are responsible for a very large part (more than 60%) of the final energy consumption in both residential and non-residential sectors.
4. Electricity use for major household appliances (white goods) and lighting also has a large share (60%) and this share increases regularly. Brown goods (small electrical appliances) consume about 40% of the total electricity used by European households.
5. Although there is a strong increase in renewable sources, the energy supply still relies largely on fossil fuels. However, the use of combustible renewable and waste sources is high (more than 20%) in Austria, Finland, and in the residential sector in France. Electricity also has, as an energy source, a high share in all countries. District heating has a high degree of penetration in Finland, Sweden and Germany.
6. The sustainability of the electricity production differs a lot by country. Austria, Sweden and Switzerland largely use hydropower (more than 50%). France, Sweden and Switzerland also use nuclear power (75%, 50% and 45% respectively). Except for hydropower, renewable energy sources are used in a very limited way for electricity production with biomass and waste being the most utilised and wind having the fastest growing share.

Because water and space heating are still responsible for a large part of the energy consumption, activities aimed at reducing this consumption will continue to be needed in the coming years. The electricity use is also relatively high in all countries and increases continuously. Although part of this electricity use is not related to the building itself, the building could have a role in reducing the environmental burden of electricity production. In this sense, optimising natural lighting, in the existing building stock too is an issue, as well as using the building as an energy/electricity generator, which could be even more important in countries with non-sustainable electricity production. Finland, Sweden and Germany have more experience than other countries in using district heating. Therefore, programmes aimed at knowledge sharing could contribute to more successful implementation in other countries.

3 Characteristics of the residential building stock

3.1 Introduction

The residential sector represents almost 70% of the building floor area of the eight countries studied. As already stated in Chapter 2, statistical data are available, but they differ a lot between the various countries in terms of definitions and methods used. A main difference is the type of accommodation accounted for in the dwelling stock. This makes a thorough comparison difficult, but does not affect the results too much as presented in this report.

- Summer and winter houses are accounted for, except in Finland, Germany, the Netherlands and Sweden.
- Second homes are accounted for, except in the Netherlands and Sweden.
- Collective homes are not accounted for, except in Sweden.
- Hotels, caravans and ships are not accounted for, except in France.
- Vacant dwellings are accounted for, except in Germany.
- Non-permanent habitations are not accounted for, except in Finland.

In this chapter, the following characteristics of the existing building stock are considered: ownership structure, building types and tenure, regional specificities, and age.

3.2 Ownership structure and stakeholders

The residential building sector is divided into three main categories: owner-occupied, social rented, and private rented. These categories are relatively well documented in official sources. The data are summarised in Table 3.1 and in Figure 3.1.

Table 3.1: Residential building stock: breakdown by tenure type and stakeholder (%)

In %	Owner-occupied	Social rented			Private rented			Others	Total
		Housing associations	Municipality	Others	Private investors	Corporate investors	Others		
Austria[1]	49	11	9		16	4		11	100
Finland[2]	63		17.2		16.8			3	100
France[3]	56.2	14.4		4.4	23.9	1.1			100
Germany[4]	40.3	1.1	5.4	5.2	36.6	11.4			100
Netherlands[5]	52.5	35.7				11.8			100
Sweden[6]	46.4	21.9	1.3	16.9	3	9.5		1	100
Switzerland[7]	35	4	4		31	17	5	4	100
United Kingdom[8]	71	8	10			11			100

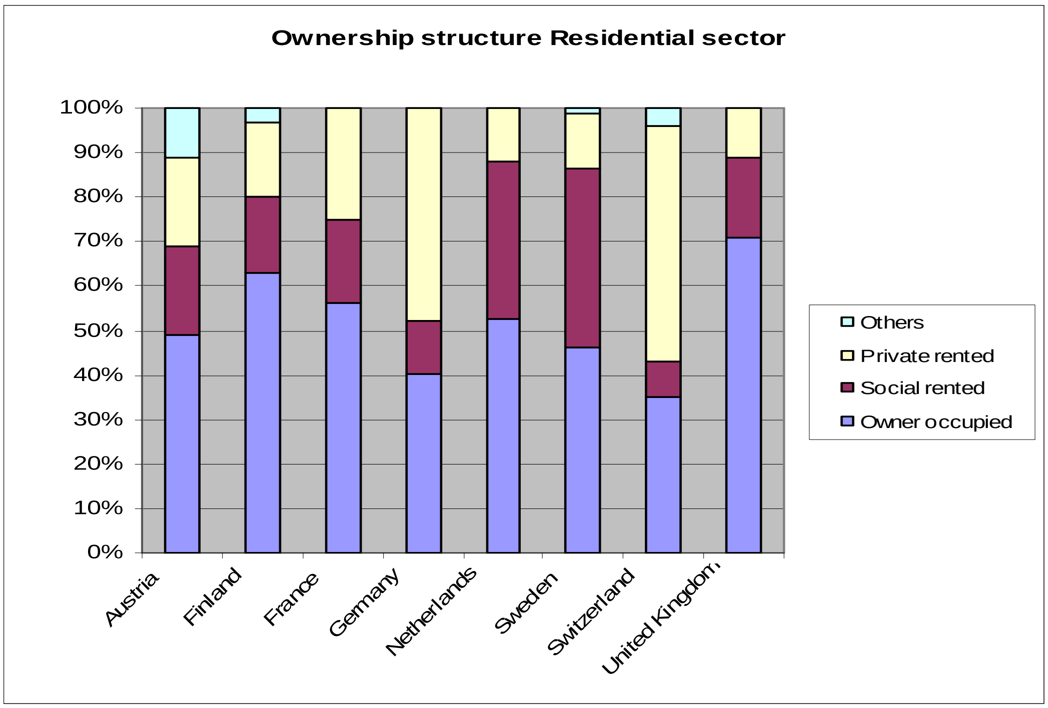
[1] from Statistik Austria Jahrbuch 2007, statistics for 2001
[2] from Statistics Finland: Housing 2005 and Housing Statistics in the European Union 2004
[3] from www.statistiques.equipement.gouv.fr and www.recensement.insee.fre
[4] data are also available in m^2, see appendix. Social rented/others are cooperatives.
[5] from KWR 2000
[6] from Statistics Sweden: Housing and Construction, for 1990. In the category Social rented/others, the percentage 16.9% refers to private cooperatives. Note that some discrepancy was found between

the data for Sweden from Statistics Sweden and the data from the regular National Report on Housing Development which gives figures other than in Table 3.1: 38% owner-occupied in 2002 and 46% rented, of which 52% social rented. It is not known whether this shift is real or whether it comes from the method used.

[7] from BFS, Wohnungszählung 2000

[8] from English House Condition Survey 2007, statistics from 2005 – data for residential are for England only

Figure 3.1: Residential building stock: breakdown in tenure type.



Owner-occupied dwellings represent 35% to 62% of the total stock, with an especially high share in England (70%). Germany and Switzerland have a large private rented sector (about 50% of total stock) and Sweden and the Netherlands have a very large social rented sector.

Roughly stated, the owner-occupied and the rented sector both share about 50% of the residential market. Therefore, they have the same importance for the achievement of sustainable renovation. However, the characteristics of these two residential sectors differ a lot. In the owner-occupied market, the investor is also the one who profits from the investment. There is often a lack of financial means to invest (see Chapter 7). Furthermore, it is a non-professional market, where small contractors and 'Do-It-Yourselfers' are predominant, with all the related characteristics (see Chapter 5).

A major characteristic of the rented sector is that the owner has to invest, whereas the occupant profits from the investment. In the private rented sector, this may be solved by increasing the rent, insofar as this is desirable and possible within the existing regulations. In the social rented sector, this would be more difficult, therefore specific financial solutions and regulations will probably be necessary (see Chapter 7).

The social rented sector is organised differently in the eight countries studied. However, a common characteristic is the high level of regulation and the closer relationship with local or national governments.

In Austria, social housing is provided by municipalities and limited-profit housing associations. The central government is responsible for the regulation of home ownership and for laws in the rented sector.

In Finland, municipalities own the largest share of social rented housing (60%) while a further 20% is owned by non-profit agencies. Cost rents are charged for all dwellings financed with the aid of state subsidised loans. "Right of occupancy" tenure was introduced in the 1990s, which falls between social renting and owner-occupancy. Residents buy a dwelling by paying 15% of its value and pay a monthly charge for management and maintenance. About 1% of the Finnish housing stock is a right-of-occupancy dwelling.

In France, social housing is provided by public agencies funded by local authorities and by private non-profit social firms. Social housing providers obtain specific loans from a public bank, funded by deposits in the housing-savings scheme, which is currently under attack by the European Commission.

German social housing is market-based and dominated by three major groups of institutional providers: public housing companies controlled by local authorities, housing cooperatives controlled by members, and private owners who manage social housing in return for a secure but limited profit.

In the Netherlands, social housing is owned by housing associations. These have to act on a commercial basis, but are required to use their profits for housing those people who are not able to find decent housing themselves.

Social housing in Sweden is provided by municipal housing companies. Next to social housing, the cooperative tenure provides an alternative to renting or owning a dwelling. Once a household is accepted as a member, it makes a payment for the right to occupancy and pays a monthly charge to cover the cooperative running costs.

In Switzerland, there are two categories of social housing: subsidised low cost apartments, generally owned by public bodies, and medium cost apartments, generally owned by the private sector. Subsidies are paid directly to the tenant.

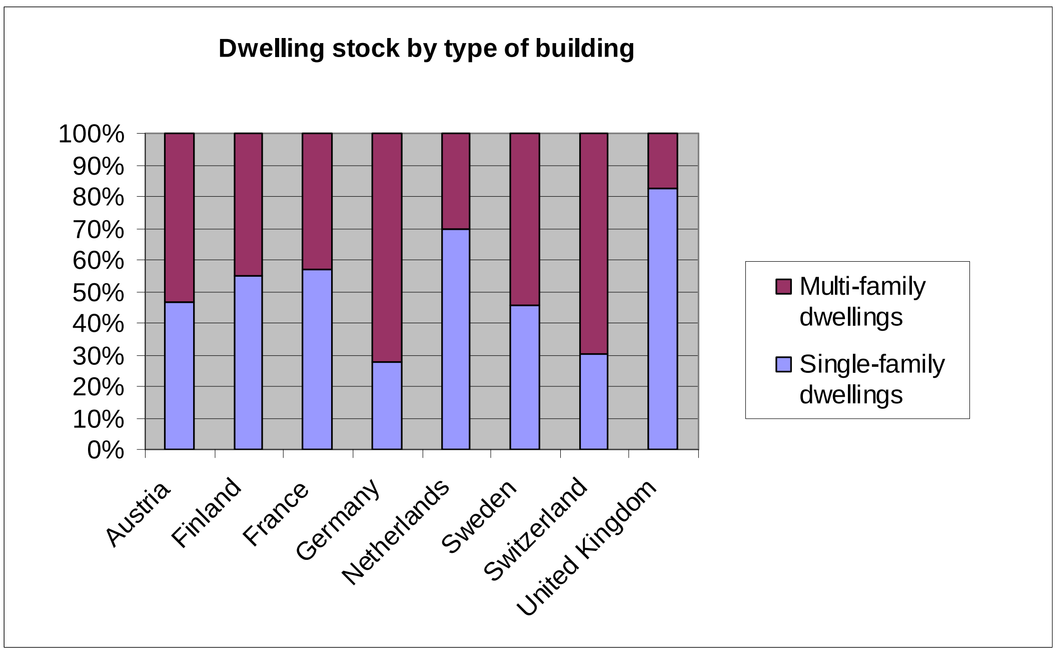
In the United Kingdom, social rented dwellings are owned by local authorities and registered social landlords.

3.3 Building types

Dwellings are generally divided into single-family houses and multi-family houses. Statistics are presented in Housing Statistics in the European Union 2004. Most of the data provided at national level are quite similar to these statistics. However, both sources of data are not completely reliable because different definitions have been used in the national data collection by the countries. As stated in Housing Statistics in the European Union 2004, the concept of a single-family dwelling is defined to include detached, semi detached and terraced houses. However, the concept of the single-family may have been interpreted by some countries in such a way that two-family houses and/or terraced houses have been put into the category of multi-family houses. This is especially true in the case of Switzerland and Finland. A second point for attention is that secondary homes and vacant dwellings may have been treated differently in different countries (see also Section 3.1). The total number of dwellings presented in Table 2.2 may differ slightly from the number presented in Table 2.1, because the breakdown in building types was not always available in the sources used in this table.

Figure 3.2 shows the breakdown of the residential building stock into single-family and multi-family dwellings. In Austria, Finland, France, and Sweden, there is approximately the same number of multi-family dwellings and of single-family dwellings (around 50% for each). The Netherlands and the United Kingdom have a large number of single-family homes (up to 80% for the UK). Germany and Switzerland have a large share of apartment buildings (more than 70%) whereas the United Kingdom has a very low share (less than 20%).

Figure 3.2: Dwelling stock by type of building



In Switzerland, two-family houses are counted separately from single-family houses, but in Table 3.2 both categories have been combined. In France, Germany, and Switzerland there is no breakdown of single-family houses into detached and terraced houses. However, in Germany there is a breakdown into these categories based on floor area. On the basis of floor area, almost 87% of single-family houses are detached. In Austria, almost all single-family houses are detached as well, but in Sweden most of them are terraced houses. In Finland and the United Kingdom, the share of terraced houses is 26% and 39% respectively. In the Netherlands, it amounts to 57%.

Table 3.2: Dwelling stock by type of building (in number of dwellings)

	Single-family houses		Multi-family houses		Total
	Terraced houses	Detached houses	Apartment blocks	Apartments	
Austria[1]	1 810 000			2 053 000	3 863 000
Finland[2]	346 920	991 200		1 090 320	2 478 000
France[3]	15 789 815			11 964 735	27 754 550
Germany[4]	10 658 000		9 078 584	27 500 000	38 158 000
Netherlands[5]	2 787 972	2 090 979		2 090 979	6 969 930
Sweden[6]	2 018 093			2 417 810	4 435 903
Switzerland[7]	1 081 239		501 091	2 499 761	3 581 000
United Kingdom[8]	6 299 000	11 678 000		3 804 000	21 781 000

[1] from GWZ 2001 + Amann & Komendantova 2007
[2] from Housing Developments in European Countries 2004. Secondary homes are excluded from these statistics. There are about 470000 secondary and holiday homes in Finland.
[3] Laboratoire Economie et Statistiques du CSTB
[4] from Housing Statistics in the European Union 2004. Total is different from Table I.1.1 because of other sources used.
[5] Basisrapportage KWR 2000 + Statistics Netherlands
[6] from Statistics Sweden: Housing and Construction, with projection to 2006 + Statistics Sweden 2007
[7] from BFS, Wohnungszählung 2000; two-family houses were put into the category single-family houses whereas “more than two-family houses” were put into the category multi-family houses.
[8] from English House Condition Survey 2007, statistics from 2005 – data for residential are for England only. % for the UK will be assumed to be the same.

3.4 Relationship between type of building and tenure

Because barriers and opportunities are likely to differ according to the type of tenure (see Chapter 7) and to the type of dwelling the relationship between both may be of importance. This relationship is shown in Table 3.3. With the exception of Germany and Finland, the breakdown by tenure and type of building is available for all countries. In general, a very large share of single-family houses is owner-occupied. For multi-family houses the shares vary a lot. In Sweden, for instance 68% of the multi-family houses are social rented, while this percentage is only 6% in Switzerland. In a country like Switzerland, it may be more difficult to implement the renovation of apartment buildings because the ownership – and therefore the responsibility – is shared between several households. In France, a very detailed breakdown by tenure and type is available and can be found in Appendix C, Table C.1.

Table 3.3: Distribution of building types per stakeholder (%)

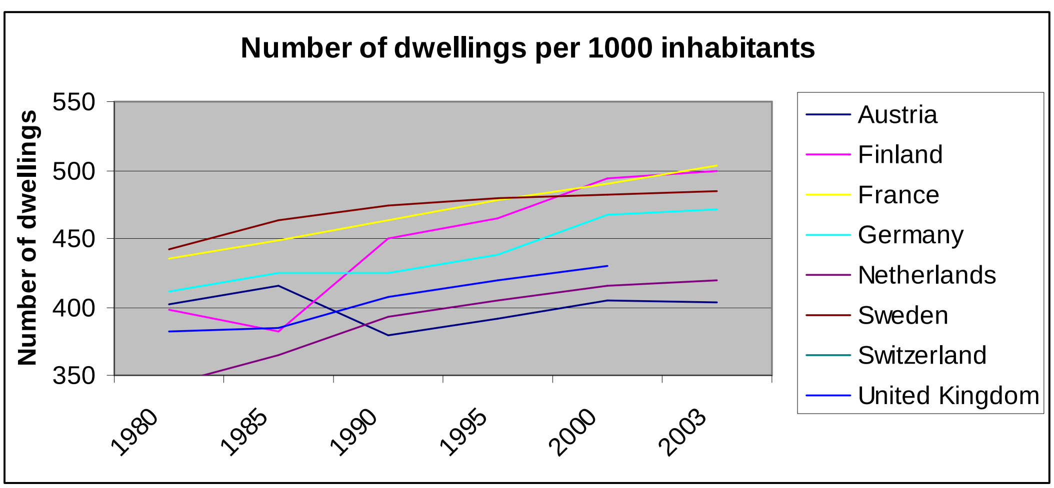
		Owner-occupied	Social rented	Private rented	Total
Austria[1]	*Single-family houses*	96	2	1	100
	Multi-family houses	63	29	7	100
Finland[2]		n.a.	n.a	n.a	
France[3]	*Single-family houses*	80	8	12	100
	Multi-family houses	25	35	40	100
Germany[4]		n.a	n.a	n.a	

Netherlands[5]	*Single-family houses*	66	26	8	100
	Multi-family houses	21	58	21	100
Sweden[6]	*Single-family houses*	91	8	1	100
	Multi-family houses	13	68	19	100
Switzerland[7]	*Single-family houses*	86	14		100
	Multi-family houses	20	80		100
United Kingdom[8]	*Terraced houses*	69	18	13	100
	Detached houses	84	9	7	100
	Multi-family houses	32	45	23	100

[1] from GWZ 2001, ISIS Databank. For the social rented sector, an additional breakdown for multi-family houses is available in housing associations (16%) and municipalities (13%).
[3] from LES/CSTB study (see REF2) based on Housing Inquiry 2001-2002, Census 1999, database COMMbat and specific data from CSTB and INSEE. A detailed breakdown by type of tenure is available, see Appendix C.
[6] from Statistics Sweden 1990. For the social rented sector, an additional breakdown is available in public social housing (3/38% respectively), municipalities and state (1/2% respectively) and private corporations (4/28% respectively.)
[7] from BWO 2005, Spezialauswertung, p.31. For the social rented sector, an additional breakdown is available in housing cooperatives (1/3% respectively), municipalities, cantons and state (2/3% respectively) and corporate housing by employers (0/4% respectively).
[8] from English House Condition Survey 2005. For the social rented sector, an additional breakdown is available in housing associations (9/4/20% respectively) and municipalities (9/5/25% respectively).

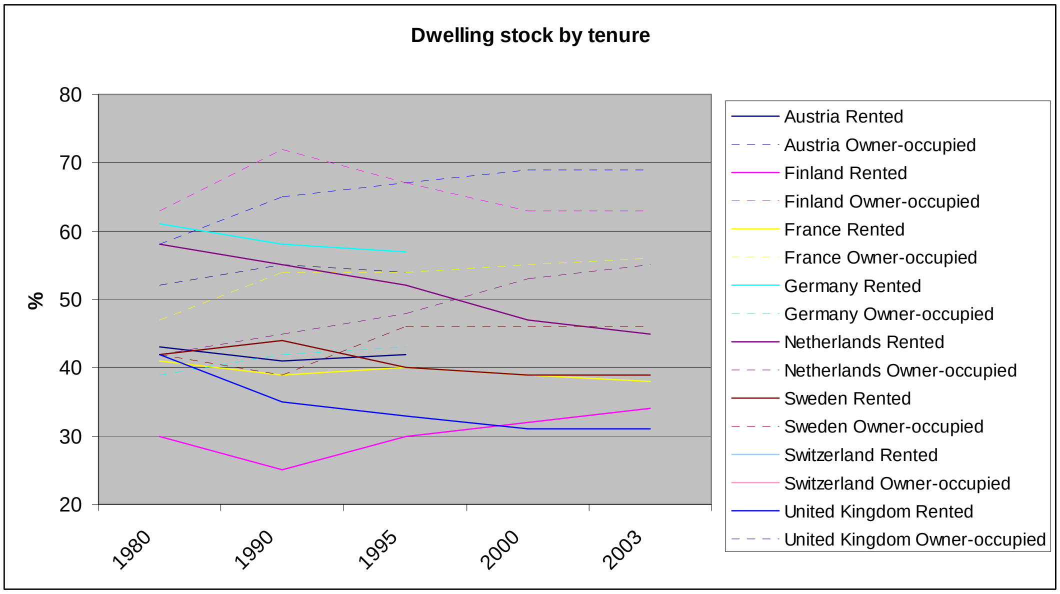
Figures 3.3 and 3.4 show the evolution of the number of dwellings per inhabitant, and the evolution of tenure type is shown between 1980 and 2003. In all countries, the number of dwellings per inhabitant increases regularly, because of population increase and because households are getting smaller. In all countries except Finland, the share of owner-occupied dwellings increases regularly while the share of rented dwellings decreases. This trend is likely to persist in the coming years.

Figure 3.3: Evolution of the number of dwellings per 1000 inhabitants*.



* Data from Housing Statistics in the European Union 2004

Figure 3.4: Evolution of tenure in the residential building stock*.



* Data from Housing Statistics in the European Union 2004

For the Netherlands and United Kingdom, more detailed data on the evolution of the type of tenure are available for a longer period.

In the Netherlands, owner-occupation grew from 30% in 1950 to 55% at present, whereas the private rental sector declined from 25% to hardly 11%. Almost two thirds of the stock is at present privately owned. In the near future, the importance of the privately owned housing stock is expected to continue to grow (Thomsen & Meijer 2007).

Since the early 1980s, there has been only a modest growth in the population of the United Kingdom, but the decline in average household size over this period has resulted in a considerable rise in the total number of households in England. The number rose by over two million in the 1980s from 17.2 million households in 1981 to 19.3 million in 1991. This growth has since continued at a slower rate, reaching a total of 20.8 million households in 2006 (GDLC 2007, Housing in England). The growth in home ownership has slowed since the early 1990s. The total number of owners increased from 9.9 million (57% of all households) in 1981 to 14.6 million (70%) in 2006. The number of households renting from the council (social housing) fell from 30% in 1981 to 11% in 2006. The decrease in council tenants in the 1980s can be attributed to the Right-to-Buy scheme where council tenants were given the opportunity to buy their own home. More recently, the direct transfer of council dwellings to housing associations has contributed to the continued decline in the number of households in council dwellings. Overall, the proportion of households in the social sector has declined by 1.8 million since 1981. In 2006, 2.5 million households were renting privately – a rise of about 25% since 1999. There are several possible reasons for this. First of all the continuing rise in property prices has forced younger people to remain longer in the private rented sector; secondly, increasing numbers of people are looking to buy an additional property for their pension portfolio; and thirdly, the advent of the Buy-To-Let mortgage has made it easier to finance this type of purchase.

3.5 Regional specificities

First, the difference between urban and rural areas is briefly studied. The definitions of urban and rural area may differ by country. The results are therefore only indicative. In general, rural areas include all territory lying outside cities, which includes small towns with less than 2500 inhabitants, agricultural lands and remote areas. From Table 3.4 it can be concluded that apartments are mainly located in large municipalities. Single-family houses may be found in equal shares in rural and urban areas. However, large differences are observed between countries. In Switzerland, 63% of single-family houses are located in urban areas whereas the figure is only 22% in Germany.

Table 3.4: Share of dwelling types located in urban areas

	Single-family	Apartments
Austria[1]	n.a.	n.a.
Finland[2]	n.a.	n.a.
France[3]	59%	95%
Germany[4]	22%	78%
Netherlands[5]	35%	93%
Sweden[6]	n.a.	n.a.
Switzerland[7]	63%	76%
United Kingdom[8]	82%	93%

[3] from Laboratoire Economie et Statistiques CSTB
[4] from Bundesamt für Bauwesen und Raumordnung/BBR: Wohnungsmärkte in Deutschland. Ausgabe 2004 Berichte Band 18.
[5] from Basisrapportage Kwalitatieve woonregistratie 2000 VROM. Rural area is defined as municipalities with less than 30000 inhabitants.
[7] from BFS Wohnungszählung 2000
[8] from English House Condition Survey 2001

Second, a few other regional specificities that may be of importance have been noted.

In Austria, the structure of the housing market differs greatly between Vienna and the rest of the country. Social housing accounts for 25% of dwellings in the country as a whole (N.B.: this figure differs a little from Figure 3.1 because other sources were used), but in Vienna, this figure is 48%. In Austria as a whole, 10% of the dwelling stock is publicly owned, whereas in Vienna, this figure is 26% (Social housing in Europe 2007).

In France, there is spatial polarisation around the largest metropolitan areas (Paris, Lyon and Marseille), between municipalities without any social housing and municipalities with 70% social housing. Social housing is also predominantly urban; 62% is located in cities of more than 100 000 inhabitants, whereas 14% is located in cities with less than 10000 inhabitants or in rural areas (Social Housing in Europe 2007).

In Finland, the population is centred on growth centres like the Helsinki Metropolitan area, Tampere, Turku and Oulu. The high demand for housing in those areas ensures market demand and the renovation of existing stock. In other parts of the country, there are problems with vacant properties especially in the housing blocks built in the seventies where one can buy a detached house for the price of a small studio in Helsinki.

In Germany, there is a general oversupply of rental housing in economically weak regions especially in the eastern states of Germany, and a strong demand in the more prosperous regions along the so called "blue banana" including Hamburg, the Rhine river valley, Stuttgart and Munich. Due to the lack of job opportunities in the eastern part of Germany, there is a substantial drain of population to the western states of Germany, significantly reducing the permanent resident population. Actually, in eastern Germany the demand for additional housing in multi-storey houses does not exist – the argument is rather to demolish high-rise housing estates to make the market smaller by reducing the supply side. New constructions are predominantly single-family homes. As the greater part of rental housing in Germany dates back to between the 1950s and 1970s, there is a great deal of housing characterised by small rooms which does not match the current priorities of tenants. Due to the construction of the buildings - load bearing inner walls of brick or concrete - in many cases the dwellings cannot be altered significantly to match the changed demand. The solution then would be demolition and new construction.

In the United Kingdom, there is little variation in the quality of social housing in areas of different socio-economic status, but the quality of owner-occupied housing does vary with the social-economic status of the location.

3.6 Age of the residential building stock

Data on the age of the building stock give a good indication of the physical characteristics of buildings and therefore also an indication of the construction current at the time and the buildings' thermal quality. However, this quality also depends on whether and to what extent these buildings have been renovated. This will be dealt with in Section 3.7. Table 3.5 and Figure 3.12 give a breakdown by different construction periods. Because the periods used in each country vary, estimates based on several sets of data have been used for Germany, the Netherlands, and the United Kingdom that may introduce some inaccuracies. However, the level of accuracy is good enough to describe main trends.

The pre-war dwelling stock accounts for 20% to 39% of the total dwelling stock, with the exception of Finland where this figure is only 10%. In general, the pre-war building stock is reasonably homogenous in terms of construction characteristics (see also Section 3.7).

Dwellings built after World War II and before the oil crisis account for 18% (France) to almost 38% (Sweden) of the dwelling stock. The average is 29%. This dwelling stock, which represents almost one third of the total stock, is not very homogenous. A varied mix of construction types exists, from traditional to modern, from low rise to high-rise. A common characteristic, however, is that the buildings were generally poorly insulated at the time of construction and that there is a need for renovation (see Section 3.7 and Chapter 5).

In most countries, the dwellings built between 1970 and 1990 account for 21% to 27% of the total stock. Exceptions to this are France and the Netherlands with a share of more than 35% for this building period, and Finland with more than 43%. In general, the dwellings built during this period are reasonably well insulated, but already need some kind of renovation, especially the older ones.

Table 3.5: Residential building stock: breakdown by period of construction (%)

	<1919	1919-1944	1945-1960	1961-1970	1971-1980	1981-1990	>1990	Total
Austria[1]	19	8	12	16	15	12	18	100
Finland[2]	1.6	8.8	30.6		23.4	20	14.4	98.8
France[3]	19.9	13.3	18		26	10.4	12.4	100
Germany[4]	12	9	31		26		22	100
Netherlands[5]	7.3	13.6	30.9		35.4		11.6	98.8
Sweden[6]	12.3	14.9	37.8		17.2	9.6	8.2	100
Switzerland[7]	25	13	26		25		11	100
United Kingdom[8]	21.7	17.5	28.1			21.6	11.1	100

[1] from ISIS database, data from 2003. These data are similar to the data in Statistics in the European Union 2004, data for 2002

[2] from Housing Statistics in the European Union 2004, data for 2002

[3] from Housing Statistics in the European Union 2004, data for 2002

[4] Data in m^2 from IWU, based on micro census 1998 from Housing Statistics in the European Union 2004, data for 2002, (<1919: 14.6%; 1919-1944: 12.6%; 1945-1970: 47.2%; 1971-1990: 10.9%; 1980-1990: 14.6%)

[5] from Housing Statistics in the European Union 2004, data for 2002 and from KWR 2000

[6] from Statistics Sweden (data for 2005). Differs a little from Housing Statistics in the European Union 2004, data 2003 (<1919: 12.4%; 1919-1944: 17.7%; 1945-1970: 21.2%; 1971-1990: 21.8%; >1990: 18.5%)

[7] Data from BFS Wohnungszählung 2000

[8] Data based on English House Condition Survey 2005. Data from Housing Statistics in the European Union 2004 give a slightly different share (<1919: 20.8%; 1919-1945: 17.7%; 1946-1970: 21.2%; 1971-1980: 21.8%; 1980-1990: 18.5%)

The percentage of newly built dwellings (since 1990) appears to be almost 14% on average, varying from 8% to 22%. However, these figures should be taken with caution because they are based on different types of estimates and sometimes on number of dwellings and sometimes floor area. The percentage of dwellings constructed each year is given in Figure 2.15 and the percentage of dwellings demolished each year in Figure 2.16. The construction rates in 2003 are between 0.5% and 2%, with Austria having the highest rate and Sweden the lowest. In most countries, the rate is about 1%, which emphasises the importance of the existing dwelling stock in achieving sustainability. The demolition rate varies between 0.025% and 0.23%, with the Netherlands having by far the highest rate and Switzerland the lowest. In the Netherlands, less than one third of new dwellings replace demolished ones. In Switzerland, only 2% of new construction is replacement. This means that the Swiss building stock grows much more quickly than the Dutch one.

Figure 3.14: Age distribution of
the housing stock

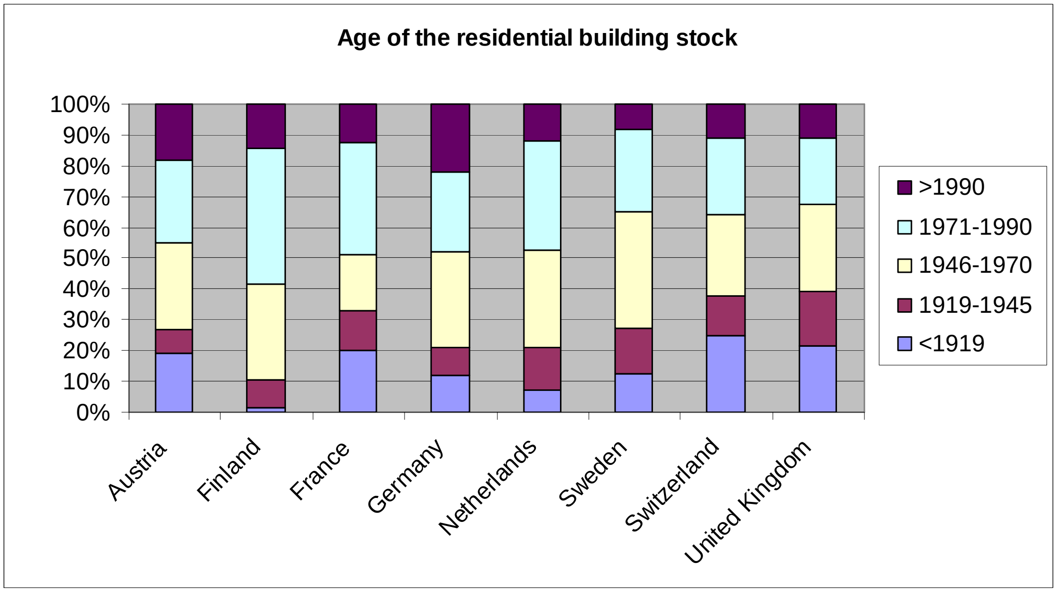
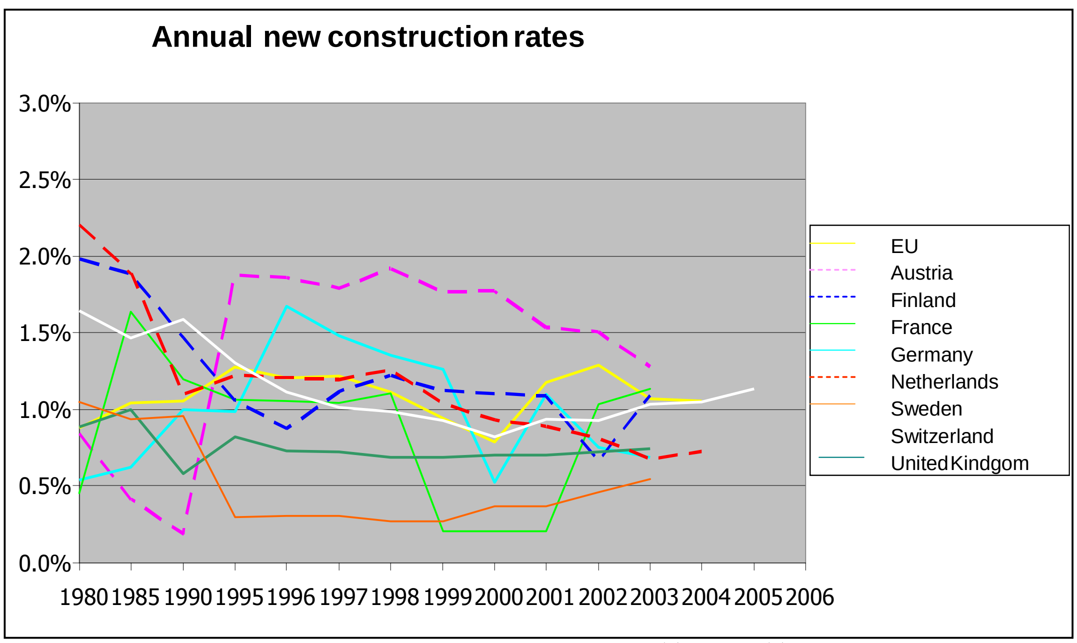
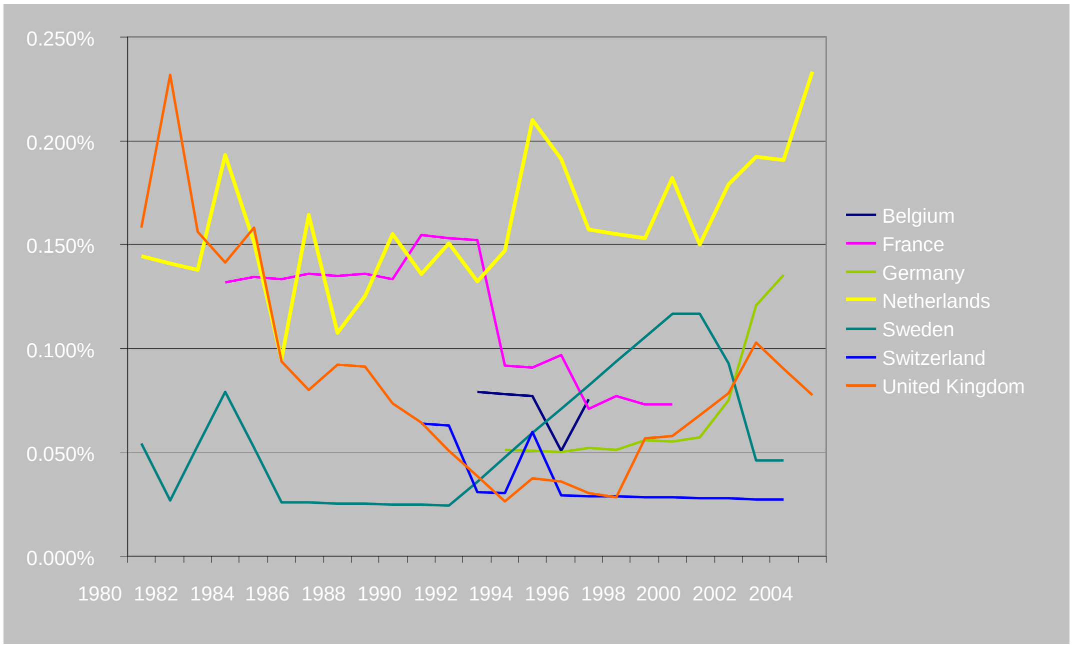


Figure 3.15: Annual construction
rates as % of the total housing
stock*



* Data from Housing statistics in the European Union and from A. Thomsen, TU Delft

Figure 3.16: Annual demolition
rates as % of the housing stock*



* Data from Housing Statistics in the European Union and from A. Thomsen, TU Delft

In addition to general data on the age of the dwelling stock, in Austria, France, Germany, the Netherlands, and Switzerland there is also data relating to the age of the building stock by the type of dwelling (single-family or multi-family).

In Austria, the breakdown does not differ very much between single-family and multi-family dwellings. The main differences noted are that in the old building stock (built before 1919) multi-family dwellings are more highly represented (21%) than single-family dwellings (only 14%). The opposite is true for the new building stock; 15% of multi-family dwellings and 22% of single-family dwellings were built after 1990. Detailed data can be found in Appendix C, Table C.2.

For France a very detailed breakdown is available in Appendix C, Table C.3, relating building age, building type (single-family dwelling or multi-family dwelling) and tenure. A very large proportion of single-family houses are owner-occupied (more than 95% for the dwelling stock built before 1974 and 98% for dwellings built before 1914). This percentage decreases slightly but regularly after 1974 to 89% for buildings built after 1998. Apartments built before 1948 are mainly owner-occupied (more than 82%). For buildings built between 1949 and 1981, owner-occupancy decreases to 50-55% and social rented increases from very low to 35-42%. Private rented apartments have quite a constant share across all the building periods, varying between 3 and 7%.

In Germany there is, in addition to the breakdown into single and multi-family dwellings, also a breakdown into terraced houses and detached houses, see Appendix C, Table C.4 The oldest building stock is found primarily in detached dwellings and multi-family dwellings. For both categories, 13% of the dwellings were built before 1918. For terraced dwellings, this is only 5%.

For the Netherlands, a detailed breakdown is available in Appendix C, Table C.5, relating building age, building type and tenure. Of the single-family houses, 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; almost no social rented single-family dwellings have been built since 1990. 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.

In Switzerland, the breakdown – see Appendix C, Figure C.6 - does not differ very much between single-family and multi-family dwellings. The main differences noted are for the old dwelling stock (before 1919), which has a larger share of multi-family dwellings than single-family dwellings. The opposite is true for the dwelling stock built between 1970 and 2000.

3.7 Reference buildings

Reference buildings have been defined in Germany and the Netherlands and to a lesser extent in Austria and the United Kingdom. The definitions are given in Appendix C, Tables C.7 to C.9.
In Germany, five types of dwelling have been defined, of which there are two types for single-family houses and three types for multi-family houses. In the Netherlands, 27 types of building are described in detail. These buildings are representative of a very large part of the Dutch building stock and are systematically used for studies on the energy efficiency of the building stock. In Austria, four categories have been defined in relation to the Rental Law in order to differentiate dwellings according to quality and to apply different levels of rent control. These four categories describe the quality in terms of floor area and the presence of sanitary and heating systems. In the United Kingdom, eight types of dwellings have been defined by BRE for their modelling studies, using eight geometries and a range of values for construction, servicing and occupancy. These reference buildings are used by BRE for studies on energy efficiency but there are no public data on it.

3.8 Match with market demand

In this section, a brief overview of the match of the existing building stock to the market demand is given. The data are mainly based on literature and expert judgment. In general, there seems to be a consensus that the location characteristics (in town centres, more green areas) of existing buildings contribute mainly to their attractiveness. Regional market disparities are pointed out in Finland, Germany, and Sweden. In France, the United Kingdom and to a lesser extent in the Netherlands and Austria, there seems to be a lack of affordable housing.

Austria
In general, there is a lack of cheap low quality housing and a lack of subsidised freehold flats. There are formal income limits on access to social housing, but these are high enough to cover a large part of the population. There are also eligibility rules and priority is given to those in employment. Because of the barriers to access social housing for the very poor and immigrants, they are dependent on poorly equipped dwellings in the private rented sector. These dwellings are mostly overpriced and do not offer security of tenancy (Social Housing in Europe, 2007). The quality of the existing building stock is believed to be associated with its high ceilings and city centre location as opposed to the newly built stock with its low ceiling heights and location mainly at the periphery of cities.

Finland

The population is centred on growth centres like the Helsinki Metropolitan area, Tampere, Turku and Oulu. The high demand for housing in those areas ensures market demand and the renovation of existing stock. In other parts of the country there are problems with vacant properties especially in the housing blocks built in the seventies and one can buy a detached house for a price of a small studio in Helsinki. It is estimated that 10% of the pre-1975 stock does not match market demand, whereas 60% matches it very well. For dwellings built between 1976 and 1990, this drops to 50% and increases again to 80% for buildings built after 1991. Social rented dwellings tend to be better renovated than owner occupied dwellings, especially in the dwelling stock built between 1960 and 1970. This is due to the availability of renovation subsidies and the complexity of decision-making in the owner-occupied multi-family dwelling sector, where everyone in the apartment block needs to agree on renovation.
The specific quality of the existing building stock is believed to be related to its location, the large floor area allowing for more flexibility and the lower density (more green spaces) than in newly built stock.

France
The housing sector has to respond to new demands with regard to individual aspirations, which is mostly to own one's own dwelling. Social housing suffers from a degraded image, except in some favoured areas at the centre of cities like Paris. It is believed that better maintenance and management of buildings and urban services would help to restore its attractiveness. The number of households will continue to grow quickly. Half these households will be single people, elderly and students, with their specific needs (Social Housing in Europe, 2007). However, the contrary is also apparent. At the end of the 1980s, the most visible housing problem was homelessness. Although different types of emergency housing have emerged, mostly operated by associations and charities, this problem still exists. With the recent increase in house prices, the new concern of lack of affordable housing for working families has emerged, putting the social rented sector under pressure (Social Housing in Europe, 2007). Two thirds of the French population is estimated to have low to moderate incomes; however only 25% of new build is affordable for these households. In 1900, 50% of the private rented sector had rent charges at the same level as social housing. Nowadays this has decreased to only 6% (Rapport sur le logement, Fondation Abbe Pierre).

Germany
After 1990 substantial investment in the refurbishment and improvement in the energetics of the East German housing stock was subsidised by the federal government and supported by tax reductions with little or no regard for the market and demand. Due to the lack of job opportunities in Eastern Germany, there was a substantial drain of population to Western Germany significantly reducing the permanent resident population. In fact, in Eastern Germany the demand for additional housing in multi-storey houses does not exist - the contention is rather to demolish high-rise housing estates to make the market smaller by reducing the supply side. New constructions are predominantly single-family homes. As the greater part of rented housing in Germany dates back to between the 50s and 70s there is a great deal of housing characterised by small rooms which does not match the current priorities of tenants. Due to the construction of the buildings - load bearing inner walls of brick or concrete - in many cases the dwellings cannot be altered significantly to match the changed demand. The solution then is demolition and new construction. In prosperous regions with high land prices and a high demand for affordable housing, new multi-storey buildings as well as single-family homes are built due to demand. In

Western Germany, the stock is generally very well kept; areas where the stock has been neglected can only be found in some regions with economic decline. In Eastern Germany, in inner city and country areas, vacant buildings exist due to the economic situation and the migration of the population. The rental stock is generally professionally kept; problems arise in regions with low demand, where investment does not pay. However, in general, the existing building stock is often believed to offer more decent urban surroundings and lower rents and costs than newly built dwellings.

Netherlands

Studies in the social rented sector, as well as in other tenures (Meijer et al. (2007), Social Housing in Europe, 2007), show that most occupants are satisfied with both their dwellings and their surroundings. Some 8% of all households and 12% of households in the social sector are not satisfied with the surroundings and complain about safety. One major challenge in the coming years is believed to be the renewal of the post-war housing stock. Depending on the condition and age it may be refurbished, enlarged, upgraded or demolished and replaced. The large majority of these urban renewal projects are located in the social housing sector. Government policy is to create a better tenure mix in these areas, offering opportunities for people to buy a house in their neighbourhood and attracting newcomers. The share of owner-occupied dwellings has been growing since 1945. Since 1997, owner-occupied households are in the majority. However, houses prices have increased a lot in the last 20 years, leading to affordability problems in particular for first-time buyers. Bridging the gap between the rented and the owner-occupied sector is now a key concern of policy makers (Social Housing in Europe). The existing dwelling stock is believed to be attractive because it is more affordable, the environment is more attractive in terms of social coherence and green spaces, and people like the traditional type of construction. The quality of dwellings is often considered in relation to social problems.

Sweden

Housing preferences in Sweden have been quite constant over the past decade. There is a general preference for owner-occupied and cooperative dwellings. Increasing houses prices have made it more difficult to move away from the countryside or out of the rented sector. Low income households avoid high price regions like the three metropolitan areas of Stockholm, Göteborg and Malmö, where one third of households live, even if that is where the jobs are located, or they move into more crowded accommodation. At a regional level, there are large differences in access to public housing. There is a surplus of social dwellings in smaller and less successful areas and a shortage in larger cities.

Switzerland

The number of subsidised apartments has decreased since 1980 from 24% to 12% of all apartments in 2002. The construction of new subsidised apartments by public aid reached little over 400 in 2001.

United Kingdom

Overcrowding is concentrated in the social sector, with 5.5% overcrowding as compared to 2.5% for the whole building stock. In London, these figures are 12.2% and 6.6% respectively. Homelessness increased by more than 100% between 1997 and 2004 and is a significant and increasing problem across all regions, but most particularly in London. An increasing proportion of these households are being placed in private rented dwellings that are then leased by the local authority. The 1977 law, later amended by the 1996 Housing Act, states that councils have an obligation to house persons whom they define as 'homeless', or having 'serious problems' such as those who are pregnant, families with children, and old people. The 'right to housing' is designed to assist people who fit into these categories. Furthermore, the act also states that the authorities are obliged to pay particular attention to not omitting such people from the system. Homelessness criteria are subject to separate regulations in each UK country (CECODHAS). The Housing Act emphasised the need for the rehabilitation of old inner city housing. From 1979, the Thatcher government introduced a radical change in housing policy encouraging home ownership with the introduction of 'the right to buy' for tenants of local authorities and of some housing associations. Consequently, more than a third of the 5 million tenants of social housing have bought their homes outright. The 1988 Housing Act enabled housing associations to use private finance to supplement public funds. The Act also established separate regulatory and funding frameworks for England, Wales and Scotland (CECODHAS).

3.9 Summary and conclusions

In this chapter the main characteristics of the existing building stock were studied in terms of ownership structure, building types and ages, construction and demolition rates, regional specificities and existence of standard reference buildings. The following conclusions can be drawn:

Ownership structure and building types

1. Depending on the country, owner-occupied dwellings represent 35% to 62% of the total stock, with an especially high share in England (70%).
2. Germany and Switzerland have a large private rented sector (about 50% of the total stock).
3. Sweden and the Netherlands have a large social rented sector (30% to 35% of dwellings).
4. In general, a very large share of single-family houses is owner-occupied. For multi-family houses the shares vary a lot. In Sweden, for instance, 68% of the multi-family houses are social rented while this percentage is only 6% in Switzerland.
5. In Austria, Finland, France and Sweden approximately half the building stock are single-family dwellings and half multi-family dwellings.
6. In the Netherlands and United Kingdom, more than 70% of the dwelling stock is single-family dwellings.
7. In Germany and Switzerland, more than 70% of dwellings are multi-family dwellings.

The owner-occupied market constitutes an important part of the dwelling stock in all countries and should therefore be addressed by policies on sustainable renovation. It can be expected that the decision-making process in the renovation of owner-occupied multi-family dwellings will be more complex than in single-family dwellings, due to co-ownership, and that specific solutions for both sectors will be needed. Because the private rented sector is very important in Germany and Switzerland, these countries have a common interest in tackling specific policies for this group. The same synergy could be found between Sweden and the Netherlands for the social rented sector.

Construction periods and demolition rates

1. The pre-war dwelling stock accounts for 20% to 39% of the total dwelling stock, with the exception of Finland where only 10% dates from before WWII. In general, the pre-war building stock is reasonably homogenous in terms of construction characteristics.
2. Dwellings built after World War II and before the oil crisis amount to between 18% (France) and almost 38% (Sweden) of the dwelling stock. On average, this is 29%. This dwelling stock, which represents almost one third of the total stock, is not very homogenous. A common characteristic, however, is that the buildings were generally poorly insulated at the time of construction and that there is a need for renovation.
3. In most countries, the dwellings built between 1970 and 1990 account for 21% to 27% of the total stock. Exceptions to this are France and the Netherlands with a share of more than 35% for this building period and Finland with more than 43%. In general, the dwellings built during this period are reasonably well insulated, but already need some kind of renovation, especially the older ones.
4. The percentage of dwellings built after 1990 is estimated to be almost 14% on average, varying from 8% to 22%.
5. The construction rates in 2003 were between 0.5% and 2% with Austria having the highest rate and Sweden the lowest
6. The demolition rates vary between 0.025% and 0.23%, with the Netherlands having by far the highest rate and Switzerland the lowest. In the Netherlands, about one third of new dwellings replace a demolished one. In Switzerland, only 2% of new construction is replacement, which means that the Swiss building stock grows more quickly than the Dutch one.

Because pre-war dwellings account for 20% to 40% of the total building stock and are expected to be quite homogeneous in each country, standardisation of renovation solutions could be an important item for this stock. For the dwelling stock built between the forties and the seventies large-scale standardisation could be more difficult to achieve because of the large diversity of building methods. The replacement of existing buildings by new ones occurs at a very low rate. This rate is not expected to vary much during the coming years. This emphasises the importance of the existing building stock for the realisation of a sustainable housing stock.

Regional specificities and match with market demand

1. Apartments are mainly located in large municipalities.
2. In Switzerland, 63% of single-family houses are located in urban areas whereas this is only 22% in Germany. The figures for other countries are in between.
3. In Austria, the structure of the housing market differs greatly between Vienna and the rest of the country. In Vienna 48% of dwellings are social housing and 26% are publicly owned, whereas these figures are 25% and 10% respectively for the whole country.
4. In France, social housing is predominantly urban and in large metropolitan areas there is a polarisation between municipalities without any social housing and municipalities with 70% social housing.
5. Finland has a high housing demand in growth centres like Helsinki and Tampere which ensures the renovation of the existing stock. In other parts of the country there are problems with vacant properties.

6. In Germany, there is also a general oversupply of rental housing in economically weak regions especially in the eastern parts of Germany, where demolition seems to be a solution to reduce vacant buildings. On the other hand, a strong demand can be identified in the more prosperous regions like Hamburg, the Rhine river valley, Stuttgart and Munich.
7. In general, there seems to be a consensus that the location characteristics (in town centres, more green areas) of existing buildings contribute mainly to their attractiveness.
8. Regional market disparities are pointed out in Finland, Germany and Sweden.
9. In France, the United Kingdom and to a lesser extent in the Netherlands and Austria, there seems to be a lack of affordable housing.

In almost all countries, regional specificities exist that should be taken into account by policies. Probably, the problems of vacant dwellings in less economically strong regions and the lack of affordable housing are beyond the scope of policies for sustainable renovation.

Reference buildings

1. Reference buildings have been defined in Germany and the Netherlands and to a lesser extent in the United Kingdom. These reference buildings are used for studies on the energy efficiency of the building stock.
2. In Austria, four reference buildings have been defined in order to differentiate dwellings according to quality and to apply different levels of rent control.

Because only a few countries have defined reference buildings for their building stock, more research could be done into defining sets of representative buildings by country. This would be a very useful step in the determination of the possibilities for standardisation and in the harmonisation of estimations of the energy saving potential of renovation activities.

4 Physical quality of the residential building stock

4.1 Introduction

In the Regular National Report on Housing Developments, housing quality is defined based on the following criteria; availability of running water, of a lavatory, a bath or shower, central heating, the average number of rooms and the average floor area. In Housing Statistics in the European Union, the average number of persons per occupied dwelling is also used as indicator. These data are summarised in Table 4.1. For the countries studied in this report and for which data are available, the indicators chosen are too low level to reflect the real quality of the dwelling stock and they only show that basic quality is met in almost all the existing dwelling stock.

Table 4.1: Basic quality of the residential building stock

	Running water (%)	Lavatory (%)	Bath/Shower (%)	Central heating (%)	Average number of rooms	Floor area (m^2)	Average number of persons (2003)
Austria	99.9	98.7	97.5	87.3	4.3	60-90	2.4
Finland	98	96	99	92	3.8	85.7	2.2
France	99.9	99.2	99.2	96.3	4	90	2.4
Germany	n.a.	n.a.	n.a.	n.a.	n.a.	88.4	2.2
Netherlands	100	100	100	90	4.2	n.a.	2.4
Sweden	100	100	100	100	4.2	71	2.1
Switzerland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
United Kingdom	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.3 (2000)
Mean in Europe 29	93.3	88.2	88.7	72.7	3.6	76.5	n.a.

In this chapter the physical quality of dwellings is defined in more detail in terms of energy use, type of construction and insulation level, type of heating and cooling systems, hot tap water heating systems, ventilation and sanitary systems, presence of elevators, thermal comfort and health quality. Finally, the match between market demand and building stock is briefly studied.

4.2 Energy Use

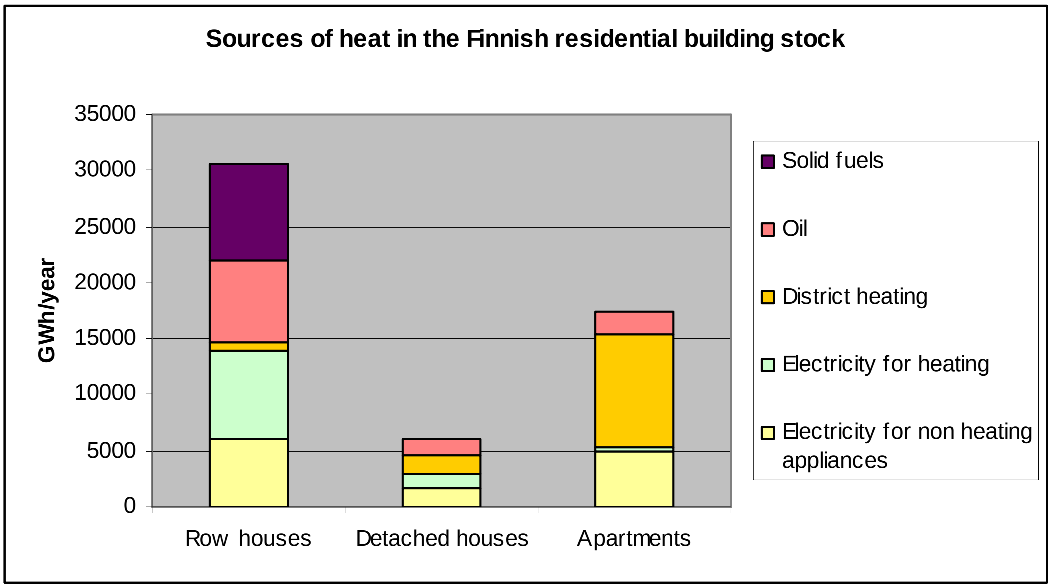
There is no European source giving consistent data on the breakdown of the energy consumption by end use, except for the Database Odysee which is not freely accessible (http://www.odyssee-indicators.org/). In this section an overview of the data available in each country is given. The type of data available may differ greatly by country. For Austria, Sweden and Switzerland, there is no more specific information than given in Section 2.4.

Finland

The residential sector is responsible for 11% of total Finnish gas consumption, 20% of biomass (coal and turf) and coal consumption, 22% of light oil consumption, 5%

of heavy oil consumption and accounts for 38% of the use of district heating. A detailed breakdown of energy sources for space heating and hot tap water is available from the Ekorem report for terraced houses, detached houses and apartments and is given in Figure 4.1.

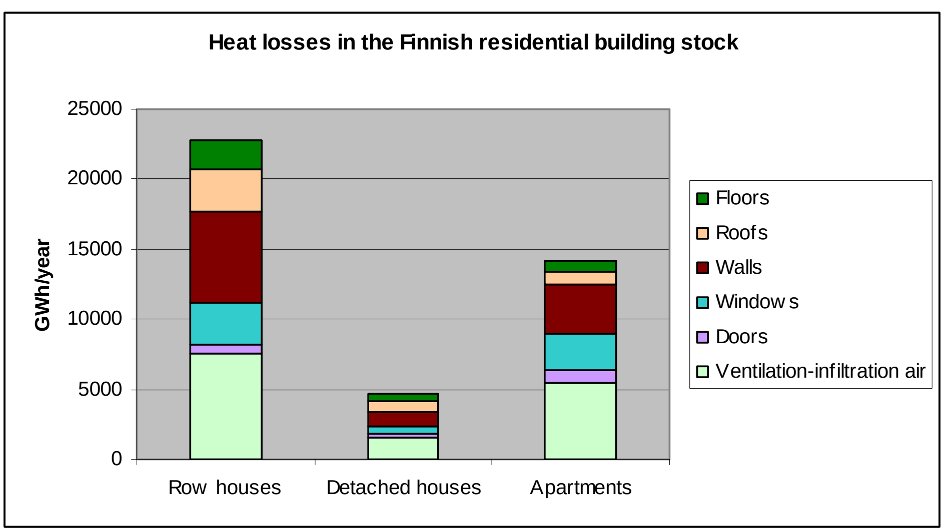
Figure 4.1: Sources of heat in Finnish terraced houses, detached houses and apartments*



* Ekorem report, 2005

The Ekorem report also gives data on the average heat losses through each building component of an average dwelling. These data are calculated based on estimates of the average heat transfer coefficient of the building components considered. In general, walls and ventilation are responsible for the main losses.

Figure 4.2: Heat losses in average Finnish building components*

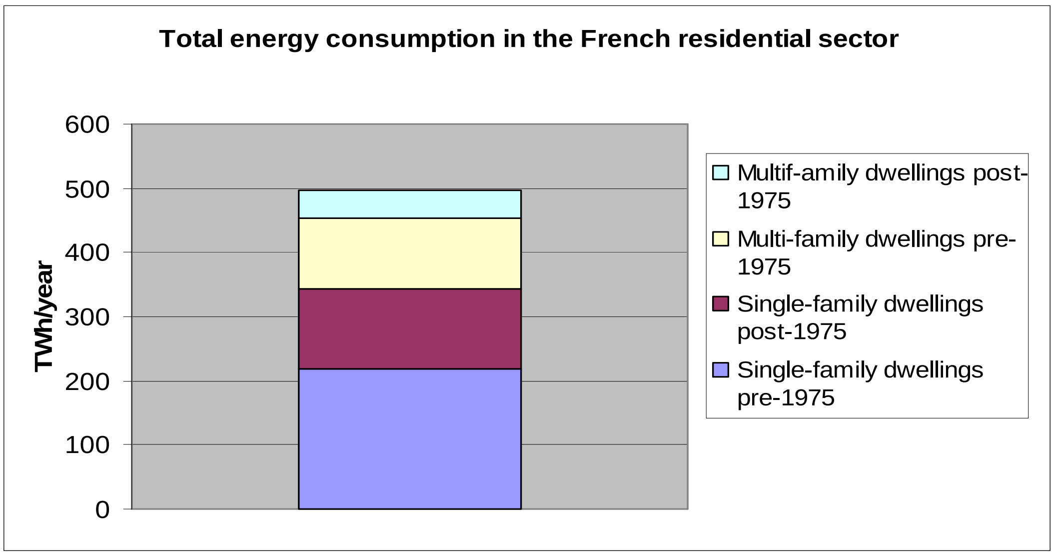


* Ekorem report, 2005

France

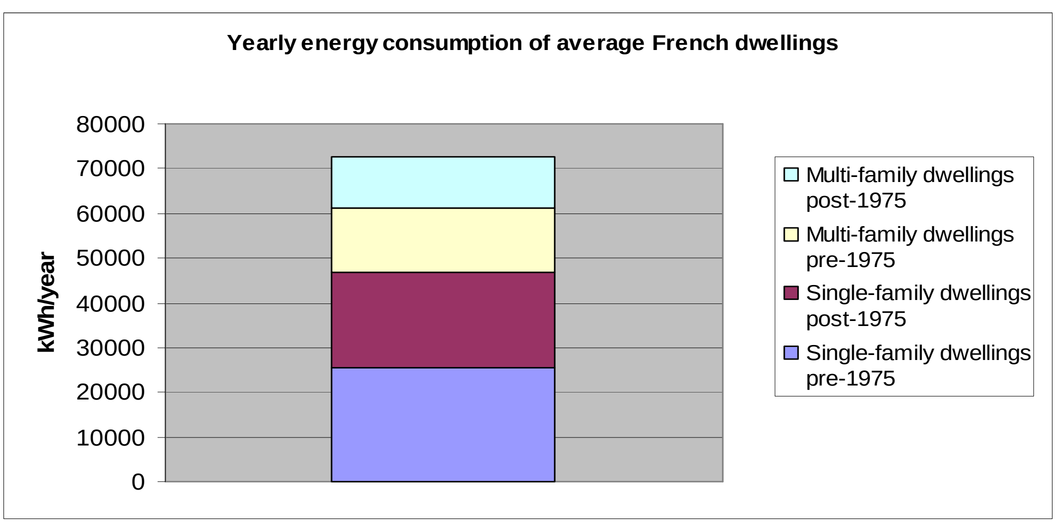
A breakdown of the energy consumption by type and age of building is available at the level of the entire building stock (Figure 4.3) and at the level of an average building (Figure 4.4). On average, a post-1975 single-family dwelling consumes 11% less energy than a pre-1975 dwelling. For multi-family dwellings, this figure amounts to 16%.

Figure 4.3: Total energy consumption in the French residential sector: breakdown by dwelling type and age*



*from "Les Chiffres clés du bâtiment, Energie – Environnement", édition 2006, ADEME.

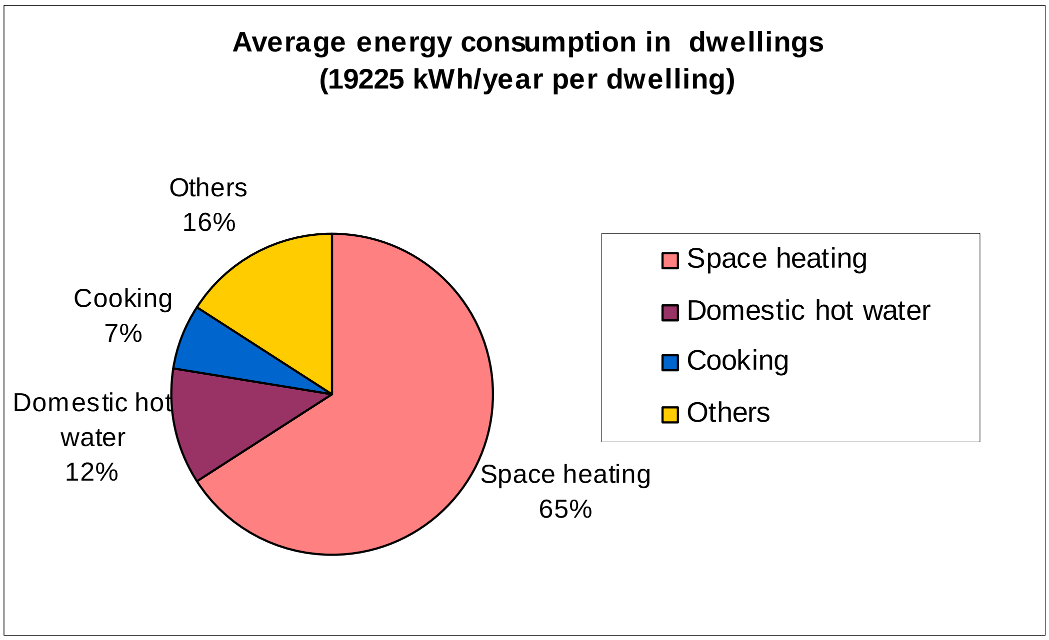
Figure 4.4: Energy consumption of average French dwellings: breakdown by dwelling type and age*



* from "Les Chiffres clés du bâtiment, Energie – Environnement", édition 2006, ADEME.

The breakdown of the average energy consumption in dwellings by space heating, domestic hot water and cooking is also available and shown in Figure 4.5. The breakdown is similar to the European breakdown given in Figure 2.11, except that space heating has a larger share in France than in Europe (65% instead of 57%) and domestic hot water a lower share (12% instead of 25%). Specific data for each type of dwelling can be found in Appendix D, Figure D.1.

Figure 4.5: Energy consumption of average French dwellings: breakdown by end use*



* from "Les Chiffres clés du bâtiment, Energie – Environnement", édition 2006, ADEME.

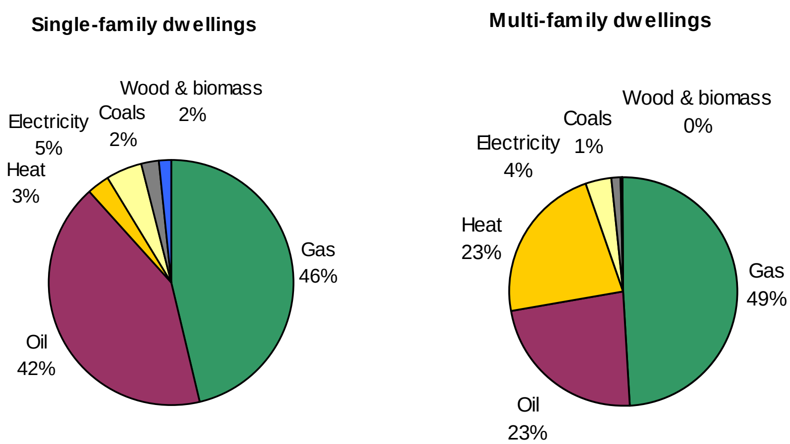
Germany

An estimate of the breakdown of energy consumption by type of fuel for single-family and multi-family dwellings is made based on calculations of the IWU, see Figure 4.6. In multi-family dwellings, district heating replaces half the oil consumption, which is still very large in single-family dwellings. The importance of all renewable energies for heating is, however, steadily growing. The percentage of the supplied energy for heating increased from 3.9% in 2000 to 6% in 2006 (BMU 2007). Owner-occupied dwellings might be the most advanced sector. From this renewable energy, 69% is biogenic solid combustibles, 3.7% solar thermal and 2% geothermic.

The Netherlands

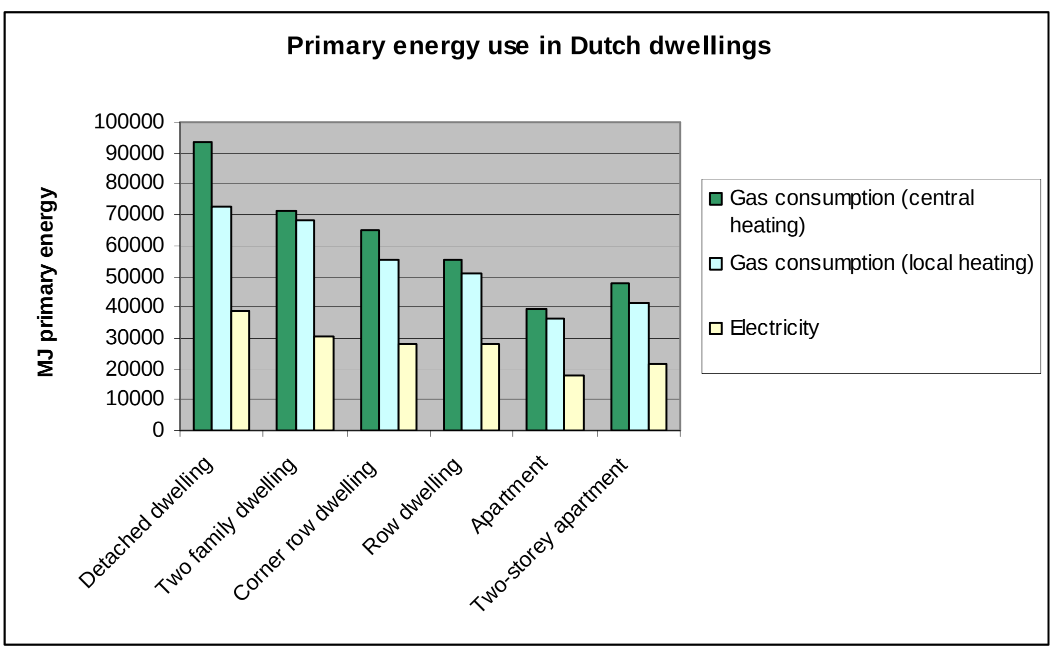
In the Netherlands, a breakdown of the primary energy use by building type is available from KWR (2000) and related publications from VROM. In a Dutch dwelling 3100 kWh electricity is consumed on average. The electricity use of Dutch households varies a lot depending on the incomes of the household. The average values shown in Figure 4.7 may be 20% lower for low income households and 20% higher for high income households. The average gas use is 2000 m^3 per dwelling when central heating is present and 1600 m^3 when only local heating is installed. Detached houses have a gas consumption that is almost twice the consumption of apartments.

Figure 4.6: Energy consumption of single-family and multi-family German dwellings: breakdown by type of fuel*



* IWU calculation

Figure 4.7: Final energy consumption in Dutch dwellings: breakdown by type of building*



* from Basisrapportage Kwalitatieve Woningregistratie 2000, VROM

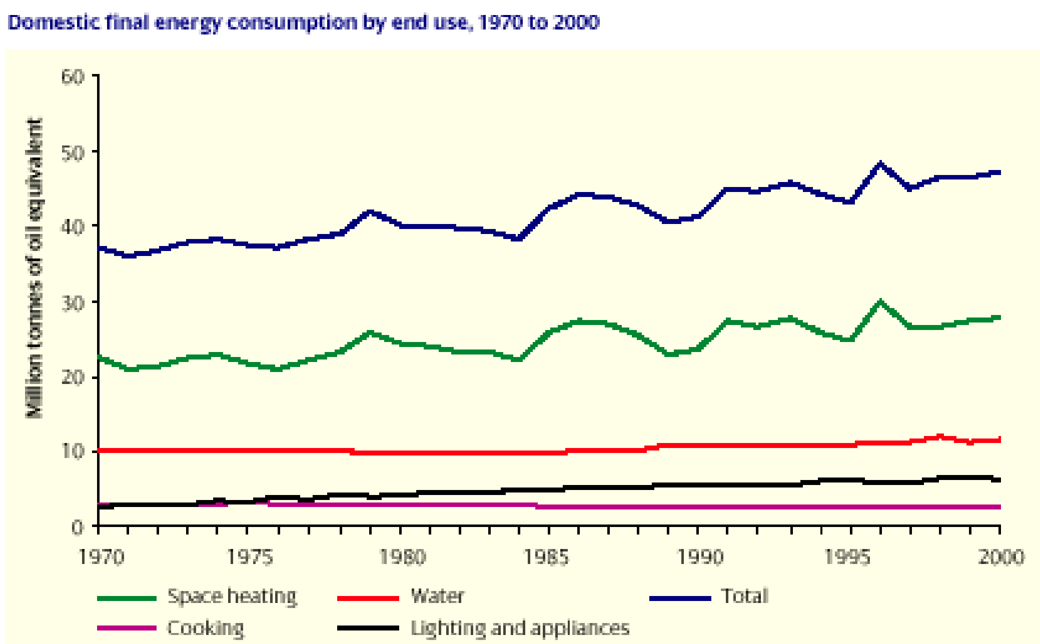
In the KWR, an energy indicator is used to indicate the energy efficiency of the dwelling. The value of this energy indicator, a figure between 0 (low quality) and 5 (high), depends on the number and type of insulation measures and the heating system. The relationship between gas consumption and energy indicator is shown in Appendix D, Figure D.2.

United Kingdom

In the UK, 82% of energy used by households is for space or water heating (see Figure 4.8). Since 1970, energy use for space heating has risen by 24%, for water heating by 15%, and for lighting and appliances by 157%. In contrast, energy use for cooking has fallen by 16%. The individual countries within the UK have wide disparities in the mix of fuels used in the domestic sector. Northern Ireland uses more coal and oil, since gas has only recently been introduced, while Scotland consumes more electricity. This comes from the higher proportion of flats in cities in Scotland, which often use electrical heating instead of gas or oil driven systems. Central heating is based on gas for 71% and on solid fuels for only 3%. Electrical storage heating accounts for 9%.

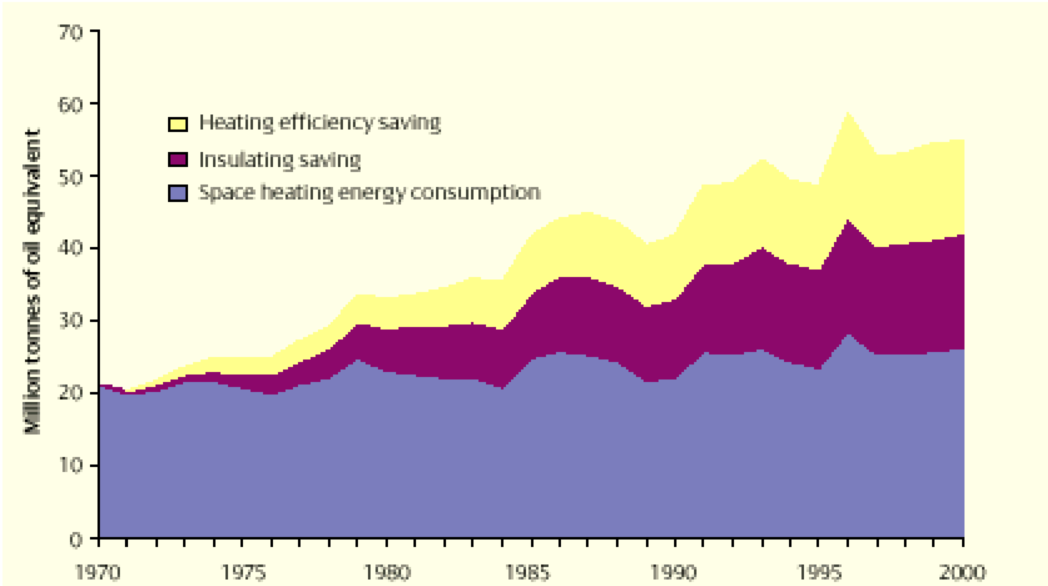
There is also data available on the effect of insulation and more efficient heating systems on the energy use for space heating (see Figure 4.9). Without insulation, energy consumption would have been 59% higher by 2000 compared to 1970. Without insulation and more efficient heating systems the energy consumption would have been 110% higher.

Figure 4.8: Evolution of the final energy consumption in dwellings in the UK: breakdown by end use*



*Graph from Energy Consumption in the UK, DTI.

Figure 4.9: Energy savings due to insulation and heating efficiency in the UK*



* Graph from Energy Consumption in the UK, DTI.

4.3 Insulation and type of external walls, roofs, floors and glazing

Data on the degree of insulation of dwellings are of major importance to determine the potential for energy savings in the residential building stock. Surprisingly enough almost no statistical data exist on the degree of insulation of existing buildings. Yet, there are a lot of studies conducted by architects and consultants giving indications about typology and the thermal quality of dwellings. Many scientific papers can be found describing specific renovation projects. Although this information is very fragmented and has no statistical value, it is a good basis to identify trends and perhaps to set up further statistical studies.

In the EURIMA project, measures to reduce the energy consumption for heating were studied in relation to the EPBD and predictions were made for the whole European building stock. These predictions on the effectiveness of measures are based on an evaluation of the number of buildings per age category, as given in Table 3.5 and on simple assumptions about the U-value (Heat Transfer Coefficient) of the construction. The building stock built before 1975 is subdivided into buildings already having undergone energetic refurbishment and buildings in their initial condition. However, the share of both is not publicly known. The U-values used in the EURIMA report are given in Table 4.2 for the cold and moderate climatic zones, which are the zones of interest for the eight countries studied in this report.

The energy consumption for the heating of buildings is directly related to the heat losses through the building components and to losses through ventilation and air infiltration and inversely related to the heat gains in the buildings through sun radiation and internal gains from appliances and human occupancy. In well insulated buildings, losses through ventilation and air infiltration become relatively more important, as does the demand for cooling when the heat gains are high. When insulating dwellings and improving their air-tightness, it is important to also make sure that enough fresh air is still coming into the dwelling and that no super-heating will occur in the warm season. This can be achieved without using too much cooling energy by applying external sun-shades and night-cooling for instance. However, in the current situation of the existing building stock, the energy demand for heating is still predominant. To reduce this energy use, insulation of the external envelope of the building is needed.

Table 4.2: Assumptions for the insulation of the European building stock as used in the EURIMA project*.

U-value [W/m²K]	<1975 Not retrofitted	>1975 Already retrofitted	1975-1990	1991-2002	2003-2006 Newly built & retrofit	>2006 Newly built & retrofit
			Cold climatic zone			
Roof	0.5	0.2	0.2	0.15	0.15	0.13
Façade	0.5	0.3	0.3	0.2	0.18	0.17
Floor	0.5	0.2	0.2	0.18	0.18	0.17
Windows	3.0	1.6	2.0	1.6	1.42	1.33
			Moderate climatic zone			
Roof	1.5	0.5	0.5	0.4	0.25	0.23
Façade	1.5	1.0	1.0	0.5	0.41	0.38
Floor	1.2	0.8	0.8	0.5	0.44	0.415
Windows	3.5	2.0	3.5	2.0	1.84	1.68

* EURIMA report Cost Effective Climate Protection in the EU Building Stock, www.eurima.org

Heat losses through building components are proportional to their heat transfer coefficient and to their surface area. Insulating the largest surfaces with the highest heat transfer coefficient is therefore the most efficient in terms of energy and, for the most part, in terms of economics. Detached houses have a large area of external walls, which makes the insulation of these walls very important. Terraced houses have fewer external walls, which increases the importance of insulating roofs. Multifamily dwellings share a common roof, which reduces its importance and makes the insulation of external walls an issue again. Floor insulation will be more important in low rise buildings than in high-rise buildings. For dwellings with a large glazing percentage, using high efficiency glass is the preference.

There are two main types of external walls; solid walls and cavity walls. Cavity walls consist of two layers (of bricks or concrete for instance) with an air gap or cavity between them. In solid walls, there is no air cavity. When considering the insulation of existing external walls, the most important thing is to determine whether it is a cavity wall or a solid wall. The insulation of cavity walls is a relatively easy task because the cavity wall has just to be injected with insulating material, mostly foam. Companies have specialised in this task and a lot of practical experience has been gained. Solid walls, in contrast, are much more difficult to insulate because this can only be achieved by adding insulation material to the outside or the inside of the wall. In general, it is better to insulate walls from the outside, because it avoids the typical moisture problems that often occur with indoor insulation. However, outside insulation is expensive and often not desirable because it changes the whole appearance of the façade. Furthermore, outside insulation may be impossible if the municipal land-use plan does not allow for the offset of the façade alignment. Outside insulation is regularly carried out on office buildings and apartment blocks but will remain very difficult for traditional dwellings because the external appearance of the façade is often very important. The other solution is to insulate the wall indoors. It is cheaper than external insulation, but it causes a non-negligible loss of inside space (5 to 10 cm for each wall) and moisture and condensation problems often occur, not least because the placement of the insulation has not taken into account the interaction between the existing walls, the vapour sealing layer and the insulation material itself. The sustainable design of details, cold bridges for instance, is a key issue. In this sense it would be important to assemble enough data on the typology of solid walls to determine which kind of technical solution may be applied and to estimate the possible energy savings at the level of the building stock. Even now, a rough estimate of the number of brick, stone and concrete solid walls would be helpful. Concrete walls for instance may offer more possibilities for outdoor insulation because various panels may be used to finish the façade. Table 4.3 summarises the data collected in the different countries.

There are large disparities between the types of walls in the different countries. Finland and France have a very high percentage of solid walls (90% to 100%), the Netherlands a very low percentage (4%) and the United Kingdom about 30%. Cavity walls are more often insulated than solid walls, but in Finland, which has a younger building stock, almost all solid walls have been insulated.

With respect to roofs, the main distinction is between flat and sloping roofs. In general, flat roofs, which represent only a small share of all roofs except in the Netherlands, are already insulated. Sloping roof insulation, which is quite easy to implement, has been realised in approximately 70% of the dwellings.

The degree of insulation of floors seems lower than that of roofs, with percentages varying around 30-60%.

The penetration of double-glazing is high in all countries, and the penetration of triple glazing is low except for Finland and Sweden.

Table 4.3: Type and insulation of walls, roofs, floors and glazing

	Solid walls as % of total walls	**% Insulated solid walls**	**% Insulated cavity walls**	**% Insulated roofs**	**% Insulated floors**	**% Double-glazing**	**% Triple glazing**
Austria[1]	n.a.	20	~100.	50-70	30-60	90	5
Finland[2]	~100	90-98	-	98%	50-100	25	75
France[3]	84	n.a.	n.a.	n.a.	n.a	n.a	n.a
Germany[4]	n.a.	n.a.	n.a.	n.a.	n.a	n.a	n.a
Netherlands[5]	4		59	>71	43	80-85	~0
Sweden[6]	n.a.	high		high	high	average	high
Switzerland[7]	n.a.	n.a.	n.a.	n.a.	n.a	90-96	
United Kingdom[8]	31	~0	~40	72-95	n.a.	71	~0

[1] Estimate from IIBW, based on projects, reports and literature and DEMOHOUSE
[2] from Statistics Finland and expert estimation (Sunikka)
[3] from French Agency for Quality in Construction AQC
[4] no data
[5] from KWR 2002, Dossier Energy Saving and Insulation (VROM) and Basisrapportage Kwalitatieve Woningregistratie 2000 (VROM).
[6] from expert estimation (Sunikka)
[7] Gerheuzer 1998 and Jakob/Jochem 2003
[8] English House Condition Survey 1991, Energy Consumption in the UK (DTI 2002) & ACE report

Detailed data, when available, are given hereafter by country.

Austria

The figures given are based on expert opinion. More details can be found in Appendix D, Table D.1.

Solid walls are likely to make up the largest part of external walls in the pre-1980 residential building stock. Of these solid walls, mostly of brick, about 80% have no insulation. However, very thick walls (>0.45 m) are assumed to offer sufficient thermal insulation. Thick brick walls were built mainly before 1919 and this stock is very homogenous. From 1919 to 1944 the dwelling stock became more heterogeneous and several materials were used for walls, like pumice stone. Walls were thinner without any sound or thermal insulation. After 1945 the construction of large housing estates became dominant and from the mid-fifties standardisation started. Thin walls were built with poor sound and thermal insulation. Construction with prefabricated reinforced concrete components was dominant. From 1961 to 1980, walls were built with brick or concrete panel construction. After 1980, there was a renaissance of brick and poured concrete constructions, but these had thermal insulation applied (DEMOHOUSE). Solid wall buildings built after 1970 are all insulated, with an insulation thickness increasing from 6 cm to more than 10 cm nowadays. About 1% of the older solid walls are estimated to be insulated (inside insulation) each year.

Cavity walls have been used since the eighties in single-family dwellings and are all insulated. In multi-family houses, these walls are very uncommon.

Most single-family houses have a basement, either for living purposes (before 1970) or not (after 1970). Of the floors placed above a basement, 70% are not insulated. Small houses and modern passive houses have floors on solid ground, of which about 40% are not insulated. Floors placed above a crawl space are very uncommon in Austria. In multi-family dwellings, almost all floors are placed above a basement; 40% of which are estimated not to be insulated.

Flat roofs are uncommon in Austrian single-family houses and when they are used they are insulated. They are more common in recent multi-family buildings and only 10% of them are estimated not to be insulated. About 50% of sloping roofs are not insulated, mostly in houses where the attic is not used for living purposes. In this case, there will probably be insulation between the attic and top floor. The other 50% of sloping roofs are insulated, mostly in houses where the attic is used for living purposes. In multi-family houses, about 30% of the sloping roofs are not insulated. From 1968 to 1980, cement asbestos was used for roofs (DEMOHOUSE).

The glass percentage in Austrian dwellings varies from 15% to 30%. The highest percentages are found in the more recent building stock. Single glazing is almost non-existent. 90% of the glazing is double glass and 5% is triple glass, mainly in modern low energy or passive houses. Window frames are made from wood, PVC or aluminium with a new trend in wood-aluminium combinations.

Between 1919 and 1944 reinforced steel started to be used for ceilings instead of wooden trusses. After 1945, ceilings were mainly of reinforced concrete. From 1968, gypsum board was used for partition walls (DEMOHOUSE).

Finland

The data for Finland are a mix of statistical data from Statistics Finland and educated guesses based on observation.
Cavity walls are extremely rare in Finland. Most external walls are solid walls. Due to the cold climate, almost all solid walls (90%) in single-family houses and in the old building stock are insulated. In multi-family houses this percentage is 98%. Non-insulated solid walls are mainly found in pre-1919 dwellings and in log and summer houses.

The share of floors on basements, crawl spaces and solid ground is unknown. It is estimated that almost all floors on solid ground and above crawl spaces are insulated, except for 2% of them, which are mostly in the pre-1919 stock. Only 50% of floors on basements are insulated (mostly under the basement floor).

Flat roofs are always insulated and sloping roofs almost always (98%). Non-insulated roofs are mostly found in pre-1919 dwellings.

The glass percentage in dwellings varies from small for the building stock before 1945 to average or large after. Dwellings built before 1970 all have double-glazing that is increasingly being replaced by triple glazing. Dwellings built after 1970 all have triple glazing. Considering the whole dwelling stock, about 75% of glazing is triple glazing and about 25% is double-glazing, most of which is found in dwellings built between 1960 and 1980. If single glazing remains, it will be in the pre-1960 building stock. Window frames are made from wood, steel or more recently aluminium.

Sun rooms and verandas are occasionally found in the single-family dwelling stock. In post-1971 apartment buildings, they are almost systematically present. Roof overhangs are common. External sun blinds are rare and internal sun blinds are common in buildings built after 1971.

France

A report was produced recently by the Ministry of Equipment, Transport and Special Planning, “Typologies of existing residential buildings”. This report was however not made publicly available. There is however data from 1996 from the French Agency for Quality in Construction AQC, indicating that in single-family dwellings the external walls are built of concrete blocks in 83% of cases, of brick cavity walls in 16% and of wood in 2%. Insulation used is 98% polystyrene, 10% mineral wool and 3% others (polyurethane). In the multi-family dwelling stock, the external walls are made of reinforced concrete in 68% of cases, of concrete blocks in 24%, 3% are curtain walls, 2% are cavity brick walls, 2% are solid brick walls and 1% are made of prefabricated concrete panels. Insulation used is 95% polystyrene and 4% mineral wool.

Germany

There are only data available on glass percentage and shading devices, based on a study by Herbert & Karsten and data from the IWU. On average, the glass surface seems to be around 18% of the heated floor space of dwellings. Sun rooms are found in the old building stock (built before 1900 for single-family houses and before 1945 for multi-family houses). Roof overhangs may be present in all age categories of apartment buildings, but only in single-family houses built before 1945. External sun shades are found in buildings built before 1945 and internal sun shades in buildings built after 1945.

The Netherlands

Detailed data on the evolution of the insulation level since 1995 can be found in Appendix D, Table D.2. The data, based on KWR 2002, Dossier Energy Saving and Insulation (VROM) and Basisrapportage Kwalitatieve Woningregistratie 2000 (VROM) presented hereafter are for 2005.

Of all external walls in the Netherlands 43% have not been insulated. When looking at buildings built before 1971, the figure is 77% (in 2000). Data from 1998 indicate that 59% of cavity walls have been insulated in multi-family buildings. Solid walls are very uncommon (3.5%) and are found practically only in two-family terraced houses built before 1966. Before 1925, walls were mainly of brick. Since then, brick walls are constructed as cavity walls, originally to improve moisture protection. On-site concrete building techniques were introduced only after 1966. From 1970, dwellings are characterised by thicker façades and concrete-brick construction walls (DEMOHOUSE). The insulation rate of external walls has been 1.6% per year on average since 1995.

Almost 60% (57%) of the floors are not insulated. For pre-1971 buildings, this figure is 90%. Pre-war dwelling floors are mainly made of wood. Concrete floors with ceramic were introduced from 1970. The insulation rate of floors has been 2% per year on average since 1995.

29% of sloping roofs are not insulated. For pre-1971 buildings, the figure is 60%. About 23% of all roofs are flat and mostly insulated. Until 1970, roofs were constructed from beams and planking. After that, concrete tile roofs were introduced (DEMOHOUSE). The insulation rate of roofs has been 1.5% per year on average since 1995.

The glass percentage of Dutch dwellings remains approximately constant over the years at around 25-30%. There are still 20% of single-family dwellings and 15% of multi-family dwellings with single glazing. The remaining 80% and 85% respectively have double-glazing. Double-glazing was utilised in new dwellings from 1980. Wood and sometimes steel are used for the window frames in buildings built before 1976. Since 1976, PVC, aluminium or wood have been used. The rate at which single glazing is replacing double-glazing has been 2.2% per year on average since 1995.

Sweden

There is no statistical data available, but it is likely that insulation values are very high for the whole building stock and that its quality is comparable to that of the Finnish building stock.

Switzerland

In single-family houses, 96% of the roofs are sloping roofs. In multi-family dwellings this figure is 90%. More than 96% of single-family dwellings and more than 90% of multi-family dwellings have double-glazing (source Gerheuzer 1998 and Jakob/Jochem 2003).

United Kingdom

The data come from the English House Condition Survey 1991, which gives more information than the last survey, the report Energy Consumption in the UK from the DTI (2002), and the ACE report. Unless otherwise mentioned, the figures refer to England and not to the whole of the UK. However, the percentages for the UK are not expected to be very different from those for England.

40% of external walls are insulated. Almost all insulated walls are cavity walls.

Solid external walls are found in 31% of all dwellings and are not insulated. For the whole of the UK, the ACE report gives a figure of 36% not insulated. The pre-1919 dwelling stock consists of 85% solid external walls. For buildings built between 1919 and 1944, this share decreases to 41%, and to 14% for the building period 1945-1964. In post-1965 dwellings, solid walls are used in less than 10% of the dwellings. 68% of solid walls are estimated to be 9 inch thin brick constructions. The other 32% are divided into timber and half timber frame houses typically built before 1944, "no-fines" houses (concrete panel houses where the concrete is cast in situ) and post-war prefabricated systems. On average, 30% of owner-occupied, 25% of social rented and 50% of private rented houses could be solid wall dwellings. Two thirds of solid wall dwellings are owner-occupied, 18% are in the social rented sector and 16% in the private rented sector. A little less than half of solid wall dwellings are terraced houses, about 25% are semi-detached, about 10% are detached houses and another 10% are multi-family dwellings.

Cavity walls are more common and are found in 69% of the dwelling stock, mostly from the post-war period. Only 40% of these cavity walls are insulated (according to the report Energy Consumption in the UK from the DTI, this is 28% for the whole of the UK. In Hitchin, the figure is 55%).

The degree of insulation of floors is unknown, as well as the type of ground floor construction, as this is not studied in the housing survey. Floors above basements are very rare. Floors above a crawl space are typical in buildings built before 1944 and floors on solid ground are typical in post-1945 dwellings.

Flat roofs account for 4% of all buildings, sloping roofs for 96%. 72% of all houses in the UK have loft insulation (according to Hitchin, this is 95%).

71% of dwellings are fitted with double-glazing, and the remaining 29% have single glazing for the large part. According to the report Energy Consumption in the UK from the DTI, in 39% of houses more than 80% of the windows are double-glazed.

4.4 Heating and cooling systems

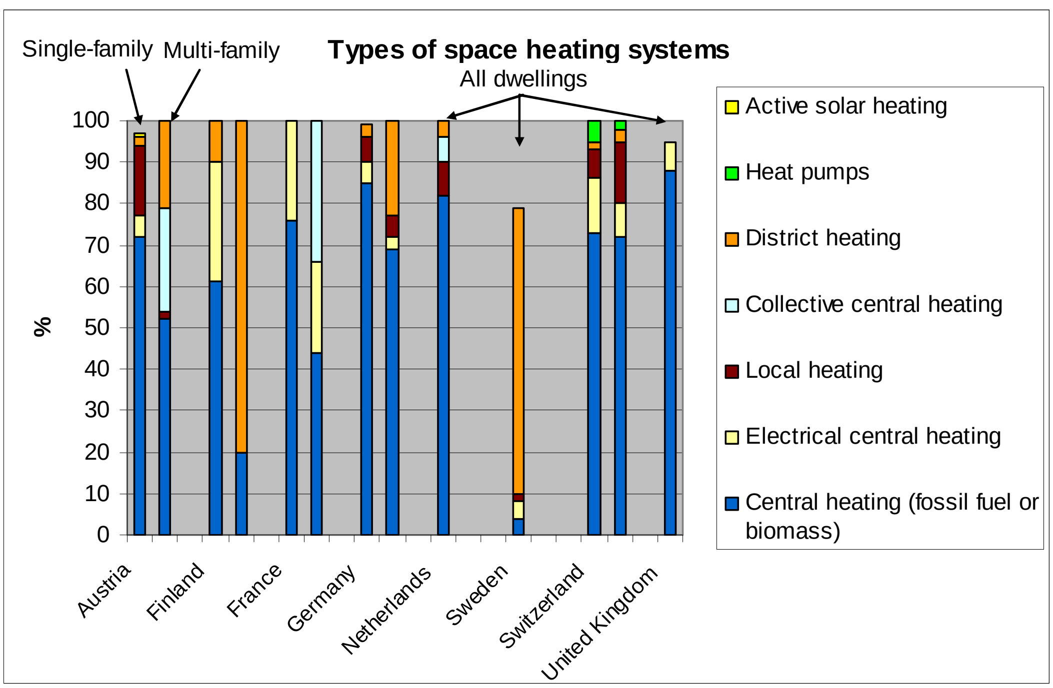
In general, reasonably detailed information is available on the types of building services used for heating and domestic hot water. Percentages or estimates of the penetration of techniques are given. Aspects that are taken into consideration here are heating and cooling systems, domestic hot water installations and ventilation systems.

Figure 4.10 shows the share of different heating systems for single-family dwellings and multi-family dwellings. In single-family dwellings, central heating based either on fossil fuel or on biomass is predominant. District heating is used mainly in multi-family dwellings. Local heating (stoves) still represents 5% to 17% of heating systems in Austria, Germany, the Netherlands and Switzerland. Local heating is mostly less efficient than central heating, but if installed only in one room, it often consumes less energy than central heating. In Swiss single-family dwellings, heat pumps already represent 5% of the total heating systems. Electrical heating is widely used in Finland and France with shares up to 30%. Although one could argue that the direct use of electricity (without the additional use of a heat pump) for heating applications may be sustainable if the electricity production is sustainable, from the point of view of rationally using energy sources it would be better to use electricity only for applications where it is really necessary, as for the generation of mechanical work or lighting. Furthermore, nuclear energy is (partly) used in both countries to produce electricity, and except for CO_2 emissions, the environmental friendliness of nuclear energy is doubtful. In terms of rational energy use, the use of relatively low temperature waste heat, as in district heating, is the most sustainable.

The efficiency of the different systems in terms of the ratio of the energy produced by the primary energy input may be assumed as indicated below.

- Central heating: 0.75 for conventional boiler, 0.8 for increased efficiency boiler and 1.07 for high efficiency (condensing) boiler
- Electrical heating: 0.4-0.7 depending on the efficiency of the electricity generation in the region.
- Local heating: 0.6-0.7
- Collective heating: equivalent to central heating
- District heating: theoretically infinitely high if based on waste heat from power plant or industry.
- Heat pumps: 0.8-3 depending on COP heat pump and efficiency of electricity generation.
- Active solar heating: not relevant because a renewable source is used

Figure 4.10: Types of space heating systems used in each country



[1] Austria: GWZ 2001
[2] Finland: Ekorem report
[3] France: Les Chiffres clés du batiment, Energie-Environnement, 2006, ADEME.
[4] Germany: IWU estimates based on micro census 2002
[5] Netherlands: SenterNovem, KWR 2002 and Basisrapport Kwalit. Woningregistratie 2000 (VROM).
[6] Sweden: Sveriges Officiella Statistik
[7] Switzerland: BFS
[8] United Kingdom: CAR Ltd estimates and Energy Consumption in the UK (DTI)

Data for cooling systems were not available. Although the energy used for cooling is still very low in the residential sector, there seems to be a trend to install cooling in new dwellings to avoid super heating during the warm months.

Austria

The data for Austria were obtained from GWZ 2001. 80% of single-family houses have central heating with radiators. Of these, 78% use a gas, oil or coal boiler. In new single-family buildings, high efficiency gas or oil boilers are used. In multi- family houses, they account for half of all boilers. About 12% is central heating with wood or biomass and 6% is electric heating, principally used in the pre-1945 building stock. In multi- family dwellings, individual central heating is employed in 52% of dwellings and collective central heating in 25% of dwellings. Collective central heating is more than 96% reliant on coal, gas or oil and half of this is a high efficiency system. Individual central heating is 71% reliant on gas, oil or coal and half of this is high efficiency.

17% of single-family houses use local heating (stoves) for heating, mainly in buildings built before 1960. Of these 71% are wood or biomass driven, 24% are coal, oil or gas driven, and 5% are electrical stoves. In multi-family dwellings, local heating is used in only 2.5% of the stock.

District heating is used in 2% of single-family dwellings, mostly post-1960, but in 21% of multi-family dwellings. Active solar heating is employed in only 1% of single-family dwellings and in 0.2% of multi-family dwellings.

Less than 5% of the total dwelling stock uses local air conditioners, but this number is rising. In 2007, around 1400 single-family houses and 240 multi-family houses had been built according to the principle of the passive house.

Finland

The Ekorem report gives aggregated data for space heating and tap water heating. There is no breakdown in building services but there is for type of energy consumed.

In single-family houses, 32% of the energy used for heating comes from oil and 29% from solid fuels (like coal). It is unknown if this energy is consumed by local heaters or by central heating. In Figure 4.10, it is assumed to be central heating. Solid fuels are used only in terraced houses, not in detached houses. Electrical heating is responsible for 29% of the energy used and district heating for 10%.

In multi-family dwellings, the energy consumption for heating is 80% from district heating and 20% from oil, which is assumed to be for central heating in Figure 3.17.

France

The reports “Les Chiffres clés du bâtiment” (ADEME) and “Le parc des logements existants” (CSTB) give the following data: in 24% of single-family dwellings and in 22% of multi-family dwellings, electrical central heating is the main heating source. In single-family houses, 36% of these electrically heated dwellings are found in the building stock built before 1975 and 64% in the post-1965 stock. In multi-family dwellings, these shares are 47 and 53% respectively.

Central heating (not electrical) is used in 76% of single-family houses. Collective central heating is employed in 34% of multi-family dwellings and individual central heating in 44%. For individual central heating in the total dwelling stock, data from 2000 indicate that 22% of boilers are more than 20 years old, 67% are less than 14 years and 53% are less than 9 years old.

Germany

The data for Germany are based on a mix of quantitative data and estimates. Central heating with gas or oil is utilised in approximately 85% of single-family dwellings, electrical heating in 5%, district heating in 3% and local stoves with gas, oil, coal or biomass in 6%. For multi-family dwellings, the figures are 69% for gas or oil central heating, 3% for electrical heating, 23% for district heating and 5% for local stoves. On average boilers and stoves are replaced every 20 years and piping every 40 years.

Netherlands

Data are available from SenterNovem, KWR 2002 and Basisrapportage Kwalitatieve Woningregistratie 2000 (VROM). In 2004, 82% of all dwellings had central heating, mostly gas-driven. Of these, 12% had a conventional boiler, 49% have an increased efficiency boiler and 39% a high efficiency condensing boiler. In addition to this, 30 939 heat pumps have been installed since 1990. This is less than 0.5% of all central heating systems.

Local stoves are found in 8% of dwellings, mostly gas-driven or using biomass. Biomass local heating accounts for 6.5% of the renewable energy use in the Netherlands. Collective central heating is employed in 6% of dwellings and district heating is used in 4% of dwellings. District heating by biomass accounts for 33% of renewable energy use, and district heating by waste heat for 15%. Active solar heating accounts for 1.5% of the Dutch renewable energy use.

Sweden

According to data from Sveriges Officiella Statistik 2005, 69% of all dwellings are connected to a district heating system, 4% are heated electrically, 4% have central heating with an oil boiler, and 2% have oil stoves. For 17% the type of heating is unknown.

Switzerland

The data come from BFS. 59% of single-family dwellings are equipped with a gas, oil or coal central heating system. 14% use central heating driven by wood or biomass and 13% use electrical central heating. District heating accounts for 2% and heat pumps for 5%, which is an unusual situation within Europe. Local oil, coal or gas stoves are used in 6% of single-family dwellings and local heating with wood or biomass in 1%.

65% of multi-family dwellings are equipped with a gas or oil central heating system. 8% use central heating driven by wood or biomass and 8% use electrical central heating. District heating accounts for 3% of systems, heat pumps for 2%. Local oil or gas stoves are used in 14% of multi-family dwellings and local heating with wood or biomass in 1%.

United Kingdom

From estimates based on the report Energy Consumption in the UK, DTI, it seems probable that 88% of the total dwelling stock has central heating which uses gas or oil; oil being mainly restricted to rural areas. 7% of the stock has electric storage heaters.

4.5 Domestic hot water

At the level of the European Union domestic hot water is responsible for 25% of the energy use of the residential sector. Based on Bertoldi (2001) and expert estimates, about 30% (43.5 million) of the EU's 142 million households use electric water heating systems. The percentage of households in each country using electricity to heat water is more than 40% in Austria, France and Switzerland, between 30% and 40% in Finland, just over 20% in the UK, and between 10% and 20% in Sweden, the Netherlands, and Germany. Boilers, whether or not combined with space heating, are used in various degrees and local water heating seems to still be in use in many countries, particularly in France. When district heating is used for space heating, it is often combined with water heating, at least when the heat distribution net is not at too low a temperature.

Austria

According to Statistik Austria, there are no statistical data on domestic hot water. An estimate from the IIBW indicates that 50% of single-family houses use a gas, oil or combination warm tap water boiler. For multi-family dwellings this is 60%, including collective hot tap water boilers. Electrical water heaters are used in 40% of single-family houses and in 30% of multi-family dwellings. Solar thermal boilers are employed in 2% of single-family houses and in 1% of multi-family dwellings.

Finland

No specific data, see Section 4.4.

France

According to data from the CSTB, 47% of single-family dwellings are equipped with a central hot water supply and 53% with a local hot water supply. The shares are identical for multi-family dwellings. The requirements in the thermal regulations for new buildings (RT 2005) about the consumption of domestic hot water are such that the implementation of solar panels will be almost indispensable in the future.

Germany

3% of all dwellings have no hot water service or use a wood stove, 18% of all dwellings have an electrical water heater and 79% use an individual gas or oil heater.

Netherlands

According to the data from VROM (KWR 2000), in which a breakdown in tenure is also available, about 60% of hot tap water is generated by combination boilers, 8% by electrical boilers and 3% by gas boilers. Local gas heaters (in kitchens or bathrooms) are found in 22% of all dwellings, and collective installations in 6%. Solar thermal boilers are found in 0.6% of the housing stock.

Sweden

Because district space heating is used in 69% of all dwellings, one can assume that 69% of all dwellings will also have warm tap water from the district heating system. According to Bertoldi (2001), 10% to 20% of hot tap water systems are electrical.

Switzerland

Data are available from BFS 2000 and BFS 2002. 3% of single-family and 1% of multi-family dwellings have no water services or use a wood stove. Electrical water heaters are used in 52% of single-family dwellings and 35% of multi-family dwellings. Gas and oil boilers are used in 38% of single-family dwellings and 57% of multi-family dwellings. The latest figures include collective boilers. 1% of single-family dwellings and 2% of multi-family dwellings are connected to district heating for hot tap water. In both categories, solar thermal boilers are employed in 1% of the dwellings. Heat pumps are used in 2% of the single-family building stock and 1% of the multi-family building stock. According to BFE 2002, solar thermal boilers already account for 1.4% to 2% of the domestic hot water installations in single-family houses and for 0.8% in multi-family dwellings. At the level of the total dwelling stock this is about 1%.

United Kingdom

From Bertoldi (2001), it is estimated that about 20% of dwellings have electrical water heaters. The other 80% is shared between gas-oil boilers, gas-oil combination boilers and local gas heaters (Estimates of hot water consumption from 1998, BRE, http://www.berr.gov.uk/files/file16568.pdf).

4.6 Ventilation

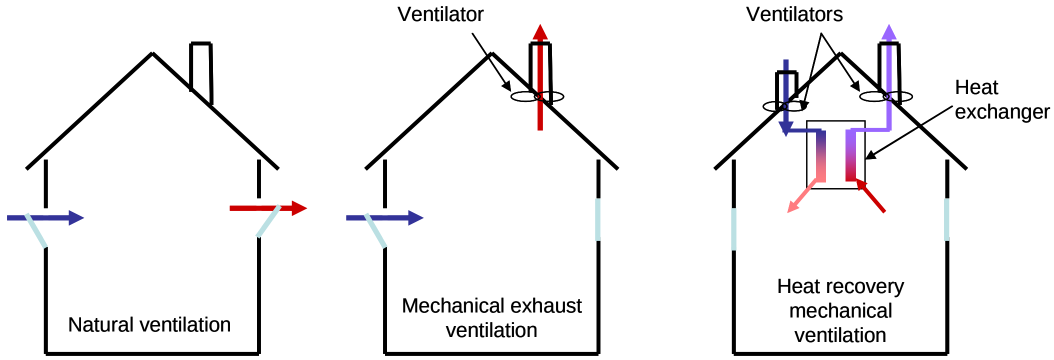
Ventilation is very important from the point of view of indoor air quality, health of occupants and occurrence of humidity problems. This appears to be especially important in well-insulated air-tight buildings (newly renovated), where ventilation by infiltration through thin construction cracks and by simply airing with open windows is not enough to ensure reasonable air quality. There is a lot of international research in this area, see for instance the proceedings of the International REHVA Conference Clima 2007 (see references) or the International Indoor Air Conferences. Ventilation is necessary but is also a main source of heat loss from buildings. It is therefore an important issue for sustainable dwellings. Three main systems are in use in dwellings and are shown in Figure 4.11.

The first one is natural ventilation, which covers airing through windows and continuous ventilation through grilles placed in the window itself. It is often combined with a fan in the bathroom and/or the kitchen. The main advantage of natural ventilation is that no electrical energy is needed to power ventilators. An inconvenience in air-tight dwellings could be that the ventilation flows may be too low under certain weather conditions.

The second system is called mechanical exhaust ventilation. The air supply occurs naturally through grilles in the window. A ventilator placed in an exhaust duct ensures that the air is continuously expelled outside. This way, a sufficient flow of fresh air is ensured, even when the wind pressure is low – as long as the system is well-designed. The main advantage of this system is that minimal air flows are ensured. A disadvantage is the electricity consumption of the ventilator and possibly noise nuisance. These systems are sometimes combined with natural systems; the ventilator is only switched on when the CO_2 concentration in the indoor air exceeds a certain value.

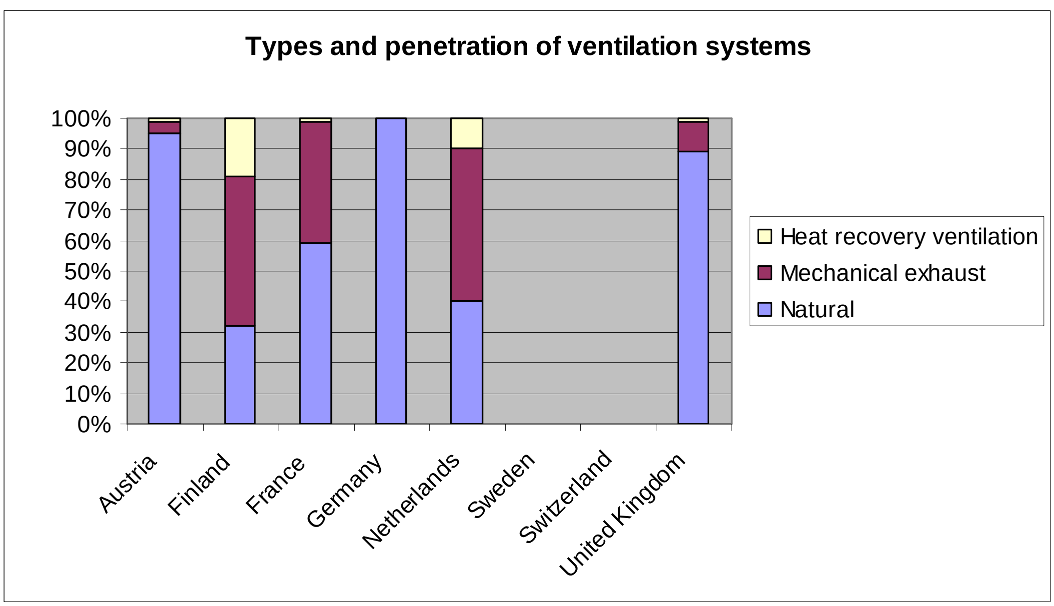
The third system is heat recovery mechanical ventilation, also called balanced ventilation or mechanical supply and exhaust heat recovery ventilation. In this system outdoor air is mechanically supplied to a heat exchanger that transfers heat from the exhaust hot air to the incoming cold air. This way, the outside air is preheated before being supplied to the room, reducing the heating demand of the building. These systems are theoretically very energy efficient, but in practice, their efficiency is much lower than expected, because occupants do not operate them the right way, partly because they are often poorly designed (Soldaat et al. 2007).

Figure 4.11: The three main types of ventilation systems



Except for Finland, the Netherlands and probably Sweden, where their share is 10% to 20%, mechanical supply and exhaust systems with heat recovery are not widely used. Natural ventilation of dwellings through windows and sometimes grilles, and kitchen or bathroom fans is still the most common way of ventilating. In Austria, Germany, the United Kingdom and probably Switzerland, natural ventilation accounts for almost 100% of all systems. In Finland, France and the Netherlands, its share is 30%, 40% and 60% respectively. Mechanical exhaust systems are used largely in Finland, France and the Netherlands as well (with shares of 40% to 50%).

Figure 4.12: penetration of the three main types of ventilation system



In Austria, 95% of all dwellings are naturally ventilated; probably this is mainly airing through windows. Only 1% has heat recovery mechanical supply and exhaust ventilation (estimate from the IWU).

In Finland, 30% of single-family dwellings and 5% of multi-family dwellings have a heat recovery mechanical supply and exhaust ventilation. 30% of single-family dwellings and 75% of multi-family dwellings have a mechanical exhaust ventilation system. Almost 40% of single-family dwellings and 20% of multi-family dwellings have a natural ventilation system through grilles, whether or not in combination with local ventilation by a fan in the bathroom or kitchen (estimate from Le Dean, Clima2007). The trend in new buildings is to install heat recovery mechanical supply and exhaust ventilation systems (in 90% of new single-family dwellings and 30% of multi-family dwellings) or mechanical exhaust ventilation (in 10% of new single-family dwellings and 70% of multi-family dwellings).

In France, 1% of the dwellings have a heat recovery mechanical supply and exhaust ventilation system, 40% have exhaust mechanical ventilation, 19% have a natural ventilation system through grilles, 30% have local ventilation in kitchens and/or bathrooms in combination with airing and 10% have only airing through windows (estimate from Le Dean, Clima 2007). The trend in new buildings is 5% heat recovery mechanical supply and exhaust ventilation and 95% mechanical exhaust ventilation. A large study about ventilation in existing buildings was launched recently by "AIR.H" and will give statistical data about ventilation systems, their numbers by type and their share in different building types. The results of this study are not yet public (www.airh.asso.fr) but are not expected to be very different from those presented by Le Dean.

In Germany, the IWU estimates that almost 100% of dwellings are ventilated through airing by windows, mostly in combination with fans in the kitchen and bathroom.

In the Netherlands, 10% of the buildings have heat recovery mechanical supply and exhaust ventilation, 50% have mechanical exhaust ventilation, 30% have natural ventilation with grilles and 10% have a combination of airing by windows and local fan ventilation in the kitchen and/or bathroom (estimate from Le Dean, Clima 2007).

Sweden and Switzerland: although no specific data could be found, one can expect the situation in Sweden to be similar to that of Finland and the situation in Switzerland to be similar to the situation in Germany.

In the United Kingdom, less than 1% of dwellings have heat recovery mechanical supply and exhaust ventilation, around 10% have mechanical exhaust ventilation, 2% have natural ventilation through grilles, 20% have airing through windows and local fans in kitchens, and 67% only have airing through windows (estimate from Le Dean, Clima 2007).

4.7 Sanitation

Although sanitary equipment in itself is not an accurate indicator of energy consumption, it plays an important role in the perceived quality of dwellings. There could also be a relationship between the number of bathrooms and the consumption of hot tap water. The figures presented in the following sub-sections may be slightly different from the data presented in Table 4.1, because apart from statistical data, estimates from experts are used as well.

Austria

In Austria, and especially in Vienna, bathrooms and WCs are often in two separate rooms. 5% of multi-family dwellings and 3% of single-family dwellings have no bathroom or WC inside the dwellings. 53% of single-family dwellings have one bathroom and/or WC and 45% have two or more bathrooms and/or WCs. For multi-family dwellings, these shares are 78% and 20% respectively. Two or more bathrooms and WCs are found mainly in large apartments and houses. There is a moderate trend to more than one bathroom, particularly in single-family dwellings. In a large part of the stock without a bathroom, improvements are difficult because of the small size of the dwellings. There is a trend towards larger bathrooms and bathrooms with natural ventilation (on an external wall with a window). These data are based on the ISIS database and on an educated guess from the IIBW.

Finland

Only 1% of the building stock is estimated to have no bath or shower (see Table 4.1).

France

In France, a detailed breakdown is available according to the age of the building. The data used comes from the CSTB (Le parc des logements existants, Laboratoire économie et statistique, 2003) and is shown in Figure 4.13. At the level of the whole dwelling stock about 2% has no bathroom or shower inside. Most of the dwellings without bathroom, shower or WC are found in the pre-war building stock.

Germany

The data is based on results from representative inquiries on the level of rents to be paid for dwellings in Frankfurt in 2003 and Darmstad in 2001, and may be assumed to be representative of multi-family dwellings in Germany, at least western Germany. 2% of multi-family dwellings are estimated to have no bathroom, 97% are estimated to have 1 bathroom and 1% is estimated to have more than 2 bathrooms. There is no data for single-family dwellings.

Table 4.13: Basic quality of the sanitary equipment in French dwellings

In %	No bathroom No shower WC outside	No bathroom No shower WC inside	Bathroom or shower and WC outside	Bathroom or shower and WC inside	Total
Pre-1915	3.6	2.9	3.7	89.7	99.9
1915-1948	2.3	2.5	3.6	91.7	100.1
1948-1967	0.4	0.5	1.6	97.4	99.9
1968-1974	0.1	0.1	1.3	98.4	99.9
1975-1981	0.1	0.1	1.2	98.6	100.0
1982-1989	0.1	0.1	1.4	98.5	100.1

The Netherlands

Data from CBS 1998 indicate that 0.2% of dwellings are without a bathroom inside the house, 59% of dwellings have a shower and 41% of dwellings have a bathroom and a shower. The trend in new buildings is to have a separate bath and shower in the bathroom. In 1995, 39% of dwellings had a bath and a shower; in 2000, this figure was 44%. 63% of all dwellings had one WC in 1995 and in 2000, 50% of all dwellings had two or more WCs (KWR 2000).

Sweden

Although there are no official statistics, all dwellings in Sweden are estimated to have at least one bathroom and WC inside.

Switzerland

The data comes from Gerheuzer (1998). It is estimated there are almost no dwellings without a bathroom. In multi-family dwellings, 80% have one bathroom and 20% have two or more bathrooms. In single-family dwellings, 40% have one bathroom and 60% have two or more bathrooms. For the whole building stock, the estimate is that around 60% of dwellings have one bathroom and 40% have more than one. It is also known that in 1998, 75% of the owner-occupied dwelling stock has more than one bathroom. In the rented dwelling stock, this percentage is 25%. In newly built dwellings this percentage is higher.

United Kingdom

Data from the English Housing Condition Survey 2005 were used. The number of dwellings without a bathroom is estimated to be insignificant. 38% of dwellings have more than one WC. There are no data about bathrooms.

4.8 Elevators

The presence of an elevator in multi-storey buildings or the possibility of installing one is important for the accessibility of the building, especially for the elderly and for disabled persons. It increases the perceived comfort and also the degree of flexibility of the building. If there is enough space to install an elevator in a multi-storey building, this will probably enhance its service life. From the data collected in this study, and for all the differences between countries, it seems that a large share of multi-storey apartment buildings is still not equipped with an elevator. More detailed data are given in the following subsections for the countries where data were available.

Austria

In Austria, the IIBW estimates that 30% of apartment buildings with four levels and 15% of buildings with more than four levels have no elevator.

France

In France, 89.5% of dwellings with less than four levels have no elevator, 41.2% of dwellings with four to eight levels have no elevator and 2.6% of dwellings with more than 8 levels still have no elevator. A detailed breakdown in age and ownership structure can be found in "Le parc des logements existants, Laboratoire économie et statistique" (2003).

Germany

The data are based on results from representative inquiries into the level of rents to be paid for dwellings in Frankfurt in 2003 and Darmstad in 2001, and may be assumed to be representative of dwellings in Germany, at least Western Germany. 94% of dwellings with four floors have no elevator, whereas this figure decreases to 65% for dwellings with more than four floors.

The Netherlands

From estimates from SenterNovem, 78% of dwellings with four or more levels are equipped with an elevator. More than 40% of all multi-family dwellings had an elevator in 2000. This is an increase of more than 50% when compared to 1995. Only a small part of this increase is a consequence of renovation. The increase is due mainly to new buildings. In pre-war multi-family dwellings there is often still no elevator, probably because these multi-family dwellings have only three or four levels and/or have separate entrances from an outside staircase and/or are combined with stores or small companies on the ground floor, which makes the installation of a common elevator difficult.

Sweden

Data from Sveriges Officiella Statistik 2002 were used. In the rental sector, 45% of dwellings located on the third floor have an elevator. In the privately owned sector, this is 40%. Of dwellings located on the fourth floor or higher, more than 84% have a lift in both the rental and the privately owned sectors.

Switzerland

Data from Gerheuzer (1998) show that 40% of dwellings located in buildings with four levels have no elevator. For dwellings located in buildings with more than four levels this percentage is 15% to 20%.

United Kingdom

Except for estimates from CAR Ltd, no data were found. Three-storey flats commonly seem to have no elevator. Four-storey flats without elevators seem to be rare and flats of more than four-storeys without elevators are very rare.

4.9 Thermal comfort and health quality

Thermal comfort and health quality aspects are more difficult to evaluate from objective indicators, as they are very sensitive to the perception of the occupants of the dwelling. However, they are essential to the perceived quality and therefore to occupant satisfaction. Although numerous studies exist on thermal comfort and health quality, these are mostly related to complaint handling by health authorities and have little statistical value. In general, problems of humidity and mould are reported in a part of the building stock, as well as acoustic nuisance. In France and the UK, problems with non-decent housing in a small part of the stock are reported as well.

Austria

In Austria, there are health problems in about 5% (estimate IIBW) of the pre-1945 dwelling stock. These health problems are related to the existence of lead pipes, to the absence of foundations, and to moisture problems. Asbestos has been a problem for a long time too, but is mainly solved now. In the dwelling stock built in the period 1976-2000, some problems of fungi are noticeable. When considering thermal comfort, there is still part of the dwelling stock without central heating or with an outdated system (5% to 10%). The single-family and multi-family dwelling stock built between 1945 and 1970 have for a large part (30%) low thermal quality and energy efficiency. In comparison, the pre-war dwelling stock has higher energy efficiency. In the dwelling stock built in the sixties and seventies of panel construction, the acoustic quality is estimated poor (5%) to reasonable (25%). Due to the new earthquake directive, a lot of existing buildings do not comply on construction quality.

Finland

In Finland, the main problems with the existing building stock are believed to be mould and moisture problems due to construction problems (type of walls and cold bridges). These problems are mainly noticeable in the dwelling stock built between 1945 and 1975. Of these dwellings, 10% are assumed by experts to have a poor health quality and only 30% a reasonable quality. In the building stock built before 1945 and between 1976 and 1990, the estimate is 5% poor and 20% reasonable. In the stock built before 1975 about 10% of dwellings are estimated to score poorly on all technical quality aspects. However, compared to other EU countries the existing dwellings stock may be assumed to be rather energy efficient because most of it has been built after the energy crisis and large renovation programmes have been carried out.

France

In France, there is also an increasing lack of affordable housing with a minimum quality [Social Housing in Europe]. About 600 000 dwellings are considered to be non-decent housing (La Fondation Abbé Pierre).The acoustic quality may be a problem too in multi-family dwellings.

Germany

In Germany, the three main quality problems in the existing building stock are related to the energy quality and the acoustic quality.

Netherlands

In the Netherlands, dwellings in the private rented sector have a much lower degree of insulation (20% to 30% less) than owner-occupied or social rented dwellings. An exception to this is double-glazing which has been installed relatively often in the private rented sector. In dwellings built after 1990, there may be a thermal comfort problem in the summer because of superheating. In buildings equipped with mechanical supply and exhaust heat recovery ventilation systems, numerous studies show a correlation with health problems (allergy and respiratory problems). A possible cause of this is the poor design of the ventilation system (low capacity, noise), poor maintenance (no cleaning) and too little knowledge by the occupants about the working of the system (Soldaat et al. 2007). Poor indoor air quality (inadequate ventilation, moisture and Nox/CO emissions) is a current point of attention.

Sweden

The general state of the Swedish dwelling stock is good compared to many other European countries and it has been well renovated. The energy efficiency of the existing stock is good because thermal regulations have always been rather stringent due to the cold climate. As in Finland, problems with mould and moisture may be observed in some parts of the stock. Social rented dwellings tend to be better renovated than owner-occupied dwellings for the same reasons as in Finland.

Switzerland

In Switzerland, the insulation level of the building stock is believed to be low in 40% of the building stock built before 1975. No data were available on specific comfort and health aspects.

United Kingdom

About one third of the social rented sector does not meet the decent home standard. The main reasons for this relate to insulation and energy conservation. From the English Condition Survey 2005 a considerable part of the older building stock is considered to have poor thermal comfort (25% of pre-1945 dwellings, 15% in the building period 1919-1944, 8% in the period 1945-1964, 6% in the period 1965-1990 and 1% in buildings built after 2000). When considering the total thermal quality (comfort and energy efficiency), these percentages are higher: 41, 30, 26, 28 and 11% respectively. Fitness, repair or modernisation activities are considered to be needed in 15% of the pre-1945 stock, in 22% of the stock built between 1965 and 1990 and in 10% of the stock built after 2000.

4.10 Summary and conclusions

In this chapter, the physical quality of the existing building stock was studied in terms of energy use, insulation levels, space and hot water heating, ventilation, sanitation, lifts, and comfort and health. The main results are summarised hereafter.

Energy use and insulation level

1. Detailed data on the end energy use in dwellings are lacking and the breakdowns are different in each country.
2. Reliable data on the construction types and insulation levels are lacking.
3. Space heating and hot tap water heating are responsible for a large part of the energy consumption in dwellings.
4. In the European Union as a whole, domestic hot water is responsible for 25% of the energy used in the residential sector.
5. Finland and France have a very high percentage of solid walls (80% to 100%), the Netherlands a very low percentage (4%), and United Kingdom about 30%.
6. Cavity walls are more often insulated than solid walls, but in Finland, which has a young building stock, almost all solid walls have been insulated.
7. Sloping roof insulation has been realised in approximately 70% of the dwellings.
8. The degree of insulation of floors varies from 30% to 60%.
9. The penetration of double-glazing is high in all countries, and the penetration of triple glazing is low except for Finland and Sweden.

For monitoring the effectiveness of policies and for the estimation of potential savings and of possible penetration of insulation measures it is important to gather data on the thermal construction quality of buildings. The main recommendation is therefore to launch statistical studies to collect these data and to monitor energy use as well. To a certain extent this could be related to the implementation of the EPBD, in as far as the collection of harmonised data would be possible within this framework.
A second recommendation is to put effort into technical solutions and into the market diffusion of these solutions for the insulation of façades and, to a lesser extent, roofs.

Space and hot water heating

1. Although cooling systems are installed more often in new dwellings there is in general no cooling equipment in the existing building stock.
2. In single-family dwellings, central heating based on either fossil fuel or biomass is predominant.
3. District heating is predominant in Sweden and in Finnish multi-family dwellings.
4. Local heaters still represent 5% to 17% of heating systems in Austria, Germany, the Netherlands and Switzerland.
5. In Swiss single-family dwellings, heat pumps already represent 5% of the total heating systems.
6. Electrical heating is widely used in Finland and France with shares up to 30%.
7. Electricity is used to heat water in more than 40% of households in Austria, France and Switzerland, in 30% to 40% in Finland, in just over 20% in the UK, and between 10% and 20% in Sweden, the Netherlands and Germany.

8. Boilers, whether or not combined with space heating, are used in various proportions.
9. Local water heating is still in use in many countries, particularly in France.
10. When district heating is used for space heating, it is often combined with water heating.

> Space heating and domestic hot water heating take place using conventional fossil fuel technologies. The penetration of renewable energy is low. High quality energy (electricity) is still often used for low quality applications (heating), which do not comply with the idea of rational energy use. Because building services must be replaced on a regular basis of about 15 years, they offer a good opportunity to implement sustainable solutions. Because the penetration of sustainable solutions is low, it is recommended that specific diffusion programmes and research on the causes of this market failure be launched. Analysis of the success factors in countries that have succeeded in the large-scale implementation of technologies like district heating and heat pumps is recommended.

Ventilation, comfort and health

1. Natural ventilation of dwellings through windows and sometimes grilles and kitchen or bathroom fans is still the most common way of ventilating.
2. In Austria, Germany, the United Kingdom and probably Switzerland, natural ventilation accounts for almost 100% of all systems.
3. In Finland, France and the Netherlands, natural ventilation accounts for 30%, 40% and 60% respectively.
4. Mechanical exhaust systems are used predominantly in Finland, France and the Netherlands as well (shares of 40% to 50%).
5. Mechanical supply and exhaust systems with heat recovery are not widely employed. Exceptions are Finland, the Netherlands and Sweden, where their share is 10% to 20%.
6. In general, the thermal and acoustic quality of dwellings built between 1945 and 1970 is relatively low. In Austria, it is even lower than the quality of the pre-war stock.
7. The general quality of Finnish and Swedish dwellings is believed to be very high in comparison to many other European countries.
8. Moisture problems and mould have been identified in the Austrian, Finnish and Swedish building stock. In Austria, this is mainly in the pre-war and post-1975 stock and in Finland it is mainly in dwellings built between 1945 and 1975. Probably these problems are also present in other countries, but are not considered to be an issue.
9. In buildings using mechanical ventilation with heat recovery, allergy and respiratory problems have been identified in the Netherlands and to a lesser extent in Finland.
10. France and the United Kingdom have still to cope with non-decent housing in a small part of the building stock.

> When buildings are thermally renovated, much attention must be paid to the ventilation system. Poor ventilation can lead to moisture and fungi and to several health problems. Draught related to ventilation may also cause thermal discomfort. There seems to be an urgent need for integral renovation concepts taking ventilation into account and for products which take into account the occupant's needs and behaviour. Acoustic insulation should be part of these concepts. For countries coping with non-decent housing, specific programmes could be set up.

Sanitation and elevators

1. Almost all dwellings have basic quality requirements like having running water, a lavatory, a bath or shower and a heating system.
2. Dwellings that do not meet these requirements can almost all be found in the older pre-war stock.
3. The current trend is to equip new houses with more than one bathroom and WC.
4. In contrast to new buildings, existing apartment buildings of more than four storeys are not always equipped with an elevator. In all countries it is estimated that only 65% to 85% of these buildings have an elevator.

Some attention should be paid to the trend for more sanitation equipment, which could counteract the aim of sustainable material and water use. When considering lifts, it can be argued that equipping multi-storey buildings with a lift is or will be necessary to meet market demand. Because of the practical difficulties in installing such an elevator, standardised low space-use solutions should be developed or diffused.

5 Non-residential sector

5.1 Introduction non-residential

The aim of this chapter is to provide information about the non-residential building stock and its quality in the eight countries participating in this study. The non-residential building stock is defined in this study as the sum of educational buildings, health care buildings, shopping and leisure buildings, and office buildings. The total non-residential building stock of these countries amounts to 43% of the residential building stock in terms of floor area. The percentages differ by country, from only 4% in Switzerland to 57% in Finland and 31% at the European level (at the European level, only the cold and moderate climate zones were taken into account, and Switzerland was not accounted for in the data).

As already stated in Chapter 2, the data about the non-residential sector are often outdated and assembled from sector estimates, as a result of which their statistical validity can be doubted. Furthermore, the comparability of data between countries may be low because different definitions may have been used in the different sectors and in the different countries. Unfortunately, the methodology and definitions used in many studies are not always clear. For instance, the definitions of useful area differ in each country and some of our data are based on useful floor area and others on heated area. The availability and quality of data are summarised in Table 5.1.

Table 5.1: Availability and quality of data for the non-residential sector

	Availability and quality of data
Austria	The availability of data is limited. Educational buildings, cultural and leisure buildings, and health care buildings are mostly considered as one category.
Finland	There is only detailed information available about the buildings owned by municipalities; they represent 9% of the total building stock. There are no official statistics about the ownership structure of the non-residential buildings. The stock information is managed by tenure. However, municipalities have well collated information. The state-owned stock is developed and managed by Senaatti Kiinteistot. Collecting information about the portfolios of real estates is a very fragmented task. However, the Ekorem report gives detailed information about the energy use at national level.
France	The government does not arrange systematic studies of the non-residential sector as it does for residential buildings. The actors are diverse; they are mainly private or public owners depending on the sector. Data for educational buildings exist and can be detailed but they are dispersed between local, regional and national authorities. In the private sector the data, when in existence, are generally not made public.
Germany	There are no official current statistical data on non-residential buildings provided by official census. In West Germany there is only one census of all buildings (except those related to agriculture) and it dates from 1950. In East Germany continuous statistical data on non-residential buildings were available until the end of the 1980s, but the enormous changes from then on do not allow for mere updating.
Netherlands	There are very few data available for buildings owned by private investors. However, the SenterNovem/EBM report “Energiebesparingsmonitor 2006” provides relevant information.
Sweden	Only very limited data sources are available.
Switzerland	According to the experts consulted (among others from BFS), the non-

	residential building stock is not well documented. The 2000 census only recorded inhabited and habitable buildings.
United Kingdom	Only limited data are available. Statistics about floor area and energy use are only available at a high level of aggregation.

5.2 Ownership structure and stakeholders

Although the ownership structure for the non-residential buildings is not well documented, Table 5.2 and Figure 5.1 give an indication based on literature, sector studies and a few databases. The figures presented must be interpreted as an indication, not as firm statistics.

In Finland, there are only data available for the whole building stock (residential + non-residential). Finnish municipalities own 35 471 buildings, accounting for 33 million m^2. 65% of this area is non-residential buildings. For Austria, France and Germany, it was not possible to make a distinction between owner-occupied buildings and privately owned rented buildings. In general, privately owned buildings (either owner-occupied or rented from private or corporate investors) account for a large part of the non-residential sector (45% to 97%), the lowest share being observed in France, where 50% of all non-residential buildings are owned by governments or municipalities. In the Netherlands, 81% of office buildings and 79% of shopping buildings are rented from corporate or private investors (SenterNovem 2007). In general, educational buildings are owned by governments or municipalities. In France, for instance, educational buildings for primary education are managed by municipalities, buildings for secondary education by departments and regions, and finally universities are managed by the state. For health care buildings, a mixed situation is observed. In France, the government owns only 33% of all health care buildings whereas this figure is 90% in Germany.

Table 5.2: Ownership structure in the non-residential building stock (in % of buildings, except for France)

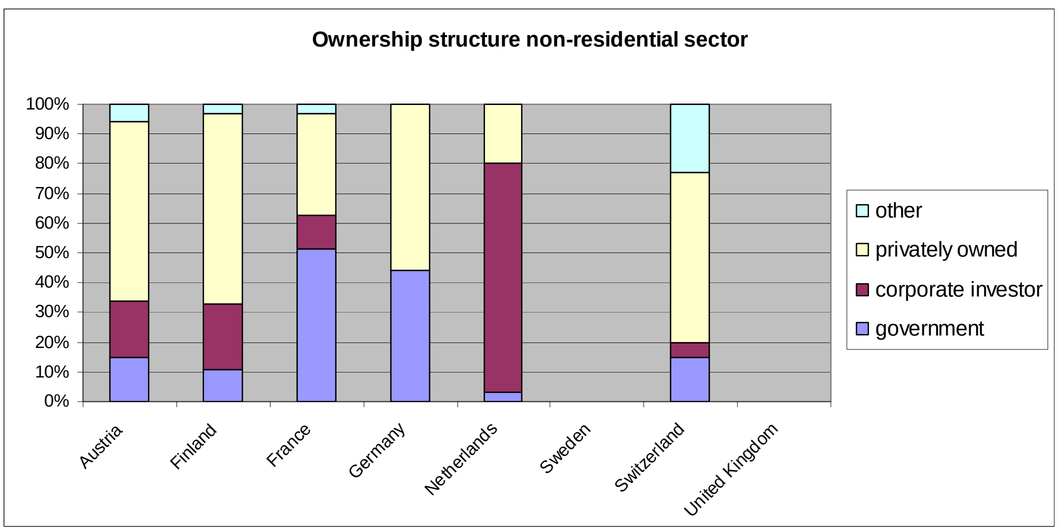
%	Category	Owner-occupied	Private investor	Corporate investor	Governments & Municipalities	Other *	Total
Austria[1]	Office	43		33	17	7	100
	Shopping	70		24	4	2	100
	Hotels & similar	87		7	2	4	100
	Educational, Leisure, Health	10		6	68	16	100
	Total	**60**		**19**	**15**	**6**	**100**
Finland[2]		35	29	22	11	3	100
France[3] (in % floor area)	Office	49		17	30	4	100
	Educational	13		7	80		100
	Health care	49		10	33	8	100
	Total	**34**		**11**	**51**	**3**	**99**
Germany[4]	Office	80			20		100

	Shopping & leisure	67			33		100
	Educational	10			90		100
	Health care	10			90		100
	Total	**56**			**44**		**100**
Netherlands[5]		20		77	3		100
Sweden[6]		n.a	n.a	n.a	n.a	n.a	n.a
Switzerland[7]		28.5	28.5	5	15	23	100
United Kingdom[8]		n.a	n.a	n.a	n.a	n.a	n.a

*: Category "Other" includes non-profit associations.
[1] ISIS Database, GWZ 2001.
[2] Vainio, T., Jaakkonen, L., Nippala, E., Lehtinen, E., Isaksson, K., 2002, Korjausrakentaminen 2000-2010, Espoo: VTT Tiedotteita 2154, estimates for the total building stock (residential + non-residential).
[3] in % total floor area, from ADEME, AICVF, Programmer, concevoir, gérer – Enseignement, Bureaux, Santé; édition Pyc -1993, shopping & leisure excluded.
[4] Estimate from IWU. Estimate based on EUROPARC - Der Gebäudebestand in Europa: Deutschland, Frankreich, Großbritannien, Italien und Spanien, Deutsche Gesamtausgabe Februar 1999.
[5] Energiebeparingsmonitor gebouwde omgeving, SenterNovem 2006.

[7] from BFS, Wohnungszählung 2000.

Figure 5.1: Ownership structure in the non-residential building stock (in % of buildings)*



*: France: % of floor area; Germany: privately owned sector includes corporate investors

5.3 Building types and relationship to tenure

In this section, data on the number of buildings in each sub-sector are presented. As stated in the introduction, the comparability of data is limited by differing definitions of the sectors and by the fact that some data are expressed in floor area (France, Germany, Sweden and the United Kingdom), in heated floor area (Switzerland) or in number of buildings (Austria, Finland and the Netherlands).

The large variations in the share of the sector Shopping and Leisure in different countries may be partly the result of these different units as well as different definitions of this sector (see notes under Table 5.2). Within these inaccuracies it seems that Shopping and Leisure represents 21% to 80% of the non-residential building stock, and could therefore play an important role in sustainable renovation. For so far as data could be collected about the tenure type in this sector (see Section 5.2), it seems that a large part of the Shopping and Leisure sector is owned by private or corporate investors. In what proportion this sector is owner-occupied or rented is difficult to say from the collected data. However, the problems related to this sector will be related to either the specific problems of owner-occupants: little knowledge of measures, non professional market and, except for the larger chains, little investment capacity; or to the specific problems of rented buildings (the investor is not the one who profits from the measures).

Except for Finland and Germany, where their share seems to be quite low, office buildings account for 20% to 40% of the non-residential building stock. Although a larger share of office buildings is owned by local or national governments, especially in Austria, France and Germany, the main office stock is privately owned, whether or not owner-occupied.

Educational buildings account for 7% to 32% of the non-residential buildings and are for a large part owned by the local or national governments. As far as health care buildings are concerned, in some countries they may represent up to 19% of the non-residential building stock, but the ownership structure is less clear. In general, governments own a large part of this sector, but for instance in France, private buildings are in the majority. Furthermore, there are probably large differences in ownership between hospitals and community accommodation (nursing and rest homes).

Table 5.3: Building types in the non residential building stock (in million m^2 or in number of buildings (underlined figures))

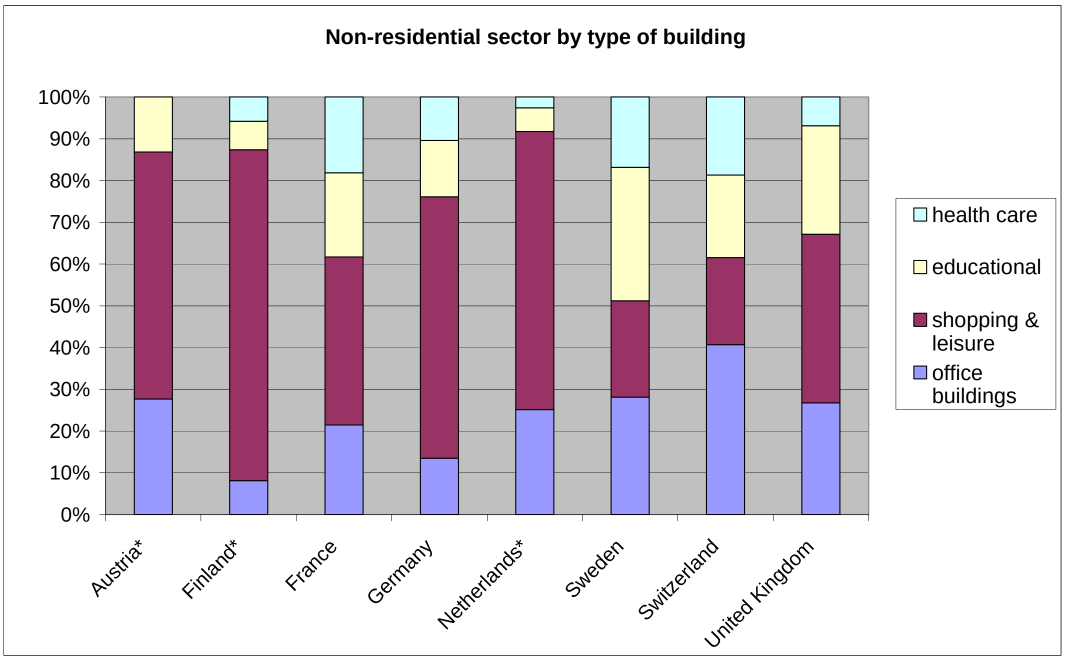
	Office buildings		Shopping & Leisure		Educational buildings		Health care buildings		Total	
	10^6 m^2/ number	%	10^6 m^2/ number	%	10^6 m^2/ number	%	10^6 m^2/ number	%	10^6 m^2/ number	%
Austria[1]	32235	*27.7*	68909	*59.1*	15393			*13.2*	116537	*100*
Finland[2]	10695	*8.1*	103986	*79.2*	8968	*6.8*	7654	*5.8*	131303	*100*
France[3]	182	*21.4*	342	*40.0*	172	*20.0*	154	*18.1*	850	*99.5*
Germany[4]	141	*13.5*	654	*62.6*	141	*13.5*	109	*10.4*	1045	*100*
Netherlands[5]	60000	*25.1*	158635	*66.5*	13700	*5.7*	6300	*2.6*	238635	*99.9*
Sweden[6]	34	*28.1*	28	*23.1*	38.7	*31.9*	20.5	*16.9*	121.2	*100*
Switzerland[7]	37	*40.7*	19	*20.9*	18	*19.8*	17	*18.7*	91	*100*
United Kingdom[8]	120	*26.7*	181	*40.4*	116	*25.9*	31	*6.9*	448	*99.9*

[1] ISIS Database, GWZ 2001; the data give number of buildings, no floor area. Shopping & Leisure buildings include hotels; Educational and health care buildings are joined into one category.
[2] Statistics Finland; Shopping & Leisure buildings include transport buildings (airports, stations).
[3] Les Chiffres clés du bâtiment, Energie-Environnement/édition 2006 – ADEME; Shopping & Leisure buildings include hotels, restaurants, sport and transport buildings (airports, stations); Health care buildings include community accommodation (elderly & disabled people).
[4] Year 1998; estimate based on EUROPARC - Der Gebäudebestand in Europa: Deutschland, Frankreich, Großbritannien, Italien und Spanien, Deutsche Gesamtausgabe Februar 1999.
[5] Energiebeparingsmonitor gebouwde omgeving, SenterNovem 2006 and Duurzame Warmte en Koude 2008-2020, Ecofys 2007; Shopping & Leisure includes hotels, restaurants, congress buildings, sport and swimming pools; Health care buildings include community accommodation (elderly & disabled people).
[6] SCB, energistatistik för lokaler (urvalsundersökning)
[7] Estimate by Jakob et al., 2006, based on heated surface area. In this data, buildings for collective living (elderly, disabled people, etc) and non-residential buildings including at least one dwelling are not

taken into account. These two types of dwellings are estimated at 84 615 buildings and 60 million m². When these buildings are taken into account, the total non-residential floor area amounts to 151 million m².

[8] Based on data from CaRB project.

Figure 5.2: Non-residential building stock by type of building (in % m² or in % number of buildings (*). For Austria, health care and educational buildings are joined in one category).



5.4 Age of the non-residential building stock

In general, the age of the non-residential building stock is not well documented at national level. Appropriate data were found only for Finland, Germany and the Netherlands (see Table 5.4). The EURIMA report "Mitigation of CO_2 emissions from the building stock" also provides estimates of the construction periods of small and large non-residential buildings (see Table 5.5). The underlying data for these estimates are not publicly available. According to the data from Table 5.4 and Table 5.5 it seems that a considerable part of the non-residential building stock was built before the oil crisis: 64% at European level, 43% for Finland, 74% for Germany and 49% for the Netherlands.

Table 5.4: Age of the non-residential building stock in Germany and the Netherlands (%)

%	< 1960		1960 – 1975	1976-1985	1986-1995	1996-2005	Total
Germany[1]	74.3			11.6	14.1	n.a.	100
Netherlands[2]	39.2		19.5	11.9	14.3	15.1	100
	<1950	**1951-1960**	**1961-1970**	**1971-1980**	**1981-1990**	**1991-2000**	
Finland[3]	19.9	8.6	14.7	18.9	24.1	13.8	100

[1] Year 1998; estimate based on EUROPARC - Der Gebäudebestand in Europa: Deutschland, Frankreich, Großbritannien, Italien und Spanien, Deutsche Gesamtausgabe Februar 1999; table Germany 2.10.1.
[2] Monitor energy saving built environment 2006, SenterNovem
[3] Ekorem report; the non-residential sector consists of the categories “business & office buildings”, which includes offices, shops, restaurants, hotels and transport buildings, “public service buildings” and “leisure buildings”.

Table 5.5: Average age of the European non-residential building stock for buildings smaller and larger than 1000 m^2*

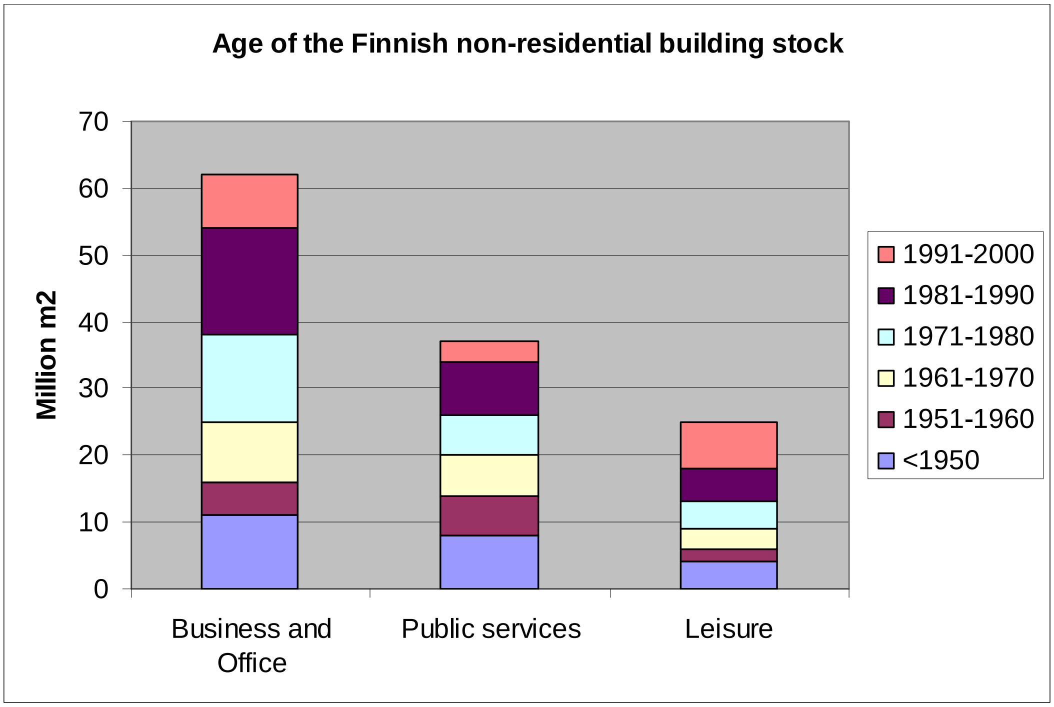
	<1975		**1975-1990**		**1991-1992**		**Total**	
	Million m^2	%	Million m^2	%	Million m^2	%	Million m^2	%
European stock <1000 m^2	835	*64*	232	*18*	244	*18*	1311	*100*
European stock >1000 m^2	1940	*64*	538	*18*	565	*18*	3043	

* Data from EURIMA & EuroACE, Mitigation of CO_2 emissions from the building stock, Ecofys 2007. The data are only for buildings in the cold and moderate climatic zones: sum of all eight countries of the present study, minus Switzerland, plus Belgium, Denmark, Ireland and Luxemburg.

In Finland, the Ekorem report gives data on the age of the building stock for the categories “business and office buildings”, which includes offices, shops, restaurants, hotels and transport buildings, “public service buildings” and “leisure buildings”. These data are shown in Figure 5.3.

There are also specific data on the building stock owned by municipalities. Municipalities own 9% of the total Finnish building stock. The construction periods of non-residential buildings managed by municipalities can be found in Table E.1, Appendix E. 22% of office buildings, 24% of cultural buildings, 15% of schools, 16% of health care buildings and 9% of nursing homes were built before 1949. The stock built between 1950 and 1974 amounts to 36% of office buildings, 18% of cultural buildings, 51% of educational buildings, 38% of health care buildings and 20% of nursing homes. The Finnish non-residential building stock – at least the part owned by municipalities – seems to be older on average than the residential building stock, especially educational buildings of which 66% were built before the oil crisis.

Figure 5.3: Age of the Finnish non-residential building stock, according to the Ekorem report



For France, there are only data about the evolution of the building stock from 1986 to 1990, see Table 5.6.

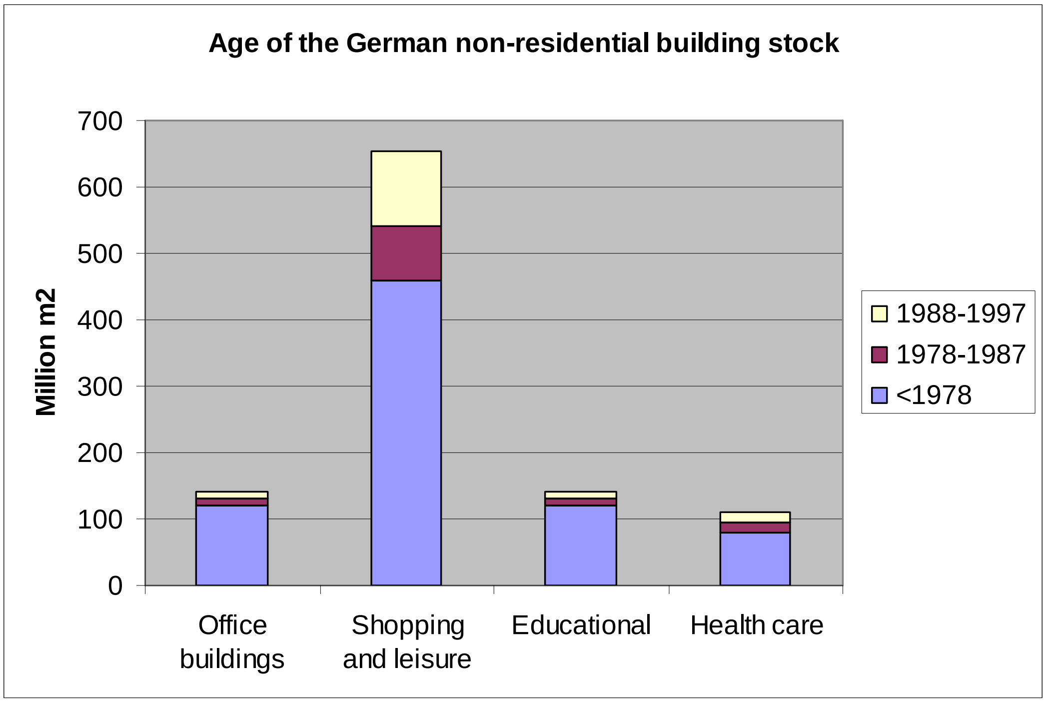
Table 5.6: Evolution of the French non-residential building stock between 1986 and 1990*

million m²	Office buildings	Educational	Health care
1986	118	132	76
1987	119	133	77
1988	122	122	77
1989	127	127	78
1990	131	131	79

*data from ADEME, AICVF, Programmer, concevoir, gérer – enseignement, Bureaux, Santé, édition Pyc -1993

In Germany, there are data available by sub-sector, see Figure 5.4. A large part of the German non-residential building stock seems to be quite old (built before 1978).

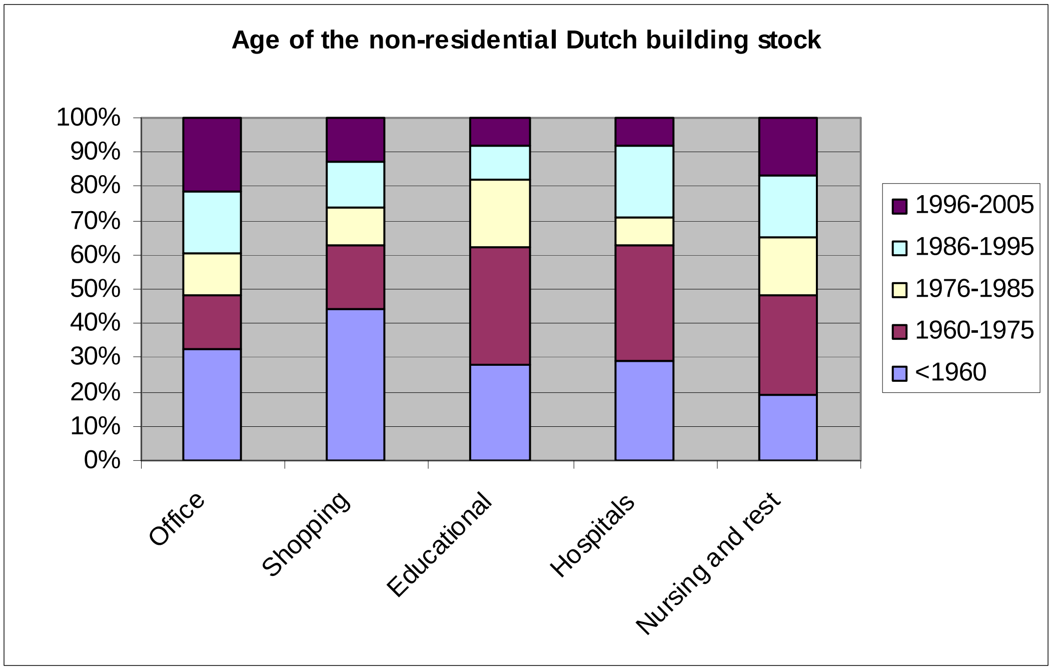
Figure 5.4: Age of the German non-residential building stock* (no data after 1997)



* estimate based on EUROPARC, Year 1998 - Der Gebäudebestand in Europa: Deutschland, Frankreich, Großbritannien, Italien und Spanien, Deutsche Gesamtausgabe Februar 1999; table Germany 2.10.1

In the Netherlands, there are also data available by sub-sector, see Figure 5.5. More than 50% of the non-residential building stock was built before the oil crisis; in particular, shopping buildings seem to be older.

Figure 5.5: Age of the Dutch non-residential building stock*



In Switzerland, there are data relating ownership structure and building period, see Table 5.7. In general, the pre-war non-residential building stock represents a large part of the total stock, varying between 31% and 51% depending on the tenure. By contrast, the building stock built after 1991 represents less than 10% of the non-residential building stock.

Table 5.7: Ownership structure and building periods in the Swiss non-residential building stock*

%	<1919	1919-1945	1946-1970	1971-1990	1991-2000	Total
Owned - individuals	37%	14%	22%	19%	8%	100%
Owned - corporate	28%	13%	24%	24%	11%	100%
Owned - non-profit, assoc.	30%	15%	27%	23%	8%	103%
Owned - munic., cantons, state	40%	13%	23%	18%	5%	99%
Owned - employer	20%	11%	26%	32%	11%	100%
Other buildings	36%	14%	26%	20%	7%	103%

* Data from BFS 2000. The category "Other buildings" includes buildings used exclusively for collective living (old people's homes, hotels, hospitals, monasteries) and buildings with primarily non-residential aims but which include at least one (inhabited or habitable) dwelling (factories, schools, offices etc).

5.5 Reference buildings

Non-residential reference buildings have been defined in France, Germany and the Netherlands.

In France, reference buildings for thermal regulations were defined. They are based on the results of former building stock studies. In these reference buildings, the floor plans are not fixed but characteristics such as the U-value of the building envelope, reference heating system, lighting system and glass percentage with regard to total façade area are fixed. In addition to this, typical buildings (with a fixed floor plan) were defined that are used to calculate mandatory requirements or to demonstrate the effects of energy saving measures (see Francois 1994, Richard 1996 and Lahrech 1996).

In Germany, a typology of non-residential buildings was developed in Gierga (1994), but it seems that the use of these references buildings is not widely applied.

In the Netherlands, eight building types were selected as reference buildings for the non-residential sector. These reference buildings are used to define the feasibility of energy saving measures in an early stage of the design process and to demonstrate the potential of energy saving measures. A description of these reference buildings can be found in Appendix E, Table E.2.

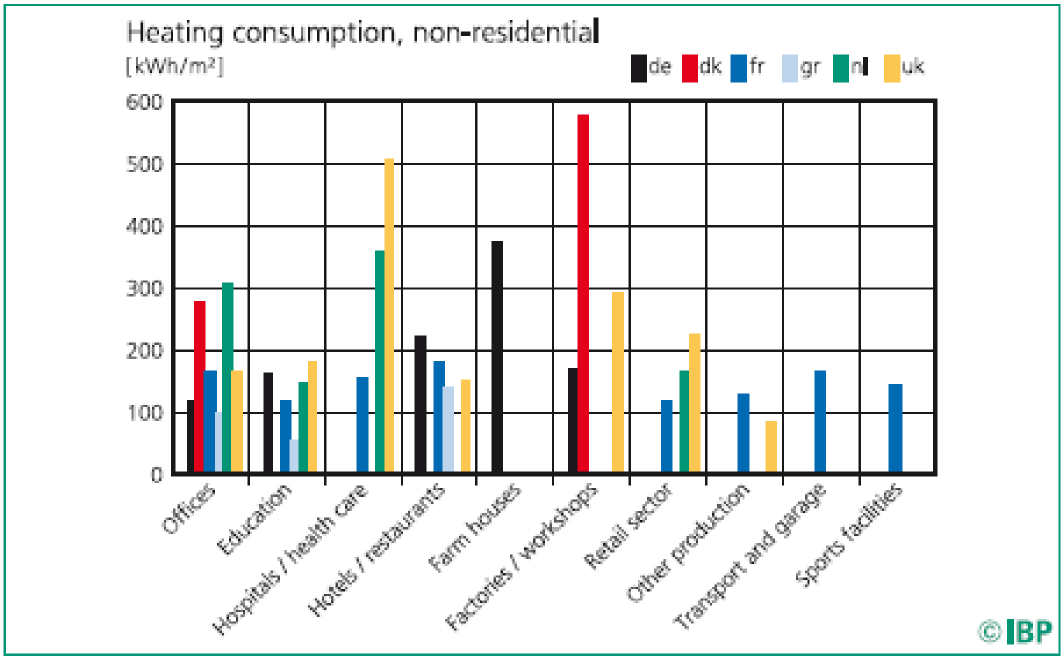
5.6 Energy use

In Chapter 2, basic data about the energy use of the non-residential sector were presented, as well as data on the sources of energy. One of the important conclusions of Chapter 2 was that lighting and electrical appliances account for more than 30% of the energy use in the non-residential sector. In this section an overview of the data available in each country is given. The type of data available may differ greatly by country and is not always a statistical value. Except for the United Kingdom and at European level (see Chapter 2), there is no breakdown available by end use like lighting, cooling and appliances.

From data on the specific energy use of the different types of building in the non-residential sector it is interesting to estimate the energy efficiency of the different sub sectors. In the project ENPER-EXIST data about the specific energy used for heating non-residential buildings was collected in Denmark (dk), France (fr), Germany (de), Greece (gr), the Netherlands (nl) and the United Kingdom (uk). These data are presented in Figure 5.6. Except for schools and hotels/restaurants large differences between countries can be noted, especially in the health care sector. In addition to country specificities like climate, part of these differences may arise from different definitions of the sectors. However, it seems that the sector shopping and leisure has high energy intensity, followed by health care buildings and/or offices. Educational buildings have a relatively low specific energy use.

For the Netherlands, Switzerland and the United Kingdom, the data are summarised in Table 5.8. The figures are calculated as being the sum of the kWh heating and kWh electricity, which means that the efficiency of the electricity production is not taken into account in these data. Additional data, if available, are given thereafter. For Austria, no data other than that presented in Chapter 2 are available.

Figure 5.6: Yearly energy use for heating in the European non-residential building stock*



* From ENPER-EXIST report "Building stock knowledge"

Table 5.8: Specific energy use in the Dutch and Swiss non-residential building stock (kWh/m^2 per year)

	Office buildings	Shopping & Leisure	Educational buildings	Health care buildings
Netherlands[1]	220	262	163	281
Switzerland[2]	210	322	124	229
United Kingdom[3]	245	306	215	447

[1] Monitor energy saving built environment 2006, SenterNovem; Leisure excluded from category Shopping & Leisure.

[2] Estimate Jakob et al., 2006

[3] Data from CaRB project - Carbon Reduction in Buildings, BRE

In Finland, a breakdown is available for heating and electricity use in the categories "business and office buildings" (which includes offices, shops, restaurants, hotels and transport buildings), "public service buildings", and "leisure buildings", see Table 5.9.

Table 5.9: Yearly specific energy use for heating and electricity in the Finnish non-residential building stock*

Kwh/m^2	Business & Office	Public services	Leisure
Heating	231	198	40
Electricity	97	72	13

* Ekorem report

In France, detailed data about the specific energy consumption are available by sub sector.

Table 5.10: Yearly specific total energy use (kWh/m^2) in the French non-residential building stock*

Office	Shopping	Educational	Health care	Sport	Hotels/restaurants	Community living	Transport buildings	Total
283	243	131	221	203	255	163	322	**221**

* from CEREN (Centre d'Etudes et de Recherches Economiques sur l'Energie) - http://www.ceren.fr/

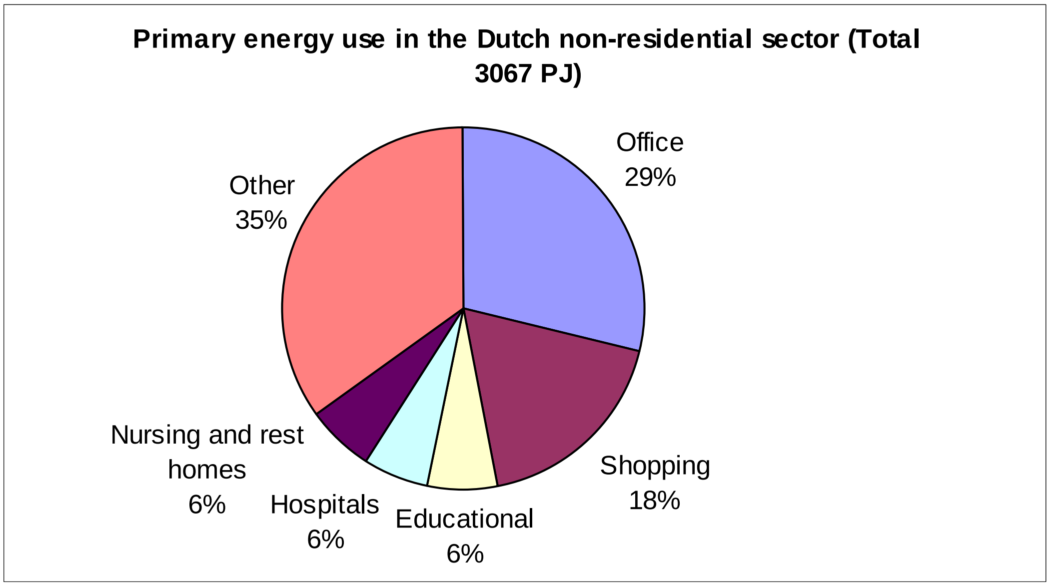
In the Netherlands, there is a breakdown by electricity and gas (heat) and by end use. The share of heating is highest in educational buildings, as is the share of lighting. Although a lot of Dutch office buildings are equipped with cooling devices, the share of cooling remains very low. Figure 5.7 shows the percentage of energy use by the different Dutch non-residential sectors.

Table 5.11: Yearly specific total energy use in the Dutch non-residential building stock and breakdown by end use (%)*

	Office buildings	Shopping	Educational	Health care	
Gas (Kwh/m^2)	132	123	132	202	
Electricity (Kwh/m^2)	88	139	31	79	
				Hospitals	Rest homes
Heating (%)	39	34	65	43	59
Hot tap water (%)	1	0	1	5	6
Lighting (%)	22	24	27	21	17
Cooling (%)	4	1	0	5	1
Other (%)	35	41	7	26	17

*Monitor energy saving built environment 2006, SenterNovem.

Figure 5.7: Primary energy use of the different Dutch non-residential sectors*



*Monitor energy saving built environment 2006, SenterNovem.

In Sweden, there are data available on the energy use for heating per square metre of heated floor area for the non-residential building stock with a breakdown by building age and type of heating. This breakdown is given in Table 5.12.

Table 5.12: Yearly specific energy use in the Swedish non-residential building stock*

	Oil boiler (litre oil/m²)	District heating (kWh/m²)	Electricity (kWh/m²)	Collective boiler (kWh/m²)
<1940	15.3	133	135	n.a.
1941-1960	15.0	136	110	103
1961-1970	16.1	139	148	187
1971-1980	15.4	129	133	n.a
1981-1990	10.5	109	141	n.a
1991-2000	15.7	113	139	n.a
>2001	n.a.	96	148	n.a
Unknown age	16.0	139	129	136

* Sveriges Officiella Statistik

In Switzerland, there is a breakdown by heat and electricity, see Table 5.13.

Table 5.13: Yearly specific total energy use in the Swiss non-residential building stock*

Kwh/m²	Office buildings	Shopping & Leisure	Educational	Health care	Total (others included, see Table 5.7)
Heat*	143	146	108	180	145
Electricity	68	176	16	49	85

* The values for heat are based on data for district heating.

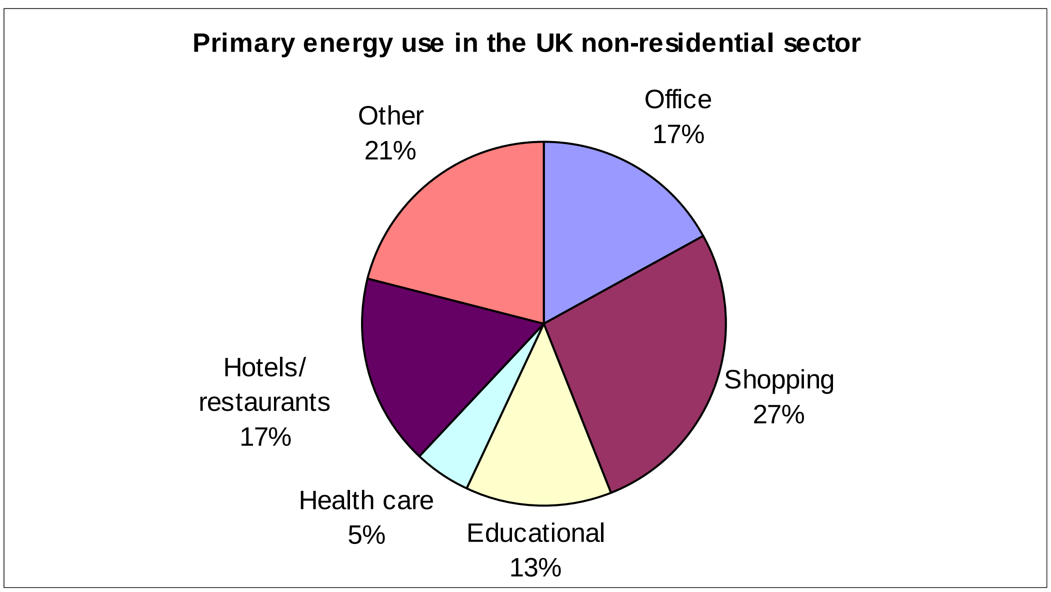
In the United Kingdom, a detailed breakdown by type of energy is available, see Table 5.14. There are also data on the share of energy consumption in several subsectors, see Figure 5.8.

Table 5.14: Yearly specific energy use in the UK non-residential building stock*

kWh/m²	Heating	Cooling	Lighting	Computing	Hot water	Catering	Other	Total heat	Total elect.
Office	110	42	35	22	13	10	13	**133**	**112**
Shopping & leisure	117	15	61	3	27	50	33	**194**	**112**
Educational	154	0.2	14	2	28	12	5	**194**	**21**
Health care	338	0.2	29	3	61	13	3	**412**	**35**
Total	**140**	**17**	**40**	**7**	**25**	**27**	**19**	**192**	**83**

*Data from CaRB project - Carbon Reduction in Buildings, BRE. Total heat is the sum of heating, hot water and catering. Total elect. is the sum of cooling, lighting, computing and other.

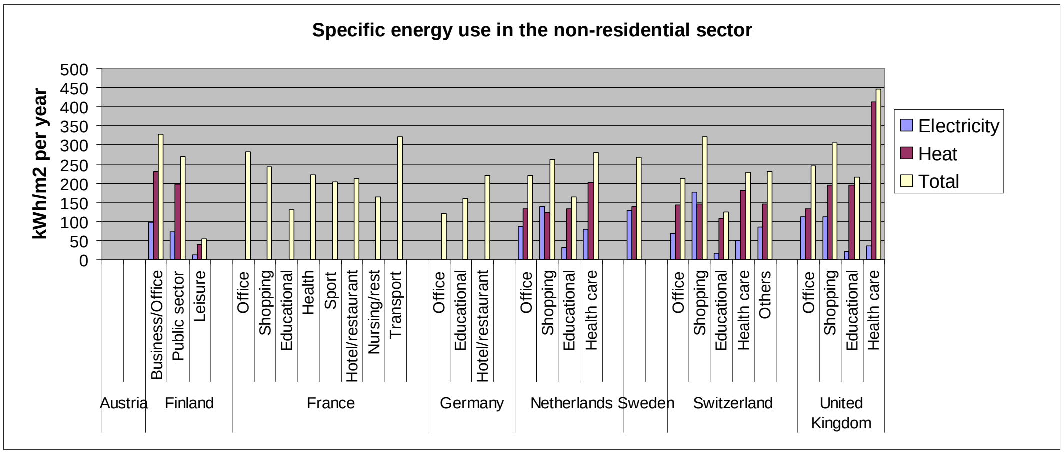
Figure 5.8: Energy use of the different UK non-residential sectors*



* From Energy Consumption in the United Kingdom, DTI, national statistics.

Figure 5.9 summarises the results for specific energy use. In this figure there is no data for Austria because of the lack of data on surface area in the non-residential sector. For data on Austrian total non-residential buildings, see Chapter 2. The bar "Total" is the sum of the bars "heat" and "electricity". Within the limits of the accuracy of the data, there seems to be large differences between countries. The specific energy consumption of French offices is for instance more than twice the consumption of German offices. However, these differences may arise from different definitions of electricity and heat consumption. It is not known which type of appliances and equipment (only building related or also appliance related) have been taken into account in both cases. It seems that, generally, the heat or gas consumption is higher than the electricity consumption, except for shopping buildings, where it may be higher. However, it is difficult to draw hard conclusions based on these data, except that there is a great need for better documented statistical data.

Figure 5.9: Yearly specific energy use in the European non-residential building stock



5.7 Quality of the building envelope in the non-residential building stock

In general, the physical quality of the non-residential building stock is not well documented.

An overview of the collected data is given hereafter by country, if available.

Austria

The data for Austria are based on expert estimates by the IIBW. Many concrete frame buildings, particularly the ones built after 1980 have insulated external cavity walls. In general, when cavity walls are utilised they are insulated. For the buildings with solid external walls, 40% are estimated to be insulated in the office sector, 30% in the shopping and leisure sector, and 70% in the educational and health care sectors. The non-insulated buildings are mainly found in the pre-1970 stock. The old "Gründerzeit"-stock contains a large number of offices and shopping facilities. Twentieth century non-residential buildings usually have a poorer thermal quality than residential buildings because of a lack of incentives. Even modern style non-residential buildings are frequently constructed with solid external walls. The number of transparent buildings with a very high glass percentage is growing, but in absolute numbers is still the minority.

60% of floors are estimated to be insulated. Buildings with non-insulated floors are mostly pre-1980. Almost 100% of flat roofs are insulated. Non-insulated flat roofs can only be found in some old retail and storage buildings. 70% of sloping roofs are estimated to be insulated, mostly in buildings in which the attic is also designed for office use. Until 1990, the insulation thickness was less than 16 cm, since 1990 it has been more then 16 cm. In most buildings with a non-insulated roof, insulation has been placed between the attic and the top floor.

In 90% of all non-residential buildings, double-glazing has been installed and triple glazing in 5% of cases. On average the glass percentage (as a percentage of the façade area) has increased from the following levels in old buildings: 20% in office buildings, 30% in shopping and leisure buildings, and 25% in educational and health care buildings to 30%, 40% and 30% respectively in the newly built. PVC and aluminium window frames are very often used, as well as wood-aluminium combinations.

Finland

The overall condition of the building stock is good. Commercial buildings (privately owned) are usually in a better condition than public buildings (owned by the state or a municipality) because they have been better maintained. The 1940s' and 1950s' building stock in use today is relatively better than the stock in use dating from 1960s and 1970s. Most problems have been with moisture and mould because new building materials (construction board) were introduced in the 1970s which did not suit the Finnish climate. This also created formaldehyde emissions. A large part of the moisture problems, however, comes from a lack of maintenance. Incorrect underground drainage of water outside the buildings also caused many moisture problems in the foundations. In some pre-seventies buildings wood has been left inside the concrete structure where it has rotted, worsening the indoor climate. Such structures must be demolished. The construction materials in pre-war buildings (stone and brick) have often been better suited to the Finnish climate than new materials, and the quality of timber also seems to be better in old buildings than in contemporary ones. Generally, older buildings have more generous dimensions allowing more flexibility than in post-1980 buildings.

France

Studies and information about the physical quality of the non-residential buildings exist, but are very dispersed according to the domain (acoustic, thermal, etc.) or the type of building (offices, educational buildings, health care buildings, etc.). Partial data by type of building and for a given domain could be collected. One of the main problems in non-residential buildings concerns the "asbestos" in existing buildings. Studies about air quality in educational buildings were carried out as well but the results are not yet known.

Germany

There is no specific data about the insulation level of German non-residential buildings. However, this building stock seems to be in rather good condition. There is a quality gap between eastern and western Germany regarding buildings more than 17 years old. In eastern Germany such buildings – if they have not been renovated since – have a much lower energetic standard, the equipment is poorer and the construction of some is not very well kept. Through maintenance, there is continuous improvement of buildings in use.

Netherlands

There are data available from the "Energiebesparingsmonitor 2006". 48% of Dutch office buildings are estimated to have well insulated façades, 53% well insulated roofs and 39% well insulated floors. 84% of office buildings are estimated to have at least double-glazing; another 15% still have single glazing.

30% of Dutch shopping buildings (leisure excluded) have well insulated façades, 47% well insulated roofs and 26% well insulated floors. 57% of shopping buildings are estimated to have at least double-glazing; another 43% still have single glazing.

Only 31% of Dutch educational buildings have well insulated façades, 38% well insulated roofs and 21% well insulated floors. 56% of office buildings are estimated to have at least double-glazing; another 44% still have single glazing.

For the health care sector, data are available for hospitals and for nursing and rest homes. 39% of Dutch hospitals have well insulated façades, 56% well insulated roofs and 19% well insulated floors. 85% of hospitals are estimated to have at least double-glazing; only 15% still have single glazing. 35% of Dutch nursing and rest homes have well insulated façades, 48% well insulated roofs and 35% well insulated floors. 88% of these homes are estimated to have at least double-glazing; only 12% still have single glazing.

Sweden

The general state of the Swedish stock is estimated to be good compared to many other European countries and it has been well renovated. Efficiency of the existing stock is good because thermal regulations have been rather stringent due to the cold climate.

Switzerland

There is very little information about the quality of the Swiss non-residential building stock. From an estimate by the IIBW, one can state that about 60% of all non-residential buildings have a flat roof, when built since 1950. These flat roofs are always insulated. Sloping roofs in educational and health care buildings are estimated to all be insulated. In 90% of these buildings, double-glazing has been installed. In office buildings, the glass percentage increased from 20% in 1947 to 43% since 1976. In shopping and leisure buildings, the glass percentage remains quite constant over the years, at around 20%.

United Kingdom

There are no published data on the physical quality of the non-residential building stock in the United Kingdom.

5.8 Building services

Except for France and Germany, reasonably detailed information is available on the types of building services used for heating. Estimations of the penetration of several techniques based on databases and expert judgement are available and are described hereafter by country.

Austria

The data are based on expert opinion in combination with data from the ISIS database. In Austria, most buildings are heated by a central gas or oil boiler (57% of office buildings, 60% of shopping buildings and 51% of educational, health care and leisure buildings). Electric heating is also popular (26% of office buildings, 28% of shopping buildings and 29% of educational, health care and leisure buildings). District heating is used in 14% of office buildings, 8% of shopping buildings and 18% of educational, health care and leisure buildings. Central heating by wood or biomass is used in approximately 2% of the non-residential building stock and active solar heating is used in less than 1% of the stock.

About 30% of office buildings have a local or central air conditioner. In shopping buildings, there are more and more shopping malls equipped with local or central air cooling, whereas the penetration in educational buildings is very low.

There are about 160 office buildings and 30 educational buildings constructed according to the principles of passive buildings.

Table 5.15 gives an overview of the ventilation systems used in Austria. Mechanical supply and exhaust ventilation without heat recovery seems to be widely used.

Table 5.15: Penetration of several ventilation systems in the Austrian non-residential building stock*

%	Office buildings	Shopping & leisure	Educational	Health care
Natural ventilation through windows	30	30	60	10
Natural supply, mechanical exhaust	10	10	0	0
Mechanical supply & exhaust ventilation	60	60	40	80
Heat recovery ventilation	<1	<1	<1	10

*Estimates from IIBW.

Finland

Most non-residential buildings are heated by a district heating system. From expert opinion, it seems that almost every municipality has a power plant based on CHP, using oil, turf or wood. 77% of municipal buildings use district heating, 6% central air heating, 6% direct electrical heating and 1% local heating (stoves). Most ventilation systems in non-residential buildings are mechanical supply and exhaust systems. Heat recovery has become more common since the 1980s and is now a basic requirement of the thermal regulations. Almost all shopping buildings have cooling equipment, as do the new office buildings.

France

There is no detailed information available yet. A study about ventilation in existing buildings by AIR.H (www.airh.asso.fr) provides statistical data about ventilation systems, their numbers by type and their share in different building types. The results of this study are not yet public.

Germany

No information exists, as there is no systematic, continuous and general collection of data in the non-residential sector.

Netherlands

There is information available from the SenterNovem report “Energiebesparingsmonitor 2006”.
Heat pumps have a relatively high share in non-residential buildings. This is because the heat pump, if reversible, can be used as a cooling machine. Furthermore, energy storage in aquifers is widely used in the Netherlands, mostly in combination with a heat pump for heating.

Table 5.16: Penetration degree (%) of building services in 2006 in the Dutch non-residential building stock*

%	Office buildings	Shopping & leisure	Educational	Health care
High efficiency gas boiler	77	74	70	62
Heat pump	11	8	11	17
Heat recovery ventilation	19	7	7	29
Mechanical cooling	71	48	29	60
High efficiency lighting	15	9	17	16
Very high efficiency lighting	6	2	5	6

*SenterNovem report "Energiebesparingsmonitor 2006".

Sweden

There are data available from Sveriges Officiella Statistik. These data are summarised in Table 5.17. District heating has a very large degree of penetration in all sectors.

Table 5.17: Heating systems (%) in each sector of the Swedish non-residential building stock*

%	Oil boiler	District heating	Electricity	Collective heating	Gas boiler	Oil & electricity	Biofuel & electricity	Other
Hotels, restaurants	5	37	8	0	1	8	1	37
Grocery stores	2	33	11	0	0	2	0	50
Shops and retail	5	56	8	0	1	3	0	28
Theatres	5	53	8	0	2	3	2	25
Offices	2	69	5	0	1	1	0	20
Health care-24 hr	3	69	2	0	1	3	1	21
Health care other	4	63	5	0	2	5	0	21
Schools	4	61	6	1	1	3	1	22

Switzerland

There are (scarce) data available from Jakob et al. (2006) on ventilation. More than 50% of office buildings have natural ventilation. In large office buildings and hospitals mechanical supply and exhaust ventilation is often employed, in combination with air cooling, see Table 5.18. No data could be found on heating systems.

Table 5.18: Ventilation systems in Swiss non-residential buildings *

Mechanical ventilation	Cooling	Small buildings	Large buildings
Supply & exhaust	Yes	0	35
	Limited or no	0	7
Supply or Exhaust	Limited	10	28
	No	19	20
No	Limited	13	3
	No	58	6

* Data from Jakob et al. (2006)

United Kingdom

There are no data publicly available on the type of building services used in the United Kingdom.

5.9 Renovation activities

In this section a brief description of the main renovation activities in each country is given, if available. For France, Germany, Sweden, Switzerland and the United Kingdom no data were found. In all countries, there are studies ongoing on the indoor air quality of schools.

Austria

In general, renovation activities for the purpose of energy efficiency take place more often in government owned buildings. In the shopping and leisure sector, fewer buildings are renovated than newly built. For educational buildings and hospitals the opposite occurs. In these sectors the renovation rate is high and new schools and hospitals are rarely built. Data from the ISIS database indicate that outer façade insulation is applied yearly to 6% of office buildings, 4% of shopping and leisure buildings, and 8% of schools and hotels. Completely new façades are installed yearly in 8% of office buildings, shopping and leisure buildings and schools, and in 10% of hotels. Roof renovation takes place yearly in 9% of office buildings, 8% of shopping and leisure buildings, 12% of schools and 13% of hotels.

Finland

There is only detailed information available about the buildings owned by municipalities. They represent 9% of the non-residential building stock. From 1980 until now, the investments for the renovation of non-residential buildings have increased in Finland and are expected to increase more. Up to now 49% of the existing offices, 28% of meeting and cultural buildings, 63% of educational buildings, 58% of hospitals and 34% of nursing homes have been renovated.

Netherlands

The average energy use and indoor environment of educational buildings is far below the standards in other non-residential buildings. Research shows that the indoor air environment of 80% of the schools is unhealthy. This is the reason why the government started a large renovation project called 'fresh schools' to improve the quality of the indoor environment in schools by renovating the ventilation systems. Renovation of the heating, cooling and ventilation systems in office buildings may be related to complaints by employees. 24% of employees seem to be dissatisfied with the indoor environment. Table 5.18 gives the percentage of buildings that have been renovated. Only a small part of the non-residential building stock has never been renovated.

Table 5.18: Renovations in the Dutch non-residential buildings (%)

%	Built or renovated after 2000	Never renovated	Renovated before 2000	Total
Office buildings	43	14	43	100
Shopping buildings	38	9	53	100
Educational buildings	48	10	43	101
Health care buildings	39	16	46	101

5.10 Summary and conclusions

The following conclusions are drawn from the analysis presented in Chapter 5:

Quality of data

The main conclusion for the non-residential sector is that there is a lack of quantitative data of sufficient quality. Most data that were found are estimates based on expert judgement. Although these data give an idea of the specificities and quality of the non-residential building stock, they have little statistical value. There is, in particular, a lack of data on

1. the physical building quality
2. the types of building services used
3. the energy efficiency of the non-residential building stock
4. the construction periods
5. the ownership structure

A major recommendation related to the non-residential building sector is to launch national or European statistical studies to regularly collect data of better quality than the current data. The possibility of relating these future studies to the data collected through the EPBD should be taken into account. A point of attention should be the comparability of data between countries and sectors.

Quality of the non-residential building stock and stakeholders

1. Because the non-building related energy use seems to increase regularly and considerably, it could be interesting to look at building concepts that also help to reduce this electricity use.
2. Although the energy use for cooling is still low on average, there is an increasing trend towards cooling buildings.
3. Indoor air quality problems in schools are mentioned in several countries and could be an incentive to sustainable renovation.

4. The sector "shopping and leisure buildings" seems to have a high specific energy use. Because this sector also accounts for a large part of the floor area of the non-residential sector, attention should be paid to it.
5. A large part of the existing non-residential buildings are still not well insulated.

Increased demand for cooling systems is not necessarily a problem because the need for cooling is a logical consequence of better insulated buildings in moderate climates. However, research is needed to determine optimum levels of insulation and the balance between heating and cooling. Although schools are not the most energy intensive sector, educational buildings may offer good opportunities for sustainable renovation because of the related indoor air quality problems, because of the fact that they are mostly owned by national or local authorities, and because of the educative and promotional results that could be achieved. Additionally, the sector "Shopping and Leisure" is of interest because of its high energy use. Because most shopping buildings seem to be privately owned (owner-occupied or rented) policies for sustainable renovation in this sector should take into account the specificities of Medium and Small Enterprises.

WORK PACKAGE II: CURRENT POLICIES, BARRIERS TO SUSTAINABLE RENOVATION AND OPPORTUNITIES

6 Main features of the renovation market

6.1 Introduction

In general, one can observe that the (sustainable) renovation of town centres and the restoration of housing has become a priority in many Member States of the European Union. National housing and renovation policies have been and are being developed to cover and encourage this new priority. All kinds of renovation projects are being carried out at the moment in the various countries. The subject also draws a lot of scholarly attention. Numerous projects aimed at best practices for sustainable renovation have been developed and are being developed within, for instance, the European Community Framework Programme for Research, Technological Development and Demonstration. Besides that, nationally oriented research and demonstration projects are taking place. In later chapters (particularly in Chapter 9), we will elaborate on these matters.
This chapter focuses on the relative importance of renovation activities in the countries studied (Section 6.2), the renovation activities that are being undertaken (Section 6.3) the main reasons for renovation (Section 6.4) and names the crucial actors in the renovation processes (Section 6.5).

6.2 Relative importance of renovation

The Tables 6.1 and 6.2 give an overview of the relative importance of renovation activities in various countries.

Table 6.1: Financial share of renovation compared to newly constructed dwellings

Country	Lower investments in renovation than in newly built		Equal share	Higher investments in renovation than in newly built	
	much lower	little lower		little higher	much higher
Austria	X				
Finland			X		
France			X		
Germany					X
Netherlands		X			
Sweden					X
Switzerland	X				
United Kingdom				X	

Table 6.2: Number of existing buildings renovated, compared to newly constructed dwellings

Country	Lower number of buildings renovated than newly built		Equal share	Higher number of buildings renovated than newly built	
	much lower	little lower		little higher	much higher
Austria					X
Finland					
France					X
Germany				X	X
Netherlands				X	
Sweden				X	X
Switzerland				X	X
United Kingdom				X	

The general consensus seems to be that the amount of money invested in renovation activities is lower than, or at the most equal to, the money invested in newly built houses. The United Kingdom and especially Sweden and Germany (with much higher investments in renovation than in new construction) seem to be the exceptions to the rule. Although the investments are lower in most of the countries, the number of buildings that are being renovated yearly (clearly) exceeds the annual number of newly built dwellings.

We have to emphasise here that only a part of these observations are based on actual data. Sweden provided us with data about the number of dwellings; Finland, France and Switzerland with data about investments; and Austria and Germany about both.

- In Austria, ca. 45 000 new dwellings are built annually while approximately 100 000 dwellings undergo refurbishment. The expenditure on housing subsidisation in 2005 was as follows: total new residential construction: €1.55 billion and renovation: €0.53 billion. So, in Austria twice as many dwellings are being renovated each year than being newly built, with the involvement of roughly 25% of the total investment.
- In Finland, in 2006, renovation investment in construction was estimated to be roughly half of the total construction investment. Residential buildings account for half of the renovation and their share is expected to increase as the stock built from 1960s-1970s will need to be renovated in the coming years. Investments in renovation in the period 2006-2015 are estimated at €1.8 billion per year and in 2016-2025 at around €1.9 billion per year. Renovation in the rental sector is expected to be higher than in apartment blocks in the owner-occupied sector.
- In France, the following figures are known for 2005: €67.4 billion were invested in the acquisition of new housing, €144.9 billion in the acquisition of existing housing, and €38.1 billion in the renovation of dwellings. Therefore, for residential buildings, the cost of renovation represents a little more than half of the acquisitions of new housing (Comptes du logement, various years).
- In Germany, the situation is different: €84 billion were invested in refurbishment and repair of residential buildings (62%) and €52 billion in new constructions (38%) (Schaetzel 2005). There are no data available about the number of dwellings that are being built and renovated.

- In the Netherlands, it is estimated that the ratio of newly built dwellings to renovated dwellings is 1:2. Each year twice as many dwellings are being renovated as newly built.
- In Sweden, 61 300 new dwellings were built between the end of 1999 and the end of 2004, while 120 000 apartments were renovated in existing buildings. Therefore, the number of renovations is double the number of new constructions.
- In Switzerland, €29.5 billion (CHF 49.4 billion) were invested in construction in 2005, of which two thirds was spent on new construction, and one third on renovation and refurbishment (BFS 2006). Even though more money is spent on new construction than on renovation, the number of buildings renovated each year exceeds the number of those that are newly built. Obviously, the unit costs per renovation are lower than for newly built buildings.

6.3 Renovation activities

Renovation activities may vary from demolishing entire buildings to simple maintenance activities. The data and information the various countries have provided differ widely, however general trends are visible.
There are European data from Housing Statistics in the European Union about the number of dwellings being demolished yearly. These percentages may vary a lot each year. When looking at the most recent data (no data for Switzerland, 1990 for the UK, 1995 for Germany and Finland, 1993 for the other countries), Austria and the Netherlands have the highest percentage of the building stock being demolished (0.4 and 0.3% respectively), followed by Finland (0.1%). France, Germany and the United Kingdom have percentages of 0.08%, 0.06% and 0.07% respectively, whereas the percentage of buildings being demolished is lowest in Sweden (0.03%). Demolition of buildings seems to occur mainly in areas of urban renewal in Austria, Germany, France and the Netherlands. In the first three countries, the buildings in these areas also have the common characteristic of being mainly of prefabricated concrete panels.

Austria

In Austria, the renovation activities are especially aimed at (simple) maintenance and modernisation activities, like modernisation of the kitchen and bathroom, generally to meet new demands for comfort. Every year 4% of the Austrian housing stock is provided with a new heating system. According to the Austrian respondents in the non-profit housing sector, as well as in public housing, nearly two-thirds of the dwellings have undergone thermal renovation, reducing energy consumption in these buildings by approximately one half (Bauer 2007).

Finland

In Finland, the main attention of renovation activities is aimed at renewing heaters and heating systems. Every year 18% of the Finnish housing stock is provided with a new heating system. New electrical wiring was installed in 8% of dwellings. The main reasons for renovation are to fix damaged components and to upgrade the comfort level of the dwelling.
Of the total €1750 million invested in renovation of the exterior:

- 51% was spent on detached houses and dwellings,
- 20% by housing companies (owned by private persons),
- 6% on offices and commercial buildings,
- 14% on public buildings and,
- 9% on industrial and storage buildings.

Of the total €1400 million invested in renovation of the HVAC systems:

- 37% was spent on detached houses and dwellings,
- 16% by housing companies (owned by private persons),
- 10% on offices and commercial buildings,
- 22% on public buildings and
- 15% on industrial and storage buildings (Vainio et al. 2002)

France

In France, there is information about renovation activities that are specifically aimed at energy savings. In France, 11.1% of households (which amounts to 2.9 million dwellings) undertook renovation activities aimed at realising energy savings. 70% of the renovation work aimed at energy savings deals with insulating the dwelling, especially double-glazing (26%), installing shutters (10%) and insulating floors or roofs (14%). The other 30% of the activities are aimed at renewing the HVAC systems, with again an important role for the improvement of the heating system: 25%.

Germany

Some 6% to 10% of all German dwellings undergo annual simple maintenance work (dependent on change ownership/tenancy). Roughly 4% to 6% of the dwellings are equipped with a new heater and heating system, under the influence of new legal technical requirements or due to the fact that the technical service life has come to an end. In general, housing companies invest in renovation to meet market demand or when repair seems necessary after inspection or complaints.

The Netherlands

From the Housing Demand Survey 2002, it can be concluded that residents put considerable effort into their homes. With regard to the kind of activities, tenure does not make much difference. Regardless of ownership, the majority of investment is put into maintenance and structural repairs, slightly more by owner-occupiers and in single-family houses. Owner-occupiers invest considerable amounts of money in their homes, the annual average being between €2900 and €3500. Considerable amounts are also invested in the segments with the poorest structural condition with annual averages of €2900 in pre-war single-family dwellings and €2500 in pre-war apartments. This includes modernisation investments. However, in part of these segments, the costs for minimal necessary repairs are much higher [Thomsen, Meijer 2007].

Sweden

For Sweden, there is information about (annual) subsidised renovation activities in multi-dwelling buildings and about energy saving measures in one- or two- dwelling buildings. In general, most subsidised renovation activities deal with changing/modernising the water management and drain sewage systems. Changing the electricity system and the sanitary equipment also has relatively high scores. When looking at energy saving measures, changing the heating system is the winner. By 2005, the heating systems had been renovated in 45% of Swedish pre-war one or two dwelling buildings.

Switzerland

Roughly half the residential stock built between 1946 and 1970 had been renovated before the year 2000 (BFE 2005). Although the volume of renovation activities has grown in the last decade in Switzerland, renovation still lacks a robust sustainable direction. The emphasis lies on simple maintenance activities like replacement of windows and improvements to toilets, kitchens and bathrooms (Gerheuser 2003). It is estimated that ground floor insulation is being installed in 2.5% of the Swiss housing stock each year.

United Kingdom

There is, as in the Netherlands, no data on yearly renovation activities. From the English House Condition Survey, it is known, however, that a typical household invests £683 in repairs and replacement. 28% of the households have no costs, 28% have costs between £0 and £1000, and a small number of households have very high maintenance costs. The average investment in repair and replacement is £2115.

For further information see Appendix F.

6.4 Reasons for renovation of residential buildings in the past and until now

The reasons for renovating the stock that have been mentioned by our partners in the various countries differ slightly. In most cases, energy ambitions play a role (especially for housing associations and municipalities) in combination with the need to replace building components at the end of their service life or to solve comfort problems. Other important reasons that have been specifically mentioned by some respondents are mould and moisture problems in Finland, and the (social) upgrading of neighbourhoods in the Netherlands, United Kingdom and Sweden.

We have asked the respondents to prioritise the reasons and to make a distinction between the various ownership categories in the residential sector (social rented, private rented and owner-occupied. Not all respondents have made or could make these distinctions. As far as possible, we give the answers by country.

Austria

In Austria, the main reason for renovation in all sectors is that the service life of the building components has been exceeded.
Other reasons specific to the social housing sector are the realisation of energy ambitions and the upgrading of the neighbourhood (the social sector is strongly driven by political targets).
In the owner-occupied sector, the improvement of the asset value and moving/turnover are important factors.
More or less the same applies to the private rented sector where the improvement of the asset value and the changing market are important reasons. Also of importance here is the fact that subsidies aimed at the social upgrading of the neighbourhood work as a strong incentive to renovate private rented dwellings.

Finland

In Finland, overall reasons for renovation are the government's wish to realise its energy ambitions and the need to cure and prevent mould problems. The first reason seems to be a 'politically correct' answer; the interviewees state that because of the high standard of living and cheap energy prices in Finland, energy efficiency has played and will continue to play a minor role as a reason for renovation. The nuisance of moisture and mould is the reason behind many large renovations.
Another specific reason in the social housing sector is the upgrading of the social quality of neighbourhoods.

France

In France, there seem to be two important reasons for renovation, irrespective of the ownership category. In the first place, there is exceeding the technical service life of

HVAC equipment and, in the second place, there is the wish to raise the poor standard of comfort in the dwellings.

Germany

In Germany, all the possible reasons we proposed in the questionnaire were prioritised by the respondent. We give the first three reasons mentioned (sometimes more than one reason was given the same rank).
In the social rented sector, the main reasons are the wish to improve the asset value and the fact that a dwelling becomes vacant (moving turnover). Other reasons are the wish to upgrade the social quality of a district, the changing market demand, exceeding the technical service life of building/installation elements and the 'appearance' of a dwelling.
In the owner-occupied sector, energy ambitions and aesthetic reasons (it is important to have an attractive dwelling) are put in first place. Another reason is the wish to enhance the comfort of the dwelling. Renovation activities are also being carried out after moving house or changes to a family's situation.
The main reasons in the private rented sector are the improvement of the asset value and the wish to meet changing market demands. Other reasons are the increased comfort demands of tenants, exceeding the service life of building components and the movement of tenants.

Switzerland

The main reason for renovation seems to be problems of comfort. Professional owners, however, renovate and modernise buildings in relation to their sale and rent strategies (BFE 2005)

The Dutch, Swedish and United Kingdom respondents hardly prioritised their answers. The general picture is that in the social rented sector the upgrading of the social quality of the neighbourhood in combination with the wish to increase comfort are important reasons to renovate. An important driver in the United Kingdom is the requirement for all social housing to meet the Decent Home Standard by 2010, including the need for "effective insulation and efficient heating".

For further information see Appendix F.

6.5 Crucial actors in the renovation process

The focus in this paragraph lies on the parties that play a crucial role in the renovation of dwellings. Again the information is based on educated guesses by partners in the various countries. The answers are quite predictable: in general, governments and housing associations play a crucial role. Particularly remarkable is the important role that architects and contractors apparently play in France. In the overview below a distinction is made between the various ownership categories.

Social rented sector

Not surprisingly in almost all countries, the housing associations and local and national governments are important players in the renovation process of the social housing stock. In some countries, specialists or consultants are also involved with the renovation of social houses (Austria, Germany and the Netherlands). The answers by country are as follows:

- Austria: local government (through subsidies), housing associations and specialist consultants.
- Finland: housing associations, national government and local government.
- France: housing associations, national government and local government.

- Germany: professional housing organisations, specialists and consultants, national government.
- Netherlands: housing associations, national government, consultants/specialists.
- Sweden: housing associations, national government and local government.
- United Kingdom: almost all parties play an important role (apart from the contractor and project developer).

Owner-occupied sector

It seems logical that in the owner-occupied sector the owners themselves are the crucial players. Governments and other parties could play a role because they set the regulations, sometimes provide subsidies and/or provide knowledge and skills. The answers the respondents have given in general meet with these expectations. Nonetheless there are some extraordinary answers. For instance in Germany the owner-occupant is not mentioned at all. In Finland, the Netherlands and Sweden, financial institutions are explicitly named as an important actor (financing the renovation activities). The French respondent points to the role of the architect and the respondents from the United Kingdom on the role of the specialist/consultant. The answers for the eight countries:

- Austria: local government (subsidies), owner-occupants, housing organisations (housing managers).
- Finland: owner-occupant, national government, financial institutions.
- France: owner-occupant, contractor, architect.
- Germany: professional housing organisations, contractor, national government housing organisation.
- Netherlands: owner-occupant, national government, financial institutions.
- Sweden: owner-occupant, national government, financial institutions.
- United Kingdom: almost all parties play an important role (however the role of the specialist/consultant is stressed).

Private rented sector

In the private rental sector the owners (corporate investors and private landlords) and the government play important roles:

- Austria: housing organisation (housing managers), local government (through subsidies) and the owner.
- Finland: housing organisation, national government and financial institutions.
- France: housing organisation, architect and contractor.
- Germany: professional housing organisations, specialists and consultants, national government.
- Netherlands: housing organisations and the national government.
- Finland: housing organisation, national government and financial institutions.
- United Kingdom: almost all parties play an important role.

6.6 Conclusions

With regard to the relative importance and reasons for renovation, there are only fine distinctions between the countries studied in this report. This also applies to the relative importance that parties play in the renovation of the existing residential building stock. This result can partly be explained by the fact that this research is approached predominantly from a helicopter view. A more detailed case study approach will undoubtedly lead to the identification of more differences. However, we do not expect that this would lead to a completely different overall view:

- Investments in renovation are generally (much) lower or at most equal to the money invested in newly built houses. The United Kingdom and especially Sweden and Germany (with higher investments in renovation than in new construction) seem to be the exceptions to the rule.
- Although investments are lower in most countries, the number of buildings that are being renovated each year (clearly) exceeds the annual number of newly built dwellings.
- In most cases, energy ambitions are an important reason to renovate (especially for housing associations and municipalities) in combination with the need to replace building components at the end of their service life or to solve comfort problems in the dwellings.
- Other important specific reasons are mould and moisture problems in Finland and the (social) upgrading of neighbourhoods in the Netherlands, United Kingdom and Sweden.
- In general, governments and housing associations play a crucial role in the renovation of residential dwellings.

7 Existing policies and incentives

7.1 Introduction

A lot is already known about existing renovation and energy policies in Europe.
For instance, in the regular National Report on Housing Developments in European countries (Norris & Shiels 2004) from the Housing Unit of the Irish Department of the Environment, Heritage and Local Government, an elaborate overview is given of recent developments in housing and housing policies in the Member States of the European Union. This report from Norris & Shiels approaches housing policies from a broad point of view and does not focus on renovation or energy policies. In other projects, the focus lies more on sustainable renovation policies. In a study for the EURIMA Blueprint Project (Klinckenberg & Sunikka 2006), the results of a quick scan of best practices in building energy efficiency policies and programmes are given. On the basis of the analysis, the following prototype instruments were identified:

Regulatory instruments	Regulatory benefits for above-standard energy performance
	Above-standard requirements for government buildings
	Mandatory environmental performance evaluation with minimum requirements
	Energy upgrading requirements when renovating a building
Economic instruments	Preferential loans for significant (above-standard) energy performance improvements
	Tax credits for installing energy-saving products
Communicative instruments	Building energy performance audits
	Demonstration projects
	Voluntary energy conservation agreements
Organisational instruments	Independent energy audits with organisational support
	Professional management for multi-family housing
	Independent verification of sustainable real estate investments
	Energy service contracts

Source: Klinckenberg & Sunikka, 2006

EuroACE (the European Alliance of Companies for Energy Efficiency in Buildings), has recently (Guertler & Smith 2006) investigated the potential for energy savings in high-rise residential buildings in Europe. On the basis of that investigation EuroACE advocates the incorporation of energy efficiency improvements into widely needed overall refurbishment as a central element of sustainable refurbishment. The study by EuroAce also identifies the barriers that need to be addressed in order to improve the energy efficiency of high-rise residential buildings (see also Chapter 8).

The above named projects and reports are only the tip of the iceberg. Many more national and international studies and projects have been and are being carried out in this field (see also Chapter 9).
This chapter goes into the existing policies and incentives at a national level, and gives a short overview of the initiatives that are being undertaken on a European level.

7.2 Existing policies and incentives at national level

We have structured the information about the policies/instruments of the countries via the following classification framework:

1) Regulatory instruments (building codes, standards, etc.).
2) Economic instruments (subsidies, taxes, etc.).
3) Communicative instruments (education, information, organisation, etc.).

The communicative and organisational instruments that were identified in the table on the previous page have been combined under the heading 'communicative' instruments.
Again, we have to emphasise here that the information in this chapter is not the result of elaborate field studies but is based on the answers of one or (at the most) a few respondents in the various countries.
The focus lies on the role and effect of energy and renovation policies. However, there does not seem to be a wide differentiation between the countries. In general, one can observe that in recent years many countries have adapted their housing and construction regulations in order to stimulate more sustainable developments. Most countries rely on regulatory and communicative instruments (the dissemination of information: publicity campaigns, etc.) to try to realise a more sustainable residential stock. Insulation, heating regulations and such have been sharpened, and through demonstration projects the feasibility of all sorts of sustainable measures and techniques is tested. In general, the main incentives to be identified are subsidies, tax reduction and publicity campaigns. The reduction of the environmental impact of existing housing is in many countries an important subject on the political agenda.
Appendix G contains more information on the various countries.

Austria

Austria has a whole range of tools available. The greatest effects on energy use/sustainable renovation are derived from the individual cost allocation (very high, obligatory in apartment buildings), information campaigns, promotion campaigns to change behaviour and the building regulations (especially demands on insulation, installations and energy use). A major incentive to realise sustainable renovation in Austria is, according to our respondents, the subsidy instrument. Besides that many other incentives are in place: technological innovations, tools to support the design process, publicity campaigns, political support, etc. The Austrian policies aimed at upgrading socially downgraded areas (including the stimulation of the economic development of these areas) seem to be quite successful but do not have direct effects on energy use or sustainability. Norris & Shiels (2004) established that Austria - in contrast to most other European countries - has not developed a large-scale refurbishment programme. In Austria, refurbishment is the responsibility of regional government and, in recent years, activities have focused on promoting measures to reduce energy consumption and CO_2 emissions.

Finland

The Finnish respondent describes the tools that are available. In general, in Finland, sustainable construction is being achieved through technology, research and development programmes. The regulatory instruments (insulation demands in the building regulations) and the energy tax seem to be the two most important instruments. Subsidies are important for energy audits and for energy saving agreements. Energy audits and energy saving agreements play a central role in the implementation of energy efficiency in Finland. The effects of these tools on the residential sector are not known.
In Viiki in Helsinki, an extensive experimental construction area has been established. In this area, a set of ecological criteria is being applied. These criteria direct town planning, building land transfer, construction, planning and permit procedures and also stipulate minimum values for pollution, use of natural resources, health,

natural diversity and nutrient productivity. Furthermore, the Ministry of the Environment has adopted the use of energy grants for renovating residential buildings, as an economic instrument, to reduce energy consumption in existing high-rise buildings (Norris & Shiels 2004).
The Finnish Ministry of the Environment has recently developed a national renovation strategy that will run until 2017. The policy programme recognises the value of the existing housing stock and identifies the barriers that prevent its sustainable use and improvement. Four research and development priorities have been established:

- Maintenance practices.
- Renovation processes and guidance.
- Improving knowledge in renovation and ensuring resources.
- Supplying relevant information.

France

The French government established a national strategy for sustainable development in 2003. This strategy contains a range of measures and sub-measures aimed at identifying the appropriate direction to be adopted in reducing energy usage and waste production and implementing a set of policies to achieve these goals. To facilitate the strategy, a series of action plans has been prepared. Increasing the level of restoration of old buildings is a priority measure. In our questionnaire, the French respondents have ticked the instruments that are applied in France. The instruments that seem to have the most importance all have a regulatory basis: minimum requirements on installations and energy use in dwellings. Also of importance are tools aimed at supporting alternative energy sources (publicity campaigns, subsidies).
The French housing policy also aims at the upgrading of downgraded areas, the economic development of neighbourhoods, the incorporation of a decent home standard and solving the problems of unoccupied dwellings. These policies have however little or no effect on sustainability issues.

Germany

Germany has a wide range of tools available, particularly in the field of legislative (ensuring minimum level of insulation, etc.) and communication instruments. Emphasis is placed on the refurbishment and modernisation of the housing stock in the 'housing improvement assistance' programmes that are funded by the Federal Government. Modernisation and repair work on owner-occupied and rented housing and also measures to improve the neighbourhood environment around multi-family housing are promoted by providing lower-interest loans (Norris & Shiels 2004). The existing energy regulations have been updated. Through information campaigns the government aims to broaden the knowledge of available instruments and conditions of energy efficiency. Also in Germany the existing renovation policies are aimed at the upgrading of downgraded areas and at bringing downgraded dwellings to an updated housing standard. This of course can lead indirectly to more sustainable dwellings.

The Netherlands

The Dutch have a long tradition of promoting sustainable building. The central ambition of the policy programme Sustainable Building 2000-2004 was the embedding of sustainable building in policy and practice, which in 2004 resulted in leaving the implementation of sustainable building to private market operators. As a consequence of this development, there is limited legislation on sustainable building available. The current national policy on sustainable building is only directed at energy-efficiency and the insulation of new dwellings. Besides regulations on sustainable building, some voluntary tools are available which actors can use to stimulate its implementation e.g. national packages for sustainable building of residential buildings, sustainability profile for a location, calculation models for working out the environmental impact of a building, and voluntary energy performance advice for existing buildings (Soldaat 2005). In the coming years, government policy will increasingly focus on energy-saving measures, with the objective of reducing CO_2 emissions, making responsible use of materials and improving the internal conditions of housing for occupants. 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 (generated by gas) in the existing social housing stock by 2018.

Sweden

The Swedish respondents give (an elaborate) description of the tools that are in use. A major goal of the Swedish government is to transform the country into a sustainable society. In order to achieve this goal a large number of measures have been initiated. These include amendments to the Planning and Building Act which identify the environment and sustainability of the built structures as key priorities, and the Environmental Code which combines fifteen previously independent laws into one. A Climate Investment Programme was introduced for the period from 2003 to 2004, with the primary aim to decrease CO_2 emissions. A new plan of action "The Environmental Programme for the Building Sector" covers the period 2003-2010. The programme contains environmental goals for: energy conservation, economising on building materials, a gradual decrease of hazardous substances and encouragement of sound indoor environments (Norris & Shiels 2004). Recently the government has submitted several proposals for energy use in buildings. New measures for improving energy efficiency are presented in the Bill "A National Programme for Energy Efficiency and Energy-smart Construction (2005/06)".

Switzerland

Although not a member of the EU, Switzerland implements more or less the same tools as the other countries: a combination of information/promotion and regulations. The more efficient use of energy in buildings is one of the main objectives of the federal government (in particular the Swiss Federal Office of Energy or SwissEnergy). There is enormous potential for economic and ecological gains in the area of renovation of existing buildings, but these are seldom fully exploited today, even though further-reaching measures such as insulation of the building shell and roof lead not only to savings in energy costs and increased living comfort, but also to an increase in the value of the property. SwissEnergy works closely with the cantons, which are responsible for measures in the building sector, to initiate various actions aimed at the energy-efficient construction of new buildings and renovation of existing ones. The MINERGIE method, i.e. the design and construction of buildings with low energy consumption and a high level of comfort (air-tight shell, excellent heat insulation, mechanical air-flow, efficient heat production), is one of those instruments. It is widely accepted among developers, property owners and investors. But it is not only applicable to new buildings: the MINERGIE standard can also be applied to the optimal renovation of existing buildings from the point of view of energy efficiency. Buildings constructed and renovated on the basis of this method require very little energy for heating purposes. The 18 cantons now promote the MINERGIE standard either directly or indirectly.
Switzerland is at the moment about to decide on a new energy policy framework including measures to be taken in the context of energy consumption, traffic and buildings. Some of the measures will be voluntary some legally binding. The recommended measures are currently the subject of discussion.

United Kingdom

The respondents from the United Kingdom classify the policies into four types of tools: regulations (systems of building regulation and planning permission, EPBD, EPCs), taxes (on a very small scale), grants (many possibilities) and training (a lot of information is available). Building refurbishment is promoted by extremely tight control of new construction under planning legislation. Building renovation is often seen by building owners as a quicker and more predictable path to stock improvement. There are some regional regeneration schemes for housing improvement in specific geographical areas, mostly in older industrial cities in northern England.
Contrary to most other European countries the United Kingdom has introduced a statutory measure to promote housing renovation and improvement by 2010; all social housing (and private housing occupied by vulnerable groups) should be brought into decent condition. The government has provided guidance for local authorities and for social landlords, explaining how the decent homes standard can be implemented. Lack of thermal comfort appears to be the main reason (80%) why social dwellings fail the decent home standard (ODPM 2003). In the recent Energy White Paper the government signalled its intention to reduce energy use in buildings as an important element in its climate change strategy, and its approach to securing energy supplies in the future. The minimum energy efficiency requirements in Part L of the building regulations are one of the mechanisms through which these reductions are to be achieved. The latest revision of Part L came into effect in April 2006. The government is currently proposing a series of further amendments in its Green Paper "Homes for the future: more affordable, more sustainable" (2007).
The long-term goal is to reduce carbon emissions by 60% by 2050. The Department of Communities and Local Government (DCLG) published "Building a Greener Future: policy statement" in the summer of 2007. This policy statement contains the government's intention for all new homes to be zero carbon rated by 2016 with a progressive tightening of the energy efficiency building regulations - by 25% in 2010 and by 44% in 2013 - up to the zero carbon target in 2016. The "Local Government White Paper" (October 2006) gives councils new opportunities to drive local action on reducing carbon emissions and adapting to the impacts of climate change. At the moment the DCLG is looking at ways of improving the energy and water efficiency of existing homes; and looking for opportunities to include exemplars of sustainable development in its housing (source: website DCLG).

7.3 Demands on decent housing

Some countries use specific minimum standards for (parts of) their residential building stock. A distinction is then made between decent and non-decent dwellings. A short overview is given below.

Austria

According to the rental law MRG&15a, non-decent housing is housing that may be harmful to occupant health. It must then be classified as defective and cannot be rented.

Finland

Finland has a "living ban" that is part of the Health Protection Act and the responsibility of municipal health officers. If a dwelling is in a very bad state a health inspector can ban people from living there until the health risk has been removed. The ban focuses on health risks which could be mould with health implications, dust, noise, smell, resonance, smoke, excessive heat or cold, radiation or moisture problems. The ban is preceded by a warning and a threat of a fine. The inhabitants have to organise temporary housing for themselves and often meet extra costs. There is discussion as to whether to move the responsibility increasingly onto the contractor or the developer instead of the owner [Kinnunen et al.].

France

There is a decree from 30 January 2002 defining a decent dwelling. This decree applies only to rented dwellings. If the dwelling does not conform to the regulations, the owner is obliged to renovate it. Such a decent dwelling must not harm the health of occupants and the construction must be safe. It must have at least one room of at least 9 m^2 and a height of 2.20 m or a volume of at least 20 m^3. There must be at least one kitchen block, one separate WC and bath or shower, hot and cold tap water, a heating installation, electricity and sewerage.

Germany

A basic definition was put into writing in the law on social housing (II. Wohnungsbaugesetz expired in 2002 and was replaced by the Wohnraumförderungsgesetz focussing on low income households) which determined to promote the supply of decent housing, "appropriate for broad classes of the people". The objective was to enable a "sufficient supply with dwellings for all classes of the population due to their different requirements", especially to "provide for the development of a healthy family life". These general stipulations were detailed in technical regulations defining a "good" qualitative and quantitative standard – in fact a standard also applied to and often above that of privately financed dwellings.

Netherlands

Non-decent housing is defined as dwellings where the recovery costs are 25% or higher in comparison to the value of an equal new build dwelling. The number of non-decent dwellings has decreased from 19% in 1985 to 1% in 2000 (KWR 2002).

Switzerland

The right to housing is guaranteed in the article 10A of the Constitution. The state encourages construction of social housing and plays a political role in social housing. The principal law governing social housing in Geneva is based on article 10A and is called 'LGL'. The law defines a range of means encouraging the construction of social housing.

United Kingdom

In the United Kingdom, there is a decent homes standard (see Section 7.2). These standards include basic requirements for walls and roofs and internal standards with regard to bathrooms, kitchens and thermal comfort requirements. Providers of social housing were required to identify all homes that did not meet these standards and to propose a plan to bring them up to standard by 2010. Although there have been considerable improvements, some 37% of local authority and 27% of housing association dwellings do not meet the decent home standard. The main reasons for this relate to insulation and energy conservation.

7.4 Energy requirements for the residential sector (new and existing)

In this paragraph, a short overview is given (and not the demands in detail) of the existing energy requirements for newly built housing and the housing stock. In most countries, the requirements for new buildings should be met when complexes or dwellings are renovated on a large-scale. The main sources here are the information papers in which EU Member States indicate how they are going to implement the EPBD in their national regulations (www.buildingsplatform.eu).

Austria

Requirements for new buildings are set out in a guideline developed by the Austrian Institute of Building Technique and include:

- Maximum annual final energy consumption per m² of floor area.
- Maximum u-values of different elements of the building.
- Building air-tightness.
- Prevention of thermal bridges.
- Requirements on the quality of boilers, aeration systems and chillers as well as on systems for storage and distribution.

The proof of compliance with the requirements must be made before and after completion of the building. Municipal authorities are responsible for controlling if the requirements are being met. Residential buildings have to fulfil special requirements. Additional requirements may be fixed by the federal states.
The requirements for existing buildings are also set out in the mentioned guideline. They include mainly demands on:

- Maximum annual final energy consumption per m² of floor area.
- Maximum u-values of different elements of the building.
- Prevention of thermal bridges.
- Requirements on quality of boilers, aeration systems and chillers.

Finland

The Finnish energy regulations apply to

- Building components and air-tightness of the building envelope and,
- Thermal insulation of the building envelope.

The regulations are binding and concern the construction of new buildings. The regulations are applicable to renovation and alteration works only insofar as the type and extent of the measure and a possible change in use of the building require. The instructions are not binding but considered as currently acceptable solutions.

France

In May 2006, the French government adopted the minimum requirements for new buildings. The requirements came into force for building permits requested after 1 September 2006. The type and level of requirements are governed by the function of the type of building (dwellings, office buildings, schools, etc.) and may cover:

- Maximum U-values for windows, walls, roofs and ceilings.
- Requirement on average insulation level.
- Maximum primary energy consumption per m² of floor area.
- Maximum interior temperature in summer.

The calculation procedures include the:

- Influence of climate.
- Position and orientation of buildings, including outdoor climate.
- Passive solar systems and solar protection.
- Indoor climate conditions, including the designed indoor climate.
- Active solar systems and other heating and electricity systems based on renewable energy sources.

- Natural lighting.

The French government is going to adopt minimum requirements for new building components when building renovation is done and for extensions to existing buildings. The levels of these requirements are now decided, but will concern in particular:

- Boilers fired by non-renewable liquid or solid fuel.
- Electric heating systems.
- Air-conditioning systems.
- Hot water production systems.
- Windows and glazed walls (with or without openings).
- Equipment for energy production using renewable energy sources.
- Insulation materials for transparent walls.
- Ventilation systems.
- Lighting systems.

It is expected that the requirements for existing dwellings will come into force from the end of 2007 onwards.

Germany

The level of requirements for new buildings is governed by the function and the type of building (residential and non-residential with detailed conditions of use) and also the ratio between surface/volume. They consist of:

- A maximum primary energy demand.
- A maximum average u-value.
- Maximal u-values of each element of the building's fabric.
- Several requirements on the quality of boilers, controls and pipe insulation.
- Building air-tightness.
- The prevention of thermal bridges.

The requirements in cases of refurbishment consist of either:

- A maximum primary energy demand (140% new buildings), and
- A maximum average u-value (140% new buildings), or
- Maximum u-values (which are state of the art) for each element of the refurbishment.

The requirements have to be met if more than 20% of the element in question (walls, windows, roof/upper ceiling, cellar ceiling/walls) is subject to refurbishment.

The Netherlands

The main requirement for new buildings and major renovations is to comply with a given maximum value for the Energy Performance Coefficient (EPC). At the moment, this value is 0.8 in the Netherlands. In the current national building regulations, proof that the requirements are met must be given before the completion of the building. Verification of this legal provision is the responsibility of the local authority building control where the building is located.
For small renovations there are minimum requirements concerning ventilation and insulation.

Sweden

Sweden first adopted minimum requirements for all new buildings in 1942. The latest requirements came into force for building permits requested after 1 July 2006. The

type and level of requirements are different for residential and non-residential buildings. A maximum energy consumption per m² of tempered floor area is given (for heating, cooling and domestic hot water demand) along with other advice about comfort and the indoor environment. There are two climate zones. The proof of compliance must be made within 24 months of the completion of the building. Control of this regulation is the responsibility of the municipality where the building is located.
The requirements for existing buildings are under revision. The existing regulations state that if the building is renovated or extended the changed part of the building should fulfil the requirements for new buildings. There may be exceptions to this, for example, cultural or listed buildings.

Switzerland

The energy regulations are at the level of cantons and are based on the norm SIA 380/1. For new buildings, there are minimum energy requirements. These requirements do not apply to all renovations, but only to transformations and extensions of buildings. In these cases, the minimum energy requirement is 140% of the value for newly built (BFE 2005). The cantons are also involved in the private label MINERGIE®, with more stern prescriptions than the legal ones.

United Kingdom

We describe here the current situation in England and Wales. The energy requirements for new buildings in England and Wales came into force in April 2006. A building complies with the regulations if it satisfies the following tests:

- CO_2 emissions per m² lower than the target. The building design is acceptable if the emissions are below a target level, which is set at between 20% and 28% below the national building standard, depending on the type of building and the level of servicing provided. The more intensely the building is serviced, the greater the improvement required (20% for dwellings, 28% for air conditioned buildings). This approach provides maximum flexibility to the designer but focuses attention on energy efficiency to reduce CO_2 emissions as the main compliance target.
- Limits on design flexibility for building fabric and energy systems.
- Limits on solar gains for non air-conditioned buildings (the cooling load calculation procedures address solar gain in air-conditioned buildings).
- Construction quality - including air tightness and commissioning tests.
- Satisfactory provision of operating and maintenance instructions.

The requirements for existing buildings also came into force in April 2006. When work is carried out on existing buildings, all such work is expected to meet minimum energy efficiency standards defined at the elemental level. For certain types of major improvement works in buildings with floor areas over 1000 m² where the work has the potential to increase energy intensity (e.g. extending the building or installing air conditioning), there is a further requirement for additional improvements to energy efficiency, provided these are technically, functionally and economically feasible.

7.5 Europe

Housing policy is a policy field for which the European Union has no mandate. This has been stated several times at the regular informal meetings of Housing Ministers in the EU. Nonetheless housing policy is considerably affected by EU legislation in related fields. As far as the renovation policies are concerned, there is a major EU influence on housing policy through the following Directives:

- the EU Construction Products Directive
- the EU Energy Performance of Buildings Directive
- (the Air Quality Directive)
- (the Energy End-Use Efficiency and Energy Services Directive)

A number of countries are modifying their legislation to conform to the energy performance directive and, specifically, construction products directives.

European key actions

The *City of Tomorrow and Cultural Heritage* Key Action aims to improve urban sustainability through delivering real, noticeable benefits to citizens throughout the EU by 2010. It will achieve this by:

- Concentrating these resources on four specific areas: city planning and management, cultural heritage, built environment, and urban transport; where action is urgently required, and where there is untapped technological potential and strong demand for new solutions from cities themselves.
- Focusing primarily on the integration and co-ordination of outputs from other EU and national research programmes, thus avoiding duplication of effort.
- Selecting only projects likely to have significant impacts, regionally and at European level, managing and clustering them with a view to practical implementation and the transferability of their results.
- Ensuring appropriate end-user involvement and creating transnational networks with the capacity, opportunity and motivation to continue to exploit and disseminate results after the research phase is completed.

The Key Action has thus been specifically designed to ensure rapid, EU-wide take-up of practical new approaches to urban governance, planning and management. It is expected to produce, within a decade, measurable advances in economic development, environmental performance and quality of life which will directly benefit the 80% of EU citizens who now live in cities and large towns. This Key Action has already been underway for quite some time and in the mean time all kinds of policies have been developed that have set a research agenda for this Key Action area.

7.6 Conclusions

- All countries have adapted their housing and construction regulations in recent years in order to stimulate more sustainable developments.
- Energy reduction and the reduction of the environmental impact of the existing residential stock is an item that can be found high on the political agenda of every country.
- Most countries use regulatory and communicative instruments (the dissemination of information: publicity campaigns, etc.) to renovate (in a sustainable way) their housing stock.
- Insulation, heating regulations, etc. have been sharpened and through demonstration projects the feasibility of all sorts of sustainable measures and techniques is tested.
- In general, the main incentives to be identified are subsidies, tax reduction and publicity campaigns.
- The number and variety of policy instruments that have been and are being implemented in the various countries is huge. Nonetheless there is little evidence that the effectiveness and efficiency of these policy instruments is

measured in a robust and systematic manner. In the field of monitoring the effects of policy instruments, the countries studied could have much to gain.

8 Barriers and opportunities

8.1 Introduction

In this chapter, the focus lies on the barriers to (Section 8.2) and opportunities (Section 8.3) for the sustainable renovation of residential buildings. The main sources are the opinions of the experts in the eight countries, but other sources are also going to be assessed (Section 8.4).

8.2 Barriers to successful sustainable renovation of residential buildings

The information about barriers is not available to the same level of detail for all countries. Detailed information is provided for Austria, Finland, Germany and Sweden. Most countries (except Sweden) have tried to make a distinction between barriers in the different ownership categories. However, it should be noted that they do not have any statistical value. They are experts' opinions, partly based on their own observations, discussions with building actors and available literature.
In general, the main barriers identified are a lack of knowledge and the relationship between costs and profits (investor does not profit and investment is not cost effective). Also identified are inappropriate products (Finland) and lack of experience and best practices (Austria, France, Switzerland). We give an overview by country.

Austria

For Austria, the main barriers, in general, are cost effectiveness and funding. Technical complications are also identified as a barrier. Knowledge in general is available, but there is a problem in translating this knowledge into the actual execution of renovation activities.
For the social rented sector, no specific barriers are mentioned. Cost effectiveness and funding are not so much of a problem because of the existence of obligatory regulations and repair funds.
In the owner-occupied sector, the funding problem is considered to be a major barrier. Sustainable renovation is not a real issue: the quality of the dwelling is considered to be sufficient and there are other priorities in which to invest money.
In the private rented sector the major barriers are also financial: it is not cost effective, there are funding problems, and the investor does not profit from the investment. Other barriers have to do with the fact that sustainable renovation is not really an 'issue'.

Finland

In general, the main barriers are the lack of the right knowledge and the non-cost effectiveness of the sustainable measures. Also, the fact that the investor does not profit from lower energy use is identified as a barrier.
Specifically mentioned in the owner-occupied and private rented sector is that renovation is often carried out by non-professionals who do not have the precise knowledge about energy saving (or sustainable) solutions. This also applies to the small contractors who are often involved in renovation activities in these residential sectors.

France

In general, the following barriers are identified in France: lack of examples and knowledge, and financial barriers.
The main barrier for the social rented sector is the fact that the investor is not the one who profits from the lower energy use.
Specific barriers in the owner-occupied sector are funding problems and the lack of experience and knowledge on the part of the contractors. The same applies to the private rented sector.

Germany

The important barrier in Germany is considered to be the cost of the investment. The fact that the investor is not the one who profits from lower energy use, adds to the problem in the social and non-profit rental sector. A specific barrier in the owner-occupied sector is a lack of knowledge about the technical implementation of energy saving and other sustainable measures and about best practices.

The Netherlands

In the Netherlands, the cost of the investment and the divide between the investor in and the beneficiary of the sustainable investments are the main issues.
For owner-occupiers the lack of knowledge and information is still a barrier. Also the observation that energy saving and sustainability measures are not real issues for home owners (and private landlords) are considered to be barriers.

Sweden

The main problem in Sweden is the cost effectiveness. Upfront money remains the main problem. Research projects have addressed the economic value of renovation projects. Some of the projects have tried to compare the costs of traditional renovation methods with the costs of sustainable methods. According to the Swedish respondents it has been difficult, if not impossible, to differentiate between immediate costs and long-term investments.

Switzerland

In Switzerland, (the lack of) knowledge and funding are also major barriers. Particularly for the private rental sector, the non-cost effectiveness and the distinction between the investor and the beneficiary are extra barriers.

United Kingdom

Many of the barriers previously mentioned for the other countries apply to the residential sector in the United Kingdom for all residential ownership categories. For the owner-occupied and the private rental sector, knowledge and information problems and the lack of support and ambition of the occupants seem to be extra barriers.

Specific information for various countries is given in Appendix H.

8.3 Opportunities and needed incentives

8.3.1 Opportunities

The opportunities that are recognised vary only slightly in the different countries. In most cases, they deal with opportunities that are going to be generated by governmental actions (realising energy ambitions, legislative adaptations) and opportunities that are the result of market processes. Demands of owners and occupants (e.g. with regard to comfort) have been changing and are going to change in the near future which will have a positive effect on sustainable renovation. In this context the introduction of the EPBD offers specific opportunities according to the respondents in the various countries. Other opportunities identified are the positive influences of the dissemination of existing demonstration projects (e.g. in the United Kingdom, Netherlands and Austria) and the growing use of existing practical energy concepts (France).

Austria
In Austria, a couple of major opportunities are recognised. First of all, the current and future large-scale renovation operations are being considered a large-scale communication challenge. The fact that there have already been many demonstration projects which are well documented could stimulate the execution of future projects. It is further expected that the introduction of the EPBD will lead to a changing market demand. Owners and occupants will anticipate and consider the energy label of a dwelling.

Finland
The Finnish respondents expect special effects from the increasing comfort demands of occupants. The consequent change of market demand will stimulate sustainable renovation. The opportunities caused by the realisation of the Finnish energy ambitions are put into third place.

France
It is expected that the opportunities are going to work slightly differently in the various residential sectors.
The influence of practical energy concepts is seen as a major opportunity in the social rented and owner-occupied sectors. Further opportunities in the social housing sector are derived from the upgrading operations that are currently taking place in many neighbourhoods in France. In addition, the French energy ambitions will have a positive effect on the sustainable renovation of the sector.
The energy ambitions of the government are also viewed as an opportunity for the owner-occupied and the private rented sector. A major opportunity, especially for the private rented sector, is the introduction of the EPBD.

Germany
The main opportunities for social landlords are seen in the wish to improve the asset value of their stock (in combination with the changing market demand) and the positive influence of demonstration projects.
The major opportunities for the owner-occupied sector are the current energy ambitions of the national government and the introduction of the EPBD in relation to the increasing demand for comfort.
For the private rented sector more or less the same opportunities are being recognised. A major opportunity results from the combination of the wish to pursue an improvement in the asset value, of the changing housing market and of an increase in the demand for comfort. The introduction of the EPBD will support these opportunities.

Netherlands
Through the current and planned upgrading (restructuring) operations of the social quality of neighbourhoods opportunities arise for sustainable renovation in the social rented sector. The fact that (see Chapter 6) the Dutch housing associations are going to invest in the next decade in improving the energy efficiency of their existing housing stock can be seen as a major opportunity.

The coming introduction of the EPBD and the energy ambitions and policies aimed at energy saving can be seen as opportunities for the owner-occupied and private rented sector.

Sweden

According to the Swedish respondents, the opportunities for sustainable renovation in Sweden lie principally in the hands of the government; either through government 'encouragement' (e.g. that efficient energy requirements should be imposed in connection with major construction work) or through legislation (e.g. the translation of the EPBD into national energy performance labelling).

United Kingdom

In the United Kingdom, the same range of opportunities is recognised as in the other countries. Besides the positive influence of demonstration projects, 'market' developments (the wish to improve the asset value, the changing market demand in conjunction with the introduction of the EPBD), will steer developments in the direction of sustainable renovation.

8.3.2 Needed incentives

In general, the respondents argue that in order to increase the rate of sustainable renovation, the governments should play a larger and more leading role than currently is the case. The changing market demands and consequent occurrences of opportunities for a more sustainable housing stock are apparently not enough to pull the trigger. There is also a need for more support for technical innovations (Finland, France, Netherlands) and more support for educational programmes, including programmes for DIY stores and warehouses (Finland, France and the Netherlands). No new revolutionary incentives are mentioned.

Summarised below is an impression by country of the needed incentives:

- Austria describes the contribution of a whole range of incentives and points out how the contribution of each incentive can be further increased. A major incentive is the subsidy instrument. A major role is and should be played by the government.
- Finland: it should be ensured that contract forms (in relation to procurement?) support the role of technical innovations. Specific educational programmes (aimed at sustainability) could be connected to DIY stores/warehouses.
- France: the most important incentives needed are innovations in construction (increase contribution by research programmes), educational programmes (increase contribution thorough development of PhD programmes), publicity campaigns, and energy and sustainable quality labelling.
- Germany describes the possible contribution of all the incentives named in the table and makes no distinction with regard to their relative importance. There are important future roles though for the government and the construction industry.
- Netherlands: all incentives are mentioned. Governmental parties (local or national) play a role, but social landlords can also be of importance.
- Local investment programmes represent the Swedish government's investments in stimulating and supporting improved sustainability. Other incentives: publicity campaigns, sustainable quality labelling, (voluntary) agreements between parties, tax reduction and facility management tools.
- Switzerland also seems to rely on future subsidies (and tax reduction), publicity campaigns and energy and sustainable quality labelling.

In Appendix H more details of the experts' opinions are given for some countries.

8.4 Other sources

The studies we referred to earlier (EuroACE and EURIMA) also identify barriers and opportunities that need to be addressed in order to improve the energy efficiency/sustainability of residential dwellings.

EuroACE

The EuroACE project observed that the realisation of significant energy and emission saving potential is faced with a number of institutional, economic, legal and social barriers and opportunities (Guertler & Smith 2006). As the project also looked at the new and candidate EU member states (mainly eastern European countries) and focussed on high-rise residential buildings, some barriers and opportunities do not apply to the residential sector as a whole. We give a short overview of the barriers and opportunities that are considered relevant to this project.

Political and institutional

- Knowledge and know-how is needed about the accurate state of high-rise buildings, the successful implementation of financial instruments and best practices. A number of important European projects can contribute to filling these knowledge and know-how gaps.

Financial and economic

- The incentives to save energy should be strengthened so that the target groups of the new and existing financial instruments promoting energy efficiency would become more receptive to them. In this context, there is an important opportunity in the extensive European body of knowledge surrounding the design and implementation of effective financial instruments.
- District heating in the high-rise housing stock of new EU members is a barrier because there is no incentive for a householder to save energy and thus it undermines the effectiveness of financial instruments. Creating a framework for district heating suppliers to provide a full energy service may supply another means by which to improve high-rise energy efficiency.
- Financial incentives designed to link to the EPBD (and ESD) certification requirements present a powerful opportunity to strengthen the case for incorporating energy efficiency improvement into refurbishment.

Legal

- The EPBDs incorporation into national legislation offers a central legal opportunity to drive the improvement of (high-rise) energy efficiency as part of the refurbishment cycle.
- Inadequate legislation or procedures governing collective ownership of, and decision-making about high-rise buildings or estates pose a significant barrier to implementing energy efficient refurbishments. Effective laws or codes of conduct are essential.

Social

- Marketing and energy advice appropriate to the culture and tailored to the individual are an essential part of any refurbishment, in particular to counter the barrier of entrenched energy use practices, such as opening windows and/or using secondary heating systems in response to the widespread problem in high-rise buildings of over- and/or under-heating.

- The potentially collective nature of living in high-rise buildings should be harnessed to get residents to support each other's energy-saving behaviour, especially in lieu of the requirements for individual metering and billing.
- Employing tried and tested methods of holistic stakeholder involvement with both pre-refurbishment consultation and post-refurbishment evaluation of stakeholders' views, helps strengthen communities, helps eliminate potential problems before they arise, and contributes to the body of good energy efficient refurbishment experiences, in turn helping to improve the often negative perception of high-rise living.

EURIMA

On the basis of a workshop and (scarce) data available an inventory was made of the main barriers in various sectors of the residential market (Klinckenberg & Sunikka 2006). The barriers were consequently linked with promising instruments identified to tackle these barriers using prototypes that have already been in use in various countries. In the table below an overview is given of the key barriers for existing residential buildings and possible promising instruments.

Key barrier(s)	**Promising instrument(s)**	**Suggested policy packages**
Owner-occupied		
· Lack of upfront money · Lack of professional advice and support, limited offers, complicated procedures · Lack of specific knowledge/knowledge of alternatives · Lack of obligation · Lack of organisation of homeowners/complex decision-making process	· Preferential loans (perhaps in combination with the EPBD energy certificates) and tax credits for installing energy saving products · Utility obligations · Energy performance advice · Organisational support like Chance Energiepass Partner concept · Homeowner associations · Demonstration projects and perhaps · Energy regulations for the existing stock	· Preferential loans for significant energy performance improvements combined with energy audits with organisational support · Energy upgrading requirements combined with energy audits with organisational support · Tax rebates and VAT reduction are not seen as being beneficial
Private rental		
· Lack of market demand · Removal of benefits · Lack of obligation · Lack of upfront money · Lack of specific knowledge/knowledge of alternatives	· Preferential loans (perhaps in combination with the EPBD energy certificates) and · Tax credits for installing energy-saving products · Utility obligations · Tax credits as in Green Landlord Scheme · Organisational support like Chance Energiepass Partner Concept · Demonstration projects and perhaps · Energy regulations for the existing stock	· Energy upgrading requirements combined with energy audits with organisational support · Tax credits for installing energy-saving products (for landlords) combined with energy audits with organisational support
Social rental		
· Lack of obligation · Removal of benefits · Implications for low-income households	· Energy regulations for the existing stock and · Energy Audits · Reduced VAT for energy-saving materi-	· Energy upgrading requirements combined with energy audits with organisational support

	als and installations · Utility obligations	· Obligations for the public authorities to set an example in terms of finance schemes

Source: Klinckenberg & Sunikka, 2006.

8.5 Conclusions

Barriers

- In general, the lack of knowledge and information and the lack of cost effectiveness and funding.
- For the social sector there are not many extra or specific barriers mentioned.
- For owner-occupiers and private landlords the lack of knowledge and information, and funding are seen as the main problems. In these sectors, sustainability is not a real issue or a priority. The quality of the dwelling is considered to be sufficient and there are other priorities in which to invest money. An additional barrier for private investors is that they do not profit themselves from the investment.

Opportunities

- Opportunities are going to be generated by governmental actions (realising energy ambitions, legislative adaptations) and market processes. Demands of owners and occupants (e.g. with regard to comfort) have been changing and are going to change in the near future which will have a positive effect on sustainable renovation. In this context, the introduction of the EPBD offers specific opportunities according to the respondents in the various countries.
- Other opportunities identified are the positive influences of the dissemination of existing demonstration projects (the United Kingdom, the Netherlands, Austria) and the growing use of existing practical energy concepts (France).
- Governments should play more of a leading role to realise sustainable renovation.
- There is also a need for more support for technical innovations (Finland, France, Netherlands) and more support for educational programmes, including programmes for DIY stores and warehouses (Finland, France, Netherlands).

WORK PACKAGE III: MODERNISATION AND RENOVATION RESEARCH

9 Modernisation and renovation research

9.1 Introduction

In this chapter, the main subjects of the research projects in the field of sustainable renovation are presented. In Section 9.2 the focal points of the research projects in the eight countries are given (according to our respondents).
Section 9.3 describes the content of some relevant European research projects. After which we focus in more detail on the main current and future research programmes and projects in the eight countries (Section. 9.4).

9.2 Main focus of sustainable renovation research

We have asked the respondents to name the main focus of research activities in their country. The research focus in the various countries differs. The main subjects of sustainable renovation research according the respondents are:

- Austria: focus lies on energy conservation and building product innovation.
- Finland: management of maintenance quality and the improvement of renovation processes and management tools.
- France: building product innovation and building regulations.
- Germany: energy conservation and life cycle assessment.
- Netherlands: energy conservation and safe and healthy housing.
- Switzerland: building regulations and renewable energy application (and energy conservation).
- United Kingdom: economic feasibility of retrofit measures.

A summary of the priorities by country is given in Appendix I.

Research organisations that specialise in (sustainable) renovation

Some respondents have provided us with a list that describes in great detail the research organisations in their country (e.g. Germany). Others (e.g. Sweden) have named only one research organisation. In most cases, the research that takes place in the field of sustainable renovation is found in universities and governmentally funded organisations. A list provided by the country experts can be found in Appendix I.

9.3 European research projects

Significant EU resources have been devoted to the development and piloting of sustainable development tools and technologies for cities and regions during the (5th and 6th) Research Framework Programmes. Projects have included both generic and sector specific research, as well as dedicated research on urban sustainability mainly carried out within the key action 'City of tomorrow and cultural heritage'. Some important projects are named in this paragraph.

EUROACE (1998)
In 1998, twenty European companies involved in the manufacture, distribution and installation of a variety of energy saving goods and services joined forces as The European Alliance of Companies for Energy Efficiency in Buildings (EuroACE). This initiative followed an invitation from the former deputy Director General of the

Environment at the European Commission to attend a meeting in Brussels where, in the presence of the then Chairman of the Parliament's Foreign Affairs Committee, they were informed about the importance of reducing energy consumption in buildings - responsible for over 40% of Europe's greenhouse gas emissions. The challenge was set: why do you not work together to ensure this happens? Since that time, the EuroACE project has been in continuous dialogue with those in the European Union charged with developing programmes, both to assess and realise this objective. The EuroACE project has commissioned several substantial research documents, intended to facilitate effective policy making in this area (www.euroace.org).

SUREURO (2000)
Sureuro (Sustainable Refurbishment Europe) offers housing companies practical management tools that enable them to integrate sustainable development and tenant participation into their refurbishment management processes without exceeding conventional project timescales and budgets. SUREURO has developed new design tools for construction companies, designers and engineers, and new models for the improved planning, design and technical specifications of refurbishment projects. Tested in the sustainable refurbishment of more than 13 000 apartments in seven European countries, SUREURO's innovative systems have been shown to deliver significant environmental improvement and energy savings (www.sureuro.com).

CRISP (2000)
CRISP is a European Thematic Network gathering 24 partners from 16 countries, whose general objective is to create a group dynamic in the field of Construction and City Related Sustainability Indicators. The main activities of the Network are:
· To define a framework and general methodology for construction and city related sustainability indicators.
· To stimulate and co-ordinate the development and use of such indicators.
· To gather and organise indicators within a database including information on validation, testing and criteria of use.
· To widely disseminate the results of the research carried out.
The indicator database is the main deliverable of this network and is included in a public website gathering several other types of information regarding sustainability indicators. (http://crisp.cstb.fr).

ENPER-TEBUC SAVE (2001)
The ENPER-TEBUC study deals with the issue of harmonisation in European Building Codes integrating the project proposals 'ENPER' and 'TEBUC' into a single clustered project programme.
The first part of the study concerns the investigation of the possibilities to design harmonised building codes at the European level. Therefore, the existing European building regulations are compared, extending existing work in that field. Since within the time frame of the Kyoto protocol (2008-2012), the existing building stock will be responsible for most of the energy consumption and CO_2 emissions, possible measures to foster energy efficiency in this field will be particularly scrutinised. On this basis general principles for a model building code for use in new buildings and, where applicable, renovation will be developed. Furthermore, the questions of checking the application and building certification will be investigated, so that this code can serve as a reliable and visible tool for ensuring building energy efficiency.
Since the Energy Performance (EP) standardisation and legislation is in many member states considered to be an attractive tool for increasing the energy efficiency of new buildings and existing buildings, the second part of the study is dealing with this issue in detail. Several countries already have an Energy Performance Regulation

(EPR) in place and/or are preparing a new regulation. Whereas a whole range of European standards are prepared and/or adopted that cover several sub-domains of an EP standard, there are major differences in the overall approach used in the different countries for determining the EP level of a building. Setting up a platform for information exchange among the prominent national players, to systematically collect and summarise the different approaches and to develop suggestions for a European 'model code' is therefore another major goal of this project (www.enper.org).

EUROPROSPER (2002)
Europrosper's objective is to improve the energy performance of existing buildings, specifically in the office sector, across the EU by the process of energy audit, benchmarking and certification. The project focuses on office buildings because of the rapid expansion of this type of building in the EU, both in terms of floor area and energy intensity. In addition, there is a wealth of good practice information on achieving lower energy design and operation for this building type. The concept of benchmarking the energy use of existing office buildings as a tool for saving energy has been promoted for many years in some EU countries, but nevertheless is not widely applied. The Europrosper project will make the methods of implementing this good practice procedure accessible to all. Good practice methods of energy benchmarking office buildings have benefits beyond saving energy cost and reducing CO_2 emissions: they can lead to improved thermal and visual comfort for occupants, thereby creating a healthier and more productive working environment and greater occupant satisfaction. All these benefits can lead, in addition, to an increase in the asset value of the building. The key outcome of the project will therefore be the combination of creating quality assured good practice procedures and a training package that will enable the know-how embodied in the procedures to be disseminated effectively to practitioners in each country (europrosper.energyprojects.net).

FRAMES (2003)
The FRAMES project (Framework Innovations for Building Renovation) aims to improve the framework conditions for building renovation in Member States and CEE Countries. The principal focus of the project is the regulative framework. The guiding idea of the FRAMES project is to involve relevant stakeholders in a process of framework innovation and implementation. Key actors (representatives from the housing and real estate sector, representatives from regional and national administration) participate in National Focus Groups, which are initiated and hosted by the project partners. Based on the national framework analysis and the discussion in the National Focus Groups the FRAMES project concentrates on five core issues (each of them specifically related to the issue of renovation of residential building blocks):

- Implementation of Energy Certification according to the EPBD
- Energy Audits as a prerequisite for Energy Certification and Financial Incentives
- Ownership problems with respect to comprehensive renovation in the residential sector
- Guaranteed Energy Services (Energy Performance Contracting, Third Party Financing, Guarantee Models)
- Financing incentives for comprehensive renovation in the residential sector

On each of these five core issues, the project team produced a position paper containing the basic requirements for beneficial framework conditions, draft recommendations and examples of good practice (www.energyagency.at/projekte/frames/index.htm).

REVIVAL (2003-2008)

The global objective of this project is to demonstrate that tertiary buildings from the post-war pre-energy conscious era, can be refurbished economically, with improvements in energy performance that lead to lower life-cycle CO_2 emissions than the original building, or an equivalent new building. Thus, refurbishment would make a significant contribution towards the EU policy of meeting the Kyoto protocol. The work focuses upon the refurbishment of six buildings:

- one hospital
- one educational building
- and four office buildings

All have the common characteristics of poor insulation standards, an over-provision of glazing, inefficient plant, and degraded fabric. The local design teams will develop refurbishment packages of fabric and system improvements, aimed at improving energy performance, whilst simultaneously addressing the problem of fabric degradation and the quality of the internal environment. They will include both 'design-based' solutions, which may involve re-modelling and re-organisation, and 'product-based' solutions which will apply innovative products newly available from industry. The OFFICE design manual will be used as a basis. A procedure for life cycle analysis will be developed early in the project to assist the prioritising of various environmental measures. The methodology will also be extended to populations of buildings, enabling building owners to assess the impact of broadly similar refurbishment strategies on their building stock. By carrying out a CO_2 emissions budget, they will be able to test their building stock renewal and refurbishment programme against the Kyoto commitment. A major component of the work will be the support offered to the local design teams by the Scientific Committee, mainly through the activity of the Design Forums using the OFFICE design manual, where participants and invited experts meet to expose the current stage of the local projects. As well as peer review of the design proposals, the Scientific Committee will act as broker for specialist consultation – for example computer simulation or physical modelling. All buildings will be monitored, both technically and socially. The results will allow a critical assessment to be made of the success of the measures to meet their targets, and will assist in the main dissemination task, the revised Design Guide for Refurbishment.

DEMOHOUSE (2005)
The overall goal in DEMOHOUSE research and innovation is to reduce the energy consumption of heating, cooling, ventilation and domestic hot water in the renovation of housing by at least 30%, compared to the present standards. In addition, a decision support tool will be developed to assist project developers, housing corporations etc. with a viable implementation of the measures suggested. This includes a closer look at organisational and financial aspects of renovation. The objectives in DEMOHOUSE are to:

· Develop minimum standards for sustainable renovation.
· Develop a decision-making tool to improve sustainable renovation.
· Create long-term management structures to implement a lifetime orientation towards sustainable renovation.
· Create long-term communication structures to guarantee ongoing dissemination and training concerning sustainable renovation.
· Develop, implement and demonstrate technological solutions to reduce energy consumption by a minimum of 30% compared to the present renovation standards.
· Develop a multidisciplinary approach to sustainable renovation to improve quality of life. (www.demohouse.net).

9.4 Major ongoing and future research in the field of renovation

9.4.1 Main current and future research programmes

In this paragraph a description is given of the main current and future research programmes in the countries (name of programme and the main research topics).

Austria

Ongoing research projects:

- Haus der Zukunft/Fabrik der Zukunft (House of the Future/Factory of the Future, finished by 2007): low energy and passive house standards in housing construction, refurbishment and in the non-residential sector too; sustainable construction; demonstration projects.
- Energy Economics Group (Vienna University of Technology for Dachverband Energie-Klima, Wirtschaftskammer Österreich): study on the use of renewable energy in the building stock (published September 2007).
- BRA.IN (Branchen-Initiative) Bauwirtschaft (Sectoral Initiative for the construction sector): construction products; integrative research into the value-added chain of construction products; construction industry-related services.
- Housing research within the housing subsidy schemes of the provinces: mainly bottom-up research; evaluation of construction processes; development of energy standards and promotional tools.
- Klima:aktiv: mainly aimed at communication.

The last three projects named above (BRA.IN, Housing research, Klima:aktiv) will also be important in the near future.

Finland

Ongoing projects:

- Ihmisten ja kiinteistojen elamansyklit (IKE): life cycle of buildings and real estate.
- ClimBus: Business Opportunities in Mitigating Climate Change (2004-2008): focus on developing technologies and business concepts to reduce GHG emissions but can include buildings (total EUR 70 Million, managed by TEKES).
- SARA: Value networks in construction (2003-2007): focus on IT and managing customer needs and competence of the construction industry in the world market (EUR 33 Million, managed by TEKES)
- KITARA: IT adaptation in machine, building and automation techniques (2005-2009), managed by the Academy of Finland.

Future projects:

- Sustainable urban communities, prepared by TEKES.

France

Ongoing and future projects:

- PREBAT: energy efficiency in new and existing buildings.
- Fondation Bâtiment Energie: low energy in new and existing buildings.

Germany

Important ongoing projects:

- Energieforschungsprogramm der Bundesregierung (2006): Innovation und neue Energietechnologien: renewable energies.

- Zukunft Bau/BMVBS (Federal Ministry for Transport, Building and Urban Development): construction industry, life cycle assessment, market transparency, technical and legal regulations, quality, new materials etc.
- Umweltforschungsplan UFOPLAN 2007/BMU (Federal Ministry for the Environment): material efficiency, energy efficiency, renewable energies, climate protection, health (www.bmu.de/forschung/ufoplan_2007/doc/38678.php).
- Forschung für Nachhaltigkeit - FoNa/BMBF (Federal Ministry for Education and Research: climate protection, resources management.

Future projects:

- Umweltbundesamt/Federal Office for the Environment: Umweltforschungsplan/environmental research plan 2007: general environmental topics, among them energy and construction: e.g. Entwicklung von Methoden zur Evaluierung von Energieeinsparung (EU-RL 2006/32/EG). http://www.umweltbundesamt.de/service/ufoplan.htm
- Federal Ministry for Transport, Construction and Housing/BMVBW: Forschungsinitiative Zukunft Bau: construction industry, life cycle assessment, market transparency, technical and legal regulations, quality, new materials etc.

Netherlands

Ongoing projects:

- Energy transition: PeGO (energy in the built environment platform; (www.senternovem.nl).
- EOS (energy subsidy research): aims to initiate and support innovation and research in the fields of energy efficiency and sustainable energy (www.senternovem.nl).

Projects for the near future:

- Energy saving in existing buildings.
- MEP (Environmental quality of the Electricity Production).

Sweden

Ongoing projects:

- MISTRA: sustainable building; the focus still lies on new construction.

Future projects:

- The government estimates that about one million housing units will need to be renovated in the next 20 years and states that this is a unique opportunity to use the new technology that emerged in the 1980s and 1990s aiming to make housing from the "Million Homes Programme" the most energy-smart buildings in Europe. Experience from earlier projects should be demonstrated and spread as a basis for this work. In the Energy Bill, the Government would therefore like to augment measures for research, development and demonstration as regards energy use in buildings and energy-smart construction.

The Government wants the Swedish Energy Agency, together with the Swedish Environmental Protection Agency, the National Board of Housing, Building and Planning and the Swedish Consumer Agency, to run a targeted national energy efficiency campaign. The objective is to demonstrate technical solutions that contribute to increased energy efficiency. The campaign will provide information about the coming energy declarations and addresses individual homeowners and owners of multi-dwelling buildings and premises as well as other relevant key players.

Switzerland

Ongoing projects:

- Energiewirtschafltiche Grundlagen: ongoing research by the BFE, all topics of energy policy.
- CCEM (Competence Centre of Energy and Mobility), managed by PSI (Philipp Dietrich): check their website ccem-ch.web.psi.ch. Ongoing research and partners: http://ccem-ch.web.psi.ch/documents/CCEM%20Report%202006_final.pdf

In the near future research projects from the CCEM (Competence Centre of Energy and Mobility) will be of importance:

- Advanced Energy-efficient Renovation of Buildings (http://www.empa-ren.ch/ccem-retrofit.htm; contact Dr Mark Zimmermann, EMPA/+41 44 823 4118).
- Innovative Building Technologies for the 2000-Watt-Society (House2000); (http://www.sysecol.ethz.ch/OptiControl; contact Dipl. Ing. Thomas Frank, EMPA).

United Kingdom

Current projects:

- CaRB (Carbon Reduction in Buildings) :the CaRB project is developing computer models that will predict how much carbon can be saved by incorporating different energy efficiency or renewable energy measures (e.g. cavity wall insulation or solar power) into different types of domestic and non-domestic buildings. Savings from campaigns to modify consumer preference – such as advertising campaigns and financial incentives – can also be estimated. (Professor Kevin Lomas, De Montfort University (Tel 0116 257 7961); CaRB website
- TARBASE (Technology Assessment for Radically Improving the Built Asset Base): the TARBASE project is identifying carbon-saving technologies that, if incorporated into existing buildings, could deliver a 50% cut in their carbon emissions by 2030. Andrew Peacock (TARBASE Project Manager), Heriot-Watt University (Tel 0131 451 4359)
- BMT (Building Market Transformation): the BMT project aims to explore what is needed to ensure that measures with the potential to deliver a 50% cut in buildings' carbon emissions are taken up as widely and as quickly as possible. Although there is significant potential for existing technology to reduce carbon emissions in both domestic and non-domestic buildings, improvements are not being made. This applies both to new buildings and the refurbishment of existing ones. Dr Brenda Boardman, Principal Investigator (Tel 01865 285170) or Dr Mark Hinnells, Project Manager (Tel 01865 285164)

Besides Carbon Vision the following projects will be of importance in the near future:

- UrbanBuzz: building Sustainable Communities is a 2 year programme that aims to develop new ways of delivering genuinely sustainable forms of development and community in London and the wider Southeast region. University College London (UCL) and University of East London (UEL) are the co-originators and facilitators of UrbanBuzz.
- Carbon Trust: the Carbon Trust provides funding for research and demonstration projects, for example Bristol City Council. The Carbon Trust worked with Bristol City Council to produce a longer-term Carbon Management Action Plan – a list of energy-saving recommendations designed to save Bristol City Council more than £400 000 in the next five years and to reduce its level of carbon emissions.

9.4.2 Research orientation

The experts consulted in Austria, France and Switzerland have provided us with information about the focus of their research projects. Table 9.1 gives an overview.

Table 9.1: Research orientation and scope of the research

Name of institute or researcher	Research orientation				Scope of research	
	Technical	Economic	Political	Social	Scientific	Strategic
Austria						
Universities in cooperation with industry: multiple product developments	■	■			■	
IIBW: Research projects on promotion schemes for housing renovation		■	■			■
Institut für Bauschadensforschung: "Österreichischer Bauschadensbericht"	■	■				■
IBO: research on ecological products, standards, labelling and implementation	■				■	■
Austrian Energy Agency: implementation of Energy performance labelling (EPBD)		■	■			■
France						
CSTB	■	■		■	■	■
Switzerland						
ETH Zurich (several institutes)	■	■		■	■	
EMPA, Dübendorf, CCEM project "advanced energy-efficient renovation, various other projects (M. Zimmermann)	■	■		■	■	
HTA Luzern various projects (U. Menti)	■					
Fachhochschule Nordwestschweiz various projects (Prof. Binz)	■					

Table 9.1 indicates that the research projects are predominantly technically and economically oriented.

9.4.3 Funding of research

Various experts have made an estimate of how the research on sustainable renovation is funded in their country. Table 9.2 gives an impression.

Table 9.2: Funding of research on sustainable renovation; estimates (%) by experts in various countries

	Austria	France	Germany	Netherlands
National government	50	35	16	80
European Commission	5	10		10
University	5	5	47	10
Private operators	30	30	37	
Provincial governments	10			
Public-private funds		10		
Other: : local authorities		10		

Source: experts' opinions (questionnaire).

Table 9.2 shows that the funding (or rather the estimation of the funding) differs between the countries. The national government (sometimes via universities as in Germany) seems to be the most important financier of the research projects. Private operators are responsible for one third of the funding, roughly speaking.

The Finnish and Swiss research projects are financed by the national government, European Commission, universities, private operators and sometimes by a combination of public-private funds. All these parties fund research but there is no breakdown available for sustainable renovation.
The main financiers in the United Kingdom are the Engineering and Physical Sciences Research Council (EPSRC) (by far the largest) the Carbon Trust, the Department of Trade and Industry (DTI, now replaced by DBERR and DIUS), the Leverhulme Trust and the National Environment Research Council (NERC).

9.4.4 Organisations that have developed research programmes

The organisations that have developed research programmes for the future are roughly the same as those that carry out the current research programmes. Most of them are public organisations: ministries (of housing, of environment, etc.), energy agencies, national organisations for building technology, universities, etc.
A list provided by the countries' experts can be found in Appendix I.

9.4.5 Main future themes of research on sustainable renovation

For six countries, we have information about the main themes on sustainable renovation in the years to come.

- In Austria, the focus will lie on research into energy conservation and research on sustainable construction products.
- Finland's research projects will be aimed at indoor climate and public health.
- The French respondents think that research on energy conservation and research aimed at the realisation of low energy renovation will be the most important in the near future.
- In Germany and the Netherlands, future research will also be aimed at energy conservation.

9.5 Conclusions

The main focus of current research projects lies on energy efficiency and energy saving:

- Austria: low and renewable energy, sustainable construction products.
- Finland: life cycle studies and their use in the building industry.
- France: energy efficiency and low energy.
- Germany: renewable energy, energy and material efficiency and the future of the building industry.
- Netherlands: energy efficiency, sustainable energy.
- Sweden: sustainable building of new constructions.
- Switzerland: energy policy and energy efficiency.
- United Kingdom: reduction of carbon emissions through carbon-saving technologies, energy efficiency and renewable energy.

The current research projects are in essence technically and economically oriented and combine a scientific and strategic approach.
In the near future energy efficiency and the use of renewable energy will remain important research topics. The main bulk of research projects are being carried out by public organisations: ministries, national energy agencies, national organisations for building technology, and universities.

WORK-PACKAGE IV: RECOMMENDATIONS

10 Recommendations

In this chapter, the main findings of Work Packages 1 to 3 are first summarised according to the research questions described in Section 1.2. Finally, general conclusions and recommendations for further research and activities are drawn.

10.1 Work Package 1: Building typologies and stakeholder interest

In this work package the residential and non-residential building stock is analysed in relation to building typology and stakeholder interest.

10.1.1 What is the share of the different building typologies (single-family houses, apartment buildings, office buildings, shopping and leisure buildings, schools and health care buildings)?

The total useful floor area of the eight countries considered in the study amounts to almost 10 billion square metres for the residential sector and 4.3 billion in the non-residential sector. Although the residential building stock accounts for about 70% of the total building stock, the non-residential stock, with its share of 30% is far from negligible. Due to the number of their inhabitants Germany, the United Kingdom and France are responsible for the largest part of this surface area. In the residential sector there are, however, no large differences between the useful floor areas per inhabitant in the different countries. On average, this residential useful floor area is 39 m^2.

In Austria, Finland, France and Sweden, there is approximately the same number of multi-family and single-family dwellings (around 50% for both). The Netherlands and United Kingdom have a large number of single-family homes (70% and 83% respectively). Germany and Switzerland both have a large share of apartment buildings (more than 50%).

Within the limits of the accuracy of the data collected, office buildings, depending on the country, account for 13% to 28% of the non-residential building stock, except for Switzerland where their share seems to be higher (41%). Shopping and leisure buildings account for 20% to 65%. In four countries (Austria, Finland, Germany and the Netherlands) the share is above 60%. Educational buildings represent 6% to 32% of the non-residential building stock, the highest shares being found in Sweden, the United Kingdom and France. Finally, health care buildings have on average the lowest share, representing 3% to 19% of the non-residential building stock.

10.1.2 What are the main types of construction in relation to building typology and year of build?

Residential sector

The pre-war dwelling stock accounts for 20% to 39% of the total dwelling stock, with the exception of Finland where only 10% dates from before WWII. In general, the pre-war building stock is reasonably homogenous in terms of construction characteristics.

Dwellings built after World War II and before the oil crisis amount to between 18% (France) and almost 38% (Sweden) of the dwelling stock. The average is 29%. This dwelling stock, which represents almost one third of the total stock, is not very homogenous. A varied mix of construction types exists, from traditional to modern, from low rise to high-rise. A common characteristic, however, is that the buildings were generally poorly insulated at the time of construction and that there is a need for renovation.

In most countries, the dwellings built between 1970 and 1990 account for 21% to 27% of the total stock. Exceptions to this are France and the Netherlands with a share of more than 35% for this building period, and Finland with more than 43%. In general, the dwellings built during this period are reasonably well insulated, but already need some kind of renovation, especially the older ones.

The percentage of dwellings built after 1990 is estimated to be almost 14% on average, varying from 8% to 22%. The construction rates in 2003 were between 0.5% and 2%, with Austria having the highest rate and Sweden the lowest. In most countries, the rate is about 1%, which emphasises the importance of the existing dwelling stock in achieving a sustainable residential sector. The demolition rate varies between 0.025% and 0.23%, with the Netherlands having by far the highest rate and Switzerland the lowest. In the Netherlands, less than one third of new dwellings replace a demolished one. In Switzerland, only 2% of new construction is replacement, which means that the Swiss building stock grows more quickly than the Dutch one.

Data on the degree of insulation of dwellings are of major importance to determine the potential of energy savings in the residential building stock. Surprisingly enough there are few statistical data available on this subject and the information is very fragmented. However, a number of trends can be identified.

There are large disparities between the types of walls in the different countries. Finland and France have a very high percentage of solid walls (80% to 100%), the Netherlands a very low percentage (4%) and United Kingdom about 30%. Cavity walls are more often insulated than solid walls, but in Finland, which has a younger building stock, almost all solid walls have been insulated.
With regard to roofs, the main distinction is between flat and sloping roofs. In general, flat roofs, which represent only a small share of all roofs except in the Netherlands, are already insulated. Sloping roof insulation which is quite easy to implement, has been realised in approximately 70% of the dwellings. The degree of insulation of floors seems lower than that of roofs, with percentages varying from 30% to 60%. The penetration of double-glazing is high in all countries, and the penetration of triple glazing is low except for Finland and Sweden.

Non-Residential sector

Except for Austria, Finland, Germany and the Netherlands, there is almost no data on the building typology of non-residential buildings. This is probably to do with the lack of homogeneity of this sector and because of the fragmentation of data. For most countries only project data are available, which are not representative of the whole stock. It seems that in Germany and in the Netherlands, a large part of the non-residential building stock is pre-1975 (74% in Germany and 59% in the Netherlands). In both countries, 12% was built between 1976 and 1995 and 14% between 1986 and 1995. 15% of the Dutch non-residential building stock is post-1996.

In general, German office buildings have a high energy use due to bad insulation and a high glass percentage. In the Netherlands, 30% to 48% of non-residential walls are insulated, 21% to 39% of floors, and 38% to 53% of roofs. The best insulated sector is office buildings whereas educational buildings are more poorly insulated on average. Double-glazing has been installed in more than 85% of office and health care buildings, but only in about 56% of educational buildings and shops.

10.1.3 What are the main types of building services (space and tap water heating, cooling and ventilation systems) in relation to building typology?

Residential sector

Although cooling systems are now more often installed in new dwellings there is, in general, no cooling equipment in the existing building stock. However, attention should be paid to this new trend.

In single-family dwellings, central heating based on either fossil fuel or biomass is predominant. District heating is predominant in Sweden and in Finnish multi-family dwellings. Local heating (stoves) still represents 5% to 17% of heating systems in Austria, Germany, the Netherlands and Switzerland. Local heating is often less efficient than central heating, but if installed in only one room, it may consume less energy than central heating. In Swiss single-family dwellings, heat pumps already represent 5% of the total heating systems. Electrical heating is widely used in Finland and France with shares up to 30%.

In the European Union as a whole, domestic hot water is responsible for 25% of the energy use of the residential sector. The percentage of households in each country using electricity to heat water is more than 40% in Austria, France and Switzerland, between 30 and 40% in Finland, just over 20% in the UK, and between 10% and 20% in Sweden, the Netherlands and Germany. Boilers, whether or not combined with space heating, are used to various degrees and local water heating still seems to be in use in many countries, particularly in France. When district heating is used for space heating, it is often combined with water heating.

Mechanical supply and exhaust systems with heat recovery are not widely used. Exceptions are Finland, the Netherlands and Sweden, where their share is 10% to 20% Natural ventilation of dwellings through windows and sometimes grilles, and kitchen or bathroom fans, is still the most common way of ventilating. In Austria, Germany, the United Kingdom and probably Switzerland, natural ventilation accounts for almost 100% of all systems. In Finland, France and the Netherlands its share is respectively 30%, 40% and 60%. Mechanical exhaust systems are used predominantly in Finland, France and the Netherlands as well (shares of 40% to 50%).

Non-residential sector

There is again little systematic information on building services in the non-residential sector. Both in Finland, as in Sweden, most non-residential buildings (33% to 69% in Sweden) are connected to district heating and most ventilation systems are mechanical. Heat recovery has often been installed since the 1980s and is now a basic thermal requirement in the building regulations. Almost all shopping buildings and new office buildings have cooling appliances. In German office buildings, air cooling is often necessary and the shopping and leisure sector shows an increasing trend towards the use of air cooling, mainly in shopping malls. In the Netherlands, more than 60% of all buildings (approximately constant in all categories) have a high efficiency boiler. Cooling is installed in 71% of offices, 40% of health care buildings, 48% of shops and only 29% of educational buildings. Heat recovery ventilation is employed more often in office and health care buildings (19% and 29%) than in schools and shops (7%). Heat pumps are utilised in 8% to 17% of the non-residential sector, which is much more than in the residential sector, often this is in combination with energy storage in aquifers.

10.1.4 What is known about the share in energy use of buildings and how is it related to the total energy consumption of the country?

Although there is a strong increase in renewable sources, the energy supply still relies largely on fossil fuels. However, the use of combustible renewable and waste sources is high (more than 20%) in Austria, Finland and in the residential sector of France. Electricity also has, as an energy source, a high share in all countries. District heating has a high degree of penetration in Finland, Sweden and Germany.
The sustainability of the electricity production differs a lot by country. Austria, Sweden and Switzerland use largely hydropower (more than 50%). France, Sweden and Switzerland also use nuclear power (75%, 50% and 45% respectively). Except for hydropower, renewable energy sources are scarcely used for electricity production with biomass and waste being the most widely employed and wind having the most rapidly increasing share. When comparing the different countries, there seems to be no direct correlation between the degree of insulation of buildings and energy use. However this does not mean that insulation measures have no effect, because the national energy use is also determined by the climate, which is different in the Netherlands and Sweden; by non-building related energy use like electricity for appliances; and of course by the efficiency of energy generation systems.

Residential sector

In the eight countries studied, the residential sector accounts on average for 30% of the final energy consumption, with shares varying between 34% (Germany) and 19% (Finland). The electricity for household appliances and lighting has an increasing share. In the European Union as a whole, domestic space heating is responsible for 57% of the energy use of the residential sector and hot tap water for 25%. In Finland, France, Germany and the Netherlands, the breakdown of energy use by single-family and multi-family houses is known.

Non-residential sector

Lighting and electrical appliances account for more than 30% of the final energy consumption in the non-residential sector. In general, educational buildings have the lowest energy consumption when compared to other types of non-residential buildings. However, large variations of the absolute values are observed between countries. Shopping and leisure buildings have in general a higher consumption than educational buildings. The variations are also very high in health care buildings. However, the quality of the data does not allow for firm conclusions.

10.1.5 What is known about the quality of the building typologies in terms of construction, energy use, comfort and health, and market demand and how does it relate to the quality of newly built?

For energy and construction, see Sections 10.1.4 and 10.1.2.

Residential sector

Almost all dwellings (more than 98%) in the eight countries studied comply with basic quality requirements like having running water, a lavatory, a bath or shower and a heating system. Dwellings that do no meet these requirements can almost all be found in the older pre-war stock. The current trend is to equip new houses with more than one bathroom and WC. In contrast to new buildings, existing apartment buildings of more than four storeys are not always equipped with a lift. For all countries, the estimate is that only 65% to 85% of these buildings have a lift.

In general, the thermal and acoustic quality of dwellings built between 1945 and 1970 is relatively low. In Austria, it is even lower than the quality of the pre-war stock. The general quality of Finnish and Swedish dwellings is believed to be very high in comparison to many other European countries. Moisture problems and mould have been identified in the Austrian, Finnish and Swedish building stock. In Austria, this occurs mainly in the pre-war and post-1975 stock and in Finland mainly in dwellings built between 1945 and 1975. Probably these problems are also present in other countries, but are not considered as a major issue. In buildings using mechanical ventilation with heat recovery, allergy and respiratory problems have been identified in the Netherlands and to a lesser extent in Finland.

In the Netherlands and Germany, the match with the market demand may be a problem, especially in post-war and pre-oil crisis dwellings. In Austria, France, the Netherlands and the United Kingdom, there is lack of affordable housing for low income households.

In comparison to new buildings, the existing stock may offer specific qualities like location, larger floor areas, higher ceilings and a traditional appearance.

Non-residential sector

The general condition of non-residential buildings is estimated to be good in Finland, the western states of Germany, the Netherlands and in Sweden. Generally privately owned buildings are in better condition than buildings owned by the state or local authorities, because they are better maintained. In Austria, the insulation of office buildings is poor. In Finland, mould problems are identified in buildings from the sixties and seventies and a major concern in France is the presence of asbestos in many non-residential buildings. In almost all countries, the indoor air quality of educational buildings is a concern.

10.1.6 What is the share of the different building typologies between urban and rural regions and is there a difference in quality of the building stock between urban and rural regions?

Apartments are mainly located in large municipalities. Single-family houses may be found in equal shares in rural and urban areas. However, large differences are observed between the countries. In Switzerland, 63% of single-family houses are located in urban areas whereas this is only 22% in Germany. In Austria, the structure of the housing market differs greatly between Vienna and the rest of the country. In Vienna 48% of dwellings are social housing and 26% are publicly owned, whereas these figures are 25% and 10% respectively for the whole country. In France, social housing is predominantly urban and in large metropolitan areas there is a polarisation between municipalities without any social housing and municipalities with 70% social housing. Finland has a high housing demand in growth centres like Helsinki and Tampere that ensures the renovation of the existing stock. In other parts of the country, there are problems with vacant properties. In Germany, too, there is a general oversupply of rental housing in economically weak regions especially in the eastern parts of Germany, where demolition seems to be a solution to reduce vacant buildings. On the other hand a strong demand can be identified in the more prosperous regions like Hamburg, the Rhine river valley, Stuttgart and Munich.

10.1.7 Are standard reference buildings provided for the building stock; which ones and by whom are they used?

Reference buildings have been defined in Germany and the Netherlands and to a lesser extent in Austria and the United Kingdom. In Germany, five types of dwellings have been defined, of which two types are for single-family dwellings and three types for multi-family houses. In the Netherlands, 16 types of building are described in detail. These buildings are systematically used for studies on the energy efficiency of the building stock. In Austria, four categories have been defined, in relation to the Rental Law in order to differentiate dwellings according to quality and to apply different levels of rent control. These four categories describe the quality in terms of floor area and presence of sanitary and heating systems. In the United Kingdom, eight types of dwellings have been defined by BRE for modelling studies, using eight geometries and a range of values for construction, servicing and occupancy.

10.1.8 What are the main renovation activities, how many buildings does it concern on a yearly basis and what are the main reasons for renovation?

Residential sector

The demolition rate varies between 0.025% and 0.23%, with the Netherlands having by far the highest rate and Switzerland the lowest. In the Netherlands, less than one third of new dwellings replace a demolished one. In Switzerland, only 2% of new construction is replacement. Demolition of buildings seems to occur mainly in areas of urban renewal in Austria, Germany, France and the Netherlands. In the first three countries, the buildings in these areas also have the common characteristic of being mainly of prefabricated concrete panels.

Maintenance and modernisation of kitchens and bathrooms are the most common activities in all countries. Each year heating systems are replaced in 4% of Austrian, 3% of French, 5% of German and 18% of Finnish dwellings. In Sweden, the replacement of the heating system gets a high score, as well as the replacement of electrical wiring and the water and sewage system. In Finland, new electrical wiring was installed in 8% of dwellings. In Switzerland, ground floor insulation is installed in 2.5% of the housing stock each year. In France, 11% of households (which amounts to 2.9 million dwellings) undertook renovation activities aimed at realising energy savings, in particular the installation of double-glazing and shutters, and floor or roof insulation. Other activities are aimed at renewing the HVAC systems, with again an important role for the improvement of the heating system.

In Finland, €1.75 billion were invested in the dwelling envelope, of which 51% was spent on detached houses, 20% by housing companies, 6% on office and commercial buildings and 14% on public buildings. Another €1.4 billion were invested in the renovation of HVAC systems, of which 37% was spent on detached houses, 16% by housing companies, 10% on office and commercial buildings and 22% on public buildings. In the Netherlands, regardless of ownership, the majority of investment is put into maintenance and structural repairs, slightly more by owner-occupiers and in single-family houses. Owner-occupiers invest considerable amounts of money in their homes, the annual average being between €2900 and €3500. In the United Kingdom, this figure is about €1000.

Non-residential sector

In Austria, renovation for energy savings occurs more often in public buildings than in commercial buildings. There are more shopping and leisure buildings built than renovated. In schools and hospitals, the opposite is true. In Finnish buildings managed by municipalities, about 47% have undergone some kind of renovation, with the lowest share being in shopping and leisure buildings. Investments in the renovation of non-residential buildings have increased since the 1980s and are expected to increase further. In the Netherlands, 14% of all office buildings, 9% of all shopping buildings, 10% of educational buildings and 16% of health care buildings have never been renovated.

10.1.9 What is the ownership structure of the different building typologies?

Residential sector

Owner-occupied dwellings represent 35% to 62% of the total stock, with an especially high share in England (70%). Germany and Switzerland have a large private rented sector (about 50% of total stock) and Sweden and the Netherlands have a very large social rented sector. In general, a very large share of single-family houses is owner-occupied. For multi-family houses the shares vary a lot. In Sweden, for instance, 68% of the multi-family houses are social rented while this percentage is only 6% in Switzerland.

Non-residential sector

The ownership structure for non-residential buildings is not well documented for all the countries. In France, about 50% of the buildings are owned by the government or municipality. In Germany, 56% of the buildings are owned by a private owner (office buildings, and shopping and leisure). Educational and health care buildings are mostly owned by the government or municipalities. In general, owner-occupied buildings represent approximately 30% of the total building stock.

10.1.10 Who are the current stakeholders in the renovation process in the different ownership structures, what responsibility do they usually bear and how is the renovation/building process organised?

Because the owner-occupied and the rented sector both share about 50% of the market they both have the same importance in the achievement of sustainable renovation. However, the characteristics of both sectors differ a lot. In the owner-occupied market, the investor is also the one who profits from the investment. However, there is often a lack of financial means to invest. Furthermore, it is a non-professional market, where 'Do-it-Yourselfers' and small contractors are predominant, with all the related characteristics of SMEs. A major characteristic of the rented sector is that the owner has to invest, whereas the occupant profits from the investment. In the private rented sector, this may be solved by increasing the rent, insofar as it is desirable and possible within the existing regulations. In the social rented sector, this would be more difficult, therefore specific financial solutions and regulations will be necessary. The social rented sector is organised differently in the eight countries studied. However, a common characteristic is the high level of regulation and the closer relationship with local or national governments.

Because barriers and opportunities are likely to differ according to the type of tenure and to the type of dwelling the relationship between both may be of importance. In general, a very large share of single-family houses is owner-occupied. For multi-family houses, the shares vary a lot. In Sweden, for instance, 68% of multi-family houses are social rented, while this percentage is only 6% in Switzerland. In a country like Switzerland, it may be more difficult to implement the renovation of apartment buildings because the ownership – and therefore the responsibility – is shared between several households.

In general, governments and housing associations are assumed to play a crucial role in sustainable renovation. Particularly remarkable is the important role that architects and contractors apparently play in France. The housing associations and local and national governments are important players in the renovation process in the social housing stock. Austria, Germany and the Netherlands also mentioned the importance of specialists and consultants in sustainable renovations. In the owner-occupied sector, the owner as well as small contractors and DIY enthusiasts should be the main players.
Governments and other parties could also play a role because they set the regulations, sometimes provide subsidies and/or provide knowledge and skills. Financial institutions are also explicitly named as being an important actor in financing the renovation activities. In France and the United Kingdom, the role of architects and consultants is also stressed. In the private rental sector the owners (corporate investors and private landlords) and the government play important roles.

10.2 Work Package 2: Current policies, barriers to and opportunities for sustainable renovation

10.2.1 What are the current technical, financial, social and political reasons for renovation at the level of owner-occupants, private owners, housing associations, corporate investors and governments?

In general, one can observe that the renovation of town centres and the restoration of housing has become a priority in many Member States of the European Union. National housing and renovation policies have been and are being developed to cover and encourage this new priority. The reasons for renovating the stock are comparable in all countries. In most cases energy ambitions play a role, especially for housing associations and municipalities, in combination with the need to replace building components at the end of their service life or to solve comfort problems. Other important reasons that have been specifically mentioned are mould and moisture problems in Finland and the social upgrading of neighbourhoods in the Netherlands, the United Kingdom and Sweden. For corporate investors a green image is probably a reason too. There is also some indication in the Netherlands that the reduction in maintenance costs begins to play a role in this kind of decision.

10.2.2 What are the reasons causing these actors to prefer demolition and building anew to renovation?

Demolition is mostly observed in areas of urban social renewal and in areas with low occupancy rates. In eastern parts of Germany for instance the demolition of the building stock arises from the lack of market demand. In France and the Netherlands, poor match with market demand is also mentioned. In the Netherlands in some areas, there is at the same time both a poor match with market demand and a high demand for dwellings. Demolition followed by the construction of a new building is then seen as a solution. Mostly then there is no relationship between the decision to demolish and the technical quality of the building. Another important reason for demolition instead of renovation is the cost and cost structure for the calculation of land prices.

10.2.3 Which technical, financial and social barriers are experienced in sustainable renovation projects?

In general, the main barriers identified are a lack of knowledge and the relationship between costs and profits (investor does not profit and investment is not cost effective). Also recognised are inappropriate products, and a lack of experience and best practice. Specifically mentioned in the owner-occupied and private rented sector is that renovation is often carried out by non-professionals who do not have the precise knowledge about energy saving or sustainable solutions. This also applies to the small contractors who are often involved in renovation activities in these residential sectors. Besides a lack of knowledge at the building level, in many countries there is a lack of knowledge about centralised district systems and their connection to dwellings. Other barriers, especially for owner-occupants, are high investment costs, long repayment times and other investment priorities. A new challenge also seems to be the cost structure applied by ESCos, or energy companies, when they invest in sustainable energy generation and earn it back largely by using the no-more-than-elsewhere principle with interest rates and connection charges which are too high and so do not earn the support of the inhabitants.

10.2.4 Are there specific opportunities for sustainable renovation?

The opportunities that are being recognised are almost identical in all the countries. In most cases, they deal with opportunities that are going to be generated by governmental actions like realising energy ambitions and legislative adaptations, and with opportunities that are the result of market processes. The demands of owners and occupants with regard to comfort have increased. This could have a positive effect on sustainable renovation. In this context, the introduction of the EPBD offers specific opportunities. The main opportunity for social landlords may be the wish to improve the asset value of their building stock. Other opportunities identified are the positive influences of the dissemination of existing demonstration projects and the growing development of practical renovation concepts. Large urban renovation projects are also considered to be potential opportunities.

A potential opportunity in the non-residential sector – and perhaps later also in the residential sector – is the interest in life cycle costing. By using life cycle costing, maintenance costs and energy savings are taken into account as well as investments.

10.2.5 What are "natural" renovation moments and how could they be used to improve the rate of sustainable renovation?

Natural renovation moments are relocation, replacement renovation of defective components and modernisation activities like changing kitchens and bathrooms. They provide the opportunity to replace components with more efficient ones. However when taking into account the whole life cycle of products and therefore their embodied energy, it appears that not replacing a product is often the most sustainable option, unless energy saving is a consequence of this replacement. For the owner-occupied market this implies that information on sustainable products and activities should be available at these moments. For housing associations and corporate investors, natural moments will be related to the maintenance cycle.

10.2.6 Is there any relationship between asset management and technical maintenance?

In general, there seems to be a weak relationship between asset management and technical maintenance. The decision-making takes place at different levels and is based on other values. However, the EPBD and interest in life cycle costing could bring changes. However, there is at least a financial relationship between asset management and technical maintenance. In the asset management policies money is reserved to pay for the investments in maintenance.

10.2.7 What is known about the effects of renovation on property value?

Although there have been few studies completed on this subject, there are indications that high quality flats, including renovated ones, outperform lower quality ones in terms of the stability of market prices (Lorenz 2007). Location is one of the essential aspects of property value. Investments in structural and constructive parts of a property could have positive effects. The effects of investments in the services/facilities remain questionable. For instance, bathrooms and kitchens often are replaced immediately after relocation.

10.2.8 Is there any large-scale monitoring of the effects of renovation on energy use, comfort and health, and occupant satisfaction in general; and what trends can then be identified?

In general, there is no national monitoring of the effects of renovation, except in Denmark, which is not included in this study. There are monitoring projects at the neighbourhood level for buildings, mostly related to demonstration projects. These monitoring projects are mostly short term.. There is also a lot of short term monitoring of buildings related to complaints about indoor air quality. However, detailed long-term monitoring is lacking, which means that very little is known about the long-term behaviour of equipment and the influence of inhabitants' behaviour on the possible energy savings.

10.2.9 What are the current national and European policies that are believed to have an effect on renovation activities and rates?

Housing policy is a policy field for which the European Union has no mandate. This has been stated several times at the regular informal meetings of Housing Ministers in the EU. Nonetheless housing policy is considerably affected by EU legislation in related fields. As far as the renovation policies are concerned, there is a major EU influence on housing policy through the EU Construction Products Directive, the EU Energy Performance of Buildings Directive and indirectly through the Air Quality Directive and the Energy End-Use Efficiency and Energy Services Directive. A number of countries are modifying their legislation to conform to the energy performance directive and, specifically, construction products directives.

In most countries, the energy requirements for new buildings should be met when complexes or dwellings are radically renovated. These requirements vary from requirement at component level, like insulation values, to performance agreements at the level of buildings. For standard renovation activities, there are mostly few requirements, except basic requirements on the quality of boilers and ventilation. In Germany, there are additional requirements when more than 20% of a component (wall, roof or window) is changed. In such cases in Sweden, the component should meet the equivalent requirements for the newly built. In the United Kingdom, the

Decent Home was launched in 2006. When work is carried out on existing buildings, all such work is expected to meet minimum energy efficiency standards defined at the elemental level. For certain types of major improvement works in buildings with floor areas of over 1000m², where the work has the potential to increase energy intensity (e.g. extending the building or installing air conditioning), there is a further requirement for additional improvements to energy efficiency, provided these are technically, functionally and economically feasible.

10.2.10 What are the current local, national and European incentives for renovation; what is their aim and expected effects?

Most countries use a mix of tools to enhance the sustainability of the building stock. The following instruments have been identified; regulatory, economic, communicative and organisational. In general, the main incentives are subsidies, tax reduction and publicity campaigns.

10.2.11 What are the national and European plans or studies for new incentives in the coming years?

In all countries the introduction of the EPBD is seen as the main incentive in the coming years, at least when considering the future possibilities for relating the existing regulations to requirements regarding the implementation of technical measures. For instance, the French Government is going to adopt minimum requirements for new building components when building renovation is done or when existing buildings are extended.

Although there seem to be no clear plans, most respondents stressed the need for support for technical innovation, educational programmes, practical renovation concepts and demonstration projects.

10.2.12 Is there any monitoring of policies and incentives, and if there is, what are the registered effects and how do they relate to the expected effects?

There is, in general, little monitoring of policy and incentives and their final effects on sustainability. Monitoring is often based on easy to use indicators, like the number of heat pumps or solar boilers installed. It generally gives a good idea of the direct effect of policy measures. However, what is not monitored is the effect of implementing a measure (like a heat pump) on the energy use. Monitoring studies in the Netherlands tend to show that on average, office buildings with heat pumps are not more energy efficient than office buildings which use a boiler. This is mostly because there is no continuous and automated control of the (complex) system. The same trends emerge with heat recovery balanced ventilation systems that are also working sub-optimally and in the end may use more energy than they save.

10.2.13 Are there any kinds of activities and demonstration projects organised by institutions other than governments and what is their possible effect on sustainable renovation?

Sustainability has become a hot topic in recent years. At the moment there seems to be a consensus among social organisations that sustainability must be increased. Environmental platforms are created which set environmental aims for some sectors. However, the roadmap to achieve the aims is difficult to set up and the realisation of often very high targets is expected to be problematic.

In general, in all countries there are a lot of demonstration projects, often within the framework of European projects.

10.2.14 What is known in general about effective environmental and building policies?

Because of the lack of monitoring there is very little known about the relative effects and efficiency of policies. Mostly it is assumed that a mix of tools is needed and that positive incentives (to promote a technique or behaviour) should be combined with negative ones (to avoid bad practices). There are also strong indications that the current preference of EU governments for deregulation and for using the free market as a tool for environmental improvements is limited. Voluntary market-led policies for sustainable renovation involve the risk that only those who are motivated will act. A policy approach combining hierarchy (regulation) and network (agreements) approaches is likely to be more effective than a market approach (Sunikka).

10.3 Work Package 3: Modernisation and renovation research

10.3.1 Which institutes and universities conduct ongoing research on renovation?

All kinds of national institutes and universities are conducting research on renovation, with very different approaches, from policy studies to building product and process innovation, to post-occupancy and life cycle studies. In general, research in the field of sustainable renovation takes place in universities and governmentally funded organisations. Research on product development is more often carried out in industry.

10.3.2 Is it technical, economic, policy or social oriented research and what are the main objectives of this research?

There is research ongoing on all these four themes. The research focus in the various countries differs. The main subjects of sustainable renovation research are:

- Austria: energy conservation and building product innovation.
- Finland: management of maintenance quality and the improvement of renovation processes and management tools.
- France: building product innovation, practical concepts and building regulations.
- Germany: energy conservation and life cycle assessment.
- Netherlands: energy conservation, safe and healthy housing, life cycle approach and policy studies.
- Switzerland: building regulations, renewable energy application and energy conservation.
- United Kingdom: economic feasibility of retrofit measures.

10.3.3 Is there research in the fields of architecture, building physics and services, indoor climate, public health and sociology that could be of importance to research on sustainable renovation?

Because of the complexity of sustainable renovation, there seems to be a need for more integrated research – and design. There is a lack of knowledge about standard solutions in the existing building stock that would take into account not only the aspect of energy savings but also the aspects of indoor air and architectural quality. There seems to be also a lack of knowledge on technical aspects like the interaction of construction and insulation materials and sustainable design. In the field of public health and indoor air quality there are a strongly increasing number of research projects relating ventilation, material emissions and health, that should be somehow related to renovation activities. In the field of sociology, studies about occupant behaviour are of interest. The more efficient the building services equipment, the larger the influence of occupant behaviour on the environmental performance of buildings. At the moment, there are no models that are able to predict with reasonable accuracy the effect of user behaviour. Also of great interest is research into the process and organisational aspects that is expected to provide interesting results for the construction sector.

10.3.4 Who is funding research?

In general, research in the field of sustainable renovation takes place at universities and governmentally funded organisations. Research on product development is more often funded by the industry. Research projects are also often co-funded by the European Union, national organisations and industry.

10.3.5 Is there specific research conducted by other than universities and research institutes (for instance consultants and property developers)? What are the aims of this research and how is it funded?

See Section 9.3.4.

10.3.6 Have the parties involved a clear idea about the type of research that will be needed in the future, and of what will this research consist?

The items identified are:

- Research on life cycle costing and value-added chain of construction products
- Post-occupancy evaluations
- Research on sustainable urban communities and citizen participation
- Overall environmental impact of buildings (LCA)
- Impact of renovation on indoor air quality
- Research on standard solutions for the implementation of renewable energy in buildings and neighbourhoods
- Use of 3D modelling GIS techniques for renovation
- Practical research on (new) insulation techniques for solid walls
- Practical research on new or better components
- Practical and cheap concepts for continuous monitoring and control of HVAC equipment
- Impact of occupant behaviour on energy conservation measures
- Sustainable financial constructions for renovation
- Demonstration and scaling-up projects
- Efficient building regulations and policies for renovation
- Process and organisation models for different stakeholders

10.4 Recommendations

In this section, all observations and conclusions from the earlier sections are brought together and ten main recommendations are drawn.

The first observation is that except from the International Energy Agency and Eurostat, data, definitions and methods used in national statistics for the residential sector differ in each country, which is not favourable for accurate comparisons between countries. There is much more official data available on the residential sector than on the non-residential sector. Data on the non-residential sector are scarce and scattered through a lot of private companies or sector organisations. Therefore, the development of consistent European statistics to assess the built environment should be considered. Although it is not necessary to centralise all statistics, it is important that at least a common basis is set up in all countries. This would allow better comparison and monitoring of the building stock and the effect of policies in the future. The implementation of the EPBD could be helpful to gather information. However, in the present state of affairs, the methods used and the data gathered in the framework of the EPBD differ greatly in the different countries. If the EPBD is to be used for monitoring and statistics as well, harmonisation between countries is considered necessary.

Second, although the residential sector accounts for about 70% of the total building stock, the non-residential sector is not negligible. In all countries office buildings are often already renovated and the degree of penetration of sustainable renovation seems to be higher than in other sectors, not least because of image. The shopping and leisure sector accounts for a large part of the non-residential sector, in terms floor area and also in terms of energy use. This is also a complex sector because next to large chain stores, a large part of the market consists of small shops with a high diversity of activities. Introducing sustainable renovation into the shopping sector seems to be a challenge that requires standard solutions and specific incentives, and policies for small and medium enterprises.

Third, educational buildings, although they have a modest share of floor area and energy use in the non-residential sector, could be considered as a sector of interest. Educational buildings are mostly owned by local, regional or national governments and their sustainable renovation could be seen as a standard bearer of political and social commitment. This also provides the opportunity to embed sustainability in education and to reach a large part of the population. Other good reasons to address the educational building stock are that the maintenance of schools is overdue in many countries and many studies indicate large-scale problems with a poor indoor air quality.

Fourth, the owner-occupied sector accounts for 35% to 70% of the residential building stock in the countries of interest in this study. This is also a sector where the penetration of sustainable renovation is low, in spite of the fact that a lot of renovation and modernisation activities are undertaken. Therefore, it seems to be an interesting sector to address. Single-family dwellings are owner-occupied in 60% to 96% of cases and multi-family dwellings in 20% to 60%. Barriers to sustainable renovation in the owner-occupied market are low investment capacity and the lack of knowledge about technical solutions. In owner-occupied multi-family dwellings, an additional barrier is the complex decision-making process related to co-ownership of the building parts.

Fifth, the other half of the residential sector consists of varying proportions of social rented and private rented dwellings. The social rented sector, very large in the Netherlands and Sweden, is strongly structured and easier to address than the private rented sector because the investment capacity and the structure are better. The private rented sector, very large in Germany and Switzerland, has to contend with a low investment capacity and a lack of knowledge about technical solutions. In both subsectors, the main barrier to sustainable renovation seems to be the return on investment; the one who invests is not the one who profits. This calls for specific financial and organisational solutions.

Sixth, in all countries except Finland and Sweden, a large part of the existing dwelling stock, mainly with non-cavity external walls, still needs to be insulated and there seems to be a lack of practical technical solutions in this area. Although sustainable building services like heat pumps, solar heating or district heating have been demonstrated in many projects, the scaling-up of these projects seems a very difficult task. An exception to this is the large-scale implementation of district heating in Finland and Sweden. In addition to the activities aimed at the scaling-up process itself, there is a need for research into methods to achieve this. There is also an urgent need for the translation of solutions into practices through technical norms, education and knowledge sharing, and for innovative solutions such as very thin insulation materials applicable indoors. The emergence of indoor air quality problems is also observed. Because natural ventilation by opening windows is still very common, but is insufficient in buildings that have been thermally renovated, integral renovation concepts should be developed, also taking into account occupants' needs and behaviour.

Seventh, the monitoring of energy use and equipment is needed to really achieve energy savings and to evaluate the efficiency of measures.

Eighth, urban renewal, which is taking place on a large-scale in Germany, Austria and France, could be an opportunity for sustainable renovation; at least if decisions on asset management were related to the technical quality of the buildings, which is mostly not the case. Here too, specific organisational and financial solutions are needed.

Ninth, most renovation activities in the residential sector are maintenance, repair and modernisation activities aimed at increasing the service life of components, increasing comfort or at replacing components. The decision-makers in these renovation activities are owner-occupants and mostly small contractors. There is a need for the dissemination of knowledge and decision tools (for instance the "repair or replace" decision tool) to these small sized firms and non-professional actors. The consultancy process is also very unclear because the contractor acts as consultant too, but is not objective. There seems to be a need here too for specific organisations and processes.

Tenth, besides the implementation activities and practical research activities described above, more strategic research themes for the future were identified; research on life-cycle costing and value-added chain of construction products; post-occupancy evaluations; research on sustainable urban communities and citizen participation; overall environmental impact of buildings (LCA); impact of renovation on indoor air quality; research on standard solutions for the implementation of renewable energy in buildings and neighbourhoods; use of 3D modelling GIS techniques for renovation; practical research on (new) insulation techniques for solid walls; practical research on new or better components; practical and cheap concepts for continuous monitoring and control of HVAC equipment; impact of occupant behaviour on energy conservation measures; sustainable financial constructions for renovation; demonstration and scaling-up projects; efficient building regulations and policies for renovation; and process and organisation models for different stakeholders.

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Appendix B Tables and data Chapter 2

Table B.1: Final energy consumption in the residential and non-residential building stocks*, additional data for Section 2.4.

		Total Final Energy use (Ktoe)	Coal (Ktoe)	Petroleum products (Ktoe)	Gas (Ktoe)	Geothermie & solar (Ktoe)	Combustible renewables & Waste (Ktoe)	Electricity (Ktoe)	Heat (Ktoe)
Austria	Residential	**7051**	140	1806	1495	50	1548	1442	571
	Non-residential	**3005**	16	536	480	41	117	1277	537
	Construction industry	**878**	634	11657	4677	91	2653	5005	1290
	Total	**26008**							
Finland	Residential	**5016**	16	857	26	0	979	1751	1386
	Non-residential	**1767**	0	364	34	0	65	1304	0
	Construction industry	**319**	1068	8173	877	0	5340	7150	3557
	Total	**26164**							
France	Residential	**48520**	408	10343	17504	140	7505	12620	0
	Non-residential	**15578**	0	5057	0	0	517	9944	0
	Construction industry	**4172**	3446	75683	32251	149	9809	35766	643
	Total	**157747**							
Germany	Residential	**76272**	570	17670	28375	335	4585	12073	12664
	Non-residential	**24349**	290	6640	7524	11	0	9884	0
	Construction industry	**6534**	8754	92231	60296	345	5576	44146	14587
	Total	**225935**							
Netherlands	Residential	**10430**	5	65	7898	18	222	2021	200
	Non-residential	**8300**	0	311	4417	0	42	2803	727
	Construction industry	**719**	772	17805	21144	18	381	8868	2556
	Total	**51543**							
Sweden[6]	Residential	**7152**	0	509	70	5	572	3558	2439
	Non-residential	**4561**	0	808	90	0	54	2370	1239
	Construction industry	**467**	761	11821	517	5	5248	11211	4090
	Total	**33654**							
Switzer-	Residential	**6075**	7	3119	995	110	240	1472	132

land	Non-residential	**3778**	0	1271	551	18	427	1415	96
	Construction industry	**n.a.**	134	12298	2483	148	1172	4831	366
	Total	**21431**							
United Kingdom	Residential	**44852**	1030	2941	30668	0	226	9935	52
	Non-residential	**16794**	35	843	6724	0	110	8182	900
	Construction industry	**2596**	3029	66500	50422	25	719	29244	2189
	Total	**152127**							

*The basic data come from the energy balances for 2004 from the International Energy Agency (IEA, see references) and refer to the final energy consumption per country to the exclusion of primary energy sources for product manufacture (so called non-energy use). In the IEA statistics, the non-residential sector is defined as being the commercial and public services. The residential sector consists of households. The other sectors are shared by industry, transport, agriculture, forestry and fishing. The data for the construction industry, which are not specified in the IEA data, are taken from the energy balance for 2004 from Eurostat. In this European database, the construction industry, defined as building materials industry, is aggregated with the glass and pottery industry, which introduces a small inaccuracy. The differences between data from Eurostat and IEA are very small (<2%).

Appendix C Tables and data Chapter 3

Table C.1: Distribution of building types by stakeholder in France*, additional data for Section 3.3.

	Owner	Individual houses	Apartments	Other	Total (in 1000 dwellings)
Farmer		*42.5*	*10.2*	19.5	**72.2**
Owner	Co-owner	*451.9*	*2487.7*	19.7	**2959.4**
	Owner	*10456.5*	*116.7*	191.2	**10764.4**
	Sub total	*10908.5*	*2604.4*	*210.9*	***13723.8***
Free of charge	Social housing (organisme HLM)	*5.7*	*25.3*	1.8	**32.8**
	Other society (public or private)	*55.0*	*29.9*	5.8	**90.7**
	Administration (state, municipality)	*42.7*	*82.9*	25.3	**150.9**
	Association	*11.3*	*1.9*	5.8	**19.0**
	Member of the family	*308.7*	*197.7*	20.9	**527.3**
	Other	*91.6*	*99.5*	14.6	**205.8**
	Sub-total	*515.1*	*437.3*	*74.2*	***1026.5***
Tenant or sub-tenant	Social housing (organisme HLM)	*547.3*	*3154.5*	67.2	**3769.0**
	Other society (public or private)	*100.9*	*460.3*	27.3	**588.5**
	Administration (state, municipality)	*76.2*	*107.8*	55.2	**239.1**
	Association	*4.5*	*26.2*	12.4	**43.1**
	Member of the family	*80.7*	*92.0*	5.3	**178.0**
	Other	*1395.2*	*3375.8*	113.8	**4884.9**
	Sub-total	*2204.9*	*7216.5*	*281.2*	***9702.6***
Total		***13671.0***	***10268.4***	**585.8**	**24525.2**

*http://www2.equipement.gouv.fr/statistiques/backoffice/C_L/comptes_L/C_log99/serie/PARCSD50.xls

Table C.2: Age of the single-family and multi-family dwelling stock in Austria*, additional data for Section 3.6

Austria	<1919	1919-1944	1945-1960	1961-1970	1971-1980	1980-1990	>1990	Total
Single-family	14	7	12	13	16	16	22	100
Multi-family	21	9	13	17	15	10	15	100

*from ISIS database, data from 2003.

Table C.3: Age of the dwelling stock in France, related to building type and ownership*, additional data for Section 3.6

France	**Before 1871**				**1871 - 1914**			
	Individual houses	***Apartments***	**Other**	**Total**	**Individual houses**	***Apartments***	**Other**	**Total**
Individual owner	98%	93%	88%	**96%**	98%	92%	91%	**95%**
Social housing (organisme HLM)	0%	1%	0%	**1%**	1%	3%	0%	**1%**
Society (public or private)	0%	3%	1%	**1%**	1%	4%	2%	**2%**
Administration (state, municipality)	1%	3%	9%	**2%**	1%	1%	6%	**1%**
Association	0%	1%	2%	**1%**	0%	0%	1%	**0%**
Total	100%	100%	100%	**100%**	100%	100%	100%	**100%**

Owner type	**1915 - 1948**				**1949 - 1961**			
	Individual houses	***Apartments***	**Other**	**Total**	**Individual houses**	***Apartments***	**Other**	**Total**
Individual owner	94%	82%	84%	**89%**	93%	51%	66%	**70%**
Social housing (organisme HLM)	2%	11%	0%	**5%**	4%	40%	8%	**24%**
Society (public or private)	3%	5%	3%	**4%**	1%	6%	4%	**4%**
Administration (state, municipality)	1%	3%	11%	**2%**	1%	2%	20%	**2%**
Association	0%	0%	2%	**0%**	0%	0%	2%	**0%**
Total	100%	100%	100%	**100%**	100%	100%	100%	**100%**

Owner type	**1962 - 1967**				**1968 - 1974**			
	Individual houses	***Apartments***	**Other**	**Total**	**Individual houses**	***Apartments***	**Other**	**Total**
Individual owner	95%	50%	52%	**66%**	96%	53%	30%	**70%**
Social housing (organisme HLM)	2%	44%	13%	**29%**	3%	42%	29%	**26%**
Society (public or private)	1%	4%	16%	**3%**	0%	4%	14%	**3%**

Administration (state, municipality)	1%	2%	15%	**2%**	0%	2%	18%	**1%**
Association	0%	0%	5%	**0%**	0%	0%	9%	**0%**
Total	100%	100%	100%	**100%**	100%	100%	100%	**100%**

Owner type	**1975 - 1981**				**1982 - 1989**			
	Individual houses	***Apartments***	**Other**	**Total**	**Individual houses**	***Apartments***	**Other**	**Total**
Individual owner	93%	53%	23%	**77%**	91%	52%	39%	**79%**
Social housing (organisme HLM)	5%	41%	42%	**19%**	7%	39%	22%	**16%**
Society (public or private)	1%	4%	7%	**2%**	1%	7%	13%	**3%**
Administration (state, municipality)	1%	2%	22%	**1%**	1%	2%	21%	**1%**
Association	0%	0%	5%	**0%**	0%	0%	5%	**0%**
Total	100%	100%	100%	**100%**	100%	100%	100%	**100%**

Owner type	**1990 - 1998**				**1999 and after**			
	Individual houses	***Apartments***	**Other**	**Total**	**Individual houses**	***Apartments***	**Other**	**Total**
Individual owner	89%	57%	41%	**75%**	89%	59%	57%	**77%**
Social housing (organisme HLM)	9%	35%	17%	**20%**	9%	31%	27%	**17%**
Society (public or private)	1%	7%	9%	**3%**	2%	7%	11%	**4%**
Administration (state, municipality)	1%	1%	30%	**1%**	1%	2%	6%	**1%**
Association	0%	0%	3%	**0%**	0%	0%	0%	**0%**
Total	100%	100%	100%	**100%**	100%	100%	100%	**100%**

*Data are based on the Housing Inquiry 2001-2002, Census 1999, database COMMbat and data from INSEE and CSTB.

Table C.4: Age of the single-family and multi-family dwelling stock in Germany*, additional data for Section 3.6

Germany		**<1918**	**1919-1948**	**1949-1978**	**1979-1994**	**1995-2001**	**2002-2006**	**Total**
Single family	Terraced dwellings	5	12	45	21	12	4	99
	Detached dwellings	13	10	36	20	15	6	100
Multi-family		13	11	47	16	11	2	100

*IWU estimate based on German micro census 1% sample 1998.

Table C.5: Age of the single-family and multi-family dwelling stock in the Netherlands*, additional data for Section 3.6

		>1945	1945-1970	1971-1990	>1990	Total
Single-family	Owner-occupied	16	15	26	10	*66*
	Social rented	3	13	9	1	*26*
	Private rented	3	2	2	(0.3)	*8*
	Total	*22*	*30*	*37*	*11*	*100*
Multi-family	Owner-occupied	6	8	4	3	*21*
	Social rented	8	20	22	8	*58*
	Private rented	10	5	5	1	*21*
	Total	*24*	*33*	*31*	*12*	*100*

*KWR 2000 and [Thomsen & Meijer 2007].

Table C.6: Age of the single-family and multi-family dwelling stock in Switzerland*, additional data for Section 3.6

	<1919	1919-1945	1946-1970	1971-1990	1991-2000	Total
Single-family	20	13	24	30	13	100
Multi-family	27	14	27	23	10	100

*Data from BFS Wohnungszählung 2000

Table C.7: Reference dwellings in Germany*, additional data for Section 3.7

Reference dwelling	Name	Short description	Share of total number of dwellings (%)	Main Construction period
Type 1	EFH Einfamilienhaus Single-family home	Detached/semi-detached buildings	52%	1984 -1994
Type 2	RH Reihenhaus Terraced house	1 family terraced house	8%	1969 -1978
Type 3	MFH Mehrfamilienhaus Multi-family home	Multi-storey apartment building up to 6 dwellings	32%	1958 - 1968
Type 4	GMH großes Mehrfamilienhaus Multi-family home	Multi-storey apartment building 6 to 12 dwellings	7%	1969 - 1978
Type 5	HH Hochhaus High-rise multi-family home	Multi-storey apartment building more than 12 dwellings	1%	1969 - 1978

*from

1. Kleemann, Manfred; Rainer Heckler, Gerhard Kolb, Maren Hille "Die Entwicklung des Wärmemarktes für den Gebäudesektor bis 2050"; Hrsg. Forschungszentrum Jülich, Jülich 2000;
2. Institut Wohnen und Umwelt: Deutsche Gebäudetypologie http://www.iwu.de/fileadmin/user_upload/dateien/energie/klima_altbau/Gebaeudetypologie_Deutschland_Dez_2003.pdf;
3. IKARUS-Datenbank Version 3.1, entwickelt vom FIZ Karlsruhe (IKARUS: **I**nstrumente für **K**limag**a**s-**R**ed**u**ktions-**S**trategien); Forschungszentrum Jülich

Table C.8: Reference dwellings in the Netherlands*, additional data for Section 3.7

Reference dwelling	Name	Subtype per construction period	Short description	Share of total residential (%)
Type 1	Detached house > 150m²	< 1966 1966-1988 1989-2000	A_g=210.6 m² A_g=182.7 m² A_g=173.0 m²	3% 2.2% 2.2%
Type 2	Detached house ≤ 150 m²	< 1966 1966-1988 1989-2000	A_g=99.4 m² A_g=112.6 m² A_g=115.1 m²	5.0% 2.3% 1.0%
Type 3	Duplex	< 1966 1966-1988 1989-2000	A_g=109.6 m² A_g=113.4 m² A_g=113.4 m²	6.0% 4.6% 2.0%
Type 4	Terraced house	<1946 1946-1965 1966-1975 1976-1979 1980-1988 1989-2000	A_g=97.8 m² A_g=95.8 m² A_g=106.0 m² A_g=107.9 m² A_g=98.1 m² A_g=100.8 m²	7.5% 10.0% 10.0% 2.5% 7.0% 5.0%
Type 5	Maisonette	< 1966 1966-1988 1989-2000	A_g=89.1 m² A_g=83.7 m² A_g=89.1 m²	3.0% 1.4% 0.3%
Type 6	Gallery flat	<1966 1966-1988 1989-2000	A_g=66.2 m² A_g=66.2 m² A_g=67.4 m²	1.7% 3.2% 1.6%
Type 7	Stair case-access flat	<1966 1966-1988 1989-2000	A_g=59.4 m² A_g=67.3 m² A_g=72.0 m²	7.0% 2.7% 1.4%
Type 8	Other flats	<1966 1966-1988 1989-2000	A_g=56.7 m² A_g=63.0 m² A_g=75.6 m²	3.4% 3.1% 1.1%

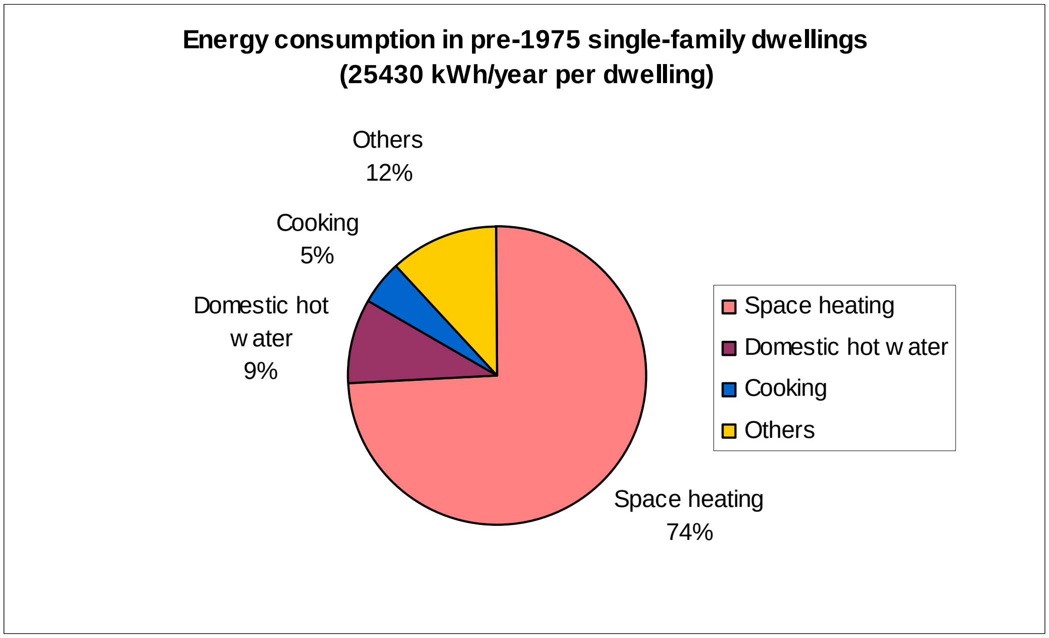
*http://duurzaambouwen.senternovem.nl/uploaded/publicaties/Voorbeeldwoningen_bestaande_bouw_2007.pdf

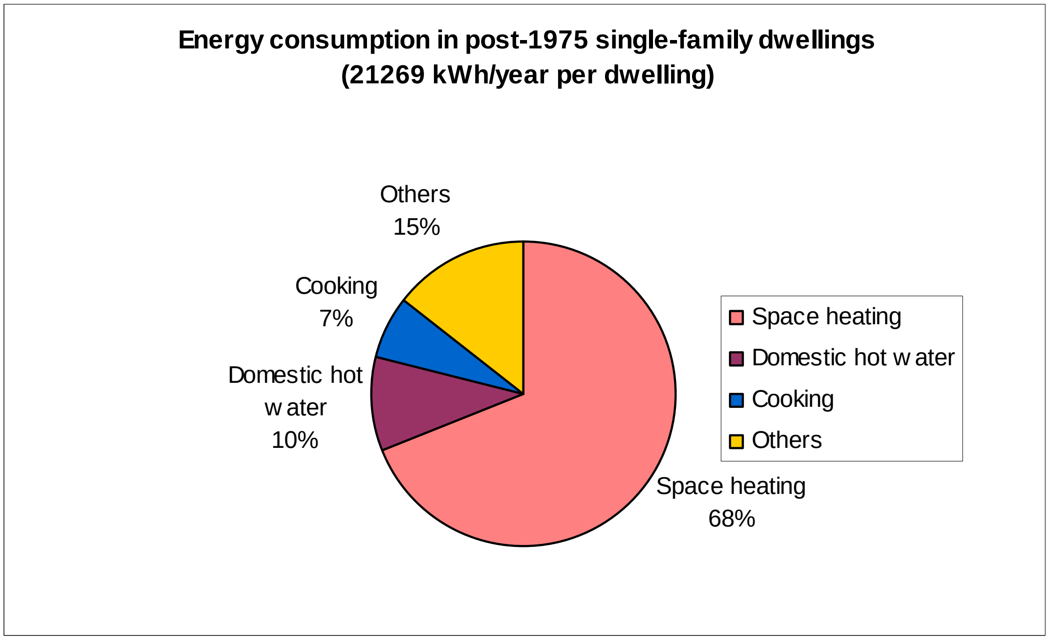
Table C.9: Reference dwellings in Austria, additional data for Section 3.7

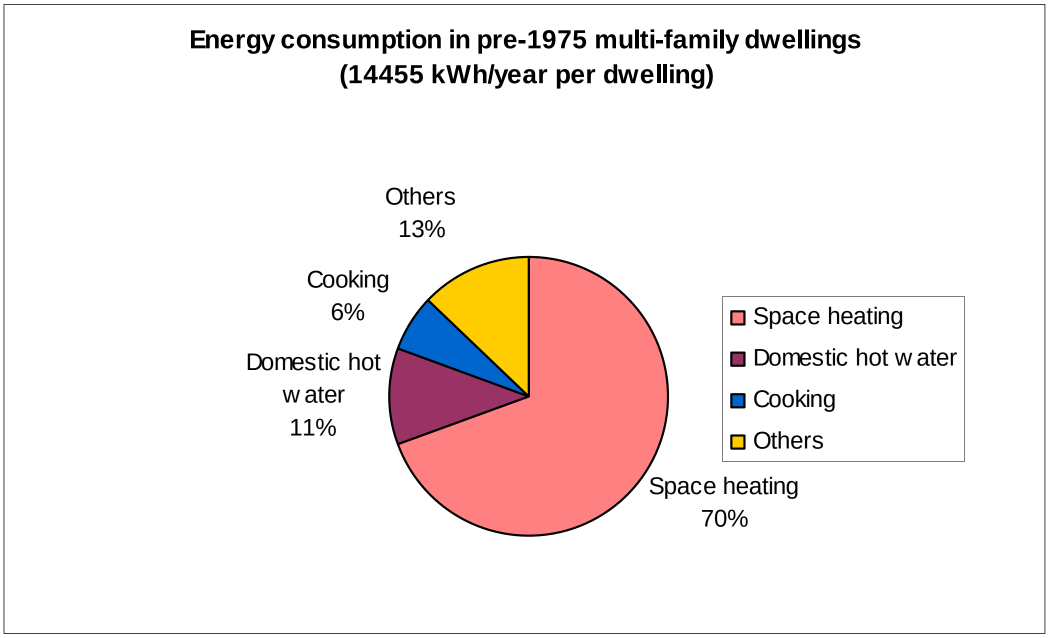
Reference dwelling	Name	Short description	Share of total residential (%)	Main Construction period
Type 1	Category A	like B, larger than 30 m², central heating	89.3%	after 1945
Type 2	Category B	1 room, kitchen, anteroom, WC, bathroom	8.1%	Beginning of 20th century, also later: Usually no central heating
Type 3	Category C	water supply and WC inside dwelling	0.5%	
Type 4	Category D	no water supply or WC inside dwelling	2.1%	Vienna Gründerzeit stock, built before 1920 (WC outside dwelling)

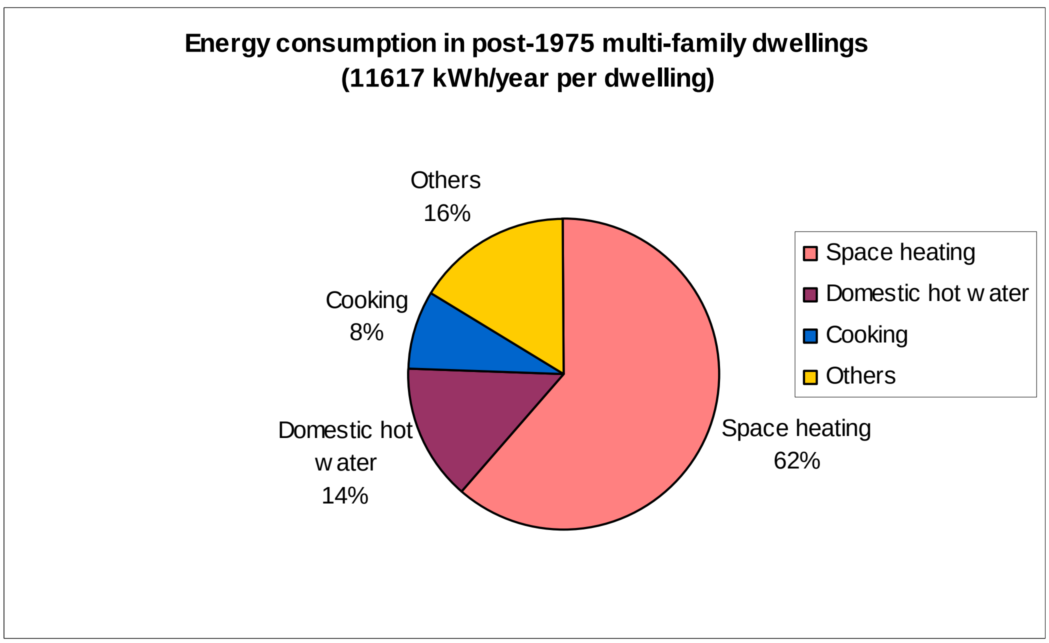
Appendix D Tables and data Chapter 4

Figure D.1: Energy consumption of average French dwellings: break-down by end use*, additional data for Section 4.2



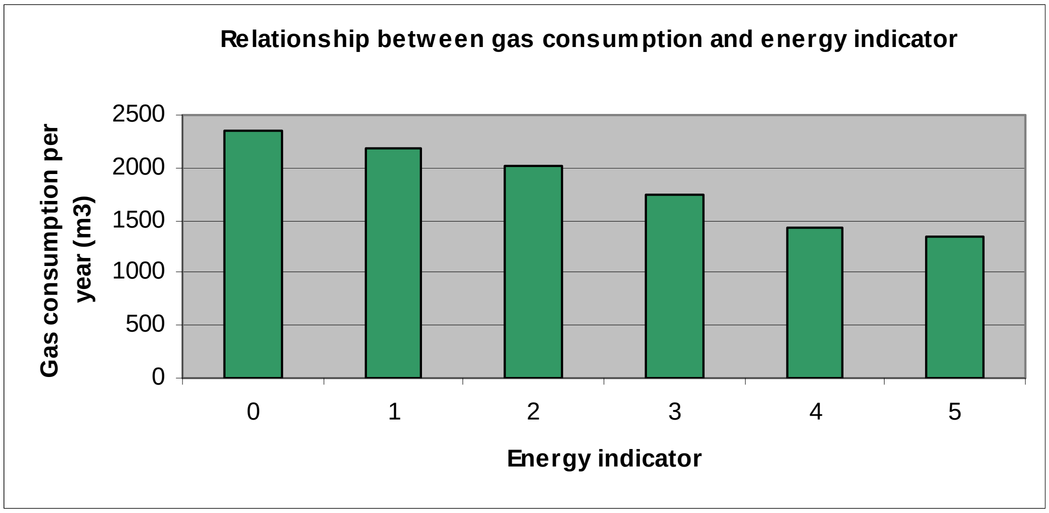






* from "Les Chiffres clés du bâtiment, Energie – Environnement", édition 2006, ADEME.

Figure D.2: Relationship between gas consumption and energy indicator in Dutch dwellings*, additional data for Section 4.2



* from Basisrapportage Kwalitatieve Woningregistratie 2000, VROM.

Table D.1: Construction characteristics of Austrian dwellings*, additional data for Section 4.3

Single Family buildings	Insulation	Number of dwellings	Characterisation	Main building periods
Solid external wall	without insulation	80%	For the largest part of buildings brick walls are predominant; in sizes up to 45 cm they were regarded thermally sufficient.	All periods
	with insulation	20%	Modern insulation is in use since the 1960s; first straw, then rockwool, then styrofoam is predominant; in the 1970s <6 cm, 1980s ca. 6 cm, 1990s <10 cm, today >10 cm; passive houses are already built with >25 cm insulation; thermal refurbishment of ca. 1% of housing stock per year	Refurbished: all periods; new: since 1970s
External cavity wall	without insulation	0%		
	with insulation	100%	Particularly prefab houses, which became successful from the 1980s on. They try to look like houses with solid walls, e.g. rather thick walls with good insulation; today >20 cm.	Particularly after 1980s
Floor above crawl space	without insulation	20%	seldom	
	with insulation	80%	seldom	

Floor on solid ground	without insulation	40%	Small houses without basement.	Until 1970s
	with insulation	60%	Small houses without basement; modern passive houses frequently have no basement, insulation up to 50 cm.	Since 1970s
Floor above basement	without insulation	70%	Most single-family houses have basements; they are partly used for living purposes.	Until 1970s
	with insulation	30%	Houses with basement not for living purposes; until 1990s insulation of <6 cm; since then >6 cm; modern houses >10 cm.	Since 1970s
Flat roof	without insulation	10%	Seldom, frequently on garages.	
	with insulation	90%	Seldom, flat roofs came into use only after the problems with insulation, impermeability and durability were solved; modern passive houses with up to 50 cm.	Modernist style (1950/60), present time
Sloping roof	without insulation	50%	Mostly if the attic is not for living purposes. In that case the insulation is between attic and top floor.	All periods
	with insulation	50%	Mostly if the attic is designed for living purposes. Until 1990s <16 cm, since then >16 cm; modern passive houses with up to 50 cm. Attics in single-family houses frequently were adapted for living purposes and included insulation.	All periods
Glazing	Single	5%	Seldom	
	Double	90%	Predominant in all periods, in older buildings usually replaced every 20-25 years; in buildings until the 1950s still frequently box-type windows; modern double-glazing has very good energy performance close to triple glazing.	All periods
	Triple	5%	Particularly in modern low energy and passive houses.	Present time
Inner walls	Mainly load-bearing		Mainly solid without insulation	All periods
	Mainly non-load-bearing		Mainly solid without insulation	All periods

Multi-family buildings	**Insulation**	**Number of dwellings***	**Characterisation**	**Main building periods**
Solid external wall	without insulation		Old "Gründerzeit"-Stock with thick brick stones hardly fit for thermal insulation; buildings from 1920s to 1950s with clay or concrete bricks are consequently refurbished; concrete panel block buildings from 1960s to 1970s the same; in the 1980s and 1990s thick brick walls dominated, which were regarded as thermally sufficient.	Until 1960s

	with insulation		Consequent thermal refurbishment of ca. 2% of the housing stock per year; since 1990s thin concrete walls with strong thermal insulation is predominant; until 1990s <10 cm; since then >10 cm; modern low energy buildings with mostly 16 cm; passive houses with >20 cm.	Refurbishment of old buildings; insulation common since 1970s
External cavity wall	without insulation	0%		
	with insulation -	100%	Seldom	
Floor above crawl space	without insulation	20%	Seldom	
	with insulation -	80%	Seldom	
Floor on solid ground	without insulation	40%	Seldom	
	with insulation -	60%	Seldom	
Floor above basement	without insulation	40%	Additional rooms for laundry, waste, cellar etc. obligatory, therefore apartment buildings predominantly with basements.	Until 1970s
	with insulation -	60%	Until 1990s insulation of <10 cm; since then >10 cm; modern houses up to 25 cm.	Since 1970s
Flat roof	without insulation	10%	Seldom	
	with insulation -	90%	Flat roofs were fashionable in the period of modernist style (1950s 1960s) and became common in panel block buildings. Early examples with poor performance regarding insulation, impermeability and durability have been thermally refurbished throughout. In present-day urban housing flat roof became predominant due to the market value of roof terraces. Until 1980s <16 cm; since then >16 cm; modern passive houses with up to 50 cm.	All periods
Sloping roof	without insulation	30%	Mostly if the attic is not for living purposes. In that case the insulation is between attic and top floor.	All periods
	with insulation -	70%	Mostly if the attic is designed for living purposes. Until 1990s <16 cm, since then >16 cm; modern passive houses with up to 50 cm. Attics in the old housing stock frequently were adopted for upscale residential housing and included insulation.	All periods
Glazing	Single	0%	Non existent	
	Double	90%	Predominant in all periods, in older buildings usually replaced every 20-25 years; in buildings until the 1950s still frequently box-type windows; modern double-glazing has very good energy performance close to triple glazing.	All periods

	Triple	5%	Particularly in modern low energy and passive houses.	Present time
Inner walls	Mainly load-bearing		Mainly solid without insulation	All periods
	Mainly non-load-bearing		Frequently cavity walls with sound insulation.	All periods

Building Period	**Glass surface in percentage of façade (indoor measure)**		**Insulated (double or triple) glazing used**		**Type of window frame**
	Single-family dwellings	**Multi-family dwellings**	**Single family dwellings**	**Multi-family dwellings**	
Before 1920	15-20%	20%	yes	yes	Box type, frequently replaced by PVC or wood
1920-1945	15-20%	20%	yes	yes	Box type, frequently replaced by PVC or wood
1945-1970	20-25%	25%	yes	yes	Wood, PVC, aluminium
1971-1990	20-25%	25%	yes	yes	Wood, PVC, aluminium
1991-2000	20-30%	30%	yes	yes	Wood, PVC
After 2000	20-30%	>30%	yes	yes	In growing number wood-aluminium-combination
Sun rooms are found in single-family houses built after 1945 and in apartment buildings built after 1991. Roof overhangs (for shading) are found in all building periods except 1920-1945 for single-family dwellings. In apartment buildings they are found only in the period 1971-1990. External shades or blinds can be found in all types (age) of single-family dwellings, whereas in apartment buildings they have been essentially installed in the building period 1945-1970.					

*Educated guess from IIBW, according to refurbishment projects, reports and literature.

Table D.2: Percentage of dwelling components insulated in a certain year in the Netherlands*, additional data for Section 4.3

%	**Whole dwelling stock**			**Pre-1971 dwelling stock**	
	1995	**2000**	**2005**	**1995**	**2000**
Solid walls	41	50	57	19	23
Cavity walls			57		
Floors	23	34	43	4	10
Sloping roofs	54	63	71	30	40
Double-glazing	58	69	80	43	59

*from KWR 2002, Dossier Energy Saving and Insulation (VROM) and Basisrapportage Kwalitatieve Woningregistratie 2000 (VROM).

Appendix E Tables and data Chapter 5

Table E.1: Age of the Finnish non-residential building stock managed by municipalities in number of buildings, floor area and % floor area*, additional data for Section 5.4

Year	Office buildings			Meeting/Cultural			Educational			Health care			Nurseries		
	no. build.	10^3 m²	% (m^2)	no. build.	10^3 m²	% (m^2)	no. build.	10^3 m²	% (m^2)	no. build.	10^3 m²	% (m^2)	no. build.	10^3 m²	% (m^2)
<49	495	510	*22*	861	657	*24*	1289	1240	*15*	524	919	*16*	229	100	*9*
50-54	111	120	*5*	110	63	*2*	514	840	*10*	217	389	*7*	56	30	*3*
55-59	117	100	*4*	92	50	*2*	632	1160	*14*	161	361	*6*	53	30	*3*
60-64	115	150	*7*	84	78	*3*	373	860	*10*	205	397	*7*	66	40	*4*
65-69	109	250	*11*	101	127	*5*	317	930	*11*	274	656	*10*	72	40	*4*
70-74	105	210	*9*	141	161	*6*	197	520	*6*	163	454	*8*	96	70	*6*
74-79	136	220	*10*	195	167	*6*	249	670	*8*	271	880	*15*	189	130	*12*
80-84	144	240	*10*	463	336	*12*	258	440	*5*	269	779	*13*	250	180	*16*
85-89	95	180	*8*	569	401	*14*	202	430	*5*	208	344	*6*	270	180	*16*
90-94	61	80	*3*	336	267	*10*	168	340	*4*	177	323	*5*	192	120	*11*
95-99	32	40	*2*	223	144	*5*	121	210	*2*	57	101	*2*	91	60	*5*
00-04	51	110	*5*	179	179	*6*	184	300	*4*	48	84	*1*	128	90	*8*
>05	74	80	*3*	386	152	*5*	310	480	*6*	168	2	*6*	82	42	*4*
Total	1645	2290	*100*	3740	2781	*100*	4814	8420	*100*	2742	327	*100*	1774	112	*100*

* from Vainio, T., Jaakkonen, L., Nuutila, H., Nippala, E., 2005, Kuntien rakennuskanta (The building stock of municipalities), Helsinki: Kuntaliitto.

Table E.2: Dutch reference buildings for the non-residential sector*, additional data for Section 5.5

Reference dwelling	Name	Geometry	Insulation	Building services
Type 1	Small office	3000 m² 57.6 x 14.4 m 4 storeys	U=0.33 W/m²K Double glass 35% glass	Heat recovery mech. ventil. High efficiency boiler No cooling 11 W/m² lighting
Type 2	Large office	15000 m²	U=0.33 W/m²K Insulation glass 35% glass	Heat recovery mech. ventil. High efficiency boiler Limited air cooling 11 W/m² lighting
Type 3	Shop	1800 m² One storey	U=0.33 W/m²K Double glass 35% glass	Heat recovery mech. ventil. High efficiency boiler Limited air cooling 30 W/m² lighting

Type 4	Sports building	1280 m² One storey	U=0.33 W/m²K Insulation glass 35% glass	Heat recovery mech. ventil. High efficiency boiler No cooling 11 W/m² lighting
Type 5	Small educational	2000 m²	U=0.33 W/m²K High Insulation glass 50% glass	Mech. exhaust ventilation High efficiency boiler No cooling 8 W/m² lighting
Type 6	Large educational	6000 m²	U=0.33 W/m²K Double glass 50% glass	Heat recovery mech. ventil High efficiency boiler No cooling 10 W/m² lighting
Type 7	Small health care	7000 m²	U=0.33 W/m²K Double glass	Mech. exhaust ventilation High efficiency boiler No cooling 12 W/m² lighting
Type 8	Large health care	37000 m²	U=0.33 W/m²K Double glass	Heat recovery mech. ventil High efficiency boiler Limited cooling 12 W/m² lighting

*http://www.senternovem.nl/epn/referentiewoningen/referentiegebouwen_utiliteit/index.asp

Appendix F Tables and data Chapter 6

Table F.1: Annual renovation activities in housing stock in Austria and main reasons for renovation; additional data for Section 6.3.

	% of apartments	% of single-family houses	% of total stock	Frequency	Reasons for renovation
Outer insulation outer walls	1.2%	0.8%	1.0%	40	Comfort Reduction of user costs Incentives from subsidies
Inner insulation outer walls	Seldom	Seldom	Seldom		If outer wall insulation is impossible
Ground floor insulation	0.5%	0.1%	0.3%	40	Total thermal refurbishment of building
New/renovated façade	2%	1.5%	1.7%		Optical improvements
New roof or substantial roof renovation	3%	3%	3%	25	Leaky roof
Acoustic insulation between dwellings	0.2%	0	0.1%		Seldom done by tenants themselves; sound insulation in general good
New heater and heating system	4%	4%	4%	20	Heater defect General refurbishment Incentives from subsidies
New ventilation system	Seldom	Seldom	Seldom		Only in the rare cases of refurbishments in passive house standard
Modernisation of kitchen interior	4%	4%	4%	20	New claims on comfort
Modernisation of bathroom interior	4%	4%	4%	20	New claims on comfort
New water or drain pipes	1.5%	1.5%	1.5%	30	Leaky pipes Replacement of lead pipes
New electrical wiring	1%	1%	1%	40	Replacement of (non earthed) wiring
Outdoor simple maintenance	4%	4%	4%	20	
Indoor simple maintenance	10%	5-10%	5-10%	10	New tenants Claims on comfort
Joining dwellings	<0.1%	0	<0.1%		Purchase of neighbouring dwelling and joining
Separating dwellings into more	0%	seldom	0%		Separating generations in single-family houses
Demolishing buildings and building new	0.1%	<0.1%	0.1%		Replacement with better quality and higher density
Demolishing buildings without rebuilding	0%	<0.1%	0%		Seldom run down rural areas

Conversion of dwellings into offices or another function	<0.1%	0%	<0.1%		Conversion of dwellings into offices and vice versa

Source: experts' opinion (questionnaire).

Table F.2: Annual renovation activities in total housing stock in Finland (in percentages and main reasons for renovation; additional data for Section 6.3.

	% of total stock*	**Reasons for renovation**
Outer Insulation outer walls	3.7%	Fixing a damaged component (34%)
		Maintenance/prevention (28%)
		Upgrading the level of the dwelling (18%)
Windows and doors	2.6%	Maintenance/prevention (35%)
		Fixing a damaged component (34%)
		Upgrading the level of the dwelling (19%)
New roof or substantial roof renovation	3.2%	Fixing a damaged component (44%)
		Maintenance/prevention (29%)
		Upgrading the level of the dwelling (11%)
New heater and heating system	18.2% (heat and water)	Fixing a damaged component (36%)
		Maintenance/prevention (23%)
		Upgrading the level of the dwelling (22%)
Air-conditioning system	3.2%	Upgrading the level of the dwelling (30%)
		Fixing a damaged component (29%)
		Maintenance/prevention (20%)
New electrical wiring	8.0% (electricity)	Upgrading the level of the dwelling (37%)
		Fixing a damaged component (29%)
		Changes in floor plan (16%)

Source: experts' opinion (questionnaire).

Table F.3: Renovation activities in France aimed at realising energy savings; additional data for Section 6.3.

Type of renovation work (for energy saving)		**Share (%)**	**Reasons for renovation**
Insulation (70%)	**Change of shutters**	10	Improvement of thermal comfort Reduction of energy consumption
	Change of windows without double-glazing	2	
	Change of windows with double-glazing	26	
	Double-glazing	2	
	Installation of 'joints'	4	
	Insulation of floor/roof	14	
	Insulation of walls	11	
	Other	0.4	
HVAC systems (30%)	**Ventilation**	1	
	Heating system improvement	17	
	Heating control system improvement	4	

	Heating system replacement	9	

Source : Les Chiffres clés du bâtiment, Energie-Environnement/édition 2006 – ADEME

Table F.4: Renovation activities in Germany aimed at realising energy savings (in % of total stock); additional data for Section 6.3.

	% of apartments	% of single-family houses	% of total stock	Frequency	Reasons for renovation
Outer insulation outer walls	Never, but insulation layers might be added.				Reduction of energy consumption Low opportunity costs in combination with necessary repair
Inner Insulation outer walls	Never, but insulation layers might be added.				Only in cases where the façade, for reasons of protection of architectural heritage, cannot be covered by insulation layers
Ground floor insulation	Never, but insulation layers might be added.				Reduction of energy consumption Low costs, if insulation can be added from the basement ceiling
New façade or substantial façade renovation	3-5%	2.5-4%	2.5-5%	Every 20-30 years	Reduction of energy consumption Low opportunity costs in combination with necessary repair
New roof or substantial roof renovation	2.5-3%	2.5-3%	2.5-3%	Every 30-40 years	Reduction of energy consumption Low opportunity costs in combination with necessary repair Better/new use for space under the roof
Acoustic insulation between dwellings				Never	New buildings: due to legal requirements. Renovation is very rare. Only in cases of continuous complaint from users.
New heater and heating system	4-6%	4-6%	4-6%	Every 20 years	New legal technical requirements End of lifespan
New ventilation system	n.a	n.a	n.a	n.a	Very rare in the Germany
Modernisation of kitchen interior	Probably at every change of tenant or owner				This is the responsibility of the tenants (and owner-occupiers).
Modernisation of bathroom interior	In the older rental stock if the demand is low: with every change of tenants. Owner-occupied: every change of owner.				Rental sector: Depending on the market Owner-occupied sector: every time before moving into the dwelling
New water or drain pipes	n.a	n.a	n.a	Depending on defects	In cases of defects or when the through flow is substantially reduced by corrosion and calcification. Otherwise never.
New electrical wiring	n.a	n.a	n.a	Depending on defects	Changes to the standard Market situation, to make the dwellings more attractive in combination with ICT.
Outdoor simple maintenance (paint, gutters etc.)	3-5%	3-5%	3-5%	Every 20-30 years	To cope with the general standard of the residential area. To increase chances for letting or selling.
Indoor simple maintenance (paint, wallpaper…)	6-10%	6-10%	6-10%	Moving/ turnover Else every 15 years.	Rental sector: responsibility of the tenants; at least with every change of tenants. Owner-occupied sector: before moving; depending on individual preferences
Joining dwellings	No cyclical data				Only reason: due to the housing market.
Separating dwellings into more	No cyclical data				Only due to the housing market.
Demolishing and	No cyclical data				There is a decreasing demand for the

building new		dwellings as they are. The existing load bearing walls do not allow an adaptation for a different demand at costs lower than for new constructions.
Demolishing buildings without re-building		Dwellings that cannot be let produce essential running costs, even for heating.
Conversion of dwellings into offices or another function	No cyclical data	Only one reason: Due to the housing market. In Germany, in some regions there is an oversupply with offices surfaces and good rents for dwellings, so offices are let as dwellings.

Source: experts' opinion (questionnaire).

Table F.5: Building activities in restored multi-dwelling buildings in Sweden with government subsidies (in % by owner, 2005); additional data for Section 6.3.

The State Urban areas	All dwellings	State, municipality	Company owned by municipality	HSB, 'state building'	Private housing corporations	Private persons	Other owners
All dwellings (number of dwellings)	28176	512	7379	9115	7647	345	3178
Installation of an elevator	7	73	11	1	3	31	15
Strengthening the foundations	0	0	1	0	0	4	0
Strengthening of the frame	4	62	6	1	1	7	7
Changing the heating system	11	82	9	7	8	17	19
Changing the heating pipes	25	93	29	21	18	70	27
Changing the water management system	100	100	100	100	100	100	100
Changing drain/sewage system	100	100	100	100	100	100	100
Changing the electricity systems	67	100	80	57	60	99	78
Changing the ventilation system	50	96	68	42	29	81	73
Changing the sanitary equipment	89	18	85	98	96	59	71
Changing the kitchen equipment	12	14	19	3	4	28	39

Source: SCB, ombyggnadsstatistik för flerbostadshus (Sveriges Officiella Statistik)

Table F.6: One or two-dwelling buildings by type of energy saving measure accomplished during 2005 (x 1000, Sweden) additional data for Section 6.3.

Building period	<1940	1940-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001>	Total
Insulation of walls/roof	24	8	8	5	1*	..	..	46
Insulating glass	17	11	10	13	2	1*	0*	53
Regulation system	9	8	6	8	2	0*	..	34
Other measures	10	6	2*	..	1*	-	-	-21
Changing the heating system	45	26	24	21	9	1*	0*	126
Of which changing of the heating mode	31	21	16	7	2	..	..	78
Total number of houses (1000x)	530	279	262	404	167	72	31	1744

* n is 4 to 9

.. N is less than 4

Source: SCB, energistatistik för smahus (urvalsundersöknog) flerbostadshus (Sveriges Officiella Statistik)

Table F.7: Annual renovation activities in housing stock in Switzerland (in percentages and by dwelling type) additional data for Section 6.3.

	% of apartments*	% of single-family houses *	% of total stock*	Frequency
Any renovation activity	8%	10%	9%	
Outer Insulation outer walls	0.8%	0.7%	0.8%	30-50 years
Inner Insulation Outer walls				
Ground floor insulation	2.2%	3%	2.5%	
New façade or substantial façade renovation	1.4%	2.4%	2%	20-25 years
New roof or substantial roof renovation	1%	1.4%	1.1%	30-40 years
Acoustic insulation between dwellings				
New heater and heating system	1%	2.1%	1.3%	15-25 years
New ventilation system				15-25 years
Modernisation of kitchen interior	2%	1.5%	1.8%	
Modernisation of bathroom interior	1.4%	1.9%	1.7%	
Indoor simple maintenance (paint, wallpaper…)	3.8%	4.1%	4%	5-10 years
Demolishing buildings and building new				Depends on several factors
Demolishing buildings without rebuilding				Depends on several factors

Source: experts' opinion (questionnaire).

Table F.8: Annual renovation activities in housing stock in the United Kingdom; additional data for Section 6.3.

	Share of apartments (%)*	Share of single-family houses (%)*	Share of total res. (%)*
Outer Insulation outer walls	**Small**	**Very small**	
Inner Insulation Outer walls	**Small**	**Small**	
Cavity wall insulation			**55% (of dwellings with cavity walls) (a)**
Ground floor insulation	**Negligible**	**Very small**	
New façade or substantial façade renovation	**Very small**	**Negligible**	
Double-glazing			**70% (a)**
New roof or substantial roof renovation (Loft insulation)			**95% (a)**
Acoustic insulation between dwellings			
New heater and heating system (hot water tank insulation)			**95% (a)**
New heater and heating system (condensing boiler)			**20% (a)**
New ventilation system (draught proofing)			**75% (a)**
Modernisation of kitchen interior			**Most dwellings**
Modernisation of bathroom interior			**Most dwellings**
Joining dwellings into one			**Very rare**
Separating dwellings into more			**Rare**
Demolishing buildings and building new			

Source: data from Hitchin, “Decarbonising buildings” & experts’ opinion (questionnaire).

Table F.9: Reasons for renovation in Austria (according to our respondents); additional data for Section 6.4.

AUSTRIA	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Energy ambitions		1 Many "pioneers" today particularly in passive houses	1 Social housing sector is strongly driven by political targets		
Improve asset value	1			1	1 Increasing importance of building valuation
Upgrade social quality of neighbourhood			1 Refurbishment has been examined as prior instrument for social upgrade		2 Strong incentives with subsidies
Changing market demand	1 Primarily regarding indoor installation standard				1 Primarily regarding indoor installation standard
Poor comfort	2 Incentives for renovation of rental dwelling by the tenants	2 Obviously			
Changing family composition		1			
Increased comfort (luxury) demand		1	1		1
Technical service life of building components is exceeded	1 Major reason	1 Major reason, but often only for sectoral refurbishment	1 Major reason	1 Major reason, but often only for sectoral refurbishment	1 Major reason, but often only for sectoral refurbishment
Important to have an attractive dwelling		1			
Moving/turnover	1 Indoor renovation mostly only possible in this case	1 Inheritance of houses	1 Indoor renovation mostly only possible in this case		1 Indoor renovation mostly only possible in this case

Source: experts' opinion (questionnaire);

Table F.10: Reasons for renovation in Finland (according to our respondents); additional data for Section 6.4.

FINLAND	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented

Energy ambitions (control and adaptation of climate change)	Important priority		This is a pressure from the government, not so recognised by households.		
Health and indoor climate	Priority				
Upgrade social quality of neighbourhood	Secon dary	-	This reason only in the social rental sector		
Prevention of moisture and mould problems	Priority		Mould problems are behind many large renovations. In a transaction, the seller is responsible for costs.		
Changing market demand	Secon dary	-			
Increasing comfort	Priority				
Technical service life of building components is exceeded	Priority				
Technical service life of HVAC equipment is exceeded	Priority				
Important to have an attractive dwelling	Secon dary	-			There is sufficient demand for rental dwellings so even in low-demand areas it is very unlikely that an owner would invest in the appearance
Ageing population	Important priority				

Source: experts' opinion (questionnaire); the priorities are based on the National Renovations Strategy YM, 2007.

Finland: general remarks:
▪ The interviewees (Seppanen/HUT; Airaksinen/VTT; Hakaste/YM) emphasise the importance of mould problems as the main driver for renovation.
▪ A similar consensus exists about the minor role of energy efficiency as a reason for renovations. As Seppanen (Helsinki University of Technology) states, the standard of living in Finland is so high and the price of energy so cheap that the price of energy has not (and probably will not) play an important role in renovation. Energy is too cheap; its percentage of household expenditure is too small. Taxes are distorted. Payback times are too long.
▪ Hakaste (Ministry of the Environment) states that the government seriously considers regulations for the existing housing stock as a part of the National Renovation Strategy 2007-2017 and the Energy Performance of Buildings Directive (EPBD). The interviewees state that regulations fit the Finnish mentality (there is a need for both stick and carrot).
▪ Seppanen (Helsinki University of Technology) states that Finland was in the lead in energy efficiency in the seventies but there has been a remarkable decline since then and, for example, the implementation of the EPBD has been lagging behind. Finland has traditionally implemented all the Directives very conscientiously and was, for example, the only country that prepared the plan required by the energy service directive in time. Seppanen states that Denmark is the leading Scandinavian country in energy efficiency in existing buildings.

Table F.11: Reasons for renovation in France (according to our respondents); additional data for Section 6.4.

FRANCE	**Apartments**	**Single-family houses**	**Specific to social rented**	**Specific to owner-occupied**	**Specific to private rented**

Poor comfort	2	3	2	2	2
Technical service life of HVAC equipment is exceeded	1	1	1	1	1
Moving/turnover		2			

Source: quantitative data from the ENPER-EXIST project.

Figure F.1: Reasons for renovation in France (according to our respondents); additional data for Section 6.4.

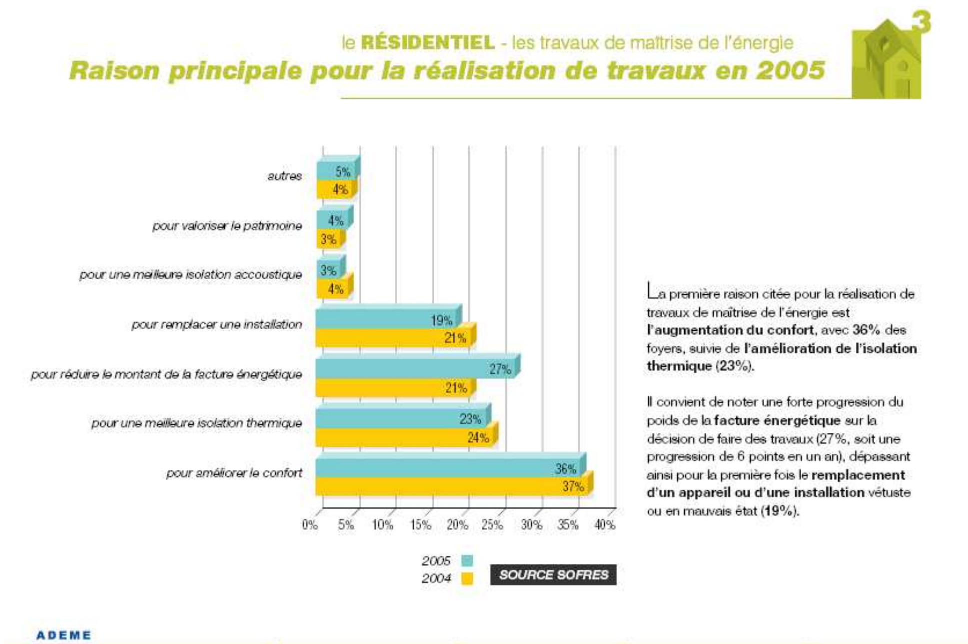


Table F.12: Reasons for renovation in Germany; additional data for Section 6.4.

GERMANY	Specific to social rented	Specific to owner-occupied	Specific to private rented
Energy ambitions	5	1	3
Improve asset value	2	5	1
Upgrade social quality of neighbourhood	3	0	3
Changing market demand	3	0	1
Poor comfort	4	2	4
Changing family composition		3	
Increased comfort (luxury) demand	4	3	2
Technical service life of building components is exceeded	3	4	2
Technical service life of HVAC equipment is exceeded	3	4	2
Important to have an attractive dwelling	3	1	2
Moving/turnover	2	2	2

Source: experts' opinion (questionnaire).

Table F.13: Reasons for renovation in the Netherlands; additional data for Section 6.4.

NETHERLANDS	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Energy ambitions	X				
Improve asset value					
Upgrade social quality of neighbourhood	X		X		
Poor comfort		X			
Changing family composition	X	X1			
Increased comfort (luxury) demand		1X	1		1
Technical service life of HVAC equipment is exceeded	X	X			
Important to have an attractive dwelling			X		

Source: experts' opinion (questionnaire).

Table F.14: Reasons for renovation in Sweden; additional data for Section 6.4.

SWEDEN	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Energy ambitions	x	x	X	x	X
Improve asset value	x		X		
Upgrade social quality of neighbourhood	X		X		
Changing market demand	x		X		
Changing family composition: accessibility	x		X		
Technical service life of building components is exceeded	x	x	X	x	X
Technical service life of HVAC equipment is exceeded	X	x	X	x	x

Source: experts' opinion (questionnaire).

Table F.15: Reasons for renovation in Switzerland; additional data for Section 6.4.

SWITZERLAND	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Energy ambitions		50%			No, only tenants benefit
Improve asset value		XX			
Upgrade social quality of neighbourhood					XXX
Poor comfort		X			
Increased comfort (luxury) demand		Main reason for renovation: energy aims secondary (1)		Main reason for renovation: energy aims secondary (1)	
Technical service life of building components is exceeded		60%			
Technical service life of HVAC equipment is exceeded		X			
Important to have an attractive dwelling		XX			

Source: experts' opinion (questionnaire) & quantitative data according to BFE 2002 and BFE 2005.

Table F.16: Reasons for renovation in the United Kingdom; additional data for Section 6.4.

UNITED KINGDOM	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Demonstration projects	xx	x	xx	x	xx
Improve asset value		x			
Upgrade social quality of neighbourhood	X		xx		
Energy service contracting					x
Energy performance labelling (EPBD)					x
Sustainable design tools	x	xx	xxx	x	x
Changing market demand					x
Increasing comfort demand	xx	xx	x	xx	

Source: experts' opinion (questionnaire).

Appendix G Tables and data Chapter 7

Table G.1: Role and effect of existing policies on energy in Austria; additional data for Section 7.2.

AUSTRIA	**Name of regulation/incentive and description***	**Role of residential sector**	**Role of non-residential sector**	**Effect**
REGULATORY				
Insulation policies	Limits of energy consumption are implemented in housing subsidy schemes of all provinces	Very high. Thermal quality in new construction and refurbishment has improved dramatically during recent years	Design still has priority over ecology, not sufficient synthesis of both	High
High efficiency installations	Part of housing subsidy schemes of most provinces	High. Incentives for low consumption water installations, high efficiency heating installations etc.	Insufficient	High
Minimum requirements on energy use	Building codes	Recently adopted, still no limits for cooling energy consumption	Recently adopted, still no limits for cooling energy consumption	High
Minimum requirements on building components	Building codes, standardisation	Three Levels of quality assessment: a) Building codes define minimum quality level. b) To attain housing subsidies, obligatory quality standards have been set (higher than building codes. c) Very high quality standards are promoted by non-obligatory financial incentives.	Building codes and standardisation are the only efficient tools for quality assessment	Medium
Individual cost allocation	Energy cost according to consumption	Obligatory in apartment buildings, specific law "HeizKG – Heizkostenabrechnungsgesetz"	Low importance, exhaustive energy costs are hidden in running costs	Very high
Also: federal energy policies aimed at the development of hydropower and nuclear energy plants. European programmes to support wind energy.				
ECONOMIC				
Taxation	VAT, deductibles income tax			
Energy cost increase	Discussion about inclusion of energy costs in housing allowances			Negative
Energy management	"Energy accounting" = comparative documentation of energy consumption	In individual provinces obligatory "energy accounting" for apartment buildings	"Energy accounting" for public buildings became common	Energy savings of 10-20% only via "energy accounting"

Support Solar thermal	Subsidy schemes in the provinces	Medium		
Support Biomass	Subsidy schemes in the provinces	Medium		
COMMUNICATIVE				
Information campaigns	"Klima:aktiv": a communication and incentive programme launched by the federal government with emphasis on PPP agreements. Different campaigns by local governments; Energy Agencies	Significant	Hardly significant, discussion about office buildings with exhaustive energy consumption	Very high
Research	European Programmes; Programme outlines "House of the future"/"Factory of the future" launched by federal government with research subsidies	Very important particularly for the development and implementation of passive house standard	Lower significance	Important for strategic development
Promote change of behaviour	Part of different programmes	Important e.g. for the implementation of passive house standard and avoidance of air conditioning	Low significance	High

Source: experts' opinion (questionnaire).

Table G.2: Role and effect of existing renovation policies in Austria; additional data for Section 7.2.

AUSTRIA	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
Upgrade socially downgraded areas	a) Subsidy schemes in the provinces b) Regional development plans c) Federal Refurbishment Law	a) Very successful, large-scale refurbishment in urban and rural areas b) For strategic decisions c) Insignificant	a) Business space may be subsidised as well, medium significance b) Definition of locations for high-rise buildings c) Insignificant	Low segregation has generally high spin-off effects
Stimulate economic development of neighbourhoods	a) Promotion programmes by chamber of commerce and local governments b) Housing subsidy schemes	b) In some provinces commercial space within housing projects is subsidised as well. Significant integrative effects	Non-residential sector generally follows market forces	Integration of housing and labour reduces traffic and energy consumption. Generally the tendency towards segregation has not yet stopped
Stimulate building economy	Housing subsidy schemes	Strong incentives	Insignificant	High
Stimulate employment		Significance of refurbishment on employment was subject of recent meeting in Vienna		
Leave it to private investors			Main practice	The market produces insufficient incentives

Energy agreements	None			
Construction sector agreements	None			
Decent homes standards	None			
Support quality of life in rural areas	Housing subsidy schemes	High	Insignificant	Regional integration has generally positive spin-off effects
Health risk reduction	Housing subsidy schemes			
Solving problems of unoccupied buildings		Housing subsidies only for main residence		

Source: experts' opinion (questionnaire).

Table G.3: Role and effect of existing policies on energy in Finland; additional data for Section 7.2.

FINLAND	**Name of regulation/incentive and description***	**Role of residential sector**	**Role of non-residential sector**	**Effect on energy use/sustainable renovation quality**
REGULATORY				
Insulation policies	Building regulations ensure basic thermal quality but only apply to new building			
Develop Hydropower	Most potential already used			
Build nuclear energy plants	Finland is one of the few EU countries still building new nuclear power plants			
ECONOMIC				
Energy tariff structure	Energy tax but energy still cheap compared to other European countries			
COMMUNICATIVE				
Research	Research programmes in energy efficiency since the 1970s			

Source: experts' opinion (questionnaire).

Table G.4: Role and effect of existing renovation policies in Finland; additional data for Section 7.2

FINLAND	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
Energy agreements	Yes			
Construction sector agreements	Around half of the renovation activities do not require building permits so supervision of any binding agreements or building regulations is difficult.			
Building heritage	Building Heritage Strategy (Rakennusperintostrategia) (2001) was a large-scale national programme to preserve the building heritage. Finland does not have very old stock but a rather large number of buildings from 1950-60s that have architectural value and need to be improved in a considerate way.			
Policy programmes	Ministry of the Environment has prepared a national renovation strategy that will run until 2017. The policy programme is important because it recognises the value of the existing housing stock and identifies the barriers that prevent its sustainable use and improvement. In order to overcome the already recognised barriers there are 4 R&D priorities: maintenance practices, renovation processes and guidance, improving knowledge about renovation and ensuring resources, and supplying relevant information. 13 actions are proposed in order to meet these objectives. The strategy includes a stakeholder survey from 2005 where different parties were consulted about barriers to renovation.			

Source: experts' opinion (questionnaire).

Table G.5: Role and effect of existing policies on energy in France; additional data for Section 7.2

FRANCE	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
REGULATORY				
Minimum requirements for building components	For new buildings: RT2005– arrêté du 24 mai 2006. For building permits since September 2006. For others: thermal regulation RT2000 For renovation of existing buildings: arrêté du 30 mai 2007			X
Minimum requirements for HVAC equipment				X
Minimum requirements for energy use of buildings	For new buildings: RT2005– arrêté du 24 mai 2006. For building permits since September 2006. For others: thermal regulation RT2000 For existing buildings (renovation): In the course of preparation of an application foreseen(planned) from April 2008			X
Build nuclear plants	X	X	X	
ECONOMIC				
Individual cost allocation	**x**	**x**		**x**
COMMUNICATIVE				
Research	x	x	x	x
Support Solar thermal	X	X	X	X
Support PV	X	X	X	X
Support Biomass	X	X	X	X

Source: experts' opinion (questionnaire).

Table G.6: Role and effect of existing policies on energy in Germany additional data for Section 7.2

GERMANY	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
REGULATORY				
Policies on high efficiency installations	Co-generation is supported by obliging suppliers to buy electricity from co-generation (Kraft-Wärme-Kopplungs-Gesetz KWkG 2002)			No effect on modernisation of buildings
Minimum requirements for building components	Minimum u-values are obligatory due to EnEV			Assures the implementation of quality products above a defined minimum level
Minimum requirements for HVAC equipment	Minimum u-values are obligatory due to EnEV			Assures the implementation of quality products above a defined minimum level
Minimum requirements for energy use of buildings	Regulation on energy saving EnEV 2002; new EnEV 2007 in force from October 1, 2007	Stipulating energy performance documents from 2008/2009 on	Stipulating energy performance documents from 2009 on	Assures the implementation of an energy efficiency concept above a defined minimum level
ECONOMIC				
Energy cost increase	No energy cost policy; suppliers of electricity are legally obliged to accept electricity from renewables to support these sources	Not specific	Not specific	The higher the energy costs the more profitable are technical solutions for energy efficiency
Support Solar thermal	Federation: available subsidies: Marktanreizprogramm (MAP) BaFa KdfW: Renewables; Laender: e.g. NRW: REN	Not specific	Not specific	Can make installation more attractive or profitable
Support Biomass	Subsidies (Erneuerbare-Energien-Gesetz/EEG 2000) BaFa KdfW subsidies available	Not for single buildings	Not for single buildings	None
Insulation policies	Information campaigns (cf below), subsidies and low interest loans to owners (federation: KfW; subsidies from the laender, e.g. NRW: REN; et al. from regional bodies proKlima, Hannover; energy consulting free of charge at municipal level, e.g. Erlangen)	Only		Disseminates knowledge about tools and financial conditions of energy efficiency; subsidies encourage investment
COMMUNICATIVE				
Information campaigns	**Federation**: dena: Zukunft Haus www.zukunft-haus.info ; BaFa subsidies for consultancy of home owners; **Laender, e.g.**: **Hesse**: Hessische Energiesparaktion (IWU), **Baden-Wurttemberg**: Impuls-Programm Altbau, Informationsprogram (Zukunft Altbau), Energie aber wie?;	Focus on residential buildings		Better information for homeowners on energy efficiency and use of renewables; information on available subsidies

	NRW: REN Etc.			
Research	Cf. 7.3: Zukunft Bau, FoNa, UFOPLAN	Priority but not specific	Not specific	Creates more knowledge about tools and conditions of energy efficiency
Promote change of behaviour	The newly stipulated information sheet on energy performance of buildings (EnEV) is intended to create more awareness of energy issues	Not specific	Not specific	Increases the demand for energy efficient buildings/dwellings

Source: experts' opinion (questionnaire).

Table G.7: Role and effect of existing renovation policies in Germany; additional data for Section 7.2.

GERMANY	**Name of regulation/incentive and description***	**Role of residential sector**	**Role of non-residential sector**	**Effect on energy use/sustainable renovation quality**
Upgrade socially downgraded areas	Federal programme for social regeneration of deprived urban quarters ("Stadtteile mit besonderem Entwicklungsbedarf - die soziale Stadt", 1999; cf. BauGB) focussed on social integration, education and labour market. Refurbishment and new construction are secondary objectives.	May be included in specific cases	May be included exceptionally, as business for local people is main concern	It is targeted to local social improvements; secondary effects are possible in cases where social objectives require physical upgrading.
	Stadtumbau-Ost (2002), -West (2004) (cf. BauGB)	Focus	Excluded	Allows refurbishment to up to date housing standard.
Stimulate economic development of neighbourhoods	Soziale Stadt (cf. above)	May be included in specific cases	May be included exceptionally, as business for local people is main concern	It is targeted to local social and economic improvements; secondary effects are possible in cases where economic upgrading requires physical upgrading.
Stimulate building economy	Subsidies supplied by the laender for refurbishment of rental housing and owner-occupied housing up to a limited household income (WoFG) Subsidies for modernisation of owner-occupied homes to energetic standards (KfW-CO_2 Minderungsprogramm) Laender subsidies for modernisation, various: e.g. NRW, Hesse, Baden Wurttemberg etc.; municipalities e.g. Erlangen			
Stimulate employment	Arbeitsbeschaffungsmaßnahmen; Sozialgesetzbuch III Jobs on the secondary labour market must not replace jobs on the first one; no refurbishment jobs may be offered. There might however be job training and education in the building sector for public or non-profit bodies.	No	Exceptionally	Marginal effects

Support quality of life in rural areas	Laender, e.g. Hesse: Rural areas regeneration programme/Dorferneuerungsprogramm (1982); similar regulations: Baden-Wurttemberg, Thuringia etc.	Focus on buildings for the public and public spaces, modernisation of rural estates and farm houses	Focus on modernisation of rural estates	No specific requirements
Solving problems of unoccupied buildings	Urban development programmes targeted at cities with declining population: Stadtumbau Ost (2002) and Stadtumbau West (2004) For selected projects in designated areas due to availability of funds	Focus	Exceptionally	Demolition of vacant dwellings in areas of low demand can contribute to a better economic situation for the remaining stock and enhance investment in refurbishment.

Source: experts' opinion (questionnaire).

Table G.8: Role and effect of existing policies on energy in Sweden; additional data for Section 7.2.

SWEDEN	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
REGULATORY				
Regulations	15 environmental laws have been amalgamated into the Environmental Code (1999) to protect the natural environment and to support sustainable development. Of interest for sustainable renovation are the demands to protect and care for natural and cultural environments, to use natural resources and land with respect to ecological, social, cultural and economic aspects and to recycle, reuse and save materials and energy.			
Insulation policies	Relatively little compared to other countries because current houses are insulated and have energy efficient windows. In sustainable building there seems to be relatively more emphasis on institutional and social aspects as well.			
Minimum requirements on HVAC equipment	Regular (obligatory) ventilation system inspections are planned			
Energy labels	In 'A National Programme for Energy Efficiency and Energy-smart Construction' the government states that more efficient use of energy at all levels and sectors is a condition for achieving a sustainable society and for breaking the dependence on fossil fuels. The Bill also proposes a law on energy declarations for buildings and presents a new target for energy efficiency in buildings under the environmental quality objectives A Good Built Environment. Furthermore The EPBD is implemented.			
Energy Bill	The Government has submitted proposals for energy use in buildings, such as investment support for energy-saving measures and conversion to renewable energy in premises used for public activities (Bill 2004/05:1). The investment support is for conversion from direct electrical heating in residential buildings (Bill 2005/06:1) and support for conversion from oil-fired heating systems in residential buildings (Bill 2005/06:32) in 2006. The new measures for improving energy efficiency presented in the Bill A National Programme for Energy Efficiency and Energy smart Construction (Bill 2005/06:145) supplemented the on-going measures.			
ECONOMIC				
Subsidy	Since 2001 housing-investments that contribute to ecological sustainability can be subsidised (ECO-subsidy; SFS 2000:1389). This subsidy is primarily for new construction of rental housing and for projects with an effective and consistent cost-control.			
Energy certificate scheme	The certificate scheme promotes electricity generated from renewable energy sources like biomass, small-scale hydro, wind and PV without any distinction between technologies. For every MWh of renewable electricity that an electricity company produces it receives one certificate. The electricity consumers are then required to buy certificates in proportion to the amount of electricity they consume. In 2004, the consumers were required to buy certificates corresponding to 8.1% of their consumption, which resulted in a market price of about 25 EUR per MWh.			
Energy tariff structure	Energy tax but impact is limited because the standard of living is high and the price of energy is low compared to other expenses.			
Support Solar thermal	Beginning in 2005, a subsidy for PV on public buildings was introduced.			
COMMUNICATIVE				
Information campaigns	Lots of information available, there was also a MISTRA sustainable building programme and Bo01 housing expo in Malmo to demonstrate the principles.			
Databases	Enyckeln for measuring and benchmarking non-residential energy consumption http://www.enyckeln.se/			
Public housing policy	In 1998 the bill on "Housing Policy for a sustainable development" was established by which ecological sustainability was introduced as one of the goals of public housing policy. This has led to some policy initiatives.			

Source: experts' opinion (questionnaire).

Table G.9: Role and effect of existing policies on energy in Switzerland; additional data for Section 7.2.

SWITZERLAND	Name of regulation/incentive and description*	Role of residential sector	Effect on energy use/sustainable renovation quality
Minimum requirements for building components	Building standards by cantons, building requirements by municipalities		Low energy standards overall have little influence on lowering energy consumption (1)
Minimum requirements for HVAC equipment	Some cantons require special authorisation for electrical heaters and cooling systems		
Minimum requirements for energy use of buildings	Building standards by cantons, building requirements by municipalities		
Energy tariff structure	Efficiency bonuses on electricity consumption granted by municipalities		
Taxation	Income Tax deductibles		
Insulation policies	18 cantons provide subsidies to MINERGIE Standards, thermal refurbishments	Tax deductibles for energetic investment; in rental apartments 50-70% passed on to renters.	
Policies on high efficiency installations	18 cantons provide subsidies to MINERGIE Standards. Subsidies for renewable energy heating systems depend on canton and municipality	Tax deductibles for energy investments particularly important for single-family houses	
Support Solar thermal	Several cantons and municipalities provide subsidies		
Support PV	Several cantons provide subsidies		
Support Wind energy	Several cantons provide subsidies		
Support Biomass	Several cantons provide subsidies		
Research	Subsidies for research organisations and energy agencies		
Information campaigns	EnergieSchweiz, MINERGIE		
Promote change of behaviour	Information campaigns, MINERGIE, Support for municipalities which adopt EnergieSchweiz goals		

Source: experts' opinion (questionnaire) & (1) according to Dettli et al. (2006).

Table G.10: Role and effect of existing renovation policies in Switzerland; additional data for Section 7.2.

SWITZERLAND	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustainable renovation quality
Upgrade socially downgraded areas		X		
Stimulate building economy	"WFG" (Wohnraumförderungsgesetz) (housing promotion law) since 2003, indirect subsidisation through federal state underwriting low income rental apartments and owner-occupied built by non-profit builders	Only residential		Subsidies for exemplary projects, for instance low energy consumption
Leave it to private investors			X	
Decent homes standards	Building codes	Building codes, Mustervorschriften der Kantone im Gebäudebereich MuKEn		

Source: experts' opinion (questionnaire).

Table G.11: Role and effect of existing policies on energy in the United Kingdom; additional data for Section 7.2.

UNITED KINGDOM	Name of regulation/incentive and description*	Role of residential sector	Role of non-residential sector	Effect on energy use/sustain able renovation quality
REGULATORY				
Minimum requirements for building and installation components	Building Regulations & system for planning permission (incl. implementation of EPBD, introduction of EPCs)	x	x	
ECONOMIC				
Taxation	Differential taxation in favour of energy-efficient building materials and components	x		
Grants/subsidies	Many (local and regional) sources. Two major sources from energy suppliers (EEC) and local authorities (HEES)			
COMMUNICATIVE				
Information campaigns	A large amount of information and publications from different sources are available			

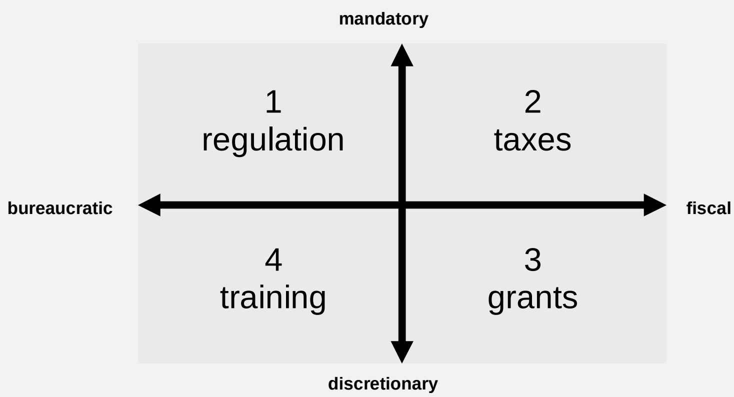
Source: experts' opinion (questionnaire).

Additional data on the implementation of energy policies in the United Kingdom is given hereafter.

ENERGY POLICIES: ***UK national targets***
Under the Kyoto Protocol, the UK has undertaken to reduce greenhouse gas emissions to 12.5% of 1990 levels by the end of the first commitment period (average 2008-2012). However, the Labour government has repeatedly stated its more stringent aim of achieving a 20% overall reduction, and 25% within the government sector. Most recent data suggest that the actual achievement will be somewhat above 12.5%, but below the extended target unless international permit trading under the CDM and JI flexibility mechanisms are taken into account (DEFRA 2007).

1. Policy options applied to energy
Policy initiatives in the UK can be classified in a simple matrix format, according to whether they are bureaucratic or financial in nature, and mandatory or voluntary in application. This gives four primary divisions of policy instrument, typified by measures such as:

1. regulations
2. taxes
3. grants
4. training



2 Renovation policies
In general, building refurbishment is promoted in the British context by extremely tight control of new construction under planning legislation. Building renovation – even when more costly than redevelopment – is often seen by building owners as a quicker and more predictable path to stock improvement.
There are some regional regeneration schemes for housing improvement in specific geographical areas, mostly in older industrial cities in northern England: see A New Commitment to Neighbourhood Renewal: a National Strategy Action Plan (DCLG 2005) at
http://www.neighbourhood.gov.uk/publications.asp?did=85.

Policy options described below are those that are relevant to sustainability and energy efficiency.

2.1 Policy options applied to renovation

Area 1: regulation
An important thrust of UK energy policy as regards the built environment has been applied through bureaucratic enforcement measures, in particular the Building Regulations and system for granting planning permission. The framework for assessing proposals and checking compliance is well established.

Implementation of the Energy Performance of Buildings Directive
The EU Energy Performance of Buildings Directive (EPBD) has created a common framework to promote the improvement of the energy performance of buildings across the EU. Member states are required to implement the Directive into their national law by 4 January 2006, although the majority of member states have been allowed to delay implementation until 4 January 2009 due to a lack of suitably qualified independent experts (EST 2007).
Among other objectives, the EPBD enforces the application of minimum requirements to all new residential and tertiary sector buildings and to the major refurbishment of existing buildings with floor areas greater than 1000 square metres; and the requirement for an energy performance certificate whenever a building is constructed, rented or sold.
For dwellings, the approved methodology is the Standard Assessment Procedure (SAP), 2005 version. The SAP rating is based on the energy costs associated with space and water heating, ventilation and lighting, less cost savings from energy generation technologies. It also produces a dwelling carbon

emission rate (DER) and target carbon emission rate (TER). It is adjusted for floor area, and expressed on a scale of 1 to 100: the higher the number the lower the running costs. The scale can however go over 100 for dwellings that are net exporters of energy.
For existing dwellings, much of the required data for a full SAP calculation is not evident in a site inspection. Reduced Data SAP (RDSAP) provides a standard method to derive this missing data, via software defaults, from a reduced data set.
The implementation of the EPBD requirement for minimum standards was achieved by an update to the Building Regulations (for England and Wales) that came into effect in April 2006. Part L1B deals with the conservation of fuel and power in existing buildings.

Energy Performance Certificates
For dwellings, EPCs will be introduced in a number of stages. From 1 August 2007, dwellings with 4 or more bedrooms, to rent or for sale, will require a Home Information Pack, with EPCs part of the associated Home Condition Report (HCR).
From 1 September, EPCs may be required for dwellings with 3 bedrooms– this is dependent on 2000 individuals being qualified and accredited/certified. EPCs may also be required for all other dwellings from this date – this is dependent on 3000 individuals being qualified and accredited/certified and the requirement will be brought in by a Commencement Order.
In the private rented sector and social housing sector, the requirement for EPCs is expected to come into force on 1 October 2008.
EPCs must be provided by members of an approved certification scheme for home inspectors or accreditation scheme for energy assessors who hold either a Diploma in Home Inspection or a Diploma in Energy Assessment.
For non-domestic buildings, Energy Performance Certification will also be introduced in stages (NHER 2007):
6 April 2008: EPCs required for the sale or rent of buildings other than dwellings with a floor area > 500 sq m
EPCs required on construction for all non-dwellings
Display certificates required for all public buildings > 1000 sq m

1 October 2008:
EPCs required on the sale or rent of all remaining buildings (other than dwellings)
For public buildings, a Display Energy Certificate will be required, as shown at http://www.eplabel.org/. This will show the operational rating, based on actual consumption data.

Parts L1 and L2 of the Building Regulations however already apply to buildings undergoing extensive renovation or change of use. At present, 'the guidance in L1 and L2 has the effect of limiting the scope of works that could be considered as "reasonable provision". It does this by requiring insulation improvements, and the like, only when other works to an element are planned, for example "when substantially replacing any of the major elements of a roof structure, providing insulation to meet the U-value considered reasonable for a new building" (quoted in DCLG 2007).

There is ongoing discussion on how to extend the scope of Part L in order to have a faster impact on reaching the national targets described above. Implementation of the following measures seems likely in the medium term:

- application of Part L, in the case of change of use, to whole buildings, not just replacement of major elements
- application to all building subsystems
- application of EPBD principles to all buildings regardless of size
- inclusion of an Energy Efficiency Statement, that makes clear what efficiency works are included in a scheme.

A list of "reasonable measures" to be considered in each case, subsequent to an energy audit of relevant building sections, would be based on the following:
a. cost effectiveness
b. technical risk – for example the impact on condensation risk in framed structures
c. impact on other part of the regulations (for example headroom and clearance in circulation areas, or provision of ventilation)
d. practicability (such things as detailing problems where wall and roof thicknesses are altered)
e. visual impacts – particularly in the case of listed buildings (i.e. those of historic or architectural importance) and conservation areas.

From the point of cost effectiveness, cost-benefit tables already exist for housing (GPG 171 and 155) and are regularly updated. Similar cost benefit tables have been suggested for non-domestic building types. Thus it has been proposed (DCLG 2007) that all measures should be included, below a prescribed cut-off point – perhaps 10% of the total cost of the scheme. Cost-benefit is currently expressed almost universally in simple payback terms. There is discussion on using a net present value (NPV) approach – but this begs the question of the appropriate discount rate to apply. A social discount rate around 3.5% would suggest that measures with a payback horizon of 15-20 years could have a positive NPV, and thus be required under new regulations. This seems unacceptably long, unless it is coupled with a subsidy scheme to cover the shortfall between mortgage-based financing (at around 6%) for building improvements, and the required level of energy efficiency investments.

Area 2: taxes
Taxation and similar measures have been little used in the UK to implement sustainability objectives in the built environment. This is in contrast to the transportation sector, where high levels of tax on diesel and (in particular) petrol have for many years been used as a policy tool to bear down on fuel consumption.
Increased taxation in this area might well be politically unacceptable – particularly in the case of domestic consumption. It may also be the case that demand is insufficiently elastic for modest price increases to have much effect (R. Hitchin, personal communication).
However, there is a small-scale use of differential taxation in favour of energy-efficient building materials and components for use in refurbishment, for example insulation: this has a reduced rate of VAT (8% as against a standard 17.5%). New construction is zero-rated.

Area 3: grants
Grants to assist in upgrading the fabric of existing buildings, particularly housing, are available from a plethora of sources. Many are administered by local bodies, such as local authorities and regional energy advice centres, and so vary from place to place. In London for example, the range of grants available is described on http://www.emptyhomes.com/documents/publications.pdf

Grant assistance may contribute to:
- Insulation, particularly lofts and cavity walls
- Replacement of inefficient boilers and other plant
- Upgraded heating controls
- Draught proofing
- Energy efficient lighting
- Renewable technologies, including solar PV; wind turbines; small hydro; solar thermal hot water; ground/water/air source heat pumps; bio-energy; micro CHP; fuel cells.

Two major sources of funding are from energy suppliers, under their Energy Efficiency Commitment (EEC); and from local authorities under the Home Energy Efficiency Scheme (HEES), in fulfilment of their obligations to improve the performance of the domestic building stock in their areas under the Home Energy Conservation Act (HECA). Grants under the HEES scheme are dependent on social and economic criteria: they are targeted at the elderly, families (particularly single-parent families) with young children, and those on social benefits.

Area 4: information
A large amount of information is available on sustainable and energy efficient refurbishment of existing buildings, again with an emphasis on the domestic sector.
Many of these publications have been produced by the Building Research Establishment (BRE) and are promoted at seminars and other educational events. Awareness programmes have been sponsored by the Energy Saving Trust and others. A good example of hands-on information is the report CE184: Practical refurbishment of solid walled houses (BRE 2006) – very clearly illustrated guidance on how to apply refurbishment techniques to an important section of the stock. This also gives a useful list of other EST publications.

Table G.12: Examples of incentives used in Austria; additional data for Chapter 7.

	Apartments	**Single-family houses**

AUSTRIA		
Technological innovations	Yes	Yes
Innovations in construction method	More efforts in construction materials than construction methods. But a new sectoral initiative of research promotion was established.	
Tools to support design process	Well established	Well established
Specific education programmes	Still difficult to motivate the target groups (professionals) to upgrade	
Publicity campaigns	Importance acknowledged, e.g. "Klima:aktiv"	Importance acknowledged, e.g. "Klima:activ"
Energy labelling	Implementation ongoing	Implementation to come
Sustainable quality labelling	Quality standards and labels in place and acknowledged	
Public-private cooperation agreements	Via subsidies and the "Klima:aktiv"-campaign	Via subsidies
Subsidies	Major incentive, very well established to attain diverse spin-off effects	
Tax reduction/green loans	Minor importance	Minor importance, but model in discussion
Local political support	Very much in place	Very much in place
Image	Publicity campaigns	Publicity campaigns

Source: experts' opinion (questionnaire).

Table G.13: Examples of incentives used in Finland; additional data for Chapter 7.

FINLAND	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Tools to support design process (energy audit with a subsidy)	Energy audits are encouraged to assess project-specific primal energy use, energy saving potential and the use of renewable energy sources, and present improvement suggestions (with their CO_2 reduction impact) and cost calculations. Depending on the floor surface area, a subsidy of €720-1369 is available for an energy audit for housing (covering maximum 40% of the accepted costs). There are also subsidies for improvement measures in the order of priorities suggested in the audit. A subsidy is regulated by the government and allocated by municipalities. If an applicant has joined a national energy saving agreement, an increased subsidy rate can be applied. €15-17 million a year are allocated in the form of energy subsidies for apartment blocks. However, single-family homes, which account for almost 50% of space heating energy consumption in Finland, are outside the scope of publicly supported energy audit programmes.				
New building requirements	Yes	Yes			
Agreements	In the National Climate Strategy and the Energy Conservation Programme, voluntary energy conservation agreements play a central role in the implementation of energy efficiency. Energy conservation agreements are framework agreements made between the government and various sector organisations. The voluntary energy conservation agreement programme was launched in 1997 for industrial companies and the building, energy, transport and public sector. Companies or municipalities could make agreements to start up energy audit or analysis operations and to compile a plan on increasing the efficiency. The government subsidies for companies within the voluntary agreement programme are subsidised on energy audits by 50%, compared to 40% for companies that are not in the agreement. Monitoring of the energy saving agreements closed between the Ministry of Trade and Industry and all main economic sectors (including the building sector) for 1997-2005 concludes that the energy conservation agreement in the building sector has resulted in a total energy saving of 4.7 TWh per year. The programme was evaluated as successful regarding the coverage of the agreement, in reaching the initial targets and in the opinions of the agreement parties interviewed for the evaluation.				
Energy labelling	EPBD				
Sustainable quality labelling	Yes (e.g. PROMISE), but very little used in the residential sector, more of a R&D tool				
Public-private cooperation agreements	In Scandinavia the use of Private Funding Initiatives (PFI) and other operating contracts has focused on infrastructure, not buildings				
Subsidies	Government support has focused on improving energy efficiency and accessibility (ageing population), and making maintenance plans. Subsidies are allocated by municipalities and the state fund for housing (Valtion Asuntorahasto) according to the resources defined in the state budget. Local centres for the environment (Ymparistokeskukset) and the institution for historic buildings (Museovirasto) give subsidies for renovations of heritage sites and listed buildings.				
Tax reduction/green loans	An important tool is the deduction for households (Kotitalousvahennys) that can be used in cases where a person has been hired to maintain or renovate the property (own dwelling or second home used for recreational purposes).				

Health policy	Mould problems can be controlled by municipal health inspectors and can lead to an apartment being declared unfit for habitation.

Source: experts' opinion (questionnaire).

Table G.14: Examples of incentives used in Germany; additional data for Chapter 7.

GERMANY	**Apartments**	**Single-family houses**	**Specific to social rented**	**Specific to owner-occupied**	**Specific to private rented**
Technological innovations	High insulation (passive house), transparent insulation. Renewable energy: solar, geothermic, fuel cell	High insulation (passive house) Renewable energy: solar, geothermic	Public subsidy is often connected with environmental requirements or is the basis for experimental concepts	High insulation (passive house) Renewable energy: solar, geothermic	High insulation (passive house)
New building requirements	Most important, e.g. regulation on energy saving in buildings (EnEV), More strict regulations on efficiency of boilers etc.	Cf. apartments			
Energy labelling (“Gebaeudepass” legislation in progress)			Additional criterion for renting a dwelling	Important criterion for the purchase of a dwelling/home	Significant especially for private rented dwellings, in markets with low demand
Subsidies	--	--	Subsidies only available as reduced interest on loans (KfW-Kredite/CO_2-Gebäudesanierungsprogramm)	Subsidies available or also reduced interest on loans (KfW.)	Subsidies only available as reduced interest on loans (KfW.)
Local political support	Supply of municipal land under conditions of environmental standards		Requirements for new buildings as the municipality is owner of the housing company		
Social policies			There are projects for disadvantaged residents connected with high energy standards		
Image	---	---	---	For owner-occupiers sustainability may be an image advantage	Possibly an advantage in the market

Source: experts' opinion (questionnaire).

Table G.15: Examples of incentives used in Sweden; additional data for Chapter 7.

SWEDEN	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Local Investment Programmes	Local Investment Programmes (LIPs) 1998-2002 represent the Government's investment in stimulating and supporting projects for improving sustainability. Some 10% of the total LIP investments were directed at the renovation of some 40-50 multi-family housing areas. The main focus of the research on the LIP renovation projects was on large housing areas from the 1950s, 60s and 70s.6200 million SEK were allocated, expecting to result in an annual reduction of 2.3 Twh energy, 2 million tons CO_2, and 493000 tons of disposed waste. Among the environmental benefits of all the investments financed until autumn 2000 (with 5200 million SEK) were: energy savings of some 2100 millions kWh per year, renewable energy production of some 2-3000 millions kWh per year, a decrease of 1.6 million tons/year of C02 emissions and a decrease of 500000 tons/year in waste to be disposed of.				
Publicity campaigns	The goal of working towards reducing the building sector's environmental impact was restated in the Building Sector's Environmental Programme 2003. (The main actor, the Ecocycle Council for the Building Sector was renamed the Ecocycle Council for a Sustainable Built Environment in 2005).				
Sustainable quality labelling	Several tools have been developed in Sweden. The EcoEffect method considers energy and natural resources consumption, building materials, waste, indoor and outdoor environments and LCC, presenting an environmental profile of a place and its different environmental loads. Applying the EcoEffect methodology to the existing buildings can be used to assess which aspects of sustainability need to be improved with renovation.				
Agreements	The dialogue project 'Building/Living', a cooperative effort between companies, municipalities and the government started in 1999 to support a sustainable building and property sector in Sweden. 15 companies, 4 municipalities and the government signed an agreement and a series of commitments in 2003. 17 new actors from other companies and municipalities joined the dialogue 2003-2005. 3 main areas were prioritised: healthy indoor environment, efficient use of energy and efficient resource management. The parties committed themselves to improving buildings' energy efficiency, supporting the use of renewable energies, using healthy materials and avoiding environmentally hazardous substances, documenting and classifying buildings' environmental effects, reducing waste and increasing the use of recycled materials.				
Tax reduction/green loans	Energy tax, Sweden is working towards the 'green switch' in energy but in reality energy is still very affordable in a wealthy country so financial incentives for improvements are very small.				
Facilities management	Tools for real estate management: a conceptual model for an Environmental Building Stock Information System for Sustainable Development (BBSISSD) focuses on the existing building stock and considering both available data and missing data, proposes a method for calculating the environmental impact of buildings as a basis for achieving environmental improvements. The environmental Status Model makes an assessment, with a hundred questions, of the environmental status of existing buildings. The results are used as a basis for planning maintenance and renovation of buildings with particular regard to their environmental impact.				

Source: experts' opinion (questionnaire).

Table G.16: Examples of incentives used in Switzerland; additional data for Chapter 7.

SWITZERLAND	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Innovations in construction method	"WFG" subsidies for exemplary projects, low energy	X	X	X	X
Publicity campaigns	Regional energy information offices (Energieberatungs-stellen)				
New building requirements	By cantons and municipalities 1)				
Quality assessment	MINERGIE	MINERGIE			
Energy labelling	MINERGIE	MINERGIE			
Sustainable quality labelling	MINERGIE	MINERGIE			
Public-private co-operation agreements	Energy contracting				
Subsidies	Subsidies to MINERGIE-Standards provided by 18 cantons, Stiftung Klimarappen**, Subsidies for Wood heating, solar systems, PV, etc.				
Tax reduction/green loans	Income Tax: Special deductions for renovation and maintenance			More important in owner-occupied	
Local political support		Subsidies for renovation and rebuilding of houses in mountain areas, large low-income households, credits funded by federal state (will change) and cantons.			

Source: experts' opinion (questionnaire).

1) Variety of Energy Standards for Newly Built and Renovation*:* SIA 380/1 Limits; MuKEn Modul 2 (only newly built); MINERGIE; MINERGIE-P

** Stiftung Klimarappen: Funds provided by cooperation of cantons attributed to large-scale thermal refurbishments of pre-1990 built buildings. Subsidies depend on overall investments and scale of thermal renovation. Sum of "energetic investment" has to be over 40000 CHF, subsidies amount to 10% to 15%.

Appendix H Tables and data Chapter 8

Table H.1: Barriers to sustainable renovation of residential buildings in Austria; additional data for Section 8.2.

AUSTRIA	**Apartments**	**Single-family houses**	**Specific to social rented**	**Specific to owner-occupied**	**Specific to private rented**
Lack of knowledge on energy saving measures	General knowledge available but "execution gap"				
Lack of knowledge on other sustainability measures	Knowledge available via subsidy incentives				
Lack of best practice examples	Not relevant, very good documentation				
Accumulation of technical problems	Yes, constructive improvements often feasible	Yes, too complicated for single owner			
Contractors have little experience/knowledge	Yes, specific professional guilds still not sufficiently developed or coordinated	Yes, often sectoral interests with no view to general results			
Not cost effective (long payback times)	Yes	Yes	Obligatory regulations on repair funds are in place	Yes	Refurbishment costs can hardly be shifted to the tenants
Funding problems (high investments costs)	Partly	Yes, major reason	Partly	Yes, major reason	Yes, insufficient reserves
Investor does not profit from lower energy use	Partly	No	No	No	Yes, major problem
No support from occupants	Partly	Partly	Partly	Yes	Partly
Sustainability or energy savings are not an issue	Decreasing	Decreasing	Decreasing	Decreasing	Yes
Occupants must be temporarily re-housed	Mostly not feasible	Mostly not feasible	Mostly not feasible	Mostly not feasible	Mostly not feasible
Specific character of the dwelling may be lost	Hardly, mainly a question of costs	Hardly	Hardly, a question of costs	Hardly	Yes, in the "gründerzeit" stock, a question of costs
Dwelling is believed to offer enough quality as it is	Yes	Yes		Yes	Yes

Other priorities	No	Yes	No	Yes	Yes

Source: experts' opinion (questionnaire).

Table H.2: Barriers to sustainable renovation of residential buildings in Finland; additional data for Section 8.2.

FINLAND	**Apartments**	**Single-family houses**	**Specific to social rented**	**Specific to owner-occupied**	**Specific to private rented**
Lack of knowledge on energy saving measures	Compared to new construction, renovation is often carried out by non-professionals, particularly in the owner-occupied and private rental sectors, who tend to rely on their own informal repair diagnoses or those made by relatives or friends, who are not necessarily aware of energy matters and who are not involved in transactions or renovation decisions often enough to learn from them. Practical assistance is still needed.				
Lack of knowledge on other sustainability measures					
Suitable products/components not available or not standard	New construction products dominate the market and in many renovations new construction products and techniques are used even when they are not appropriate (and renovation products would be available). Wrong renovation solutions are partly blamed for the moisture and mould problems.				
Contractors have little experience/knowledge	There is a lack of knowledge in construction site management practices in projects where users are living on the site: organisation, cleaning, information, logistics and disturbance. Renovation market differs from new construction: there are a lot of contractors, they are small and their knowledge varies a lot. Do-It-Yourself market has large share. On the other hand, because renovations are so case specific it can be difficult to develop renovation products, contracts are complicated and it is difficult to have services tailored for renovations.				
Not cost effective (long payback times)	Yes	Yes			
Investor does not profit from lower energy use	Yes, very important barrier and it is likely to increase because investing in real estate is increasing, also there are more foreign investors.				
No support from occupants		One group is the ageing owners of detached houses		Decision-making process in housing companies can be very complex	
Specific character of the dwelling may be lost	Less of a problem in Finland because housing stock is new and the renovation of 1960s-1970s apartment blocks is seen as an opportunity. However, there is a large group of historically valuable modernist buildings and their renovation requires sensitivity and expertise.				
Social issues are dictating	Share of demolition is very low in Finland.				

Source: experts' opinion (questionnaire).

Table H.3: Barriers to sustainable renovation of residential buildings in France; additional data for Section 8.2.

FRANCE	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Lack of best practice examples	2	1			
Contractors have little experience/knowledge		3		2	1
Funding problems (high investment costs)	3	2		1	2
Investor does not profit from lower energy use	1		1		

Source: experts' opinion (questionnaire) & quantitative data (ENPER-EXIST Project EIE/04/096/S07.38645 www.enper-exist.com).

Table H.4: Barriers to sustainable renovation of residential buildings in Germany; additional data for Section 8.2.

GERMANY	Specific to social rented	Specific to owner-occupied	Specific to private rented
Lack of knowledge on energy saving measures	Knowledge available	Lack of knowledge, especially on technical implementation	Knowledge available
Lack of knowledge on other sustainability measures	Knowledge available	Lack of knowledge, especially on technical implementation	Knowledge available
Suitable products/components not available or not standard	Products are available on the market of good technical quality and still improving	Owners may avoid products they believe are not established	Products are available on the market of good technical quality and still improving
Lack of best practice examples	Professional investors have continuous mutual exchange of information.	Owner-occupants lack the knowledge and information	Professional investors have continuous mutual exchange of information.
Accumulation of technical problems	This refers only to former generations of products and installations	Owner-occupants lack the knowledge and information	This refers only to former generations of products and installations
Contractors have little experience/knowledge	At the same time there are skilful contractors for all types of sustainable construction.	It depends if owner has connection with a good contractor. Renovation is often contracted out directly without competition.	At the same time there are skilful contractors for all types of sustainable construction.
Not cost effective (long payback times)	For some aspects: yes, second water system, PV etc.	It depends on the interest of the owners. Some would invest just for sustainability.	For some aspects: yes, second water system, PV etc.

Continuation of Table H.4

Funding problems (high investment costs)	Most important problem	Most important problem	Most important problem
Investor does not profit from lower energy use	Most important problem		Most important problem
No support from occupants	No problem		No problem
Sustainability or energy savings are not an issue	It depends on the available subsidies: it can be important to reduce running costs	There is growing understanding of sustainability issues, especially for energy saving among owner-occupiers	It depends on the market: it can be important to reduce running costs
Occupants must be temporarily re-housed	Not absolutely	Not absolutely	Not absolutely
Specific character of the dwelling may be lost	There is no concern about the specific character as long as residents are satisfied	Only a few may be concerned. Decisive factor may be an official ranking as cultural heritage	There is no concern about the specific character as long as residents are satisfied
Dwelling is believed to offer enough quality as it is	Due to available subventions	Due to available financing.	Due to market condition
Money can be invested only once	There are regulations on the investment. Money for any investment is scarce.	Decisive for owner-occupiers.	Investment follows the most important expectations of the tenants.
Social issues are dictating	It is hard to find alternative dwellings for tenants of subsidised housing restricted to specific tenants.		Anything is alright that fits into the portfolio: demolition as well as letting to low income households.

Source: experts' opinion (questionnaire).

Table H.5: Barriers to sustainable renovation of residential buildings in Sweden: additional data for Section 8.2.

SWEDEN	Apartments	Single-family houses	Specific to social rented	Specific to owner-occupied	Specific to private rented
Lack of knowledge on energy saving measures	Considering the number of demonstration projects and information available about energy efficiency since the seventies, a lack of knowledge cannot be the main problem.				
Not cost effective (long payback times)	Upfront money remains the main problem. Research projects have addressed the economic value of renovation projects. Some of the projects have tried to compare the costs of traditional renovation methods with the costs of sustainable methods (but it has been difficult, if not impossible, to differentiate between immediate costs and long-term investments).				
Funding problems	Yes				
Investor does not profit from lower energy use	Yes				
Specific character of the dwelling may be lost	This could be less of a problem than for example in the UK/the Netherlands because the stock is quite new and for example stock from 1960s and 1970s is often considered unattractive and renovation is presumed to improve the aesthetics.				

Source: experts' opinion (questionnaire).

Table H.6: What incentives are needed? Experts' opinion in Austria; additional data for Section 8.3.

AUSTRIA	Contribution	How to further increase this contribution	Role for which party?
Technological innovations	Simplify complicated high quality processes	Promote application by best practice and publicity campaigns	Research subsidies, local authorities
Innovations in construction method	Implementation of new technologies	Educational programmes for craftsmen to improve implementation of new technologies	Lobby groups, educational institutions
Tools to support design process	Thermal refurbishment changes the built environment fundamentally. It should be the role of architects to ensure high design quality	Change graduate education of architects fundamentally	Universities, Graduate Schools
Specific education programs	Specific needs identified are for architects and on implementation of new technologies on the construction site	Educational upgrade is regarded essential for large-scale sustainable refurbishment	Universities, Graduate Schools, under-graduate educational institutions, lobby groups
Publicity campaigns	Change occurs first in the mind by means of communication	Communication is regarded as the second most important tool to increase sustainable refurbishment after economic incentives	Government (federal, local), lobby groups, media
New building requirements	Defining "quality baseline"	Increase minimum standards	Government
Quality assessment	Ensuring implementation of ambitious standards	Defining assessment standards	Standardisation organisations, lobby groups
Energy labelling	Consumer information	It may be developed to a major decision criterion in purchasing real estate	Government, lobby groups, estate agents, owners
Sustainable quality labelling	Consumer information	As it is more complicated than energy labelling it is better targeted at housing developers than at consumers.	Government, housing developers
Public-private cooperation agreements	Specific strengths of both parts are summarised	Particularly in financial and organisational terms	Federal and local government, financing institutions
Subsidies	Major incentive instrument	Sharpening the saw to attain best possible leverage effects	Government, housing developers, owners, tenants
Tax reduction/green loans	Incentive instrument	Big potential to motivate owners of single-family houses to sustainably refurbish them	Government, particularly Ministry of Finance, tax offices
Local political support	Legal authority in housing policy, execution of housing subsidy schemes, dissemination of subsidies, implementation of quality standards	Further development of the present functions	Local government

Source: experts' opinion (questionnaire).

Table H.7: What incentives are needed? Experts' opinion in Finland; additional data for Section 8.3.

FINLAND	Contribution	How to further increase this contribution	Role for which party?
Technological innovations		Ensuring that contract forms support innovations	
Specific education programmes		Could be connected to DIY stores who could make an energy assessment and suggest product packages for improvement	

Source: experts' opinion (questionnaire).

Table H.8: What incentives are needed? Experts' opinion in France; additional data for Section 8.3.

FRANCE	Contribution	How to further increase this contribution	Role for which party?
Innovations in construction method	x	Research programmes	Research funding agencies
Specific education programmes	x	Develop PhD programmes	Installers' associations Local authorities
Publicity campaigns	x	Set up campaigns	Central government Energy agencies
Sustainable quality labelling	x	Apply labelling to renovation	Associations Local authorities
Tax reduction/green loans	x		State

Source: experts' opinion (questionnaire).

Table H.9: What incentives are needed? Experts' opinion in Germany; additional data for Section 8.3.

GERMANY	Contribution	How to further increase this contribution	Role for which party?
Technological innovations	To make devices and components cheaper and easier to handle	Research on technology	Industry, state
Innovations in construction method	To make construction and refurbishment cheaper, quicker and more efficient	Research on technology	Industry, state
Tools to support design process	Provide engineers and architects with relevant knowledge, make implementation of sustainability goals easier	R&D	Industry, research institutes
Specific education programmes	Professional skills for construction workers to better cope with technical specifications of materials and devices	Make it basis for general professional education	Industry, state
Publicity campaigns	Raise knowledge of sustainability issues e.g. energy saving potential	Broaden the campaigns, use all media	Industry, state
New building requirements	Requirement of higher energetic performance	More strict regulation, higher levels of efficiency	Legislation, politicians
Quality assessment	Enhance quality of maintenance, encourage refurbishment	Make it a legal precondition for sale and rent	Legislation, politicians
Energy labelling	Creates transparency on operational costs for users	Make it a legal precondition for sale and rent	Industry, state
Sustainable quality labelling	Enhance implementation of sustainability issues	Make it a legal precondition for sale and rent	Enhance quality of maintenance, encourage refurbishment
Subsidies	Increases competitiveness for sustainable solutions; compensates higher market costs	Create easier access to the subsidies and a verification of correct implementation at low cost	Banks, state
Tax reduction/green loans	Increases competitiveness for sustainable solutions; compensates higher market costs		
Local political support	Increases willingness of investors to pursue sustainability goals		

Source: experts' opinion (questionnaire).

Table H.10: What incentives are needed? Experts' opinion in the Netherlands; additional data for Section 8.3.

NETHERLANDS	Contribution	How to further increase this contribution	Role for which party?
Technological innovations	Forerunners in the building industry want to get started	By handing over knowledge to other parties	Local government
Innovations in construction method	Forerunners in the building industry want to get started	By handing over knowledge to other parties	Local government
Specific education programmes	Teaching parties how to deal with sustainability and the positive effects of it	To increase the number of participants and programmes	National government
Publicity campaigns	• Teaching parties how to deal with sustainability and the positive effects of it • To bring to the attention of a wider public	• To increase the number of campaigns • Specifically formulated for the target group	Local and national government
Energy labelling	To map out the whole dwelling stock with separate energy labels (A-G). Depending on your energy ambition, you can decide to improve the quality of the dwelling through renovation.	To involve social rented, owner-occupied and private residential to classify the total dwelling stock	National government
Sustainable quality labelling	See energy labelling		
Public-private co-operation agreements	To commit parties to sustainability	Increase the number of agreements	Local government
Subsidies	To make it affordable to introduce new techniques/systems	• Stimulate parties using subsidies • To increase the amount of subsidies by convincing the national politicians of their necessity and advantages	National government
Tax reduction/green loans	A few banks give green loans (green mortgages) with lower interest, when you buy a sustainable house.	Stimulate banks to invest in sustainability	National government
Local political support	Little	To use their power to stimulate the market operators to invest in sustainability	Local government

Source: experts' opinion (questionnaire).

Appendix I Tables and data Chapter 9

Table I.1: Main subjects of sustainable renovation research according to the countries' experts: additional data for Section 9.2.

	Importance							
Subjects	**Aus.**	**Fin.**	**Fra.**	**Ger.**	**Net.**	**Swe.**	**Swi.**	**UK**
Energy conservation	1	2b	3	1	1		2 ()	
Building product innovation	1		1	8	5			4
Installation concepts low energy housing	2		4	4			2	2
Renovation process innovation	2	1b[1]					4	
Policy monitoring and analysis	2	8		6	4			
Building regulations	2	6	2	5			1	
Financial asset management	2			7				
Other: Subsidy schemes	2							
Construction processes	2	5						
Life cycle assessment for design optimisation	3	7		2	6		2	
Safe and healthy housing	3	3		9	2			
Thermal comfort	3			10				
Behaviour of occupants	3			1				3
Architecture	3							
Management of maintenance quality	3	1a			3			
Renewable energy application	3	4	3	3			1.2	
Characterisation existing building stock			10					1

Source: experts' opinions (questionnaire).

Table I.2: Organisations that are specialists in sustainable renovation research according the countries' experts: additional data for Section 9.2.

Name of research institute or other organisations/agencies	Focus on residential	Focus on non-residential
AUSTRIA		
Many construction product companies as listed in Amann/Ramaseder (2006)	x	x
Many academic institutions (universities etc.) as listed in Amann/Ramaseder (2006)	x	x
OFI - Österreichisches Forschungsinstitut für Chemie und Technik (including "Institut für Bauschadensforschung")	x	x
IBO - Österreichisches Institut für Baubiologie und -ökologie	x	
IIBW – Institut für Immobilien, Bauen und Wohnen	x	
Several institutes at Technical University, Vienna		
Österreichisches Ökologieinstitut für angewandte Umweltforschung	x	
FINLAND		
VTT Building and Transport (www.vtt.fi)	X	X
Helsinki University of Technology (www.hut.fi)	x	x
Tampere University of Technology (www.tut.fi)	x	X
FRANCE		
CSTB	x	x
ADEME	x	x
Costic	x	x
Fondation bâtiment energie	x	x
Laboratories of higher education schools or universities : Ecole des mines de Paris, Ecole des ponts et chausses, INSA de Lyon, ENTPE, Université de la Rochelle	x	x
CETE (Centre d'études techniques de l'équipement)	x	X
GERMANY		
Arbeitsgemeinschaft für zeitgenössisches Bauen e.V., Kiel (ARGE; arge-sh.de)	x	
Bayerisches Institut für angewandte Umweltforschung und –technik GmbH, Augsburg (BifA; bifa.de)		
Deutsches Institut für Bautechnik, Berlin (DIBt; dibt.de)	x	x
Deutsches Institut für Urbanistik, Berlin/Köln (difu; difu.de)	x	
Empirica Bonn/Berlin (empirica; empirica-institut.de)	x	
Environmental Protection Encouragement Agency, Hamburg (EPEA; epea.com)		
Europäische Akademie für städtische Umwelt, Berlin (eaue; eaue.de)		
Forschungslabors für Experimentelles Bauen. Fachgebiet für Tragkonstruktion und experimentelles bauen. Universität Gesamthochschule Kassel (FEB; uni-kassel.de/fb12/fachgebiete/fe)	x	x
Forschungszentrum Karlsruhe (FZK; fz-karlsruhe.de)	x	x
Fraunhofer Institut für Arbeitswirtschaft und Organisation, Stuttgart (IAO; iao.fraunhofer.de)		x

Continuation of Table I.2

Fraunhofer Institut für Bauphysik, Stuttgart (IBP; ibp.fhg.de)	**x**	**X**
Fraunhofer Institut für Solare Energiesysteme, Freiburg (ISE; ise.fhg.de)	x	x
Hamburger Umwelt Institut e.V. (HUI; hamburger-umweltinst.org)		
Institut für Bauforschung der Rheinisch-Westfälischen Technischen Hochschule Aachen (IBF-RWTH; ibac.rwth-aachen.de)		
Institut für Bauforschung e.V., Hannover (IFB; bauforschung.org)	x	
Institut für Energie- und Umweltforschung, Heidelberg (ifeu; ifeu.de)		
Institut für Erhaltung und Modernisierung von Bauwerken, Berlin (iemb; iemb.de)	x	
Institut für industrielle Bauproduktion, Universität Karlsruhe (ifib; ifib.uni-karlsruhe.de)	x	x
Institut für Landes- und Stadtentwicklungsforschung und Bauwesen des Landes NRW, Dortmund/Aachen (ILS; ils.nrw.de)	x	
Institut für ökologische Raumentwicklung e.V., Dresden (IÖR; ioer.de)	x	
Institut für Regionalentwicklung und Strukturplanung, Erkner (IRS; irs-net.de)	x	
Institut für Sozialökologische Forschung, Frankfurt am Main (ISOE; isoe.de)	x	
Institut für Stadtforschung und Strukturpolitik GmbH, Berlin (IfS; ifsberlin.de)	x	
Institut für Umweltforschung Universität Dortmund (INFU; uni-dortmund.de)		
Institut Wohnen und Umwelt, Darmstadt (IWU; iwu.de)	x	
Katalyse Institut für angewandte Umweltforschung, Köln (Katalyse; kataly-se.de)	x	
Klaus-Novy Institut, Köln (kni.de)	x	
Öko-Institut, Freiburg/Darmstadt/Berlin (oeko-institut.org)	x	x
Rheinisches Institut für Umweltforschung an der Universität zu Köln (RIU; eurad.uni-koeln.de/riu/)		
Technische Universität Hamburg-Harburg, Stadt und Regionalökonomie (TUHH; http://kontakt.tu-harburg.de)		
Umwelt- und Prognose- Institut e.V., Heidelberg (UPI; upi-institut.de)		
Umweltforschungszentrum Leipzig-Halle GmbH (UFZ; ufz.de)		
Universität Karlsruhe, Fakultät für Wirtschaftswissenschaften, Ökonomie und Ökologie des Wohnungsbaus (ÖÖW; http://housing.wiwi.uni-karlsruhe.de)	x	
Universität Karlsruhe, Forschungszentrum Umwelt (FZU; uni-karlsruhe.de/~fzu/)		
Weeber und Partner, Institut für Stadtplanung und Sozialforschung, Stuttgart (weeberpartner.de)	x	
Wuppertal Institut für Klima, Umwelt, Energie GmbH (wupperinst.org)	x	x
NETHERLANDS		
Energy consultants	X	X
ECN	X	X
TNO	X	X
Universities	X	X
Architects	X	X

Continuation of Table I.2

Housing corporations	X	

SWEDEN
KTH Stockholm University of Technology
SWITZERLAND
ETH Zurich (several institutes, mostly in the departments of Architecture, Construction, e.g. Prof. Wallbaum)
EMPA, Dübendorf, CCEM project Avanced energy-efficient renovation, various other projects (M. Zimmermann)
HTA Luzern (U. Menti, Prof. Zweifel)
Fachhochschule Nordwestschweiz (Prof. Binz)
Fachhochschule St. Gallen (Ms Gemperle)
EPFL Lausanne (LESO-PB)
UNITED KINGDOM
Many different public and private organisations are involved in this field, including university departments, government-linked research institutes and private companies.
The Research Register of the UK Energy Research Centre (UKERC) gives a self-reported list of grants awarded in the field of energy efficiency in residential and commercial buildings - http://ukerc.rl.ac.uk/cgi-bin/ercri1.pl There are 89 different organisations on this list, with the following institutions receiving grant totals in excess of 1m GBP: De Montfort University, Heriot-Watt University, University of Manchester, UKERC, University College London, University of Cambridge
As regards existing buildings, the database records 24 funded projects. In addition to institutions listed above, the following are active in the area: University of Birmingham, Building Services Research and Information Organisation (BSRIA), BRE, University of Plymouth, Oxford Brookes University, Cardiff University, Edinburgh University, University of Newcastle, University of Leicester

Source: experts' opinions (questionnaire).

Table I.3: Organisations that develop renovation research projects according the countries' experts: additional data for Section 9.4.

Name of research institute or other agencies	Main research topic
AUSTRIA	
Austrian Energy Agency: "Klima:aktiv"	Energy research
ÖGUT – Österreichische Gesellschaft für Umwelt und Technik: "Haus der Zukunft"/"Fabrik der Zukunft"	Research coordination
FFG – Forschungsförderungsgesellschaft/IIBW: "BRA.IN Bauwirtschaft"	Research promotion
Ministeries	
FINLAND	
TEKES	
Academy of Finland	
Ministry of the Environment	
FRANCE	
ADEME – ANR/marc.casamassima@ademe.fr	Energy efficiency in new and existing buildings
Fondation Bâtiment Energie/jean-louis.plazy@ademe.f	Low energy in new and existing buildings
GERMANY	
Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke", Köln (AiF; aif.de)	Industrial products and production processes
ARGEBAU (is-argebau.de)	Building research
Baden-Württemberg Programm Lebensgrundlage Umwelt und ihre Sicherung (BWPLUS; bwplus.fzk.de)	Environmental issues
Bundesamt für Bauwesen und Raumordnung, Bonn/Berlin/(BBR; bbr.bund.de)	Construction, energy, sustainability
Bundesministerium für Bildung und Forschung Berlin/Bonn (BMBF; baufo.net)	Construction, energy, sustainability
Bundesministerium für Verkehr-, Bau- und Wohnungswesen, Berlin/Bonn (BMVBW; bmvbw.de)	Construction, energy, sustainability
Büro für Technikfolgenabschätzung beim Deutschen Bundestag, Berlin (TAB; tab.fzk.de)	Construction, energy, sustainability
Deutsche Bundesstiftung Umwelt, Osnabrück (DBU; dbu.de)	Environmental issues, sustainability
Deutsche Energie-Agentur, Berlin (dena; deutsche-energie-agentur.de)	Energy efficiency of buildings
Deutsche Forschungsgemeinschaft, Bonn (DFG; dfg.de)	Everything
Landesstiftung Baden-Württemberg, Stuttgart (landesstiftung.bw.de)	Environmental issues
Leibnizgemeinschaft/Wissensgesellschaft Gottfried Wilhelm Leibniz, Dresden (wlg.de)	everything
Projektträger Biologie, Energie, Umwelt des Forschungszentrums Jülich GmbH (BEO; fz-juelich.de/ptj)	Energy, sustainability
Projektträger Mobilität und Verkehr/Bauen und Wohnen (tuvpt.de)	Construction, energy, sustainability
Transfer Umweltforschung Baden-Württemberg/Landesanstalt für Umweltschutz (umweltforschung.baden-wuerttemberg.de)	Environmental issues

Continuation of Table I.3

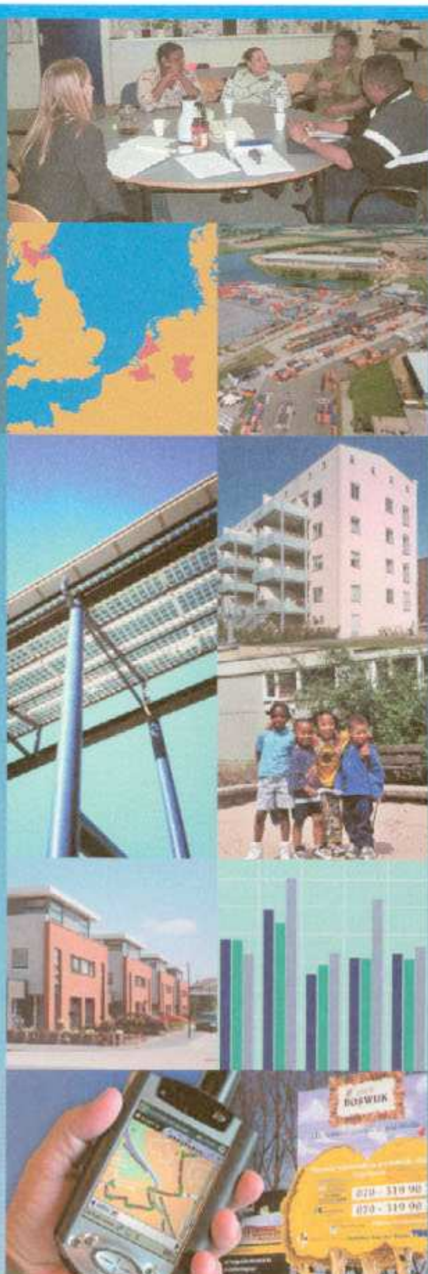
NETHERLANDS	
Ministries	
Universities	
Research organisations: SenterNovem, ECN, and many others	
SWEDEN	
Swedish Energy Agency	
SWITZERLAND	
Swiss Federal Office of Energy (SFOE; e.g. EWG: L. Gutzwiller, Rationelle Energienutzung in Gebäuden: A. Eckmanns)	
The Swiss Federal Office of Housing (BWO),	
CCEM: ETH Board (Board of all ETH institutions which are ETH Zürich, EPFL Lausanne, PSI, EMPA, EAWAG)	
Research programme "Energiewirtschaftliche Grundlagen (EWG)" of the Swiss Federal Office of Energy (BFE)	
EnergieSchweiz	
CEPE ETHZ (Zürich)	
Energieagentur der Wirtschaft EnAW, www.enaw.ch	
Schweizerische Verband für Wohnungswesen www.svw.ch	
Bundesamt für Wohnungswesen, www.bwo.admin.ch	
Energieagentur Elektrogeräte, eae	
Schweizerische Agentur für Energieeffizienz (S.A.F.E.)	
UNITED KINGDOM	
CaRB	De Montfort University, University College London, University of Reading, University of Newcastle-upon-Tyne, University of Sheffield, Royal Institute of Chartered Surveyors (RICS) and Energy for Sustainable Development Ltd. Stakeholders: NES Ltd, PowerGen, Leicester City Council, the Energy Saving Trust and DEFRA.
TAR-BASE	Heriot-Watt University, University of Ulster, University of Surrey, University of Nottingham, BSRIA, Integer, CIRIA and JB&B.
BMT	University of Oxford, University of Bath, University of Surrey, University of Strathclyde and the Welsh School of Architecture at the University of Cardiff.

Source: experts' opinions (questionnaire).

Appendix J : Definitions and abbreviations

CHP:
A Combined heat and power plant, delivering electricity as well as heat.
Combination boiler:
A boiler used for space heating as well as for domestic water heating.
Detached house:
A single-family house where no outdoor walls are shared with other houses.
Dwelling:
A set of rooms representing a closed unit intended for occupation by a family.
Dwelling stock:
See Housing stock.
End energy use:
See Final energy use.
EPBD:
The European norm Energy Performance of Buildings Directive.
Final energy use:
See End energy use. The energy directly used by a certain sector or entity (for instance electricity or heat or gas). It may be expressed in ktoe (kiloton oil equivalent) or MJ or kWh (1 ktoe=41 868 TJ; 1 TJ=10^6 MJ; 1 kWh=3.6 MJ).
Housing stock:
The housing stock consists of already existing permanent dwellings.
Infiltration:
The quantity of air that, in an uncontrolled way, comes inside a building through cracks in the construction.
Major household electrical appliances:
Also called white goods: refrigerators, washing machines etc.
Modernisation:
Renovation activities aimed at replacing kitchens, bathrooms or components that have reached the end of their service life.
Multi-family building:
A building that contains more than two dwelling units.
Multi-family dwelling:
A dwelling located in a building that contains other dwellings.
Non-residential building stock:
The non-residential building stock is defined in this study as the sum of all buildings used as office buildings, shopping and leisure buildings, educational buildings and health care buildings.
Primary energy use:
The primary energy consumption refers to the quantity of energy contained by the crude fuels needed to meet a certain end (or final) energy use. The primary energy use is mostly expressed in MJ.
Terraced house:
A single-family dwelling sharing two outside walls with other single-family dwellings.
Semi-detached house:
A single-family dwelling sharing only one outside wall with another single-family house.

Single-family dwelling:
A building containing one dwelling unit. Detached houses as well as terraced houses are categorised as single-family dwellings.
Small household electrical appliances:
Also called brown goods: hi-fi, telephone, computers etc.
Useful area:
Floor space of dwellings measuring inside the outer walls, excluding cellars and non-habitable attics and, in multi-dwelling houses, common spaces.
U-value:
The rate of heat flow through a unit area of a building component driven by a temperature difference of 1K (W/m^2K). The lower the U-value, the better the insulation.



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