SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

Survey of National Conditions

WP 2.2

Overview of potentials and estimated costs for energy savings in retrofitting of social housing

Supported by

Intelligent Energy Europe

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Overview of potentials and estimated costs for energy savings in retrofitting of social housing

Internal report

Work Package 2 Survey of National Conditions

Deliverable D2:2 Overview of potentials and estimated costs for energy savings in retrofitting of social housing in different countries

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Preface

This internal report is part of the work carried out within the SQUARE project (EIE/07/093/SI2.466701), which stands for A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings. The project is co-funded by the European Commission, supported by its Programme Intelligent Energy Europe (IEE). The SQUARE project aims to assure energy efficient retrofitting of social housing with good indoor environment, in a systematic and controlled way.

The partners of the SQUARE project are:

- AEE Institute for Sustainable Technologies, Austria
- EAP Energy Agency of Plovdiv, Bulgaria
- TKK Helsinki University of Technology, Finland
- Trecodome, Netherlands
- TTA Trama Tecno Ambiental S.L, Spain
- Poma Arquitectura S.L., Spain
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- AB Alingsåshem, Sweden

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Summary

The survey includes an estimation of the energy savings potential of retrofitting social housing in different countries together with an overview of promising existing measures for energy efficiency and good indoor environments in Europe.. This work consider and refer to the results from former projects on retrofitting of social housing. .

A review of the actual status of representative buildings for the overall social housing building stock in different countries has been made. The review also includes energy savings potential for several retrofitting actions with respect to the country's conditions such as climate, types of buildings, ownership, regulations and the building process.

In Europe there are 20-25 millions social housing units. The number of housing units has been decreasing due to privatization. Social housing represents approximately 10 % of total floor area of residential buildings.

Energy saving potential has estimated in Austria to be 50-90 %. In Finland there was some demonstration projects in mid 1990's were it was possible to save 60 % of heating energy (without domestic hot water). In Spain it is possible to reduced heat demand 60 %. In Sweden the potential for energy saving is around 50 % (including hot domestic water).

Estimated energy savings in social housing stock were 10 TWh per year (domestic hot water) and 110 TWh per year (heating energy). Social housing represents small part of housing in EU. The main energy savings must be done in single family, private houses.

Table of contents

1 Introduction

Definitions of social housing

In a number of the countries there is no single formal definition of social housing. Definitions may relate to ownership - notably non-profit organisations and local authorities (e.g. the Netherlands and Sweden); who constructs the dwellings (e.g. Austria and France); whether or not rents are below market levels (e.g., Ireland and England); the relevant funding and/or subsidy stream (e.g. France and Germany); and most importantly, in almost all of the countries included, the purpose for which the housing is provided. In some countries social housing is formally available to all households (e.g. Austria and Sweden) but in most it is actually directed at those who cannot serve their own housing needs (e.g. Netherlands and England) /Social housing in Europe/.

1.1 Description of task

Review of prevailing conditions in the different countries with respect to climate, types of buildings, ownership, regulations and the building process. The work in WP 2 in task 2 is mainly based on previous work done in other projects. .

1.2 Objectives and target groups

The objective is information transfer to Work Package 4, where the QA systems will be further developed and adopted, and to Work Package 5, where energy improvement measures will be evaluated.

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2 Results

2.1. Description of the multifamily building stock

Proportion of dwellings multifamily buildings:

- Austria 50%
- Bulgaria >50%?
- Finland 40 %
- Spain 10%
- Sweden 50%

Proportion of social dwellings in multifamily buildings in each country:

- Austria 75%
- Bulgaria 3%
- Finland 40 %
- Spain 11%
- Sweden appr. 35 %

Age distribution of the main building groups

In Austria the production of new bocks of flats were highest between 1961 and 1970 and between 1971 and 1980. One third of multifamily buildings have been built before 1945. From Bulgaria we did not have any statistic. In Finland production of dwellings was highest during the 1970's. During 1960's and 1980's production levels were also higher than normal. In Spain production levels have been high also during 2000's. Production levels have quite stable since 1970. In Sweden between 1946 and 1960, 265 000 apartments were built. Between 1960 and 1975 830 00 new apartments were built. Since 1975 production of new apartments has been in same level as before 1945.

How many are already refurbished?

In, Austria 43 % of the dwellings built between 1945 and 1980 has been renovated. The total number of dwellings, that still have to be retrofitted, is 876 113. They are divided into 562 391 private one-family-houses, 187 620 owner-occupied dwellings, 87 358 municipal dwellings and 38 744 dwellings of non-profit housing companies.

Though financial retrofit grants were increased in the recent years, the number of retrofit actions decreased. While in the middle of the 90ies about 85 000 retrofit actions were registered, in 1997 there were only 70 000. Particularly in the field of multi-family-buildings the number of completed retrofit measures is regressive.

In Bulgaria almost all dwellings needs renovation. In Finland approximately one third of social apartments have been renovation (plumbing system, ventilation system, windows, façade and balcony, electrical installation, elevators (installation of elevator), kitchen and bathroom. No special energy saving renovation actions have been made. Especially renovation of plumbing system, hot and cold water system is increasing. Increased renovation costs and lack of workers limits the renovation volume.

In Spain the renovation volume of protected dwellings has been about 50 000 dwellings per year.

In Sweden was estimated that in the year 2002 was only 13 % of the social housing built 1961 – 1975 rebuilt. The actual refurbishment volume is about 1.5% of the building stock per year. 95% of the buildings built from 1961 to 1975 need refurbishment. From these buildings, the multifamily buildings have the highest need of renovation. Approximately apartments per year need to be refurbished the next 15-20 years. The needed actions are; exchange of pipes, electrical installation, facades and roofs, windows, balcony, ventilation and elevators.

What is the actual refurbishment volume per year?

The Austrian retrofit volume is estimated to a cost of 1,4 milliard €. Retrofit activities are initiated by the introduction of financial retrofit grants. Within the time period between 1994 and 2002, the expenses for the retrofit of residential buildings increased from 520 million € to 630 million €. In average the retrofit measures are promoted by 22% of the retrofit costs through financial retrofit grants.

In Finland it has been estimated that retrofit volume in blocks of flats in the 2010 will cost 1400 millions Euros per year. Buildings built in the 1960's and 70's will be the most costly building groups. Both age groups use 30 % of renovation costs. Buildings built before 1960 use 20 % of the total investment costs and buildings built in 1980.s use 15 % of the total investment costs.

Situation in EU

The varying definitions of social housing mean that it is impossible to provide strictly comparable figures on the supply of social housing - rather we must use each country's own definition which reflects their own views of the nature and importance of social housing /Social housing in Europe/. The percentage of social housing ranges from a high of 35% in the Netherlands to a low of 4% (after mass privatization) in Hungary. France has the highest number of social housing units, with almost 4.25 million dwellings in the social sector. England lies second even after the significant decline as a result of privatization.

Trends in the total supply of social housing

In the majority of countries included in the survey the social housing stock has been declining at least in proportional terms - the exception is Denmark where output continues to keep pace with total provision. In some countries the numbers have fallen very significantly - this is notably the case in England, where the total supply has fallen by over a million from a high of 5.1 million in 1979.

In review of European social housing was found 15 millions social housing units in 9 EU countries /Social housing in Europe/. In the newest EU countries (2004 or later) the proportion of social housing is 5 %. This means approximately 1.5 millions social housing units. In Spain are one million and in Finland 0.5 million social housing units. Altogether this means 18 millions social housing units. Still data from Italy, Belgium, Portugal and Greece are missing. There must be over 20 million social housing units in EU. The number of housing units has been decreasing due to privatization. Social housing represents approximately 10 % of total floor area of residential buildings.

The average size of social housing unit is unknown. Most of them are located in apartment buildings. If the average floor area is assumed 65-70 square meters then the total flor area in EU area could be 1500 millions square meters.

2.2. Regulations and building codes

There are energy performance requirements [kWh/m2] for existing buildings in Austria.

Existing buildings: The energy performance of an existing residential building in the case of its comprehensive retrofitting* must not exceed the following maximum permitted annual energy demand for heating ($HWB_{BGF,WG,max,Ref}$) per square meter heated gross ground area depending on the geometry (l_c)of the building:

From 1.1.2008 until 31.12.2009:
$HWB_{BGF,WG,max,Ref} = 34 * (1+ 2,0/l_c)$ [kWh/m2a]
Maximum: **102,0 [kWh/m2a]**

From 1.1.2010:
$HWB_{BGF,WG,max,Ref} = 25 * (1+2,5/lc)$ [kWh/m2a]
Maximum: **87,5 [kWh/m2a]**

*) The "comprehensive retrofitting" is defined as the retrofit of a building with more than 1.000 m² used floor area,

- if the total costs for the retrofit action (including construction costs, fees and extra costs) exceed 25% of the building value (excluding land value and outside facilities) or
- if at least 25% of the building envelope is retrofitted or
- if at least three building components (windows, roof or top floor, façade and building service system) are retrofitted within one retrofitting action.

If a ventilation system with heat recovery is part of the building service system the threshold value has to be reduced by 8 kWh/m²a.

Primary energy demand
There are no requirements concerning this figure in Austria.

Ventilation rates and air tightness
Although it is known, that natural ventilation of existing and especially of retrofitted residential buildings does not ensure a sufficient ventilation rate to keep a comfortable indoor environment, the Austrian building codes do not provide minimum ventilation rates

for these building categories. The building envelope of new residential buildings has to be air tight and wind tight. The air change rate n50 must not exceed 3 per hour. If a ventilation system with or without heat recovery is implemented, the air change rate n50 must not exceed 1.5 per hour. For one-, two-family-houses and row houses these threshold values have to be observed for each house, at multi-family-buildings for each dwelling (averaging is not allowed).

Indoor temperatures in winter and summer
The Austrian methodologies for energy performance and dimensioning of boilers refer on a normal indoor temperature of + 20°C in winter.

According the Austrian norm the requirements concerning the protection against overheating in summer are met through verification, that the building components provide sufficient storage mass. During a heat wave the maximum indoor temperatures must not exceed +27°C by day time and +25°C by night.

In Finland is the design indoor air temperature during winter 21 ºC and 25 ºC is recommended during summer.

2.3. Description of voluntary systems or guidelines

OA systems are presented in WP 2.1. In Austria they have introduced the concept “klima:aktiv haus”.

According to the Program of the Austrian Government for the period between 2007 – 2010 the “klima:aktiv house” standard should be implemented in 50% of the new residential buildings. From 2015 only multi-family-buildings, which meet the requirements of a “klima:aktiv passive house”, should be promoted by housing grants.

Must-criteria for “klima:aktiv houses” regarding an improved energy performance and indoor environment

-Building envelope has to be “heat bridges poor” (avoidance of structural damages because of moisture, cold wall surfaces on the inner side, mould etc.)

("heat bridges poor" means a maximum increase of the mean-U-value of the building through heat bridges of 0.05 W/(m²K))

-Energy efficient ventilation systems

Ventilation system	air flow specific electrical power consumption
without heat recovery	≤0,25 Wh/m³
with heat recovery	≤0,45 Wh/m³

-Supply air volume: 30 m³/h (at standard occupancy)

Table 1: Air tightness in new residential buildings.

New residential buildings with ventilation systems	Maximum air change rate n_{50}*
without heat recovery	1.5/h
with heat recovery	1.0/h

*) measured according to the ÖNORM EN 13829 at 50 Pascal pressure difference between inside and outside, averaged over under pressure and over pressure, at closed supply air and exhaust air openings

Table 2: Energy demand for heating.

1 / l_c *)	Maximum energy demand for heating
≥ 0,8	45 kWh/m²a
≤ 0,2	25 kWh/m²a

*) $l_c = V_{heated} / A_{heated\ building\ envelope}$

-No usage of fossil fuels without condensing energy efficient boilers
-No electrical heating systems
-Domestic hot water must not be conditioned only electrically
-Obligatory use of one of the following heating systems:

- condensing energy efficiency boiler (gas or oil)
- heat pump
- district heating supplied by waste heat or CHP (combined heat and power)
- heating systems supplied by biomass

-Obligatory insulation of water storage
-Avoidance of overheating in summer: the room temperature must not exceed 25°C on more than 10% of the yearly hours.

Must-criteria for "klima:aktiv passive houses" regarding an improved energy performance and indoor environment

-Building envelope has to be "heat bridges free" (avoidance of structural damages because of moisture, cold wall surfaces on the inner side, mould etc.)

("heat bridges free" means a maximum increase of the mean-U-value of the building through heat bridges of 0,001 W/(m²K)).

-Energy efficient ventilation systems

Ventilation system	air flow specific electrical power consumption
with heat recovery	~ 0,21 – 0,45 Wh/m³

-Air tightness

Table 3: Maximum air change rate in new buildings.

New residential buildings with ventilation systems	Maximum air change rate n_{50}*
with heat recovery	0,6/h

*) measured according to the ÖNORM EN 13829 at 50 Pascal pressure difference between inside and outside, averaged over under pressure and over pressure, at closed supply air and exhaust air openings

Table 4: Total primary energy demand and energy demand for heating

Energy index	Maximum energy demand
total primary energy demand	≤65 kWh/m²a
energy demand for heating	≤15 kWh/m²a

Supply air volume: 30 m³/h (at standard occupancy)
Air change rate ≥ 0,3/h
Avoidance of overheating in summer: the room temperature must not exceed 25°C on more than 10% of the yearly hours.

2.4. Typical solutions for space heating, domestic hot water and ventilation

Austria
In Austria at the moment 26% of the multifamily buildings of building period 1945-60 are connected to a district heating system. Single furnaces - no central heating systems. Central heating systems without energy saving controlling systems. In most cases the existing shafts for installations in these buildings are to tight for air ducts with diameters, which are necessary for central ventilation systems in multifamily houses. An extension is not possible without invasive retrofit measures for the occupiers that means without de-settling the occupiers.

Out of that reason non-central ventilation units with heat recovery in outer walls can be an alternative to provide an adequate air change rate. If prefabricated façade elements are used for the retrofit air ducts can be implemented within these elements. With this system air ducts can be led within the insulated layer of the building shell.

The proportion of district heating is 36% for buildings of building period 1961-1980. According to the Austrian climate protection strategy (2008-2012) a focus will be put on the financial promotion of biomass district heating systems, of the retrofit of fossil driven district heating systems into biomass district heating systems and of efficient combined heat and power generation systems.

Finland
In Finland almost all apartment buildings have been connected to district heating systems. In cities with 50 000 or more habitants district heating system is CHP (combined heat and power production) type.

District cooling system is under construction in Helsinki. It utilized cool sea water and during July and August waste heat from CHP plants for water cooling. Normal heating solution inside dwelling is hot water radiator system. Domestic hot water is produced centralized from district heat.

Centralized and time controlled mechanical exhaust ventilation was the cheapest ventilation system in Finland. Almost all social homes have that system. Since 1953 all new block of flats with more than three floors over basement floor) have built mechanical exhaust air ventilation system. In the other block of flats buildings passive stack ventilation system was used until the end of 1960's. Since 1960's ventilation duct system have made from steel ducts. Typical exhaust fan is 2-speed fan. The full speed (design air flows) is normally used 6-8 hours per day. During the night time ½-speed is used. Buildings built between 1978 and mid 1990's full speed is not used when outdoor air temperature is less than -12^{o}C (Helsinki) -15^{o}C (Central Finland).

Small ventilation units with heat recovery have been used successfully for several years in Finland. Acoustical design must be careful because ventilation units are inside of apartments.

Spain
The individual heating system is the most usual in Spain and represents the 89% of all dwellings provided with a heating system. Collective heating systems in multifamily buildings have not been promoted by energy companies (gas and electricity). District heating is virtually inexistent, but few recent projects (with heating and cooling) had been implemented. The most usual energy sources gas and electricity (65%).
15% of dwellings have no heating system.

Before 2007, so all the existing housing stock, the usual typology of collective residential building had the following parameters:

- Concrete structure
- Ceramic or concrete block envelope walls
- Envelope insulation (internal side or in air cavity)
- Cement or ceramic finished façades
- Single pane glazing
- Wood window frames (most recently also plastic and aluminium frames are installed)
- Individual heating systems, with gas boiler and radiators
- the centralized ventilation installations are only common in service and administrative buildings
- renovation air heat exchangers are unusual
- building air tightness usually is low
- renovation air is procured by opening windows
- heating and space refrigeration in most homes operate only during some hours per day
- energy metering integrate many different consumptions (gas: kitchen, hot water, heating), so it's impossible to know separate heating or refrigeration expenditure
- centralized heating or space refrigeration (and paying the consumed energy) are not usual

Sweden

In Sweden space heating is in these houses are mainly distributed by hydronic radiator (95%). The remaining part is heated by electric radiators. Automatic control of supply temperature as a function of the outdoor temperature is today installed in almost all of these houses. Thermostatic valves are installed in about 70% of the houses and the circulation pump is in about 30% of the houses automatically shut down when there is no heat demand.

Nearly 90% of the multifamily buildings from this period are today connected to district heating. The remaining part has either a heat pump or a local boiler using electricity, oil and/or bio fuel.

Mechanical exhaust ventilation is the most common ventilation system, and is estimated to be installed in about 58% of the multi family houses built 1961-1975. The second most common is natural ventilation that is estimated to be installed in 38% of the houses. Mechanical exhaust and supply ventilation is estimated to be installed in only 4% of the houses, and in most cases without any heat recovery.

2.5. Typical energy performance (before and after retrofit), suitable retrofitting measures and estimates of savings potentials

Austria

Table 5. Typical energy performance (before and after retrofit), suitable retrofitting measures and estimates of savings potentials for buildings, age 1961-1980.

Energy performance before retrofit:	~ 100 - 150 kWh/m^2a
Energy performance after retrofit:	40-50 kWh/m^2a 15 kWh/m^2a in case of high quality retrofit (passive house standard)
Energy saving potential:	50 - 90%

Bulgaria

Energy consumption in social housing in Bulgaria.

From 170 kWh/m^2 to more than 200 kWh/m^2;

- 20% of the dwellings are connected to district heating;
- 80% of the dwellings are heated by and individual heaters – wood, electricity, coal ;
- 14% of the house holds expenditures are for heating and domestic hot water;
- Many dwellings are not heated normally, either the temperature is very low, or only one room is heated;
- For a normal heating at current prices of heat energy from district heating households should spend about 40% of their incomes for energy

Finland

In mid 1990's Finland were some experimental projects dealing with low-energy renovation. Even 60% reduction of heating (hot tap water excluded) energy was possible. Estimated savings if reduction of 50 % is possible are shown in next table 6.

Table 6. Estimated heating energy use in blocks of flats in year 1994.

Year	Heating energy 1994 MWh	Reduction - 50%
-1949	186 000	93 000
1950-1959	1110 000	832 000
1960-1969	2640 000	1320 000
1970-1979	4030 000	2015 000
1980-	4400 000	2200 000
	12366 000	6183 000

In 2008 average prize of district heat is Helsinki was 33 €/MWh. Potential savings are 200 M€/year. In social housing this saving might be 100 M€/year.

Spain

Fulfilment of the rules on building thermal retrofitting in Spain would produce an important reduction of energy consumption in the existing residential building.
Only the improvement of the building envelope could reduce dramatically the energy consumption. The new thermal values of this example of a building retrofitted in Barcelona would reduce its thermal demand around 60%. For example: Façades external insulation with 6 cm of insulation material (thermal conductivity 0,035 W/m2 K), roof insulation with 8 cm of insulation material (thermal conductivity 0,035 W/m2 K) and a vented cover and change of windows (better air tightness and double glazing) (< 3,0 W/m2 K).

Sweden

The total energy use for the buildings from the Swedish "million program", including household electricity, is estimate to 9,5 TWh/y. On an average the specific energy use is about 210 kWh/(m^2 y). The estimated total energy use and saving potential for different measures are given below.

Table 7. Energy use and saving potentials.

Energy usage	Energy use today (TWh)	Saving potential (TWh)
Insulation, windows	1,5 – 2,0	0,5 – 1,0
Insulation, rest of the envelope	1,0 – 1,5	0,5 – 1,0
Air tightness	0,5 – 1,0	0,5
Ventilation	2,0 – 2,5	1,5 – 2,0
Sanitary hot water	1,5 – 2,0	0,5 – 1,0
Losses in heating system	0,5 – 1,0	0,5
House hold electricity	1,0 – 1,5	0,0 – 0,5
Total	**8,5 – 10,5**	**4,0 – 5,5**

Energy saving potential in social housing units in EU

Domestic hot water

Proportion of domestic hot water on total heating energy use in residential buildings varies from 40 % (Spain) to 10-15% in Finland. In Finland it the proportion of hot water is 40 % of domestic water use. The average hot water consumption was estimated to be 50 litres/day per person in European district heating project /ECOHEATCOO/. This means over 18 m^3 per year and per person. That means also 1000 kWh per person and in EU area approximately 400 TWh per year. The proportion used in social housing units might be 40 TWh per year. Use of hot domestic water can be reduced by replacing baths by showers and using energy saving equipments. Also metering of water use decreases water consumptions. Realistic reduction might be 25 % which is equal with 10 TWh per year.

Heating of homes

In Finland an average the specific energy use in apartment buildings built in 1960' and 70's is near 200 kWh/(m^2 y). without domestic hot water. In Sweden an average the specific energy use is near 200 kWh/(m^2 y). without domestic hot water. In Bulgaria it is a little bit lower. In Austria it is 100-150 kWh/m^2 y.

Estimated existing heating energy use of social housing in EU is 225 TWh per year (1500 millions square meters and 150 kWh/m^2 y). A reduction of 50 % seems to be quite realistic. This means saving that are approximately 110 TWh per year.

3 Conclusions and discussion

The proportion of dwelling in multifamily buildings varied from 10 % (Spain) to 50 % (Austria and Sweden). The proportion of social dwellings in multifamily buildings varied much more from 3 % (Bulgaria) to 75 % (Austria). Almost all countries the production of social dwellings was highest between 1960 and 1980. In Spain production levels were high also during the 2000's.

In Austria 43 % of the dwellings built between 1945 and 1980 has been renovated. In other countries the proportion of renovated dwellings is lower. In Finland total renovation method is used. Tenants are relocated and plumbing system, kitchen, bathroom and interior surfaces are renovated. Windows and outer surfaces are also renovated. Heat recovery from exhaust air is not installed and improvement of thermal insulation is limited.

In Austria and Finland the estimated retrofitting volume is 1.4 milliard euro per year.

There are energy performance requirements for existing buildings in Austria. In Finland the biggest non-profit owner of social dwellings has plans to set energy performance criteria for buildings to be renovated.

District heating with radiators are main heating solution in Sweden and Finland. Also mechanical exhaust ventilation system is common in social multifamily buildings. In Finland 17 % of all electricity is produced in power plants connected with district heating network. Modern power plant with gas and steam turbine can produce more electricity than district heating.

Energy saving potential has estimated in Austria to be 50-90 %. In Finland there was some demonstration projects in mid 1990's were it was possible to save 60 % of heating energy (without domestic hot water). In Spain it is possible to reduced heat demand 60 %. In Sweden the potential for energy saving is around 50 % (including hot domestic water).

Estimated energy savings in social housing stock were 10 TWh per year (domestic hot water) and 110 TWh per year (heating energy). Social housing represents small part of housing in EU. The main energy savings must be done in single family, private houses.

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SQUARE partner reports:

Appendixes A, B, C, D, E

Appendix A - Austria

1 Description of the multifamily building stock (statistics about the building stock)

1.1. Size of social housing (i.e. multifamily buildings) building stock (how many % of total residential building stock)

According to the "Statistics Austria" the total residential building stock in 2006 consisted of 3,508.400 dwellings (main residences). Multi-family buildings are defined as buildings with more than 3 dwellings. The Austrian building stock is divided into **~ 49,7%** multi-family-buildings and ~50,3% one- and two-family-houses. There are 1,743.300 dwellings in multi-family-houses.

1.2. Which building types (apartment buildings, row houses, slab block, tower block…)

The "Statistik Austria" does not differ between apartment buildings, row houses, slab block, etc. From the classification according the number of dwellings of a building a conclusion can be drawn in terms of the building typology.
That means, that in Austria 37% of the dwellings are found in multi-family-buildings consisting of 3 to 9 dwellings, 34% in multi-family-buildings consisting of 10 to 19 dwellings and 29% in multi-family-buildings consisting of more than 20 dwellings.

1.3. Age distribution of the main building groups

	Main residences total	Building period							
		before 1919	1919 to 1944	1945 to 1960	1961 to 1970	1971 to 1980	1981 to 1990	1991 to 2000	2001 and later
Total	3.508.353	623.600	284.950	420.760	553.203	553.359	463.310	475.565	133.604
One- and two-family houses	1.764.944	260.167	121.147	219.562	267.746	300.946	284.139	244.362	66.875
Dwellings in multi-family-buildings*	1.743.409	363.433	163.803	201.198	285.457	252.413	179.172	231.202	66.730
One-family-houses	1.292.869	181.933	92.354	151.231	168.245	202.930	219.098	215.207	61.870
Two-family-houses	472.075	78.234	28.793	68.331	99.501	98.016	65.041	29.155	5.005
Dwellings in row houses, small apartment buildings**	646.521	116.907	78.659	70.376	86.092	67.364	78.643	114.950	33.529
Dwellings in estates of row houses, apartment blocks ***	593.239	120.729	52.063	84.072	111.705	85.926	57.449	66.165	15.130
Dwellings in apartment blocks and tower blocks****	503.649	125.797	33.081	46.750	87.660	99.123	43.080	50.087	18.071

*) residential buildings with more than 3 dwellings
**) residential buildings with 3 to 9 dwellings
***) residential buildings with 10 to 19 dwellings
****) residential buildings with more than 20 dwellings

In general it can be stated that 30% of the buildings were erected before 1944, 40% of the buildings in the time period between 1945 and 1980 and 30% after 1981.

1.4. How many are already refurbished

In Austria 1,527.400 dwelling have been built in the period between 1945 and 1980. According to the Austrian Federation of Non-profit Construction Associations (GBV) until 2006 the energy performance of 42,6 % (651.400 dwellings) of these dwellings have been retrofitted through retrofitting measures.
The total number of dwellings, that still have to be retrofitted, is 876.113. They are divided into 562.391 private one-family-houses, 187.620 owner-occupied dwellings, 87.358 municipal dwellings and 38.744 dwellings of non-profit housing companies.

Building period 1945-1980	
Total number of dwellings	**1,527.400**
Retrofitted until 2006	651.400
Number of dwellings to be retrofitted	876.113
private one-family-houses	562.391
owner-occupied dwellings	187.620
municipal dwellings	87.358
dwellings of non-profit housing companies	38.744

(Source: GBV)

1.5. What is actual refurbishment volume per year

The Austrian retrofit volume is estimated with 1.4 milliard €. Retrofit activities are initiated by the introduction of financial retrofit grants.

Within the time period between 1994 and 2002 the expenses for the retrofit of residential buildings increased from 520 million € to 630 million €. In average the retrofit measures are promoted by 22% of the retrofit costs through financial retrofit grants.

Though financial retrofit grants were increased in the recent years, the number of retrofit actions decreased. While in the middle of the 90ies about 85.000 retrofit actions were registered, in 1997 there were only 70.000. Particularly in the field of multi-family-buildings the number of completed retrofit measures is regressive.

(Source: Evaluation report about the Austrian climate strategy, 2006)

1.6. Type of occupation (tenancy, tenant-owner flat, ownership)

An inquiry of the "Statistics Austria" of 2006 showed, that 20% of the dwellings in multi-family-houses are occupied by their owners, 75% by tenants and 5% by persons within an other legal relationship.

2 Regulations and building codes

2.1. Short description of main requirements for existing and new buildings as regards, energy performance requirements and indoor climate

The Directive 2002/91/EC on the energy performance of buildings in Austria is implemented through two instruments. The legal instrument, the "Law on Submission of Energy Certificates", at national level obligates real estates owners to submit an energy certificate in case of selling and letting their buildings. The technical instrument, the "**Policy No. 6** about energy savings and thermal insulation" of the Austrian Institute for Building Construction, specifies the requirements concerning the energy performance of buildings. From 2008 this policy will be anchored in the Austrian building codes.

2.1.1. Energy performance requirements [kWh/m2]

New buildings:
The energy performance of a new residential building must not exceed the following maximum permitted annual energy demand for heating ($HWB_{BGF,WG,max,Ref}$) per square meter heated gross ground area depending on the geometry (l_c)of the building:

From 1.1.2008 until 31.12.2009:
$HWB_{BGF,WG,max,Ref} = 26 * (1+ 2,0/l_c)$ [kWh/m2a]
Maximum: **78,0 [kWh/m2a]**

From 1.1.2010:
$HWB_{BGF,WG,max,Ref} = 19 * (1+2,5/l_c)$ [kWh/m2a]
Maximum: **66,5 [kWh/m2a]**

If a ventilation system with heat recovery is part of the building service system the threshold value has to be reduced by 8 kWh/m²a.

Existing buildings:
The energy performance of an existing residential building in the case of its comprehensive retrofitting* must not exceed the following maximum permitted annual energy demand for heating ($HWB_{BGF,WG,max,Ref}$) per square meter heated gross ground area depending on the geometry (l_c)of the building:

From 1.1.2008 until 31.12.2009:
$HWB_{BGF,WG,max,Ref} = 34 * (1+ 2,0/l_c)$ [kWh/m2a]
Maximum: **102,0 [kWh/m2a]**

From 1.1.2010:
HWBBGF,WG,max,Ref = 25 * (1+2,5/lc) [kWh/m2a]
Maximum: **87,5 [kWh/m2a]**

*) The "comprehensive retrofitting" is defined as the retrofit of a building with more than 1.000 m² used floor area,

- if the total costs for the retrofit action (including construction costs, fees and extra costs) exceed 25% of the building value (excluding land value and outside facilities) or
- if at least 25% of the building envelope is retrofitted or
- if at least three building components (windows, roof or top floor, façade and building service system) are retrofitted within one retrofitting action.

If a ventilation system with heat recovery is part of the building service system the threshold value has to be reduced by 8 kWh/m²a.

2.1.2. Primary energy demand

According to the Austrian "**Policy No. 6** about energy savings and thermal insulation" the "primary energy demand" is described as the "total energy demand" of a building. There are no requirements concerning this figure in Austria.

2.1.3. U-values

The "**Policy No. 6** about energy savings and thermal insulation" includes requirements concerning the U-values of building components. These threshold values refer to new buildings as well as to retrofitted building components.

Building components	**U-value [W/m²K]**
WALLS towards outside air	0,35
Small walls towards outside air (i.e. dormers), which do not exceed 2% of the total wall surface towards outside air of the building (precondition: condensate prevention has to e fulfilled according to the ÖNORM B 8110-2)	0,70
INNER WALLS between living and service units	0,90
WALLS towards not heated, frost-protected building units (except: attics)	0,60
WALLS towards not heated or not upgraded attics	0,35
WALLS towards other buildings along plot or site boundaries	0,50
EARTH TOUCHING WALLS AND FLOORS	0,40
WINDOWS, FRENCH DOORS, GLAZED or NOT GLAZED DOORS and other vertical TRANSPARENT BUILDING COMPONENTS towards not heated building units	2,50
WINDOWS and FRENCH DOORS towards outside air	1,40
Other WINDOWS, FRENCH DOORS, GLAZED or NOT GLAZED DOORS and vertical TRANSPARENT BUILDING COMPONENTS towards outside air	1,70
ROOF-TOP WINDOWS towards outside air	1,70
Other horizontal or sloped TRANSPARENT BUILDING COMPONENTS towards outside air	2,00

CEILLINGS towards outside air, towards aerated or not insulated attics, above passages and PITCHES towards outside air	0,20
INNER CEILLINGS towards not heated building components	0,40
INNER CEILLINGS towards detached living or service units	0,90

2.1.4. Ventilation rates and air tightness

Although it is known, that natural ventilation of existing and especially of retrofitted residential buildings does not ensure a sufficient ventilation rate to keep a comfortable indoor environment, the Austrian building codes do not provide minimum ventilation rates for these building category.

Regarding the air tightness of new buildings, the “**Policy No. 6** about energy savings and thermal insulation” provides a maximum air change rate for different cases:

The building envelope of new residential buildings has to be air tight and wind tight. The air change rate n_{50} must not exceed 3 per hour. If a ventilation system with or without heat recovery is implemented, the air change rate n_{50} must not exceed 1.5 per hour.

For one-, two-family-houses and row houses these threshold values have to be observed for each house, at multi-family-buildings for each dwelling (averaging is not allowed).

New residential buildings	Maximum air change rate n_{50}*
without ventilation system	3
with ventilation system with or without heat recovery	1,5

*) measured according to the ÖNORM EN 13829 at 50 Pascal pressure difference between inside and outside, averaged over under pressure and over pressure, at closed supply air and exhaust air openings

2.1.5. Indoor temperatures in winter and summer

The Austrian methodologies for energy performance and dimensioning of boilers refer on a normal indoor temperature of + 20°C in winter.

According the ÖNORM B 8110-3 the requirements concerning the protection against overheating in summer are met through verification, that the building components provide sufficient storage mass. During a heat wave the maximum indoor temperatures must not exceed +27°C by day time and +25°C by night.

2.2. Description of voluntary systems or guidelines if exists

2.2.1. Klima-aktiv haus

The "klima:aktiv haus" program is a part of the national climate protection initiative of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management in order to reduce green house gas emissions in the fields of buildings, renewable energies, transport and municipalities. Within the klima:aktiv haus program a comprehensive catalogue with building criteria was developed, to ensure the ecological quality of planned and erected residential buildings. Depending on the degree of performance of the buildings they will be defined as a "klima:aktiv house" or a "klima:aktiv passive house".

According to the Program of the Austrian Government for the period between 2007 – 2010 the "klima:aktiv house" standard should be implemented in 50% of the new residential buildings. From 2015 only multi-family-buildings, which meet the requirements of a "klima:aktiv passive house", should be promoted by housing grants.

Must-criteria for "klima:aktiv houses" regarding an improved energy performance and indoor environment

- Building envelope has to be "heat bridges poor" (avoidance of structural damages because of moisture, cold wall surfaces on the inner side, mould,…)
- Energy efficient ventilation systems

Ventilation system	air flow specific electrical power consumption
without heat recovery	≤0,25 Wh/m³
with heat recovery	≤0,45 Wh/m³

- Supply air volume: 30 m³/h (at standard occupancy)
- Air tightness:

New residential buildings with ventilation systems	Maximum air change rate n_{50}*
without heat recovery	1,5/h
with heat recovery	1,0/h

*) measured according to the ÖNORM EN 13829 at 50 Pascal pressure difference between inside and outside, averaged over under pressure and over pressure, at closed supply air and exhaust air openings

- Energy demand for heating:

1 / l_c *)	Maximum energy demand for heating
≥ 0,8	45 kWh/m²a
≤ 0,2	25 kWh/m²a

*) $l_c = V_{heated} / A_{heated\ building\ envelope}$

- No usage of fossil fuels without condensing energy efficient boilers
- No electrical heating systems
- Domestic hot water must not be conditioned only electrically
- Obligatory use of one of the following heating systems:
  - condensing energy efficiency boiler (gas or oil)
  - heat pump
  - district heating supplied by waste heat or CHP (combined heat and power)
  - heating systems supplied by biomass
- Obligatory insulation of water storage
- Avoidance of overheating in summer: the room temperature must not exceed 25°C on more than 10% of the yearly hours.

Must-criteria for "klima:aktiv passive houses" regarding an improved energy performance and indoor environment

- Building envelope has to be "heat bridges free" (avoidance of structural damages because of moisture, cold wall surfaces on the inner side, mould,…)

- Energy efficient ventilation systems

Ventilation system	air flow specific electrical power consumption
with heat recovery	~ 0,21 – 0,45 Wh/m³

- Air tightness

New residential buildings with ventilation systems	Maximum air change rate n_{50}*
with heat recovery	0,6/h

*) measured according to the ÖNORM EN 13829 at 50 Pascal pressure difference between inside and outside, averaged over under pressure and over pressure, at closed supply air and exhaust air openings

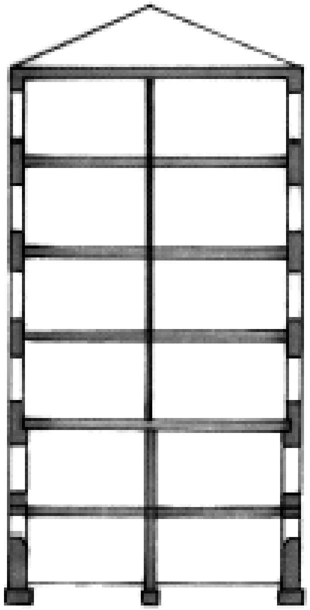
- Total primary energy demand and energy demand for heating

Energy index	Maximum energy demand
total primary energy demand	≤65 kWh/m²a
energy demand for heating	≤15 kWh/m²a

- Supply air volume: 30 m³/h (at standard occupancy)
- Air change rate ≥ 0,3/h
- Avoidance of overheating in summer: the room temperature must not exceed 25°C on more than 10% of the yearly hours.

3 Description of the most common multifamily building groups having the highest renovation need

Building period 1945 – 1960



3.1.1. Type of façade material

Typical structure of the exterior wall:	Typical U-value of the exterior wall:	Typical weak points of the exterior wall:
• External plaster • Brick walls: 24 – 30 cm • Internal plaster	1,40 – 1,90 W/m²K	• slim profile (condensate risk) • very poor insulation level • very poor sound protection level • heat bridges in radiator niches through slim wall profiles

3.1.2. Type of windows (U-value, double-glazed window)

Typical structure of the window:	Typical U-value of the windows	Typical weak points of the window:
• single-glazed wood windows	• ~ 2,50 W/m²K	• leak warped window frames with substantial coating damages • insufficient insulation and sound protection level at single-glazed windows

3.1.3. Type of roof (flat, gable roof)

Buildings of this building period typically have not-insulated pitched roofs. Most of the roofs are leak, because they do not have sarking membranes.
In general the top floor of the buildings close the thermal envelope at the top side of the object.

Typical structure of the top floor:	Typical U-value of the top floor:
• 5 cm insulation layer • brick ceiling with concrete compensation layer • internal plaster	• 1,50 W/m²K

3.1.4. Type of foundation (slab on ground, crawl space, cellar)

In general buildings of this building period do not have heated cellars. The cellar ceiling of the buildings close the thermal envelope at the bottom of the object.

Typical structure of the cellar ceiling:	Typical U-value of the cellar ceiling:	Typical weak points of the cellar area:
• floor covering • compensation layer / screed • concrete ceiling • internal plaster	• 3,70 W/m²K	• moisture penetration of earth touching walls

3.1.5. Typical insulation and air tightness of building envelope

Typically an appropriate insulation of the building components is insufficient or failing.

3.1.6. Typical solutions for space heating, domestic hot water and ventilation

Single furnaces - no central heating systems
Central heating systems without energy saving controlling systems

3.1.7. Space in existing shaft for installing air ducts

In most cases the existing shafts for installations in these buildings are to tight for air ducts with diameters, which are necessary for central ventilation systems in multifamily houses. An extension is not possible without invasive retrofit measures for the occupiers, that means without de-settling the occupiers.

Out of that reason non-central ventilation units with heat recovery in outer walls can be an alternative to provide an adequate air change rate.

If prefabricated façade elements are used for the retrofit air ducts can be implemented within these elements. With this system air ducts can be led within the insulated layer of the building shell.

3.1.8. Accessibility to district heating

Development of the district heating network-length (Austrian Association of Gas and Heating, 2007):
In Austria 3.800 km pipelines are operated by the regional heat suppliers. Between 2007 and 2016 the Austrian heat suppliers plan to add 72 – 98 km pipelines per year to the existing network

District heating	Central heating system	Heating system covering one floor	Gas convector	Electrical heating	single furnace (no gas or electricity)
(1945 - 1960)					
52.928,0	26.830,0	50.007,0	29.598,0	18.656,0	23.178,0
26%	13%	25%	15%	9%	12%

Source: Statistics Austria (2006)

At the moment 26% of the multifamily buildings of this building period are connected to a district heating system. According to the Austrian climate protection strategy (2008-2012) a focus will be put on the financial promotion of biomass district heating systems, of the retrofit of fossil driven district heating systems into biomass district heating systems and of efficient combined heat and power generation systems.

3.1.9. Typical indoor climate (before and after renovation) in terms of air change, indoor temperatures in summer and winter

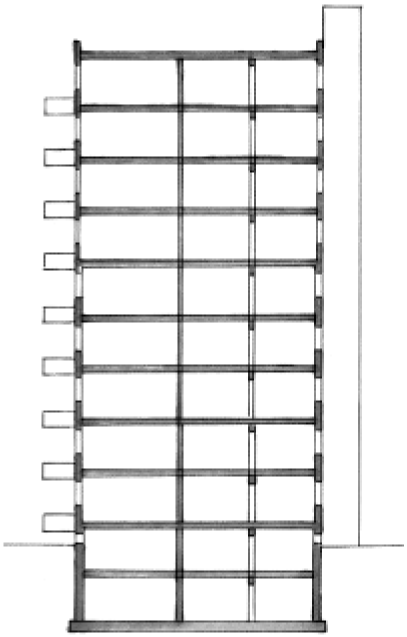
Air change - before retrofit:
Because of their building structures a blower-door-test cannot be performed in buildings of this building period. The necessary pressure difference of 50 Pascal cannot be reached due to their leak and obsolete windows and failing sarking membranes in the roof area. By this fact itself it can be stated, that the building stock of this building period has no sufficient air tightness.

Air change - after retrofit:
Depending on the retrofit measures air changes of new buildings without ventilation systems ($n_{50} \leq 3/h$) or of new building with ventilation systems ($n_{50} \leq 1,5/h$).

3.1.10. Typical energy performance (before and after renovation), suitable retrofitting measures and estimates of savings potentials

Energy performance before retrofit:	~ 130 -200 kWh/m²a
Energy performance after retrofit:	~ 55 kWh/m²a
Energy saving potential:	40-50%

3.2. Building period 1961 - 1980



3.2.1. Type of façade material

Typical structure of the exterior wall:	Typical U-value of the exterior wall:	Typical weak points of the exterior wall:
• External plaster • Mostly brick walls or concrete walls or wall blocks filled with concrete • Internal plaster	• 0,80 W/m²K	• slim profile (condensate risk, heat bridges) • very poor insulation level • very poor sound protection level

3.2.2. Type of windows (U-value, double-glazed window)

Typical structure of the window:	Typical U-value of the windows
• single-glazed wood windows • rarely insulating glass • large window areas	• ~ 2,00 W/m²K

3.2.3. Type of roof (flat, gable roof)

Buildings of this building period typically have flat roofs. Most of the roofs are leak and do not have sufficient heat insulation.

Typical structure of the flat roof:	Typical U-value of the flat roof:
• Isolation layer • 10 cm insulation layer • vapor barrier • inclining screed • reinforced concrete ceiling	• 0,35 W/m²K

3.2.4. Type of foundation (slab on ground, crawl space, cellar)

In general buildings of this building period do not have heated cellars. The cellar ceiling of the buildings close the thermal envelope at the bottom of the object.

Typical structure of the cellar ceiling:	Typical U-value of the cellar ceiling:
• floor covering • compensation layer / screed • concrete ceiling • internal plaster	• 3,70 W/m²K

3.2.5. Typical insulation and air tightness of building envelope

Typically an appropriate insulation of the building components is insufficient or failing.

3.2.6. Typical solutions for space heating, domestic hot water and ventilation

Obsolete central heating systems without energy saving controlling systems.

3.2.7. Space in existing shaft for installing air ducts

In most cases the existing shafts for installations in these buildings are to tight for air ducts with diameters, which are necessary for central ventilation systems in multifamily houses. An extension is not possible without invasive retrofit measures for the occupiers, that means without de-settling the occupiers.

Out of that reason non-central ventilation units with heat recovery in outer walls can be an alternative to provide an adequate air change rate.

If prefabricated façade elements are used for the retrofit air ducts can be implemented within these elements. With this system air ducts can be led within the insulated layer of the building shell.

3.2.8. Accessibility to district heating

Development of the district heating network-length (Austrian Association of Gas and Heating, 2007):
In Austria 3.800 km pipelines are operated by the regional heat suppliers. Between 2007 and 2016 the Austrian heat suppliers plan to add 72 – 98 km pipelines per year to the existing network

District heating	Central heating system	Heating system covering one floor	Gas convector	Electrical heating	single furnace (no gas or electricity)
(1961- 1980)					
193.537,0	175.449,0	73.601,0	33.500,0	34.539,0	27.246,0
36%	33%	14%	6%	6%	5%

Source: Statistics Austria (2006)

At the moment 36% of the multifamily buildings of this building period are connected to a district heating system. According to the Austrian climate protection strategy (2008-2012) a focus will be put on the financial promotion of biomass district heating systems, of the retrofit of fossil driven district heating systems into biomass district heating systems and of efficient combined heat and power generation systems.

3.2.9. Typical indoor climate (before and after retrofit) in terms of air change, indoor temperatures in summer and winter

Air change - before retrofit:
Because of their massive building structures a blower-door-test could be performed in buildings of this building period. The necessary pressure difference of 50 Pascal cannot be reached due to their leak and obsolete windows. By this fact itself it can be stated, that the building stock of this building period has no sufficient air tightness.

Air change - after retrofit:
Depending on the retrofit measures air changes of new buildings without ventilation systems ($n_{50} \leq 3/h$), of new building with ventilation systems ($n_{50} \leq 1,5/h$) or even passive houses ($n_{50} \leq 0,6/h$) can be achieved.

3.2.10. Typical energy performance (before and after retrofit), suitable retrofitting measures and estimates of savings potentials

Energy performance before retrofit:	~ 100 - 150 kWh/m²a
Energy performance after retrofit:	40-50 kWh/m²a 15 kWh/m²a in case of high quality retrofit (passive house standard)
Energy saving potential:	50 - 90%

4 Local conditions

4.1 Financial funding or grants for retrofit of multifamily houses

Each of the nine Federal States of Austria has its own funding system for the retrofit of multi-family-houses.
In Styria the retrofit of multi-family buildings is promoted by the following conditions:

- The energy demand for heating has to be calculated before and after retrofit.
- Basically energy savings of minus 30% have to be achieved through retrofit.
- New built building parts have to meet requirements for new buildings.
- New heating systems driven by gas or oil have to include condensing heat technology.
- Building physical suitability test

The building has to include at least three apartments. The retrofit costs have to come to minimum 21.802 €.

The planning permission of the building has to be older than 30 years.

The maximum financial funding is 1.126 € per square meter.

For each additional ÖKO point further 1,50 € per square meter can be awarded to the building owner. A few examples:

For installing a heating system based on renewable raw materials or a ventilation system with heat recovery in each case three ÖKO points can be proved.
For dropping below the minimum requirement of 30% energy saving by 60% 2 ÖKO points can be proved.
For the retrofit of existing doors and windows one ÖKO point can be proved.

4.2 Local producers

4.2.1. High quality insulation material

The Syndicate of Austrian Insulation Material Industry (GDI) aim for energy efficiency for new and existing buildings. Its members are:

- Austrotherm GmbH, Wopfing / Niederösterreich
- Steinbacher Dämmstoff GmbH, Erpfendorf / Tirol
- IDEAL-Baustoffwerk M. Reichenberger GmbH & Co.KG, Frankemarkt / Oberösterreich
- Brucha Gmbh, Michelshausen / Niederösterreich
- CPH Zellulosedämmstoffproduktion GmbH & Co KG, Hartberg / Steiermark (Isocell, Clima-super)

- PRIMA Bau- und Dämmsysteme Gesellschaft m.b.H. & CO KG, Sonntagberg / Oberösterreich
- Synthesa Chemia GmbH, Perg / Oberösterreich
- Röfix AG, Röthis / Vorarlberg

4.2.2. High quality windows

- Stabil Bauelemente GmbH, Gabersdorf / Steiermark
- Actual Fenster AG, Haid / Oberösterreich
- Gaulhofer Vertrieb GmbH & Co KG, Fenster und Türen, Übelbach / Steiermark
- JOSKO Fenster und Türen GmbH, Kopfing
- Internorm International GmbH, Traun
- KATZBECK GmbH & Co KG, Rudersdorf / Burgenland

4.2.3. Ventilation systems

- Vaillant GmbH
  www.vaillant.at
- Buderus Austria Heiztechnik GesmbH
  www.buderus.at
- Frühwald Rauchfang- und Lüftungssysteme GmbH
  www.plewa.at
- Drexel und Weiss GmbH
  www.drexel-weiss.at
- REWA Energietechnik GmbH
  http://www.rewa-wrg.at/
- Wirgler Haustechnik GmbH
  www.wirgler.at
- Meltem GmbH (D)
  www.meltem.de
- Lüfta Gmbh (D)
  www.luefta.de

4.2.4. Solar heating systems

Members of the organization „Austria Solar“ are all renowned producers and distributors of solar energy systems. Its 41 members cover 90% of the Austrian solar market. The organization is completed by 170 solar installers and planners.

Austria Email AG www.austria-email.co.at	Producer of storages for domestic hot water conditioners, indirect heated storages and solar systems
Austroflex Rohr-Isoliersysteme GmbH www.austroflex.com	Producer and distributor of flexible connection pipes, collector insulation layer
Bachler Austria GmbH www.bachler.at	Chief agency of international producers for solar and heating systems and environmental technologies
Bramac Dachsysteme International GmbH	Roof adjunctions for solar systems

www.bramac.at	
Buderus Austria Heiztechnik GmbH www.buderus.at	Complete systems for heating, domestic hot water, control and solar energy
Conergy GmbH www.conergy.at	Production and distribution of solar collectors for domestic hot water conditioning and solar-aided heating systems
Edelstahl-Technik Zechner GmbH www.edelstahltechnik.at	adjunctions
Ertl Glas AG www.ertl-glas.at	Producer of safety glasses, glasses for solar energy systems and photovoltaic
Eternit Werke Ludwig Hatschek AG www.eternit.at	solar energy systems
Gasokol GmbH www.gasokol.com	Development, design, production and distribution of solar systems
GEO-TEC Solartechnik GmbH www.geotec.at	Production and distribution of solar collectors
GREENoneTEC Solarindustrie GmbH www.greenonetec.com	Production of solar collectors
GT Glastex HandelsgesmbH glastex@aon.at	Production of glasses for solar energy systems and photovoltaic
Immosolar Alpina GmbH www.immosolar.com	Development, design, production and distribution of solar systems and heat pumps
Saint-Gobain Isover Austria GmbH www.isover.at	Insulation materials for collectors
IWT/TU-Graz www.iwt.tugraz.at	Institute for heat engineering
Junkers-Robert Bosch AG www.junkers.at	modern heating and domestic hot water conditioning systems
Metallwerk Möllersdorf Handelsges.m.b.H www.mmhg.at	Adjunctions
Neuma Solar www.neuma-solar.at	solar energy systems
Oventrop GmbH & Co. KG www.oventrop.at	Producer of adjunctions for building service components
RHEINZINK AUSTRIA GMBH www.rheinzink.at	Roof tiling for solar systems
ROTO Bauelemente GmbH www.roto-bauelemente.at	solar systems and photovoltaic
Schott Austria GmbH www.schott.com/austria	Distribution of vacuum-pipe-collectors, receiver for solar energy power station and PV solar electricity modules
Siko Solar VertriebsgmbH www.siko.at	Development, production and distribution of solar products
Solarfocus GmbH www.solarfocus.at	Solar energy systems, biomass boilers, storages, photovoltaic
Solar Power Austria www.solarpoweraustria.at	Solar energy systems, biomass boilers, storages, photovoltaic
S.O.L.I.D. GesmbH www.solid.at	construction of solar systems
SOLution Solartechnik GmbH www.sol-ution.com	solar energy systems, pellet boilers, photovoltaic
Sonnenkraft Österreich Vertriebs GmbH www.sonnenkraft.com	solar energy systems

Sun Master Energiesysteme GmbH www.sun-master.at	
Technische Alternative GmbH www.ta.co.at	Development, production and distribution of control units for solar and heating systems
Teufel & Schwarz GmbH www.teufel-schwarz.com	Solar energy systems and storages for domestic hot water conditioning and heating systems
Vaillant AUSTRIA GmbH www.vaillant.at	Heating systems
Velux Österreich GmbH www.velux.at	solar collectors
Viessmann Ges.m.b.H. www.viessmann.at	Production and distribution of energy saving heating systems
Max Weishaupt GmbH www.weishaupt.co.at	solar systems, hot water and energy storages, condensing heating technology
Wilo Handelsges.m.b.H. www.wilo.at	Pumps for energy efficient heating systems
Armacell Switzerland AG www.armacell.com	Producer of insulation pipe systems for solar energy systems
Austria Solar Innovation Center www.asic.at	Research and development, consulting
arsenal research www.arsenal.ac.at/eet/	Research, development, standardization, education, testing center
AEE - Institut für Nachhaltige Technologien www.aee-intec.at	Research and development, consulting, know-how transfer, education

4.2.5. solar cooling systems

- SOLution Solartechnik
  www.sol-ution.com
- S.O.L.I.D. GmbH
  www.solid.at
- Klötzl Vertriebs GmbH
  www.kloetzl.at

4.2.6. heat pump systems

- Alpha Innotec GmbH
  www.alpha-innotec.de
- Buderus Austria Heiztechnik Ges.m.b.H.
  www.buderus.at
- Dimplex
  www.dimplex.at
- Elco Austria GmbH
  www.elco.net
- Heliotherm Wärmepumpentechnik Ges.m.b.H.
  www.heliotherm.at

- IDM Energiesysteme GmbH
  www.idm-energie.at
- KNV Umweltgerechte Energietechnik GmbH
  www.knv.at
- Neura Electronics Technische Anlagen GmbH
  www.neura.at
- Ochsner Wärmepumpen GmbH
  www.ochsner.at
- Stiebel Eltron Ges.m.b.H.
  www.stiebel-eltron.com
- Vaillant Austria GmbH
  www.vaillant.at
- Viessmann Ges.m.b.H.
  www.viessmann.com
- Waterkotte Wärmepumpen GmbH
  www.waterkotte.at
- Weider Wärmepumpen GmbH
  www.wei.at
- Harreither GmbH Intelligente Energiesysteme
  www.harreither.at

4.2.7. biomass systems

- Fröling GesmbH Heizkessel- und Behälterbau
- Gilles Energie- und Umwelttechnik GmbH
- Hargassner GesmbH Hackgut - Pellets - Heizung
- Heizomat GmbH
- Herz Armaturen GesmbH
- ICS Energietechnik GmbH
- Kohlbach Holding GmbH
- KWB - Kraft & Wärme aus Biomasse GmbH
- Mawera Holzfeuerungsanlagen GesmbH
- Ökofen Metall & Heiztechnik GmbH
- SHT - Heiztechnik aus Salzburg GmbH
- Urbas Maschinenfabrik GmbH

5. Summary tables of EP and indoor climate

Building type	U-values, W/m²K		Building leakage	Ventilation	Ventilation	Energy performance, kWh/m²						
	external walls	windows	m³/h,m² at 50 Pa	system type	rate ach	Space heating heat	elect.	DHW heat	elect.	Cooling elect.	HVAC elect.	Appliances electricity
Apartment blocks from 1960-1970	0.5	3	4	Passive stack	0.6	180	-	50	-	-	n.a.	40
Apartment blocks from 1970-1980	0.28	2	2	Mech. exhaust	0.4	120	-	50	-	-	n.a.	40
Code level for new apartments	0.22	1.4	1	Mech. heat rec.	0.5	100	-	50	-	-	n.a.	40

Appendix B - Bulgaria

Bulgarian social housing context

Social housing in BULGARIA

Total number of inhabitants in Bulgaria towards December 2003: 7 801 300;

The housing stock amounted to 3 688 802 dwellings;
- Average no. of inhabitants per dwelling 2,8 ;
- 97% of the dwellings are privately owned;
- Only 3% of the dwellings are owned by state institutions or municipalities;

Energy consumption in social housing in BULGARIA

From 170 kWh/m^2 to more than 200 kWh/m^2;
- 20% of the dwellings are connected to district heating;
- 80% of the dwellings are heated by and individual heaters – wood, electricity, coal ;
- 14% of the house holds expenditures are for heating and domestic hot water;
- Many dwellings are not heated normally, either the temperature is very low, or only one room is heated;
- For a normal heating at current prices of heat energy from district heating households should spend about 40% of their incomes for energy

National legal framework with respect to EPBD implementation in Bulgaria

- Law for Energy
- Energy Efficiency Act
- Regulations to the Law for Energy Efficiency
- National energy certificates and labeling
- Regulation for energy efficiency investigation
- The conditions and the method for completing energy efficiency investigation of energy consumers by sites;
  - Technical standards in housing construction
  - National aspects of building categorization

Grant schemes for social housing refurbishment in Bulgaria

The Ministry of Economy and Energy Resources, the Ministry of Regional Development and Public Works and the municipalities are responsible for the elaboration and implementation of these schemes.
The state Energy Efficiency Agency (EEA) to Ministry of Economy and Energy Resources is also responsible for the elaboration and implementation of financial schemes for improvement the energy efficiency in buildings. The activitiesof EEA include among others:
– Improving the energy efficiency;
– Legislative regulation of the fund “Energy efficiency";
– Ensuring financial support for development of the energyefficiency in Bulgaria.

Grant schemes for social housing refurbishment in Bulgaria

In Bulgaria there are two grant schemes available for housing refurbishment. The grants/loans are provided by:

- Energy Efficiency Fund
- The Residential Energy Efficiency Credit Line, established by the European Bank for Reconstruction and Development.
- The National Program for Refurbishment of Dwelling Buildings in Bulgaria foresees also grantsfor refurbishment of dwelling buildings. The budget for 2006 was not adopted, but it is expected that the programme will start in 2008.

The Energy Efficiency Fund in Bulgaria (EEFB) established through the Law for Energy Efficiency. Initially capitalizing by grants with about 20 millions USD.

Objectives of EEFB:

EEFB have functions of: bank, tool for credit guarantees andconsulting centre. EEFB provides technical support to Bulgariancompanies, municipalities and legal persons at the elaboration ofinvestment projects for energy efficiency, after what EEFB support thefinancing.

EEFB offers the following financial products:

- Private guarantees on credits: financial guarantees up to 500 000 USDper project
- for trade banks that grant loans for execution of energy efficiencyprojects;
- Loans: loans for projects for energy efficiency with a value between 19000 USD and 1 900 000 USD with interests lower than these on the market.

The Energy Efficiency Fund in Bulgaria (EEFB)

Main requirements to the projects:

- At least 50% of the economic profits of the projects should be from proved energy savings;
- The project should implement energy efficienttechnologies with proved qualities;
- The share of the executor of the project should be at least 10% of the costs at joint financing by a bank and EEFB and at least 25% at own financing and credit from EEFB;
- The pay-back period of the project should be maximum 5 years.

Types of projects financed by EEFB:

Investments for improvement the energy efficiency of industrial processes through:

- Purchase of equipment and tools;
- Technical support and consultations for installing and training of staff for use of the new equipment and technologies;

Refurbishment of buildings in all sectors. The refurbishment should be oriented towards improvement the energy efficiency of the building through:

- Improvement of district heating substations with heat exchangers;
- Thermal insulation of walls, ceilings and roofs, improvement of windows;
- Devices for use passive solar energy;
- Improvement of heating and cooling installations andimprovement of lighting.

Types of projects financed by EEFB:

Change of fuel and improvement of heat supplying network;

- Installation of new efficient boilers;
- Installation of systems for automatic management of boilers;
- Different heaters for domestic hot water to be used in summer season;
- Changing of pipes and radiators;
- New metering devices;
- Insulation of pipes of heating installations;
- Small CHP's and high efficient thermal pumps.

EEFB -conditions

Beneficiary	Annual interest rate	Maximum period years	Own financing
Municipalities	2,5-5%	5	10-20%
Legal persons	4-7%	5	10-25%
SMEs and natural persons	6-9%	5	10-25%

The Residential Energy Efficiency Credit Line

The Residential Energy Efficiency Credit Line is established by the EBRD. It extends loans to 4 private Bulgarian banks for on lending to the residential sector for improvement in energy efficiency both in blocks of flats and individual houses.
Eligible sub-projects include the following energy efficiency improvement:

- Energy efficient windows;
- Thermal insulation on walls, roofs, slabs;
- Efficient biomass boilers;
- Solar water heaters;
- Efficient gas boilers.

The Residential Energy Efficiency Credit Line

Energy Efficiency Improvement measures	Incentives level per Measure	Incentive grant Cap per Measure in Euro
Energy efficient windows	20%	200
Wall insulation	20%	250
Roof insulation	20%	250
Floor insulation	20%	250
Efficient biomass stoves and boilers	20%	400
Solar water heaters	20%	400
Heat Pump System	20%	499
Efficient gas boilers	20%	400
Home Energy Efficiency Project	20%	850

REECL -conditions

- Interest rates – 11,5-12,5%
- Credit amount – up to 20 000 leva
- Repayment period – up to 5 years
- 4 Bulgarian banks are involved

The National Program for Refurbishment of Dwelling Buildings

Foresees also grants for refurbishment of dwelling buildings. The budget for 2006 was not adopted, but it is expected that the program will start in 2007.
The direct state subsidy amounts to 20% of the basic package of measures necessary for refurbishment of the buildings.

- The program foresees the refurbishment of 650 980 dwellings.
- The necessary funds for the first phase (2006-2015) are 670 000 000 Leva;
- The necessary funds for the second phase (2008-2020) are 3480 000 000 Leva;
- The total necessary funds are 4 150 000 000 Leva;
- The subsidies amounts to 830 000 000 Leva.

Drivers and barriers to housing refurbishment in Bulgaria

Legal barriers:

- The main legal barrier limiting the application of financial mechanisms in the social housing sector in Bulgaria is the out-of-date Law for ownership.
- The lack of housing associations. The current law requires the agreement of all owners of flats in a building to realise any improvement. There is no definition of the status of the social housings (owned or rented).
- The property in block of flats and the ownership of the land in the dwelling areas should be regulated.

Institutional barriers:

- There is no specialized institution for research and analysis ofthe situation of the social housing stock.
- There is no housing association that deals with the erection and the management of social rental dwellings.

Recommendations

For the refurbishment and the improvement of the energy characteristics of social housing in Bulgaria it is necessary to apply an integrated approach, aimed at some problems at the same time:

Legal:

- Definition of the status of the social housings (owned or rented);
- Regulation of the property in block of flats and the ownership of the land in the dwelling areas:
- Creation of representative organizations of the owners, registered as legal entities – associations of owners.
- Some requirements to the buildings owners should be normatively regulated, in order to clearly and explicitly define the obligations of the owners to maintain their property;
- At the main stages of a building refurbishment should be specified: examination of the town-planning decisions, technical examination of the building, energy audit, determination of the necessary and recommended operations on refurbishment and their evaluation, inquiry among the inhabitants, execution, preparation of a passport after the refurbishment.
- Improvement of the system for management and maintenance of buildings, subject to property in block of flats;
- Determination of statute of legal entities of the general assemblies on the property in block of flats

Technical:

- Implementation of higher standards for the energy characteristics of social housings.

Financial:

- Amendments to the tax laws;
- Amendments to the Law on banks;
- Implementation of contracting model: give subsidies for the implementation of energy efficient measures (as a kind of contracting model) instead of subsidies for heating.
- Increase of awareness:
- Implementation of an informational and educational campaign among the population;
- Elaboration and implementation of pilot projects, scientific researches and demonstration programs supported and coordinated by the state and municipal authorities.

Appendix C - Finland

OVERVIEW OF POTENTIALS AND ESTIMATED COSTS FOR ENERGY SAVINGS IN RETROFITTING OF SOCIAL HOUSING IN FINLAND

Housing stock

In Finland the total number of dwellings and single family houses is 2 500 000. Almost 90% of them have been built after 1945. Most of detached houses have been built after 1970. Distribution of building types is shown in Table 1.

Table 1. Number of households by type of building.

	Number of	%
All	2 453 000	100
Houses	1 3337 000	54,5
Single houses	996 000	40,6
Detached houses	341 000	13,9
Block of flats	1 065 000	43,4
Unknown	51000	2,1

Statistics Finland, www.stat,fi

Social housing

The history of social housing in Finland starts from 1949 when sate loaning system was established.

Single person or family is eligible for social house if maximum monthly incomes are less than shown in Table 2. These income limits are used only metropolitan areas within more than 100 000 habitants.

Table 2. Maximum monthly income ranges for social houses (Euros/month).

Number of persons in apartment					
1	2	3	4	5	6
3100	3900	4000	4100	4250	4400

Since April 2008 no income limits has been used any more. Need of home is now the main selection criteria for new tenants.

Since 1949 almost 1 million homes has been financed by Housing Finance and Development Centre of Finland.. It is almost 50 % of total production of new homes since 1949.

Social housing stock

At the end of 2000 there were 2,512.000 dwellings in Finland and at the end of 2006 ca. 2,7 million dwellings in Finland. The growth of building stock was slowing down in the 1990s

and 2000s from the preceding decades. In the 1990s, the building stock increased by 303,000 dwellings, 2000-2006 by 188 000 dwellings.
In 2006, owner-occupied dwellings accounted for 59 % of all permanently occupied dwellings, and rented dwellings for 30 %. The total number of owner-occupied dwellings was 1,599,000 dwellings. The majority of owner-occupied dwellings are single family houses, while about one third are in housing corporations, housing companies, row houses and blocks of flats.

Of the 822,000 households occupying rented accommodation, almost half live in a rented dwelling financed by State housing loans or in interest-subsidised rented dwellings. Almost half of all rented dwellings are State-subsidised, the rest being mostly owned by private households /The Housing Finance and Development Centre of Finland (ARA)/

Production of new social dwellings has been collapsed. In Helsinki 570 000 the social dwellings production rate by the City of Helsinki was 184 dwellings in the 2008. In the year 2009 the production level will be 220 dwellings. The main reasons are existed conditions of social housing loans, building cost and temporary lack of suitable land.

Statistics of Social Housing

The Following statistical tables provide information on dwellings financed with loans or interest subsidy loans of the Housing Finance and Development Centre of Finland.

The data of the statistical tables derive from administrative records of data bases of the Housing Finance and Development Centre of Finland. The statistics describing the lending activities break down into statistics on new building and renovations.

The statistical tables contain information on the number, type of dwellings and construction costs, applicants for State financed rental dwellings and the number of homeless people.

New buildings

In Tables 3 and 4 are shown type of social homes built since 1949. Most of them are located in blocks of flats. Detached houses for rental purposes have been built since 1970. Te proportion may be 15% but this is uncertain because no relevant statistics were found.

Table 3. Dwellings financed by State-subsidised loans in 1949-2006.

Rental dwellings	Year of loan					
	1949-70	1971-80	1981-90	1991-2000	2001-06	Total
Rental houses	66205	113960	80854	55608	9730	258603
Dwellings for the elderly		22698	11833	8634	2641	45806
Special housing	2535	1248	1420	2444	2706	10353
Right of occupancy dwellings				23314	4811	28125
Student dwellings	2700	11897	11048	7068	3062	35775
Total	72000	137000	94000	96000	28000	428000

Table 4. Interest subsidy loans in 1981-2006.

Rental dwellings	Year of loan			
	1981-90	1991-2000	2001-06	Total
Rental houses	4574	42602	13346	61522
Right of occupancy dwellings		3652	1293	4945
Total	4574	46200	14600	66500

Since 1948 182 000 single family houses have been built with social housing loans. These houses are any more social housing. Also 260 000 private apartments block of flats have been built. Those apartments drop automatically outside social housing when state loans are amortized.

Renovation

The numbers of renovated social rental dwellings are shown in Table 5. Typical renovation consists of new plumbing system, modernization of ventilation, new kitchen and bathroom, new windows and renovation of outer surfaces.

Table 5. Renovation financed by State-subsidised loan or interest subsidy loan.

Rental dwellings	Year of loan				
	1973-80	1981-90	1991-2000	2001-06	Total
State-subsi dised loan	7362	30619	90258	18988	147227
Interest subsidy loan		1902	10292	7600	19827
Total	7362	32500	100500	26600	167000

More than one third of social homes have been renovation. State gives annually 15 millions euros for private housing corporations to improve energy efficiency. This money is mainly used for new windows and extra insulation of outdoor walls.

One of the lowest energy costs in EU together with the primitive energy performance regulation, which until 2003 was based on U-value requirements only, have led to somewhat poor energy performance especially in the cost sensitive residential building market. Heat recovery from exhaust air, better U-values and better air tightness have not been required during renovation process. The new building code in 2010 may change the situation.

2. Regulations and building codes

G2 General regulations for social housing production

Special requirements for social housing project.

C2 U-values

U-values for new buildings are shown in Table 6.

Table 6. U-values for new buildings.

Building part	U-value, W/K,m²
Roof	0.15
Wall	0.24
Window	1.4
Floor	0.24

These values will be updated in the year 2010.

D2 Ventilation and indoor climate

Finnish building code, part D2 Indoor Climate and Ventilation [1] includes minimum requirements for adequate ventilation and IAQ and thermal comfort. For a long time, since 1966 to 2002 a minimum outdoor air flow rate of 4 l/s per person and 0.5 ach have been a requirements or guidelines (still interpreted as minimum requirements) stated in the building code and its predecessors. The regulation demanding the end result, i.e. being based on guideline values of airflow rates (not intake areas or other descriptive requirements) has made possible a flexible development of ventilation systems. There have been no requirements referring to mechanical supply ventilation system or heat recovery until 2003. This regulation led to mechanical exhaust ventilation in apartment buildings for many decades. In Table 7 are shown older and existing minimum ventilation requirements for new buildings and renovation.

Table 7. Design exhaust air flow rates.

Space	Design exhaust air flow l/s				
	1955	1966	1978	1987	2003
Kitchen	27	22	22	20	8-20
Bathroom	16,6	16,6	16,6	15	10-15
WC	8,3	8,3	8,3	10	7-10

Outdoor air vents in bedrooms and living room have been required since 1987. The building code has promoted the use of cooker hoods since 1987, as guideline value for kitchen extract was 20 l/s with hood and 50 l/s without hood (i.e. assuming 60% capture efficiency for the hood). From 2003 this guideline is not any more given as all new kitchens have cooker hoods anyway.

From 2003, the building code increased the airflow rate guideline value from 4 to 6 l/s per person and introduced a new requirement for heat recovery: 30% of heat energy of exhaust air shall be recovered. This heat recovery requirement was launched to supplement the rather primitive energy performance regulation based only on U-value requirements. However, it did change ventilation system in apartment buildings. Mechanical exhaust ventilation was no longer used and completely replaced by mechanical supply and exhaust ventilation with heat recovery. Both central air handling units and small units in each apartment are commonly used in these buildings. Another change was in air flow rates, as 12 l/s per bedroom was generally accepted as design value. In reality, lower ventilation rates are often used as air handling units are operated at lower speed.

3. Description of the most common multifamily building groups

During the 1950's and 1960's there was often some attic space. Flat roof was used during the 1970's and 1980's. Underground cellar was used during the 1950's and 60's. After 1971 air-raid shelters could be placed in ground floor and use of underground cellars stopped. Crawl spaces were not used until 1990's.

U-values and structures of apartment building structures

In Table 8 are shown the typical U-values

Table 8. Typical U-values / www.sureuro.com/

Period of Construction	Base Floor [W/m²K]	Roof [W/m²K]	External Wall [W/m²K]	Windows [W/m²K]
1951-1960	0,53	0,39	0,7	2,5
1961-1970	0,42	0,34	0,55	2,5
1971-1980	0,38	0,3	0,38	2,1
1981-1990	0,34	0,22	0,28	1,8
1991-2000	0,34	0,22	0,28	1,8

External wall

In Table 9 are shown typical external wall structures.

Table 9. Typical external wall structures

PERIOD	TYPICAL EXTERNAL WALL STRUCTURES
1950-1960	- 1,5- hollow core bricks (420mm), no insulation - 1,5- hollow core bricks (420mm) + wood wool (65-75mm) - aerated concrete (50-150mm) + 1-1,5 hollow core bricks (270-420mm) - 0,5- hollow core brick (130mm) + mineral wool (50mm) + hollow core brick (270mm) - brick (150mm) + aerated concrete (100-200mm) + brick with sawdust (75mm) - aerated concrete (200-300mm) - aerated concrete (175mm) + reinforced concrete (150mm) - asbestos cement board + air gap + wood-wool (125mm) + reinforced concrete (150mm) - asbestos cement board + air gap + windshield 3mm + mineral wool (80mm) + reinforced concrete (150mm) - reinforced aerated concrete (250-300mm) - (Light Expanded Clay Aggregate; LECA)
1960-1970	- 1,5- hollow core bricks (420mm), no insulation (until year 1965) - 0,5- hollow core brick (130mm) + air gap + mineral wool (50-100mm) + hollow core brick (130-200mm) - asbestos cement board + air gap + windshield 3mm + mineral wool (75mm) + hollow core brick (200mm) - 0,5- hollow core brick (130mm) + air gap + mineral wool (50-100mm) + reinforced concrete (80/150-160mm) - asbestos cement board + air gap + windshield 3mm + mineral wool (75-100mm) + reinforced concrete (80/150-160mm) - reinforced aerated concrete (250-300mm) - aerated concrete (175-200mm) + reinforced concrete (80/150160mm)

PERIOD	TYPICAL EXTERNAL WALL STRUCTURES
	- concrete sandwich element: concrete (40-50mm) + mineral wool (80-90mm)+ concrete (80/150-160mm) - building board + air gap + windshield + mineral wool 100mm + building board - concrete sandwich element: concrete (40-50mm) + wood-wool (125-150mm) + concrete (80/150-160mm) - (Elements of Light Expanded Clay Aggregate; LECA)
1970-1980	- concrete sandwich element: concrete (50-60mm) + mineral wool (100-120)+ concrete (80/150-160mm)
1980-1990	- concrete sandwich element: concrete (50-60mm) + mineral wool (120-140)+ concrete (80/150-160mm)
1990-2000	- concrete sandwich element: concrete (50-60mm) + mineral wool (140-200)+ concrete (80/150-160mm) - concrete element (50-70-90mm) + air gap (30mm) + mineral wool (150-200mm) + concrete element (100-200mm)

Source www.sureuro.com

Roof

In Table 10 are shown typical insulated roof structures.

Table 10. Typical insulated roof structures

PERIOD	TYPICAL INSULATED ROOF STRUCTURES
1950-1960	- screed (5…15mm) + reinforced concrete slab (40mm) with 130*360mm concrete beams + aerated concrete (150mm) + reinforced concrete slab (40mm) - screed (5…15mm) + reinforced concrete slab (150-170mm) + aerated concrete (130-160mm) + reinforced concrete slab (60mm) - screed (5…15mm) + reinforced concrete slab (150-170mm) + wood-wool (100-200mm) + tar paper + reinforced concrete slab (60mm) - screed (5…15mm) + reinforced concrete slab (150-170mm) + LECA (200-300mm) + tar paper + reinforced concrete slab (60mm)
1960-1970	- screed (5…15mm) + reinforced concrete element (150-160mm) + wood wool (150mm) + concrete (20-50mm) (wood wool is produced until 1967) - screed (5…15mm) + reinforced concrete slab (150-170mm) + LECA (250-350mm) + roll roofing - screed (5…15mm) + reinforced concrete slab (150-170mm) + mineral wool (125-150mm) + 3*roll roofing
1970-1980	- screed (5…15mm) + reinforced concrete slab (150-170mm) + mineral wool (150-175mm) + 3*roll roofing - screed (5…15mm) + reinforced concrete slab (150-170mm) + LECA (250-350mm) + roll roofing
1980-1990	- screed (5…15mm) + hollow core slab + vapour barrier (0,2mm) + mineral wool (200…250mm) + windshield of mineral wool (30mm) + ventilated space and roof structures - screed (5…15mm) + reinforced aerated concrete (250mm) + mineral wool (100mm)

PERIOD	TYPICAL INSULATED ROOF STRUCTURES
	+ wind shield of mineral wool (30mm) in the edge zone + ventilated space and roof structures
1990-2000	- screed (5…15mm) + hollow core slab + vapour barrier (0,2mm) + mineral wool (200…250mm) + windshield of mineral wool (30mm) + ventilated space and roof structures - screed (5…15mm) + reinforced aerated concrete (250mm) + mineral wool (100mm) + wind shield of mineral wool (30mm) in the edge zone + ventilated space and roof structures

Source www.sureuru.com

Window

In Table 11 are shown typical windows.

Table 11. Typical windows.

PERIOD	TYPICAL WINDOWS
1950-1960	- 2-glass windows, wooden frames
1960-1970	- 2-glass windows, wooden frames
1970-1980	- 2- and 3-glass windows, wooden frames
1980-1990	- 3-glass windows, wooden and aluminium frames
1990-2000	- 3-glass windows, wooden and aluminium frames

Heating

If any district heating ia available then all social houses are connected in district heating. There are some smaller towns without district heating system. In that case the main fuel is oil.

Normal heating solution inside dwelling is hot water radiator system. Domestic hot water is produced centralized from district heat.

Ventilation

Centralized and time controlled mechanical exhaust ventilation was the cheapest ventilation system. Almost all social homes have that system. Since 1953 all new block of flats with more than three floors over basement floor) have built mechanical exhaust aur ventilation system. .In the other block of flats buildings passive stack ventilation system was used until the end of 1960's. Since 1960's ventilation duct system have made from steel ducts. Typical exhaust fan is 2-speed fan. The full speed (design air flows) is normally used 6-8 hours per day. During the night time ½-speed is used. Buildings built between 1978 and mid 1990's full speed is not used when outdoor air temperature is less than -12°C (Helsinki) -15°C (Central Finland). In Table 12 are shown distribution of ventilation systems in different decades.

All apartment buildings have at least passive stack ventilation system with exhaust air ducts from kitchen and WC/bathroom. There is room for exhaust air ducts of balance ventilation system with separate ventilation units in each apartment with air intakes in outer wall. It is not possible to exhaust air from outer wall. Exhaust air should be ducted to roof level.

Table 12. Distribution of ventilation systems in different decades.

Period of construction	Passive stack ventilation	Mechanical exhaust ventilation	Mechanical supply and exhaust ventilation with heat recovery unit
	share of building stock %	share of building stock %	share of building stock %
1951 - 1960	70	30	0
1961 - 1970	30	70	0
1971 - 1980	10	90	0
1981 - 1990	0	95	5
1991 - 2003	0	75	25
2003-	0	0	100

Statistic shown in Table x is very old. It is realistic to assume that most passive stack ventilation system has been updated mainly mechanical exhaust system. During the early 1990's mechanical supply and exhaust air units with heat recovery were used commonly when passive stack ventilation system was renovated.

Average air change rates and air tightness

Actual air flows in apartments are lower than design values because the pressure losses caused by outdoor structures were neglected during design process of ventilation system. In apartments with passive stack ventilation system the average air change rate was 0.64 ach/h and in apartments with mechanical exhaust 0.68 ach/h. /Ruotsalainen et al. 1992/

As there has been no requirement for air tightness of buildings in the building code, Finnish houses are relatively leaky as regards a cold climate. There are only limited amount of air tightness data from older apartment buildings. In individual apartments measured air tightness has been from 1.0 to 5 1/h.

Energy use

In table 13 are shown statistics for heating energy consumption and electricity of building service and water consumption. Unfortunately all energy performance statistics in Finland have been using kWh/m^3 not kWh/m^2.

Table 13. Heating (including hot water) energy consumption and electricity for building services and water consumption.

	Heating energy consumption		Electricity for building services		Water consumption	
Period of construction	median (kWh/m³)	80 % of the building stock situates between following limits (kWh/m³)	median (kWh/m³)	80 % of the building stock situates between following limits (kWh/m³)	median (l/person/day)	80 % of the building stock situates between following limits (l/person/day)
1950 - 1960	52,1	40,2 – 62,2	2,4	1,2 – 4,4	170	131 – 216
1960 - 1970	55,0	45,0 – 65,4	3,4	1,8 – 5,3	176	138 – 227
1970 - 1980	49,6	41,5 – 58,7	4,2	2,7 – 6,3	173	136 – 215
1980 - 1990	47,6	38,8 – 58,0	4,4	2,6 – 6,3	164	132 – 199
1990 -	47,7	40,0 – 58,0	4,4	2,3 – 6,3	164	132 – 197

Source VTT report Nippala et. al

Specific energy use has been decreasing by 10 per cent since 1950's. From 1990 minimum ventilation has been increased by obligatory fresh air vents both in new and renovated apartment buildings.

In Finnish certification for building energy use it is assumed that proportion of domestic hot water is 40 % of total water consumption (Ministry of Environment). Heating of one cubic meter of water needs energy 58 kWh. In building with average daily water use of 120 l/day per habitant this means annually 1000 kWh per person. In building with average daily water use of 200 l/day per habitant this means annually 1700 kWh per person..

Production of domestic is centralized in Finnish apartment buildings. This requires separate circulation pipeline and pump in order to keep hot water temperature in pipeline enough high. This increases domestic hot water energy use.

Household energy use

Local electricity company in Helsinki has collected statistic dealing with domestic electricity use, table 14.

Table 14. The average use of household electricity in Helsinki.

Number of people	Number of rooms					
	1	2 + small kitchen	2 + kitchen	3 + k	4 + k	5 + k
1	950	1200	1450	1900	2200	2700
2	1300	1800	2100	2500	3000	3550
3	1750	2250	2600	2900	3500	4050
4		2750	3050	3550	4150	4750
5			3250	3900	4550	5300

Household electric energy use values shown in the table 13 means 20 – 60 kWh/m^2.

Centralized mechanical supply and exhaust ventilation systems

Centralized supply and exhaust ventilation systems seems to save 10 kWh/m^3 heating energy use. At the same time the total electric energy used for building service system in such blocks of flats is increased 100%. That means 3 kWh/m^3 for running of the centralized supply and exhaust ventilation system in block of flats. Similar trend was found in Eko-Viikki ecological experimental area built in the beginning of 2000. Heating energy use was 140 and 110 kWh/m^2 and electricity use of building services was 10 and 20 kWh/m^2.

Small ventilation units

Small ventilation units with heat recovery have been used in new block of flats. Also in the beginning of 1990's when renovation costs were lower than now such devices were used in many renovated social house. Some data was available. Household electricity use was 20 kWh/m^2 higher in apartments with mechanical supply and exhaust ventilation unit in each apartment than in apartments connected to mechanical exhaust ventilation only or centralized mechanical supply and exhaust ventilation system.

Space in existing shaft for installing air ducts

In the houses with mechanical exhaust ventilation the design exhaust air flows have been quite unchanged. It is possible to build exhaust air system up to 1.0 ach. Exhaust air air shafts were made from concrete until the end of 1960's. There often in poor conditions and difficult to clean. It might be to replace them by modern duct system.

In the naturally ventilated houses the shaft are rather large to ensure well functioning passive stack ventilation - theoretically. Fresh air vents were during 1930's but due to draught problems they were covered and have out of use. There are more space in existing shafts for installation of ducts in older apartment buildings. These shafts made from brock are often very poor conditions. .

District heating system in Finland

Nowadays all cities have district heating network available. Almost all apartment buildings have been connected with district heating.

Production of district heating energy in 2008 was 32 TWh, 74 % (24 TWh) was connected with production of electricity (www.energia.fi). The amount of electricity produced together with district heating was almost 15 TWh. This was 17 % of total the total electricity use in Finland in 2008.

The most important fuel was natural gas, 36.5 %. Coal was in second place (23.5) and peat in third place (21 %). The proportion of wood and other biomass was 11 % and oil 4.6 %. Natural gas and coal are the main fuels in Southern Finland. Peat and wood elsewhere.

Typical indoor climate

Design exhaust air flows in apartments buildings have been unchanged since 1950's. At least 0.5 ach has been required. Practically the pressure resistance of windows and outer walls have not been thought when those exhaust air systems have been design. The actual air change rate is 0.3-0.4 ach. In bedrooms there are no air flow routes (door cracks) between bedroom and bathroom (kitchen). If bedroom door is kept closed during night the CO_2-levels can be as high as 2000-3000 ppm.

In social housing no kitchen hoods was installed before 1987. In Finland there are no mandatory inspections for ventilation systems.

In Finnish study the most common IAQ problems in apartment buildings built 1950-80's were dryness, stuffiness, warmness, coldness of floors and insufficient ventilation (Ruotsalainen et al.).

Local producers:

Ventilation units for housing:
Vallox.com
Enervent.fi
Svegon.fi

Heating and sanitary pipes:
Uponor.com

Radiators
Rettig.com

Faucet systems
Oras.com

4. Summary tables of EP and indoor climate

Potential energy saving

In mid 1990's Finland were some experimental projects dealing with low-energy renovation. Estimated savings if reduction of 50 % is possible.

Table 15. Estimated heating energy use in blocks of flats in year 1994.

Year	Heating energy 1994 MWh	Reduction -50%
-1949	186 000	93 000
1950-1959	1110 000	832 000
1960-1969	2640 000	1320 000
1970-1979	4030 000	2015 000
1980-	4400 000	2200 000
	12366 000	6183 000

Source VTT report (Hekkanen)

In 2008 average prize of district heat is Helsinki was 33 €/MWh. Potential savings are 200 M€/year. In social housing this saving might be 100 M€/year.

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Pictures from typical social houses in Finland

Examples from social housing from 1950's to 1980's.

1950's

1960's

1970's

1980's

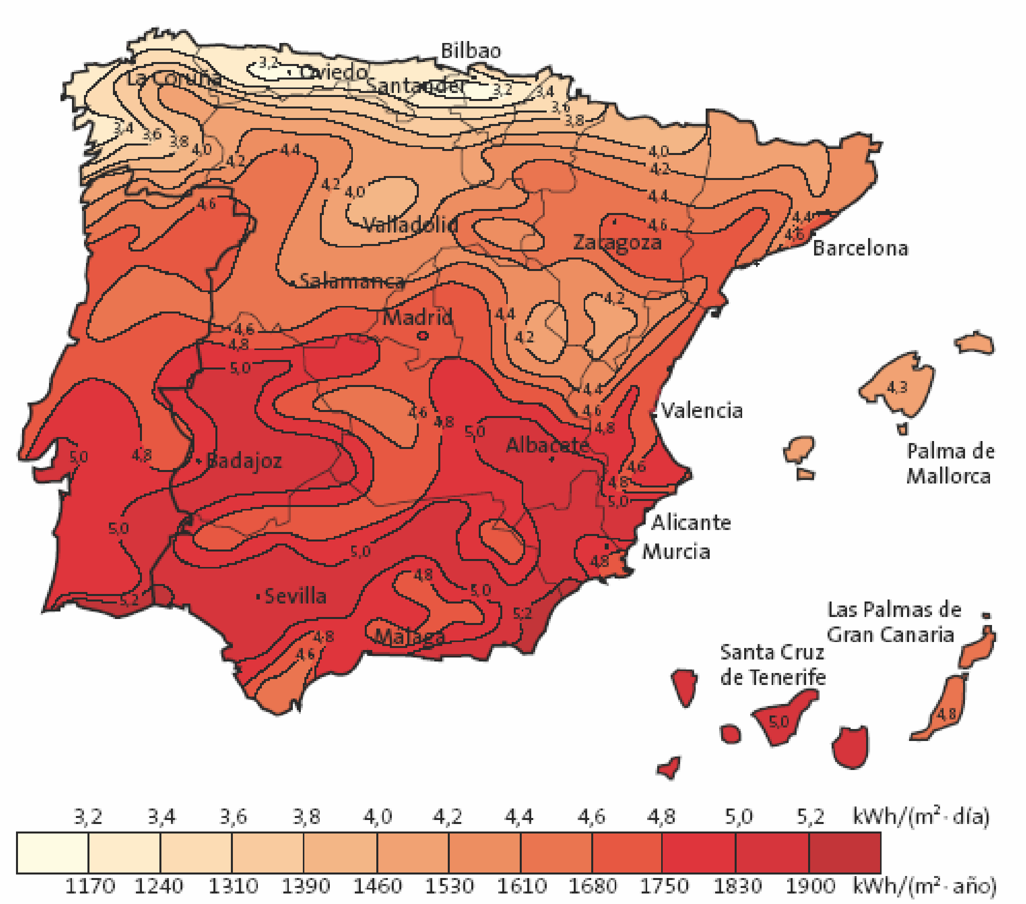
Appendix D - Spain

Survey of National Conditions: SPAIN

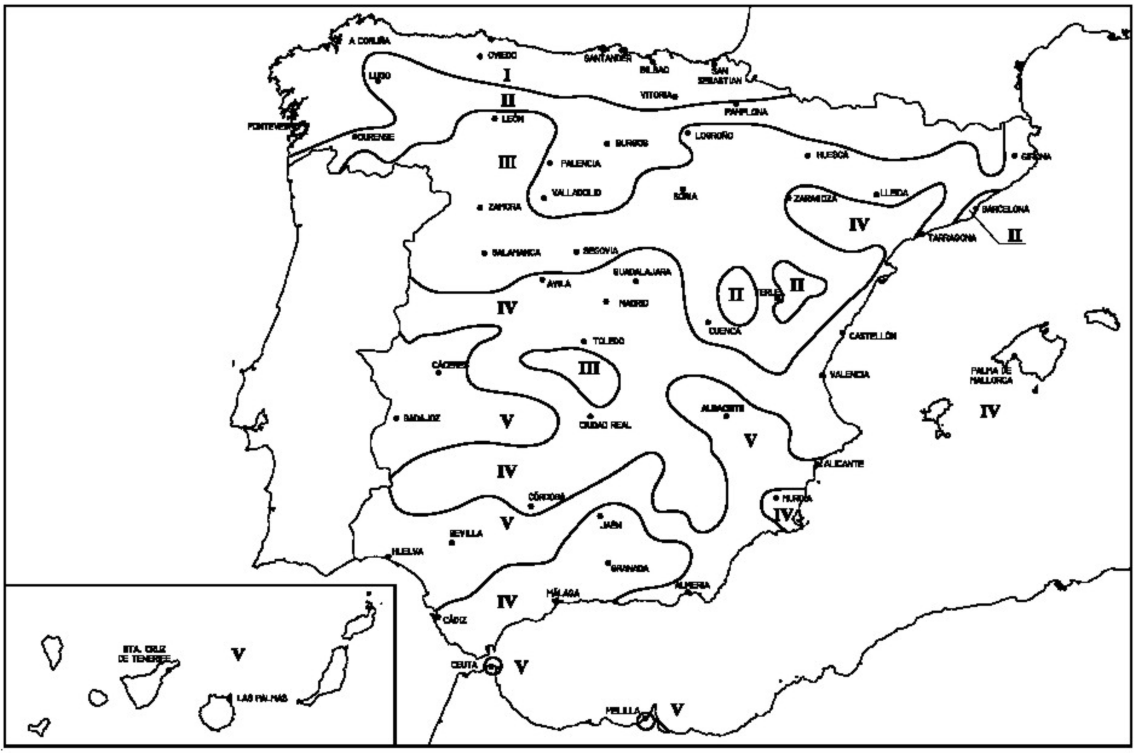
General conditions

Climate

Spanish climate is characterized by mild winters and hot summers, but with important differences respect to latitude, and distance to the sea.



Solar radiation map



Climatic zones

Climate and energy

The main characteristics of Spanish climate (with important variations) are:

- mild temperatures in winter: in southern and Mediterranean regions space heating is necessary only few months per year
- relatively high temperatures during two or three summer months
- in some regions the energy consumption in summer is higher than winter because space refrigeration
- space refrigeration is growing overall Spain individual space heating and refrigeration systems are most usual than centralized systems

Social housing in Spain

There are two models of housing: protected and free housing

- Protected housing: dwelling which cost is reduced by a subsidy from a public administration. Has a maximal surface and price limited by a government resolution.
- Free housing: not protected housing or old protected housing

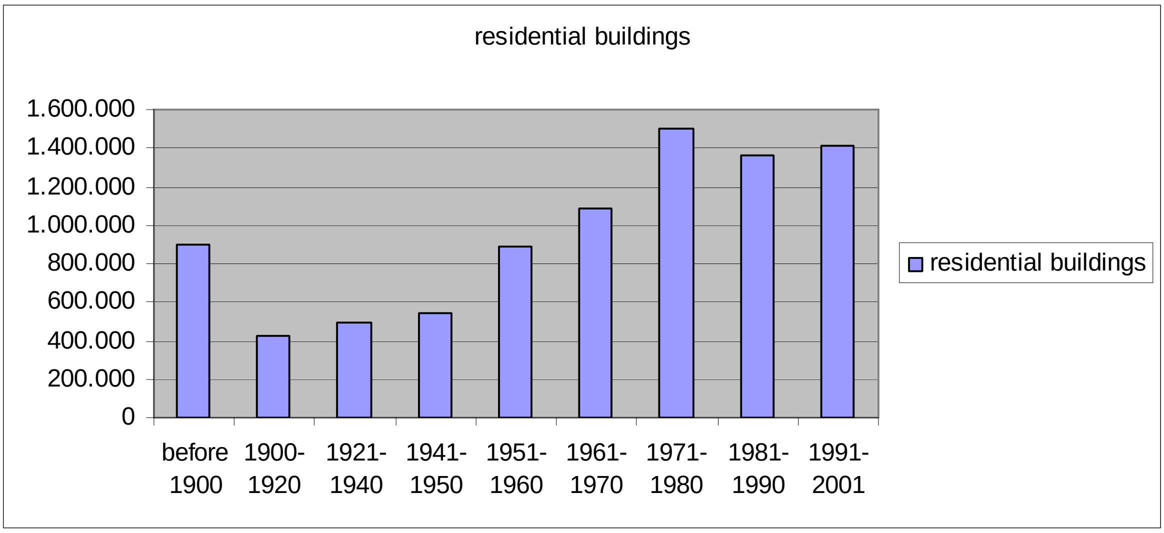
Social housing usually is promoted by public administrations (autonomous governments and municipalities).

Building survey (of all residential buildings)

Age

The building stock renovation is very high, mainly during the lasts 40 years.

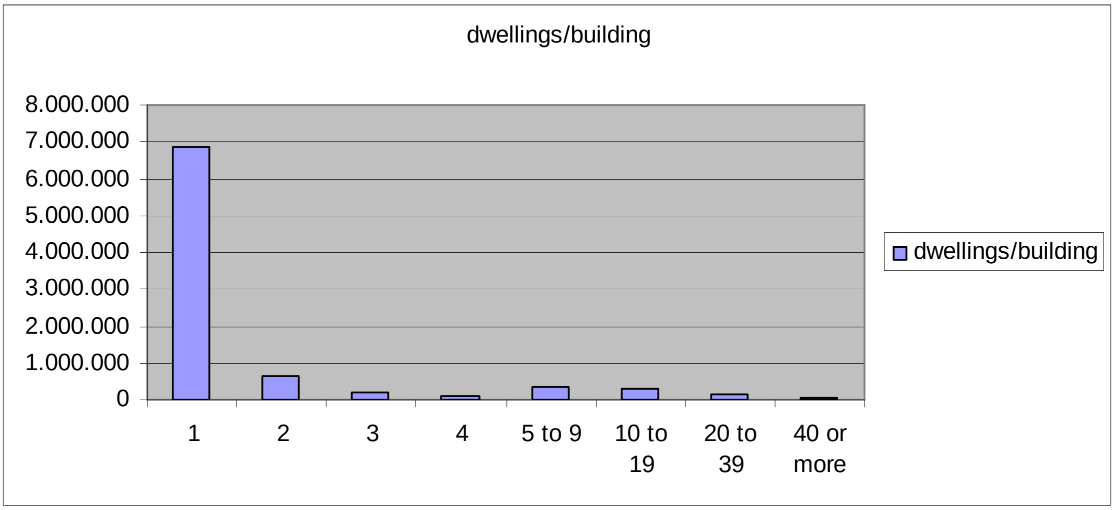
Construction year		before 1900	1900-1920	1921-1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2001
Total	8.623.875	901.299	426.872	497.039	539.425	886.544	1.090.319	1.504.984	1.360.191	1.417.202
%	100	10,5	4,9	5,8	6,3	10,3	12,6	17,5	15,8	16,4



Size

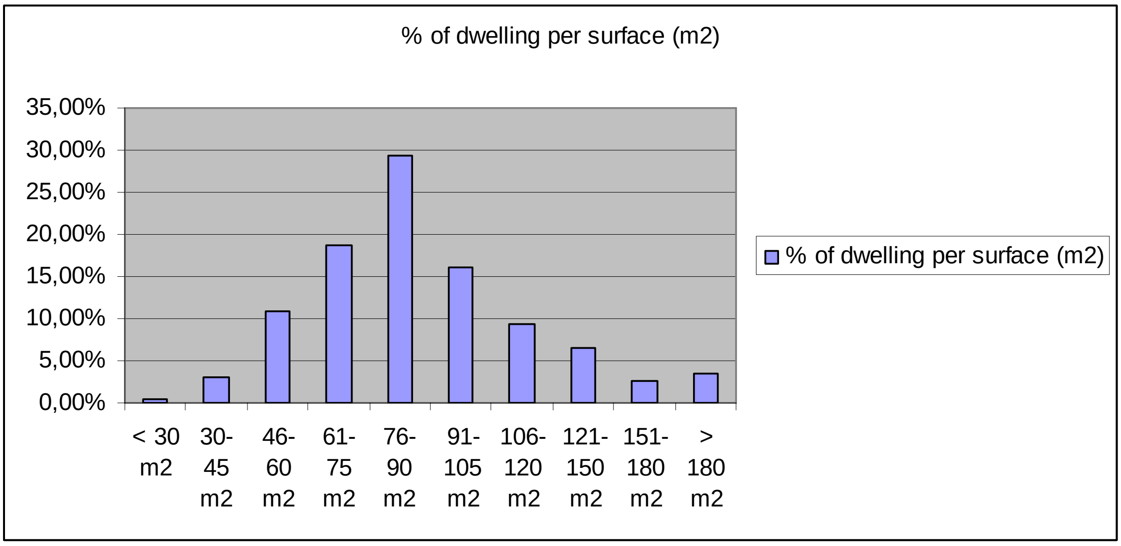
The number of single family houses is very high, with a high proportion of secondary homes. However, the number of dwellings existing in multifamily buildings represents the 62% of the total.

Number of dwellings per building	TOTAL	1	2	3	4	5 to 9	10 to 19	20 to 39	40 or more
TOTAL	8.623.875	6.885.843	623.788	174.345	121.046	356.282	302.102	129.658	30.811
%	100	79,8	7,2	2,0	1,4	4,1	3,5	1,5	0,4



Surface of dwellings

78% of dwellings in Spain have a useful surface less of 105 m2. The most usual surface are between 76 and 90 m2 (30%).



Space heating energy

The individual heating system is the most usual in Spain and represents the 89% of all dwellings provided with a heating system. Collective heating systems in multifamily buildings have not been promoted by energy companies (gas and electricity). District heating is virtually inexistent, but few recent projects (with heating and cooling) had been implemented.
The most usual energy sources gas and electricity (65%).
15% of dwellings have no heating system.

Space heating system	TOTAL	collective system	individual system	partial heating	no system	%
TOTAL	14.184.026	1.338.519	5.467.998	5.319.745	2.057.764	100
Gas	4.708.720	436.546	3.008.857	1.263.317	-	33,2
Electricity	4.488.080	49.906	1.085.537	3.352.637	-	31,6
Oil	1.990.209	756.129	1.125.112	108.968	-	14,0
Wood	358.528	9.202	95.468	253.858	-	2,5
Coal	533.766	77.272	140.047	316.447	-	3,8
Other	46.959	9.464	12.977	24.518	-	0,3
not aplicable	2.057.764	-	-	-	2.057.764	14,5
%	100	9	39	38	15	

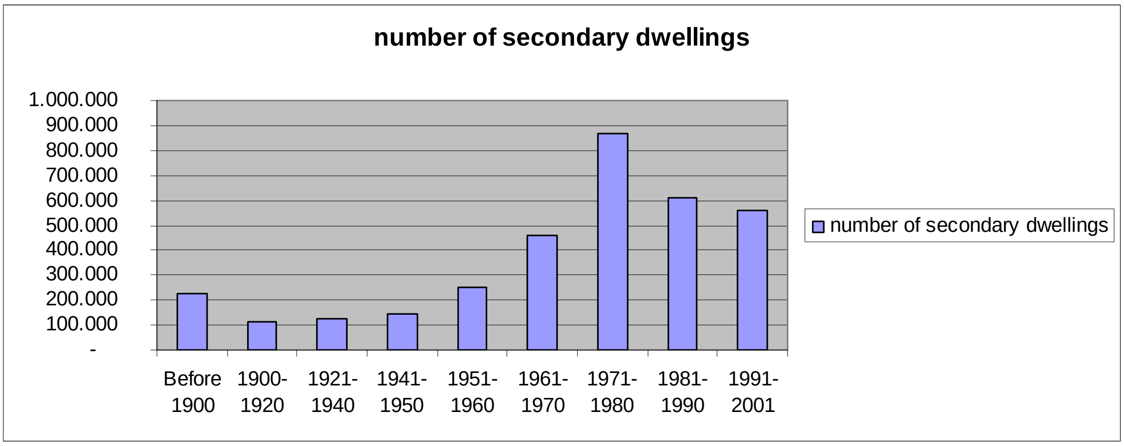
Housing by use

A significant fraction (16%) of existing housing is not used as a principal home. A large fraction of them are single family buildings. The figure of empty dwellings is also very high, a significant part of them bought by speculation purpose.

USE	number of dwellings	%
TOTAL	20.954.857	100
Principal	14.184.026	67,7
Secondary	3.360.631	16,0
Empty	3.106.422	14,8
Other	295.475	1,4

Secondary housing

The building year of construction of the actual secondary housing show the high increase of this buildings when the after war economical difficulties was overcome, mainly during the seventies.



Property vs. renting

Spain is a home property lover's country. More than 80% of principal dwellings are owned by its users. Only 11% of principal dwellings are rented.

Principal dwellings	%
TOTAL	100
property	82
rented	11
other	6

Protected housing

The equivalent of social housing in Spain is the protected housing. These buildings are granted by a public administration of any kind of public aid in order to reduce their cost. Its useful surface and final price are limited by law.

The number of protected dwellings built or refurbished per year during the last 15 years is showed in the next table.

Protected dwellings build per year

TOTAL	1991	1992	1993	1994	1995	1996	1997	1998
	44.514	35.695	45.795	67.639	71.141	77.544	85.028	74.597
	1999	2000	2001	2002	2003	2004	2005	2006
915.689	55.972	52.318	53.413	37.544	40.994	54.630	60.608	58.257

Refurbished protected dwellings

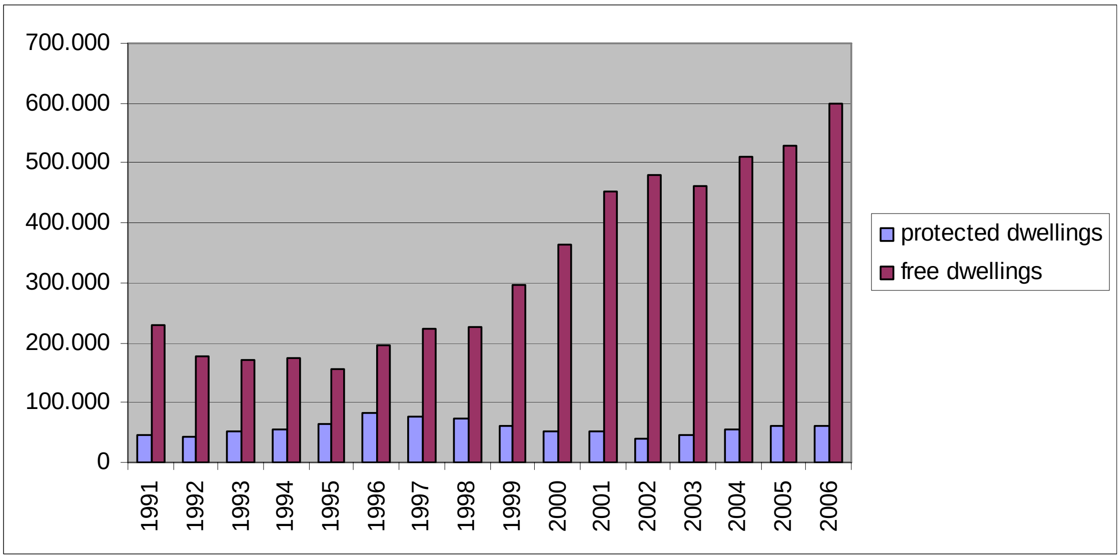
TOTAL	1991	1992	1993	1994	1995	1996	1997	1998
	12.906	11.065	9.648	13.227	16.743	19.729	25.312	17.409
	1999	2000	2001	2002	2003	2004	2005	2006
503.800	22.312	36.408	54.112	47.249	62.470	55.111	47.687	52.412

These figures can be compared with the free dwellings built in the same period.

Free dwellings build per year

	1991	1992	1993	1994	1995	1996	1997	1998
New free dwellings per year	227.970	178.501	170.403	174.793	155.902	194.871	224.332	226.631
	1999	2000	2001	2002	2003	2004	2005	2006
	296.250	362.940	452.252	480.729	462.730	509.293	528.754	597.632

Only about 15% (1991-2006 mean) are protected dwellings



It's also important to remark that the number of residential buildings (free and protected housing confused) have reached an extraordinary figure during the last five years: 600.000 (2006) to 800.000 (2007) apartments (more than UK + France+ Germany), clearly higher than the actual demand.

Families spend 40-45% of their incomes to pay their apartment, due to a high increase of building cost. The actual mean cost in Spain is 2.085 € /m2 (end 2007), but there are great differences between rural areas and big towns. Towns like Barcelona and Madrid experienced a cost increase, between 1997 and 2007, higher than 100%.

Growth and fall of construction sector

The growth of the building sector in Spain has been high, 5% per year in 1996-2007. Between 1998 and 2007, the housing stock grew by 5.7 million, nearly 30%. In the third quarter of 2007, construction accounted for 13.3% of total employment, far above than, for example, 6.7% in Germany or 8.5% in the UK.

Several factors have stimulated the demand for housing: an exaggerated economic expansion (partly due to real estate boom itself), a fall in unemployment and cuts in mortgage interest rates after the integration into the euro (from 11% in 1995 to 3.5% in 2003-2005). These rates were often negative after discounting inflation. Moreover, banking competition has facilitated access and improved conditions of mortgage credit. Another factor was the increase of the number of households, especially due to a massive influx of immigrants (about 4.2 million between 1996 and 2007). Finally, the purchase of properties by families not living in Spain has increased by a scale that is hard to calculate.

Supply responded to increased demand, as the data above demonstrates, but could not completely satisfy it, leading to large increases in housing prices: an annual building inflation rate of 1% in 1995-1997 came to 18 % in 2003 and 2004. On average, between 1995 and 2007, house price inflation was nearly 10% annually. In fact, to the extent that agents have expectations of future increases in housing prices and demand is positively influenced by them, for a time one can see a spiral of growing demand, supply and prices.

The crash of the building bubble during 2008 in Spain provoked that the sale of homes plummeted. It is estimated that at the end of the year there were between 650,000 and 1.3 million unsold new homes.

In any case, the revaluation of property in Spain between 1997 and 2007 was 191%. More rigorously, the key factors mentioned above (the expansion, interest rates …) are not explained by price alone. It seems clear that a significant part of inflation in housing is due to speculative reasons: people bought houses as investments, because they expected them to be revaluated. Furthermore, it was considered a safe investment compared to the risk of financial assets.

Building and energy

Building rules prevalent in each period determine the new buildings quality, under the energy point of view. The most important changes on building rules have been the following:
Before 1977 no thermal and energetic rule for new buildings were applied
1977: first building rule, *Normas Básicas de la Edificación* (NBE) including thermal performances (RD 1650/1977)
2000: municipal solar ordinances
2006-2007: Implementation of building and energy efficiency EU directives
Código Técnico de la Edificación (CTE) (Building Technical Code) (RD 314/2006)
Reglamento de Instalaciones Térmicas (RITE) (Thermal Installations Regulations) (RD 1027/2007)
New buildings energy efficiency certification (RD 47/2007)

Before 2007 the usual typology of collective residential building had the following parameters:

- Concrete structure
- Ceramic or concrete block envelope walls
- Envelope insulation (internal side or in air cavity)
- Cement or ceramic finished façades
- Single pane glazing
- Wood window frames (most recently also plastic and aluminium frames are installed)
- Individual heating systems, with gas boiler and radiators
- the centralized ventilation installations are only common in service and administrative buildings
- renovation air heat exchangers are unusual
- building air tightness usually is low
- renovation air is procured by opening windows
- heating and space refrigeration in most homes operate only during some hours per day
- energy metering integrate many different consumptions (gas: kitchen, hot water, heating), so it's impossible to know separate heating or refrigeration expenditure
- centralized heating or space refrigeration (and paying the consumed energy) are not usual

New energy rules
With the approved CTE (Building Technical Code) (2006) and RITE (Thermal Installations Regulations) (2007), all the aspects of building design have changed. The most important improvements on the energy aspects are:

Hot water
Solar equipments are compulsory in all buildings

Heating and cooling
Higher reduction of thermal transmissivity of building envelope (walls, roof and windows) than before
Solar protection on windows

Ventilation
Mechanical ventilation are mandatory in new buildings, and also in multifamily buildings
Its aim is improve the indoor air quality :

- Mandatory maintenance programme
- No reference to energy efficiency or heat recovery from extracted air
- Permanent forced ventilation will increase the energy loss during the space heating or refrigeration season
- Mandatory heat recovery from extracted air when >0,5 m3/s
- Mandatory free cooling when refrigeration unit power is > 70 kW
- Individual energy consumption metering (hot water, heating and cooling) in centralized installations

The objective of the *New buildings energy efficiency certification* is to improve the energy information available to the final user of dwellings and other buildings types. The owner of all residential buildings to be sold or rented must to provide an energy efficiency certification (in terms of kg of CO2 emissions and kWh/m2).
The energy consumption rates and CO2 emissions rates (heating and cooling) for each certification level in Spain are showed in the following table.

heating demand kWh/m2 year		cooling demand kWh/m2 year	
<23.8	A	<7.2	A
23.9-38.6	B	7.3-10.4	B
38.7-59.9	C	10.5-14.8	C
60.0-92.1	D	14.9-21.5	D
>92.2	E	>21.6	E

heating emissions kgCO2/m2 year		cooling emissions kgCO2/m2 year	
<7.6	A	<1.8	A
7.7-12.4	B	1.9-2.6	B
12.5-19.2	C	2.7-3.7	C
19.3-29.5	D	3.8-5.3	D
>29.6	E	>5.4	E

Energy retrofitting

Fulfilment of CTE rules on building thermal retrofitting would produce an important reduction of energy consumption in the existing residential building.
Only the improvement of the building envelope could reduce dramatically the energy consumption. The new thermal values of an old building retrofitted according the CTRE rules would reduce its thermal demand around 60%.

- Façades external insulation with 6 cm of insulation material (thermal conductivity 0.035 W/m2 K) .
- Roof insulation with 8 cm of insulation material (thermal conductivity 0.035 W/m2 K) and a vented cover
- Change of windows (better air tightness and double glazing) (< 3.0 W/m2 K).

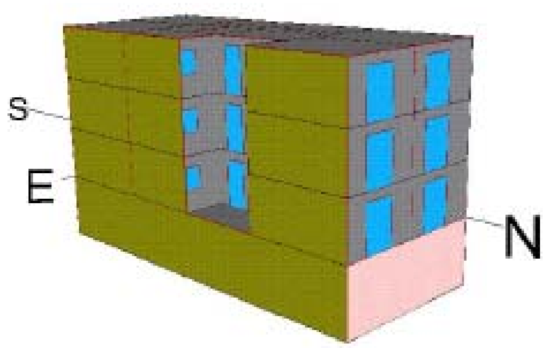
The target buildings are the apartment blocks, build after the civil war, with a similar construction typology and before the first mandatory thermal rule (1979). The following table summarizes the number of apartments build between 1940 and 1980 in Spain, the approximately living surface, the actual mean heating demand and the estimated energy demand applying the actual thermal rules (CTE).

Period	Apartments	Total surface (m2)	Mean heating demand (kWh/m2 year)		
1941-1950	411.928	26.775.320	Actual	Retroffited CTE*	Savings
1951-1960	1.079.797	70.186.805	55,7	21,9	33,8
1961-1970	2.644.881	171.917.265	Mean heating demand (MWh/year)		
1971-1980	3.436.539	223.375.035	Actual	Retroffited CTE*	Savings
TOTAL	7.573.145	492.254.425	27.418.571	10.780.372	16.638.200

** energy retroffiting according CTE rules*

The thermal characteristics before and after the retrofitting and the scale model for a representative apartment block are represented below.

ENVELOPE	U before retrofit (W/m2ºC)	U after retrofit
external façade	1,70	0,50
dividing wall	1,70	1,70
roof	2,00	0,30
basement floor	2,70	0,30
windows	4,20	2,60
internal walls	2,00	2,00
internal floors	2,70	2,00
ENVELOPE	**Uglobal before retrofit (W/m2ºC)**	**Uglobal after retrofit (W/m2ºC)**
	2,10	0,92



Financial aids

2009-2012 Housing and Refurbishment Plan

This Plan contemplates 996,000 actions over the next four years in order to make it easier for citizens to access houses to buy or let, to promote subsidized housing construction and improve the energy efficiency of existing buildings.

It establishes measures to enhance rentals (the main aim is introducing 40% of the newly built subsidized houses into the rental market). It establishes subsidies up to 410 Euros per square metre to promote rentals and it strengthens the leasing option. It promotes refurbishment (470,000 actions) focusing on housing improvement, on the improvement of the surroundings and on the improvement of energy efficiency in buildings. The Plan includes the so-called Renove Programme, which focuses on the refurbishment of specific buildings and on actions aimed at improving energy efficiency, renewable energy use and the implementation of access devices for people with disabilities.

This Plan is endowed with 10,188 million Euros and it will mobilise loans amounting to nearly 34,000 million Euros.

The plan was approved of on December 2008 and it will start to be implemented in 2009. The process for agreement subscription with the Autonomous Regions has already started. The Royal Decree 9/2008 dated 28 November approved of an extraordinary endowment of 110 million Euros for refurbishment as part of this plan, the funds will be provided by the Special State Fund for the Stimulation of Economy and Employment.

Appendix E - Sweden

Description of the Swedish multifamily building stock

Background

In the period from the end of the Second World War to the 1960s, there was a strong economical growth in Sweden. The trade and industry as well as the public sector expanded. People were moving from the countryside to the towns where they work in the industries. There was also, an extensive immigration of labour from other countries. Between 1945 and 1965 the population in Sweden increased from 6.7 million to 7.8 million people.
This resulted in an urgent shortage of housing. The standard of the existing housing stock was very poor. In the 1960s, approximately 25 % of the housing stock lacked modern facilities like central heating, water and sewer, WC and bathroom. More than 20% of the apartments were overcrowded with more than two persons per room. While the standard of living was increasing, people required better housing accommodation.

A number of committees were set up to investigate the housing situation in the country. In 1964 the government came to a decision that one million new apartments should be built over a period of 10 years, which means about 100 00 new apartments every year.

In the government bill 1967:100 the following targets were formulated for the "million program": " The entire population shall be provided healthy, spacious, well planned and appropriately equipped housing of good quality to a decent cost."
The purpose was to build housing for everyone.

The public utility housing companies were responsible for the most important part of the new production of multifamily housings.

The shortage of workers was the real challenge to manage to build this amount of apartment. Therefore, a rationalization of the building industry was required. Standardization, serial manufacture, prefabricated standard houses and large-scale production methods were necessary to keep the manpower requirements and production costs low. New materials and new productions methods were developed and used, which came to characterize the buildings of the "million program".

During the period of the "million program", 1005 614 apartments were built in Sweden.
Today, about one sixth of the Swedish population live in multifamily houses built in the period 1961 o 1975. In the 1970s, Sweden enters an economic recession and the demand for new apartments was decreasing. The immigration and moving into towns were also decreasing. All of a sudden, there were empty apartments and the construction of multifamily housing decreased dramatically.

During this period, a large net of infrastructure with roads, sewer, services lines for district heating system, electricity and telecommunication were also planned and built.

The idea was also the every larger residential area would be divided into smaller to create neighbourhoods form a sense of security and social community between the inhabitants. The residential quarters were planned in park environments round about a common centre with service facilities, both for commerce but also as a meeting place for people and for cultural activities.

The age distribution of the multifamily building stock

In Sweden, there are around 2.4 millions apartments. 35 % of those apartments are built between 1965 and 1974 i.e. social housing which means that about 1 500 000 persons in Sweden lives in these apartments.

Table 1. Age distribution of apartments

Year of construction	Number of apartments*
- 1931	230 000
1931 - 1945	265 000
1946 - 1960	550 000
1961 - 1975	830 000
1976 - 1990	280 000

* The information is from 2002.

Due to poor quality and other reasons about 175 000 of the apartments built during the million program have been demounted. However, the remaining apartments from this period still accounts for about 25% (45 million m2) of the total apartment floor area in Sweden today. The age distribution of the multifamily building floor area is shown in figure 1.

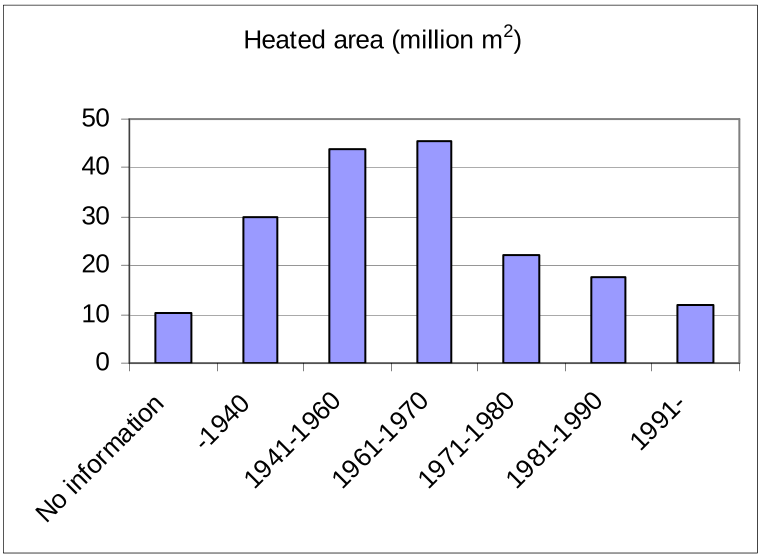


Figure 1. The amount of heated area for buildings built in different periods.

The energy use distribution of the multifamily building stock

The multifamily buildings from the period 1961-1970 have a higher energy use than the multifamily buildings built during any other decade.

Table 2. Net supply of energy for multifamily buildings

Year of construction	Net supply of energy (TWh/y) *
- 1940	5,7
1941 - 1960	8,5
1961 - 1970	8,2
1971 - 1980	4,1
1981 - 1990	2,6
1991 -	1,8
Not known	1,6

* The information is from Boverket 2003.

Also when considering specific net energy for heating, the buildings from this period have a rather high energy use. Buildings from earlier periods have even higher both total and specific energy use. However, they are built over a longer period of time and are not as homogeneous in their building technology as the buildings from the "million program".

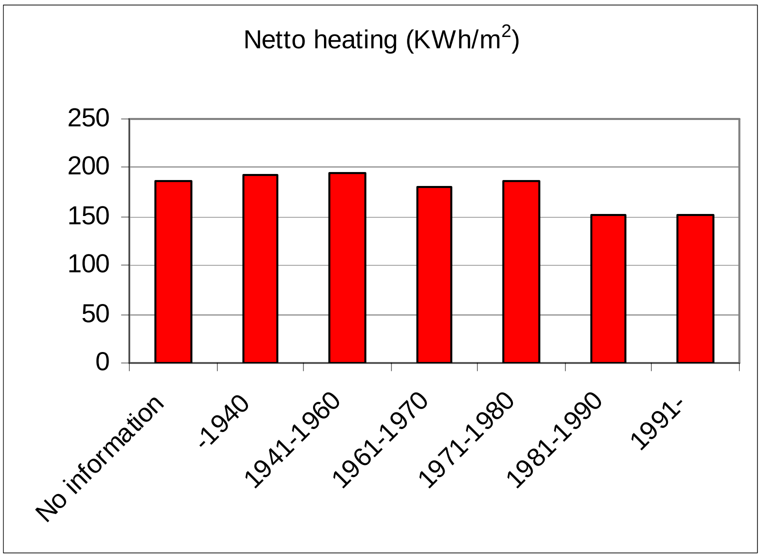


Figure 2. The amount of net heating used for buildings built in different periods.

Regulations and building codes in Sweden

Short description of main requirements

The National Board of Housing, Building and Planning – Boverket – is the central government authority for planning, the management of land and water resources, urban development, building and housing under the Ministry of the Environment. Boverket monitors the function of the legislative system under the Planning and Building Act and related legislation and proposes regulatory changes if necessary.

During the "million program" there were no specific demands on energy use. Even today there are no demands on the energy use of these buildings. But, when a building is retrofitted possibilities to reduce the energy demand should be investigated.

However, in the Swedish building regulation, PBL which came in force in 1987, careful renovation is a requirement: " Changes of a building shall be performed with care so that the characteristics of the building are taken into consideration and that the architectural, historical, cultural, environmental and artistic values are protected."

During the "million program" there were also very little or no requirements on thermal comfort, indoor air quality, air-tightness, etc. As long as the houses from this period are kept more or less in their original shape, there are no requirements to improve them to the requirements that apply for new buildings.

For multifamily houses there is since 1993 a requirement from Boverket on inspection of the ventilation system at a given interval. For houses with mechanical ventilation this also means measuring and adjusting the ventilation rate to the originally designed values. This has probably also led to an improvement of the indoor air quality in many of the houses from the "million program".

Socialstyrelsen, another central government authority (for social security) has put up some guidelines for minimum values that should apply for the indoor environment. If these guidelines are to be followed most of the multifamily buildings from the "million program" would need a thorough refurbishment. However, not necessary also meaning a lower energy use.

Opinions of today

Today the opinions about the "Million program" are divided. One side still has a negative view of the residential areas built in the "Million program" and criticizes the large scale and monotony. The other side means that the areas contain a lot of qualities and that there are cultural and historical values in these surroundings that must not be lost through careless renovation or demolition.

Description of voluntary systems or guidelines

The only national system in Sweden today that involves both requirements on indoor air quality and energy use is the P-marking system that has been developed by SP in cooperation with several Swedish building owners.

Description of most common building types (1961-1975)

Many of the buildings built in the "million program" have common characteristics of a style, typical for this period. Simple, geometric shapes, flat or low tilted roofs, flat non-decorated facades, windows fit in the outside of the façade. The most common *façade* materials were brick in red or yellow shades. Facing brick were used at more than a third of the facades and at most of the gables if the facades had wood cladding or other sheet material. A new type of smooth, hard plaster was also used to large extent. Additionally, new materials such as concrete, sheet metal panel, eternite and other types of sheeting were used.

The *roofs* of the buildings were mainly flat or low tilted roofs with internal drainage. The roof shoulders were smaller than traditionally and were removed in some cases. Underfelt was the most common roofing material. The *windows and doors* had plain profiles and had often aluminium sheathing profiles. The size of the windows was increased to let in day light in the apartments. There were usually inward opening windows.

The most common types of buildings were the *slab blocks* with tree or four floors. Houses with up to three floors did not require lift. The slab blocks were placed in groups around pedestrian precinct yards or in parallel grouping. The slab blocks were usually built of in situ concrete as gables and interior sheer walls and light curtain walls. The ground is a slab on ground without insulation.

Some of the slab block had fill in walls of prefabricated facade units of wood, which made the production fast and rational.

The slab blocks could also be made of pre-fabricated concrete elements. The wall elements had the size of a room and had a sandwich construction with concrete on the outside, insulation and a structural concrete element on the inside.

The slab blocks build in five or more floors are called *plate blocks*. The most common ones are the plate blocks with eight floors which was profitable since only one lift was needed. The plate blocks were often built in the suburbs of larger cities. The ground floor was often used as common space for laundry, store rooms and hobby rooms. The plate blocks were placed in rows around a central park. The walls in the plate blocks were often made of a concrete casting wall on the inside of a rendered light weight concrete. The plate blocks could also have pre-fabricated room sized element walls with insulation on the inside or made of sandwich elements.

Arched slab blocks were built in three to seventeen floors. The arched slab blocks were placed around pedestrian precinct yards and formed a wall to the outer surroundings, which makes them a dominating element of the town.

Tower blocks were built during the 1960s. High rising buildings with more than nine floors were favoured by favourable loan interest regulations. The tower blocks were also suitable for hilly ground. Usually four apartments in the tower blocks were placed around a central stairwell without daylight which is characteristic for this type of buildings. The walls of the lower tower blocks could be made of aerated concrete or brick shear walls with wood wool slab on the inside. In the higher tower blocks the walls were made of in situ concrete with light weight concrete on the outside.

Balcony access blocks were introduced early in the period of the million program. The typical character of the balcony access blocks are that the apartments are reached from balconies all along the facades. The balcony access blocks have slabs, intermediate floors and interior sheer walls between apartments and columns made of in situ concrete. Between the columns there are infill walls made of lightweight concrete and facing bricks.

Rows of terrace houses were built for common ownership or tenancy. The rows of terrace houses were often placed parallel with the entrances to the same side to provide all apartments with the same lighting conditions.

The table 3 below shows the different types of multifamily buildings built 1965-1974.

Table 3. Different types of multifamily buildings

Quantity	Type of building
50 %	Slab block with 3 to 4 floors
25 %	Plate block with 8 floors
15 %	Row of terrace houses
10 %	Tower block
5 %	Balcony access block

The apartments are mainly built with 2 or 3 rooms and a kitchen.

Figure 3. Brogården, a typical social area with slab block buildings.

Already refurbished building stock

Year 2002 was only 13 % of the social housing built 1961 – 1975 rebuilt. Table 3 shows the made refurbishments. The actual refurbishment volume is about 1.5% of the building stock per year.

Future demand for renovation

A report from Boverket (2003) shows that around 95 % of the buildings built from 1961 to 1975 need refurbishment. From these buildings, the multifamily buildings have highest need of renovation. Approximately 50 000 apartments per year need to be refurbished the next 15 – 20 years. The needed actions are: exchange of pipes, electrical installation, facades and roofs, windows, balcony, ventilation and elevators.

Typical insulation and air tightness of building envelope

The building elements consisted of lightweight concrete (homogenous), concrete with around 10 cm foamed plastic or light weight timbre frames with 10 cm of insulation in the spacing. Roofs often had a little bit better insulation, about 20 cm of insulation. The constructions also had rather large thermal bridges. Window were almost always two-glazed constructions with an practical average U-value of about 3 W/(m^2 K), including the frame. The mean U-values of the building envelope varied approximately from 0,4 to 0,8 W/(m^2 K).

There were no special requirements of air tightness. In the end of the million program plastic film were used to increase the air tightness, especially in the roof construction. This plastic was very thin and not thoroughly tested for ageing. Today it may therefore have lost most of its air tightening properties. The air tightness in non-refurbished buildings from this period is estimated to be 3-6 air changes per hour at ±50 Pa, meaning a mean air infiltration of about 0,1-0,2 air changes per hour for an exhaust air ventilated house and 0,2-0,3 air changes per hour for a naturally ventilated house (excluding window airing and air going through air vents).

Typical solutions for space heating, domestic hot water and ventilation

Space heating is in these houses are mainly distributed by hydronic radiator (95%). The remaining part is heated by electric radiators. Automatic control of supply temperature as a function of the outdoor temperature is today installed in almost all of these houses. Thermostatic valves are installed in about 70% of the houses and the circulation pump is in about 30% of the houses automatically shut down when there is no heat demand.

Nearly 90% of the multifamily buildings from this period are today connected to district heating. The remaining part has either a heat pump or a local boiler using electricity, oil and/or biofuel.

Sanitary hot water is mainly distributed from a central place and recirculated in the building using a small pump, so that hot water is almost instantly available in all of the apartments. Buildings with direct electric heating often also have small electric hot water boilers in each apartment.

Mechanical exhaust ventilation is the most common ventilation system, and is estimated to be installed in about 58% of the multi family houses built 1961-1975. The second most common is natural ventilation that is estimated to be installed in 38% of the houses. Mechanical exhaust and supply ventilation is estimated to be installed in only 4% of the houses, and in most cases without any heat recovery.

Space in existing shaft for installing air ducts

In the houses with mechanical exhaust ventilation the duct system often was constructed with rather small cross section areas, leading to relatively high velocities and high pressure losses. The space in existing shafts for installation of ducts is therefore rather limited in these houses.

In the naturally ventilated houses the shaft are rather large to ensure well functioning natural ventilation. It is therefore more space in existing shafts for installation of ducts in these houses. Some of the systems originally designed for natural ventilation have also already been rebuilt to mechanical exhaust ventilation, and sometimes also including an exhaust air heat pump.

Accessibility to district heating

Most of the multifamily buildings are located in cities and with high accessibility to district heating. Most of these buildings have also been connected to district heating.

Typical indoor climate

Due to the by Boverket required inspection of the ventilation system the ventilation rate is today quite good in all multi family houses, especially in those with mechanical ventilation systems. However, due to poor insulation standard and leaky envelopes, the thermal comfort is in many cases not good. Especially in the winter time problems with draft and discomfort is very common in houses from the "million program". Also in the summer time periods with very high indoor temperatures may occur.

Most of the problems, mainly concerning thermal comfort, can be eliminated by improving the building envelope (insulation and air tightness). Supply of outdoor air and the heating system may also need to be improved.

Typical energy performance

The total energy use for the buildings from the Swedish "million program", including household electricity, is estimate to 9,5 TWh/y. On an average the specific energy use is about 210 kWh/(m^2 y). The estimated total energy use and saving potential for different measures are given below.

Table 4. Energy use and saving potentials.

Insulation, windows	1.5 – 2.0	0.5 – 1.0
Insulation , rest of the envelope	1.0 – 1.5	0.5 – 1.0
Air tightness	0.5 – 1.0	0.5
Sanitary hot water	1.5 – 2.0	0.5 – 1.0
Losses in heating system	0.5 – 1.0	0.5
House hold electricity	1.0 – 1.5	0.0 – 0.5
Total	**8.5 – 10.5**	**4.0 – 5.5**

Local conditions

Financial funding or grants for retrofit of multifamily houses

There are for the moment no special financial funding or grants for retrofitting of the multifamily houses from the “million program”.

For installation of a thermal solar heating system, mainly for production of sanitary hot water in the summertime, it is possible to get a subsidy of SEK 5000 (or 540 EURO) per flat, up to a maximum of SEK 250 000 (or 27 000 EURO) per multifamily house.

It is also possible to a 30% subsidy of the cost for converting from a direct electric heating system to a hydronic heating system, up to a maximum of SEK 30 000 (or 3200 EURO) per flat. This is however only applicable on the 5% of the multifamily houses from the “million program” having direct electric heating.

Local producers

In Sweden we have local producers of high quality insulation material, high quality windows, ventilation systems, solar heating systems, heat pump systems, biomass systems, heat distribution systems, energy efficient sanitary taps and advanced control systems.

Summary tables of EP and indoor climate

Table 5: Summary table for most typical building types.

Building period	U-values, W/(m^2 K)		Building leakage	Ventilation system	Ventilation rate, ach	Energy performace, kWh/m^2				
	external walls	windows	ach at 50 Pa			Space heating	DHW heating	HVAC Electr.	Appliances electricity	Household electricity
1961-1970	0,5	3	3-6	Natural ventilation	0,33 *	125	40	10	5	35
1971-1980	0,3	2	2-4	Mech. exhaust	0,38 *	120	35	15	10	35
Req. new appartments	-	-	-	Mech. exh. and supply	0,40 *	110 in the south 130 in the north				-

SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

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