SOLAIR

Increasing the Market Implementation of Solar Air-Conditioning Systems for Small and Medium Applications in Residential and Commercial Buildings

Market Report for Small and Medium-Sized Solar Air-Conditioning Appliances

Analysis of Market Potential





www.solair-project.eu

SOLAIR – Paving the Way for Smartness

In nearly all European countries, a strong increase in the demand for building cooling and air-conditioning is detected and predicted for the following decades (by a factor of 4 in 2020). The reasons for this general increase are manifold, such as an increase in comfort habits, currently still low energy costs, architectural trends like an increased fraction of glazed areas in buildings and last but not least lowly changing climate conditions. This rising demand for cooling and air-conditioning in buildings involves unfavourable fossil fuel consumptions as well as upcoming stability problems in the electricity supply in Mediterranean countries, which in turn demands for costly upgrading of the grids to handle electricity peak power demand situations.

On this account the use of solar thermal energy for air-conditioning and all involved downstream professions has a huge unexploited potential. This can become a significant contributing factor in the acceleration of the growth of the European solar market, particularly in the southern countries, not only in terms of sales and turn-over numbers, but also in terms of job creation. Moreover the potential for environmental impact is tremendous since the housing and building sector stands for more than one third of societal CO_2 emissions.
Thus, improved building concepts, and the use of alternatives in coverage the remaining cooling demands of buildings, are of interest. Solar driven or assisted cooling is one of the possibilities to provide actively cold.

The SOLAIR project aims mainly at capacity building, promotion and influencing the process of decision making for the implementation of small and medium-sized SAC systems in order to increase the confidence on the technology and to encourage its implementation. SOLAIR also aims at resolving major market obstacles, such as the seasonal discrepancy between heating demand and availability of energy. Using solar energy for air-conditioning is a smart solution, because demand and supply correlate satisfactory. SOLAIR is running from January 2007 until December 2009, and consists of 13 partner organisations from 9 European countries.

Best regards

Erika Villa Andreas Steege

target GmbH, SOLAIR project co-ordinators

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Introduction

In the framework of SOLAIR, one of the main basic activities planned was to carry out a market review and analysis of small and medium-sized solar air-conditioning (SAC) appliances. For this purpose, national market surveys were first conducted by the Partners in their 8 countries. A market analysis report was produced for each country under an agreed standard form, compiling the data of different nature (climatic, technical, economic, social, legal, etc.) that had been deemed most relevant for the work.

The next step was to extract from these very rich data collections the most relevant indicators that would allow for a meaningful inter-comparison of the widely diverse situations in the individual countries. Finally, these indicators were used to produce the present analysis.

Although some data could not be obtained for all countries, we hope that the results will nevertheless be of interest in showing how much the national situations vary and what factors create different boundary conditions that prove more or less favourable to the deployment of SAC systems in a given European country. This information could then be used as an inspiration source for designing policies and regulations that would allow fostering the increase of penetration of SAC where necessary, which in turn would help limiting the consumption of energy and the emission of GHG and reaching the goals set at the EU level.

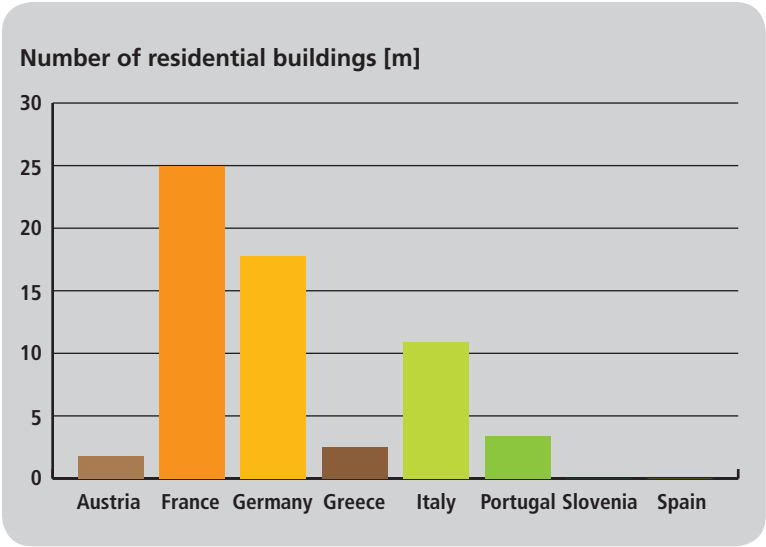
Of course, this work is to be considered as a snapshot, illustrating the situation in these 8 countries at a certain time (most statistics are dated 2005–2006), whereas the markets are obviously changing, sometimes even fast. Indeed, if some of the boundary conditions can only be evolving slowly, others like the legal/regulatory framework, the energy prices or the availability of new equipments can trigger sudden changes. Monitoring these changes thus remains an important task.

Status Quo in the SOLAIR Countries

General overview of the residential and commercial sector as well as of the solar air-conditioning (SAC) appliances

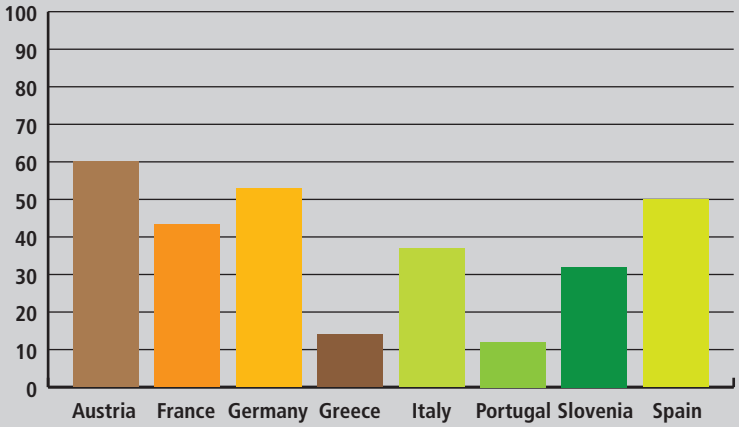
As can be seen below, there is a great potential in the residential housing sector for SAC. There are 61,317,627 residential buildings in total in the mentioned countries. Quite a share of them is multi-family houses. These buildings are the most appropriate for small and medium sized solar cooling systems. The share of privately owned buildings in this sector is also large so the financing parties are in most cases private investors. Specially Italy and Spain, which are the most appropriate countries for using solar energy for cooling, have a great share of 90% privately owned flats. In this case the most important effort to promote SAC is to motivate the private sector for renewable energy sources showing qualities and financial benefits of solar cooling.

Residential buildings

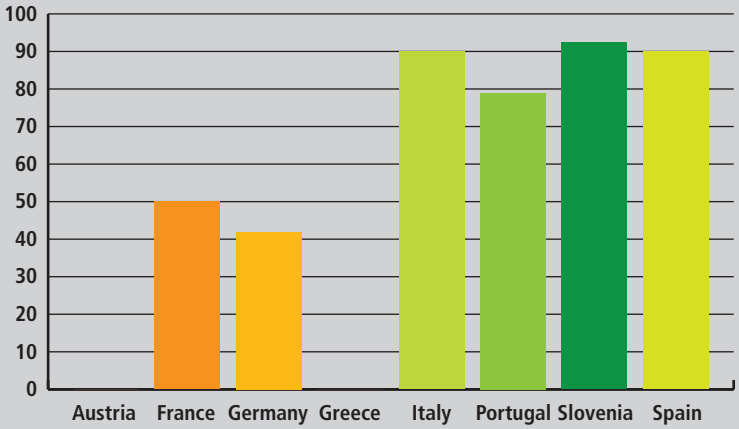


Please note:
No data are available about the number of residential buildings in Slovenia and in Spain, about the number of flats in Greece and Spain, about the share of privately owned flats in Austria and Greece and about the share of new construction in Slovenia.
Although there are no standardised definitions in the relevant countries, we agreed on definitions as follows: *residential buildings* are constructions/houses with 1 or more dwellings (flats), which are used for more than 50% for residential purposes, a dwelling is a single unit in a building (dwelling = flat), and *multi-family houses* are buildings with three or more flats, only in Greece they have two or more flats.

Share of multi-family houses [%]

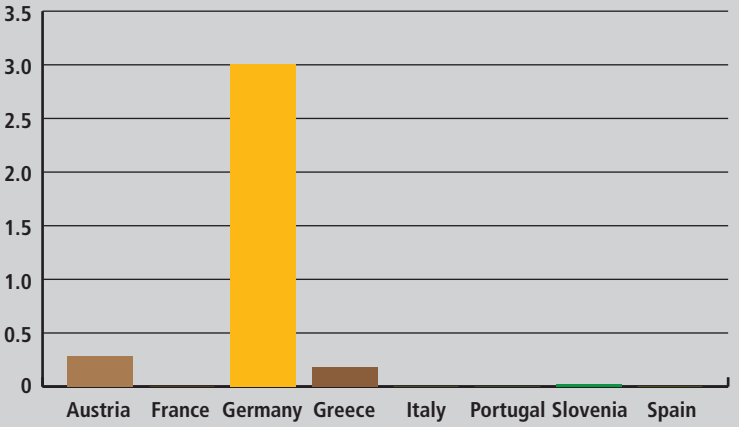


Share of privately owned flats [%]



Commercial buildings

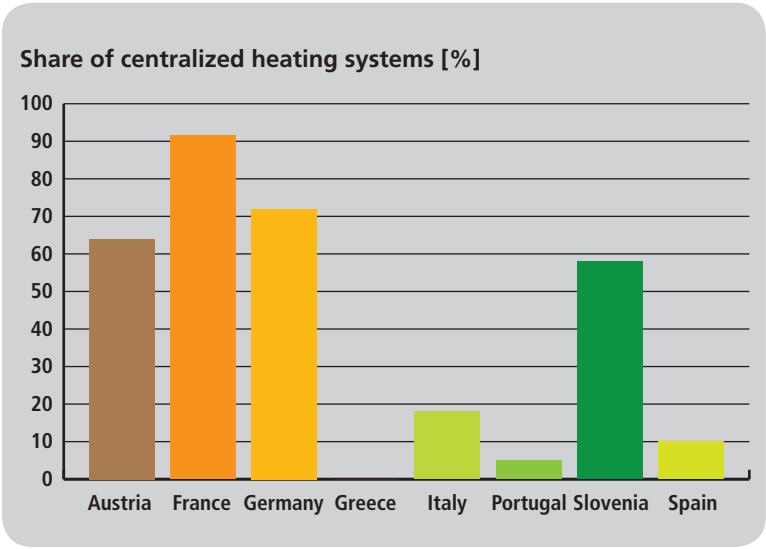
Building stock commercial [m]

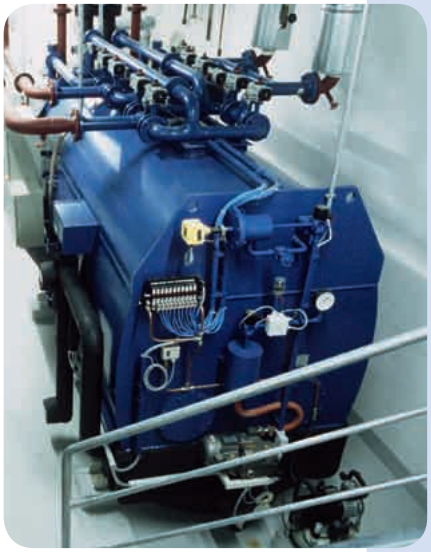




Please note:
"Zero" values actually mean that no data are available. Generally only scarce statistical data are available for this sector. Maybe because these data have not been collected by the statistical institutes – the number of "dwellings" is much higher than that of commercial buildings.
The definition of *commercial building* is not standardised in the relevant countries. It was difficult to obtain well separated data for the commercial sector. The collected information refers partly to non-residential buildings, partly to selected commercial activities (like hotels, hostels, sport halls, skittle alleys, fitness centres, bank companies, insurance companies and homes for old people), partly to the retail trade like shopping centres.

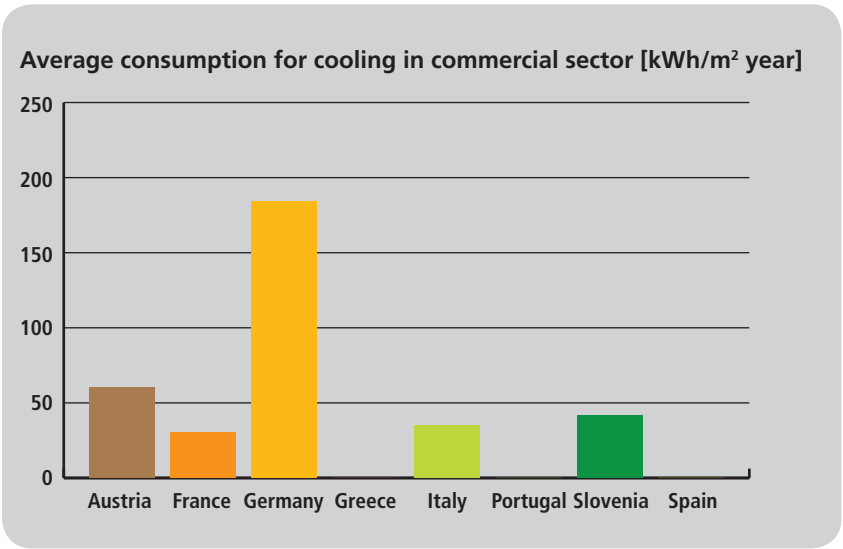
Heating system in residential buildings



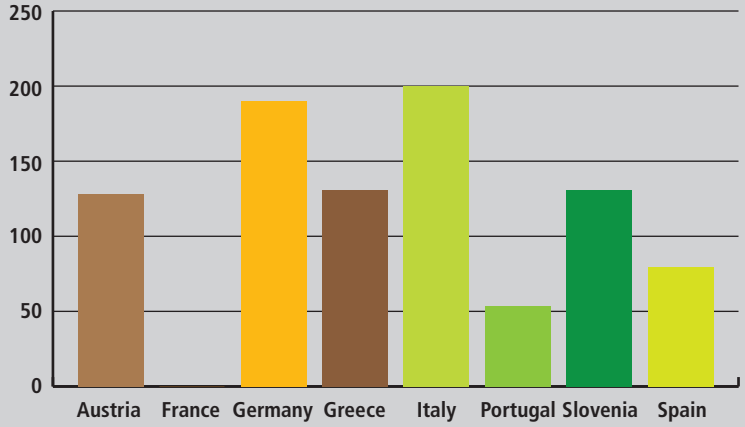


Central heating systems are the most often used for heating in these countries. So with combination of central solar heating and cooling the costs of new systems can be reduced. But Spain and Italy have a large share of decentralized heating systems, about 90 to 95%. Hence, since the share of refurbishment in both countries is above 1%, it would be meaningful to replace the decentralized systems with centralized solar heating/cooling systems. Southern France also offers a great potential for SAC and since there is a share of more then 90% of centralized systems in use, it would be easier to integrate solar systems. No data are available about the share of centralized heating systems in Greece.

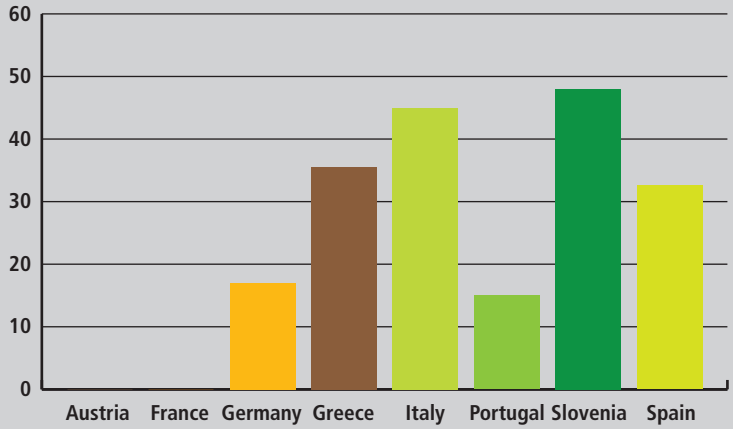
Cooling and heating consumptions in commercial and residential buildings



Average consumption for heating in residential sector [kWh/m² year]



Average consumption for cooling in residential sector [kWh/m² year]

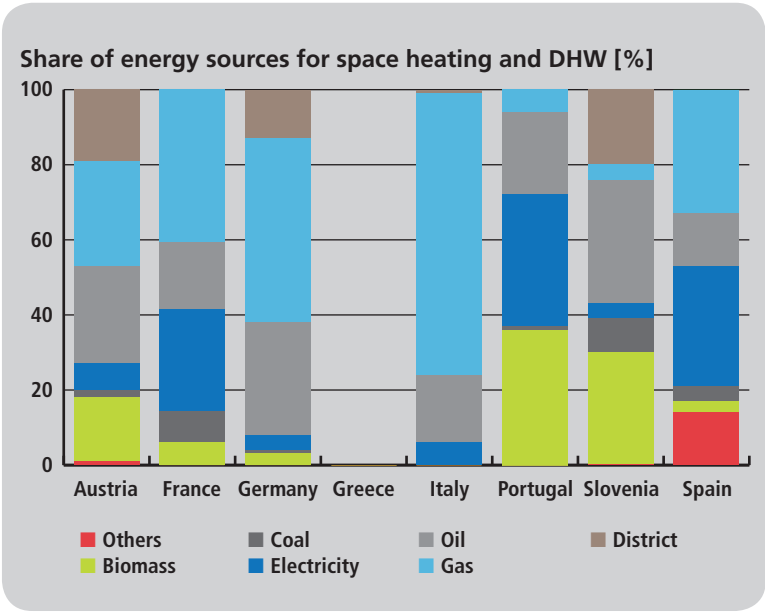


From the graphs it can be seen that approx. three times more energy is needed for heating as for cooling. Different is the case of Spain where this coefficient is smaller, twice more energy for heating as for cooling. It is also different in Italy where four times more energy is needed for heating as for cooling. This difference appears because of the northern part of Italy where there are the Alps and not a Mediterranean climate. But anyway, Italy, Spain, Greece and Slovenia are the greatest users of energy for cooling. Again the southern countries appear as the most appropriate for SAC. No data are available about average consumption of energy for cooling in residential sector in Austria and France, no data about average consumption for heating in residential sector in France and Germany and no data about average consumption of energy for cooling in commercial sector in Greece, Portugal and Spain.

Share of energy sources for space heating and DHW

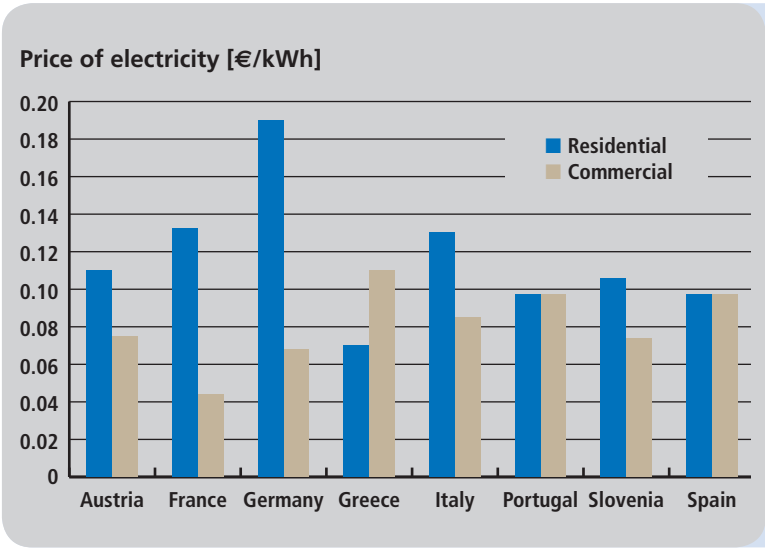
The most common used energy sources for space heating are still oil and gas which are also the most polluting and expensive. Portugal has a large share of electricity heating which is also very expensive. With solar systems the costs and usage of oil and gas can be reduced for space heating also. Spain, Portugal and France are having a large share of electricity heating about 25–35%. Italy has a large share of oil heating. These are the coun-

tries which are the most appropriate for SAC in view of reducing CO_2 emissions and involving RES into heating and cooling.



Price of electricity

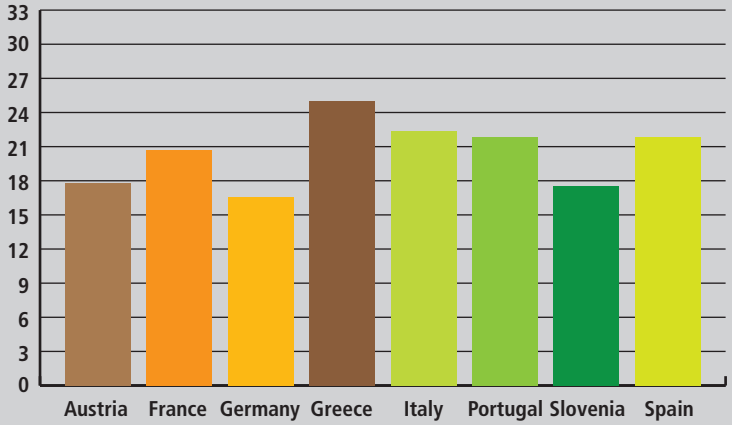
In most of the countries the price of electricity is about 0.1 €/kWh. Only in France, Italy and Germany are the prices significantly higher. So by comparing the electricity prices it can be seen which countries have a greater potential for SAC. With solar cooling systems, the electrical energy usage is reduced and consequently the operation costs. Germany is the country with the highest electricity prices and thus with best incentive for SAC at present. Austria, France and Italy also have relatively high prices of electricity in the residential sector.



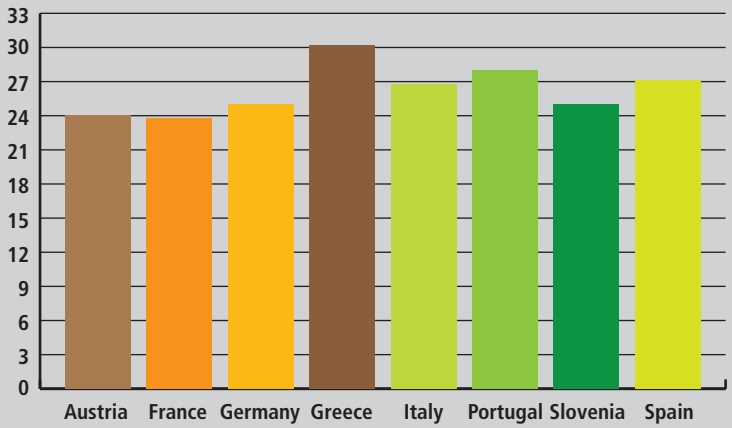
Radiation and temperatures

The strongest solar radiation is of course observed in southern countries like Greece, Italy, Spain, and Portugal. The same holds with average maximal summer ambient temperatures. These countries thus have the highest needs for cooling and also the largest amount of radiation, so the opportunity for and interest of SAC is the greatest there. In these countries also the highest summer temperatures are most of the time between 25 and 30 degrees Celsius, which possibly calls for cooling systems.

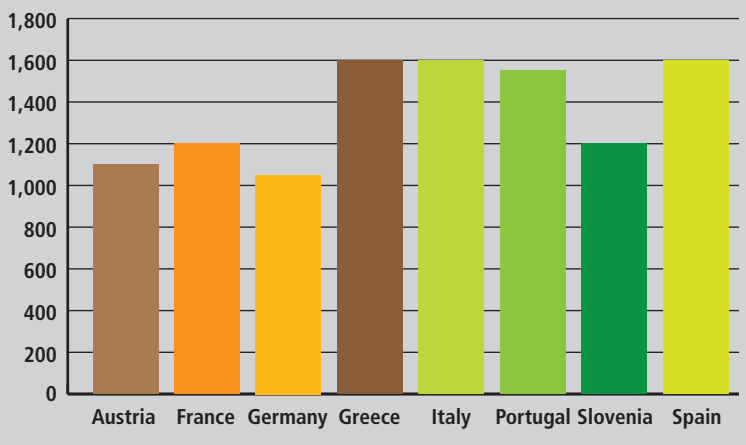
Average summer temperature [°C]



Summer average maximum temperature [°C]



Solar radiation [kWh/m² year]



Austria



The Building Stock

Main figures for the residential stock

Total stock: 1,800,000 buildings (3,200,000 flats); 60% of the flats: multi-family houses, 40% of the flats: single and double-family houses. Between 2000 and 2002, the growth of the residential buildings amounted to 40,000–50,000 units/year, quite small with respect to the total stock.

"Useable living area" [m²] for main residences in Austria

Construction period	1–2 flats/building	3–10 flats/building	> 10 flats/building	Total
1945–1960	17,290,736	8,085,171	7,948,202	33,324,110
1961–1970	21,980,857	9,565,045	13,367,405	44,913,308
1971–1980	26,804,568	9,676,739	15,310,476	51,791,783
Total	66,076,161	27,326,956	36,626,084	130,029,201

Source: Zentrum für Bauen und Umwelt, Schuster et al.

Heating, Cooling and Solar Thermal

Heating the buildings

Wood is one of the main heating sources for residential buildings. Central systems (64%) and district heating solutions (18%) are predominant. Average consumptions are: 128.3 kWh/m²/year for space heating, 1,274 kWh/person/year for domestic hot water and 108.7 kWh/person/year for cooking.

Non-residential building stock in Austria

	Number of buildings
Office	32,177
Hotel	35,846
Building for retail or wholesales	33,024
Building for traffic or communication	3,951
Building for vehicle workshops, industry or storage	71,693
Building for culture, leisure, education	15,524
Other buildings	90,039
Total (2001)	282,257

Source: Statistik Austria 2007

Results from the micro census 2004: energy sources and heating system

		Type of heating				
Energy sources	Apartments (main residence, total)	Single burners	Gas converter	Electricity heating (fix connected)	Central heating (or equivalent)	District heating*
Wood, wood chips, pellets, wood briquettes	590,119	214,212	–	–	375,908	–
Coal, coke, briquettes	63,934	22,955	–	–	40,979	–
Heating oil, liquid gas	876,304	89,861	–	–	786,444	–
Electricity	254,550	40,137	–	175,148	39,265	–
Natural gas	955,098	–	69,515	–	885,583	–
Solar, Heat pump	26,830	1,346	–	–	25,484	–
District heating	662,883	–	–	–	49,322	613,561
Total	3,429,719	368,511	69,515	175,148	2,202,984	613,561

** Central heater with unknown heat source is defined as district heating.*

Source: Statistik Austria 2007

Cooling the buildings
Energy consumption for cooling: 365 GWh/a.
Residential buildings do not use cooling systems and also the new building regulation will not consider cooling application or loads in this sector.
50% of the cooling devices are currently operating in offices and other work places, 7% in hospitals and 13% in hotels, restaurants and bars. 70% of the chilled surface use water as cold distribution fluid.
Heating demand for office buildings: 30–40 kWh/m²a
Cooling loads for office buildings: 60–80 kWh/m²a (due to internal heat loads and passive solar gain)
More than 40,000,000 m² of conditioned area for commercial buildings are expected in 2020.

Solar thermal in Austria
One of the highest markets per capita worldwide. 65% of the installed solar thermal plants are used for DHW and 35% for space heating. 35% of the installed systems are in existing buildings and 65% in new buildings.
Within the SOLAIR project, there are four documented solar cooling plants operating in the commercial sector; one for a wine storage (100 m²), and three for office buildings (40 m² and 77 m²), and one documented system in the residential sector.

Legislation Framework and Incentives

Legislation
Austria's target is to reach a 45% share of renewable energy in the final consumption within 2020.
Thanks to the implementation of the EPBD, buildings constructed after the beginning of 2006 must carry an "energy performance certification" from 2008. Buildings rented, bought or constructed before 2006, are obliged to get the certificate within the beginning of 2009.
Also, the cooling demand in a non-residential building is taken under consideration in the "agreement on the demand of energy efficiency" for new and refurbished buildings.

Incentives
A national based incentive for solar thermal systems is currently operating, also including solar cooling.
Furthermore, a subsidy scheme is available for demonstration and pilot plants for industrial and commercial applications.
In addition, several Federal States have favourable subsidy schemes for solar thermal (in the range of 25% of the investment cost), which in many cases can be cumulated with the national incentives.
Further incentives for solar thermal systems at municipal level give average subsidies of about 10% of the investment costs. The investment costs for solar thermal also reduce the income tax of private persons.
The Federal State of Styria offers incentives for energy efficient new buildings only if a solar thermal system is installed.
It is possible to receive funding for a retrofit for house/flat owners as well as for tenants, in form of support of bank interest when implementing energy efficiency measures.
Solar cooling should compete, however, with heat pumps for cooling applications, which also could benefit of some incentives, e.g. the Federal State of Styria supports building owners in installing heat pumps with COP > 4 and subsidies are available in Tyrol and Upper Austria from energy utilities.

Conclusions

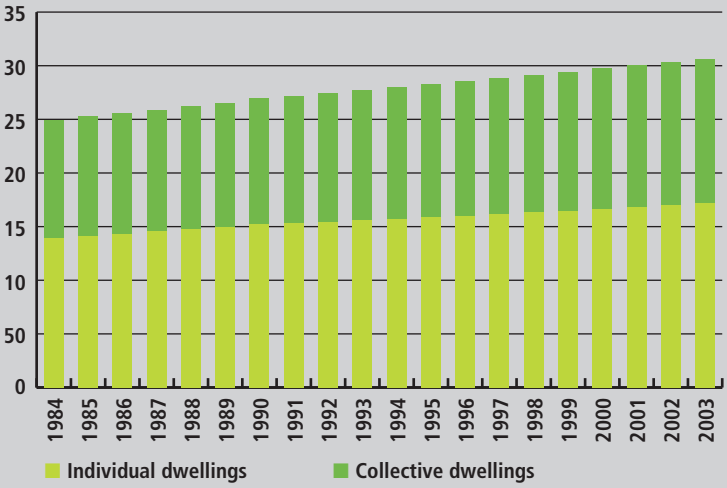
Despite an ever growing mature solar thermal market, the focus has been so far mainly on residential systems for DHW and space heating. However, subsidy schemes are already including special applications, such as solar cooling.
Solar cooling systems with small capacities are mainly applied in the commercial and non-residential building sector in Austria.



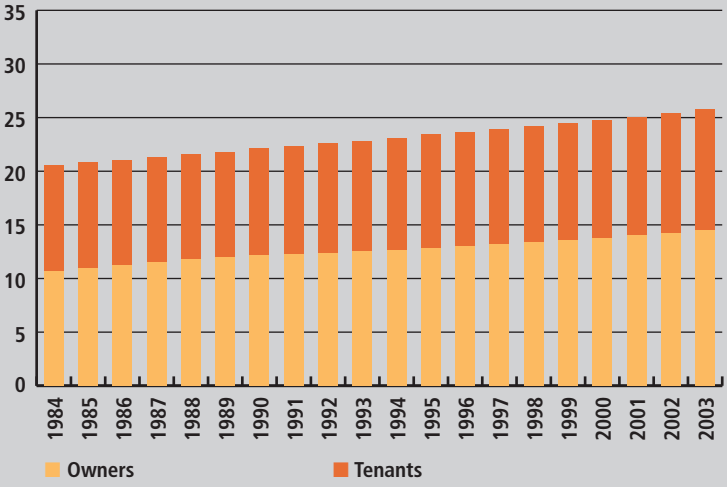
France



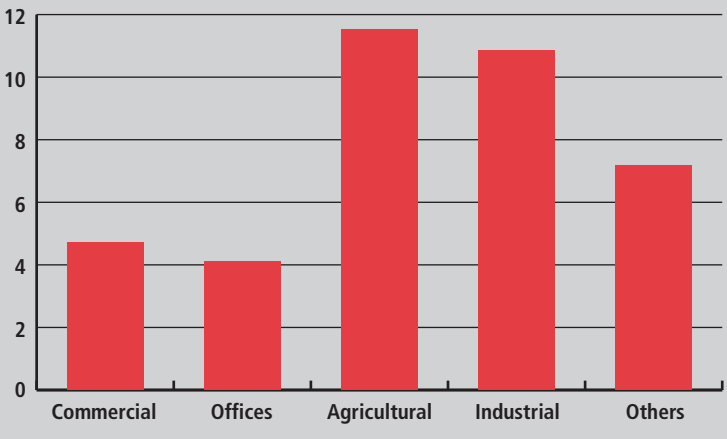
Total dwelling park [m]



Total dwelling park [m]



New constructions (except dwellings) [m m²]



Source: Fédération Française du Bâtiment – 2006

The Building Stock

The residential sector

Number of dwellings in 2005: 31.6 millions. 57% are individual dwellings and 43% are collective ones.

The ownership is very different for individual dwellings (80% of owners and 20% of tenants) and for collective dwellings (25% of owners and 75% of tenants).

436,000 new dwellings were built in 2006 (almost 10% growth) and also the refurbishment activities performed a 1.4% growth.

In 2003, the expenses of refurbishment amounted to 45 milliard €, that is to say almost equal to the expenses of new constructions.

Social dwellings play a relevant role: in 2006, their share on the total residential market was 44% (4,300,000 dwellings). 220,000 social dwellings were refurbished in 2006 and 40% of these renovations were related to energy efficiency.

Commercial buildings

Total area of the service sector buildings in 1998: 735 million m² in 1998. 70% of these buildings were built before 1980.

In 2006, 39.4% of total buildings were non-residential buildings, equally divided between new constructions and refurbishment.

Heating, Cooling and Solar Thermal

Heating the buildings

Centralised heating systems in 2002 had a share of 90% on the total residential stock (the share was 68% in 1982). Heating systems using gas or electricity increased respectively by a factor of 2.2 and 3.7 in 20 years, while coal is no longer used.

Non-residential sector:
heating consumption and heated surfaces in 2000

	GWh	Share [%]	Thousand of m²	Share [%]
Offices – Civil services	28,148	24.90	169,368	21.17
Commerce	21,456	18.99	184,981	23.12
Health – Social actions	14,666	12.98	92,582	11.57
Education	19,667	17.40	163,652	20.45
Cafe – Hotel – Restaurant	9,502	8.41	53,375	6.67
Sport – Pleasure – Culture	8,640	7.64	59,115	7.39
Common habitat	6,938	6.14	53,000	6.62
Transport	4,005	3.54	24,139	3.01
Total	113,022	100.00	800,212	100.00
Others	29,085		189,629	

Cooling the buildings
The air-conditioning market is increasing strongly since 2003, more in the commercial sector than in the residential one. At the end of 2005, it amounted to 302,000 units.
The most used systems (82%) are reversible air-conditioners, usually split devices. About 19% of the total area of the service sector was air-conditioned (149 million m², consumption of 4.5 TWh in 2000).

Solar thermal in France
At the moment, there is no solar cooling system in the residential sector in France, while in the commercial sector there are 8 demonstration solar cooling plants by absorption and also 2 solar cooling systems which use DEC technology:
Nevertheless, currently the French solar thermal market (without overseas departments) is exploding, showing a growth of 80% from 2005 to 2006, reaching about 220,000 m² (70% of small systems for DHW, 20% of combi plants and 10% of collective DHW systems).

Legislation Framework and Incentives

Legislation
Even though the current French energy policy aims at maintaining the development of nuclear power, the 2010 target is to increase the heat production by 50% from renewable energy sources.
In order to reach this objective, the government established a couple of measures. For example, the tax credit for renewable heating installations increased from 40% to 50% in 2006, or even there was the possibility to increase the Floor Space Index (FSI) by 20% if the building fulfills some energy requirements.
The government developed the project PREBAT 2005–2009, aiming at the availability, within 2010, of a set of technical solutions to provide refurbished buildings with a heating consumption below 50 kWh/m² and with a pay back time under 20 years. Moreover, the PREBAT target for 2015–2020 is to reach an overall consumption less than 80 kWh/m² in all buildings.
Thermal Regulation 2005 introduced stricter requirements for thermal insulation and heating systems.
Another decree from March 2007 states that air-conditioning systems must start in buildings, only when the internal temperature is above 26 °C.

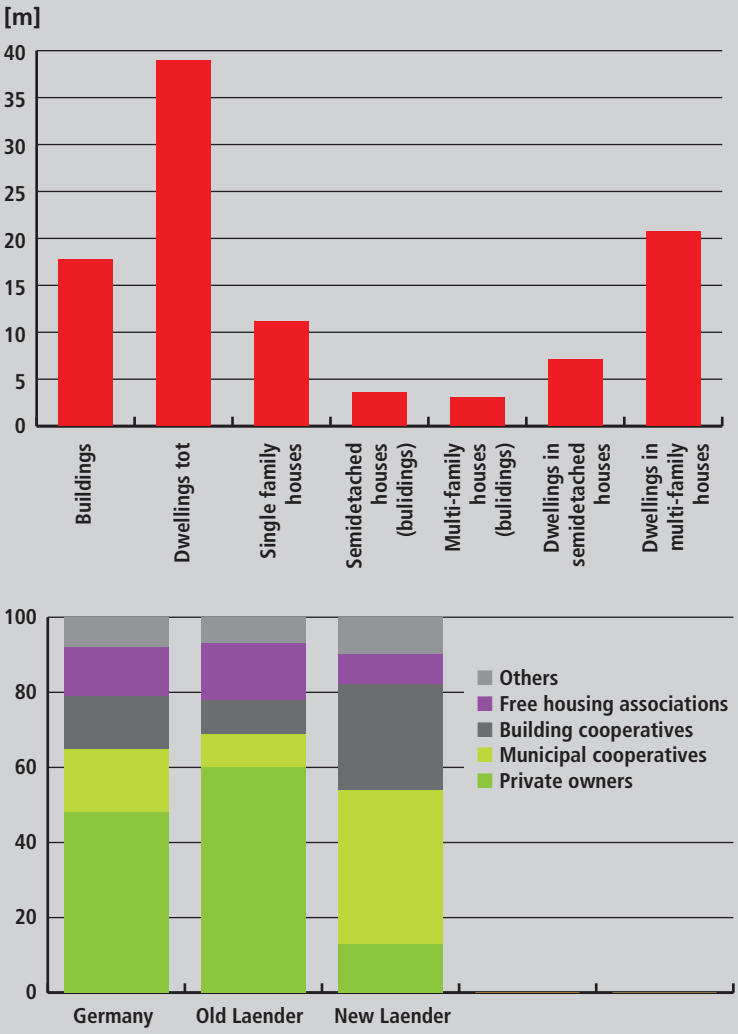
Incentives
The ANAH (Agence nationale de l'habitat – national housing agency) allows subventions for renovations of dwellings which foresee energy efficiency measures.
The 2005 financial law established a tax credit, amounting to 15% for low temperature boilers and to 50% for renewable energy equipments.
Moreover, ANAH and the Local Authorities offer rebates for installing a solar thermal system.
Finally, a "White Certificate" scheme, promoting energy efficiency in final consumption, is operating in France.

Conclusions

The building market looks quite dynamic, for both new construction and refurbishment activities.
The solar thermal market has been booming in the last years, also showing a good share of "special" plants (collective DHW or combi systems).
France has already made some practical experiences in solar cooling, especially for commercial buildings.

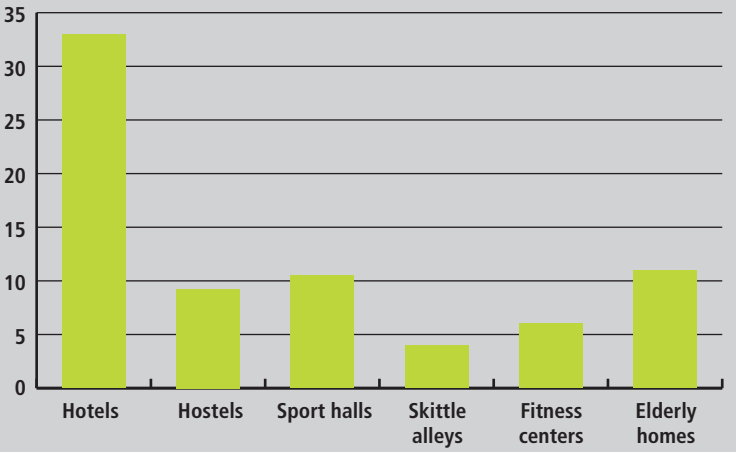


Germany



Source: Statistisches Bundesamt 2006 (Federal Statistical Office)

Distribution of some commercial activities in Germany [thousands of buildings]



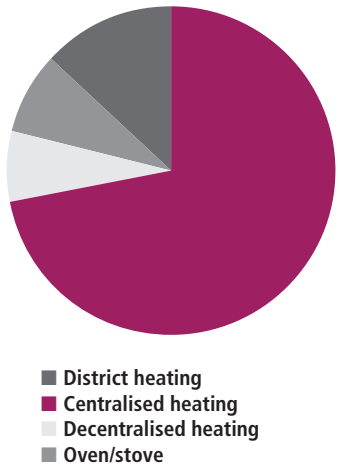
The Building Stock

In 2006, the house stock was 39,000,000 and about 220,000 new buildings (1% of the existing stock) were built (about 80% dwellings).
Between 1.5% and 2.5% of the existing dwellings were refurbished.

Heating, Cooling and Solar Thermal

Heating the buildings

More than 2/3 of the heating systems in the residential sector are centralised and the most common energy sources are natural gas (48%), oil (30%) and district heating (13%).



Source: Statistisches Bundesamt 2006 (Federal Statistical Office)

Cooling the buildings

Air-conditioning in the residential sector is small in comparison to Southern European markets. Installations in the residential sector in 2001: 300,000 units (mainly small-scale split systems). Total installed chilling capacity in the residential sector: 390 MW (cooling demand:

170 GWh/a). Conditioned area: 11 million m² (0.3% of the total). In the commercial sector, the cooling demand (above all in food sector and building space cooling) is 165 TWh/a.
The annual energy consumption for cooling amounts to 66 TWh of electricity and 11 TWh of non-electrical energy (waste heat, gas, etc.). The electricity consumption corresponds to 14% of the total electricity consumption and to 5.8% primary energy consumption respectively.
For Germany, an increase of the air-conditioned area from currently 1.2 m² per capita to 3.8 m² per capita is expected by 2020.

Solar thermal in Germany
Solar cooling systems in the residential sector have not been applied in Germany so far. For detached houses, the capacity of the chillers available some years ago (minimum 35 kW), was too large. The solar thermal market in 2006 (more than 1 GW) showed a 50% growth, but a 33% decrease was registered in 2007. The rate of combi systems has increased to about 40% of the total market.
Solar thermally driven or assisted cooling systems have not yet penetrated the market until now. The realised systems are thus pilot or demonstration installations, mainly for office cooling.
Number of solar cooling installations: about 50.
Installed cooling capacity: 3 MW
Installed collector area: 6,500 m²
There are some large (1,000 or even 2,000 m²) solar cooling systems with adsorption chillers.
Recently, new small-size chillers entered the market, in the capacity range from 5 kW to 15 kW.

Legislation Framework and Incentives

Legislation
In order to reach the EU and the national targets, the German government has foreseen precise targets, namely an increase of the renewable energy sources by 2020 in the electric sector (from 12% to 25–30%), in the heat sector (from 6 to 14%) and in the fuel production (from 6 to 17% by energy content).
Moreover the German Cabinet agreed on the "Key elements of an integrated energy and climate programme" in August 2007, foreseeing 29 measures for the energy and climate policy to be implemented by 20 legislative projects, currently under development.
Since October, 1st 2007, the new Energy Saving Ordinance foresees an energy certificate for all the buildings. Furthermore, it also defines minimum requirements for building design in summer conditions. In case of residential buildings, the planning should lead to a building with no need for air-conditioning systems.
No regulations for the installation of solar systems do exist yet. However, the German government amended on December, 5th 2007 a draft law about the use of renewable energies in the heat sectors. This foresees that building owners must cover a share of the heating demand by renewable energies, in case of new buildings or substantial retrofitting. It is estimated that the obligations will become effective in the beginning of 2009.

Incentives
The Federal Office of Economics and Export Control developed funding schemes for renewable energies, including solar thermal systems, also for cooling applications, which also could benefit from an "innovation bonus".
The German Reconstruction Loan Corporation refunds 30% of the costs for plants larger than 40 m²:
The Federal Ministry for Environment, Nature Conservation and Nuclear Safety, thanks to the "SOLARTHERMIE 2000plus" programme, has a funding scheme available for solar thermal plants larger than 100 m² and beyond hot water supply. The funding is 30% of the costs, but it could be up to 50% in case of pilot systems.
The share of solar cooling plants ranges from 15% to 20% of the total number of proposals received in the funding scheme.

Conclusions

With 13% district heating and 72% central heating systems, the majority of buildings provide a technically good framework for integration of solar cooling plants.
A significant growth of small capacity chillers may be expected for applications in small office buildings or residential solar cooling systems.
National programs are currently supporting pilot and demonstration solar thermal plants.







Greece

The Building Stock

Building stock in Greece: 2,510,759 (84% single dwellings, 14% apartment buildings, 2% commercial, hotels and public buildings). About 100,000 new houses are built each year, between 5% and 10% of the total residential building stock.

Building stock in Greece

	Number of buildings	Built before 1980	Built 1981–2001	Built 2002–2007
Single dwellings (buildings with one or two floors)	2,100,717	1,371,642	450,724	278,351
Apartment buildings (more than two floors)	367,407	194,667	91,443	81,297

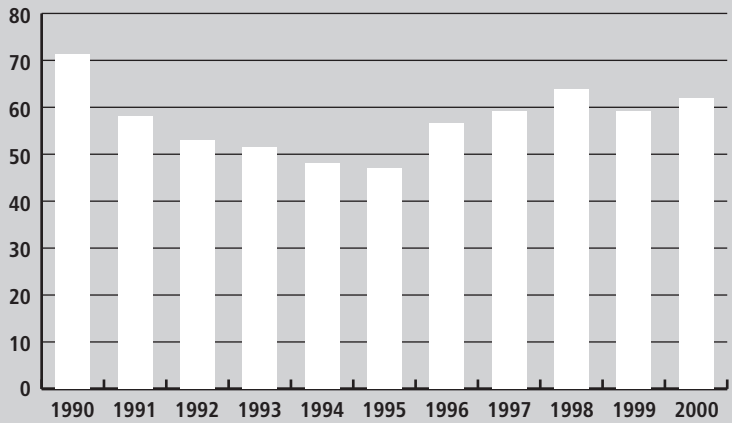
Source: Balaras and Gaglia, 2007

Commercial building stock (hotels and public buildings) in Greece

	Number of buildings	Built before 1980	Built 1981–2001	Built 2002– now
Office/commercial	152,550	89,352	39,348	23,850
Summer hotels (operating period from Apr. to Oct.)	6,809	3,015	2,580	1,214
Annual hotels (operating the whole year)	3,253	1,543	1,171	539
Schools	15,576	14,126	700	750
Health care	1,742	1,566	117	59

Source: Balaras and Gaglia, 2007

Private building growth [m m²]



Source: ICAP Air Condition field study 2006



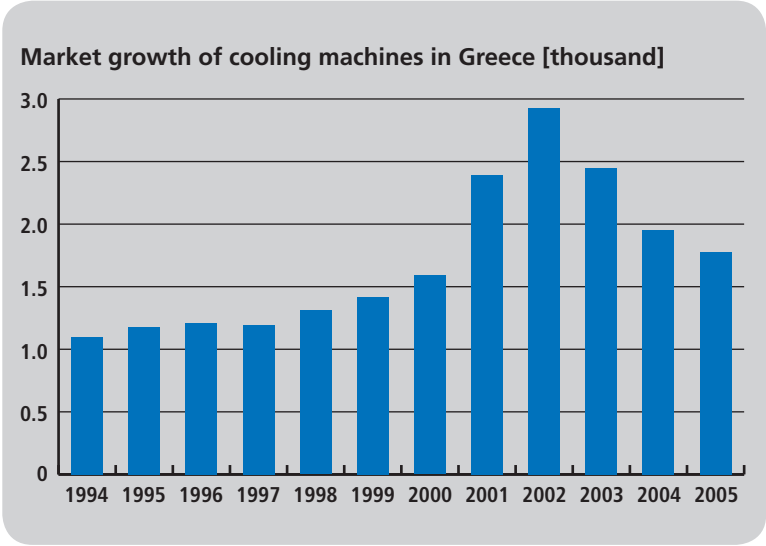
Heating, Cooling and Solar Thermal

Heating the buildings

Central heating with oil or gas burners is the most used system in both the residential and commercial sectors. In agricultural areas, also biomass is widely used (individual stoves or centralised devices). Less common are geothermal heat pumps, heating with split-units and solar space heating. Domestic water is heated mainly by thermosyphonic solar thermal systems (more than 30% of the dwellings) and by electricity.

Cooling the buildings

In the commercial sector, split-units are mainly used in small hotels and summer apartments or bungalows, while large hotels as well as industrial buildings usually use central systems.



Solar thermal in Greece

The Greek solar market is the fourth in the world on a per capita basis, also showing one of the most successful solar thermal industries, supplying both the Greek and the European market.

In 2005 the installed collector area was about 3,050,000 m² (source: ESTIF 2005), more than 95% for DHW.

The use of solar cooling systems is currently at a commercial stage and 6 installations are operating in the commercial sector, mainly in hotels and in education and research buildings.

In particular, the largest solar cooling installation in the world (2,700 m² of solar, 700 kW of cooling power) was installed at the SARANTIS cosmetic industry.

Legislation Framework and Incentives

Legislation

The target for Greece according to the EU directive on the promotion of RES electricity is to cover 20.1% of the total electricity demand, or 14.5 TWh/year, by RES by 2010. No specific target for the installation of solar thermal or solar cooling systems exists.

Currently there are two main legislative rules which affect the installation of a solar cooling system. The first is the Urban Planning legislation, where it is stated that the height of solar collectors should not exceed a maximum height according to the building's licence. The second is the legislation on heating insulation, which does not directly affect the use of SAC, but it improves the conditions for the installations by lowering the heating and cooling demands.

New legislations concerning the use of energy, thermal insulation and renewable energy sources are expected to be introduced in Greece with the EPBD coming into force.

Despite the fact that specific techniques are applied/suggested from air-conditioning companies, no specific standards or technical reports exist which could affect the solar aspect of cooling installations.

Incentives

Currently there are no support schemes for the residential sector. The main support schemes for the development of RES generally (including solar cooling installations) for the commercial sector are:

1. Amendment of the National Development Law 3299/04: the level of public support depends strongly on the particular geographic region where the private investment is planned. Regions with high unemployment rates and low incomes per capita receive the highest investment subsidies. Investments in RES installations (for both electricity and heat) have a favoured status also under the previous Law 3299/04, similar to the one bestowed to other selected categories of investments, such as investments in high technology, environmental protection, tourism, etc. The kinds of incentive alternatively provided are:
   - Cash grant and/or leasing subsidy (20–40%) or
   - Tax allowance (60–100%) or
   - Labour cost subsidy for new employment (20–40%)
2. Operational Programme for Competitiveness (3rd Community Support Framework): subsidies on the total investment costs (up to 50%) were given in many RES, Energy Efficiency and Combined Heat and Power projects including wind farms, photovoltaic plants, biodiesel plants, etc.

In the mid 80's there was a strong governmental public campaign for the promotion of solar thermal systems for domestic use, which led to a significant increase in the solar market.

Presently, there are no campaigns to promote the use of solar thermal systems and the only available incentive is the tax deduction of 20% of the investment cost.

In general, support schemes are also applicable to other conventional installations competing with solar cooling. As an example, conventional cooling machines could be funded in a general refurbishment proposal for a building. The use of RES though gives more credits to the overall evaluation score of the proposal.

Conclusions

There is a high rate of new buildings in the residential sector.

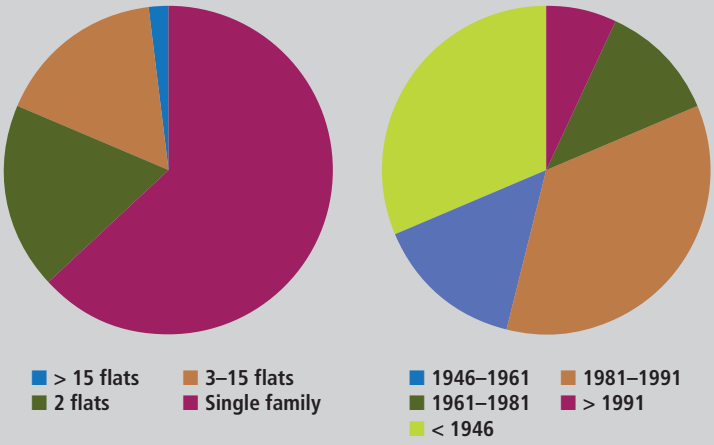
Even though Greece is one of the most relevant solar thermal markets worldwide, specific incentives are needed to promote application beyond thermosiphonic DHW, e.g. large scale solar thermal installations, solar combi (several buildings are suitable for this solution, but since they were built before 1980, they should first reduce their heating demand) and solar cooling.

Italy

The Building Stock

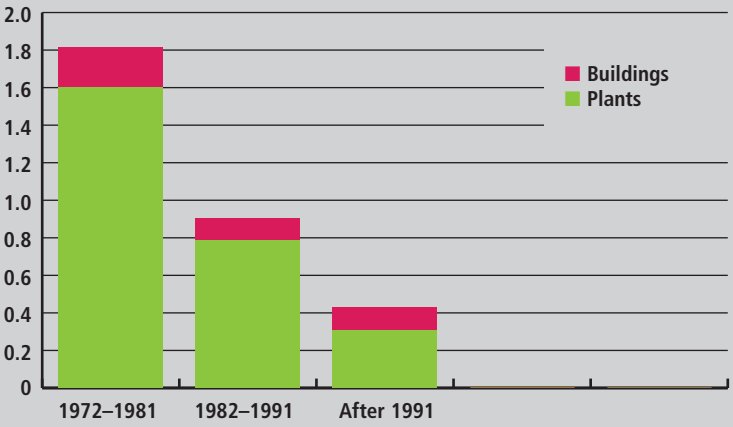
Total number of dwellings: 21,500,000
About 75% of the population own the apartments they live in (about 15,000,000 flats). Multi-family houses therefore mostly have many owners ("condominio"), with in average 20–30 flats. A condominio is usually administrated by an external company (or often by a single person), who deals with building maintenance and management.
About 5,300,000 dwellings are not occupied.
The new constructions are about 1.3% of the existing stock.
After 1991, about 430,000 refurbishments were made (70% involving technical plants).

Share of buildings versus their structure and their age



Source: ISTAT, 2001

Refurbishment activities [m]

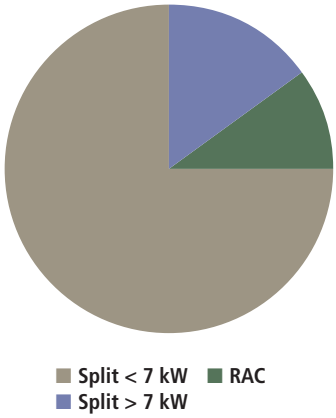


Source: ISTAT, 2001

Heating, Cooling and Solar Thermal

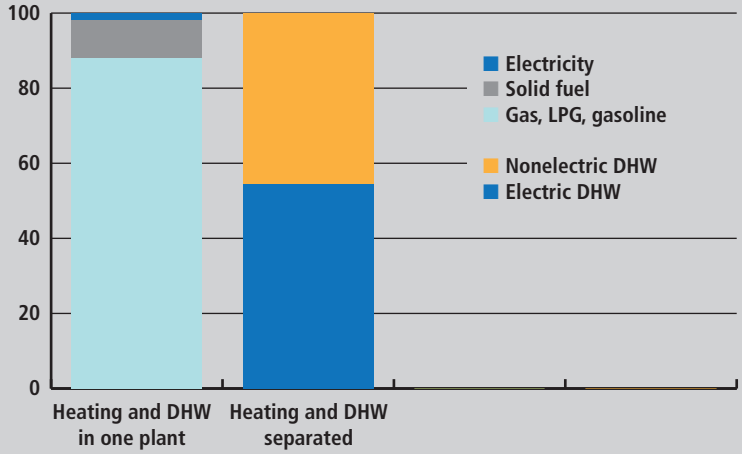
Heating the buildings
Autonomous heating systems cover more than 80% of the total for the residential sector.
Centralised systems are common in commercial enterprises located in large buildings.
The total district heating power is less than 1% of the residential heat demand (3,600 GWth/a).
Fuels used for space heating: 75% natural gas, 18.5% oil, 6.5% liquefied petroleum gas (LPG).
Average consumption for space heating: 200 kWh/m²/a.

Cooling the buildings
Average cooling load in the residential sector: 45 kWh/m²/a
Commercial sector: average chiller size is 75 kW, average split size is 12 kW, total cooled area is 400 million m², average cooling load is 90 kWh/m²/a, average electricity demand is 35 kWh/m²/a.



Solar thermal in Italy
Solar cooling in Italy is still in the demonstration stage, with just a few installations running.
Two different concepts for the residential sectors have been implemented in Milan: small scale central air-conditioning and large scale central air-conditioning.
5 installations are known in the

Share of different types of fuels for DHW preparation in Italian apartments [%]



Source: ISTAT, 2001

non-residential sectors. The most common technology is single effect LiBr chiller (wet cooled), coupled with flat plate or evacuated tube collectors. The cooling capacity ranges from 15 to 300 kW and the collector area from 138 to 425 m^2. Differently from all other systems, a small all air system is installed in Palermo. It is a hybrid desiccant and evaporative cooling system in which the desiccant wheel is regenerated through solar heat and a vapour compression heat pump cools the process air and pre-heats the regeneration air.

Legislation Framework and Incentives

Legislation

According to law 10/91 and to regional laws, municipalities are in charge of developing local building codes, which may include obligations concerning also solar thermal systems.

Several small towns around Milan already adopted a solar building regulation, where solar thermal systems are mandatory on new buildings and in case of refurbishment.

The building directive 2002/91/ICE has been introduced in Italy by means of law 192/05 and 311/06, which define maximum heat consumption values for new buildings. Therefore solar thermal combiplants will be interesting, since they reduce the total heat consumption. Solar plants providing hot water only, however, are not considered since the DHW load is not included in calculations.

Law 311/06 also obliges building companies to provide new buildings with renewable energy systems (among which solar) covering at least 50% of the DHW needs.

Finally, energy certification of buildings is also part of the new law: since July 2007, new buildings larger than 1,000 m^2 must be certified. This will be extended to every new building as from July 2008. One year later every house or apartment sold on the market must have been certified.

In Lombardia the method for calculating the energy demand for cooling has been formulated and the corresponding index has been included in the energy certificate of the building. This is a clear sign that in the near future limitations on cooling demand may be imposed.

Targets for solar thermal in 2020: market of 2.2–10.7 GW_{th} and total installed power of 12–39.5 GW_{th} (17,000,000–56,500,000 m^2).

Incentives

Even though no special incentives are foreseen for solar cooling installations, solar thermal could benefit from several opportunities:

- a special VAT reduction (10% instead of 20%)
- a 55% tax detraction in 3 to 10 years
- a national subsidy scheme for Local Authorities for installing solar thermal plants, which covers from 50% to 65% of the total costs
- some regional support schemes, covering about 30% of the investment costs

Conclusions

Italy is the largest cooling market in Europe (about 25% of the total cooled floor area in the EU). The market of room air-conditioning (RAC) has boomed after 2000, with average sales of about 1,300,000 units per year. It is estimated that the stock of RAC below 7 kW will reach 14,000,000 units by 2011. Concerning central air conditioners, trade and offices are the most growing sector. In the trade and offices sector, about 50% of the cooling demand is covered by chillers. Considering an average of 75 kW cooling capacity per unit and specific capacity of 200 W/m^2, it is estimated that about 11,000 units are sold every year.

Due to this situation and to the relevant amount of solar radiation available, Italy is a high potential country for the development of solar cooling.

Also, some solar thermal companies started to offer turn-key solutions for small and medium-sized solar cooling plants in the residential and commercial sectors.

Portugal



The Building Stock

Residential building stock in 2006: 3.4 million buildings (5.5 million dwellings, 5.3% increase from 2001).
88% of single family houses, 12% of multi-family houses.
In the last years, there had been a relevant decrease in the amount of new dwellings per year, from about 124,000 in 2002 to about 58,000 in 2006 and also refurbishment activities for the residential sector are still very low, consisting mainly of façade maintenance without involving energy efficiency measures.
About 80% are privately owned, so the costs of a refurbishment should be faced by the owner/tenant.
The yearly market for new non-residential buildings is about 16% of the total market for buildings.

Year	Total number of dwellings	Number of dwellings/year
1991	4,216,541	–
1996	4,583,503	366,962
1997	4,668,220	84,717
1998	4,770,778	102,559
1999	4,893,773	122,994
2000	5,007,100	113,328
2001	5,105,859	98,759
2002	5,230,208	124,349
2003	5,319,878	89,670
2004	5,390,876	70,998
2005	5,462,430	71,554
2006	5,519,654	57,224

Source: Estatísticas da construção de habitação 2006, INE, 2007

	Dwellings	Refurbishment	Refurbishment of existing stock [%]	New constructions	New constructions of stock [%]
2004	5,390,876	5,445	0.1	75,544	1.4
2005	5,462,430	5,714	0.1	71,809	1.3
2006	5,519,654	5,160	0.1	58,376	1.0

Source: Estatísticas da construção de habitação 2006, INE, 2007

Heating, Cooling and Solar Thermal

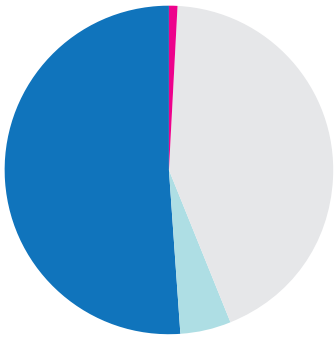
Heating the buildings

Space heating and DHW in the residential sector are mainly (from 95% to 99%) based on decentralised systems, while in large commercial areas centralised plants are widespread.

Share of used heating energy in the residential sector 2005 [%]



Share of used heating energy in the service sector 2005 [%]



Source: General Direction of Energy and Geology (www.dgge.pt in "Estatísticas/Balanços Energéticos" (28.02.2008))

Cooling the buildings

Basing on APIRAC market evaluation for 2004 and 2005, it is possible to conclude that reversible heat pumps cover 98% of the heat pump market in the residential and the commercial sector. In the outdoor units, there is a tendency of increasing the sales of mono or

multi-split with inverter from 2004 to 2005, although the shares of total sales are 24.1% and 36.5% respectively.
In large commercial buildings, also absorption chillers are used, using gas as energy source.
The cooling load (in kWh/m² year) could be 6–7 in Porto and it could raise up to 22 in Lisbon.

Source: Brotas, L. et al (2007), "Assessment of contribution of products to overall building performance. Country: Portugal European Project "GREEN-IT – Green Initiative for energy efficient eco-products in the construction industry", EIE/05/024/SI2.419623.

	2004		2005	
Units	< 7kW	> 7kW	< 7kW	> 7kW
Outdoor [%]	87.6	12.4	85.4	14.6
Indoor [%]	93.3	6.7	85.3	14.7

Solar thermal in Portugal
In spite of the about 20 MW (28,300 m²) of solar thermal systems installed in 2006, no solar cooling systems were installed in the residential and commercial sector, mainly since the systems are still considered expensive. As a matter of fact, the building stock is mainly made up of single family houses, for which solar cooling systems are rarely available or still quite expensive.

Collector area installed

	Collector area installed [m²]	Share (small DHW systems) [%]	Share (others) [%]
2003	9,210	57	43
2004	16,088	44	56
2005	18,956	58	42
2006	28,500	65	35

Source: www.aguaquentesolar.com

Legislation Framework and Incentives

Legislation
The National Strategy for Energy was defined by Ministers Council Resolution nº 169/2005, where it is clearly stated that there are huge opportunities for solar thermal energy use for hot water preparation in the residential and industrial sector.
Recently legislation on Micro Generation was also published, where an obligation for installation of at least 2 m² of solar thermal collectors is imposed for approval of private producers with micro generation (except for the case of biomass cogeneration).

Due to the new system of Building Energy Certification, a solar cooling installation can improve the energy performance of the building and therefore its energy class. Though, since this system has been implemented only recently, it is soon to have examples and an idea of the impact on the promotion of solar cooling.
The decree nº 80/2006 includes the obligation of using solar thermal collectors for hot water preparation in new buildings and large building retrofits (a minimum level of 1 m² per person).

Incentives
There are no specific programmes at national or regional level promoting solar cooling installations, except in the Azores.
Moreover, as of November 2007, no national incentive schemes for solar thermal in general are in force in Portugal, even though a tax deduction, up to 30% of system costs, is currently operating.
In the Azores there is a direct incentive (up to 25% of the cost) for renewable energy systems.
As for the incentivation of technologies competing with solar cooling, the recent "Decreto lei 363 /07" represents, in a certain way, an incentive for cogeneration/trigeneration units using biomass as energy source. The produced heat is used for DHW and space heating/cooling. The electricity produced can be exported and sold to the public grid with a bonus feed in tariff or with a common tariff, depending on the power.

Conclusions

In Portugal the building stock is growing quite slowly and also the refurbishment rate is very low and it is related more to façade maintenance than to energy efficiency renovation.
In order to spread solar cooling systems, small capacity machines are needed, since the existing building stock is composed mainly of single-family houses.



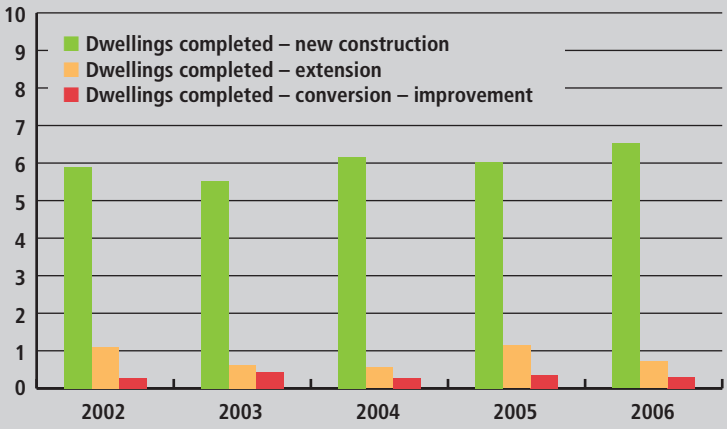
Slovenia



The Building Stock

The residential sector
Residential stock in 2002: 777,772 dwellings (58,031,187 m² useful area), 50% of which located in urban areas. About 60% of dwellings are detached houses and more than 90% are privately owned.
The building stock is quite old: 59% was built before 1975 and 31% between 1975 and 1990. In the last few years, about 6,000 new dwellings (mostly single family houses) were built or renovated.

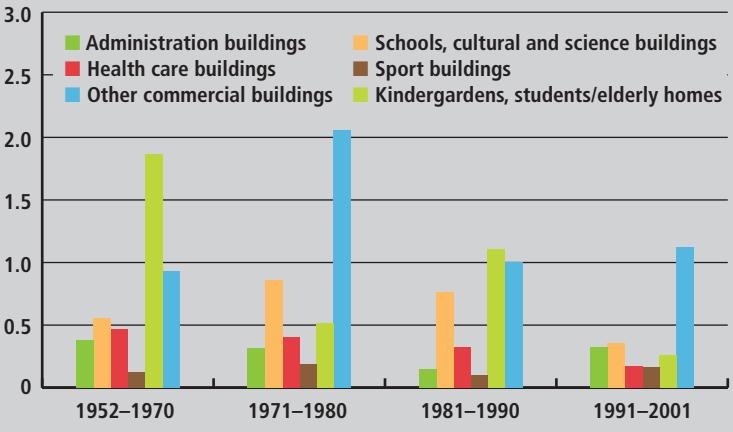
Dwelling statistics [thousand]



Source: SURS, Statistical Office of the Republic of Slovenia

Other buildings
There is a huge increase of refurbishment and construction activities at the hotel sector and the retail trade buildings sector. The hotel sector shows a large potential, since the size of capacity of new constructed hotel has increased in the last years. Also there are 500 elementary schools and 250 high schools, therefore a relevant potential of public buildings suitable for solar cooling installations. Several shopping mall chains are entering the Slovenian market, which could also represent a potential for investment in solar technology.

Size of commercial and public buildings [m m²]



Source: SURS, Statistical Office of the Republic of Slovenia

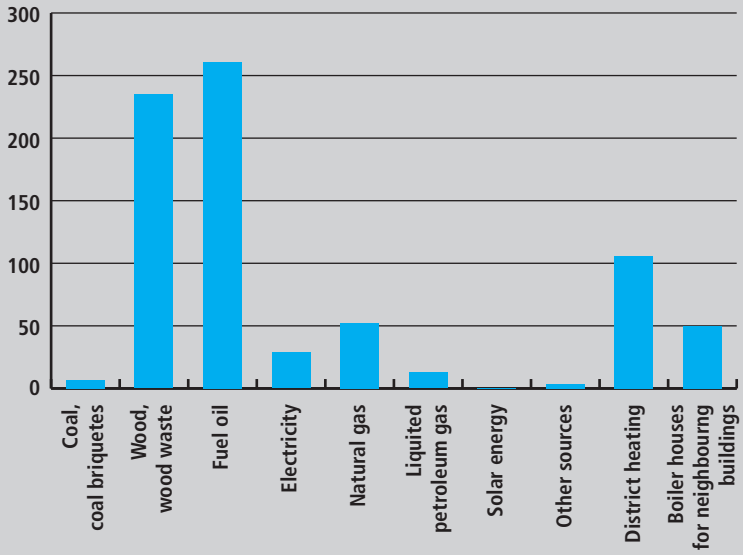
Heating, Cooling and Solar Thermal

Heating the buildings
58% of the dwellings use centralized heating system, while 20% benefit from district heating networks. Space heating is prevailing in energy consumption in households (27.4 PJ/year), followed by electricity consumption (10 PJ/year) and DWH (6.7 PJ/year).
The main energy sources for district heating are coal (63.5%) and natural gas (32.7%). In the commercial sector, there is less biomass and more district heating systems, while in office buildings, heating is often combined with cooling by using fan coil units.

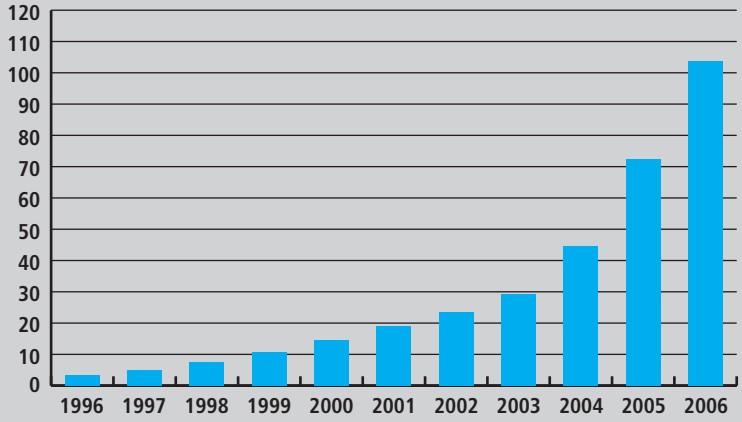
Cooling the buildings
The share of air-conditioned dwellings in 2002 was 3%, but this amount was quickly increasing, reaching about 14% (more than 100,000 dwellings) in 2006.
The annual electricity consumption in residential buildings is 48 kWh/m² and has been quite constant in the last years. New commercial office buildings are mainly equipped with centralised fan coil water cooling systems, while compact split systems are often used for the commercial building stock.

Solar thermal in Slovenia
In 2006 the market for solar thermal was less than 5 MW (about 7,000 m²), mainly in the residential sector. Given the spread ownership

Dwelling by main source of heating [thousand]



Number of air-conditioned dwellings [thousand]



Source: SURS

of dwellings, the share of large solar systems is < 1%.
On the Slovenian market, only one company offers solar cooling systems, with a 15 kW (28,000 € for the absorption unit and 22,000 € for the solar collectors) 30 kW, 50 kW and 100 kW capacity. One company manufactures high-quality absorption coolers (from 100 kW to 5,300 kW).

Legislation Framework and Incentives

Legislation
The national target regarding renewable energy sources (RES) can be found in two national strategic documents: Resolution about National Environment Protection Program 2005–2012 and National Energy Program (2003). The reduction of GHG emissions will be achieved, amongst others, by increasing the RES share in total energy supply up to 12% within 2010. According to the national plan, thermal RES should grow from 22% in 2002 to 25% in 2010, mainly by medium-sized biomass district heating plants. Even though solar thermal does not play a key role, 10,000 m²/year should be installed until 2010. The national strategy for promoting solar thermal application is mainly addressing solar heating systems for hot water in single family houses. However, in the new Slovenian Solar Thermal Technology Platform, solar cooling was declared as one of the key fields of renewable energy sources.
Since 2002, regulations about ventilation and air-conditioning define thermal comfort and air quality requirements in buildings, although no limitations about cooling energy demand or electricity demand are included, even though new requirements are expected in the next months, including overall energy demand limitations, both for heat and electricity and also cooling demand.

Incentives
From 2002 to 2004, subsidies were available for large solar cooling systems, covering 40% of the total cost, but after 2004 there were no more subsidies available. Currently subsidies of 125 €/m² only address residential solar plants (< 16 m²). AURE agency offers private investors 40% rebates for heat pump installations for heating. The same is true for Eko Sklad public trust which offers loans under favourable conditions for heat pump installations. The European Affairs and Investments Directorate offers favourable credits (with interest rates of 40% below commercial banks) for energy efficiency measures. The target groups of this fund are the industry, service sector and building sector. Eligible projects are in the area of combined heat and power, compressed air systems, energy efficient boilers, energy efficiency in building systems and heat recovery.

Conclusions

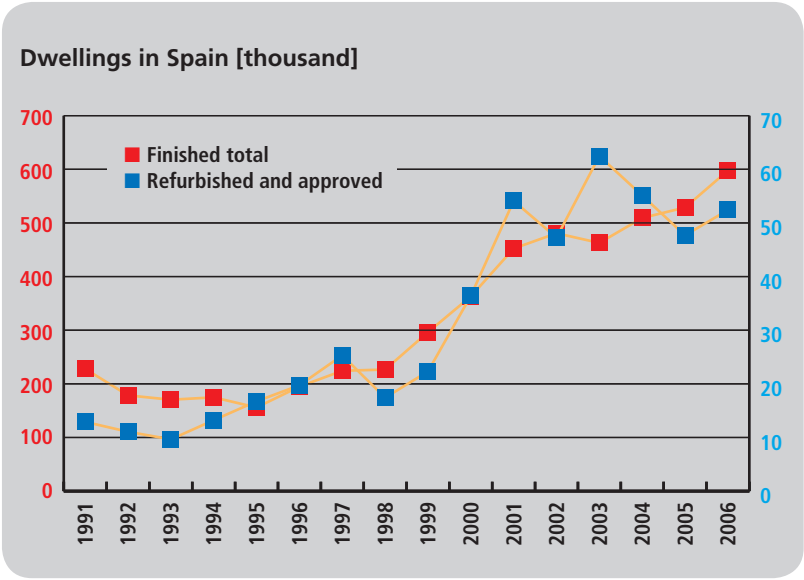
In the residential sector, the number of new buildings is definitely higher than the refurbishment, while, in hotels and retail trade buildings, a huge increase of refurbishment and construction activities is currently taking place. Due to the spread ownership of dwellings in multi family houses, there is an urgent need for small capacity cooling machines in order to introduce solar cooling in the residential sector. The tariffs for electricity will increase in a short time since, until now, they were regulated by the government and they have always been very low. Solar cooling has been recently declared as one of the key fields of renewable energy sources.

Spain



The Building Stock

Total of dwellings in 2006: 23.9 millions (3% yearly growth since 2001). 16.3 million are principal residences, 90% privately owned. About 50% are multi-family buildings. Since the end of 1997, both house costs and rate of construction have been quite high. 600,000 new houses per year were built in the period 1998–2006, the house costs have grown with an annual average of 11.8% and the renting costs with an annual average of 4%. At the end of 2007, though, the building market started to decrease.
A relevant market for new construction in the residential sector refers to the "protected" buildings, which belongs to a social project of the government.
The share of refurbished buildings is quite low, also with respect to the new construction sector.
Regarding commercial and office buildings, the total figure decreased from 1990 to 1996, showing then a slight growth. However, the figure for 2000 was only 70% of the amount registered in 1990.



Year	Houses stock	Refurbishment in total	Equivalent of existing stock [%]	New constructions	Equivalent of stock [%]
2004	22,623,443	55,111	0.24	509,293	2.25
2005	23,210,317	47,687	0.21	528,754	2.28
2006	23,859,014	52,412	0.22	597,632	2.50

Source: Ministerio de vivienda – España (http://www.mviv.es/es/)

Heating, Cooling and Solar Thermal

Heating the buildings
Space heating is mostly based on decentralised systems, due to a general social attitude. For new constructions, however, a tendency towards centralised systems can be observed.
Natural gas and electricity are direct competitors in the main cities, while in smaller cities or rural ares gasoil or propane gas are usually used. Total power consumption in the commercial sector increased, in 2000, to 5.575 ktep, about 6% of the national total consumption. In the office, hotels, restaurant and lodging sectors, heating and cooling are usually supplied by centralised systems.

Space heating in principal residences

	Centralised heating	Individual heating	No plant but devices which can heat some flats	No plant	Total
Natural gas	436,546	3,008,857	1,263,317	–	4,708,720
Electricity	49,906	1,085,537	3,352,637	–	4,488,080
Oil	756,129	1,125,112	108,968	–	1,990,209
Wood	9,202	95,468	253,858	–	358,528
Coal	77,272	140,047	316,447	–	533,766
Others	9,464	12,977	24,518	–	46,959
Not applicable	–	–	–	2,057,764	2,057,764
Total	1,338,519	5,467,998	5,319,745	2,057,764	14,184,026

Source: INE – Instituto Nacional de Estadística – España (http://www.ine.es/

Cooling the buildings
In 2000, electrically driven air-conditioning had a share of 15.5% of the residential energy consumption. Cooling for the commercial sector was 11% of the national electric consumption.

Solar thermal in Spain
Solar thermal is mainly used in residential buildings. About 100,000 m^2 of large solar thermal systems (surface > 30 m^2) were operating in 2005, mainly for DHW and not for space heating.
The solar thermal market in Spain is undergoing a remarkable growth (26% in 2006).
Small thermal driven chillers (< 20 kW) were shifted to the prototype phase to the commercialisation and some solar thermal companies have now "turn-key" solutions available for small and medium scale solar cooling plants.
A large potential for solar cooling is expected, due to the likely increase in air-cooled area for residential buildings. At the end of 2006, about 30 solar cooling plants larger than 20 kW have been reported in the commercial sector (90% with LiBr-absorption-single effect chillers), mainly offices of public administration buildings; research centres, hotels and industries.

Legislation Framework and Incentives

Legislation
Spain has developed a Strategy and Action Plan for renewable energy, which objective is to cover 12% of primary energy through renewable energy sources by 2010.
Within this framework, the objective is to increase solar thermal installed surface by 4,200,000 m^2 for the period 2005–2010.
With the coming into force of the Technical Building Code, in application of the EU Directive 2002/91/EC, new buildings must now incorporate solar energy facilities to cover part of the annual demand for DHW. However, no specific regulation is in place for solar cooling plants. Such installations should comply with the general specifications for climate control in the RITE (Regulation on Heat Facilities).
RITE covers the use of solar thermal only for generating DHW, and it would not be suitable for solar cooling.

Incentives
At national level, the IDAE (Spanish Institute for Energy Diversification and Saving) provides loans for investments in energy efficiency and renewables, including solar thermal plants larger than 20 kW.
Furthermore, several incentive schemes are operating at regional level. For instance, ICAEN in Catalonia and EVE in the Basque Country provide subsidies for solar thermal for any application, including solar air-conditioning.

Conclusions

Spain shows a quite dynamic market for new construction and also the "social buildings" promoted by the Government play a key role in the building market.
The Government has ambitious goals for solar energy and a large potential for solar cooling is expected, due to the likely increase in air-cooled area for residential buildings by 2020. Moreover, solar thermal companies are already offering turn-key solutions for solar cooling.
The fact that electricity tariffs have been constantly growing in the last years could be considered as an additional incentive for solar cooling plants.

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