Contract No: TREN/07/FP6EN/S07.68923/038659 HIGH-COMBI

HIGH-COMBI

HIGH SOLAR FRACTION HEATING AND COOLING SYSTEMS WITH COMBINATION OF INNOVATIVE COMPONENTS AND METHODS

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Instrument: **STREP**
Thematic Priority: **Sustainable Energy Systems**

Workpackage WP 4, Deliverable D22

"6.3 MARKET STUDY"

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Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group specified by the consortium (including the Commission	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Table of Contents

1. Overview of European Solar Thermal Systems Market

At the end of 2009, global installed capacity of solar collectors reached 172.4 GWth, including flat-plate and evacuated tube collectors at 151.5 GWth and unglazed water collectors at 19.7 GWth. Air collector capacity was accounted for 1.2 GWth. The glazed and unglazed water and air collectors in operation dominate a significant market share worldwide, in China (101.5 GWth), in Europe (32.5 GWth), and in the United States and in Canada (15.0 GWth), which together account for 86.4% of total installed *[Weiss and Mauthner, 2011]*.

At the end of 2010, existing solar water and space heating capacity increased by an estimated 24,5 GW_{th}, or about 16%, to reach approximately 185 GW_{th}, excluding unglazed swimming pool heating. China added an estimated 17.5 GW_{th} (25 million m^2 of collectors) for a total of just under 118 GW_{th} (168 million m^2) *[REN21, 2011]*.

In 2010, the European Union accounted for most of the remaining global added capacity. The European solar thermal market totaled 2,586 MW_{th} (3,694,940 m^2) of newly installed capacity, decreasing by an estimated 13% in comparison with 2009. The effects of the financial crisis in the last couple of years are still being felt with very low renovation and new buildings' construction rates, preventing the solar thermal sector from taking full advantage of the European trend towards more demanding standards for the energy performance of buildings *[ESTIF, 2011]*.
Due to this, new installations continued to decline in some key European markets, including Austria, Germany, and France. The Greek and Italian markets increased slightly, while Spain's market held constant in 2010 after increasing about 21% the previous year *[REN21, 2011]*.

Germany is still driving the E.U. market, with 31%, while Austria, France, Greece, Italy and Spain together account for 43%. In terms of solar thermal capacity in operation per capita, the European average is at 47.6 kW_{th}/1,000 capita. Cyprus, where more than 90% of all buildings are equipped with solar collectors, leads Europe with 623 kW_{th}/1,000 capita, followed by Austria at 321 kW_{th}/1,000 capita and Greece at about 253 kW_{th}/1,000 capita *[ESTIF, 2011]*.

During 2010, the estimated solar yield was 17.3 TWh allowing a contribution of nearly 12 Million tons of CO_2 saved thanks to solar thermal *[ESTIF, 2011]*.

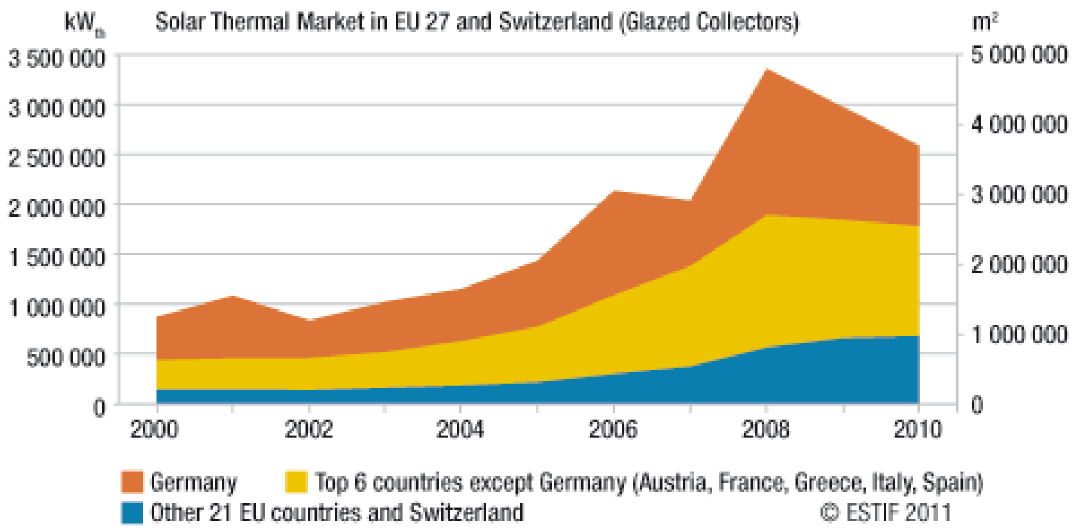


Figure 1: Solar thermal Market in EU27 and Switzerland (glazed collectors) (Source: ESTIF, 2011).

Solar hot water systems are now mandatory in new buildings according to solar ordinances in Spain, Portugal, Italy, Greece and other European countries and regions. China dominates the world market with 80,3% of glazed and unglazed water and air collectors worldwide (29.40 GWth) and followed by 10,2% in Europe (3.7 GWth), which together account for 90.8% of the overall new collector installations in 2009 *[Weiss and Mauthner, 2011]*. Practically all installations in China are for domestic hot water only. The trend in Europe is towards larger Solar Combi systems that provide both domestic hot water and space heating, accounting for half of the annual market *[Balaras et al. 2010]*.
The U.S. market for solar hot water collectors (excluding unglazed swimming pool heating) is still relatively small but is gaining ground - especially in California - and total capacity increased 5% in 2010 to some 2.3 GWth. The slower rate of growth relative to 2009 was due to the economic crisis and to the low cost of competing home-heating fuels, which extended the payback period for solar heat systems *[REN21 2011]*.

In an effort to improve the energy performance of buildings and the integration of renewables, the primary goal should always be to first reduce heating and cooling loads. Simply shifting primary energy from fossil fuels and electricity to solar energy may be environmentally sound, but on the other hand it will prove financially prohibitive; energy waste of solar energy is as unacceptable as any other energy source. Implementing proper building and plant design, construction and operation following well established principles, reducing heat losses in winter and heat gains in summer through the building envelope, using energy efficient equipment and technologies, is a practical and mandatory process for any high performance building project.

2. Solar Thermal Systems state of the art in the participating countries

The most common solar energy thermal application is for Sanitary Hot Water (SHW) production. However, the same solar collectors can be used to deliver thermal energy for space heating. A typical installation for the combined production of SHW and space heating (Solar Combi Systems) includes the solar collectors, the heat storage tank and a boiler used as an auxiliary heater. Apparently, a Combi System will require a larger collector area than a SHW system to meet the higher loads. It is possible to use a heat storage tank and a SHW storage vessel, but it may also be suitable to combine them in a single storage tank with a high vertical stratification, to meet the different operating temperatures for space heating and SHW.

Solar collector efficiency (delivered heat to incident solar radiation) depends on the type of the collector, the hot water storage and back-up systems, averaging on an annual basis 40-55% for SHW, while annual average solar utilisation (accounting for storage heat losses and waste heat) of 20-25% have been obtained in Combi Systems *[Philibert 2006]*. Depending on the size of the solar collector field, hot water storage, local climatic conditions and building loads, solar Combi Systems may cover 10-60% of the combined SHW and space heating demand at central and northern European locations.

To assess and compare performances of different designs for solar combi systems, the International Energy Agency (IEA) launched in 1998 Task 26 on “Solar Combi systems” for houses and residential buildings (www.iea-shc.org/task26). Standardised classification and evaluation processes and design tools were developed for these systems, along with proposals for the international standardisation of Combi System test procedures. A follow-up European project (Ellehauge 2003) converted the findings of the IEA Task 26 to information usable for the public, and collected practical information on installed Combi Systems.

Typically, solar combi systems need a specific design in order to avoid operating problems during summer, due to the oversize of the solar system compared to the low thermal demand, resulting to overheating. To handle this problem, it is possible to use a specific solar collector field configuration and connection with an expansion vessel, collector drainback, cooling devices in the collector loop, and a heat discharge loop. To reach a high solar collector efficiency, a low return temperature from the space heating loop is desirable. For example, an average increase of 10 K in the return temperature from radiators will require a 25 to 40% larger solar collector area in order to reach the same performance. Special care should also be exercised for proper thermal insulation of the large water storage tanks.

Solar cooling is an emerging market with a huge growth potential. There has been a strong research and development and various demonstration projects in Europe, including: Climasol "Promoting solar air conditioning" (www.raee.org/climasol); Sace "Solar Air Conditioning in Europe" (www.energycon.org/sace/sace.htm); Solair "Increasing the market implementation of solar air-conditioning systems for small and medium applications in residential and commercial buildings" (www.solair-project.eu); Solco "Removal of non-technological barriers to Solar Cooling technology across southern European islands" (www.solcoproject.net), and at international level through the IEA Solar Heating & Cooling (SHC) program, including: Task 25 "Solar assisted air-conditioning of buildings" (www.iea-shc-task25.org) and Task 38 "Solar Air-Conditioning and Refrigeration" (www.iea-shc.org/task38).

Each technology has specific characteristics that match the building's HVAC design, loads, and local climatic conditions. A good design must first exploit all available solar radiation and then cover the remaining loads from conventional sources. Proper calculations for collector and storage size depend on the employed solar cooling technology. The use of solar collectors should be maximised by also supplying heat to cover space heating or SHW loads. Hot-water storage may be integrated between the solar collectors and the heat-driven chiller to dampen the fluctuations in the return temperature of the hot water from the chiller. The storage size depends on the application: if cooling loads mainly occur during the day, then a smaller storage will be necessary than when the loads peak in the evening. Heating the hot-water storage by the backup heat source should be strictly avoided. The storage's only function is to store excess heat of the solar system and to make it available when sufficient solar heat is not available. Specific guidelines and an overview of various applications are reported in *[Balaras et al. 2006]*.

The main "drawback" of solar combi systems has been the fact that during summer the available high solar radiation and the heat produced from the solar collectors could not be fully utilized, thus making the system financially less attractive, limiting its use to the low SHW summer demand. In addition, there are some technical problems related to stagnation (i.e. the condition when the medium in the solar collector loop vaporizes as a result of high solar radiation availability and low thermal demand). Since high building cooling loads generally coincide with high solar radiation, the readily available solar heat from the existing solar collectors can be exploited by a heat driven cooling machine, thus extending the use of the solar field throughout the year; SHW and space heating in winter and SHW and cooling in summer.

2.1 Solar Thermal Systems in Austria

Considering the technical life span of solar thermal systems, approx. 4.5 million m^2 of solar thermal collectors were put in operation in Austria in the year 2010. This corresponds to an installed thermal capacity of 3,191 MW_{th}.

The solar yield of the solar thermal systems in operation in Austria was equal to 1,876 GWh_{th} in 2010. Taking into consideration the usual heat mix in Austria, the avoided CO_2-emissions are 411,596 tons. In 2010 a total of 285,787 m^2 solar thermal collectors were installed, which corresponds to an installed thermal capacity of 200 MW_{th}. 94% of the installed collectors were flat plate collectors and 4% evacuated tube collectors. The remaining part accounts for unglazed pool absorbers and air collectors. The development of the solar thermal collector market in Austria is characterized by a decrease of the sales figures of 21% in 2010. In the European context Austria ranks nevertheless on second place behind Cyprus regarding the installed collector area per capita in 2010. *[Weiss, W., et al., 2011]*.

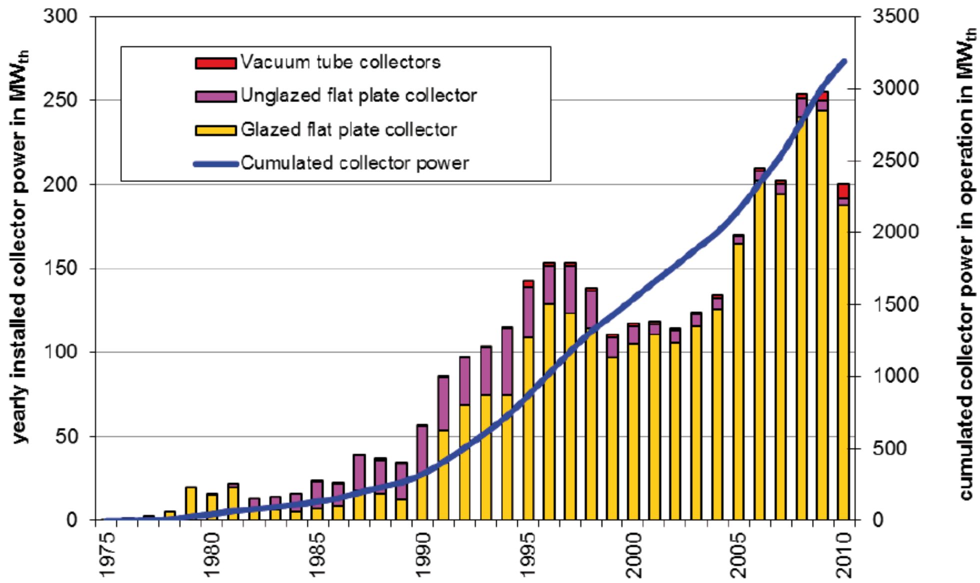


Figure 2: Market development of solar thermal collectors in Austria until 2010. (Source: AEE INTEC)

Current Heat Demand in Austria *[Weiss, W., et al., 2008]*

The final energy consumption of the major energy consuming sectors in Austria is shown in Figure 3. Of all the sectors, industry has the highest energy consumption, about 33% of total consumption. The second largest sector is transport and the third largest is the household sector.

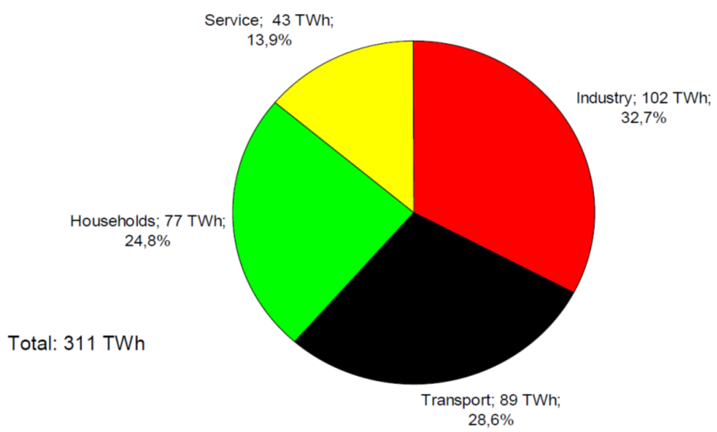


Figure 3: Final energy consumption in Austria in 2005 (Source: EU 2008)

The energy mix of Austria's final energy consumption is shown in Figure 4. Oil is by far the major energy carrier. Electricity, the second most important energy carrier, includes a high share of hydropower, about 62%. Therefore, the total share of renewables in Austria at 23.3% is comparatively high. The third most important energy carrier is gas at 16.7% of the total final energy consumption.

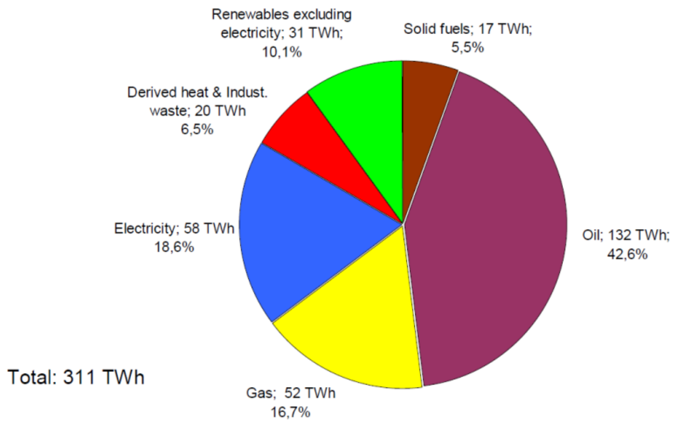


Figure 4: Austria's final energy consumption in 2005 by energy carrier (Source: EU 2008)

Final Energy consumption of households in Austria is shown in Figure 5. Space heating is by far the most important sector at 74.3%. Water heating holds 11.4% of the share and the sector "others" (appliances, cooking, electronic devices) represents the rest.

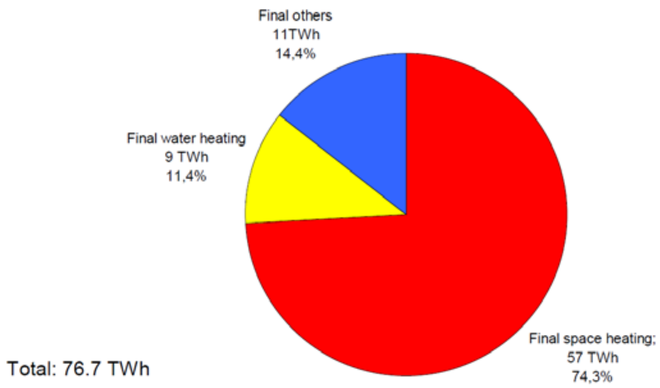


Figure 5: Austria's final energy consumption of households in 2005 (Source: EU 2008)

The structure of energy consumption for space heating and water heating is illustrated in Figure 6. In both cases, space heating and water heating, there is a high degree of diversification in the energy mix, but more than 50% is based on fossil energy carriers. Oil and gas play an important role, but biomass also has a long tradition in Austria's residential sector, particularly in the pellets and wood chips sub-sectors.

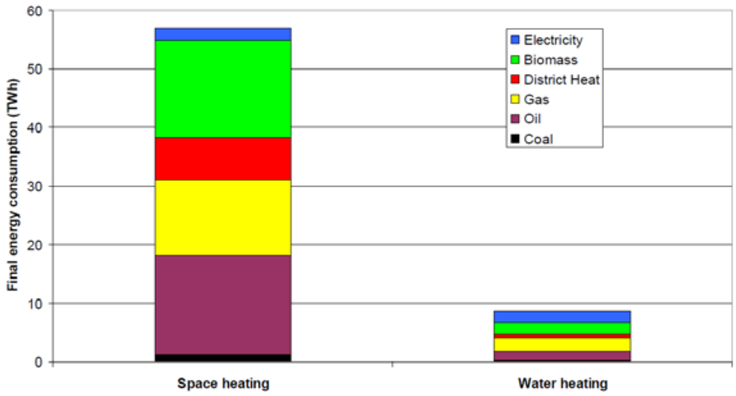


Figure 6: Structure of space heating and water heating energy mix of households in Austria (Source: statistics Austria and calculations by EEG)

Figure 7 is a summary of energy consumption in the heat and air conditioning sectors. These sectors are relevant for solar thermal potentials in Austria. The most important sector is residential space heating followed by low temperature industrial heat and space heating in the services sector. Water heating, currently the most developed part of solar thermal energy, is also worth noting. Air conditioning is at present negligible compared to the other sectors.

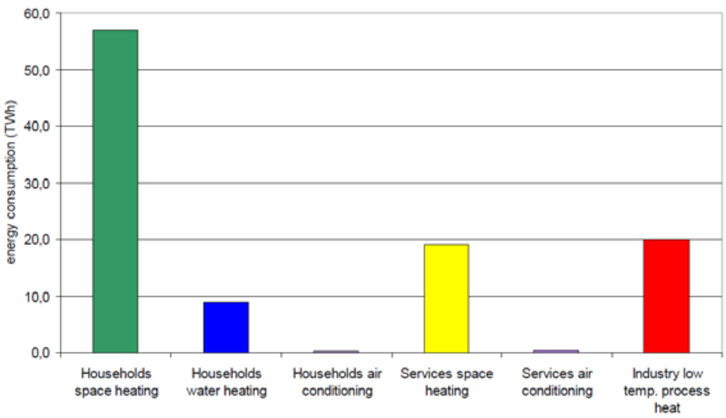


Figure 7: Summary of energy consumption in heat and air conditioning sectors relevant for solar thermal potentials in Austria, (Remark: energy consumption for air conditioning is electricity consumption) (Source: calculations by EEG)

The "ASTTP - Research Agenda – Solar Thermal" was elaborated by a group of experts of the Austrian Solar Thermal Technology Platform (ASTTP) and published by the Federal Ministry for Transport, Innovation and Technology (BMVIT) 2008 *[Weiss, W., et al., 2010]*.
A "Technology Roadmap for Solar Thermal Cooling in Austria" is currently under elaboration. This roadmap should support the development of solar thermal heating and cooling systems in Austria. It will be published by the Federal Ministry for Transport, Innovation and Technology (BMVIT) during spring/summer 2012 *[Preisler, A., et al., 2012]*.

2.2 Solar Thermal Systems in Germany

According to the German Solar Industry Association BSW-Solar (www.solarwirtschaft.de) Germany has the biggest solar thermal market in Europe. Table 1: shows the main market figures as of end of 2010.

Table 1: Solar thermal (heating) industry in Germany. Profile in brief till end of 2010 (Source: BSW-Solar/www.solarwirtschaft.de)

New collector surface installed in Germany 2010	approx. 1.15 million m^2
New solar thermal systems installed in Germany 2010	115,000
New capacity installed in 2010	approx. 800 MW (therm.)
Market development in Germany 2009 to 2010	approx. -26%
Total capacity installed	9.8 GW (therm.)
Total collector surface installed	approx. 14 million. m^2
CO_2 savings 2010	> 1 million tn
Domestic value-added share	> 75 percent
Share of German heat consumption 2010 / 2050*	< 1% / approx. 50%

* Forecast BSW-Solar

In Figure 8 the yearly new solar collector installations is illustrated. Since beginning of the 1990's are yearly mean growth rate of 18% can be seen, however with some wild fluctuations like the 23% market drop in 2009. Also in 2010 the market decreased by 29% *[ESTIF, 2011]*. In 2010 the responsible budget committee imposed a freeze on the Market Development Program (MAP). It was already cancelled in July, but the incentives changed and the customers lost trust. Thanks to an intensive marketing and informative campaign, a Million m^2 collectors were still installed by the end of the year. According to the German Solar Industry

Association, the market should come back to its best year level of 2008 in 2012.

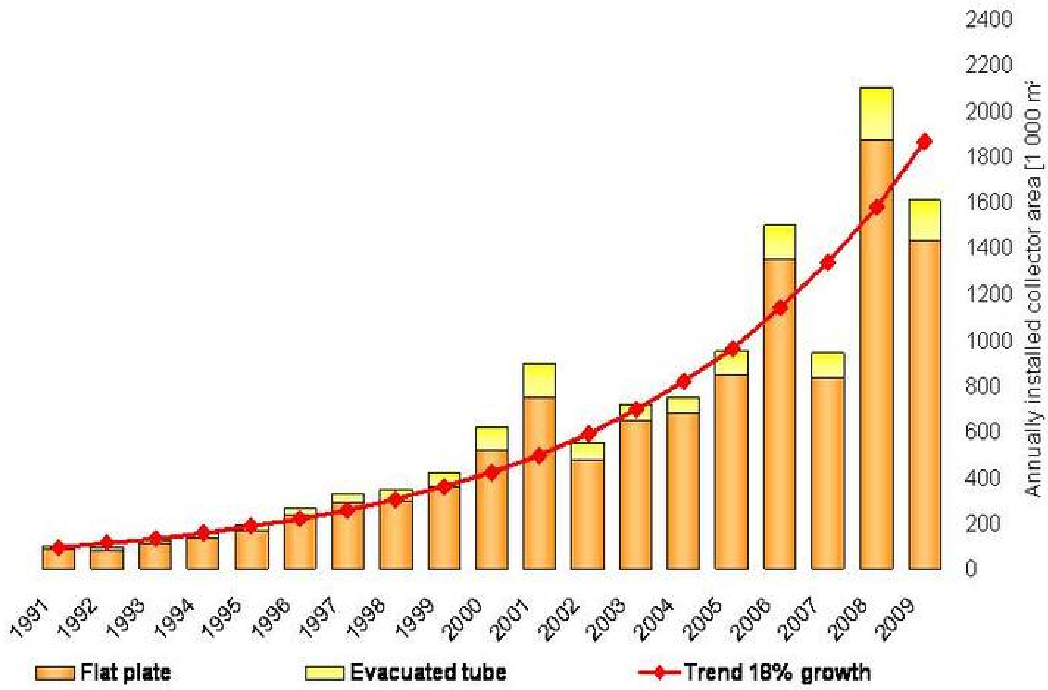


Figure 8: New Installations per year in 1,000sqm, flat plate & evacuated tube collectors. (Source: BSW-Solar/www.solarwirtschaft.de)

Table 2 shows yearly sales numbers of the solar thermal industry for the last twelve years.

Table 2: Sales in the German solar thermal industry (end-customer sales) (Source: BSW-Solar/www.solarwirtschaft.de)

Year	Sales of German solar thermal industry (solar thermal technology) in millions of €
1998	200
1999	250
2000	350
2001	500
2002	340
2003	550
2004	600
2005	750
2006	1,200
2007	850
2008	approx. 1,700
2009	approx. 1,500
2010	approx. 1,000

Table 3 summarizes the yearly new solar thermal installations and the accumulated values for total installed collector surface and total number of installations.

Table 3: New installation of solar thermal systems in Germany (Source: BSW-Solar/www.solarwirtschaft.de)

Year	New installations per year in square meters of collector surface	Accumulated collector surface (mio m^2)	Number of solar thermal installations (accumulated)
1999	420,000	2.3	265,000
2000	620,000	2.9	350,000
2001	900,000	3.8	471,000
2002	540,000	4.4	540,000
2003	720,000	5.1	623,000
2004	750,000	5.8	700,000
2005	950,000	6.8	800,000
2006	1,500,000	8.3	940,000
2007	940,000	9.2	1,034,000
2008	2,100,000	11.3	1,244,000
2009	1,550,000	12.9	1,394,000
2010	1,150,000	14.0	1,509,000

Energy demand in Germany *[Weiss, W., et al., 2008]*

Figure 9 shows the distribution of the final energy consumption in Germany in 2005 to the relevant sectors. The largest energy demand can be seen for households with 31%, followed by transport, industry and services.

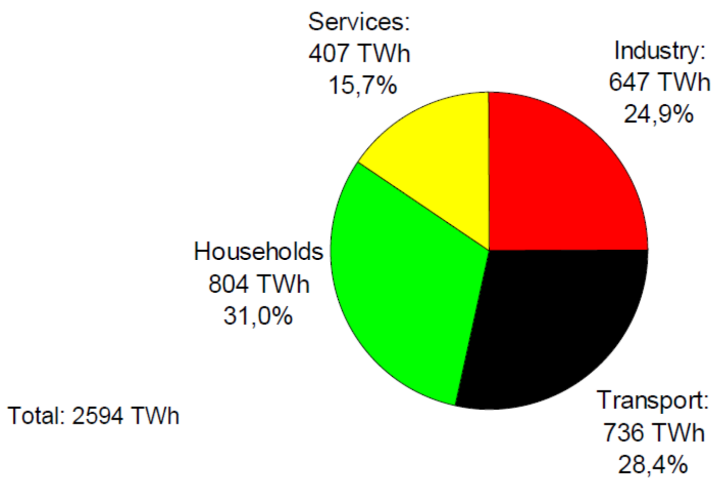


Figure 9: Germany's final energy consumption in 2005 in TWh and %, source: EU 2008

In Figure 10 a breakdown of the energy consumption for the heat supply for space heating and water heating in households can be seen. Almost 80% of this demand is covered from oil and Gas.

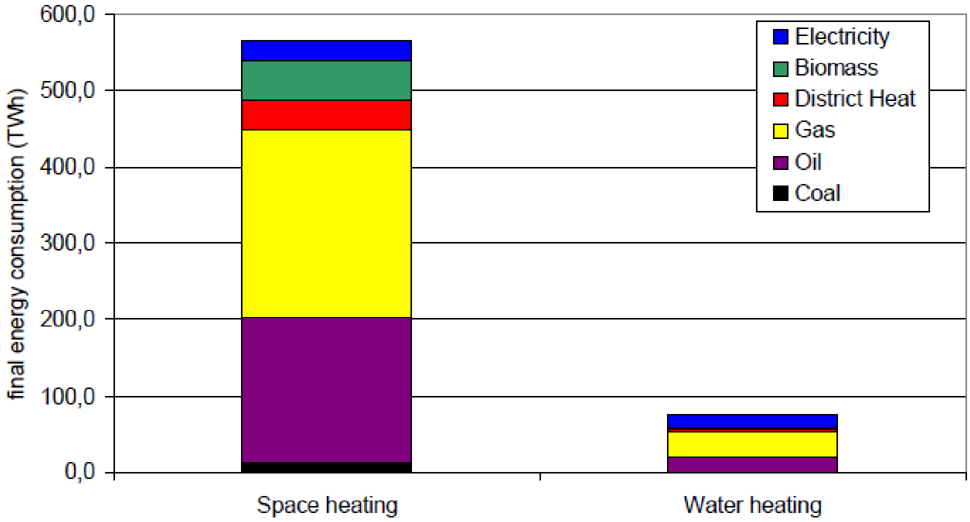


Figure 10: Breakdown of space heating and water heating energy mix of households in Germany, source: NRDLINK 4.1 and calculations by EEG

Figure 11 shows the energy consumption in the heat and air conditioning sectors that are relevant to the potential of solar thermal. The dominant sector is the space heating sector for households and in the services sector followed by low temperature industry processes and water heating in households. The energy demand for air conditioning is of minor importance.

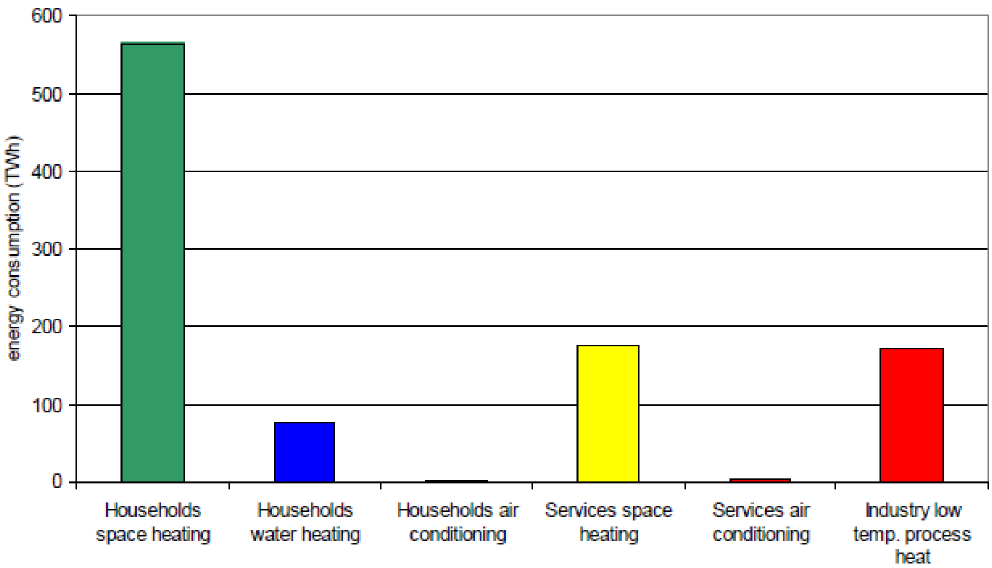


Figure 11: Summary of energy consumption in heat and air conditioning sectors relevant for the potential of solar thermal in Germany, (Note: energy consumption for air conditioning is electricity consumption), source: calculations by EEG

2.3 Solar Thermal Systems in Greece

There is surprisingly good news from the Greek market in 2010. Contrary to initial expectations and, in spite of the country's economic recession, the newly installed capacity for solar thermal products has slightly increased in 2010. With a growth of 3.9% the market has now reached 149 800 kWth of newly installed capacity (214 000 m^2). This is partly due to the support scheme available, covering energy efficiency measures and replacement of older heating equipment. Also relevant is the general sensitivity to energy price increases and the strong awareness of solar thermal advantages, being economically attractive as it provides payback periods of up to 5 years.

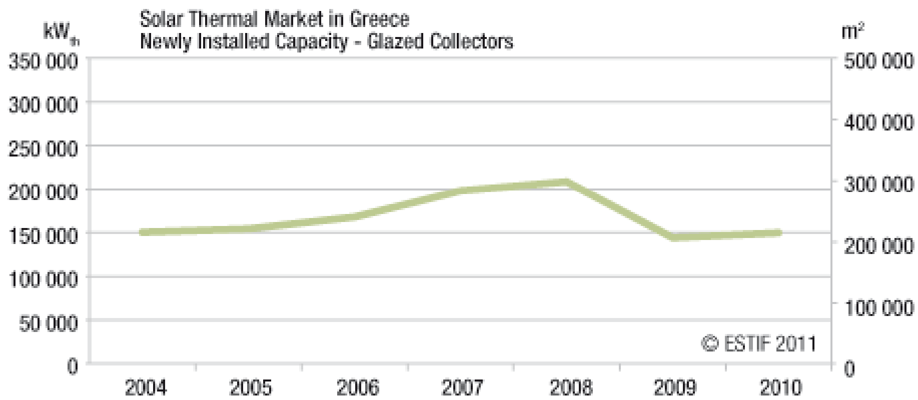


Figure 12: Solar thermal market in Greece. Newly installed capacity – Glazed collectors.

According to GSIA, 99% of the installed collector area is for thermosiphonic type water heaters, mainly closed loop systems. The closed loop systems use antifreeze liquid to avoid the freezing of the collector loop. The storage tank can be vertical or horizontal and is mounted higher than the collectors. The average size of thermosiphonic type systems is 2,4m2 collector area and 150lt storage tank. The range of the most common used systems is between 120– 220 lt with 1,8–4 m2 collector area. All the systems are equipped with electric back-up heaters and 30% of them are equipped with an additional heat exchanger connected with the fuel or gas heating system. The solar fraction is usually over 75%. A typical thermosiphonic water heater for domestic use produces 840-1.080kWh/year and helps to reduce CO2 emissions by 925 – 1.200 kg/year.

The breakdown of solar thermal applications in Greece, according to the GSIA, is as follows:

- Domestic hot water production (~98% of installed collector area). Mainly ther-mosiphonic water heaters, including hotel studios, small commercial and industrial consumers.
- Large collective solar systems (~1% of installed collector area) are installed mainly in hotels for hot water production.
- Space heating, air conditioning and industrial process heating combined have less than 1% of the installed collector area.

The costs of solar thermal systems may vary among the different manufacturers. In the Table 4, indicative costs for typically sized systems are given.

Table 4. Breakdown of solar systems costs.

Solar Systems Costs for Typically Sized Systems		
	Individual	Project (large scale)
Total costs (excl. VAT)	250 €/m^2	200 €/m^2
VAT (18%)	47,5 €/m^2	38 €/m^2
Total cost (incl. VAT)	297,5 €/m^2	238 €/m^2
Typical size of system	2,4 m^2	100 m^2

(Source: Giakoumi, A., Iatridis M., 2009)

Regarding the Solar Combi Systems a survey were conducted in the framework of the project Solar Combi + in order to strengthen the penetration of systems up to 20 kW against the competition of the conventional systems. According to the retailers involved in the survey, the biggest share of their volume of sales, hold systems of small or medium capacity; more than 50% are central or semi central systems up to 20kW and more than 60% are split units up to 12.000 BTU (fig 10 & 11). More specifically, in Greece and Italy the market of split units is mainly located until the threshold of the 12.000btu, while in Spain and France the market favours larger split unit systems. One should also notice the Spanish situation concerning the central and semi central systems, where 70% of the market is between 10-20kW. This highlights a market-parameter very important and crucial for the penetration of the mentioned market with given SC+ products.

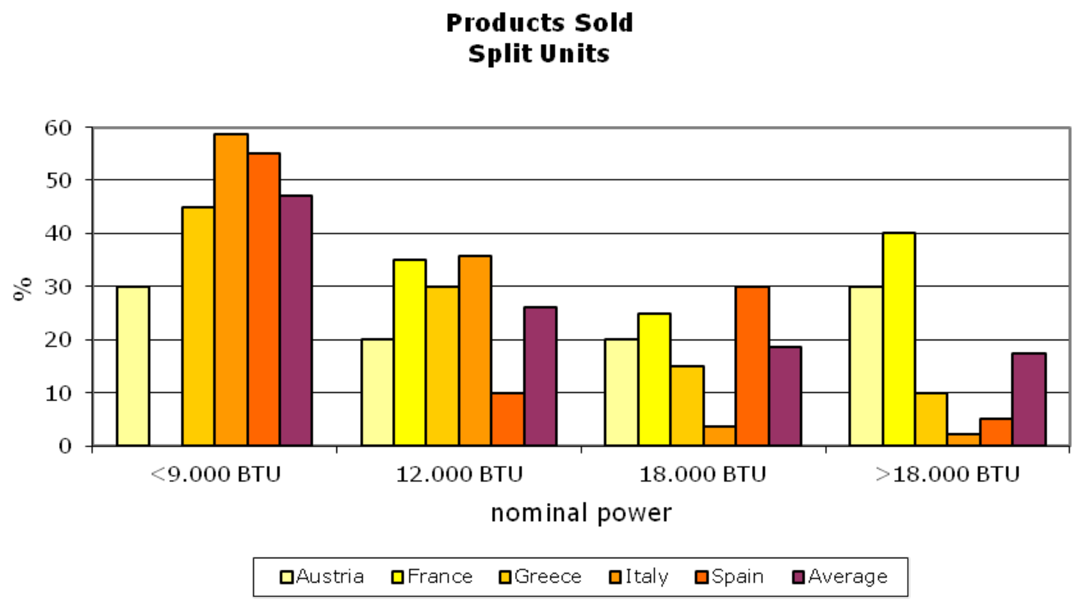


Figure 13: Central or semi central systems sold, sorted by nominal capacity

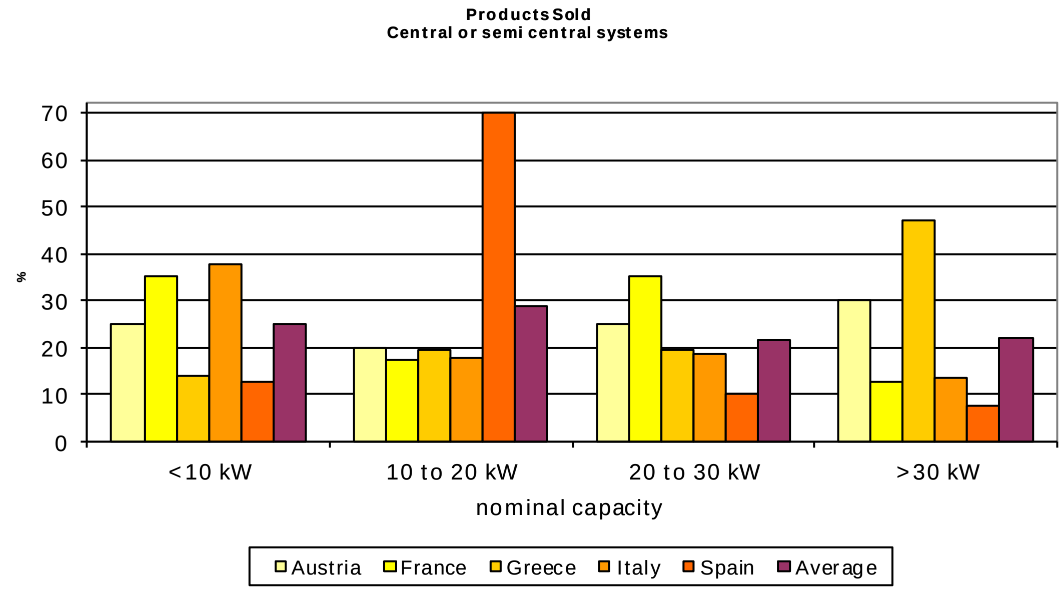


Figure 14: Central or semi central systems sold, sorted by nominal capacity

2.4 Solar Thermal Systems in Italy

In 2010, Italy confirmed its position as the second largest market in Europe, with 343.000 kWth (490.000 m^2) of newly installed capacity, almost returning to its 2009 level with an increase of 3,2%. The market seems to go through the economic world crisis quite unharmed [*ESTIF 2011*].

Recent statistics by private market research companies, however, report of a dramatic decrease in 2011 as well in Italy.

All in all about 2.670.000 m2 of glazed solar collectors were in operation in Italy in 2010. About 87 % are flat plate collectors, while 13 % are

evacuated tube collectors.

Figure 15: Solar thermal market in Italy

For what concerns available subsidies, the government finally decided to extend the 55 % tax rebate on solar thermal installations, as well as for various energy efficiency and renewable energy measures in existing buildings) for year 2012. The 55 % tax rebate supported the Italian market quite effectively in the last years, and helped avoiding illegal purchasing, which was very common in Italy before this measure was initiated. Unfortunately the tax rebate mechanism does not guarantee stable market for the future, since it's closing has only been postponed and it is not yet clear what will happen after it will be deleted. A thermal feed-in tariff will be most probably introduced.

Most common technologies in Italy are the following:

- Domestic hot water (DHW) systems:
  These systems represent by far the largest market share.
  Solar systems require a centralised distribution system, which is not available in lots of buildings in Italy, especially in large multifamily houses (which represent around 20 % of Italy's building stock): here decentralised DHW systems are most common in large

buildings, especially for DHW preparation. This is a huge obstacle against diffusion of solar thermal.

- Combi Systems:
  Solar thermal systems for DHW and space heating are relatively diffused in northern Italy, although their share to the total solar thermal market is small. In the rest of Italy they are almost non existing. This is due to the relatively warm climate in Italy, which does not make people interested in Combi Systems, especially in middle and southern Italy. One technical reason is to be found in the common heating systems, which run at high temperatures (radiators mostly, with T > 50 °C). Low temperature heating is gaining more and more importance in northern Italy, where, indeed, some solar thermal manufacturers also sell low temperature radiant heating systems.
- Solar cooling systems:
  Data available from IEA-SHC Task 38 state that about 30 plants were known in Italy by the end of 2009. Probably many more have been installed meanwhile, but the solar cooling market is likely to be still negligible. Despite the huge use of air conditioning systems in Italy, multi split compression chillers are most common. No cold water distribution is therefore available in most Italian buildings, especially in the residential sector.
  Cold water networks are available in the tertiary sector, e.g. in large commercial areas, offices, sport centers, hospitals.
- Natural circulation vs. forced circulation systems:
  Natural circulation is relatively common in the middle and the south Italy, which has at least two reasons:
  - The buildings have a flat roof (due to no or very limited risk of snow) thus the storage tank on the roof cannot be seen from the street;
  - The climate is milder, leading to lower energy losses in the storage tank.

However, even in some parts of the northern Italy (e.g. Friuli-Venezia-Giulia region), the natural circulation is very common, due to the strong commercial activity of some local manufacturers. Forced circulation is anyway the leading technology in Italy.

2.5 Solar Thermal Systems in Romania

In the 80s, solar domestic hot water systems, solar drying and industrial applications were developed. The size, variety and distribution of the solar systems installed all over the country were rather high.

Until 1989, 1,000,000 m^2 solar collectors, mainly flat plate, were manufactured and installed in Romania in large systems of up to 9,000 m^2. Evolution of solar collector systems in Romania was occurred in the middle of '80s. The peak of installations occurred in 1984-1985. The poor quality of the equipment and installation and the lack of maintenance resulted in bad operation and deep dissatisfaction, creating an additional barrier for further solar energy utilization.

After 1989, the solar thermal applications were abandoned. A very small part of the former installed collectors is still in operation. The low conventional fuel prices and the poor availability of good quality solar equipment reduced the interest for further development.

In Romania, at present, there is no professional association on solar energy, although there are companies and researchers active in this field.

Some statistical data are available from the National Authority for Energy Regulation on solar power generation only, but not on solar thermal production.

No statistical information is available for solar thermal systems. In Romania there are no manufacturers of equipment related to solar energy, but there are, of course, many companies which import any type of equipment the customers decide to order. There are also some companies that design and install solar systems, both photovoltaic and solar thermal.

The first signs of solar thermal applications market development showed up only after the year 2000. The most attractive niche market seems to be the small size systems (4-8 m^2), for hot water in residential buildings and hotels located in summer resorts (mainly on the Black See coast), followed by swimming pool water heating. Space heating and cooling are not considered a viable or reliable option by the design companies.

2.6 Solar Thermal Systems in Spain

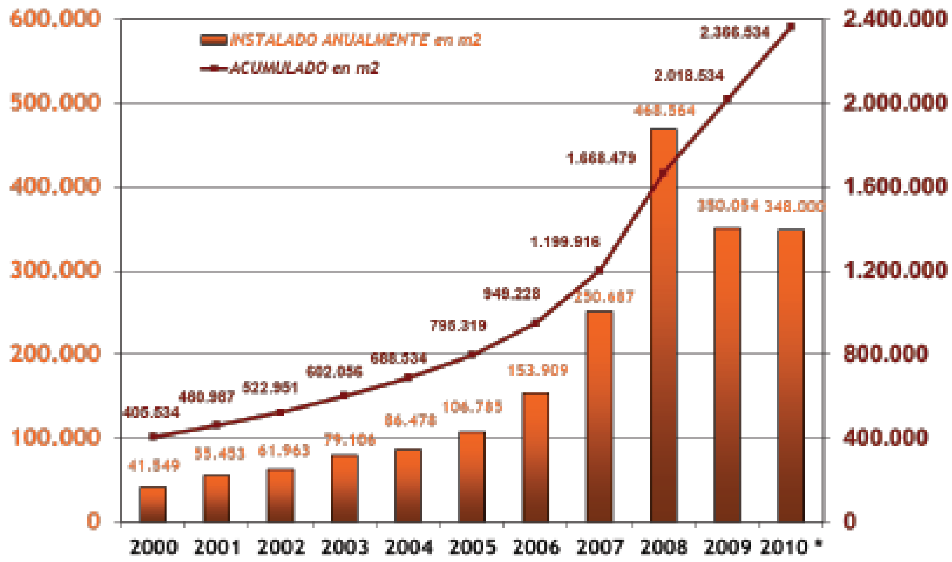
2.6.1 General framework

In 2010 almost 350.000 m^2 were installed, which meant a total amount of 2.360.0000 m^2 cumulative installed.

However, in the last years (since 2008) the total amount of installed solar thermal power has decreased enormously, based on the decrease of the construction of new buildings, to which solar thermal energy was strictly tied, because of the existing legal framework (CTE), which compelled new buildings to cover a fraction of its DHW demand with solar thermal systems.

In the renewable energy plan of 2005-2010, it was foreseen that 5.000.000 m² of collectors were installed. We have not reached half this figure.

The following graph shows the evolution of solar thermal systems



installed in Spain in the last years.

Figure 16: Evolution of yearly and cumulative installed solar thermal systems in Spain

The graph shows the clear evolution of a sector strictly tied to residential housing growth, which decayed dramatically in 2009.

The IDAE (entity responsible for renewable energy and energy efficiency in the government of Spain) has detected this trend, and has prepared a new plan on the development of solar thermal energy, focused on three sectors, which will be helped through different measures:

- Keeping the obligation of installing solar thermal in new buildings
- Focusing on solar thermal systems for heat, cold and AC systems (combi plus systems) in residential and (mainly) in services sector.
- Focusing on solar thermal systems for industrial process heat.

In order to do so, the IDAE has developed three consultancy jobs to analyze the potential of these sectors, taking into account the following numbers:

- 3,4 Mm^2 for the construction of new buildings tied to obligation
- 14,9 Mm^2 for heat, cold and DHW.
- 14,4 Mm^2 for industrial uses

Solar thermal systems are closely connected to the construction sector.

2.6.2 High-combi systems potential

Out of the second group, the combi+ systems for heat, cold and DHW, inside which the high-combi systems are included, a special analysis was done, to detect the market potential of these technologies, for the different group of new buildings to be constructed. The analysis was done, following graph 1 scheme.

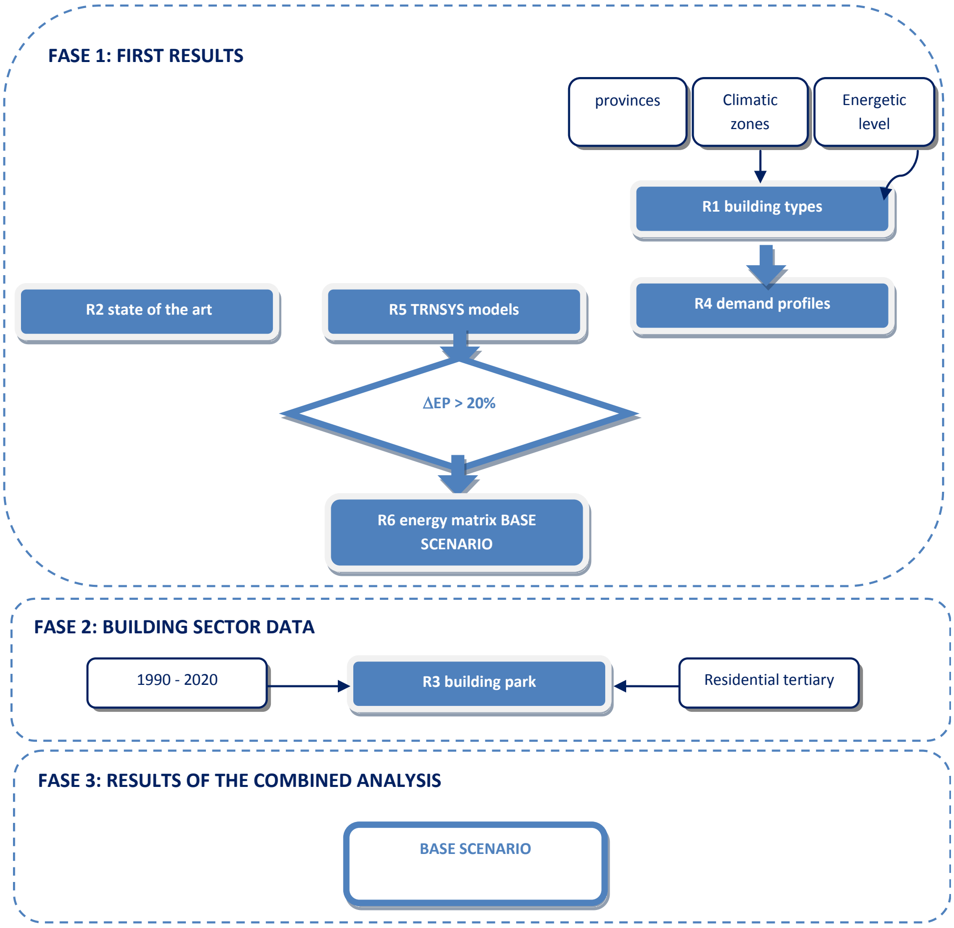


Figure 17: Methodology for the analysis

This analysis showed the following numbers for the potential in the base case scenario (a minimum of 20% of primary energy savings was required to account as potential).

		base	base
ETC/FPC+AB1	2010	91 521	12 408
	2015	106 772	14 716
	2020	122 319	17 039
PTC+AB2	2010	-	0
	2015	-	0
	2020	-	681
FPC+DEC	2010	-	0
	2015	-	0
	2020	-	181

Figure 18: Summary of results of the total potential of residential and tertiary sector, respectively

2.7 Solar Thermal Systems in the rest European countries

Europe has the most well developed market for different solar thermal applications. Small systems for SHW production using natural flow systems (thermosyphon) without any pumps or control stations are widely used in southern Europe, with an electric heat resistance in the SHW storage tank as a back-up. More complex forced circulation systems that are necessary for combined production of SHW and space heating, known as Combi systems (Figure 19a) are more common in central and northern Europe. The European market share of Solar Combi systems in 2006 was about 5% of the total solar thermal market, but in some countries it averages much higher, for example, 40% in Austria, 35% in Switzerland, 20% in The Netherlands, 15% in Denmark and 5% in France. According to the German Solar Industry Association (BSW) the German market share of Combi systems reached 45% of newly installed solar systems in 2007 *[ESTIF 2010]*.

The future is even more promising in Germany, given that as of January 2009, all new homes will be required to install renewable energy heating systems under a new national law (Renewable Energies Heating Law – Erneubare Energien Warmegesetz). Home owners will have to use RES to meet 14% of a household's total energy consumption for heating and sanitary hot water using solar collectors, wood pellet stoves and boilers. This effort will be supported by federal grants of about 350 million Euros each year. For existing houses undergoing major refurbishment after

2010, 10% of the heating and SHW energy needs will have to be covered by renewables.

a) b)

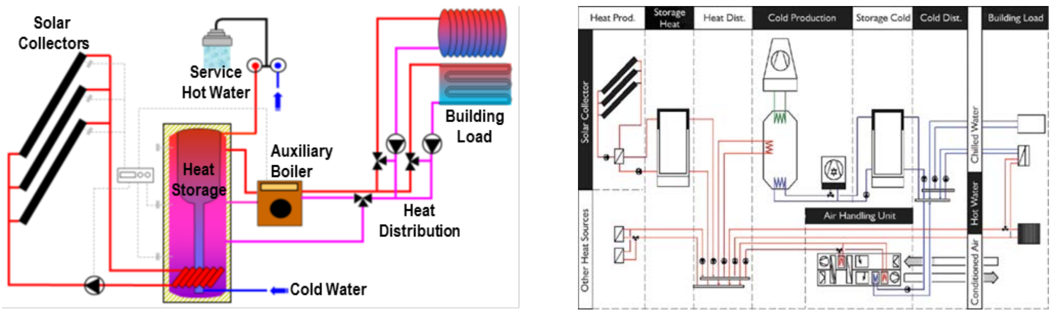


Figure 19: Typical layout of (a) solar combi and (b) combi-plus systems

Installations with large solar collector areas and heat storage capacity could cover 50 to 80% of the total heat demand or even achieve 100% load coverage when they are coupled with seasonal thermal energy storage. Central solar heating plants with seasonal thermal energy storage (STES) consist of three main components (Figure 20): the solar collector array, the seasonal storage tank and the piping network *[Argiriou 1997]*.

The heat produced by the collectors throughout the year is stored in the storage tank. This heat is then used to provide domestic hot water and space heating to the buildings, when required. STES aim for high solar fractions (50 to 80%). The heat is distributed through a hydraulic pipe network. Although solar radiation has a low power density, which requires a large collector area with small heat losses, the output from a stratified storage benefits from a high power density. STES is easily combined with existing district heating installations and is four to three times more cost effective compared to common small solar systems.

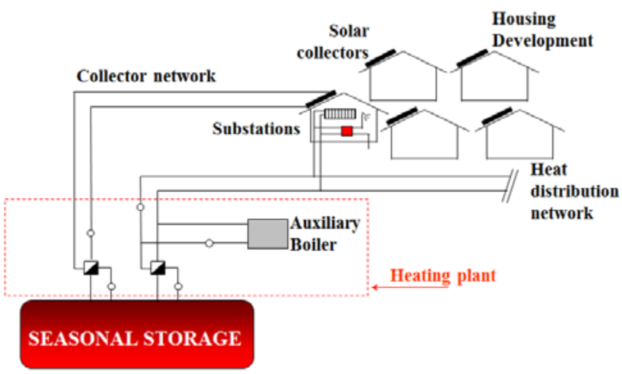


Figure 20: Schematic diagram of a seasonal thermal energy storage

STES are more suitable for heating loads greater than 500 MWh/year. The area to be covered should exhibit a relatively high heat density in order to make district heating economical. Low temperature space heating is preferable in order to operate at low temperature levels, especially of the return water in the distribution system. On average, need 0.20 to 0.30 m^2 collector area per unit heated floor area and 2 m^3 of storage (water equivalents) per unit collector area to cover 50 to 80 % of the total heating load in new buildings.

Solar cooling is an emerging market with a huge growth potential. Typical installations (Figure 19b) include: the solar collectors, a heat storage, the heat distribution system, the heat-driven cooling unit, an optional cold storage, an air conditioning system with appropriate cold distribution and an auxiliary (backup) subsystem (integrated at different places in the overall system, as an auxiliary heater parallel to the collector or the collector/storage or as an auxiliary cooling device or both). The main obstacles for wide scale applications, beside the currently high first cost, are the lack of practical experience with the design, control, operation, installation and maintenance of these systems. To overcome these barriers, there has been a strong research and development and various demonstration projects in Europe *[Balaras et al. 2006]*.

Small scale solar assisted chillers have been introduced in the market with a cooling capacity of 5 to 15 kW, averaging a thermal coefficient of performance - COP (defined as the ratio of the cooling capacity of the system and the heating power delivered to the system by the solar collectors - directly or indirectly through a heat storage tank) of about 0.7.

Solar Combi-Plus systems can contribute in reaching the 20% share of energy from RES and reduce energy consumption of conventional energy sources in buildings and problems with peak power demand, by reaching both high solar fractions and better financial performance. During summer the available high solar radiation and the heat produced from the solar collectors can be fully utilized, thus making the system more financially attractive. In addition, it is possible to avoid the technical problems related to stagnation (i.e. the condition when the medium in the solar collector loop vaporizes as a result of high solar radiation availability and low thermal demand). Since high building cooling loads generally coincide with high solar radiation, the readily available solar heat from the existing solar collectors can be exploited by a heat driven cooling machine, thus extending the use of the solar field throughout the year; SHW and space heating in winter and SHW and cooling in summer.

An overview of various European Solar Combi-Plus systems is available in Solar Combi Plus project *[Solarcombiplus, 2010]*.
A market research of commercially available small scale sorption chillers with cooling capacity up to 20 kW documented eight machines ranging from 4.5 kW to 15kW. The volume of the main system is between 1 to 1.8 m^3. The solar thermal systems that accompany the chillers consist of flat plate or vacuum tube collectors which range between 3.5-4.5 m^2/kW and 3.0-3.5 m^2/kW respectively, depending on location. Small scale Solar Combi Plus systems could easily be integrated to an existing central system for heating and/or cooling, if the existing system consists of fan coils, radiant floor or ceiling.

3. Estimation of the market size and growth in the participating countries (in terms of MWth and TOE)

3.1 Austrian Market

The determination of solar thermal potential in Austria is based on detailed studies concerning the solar thermal potential in the country, varied subsidy models and different solar thermal market developments *[Weiss, W., Biermayr, P., Kuhness, G., et al]*.

By means of a non-recursive economic optimization model the low temperature heat and cooling demand for 2020, 2030 and 2050 is calculated and presented in three scenarios. These different ambitious scenarios reach from „Business As Usual (BAU)" - „Advanced Market Deployment (AMD)" - and „Full Research Development and Policy - scenario (RDP)".

In the „Business As Usual (BAU)" – scenario no reduction of the heating and cooling demand is assumed. This scenario is based on a concept with moderate political support mechanisms, low R&D rate and low growth rate and penetration of the solar thermal market with mainly solar thermal plants for domestic hot water.

In the „Advanced Market Deployment (AMD)" – scenario a moderate reduction of the heating demand is assumed. This scenario is based on a concept with more political support mechanisms (like solar obligations for all new buildings), medium R&D rate and medium growth rate as well as the assumption that mainly solar combisystems are installed.

In the „Full Research Development and Policy – scenario (RDP)" – a significant reduction of the heating demand is assumed. This scenario is based on a concept with high political support mechanisms (like solar obligations for all - new and existing - buildings), high R&D rate (especially high energy density heat storages) and high growth rate and penetration of the solar thermal market with solar combisystems with high solar fraction from 2020 on.

Short-term potential – 2020:

The 3 different scenarios BAU, AMD and RDP show that the potential of solar thermal contribution in 2020 is between 3% and 10% of the low temperature heat demand. The corresponding annual solar yields would be 3.3 TWh (BAU) and 9.9 TWh (RDP). The specific collector area needed to reach these goals would be between 1 m^2 (BAU) and 3 m^2 (RDP) per inhabitant. The resulting total collector area would be between 8.2 million m^2 (BAU) and 24.7 million m^2 (RDP) (for more details see Figure 21 and respectively Figure 22).

Medium-term potential – 2030

In 2030, the contribution of solar thermal to the low temperature heat demand of Austria will be between 5% in the BAU scenario and 19% in the RDP scenario. The corresponding annual solar yields are 5.6 TWh (BAU) and 16.5 TWh (RDP). The specific collector area needed to reach these goals will be between 1.7 m^2 (BAU) and 5 m^2 (RDP) per inhabitant. The resulting total collector area will be between 14 million m^2 (BAU) and 41 million m^2 (RDP) (for more details see Figure 21 respectively Figure 22).

Long-term potential – 2050

In 2050, the contribution of solar thermal to the low temperature heat demand of Austria will be between 6% in the BAU scenario and 40% in the RDP scenario. The corresponding annual solar yields are 6.6 TWh (BAU) and 26.3 TWh (RDP). The specific collector area needed to reach these goals will be between 2 m² (BAU) and 8 m² (RDP) per inhabitant. The resulting total collector area will be between 16 million m² (BAU) and 66 million m² (RDP) (for more details see Figure 21 respectively Figure 22).

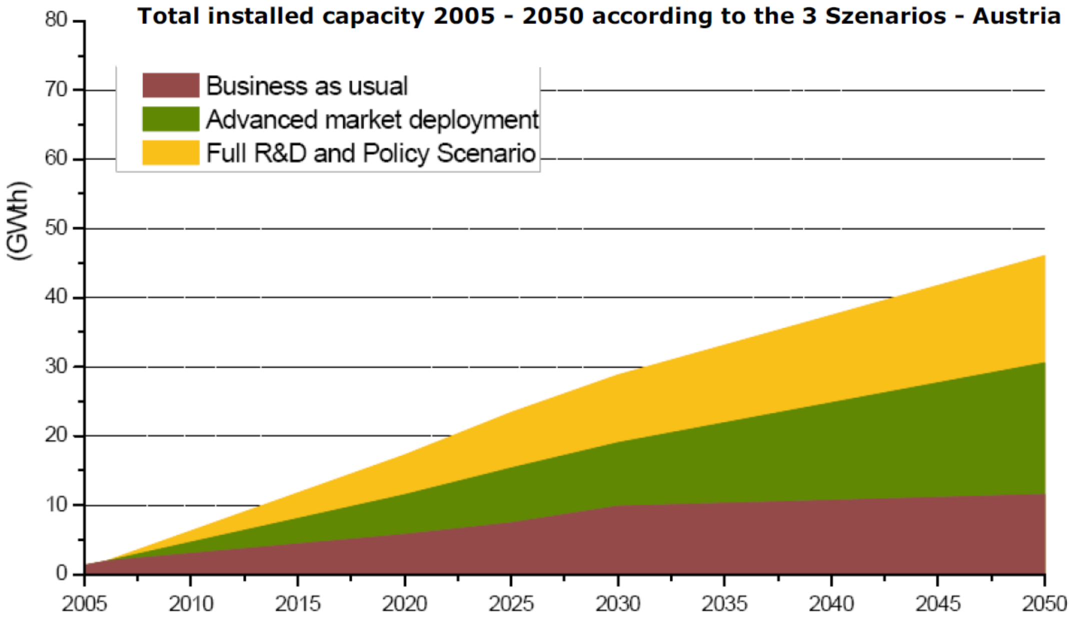


Figure 21: Solar thermal potential in Austria based on the three scenarios (Source: Weiss, W., Biermayr, P.,)

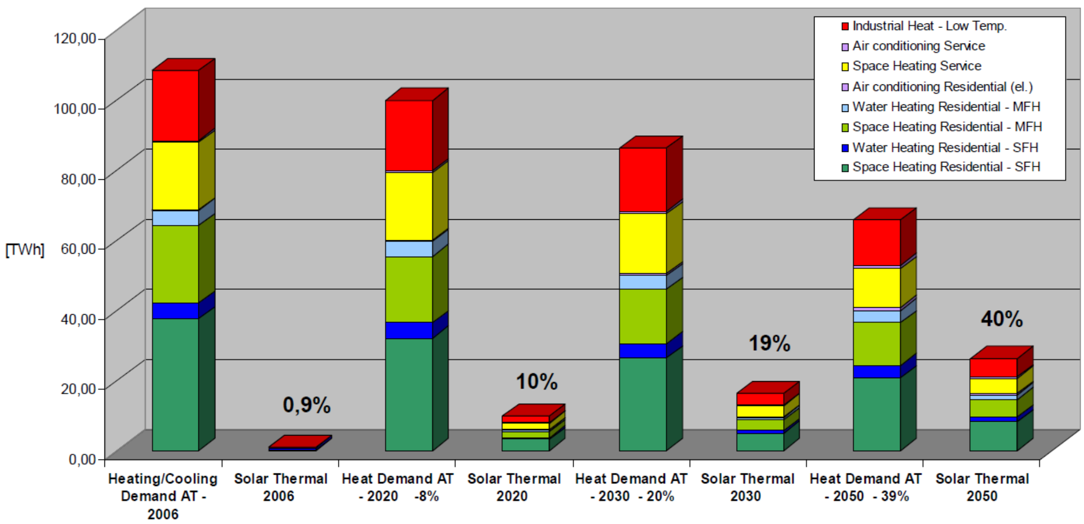


Figure 22: Total heating and cooling demand of Austria and contribution of solar thermal by sector according to the Full R&D and Policy scenario (RDP) (Source: Weiss, W., Biermayr, P.,)

By means of the results of the related report it is shown that if the whole potential for solar thermal is used nevertheless enough building area will rest for other utilization like e.g. photovoltaic cells. The most ambitious target of the scenarios with 8 m^2/inhabitant in 2050 would need only 25% of suitable façade area and about 38% of suitable roof area and none remarkable share of suitable land area.

3.2 German Market

The potential of the contribution of solar thermal in Germany was investigated in a comprehensive study *[Weiss, Biermayr, 2009]* conducted within the EU-funded project RESTMAC (TREN/05/FP6EN/S07.58365/ 020185). The following results are taken from this study. Background information and a description of the three scenarios "Business as usual", "Advanced market deployment" and "Full R&D and Policy Scenario" used for the study are given in section 3.1.

According to the findings in 2020 the solar contribution to the low temperature hat demand will be between 1.5 % and 5 % corresponding to 14.7 TWh/a and 43.7 TWh/a. In the medium term, in 2030, the solar thermal contribution will be between 3.8 % and 15 % (corresponding to between 37.2 TWh/a and 115.8 TWh/a) and in the long run, in 2050, between 6.0 % and 34 % (corresponding to between 57.8 TWh/a and 231.5 TWh/a). Figure 23 shows the resulting installed solar thermal capacity.

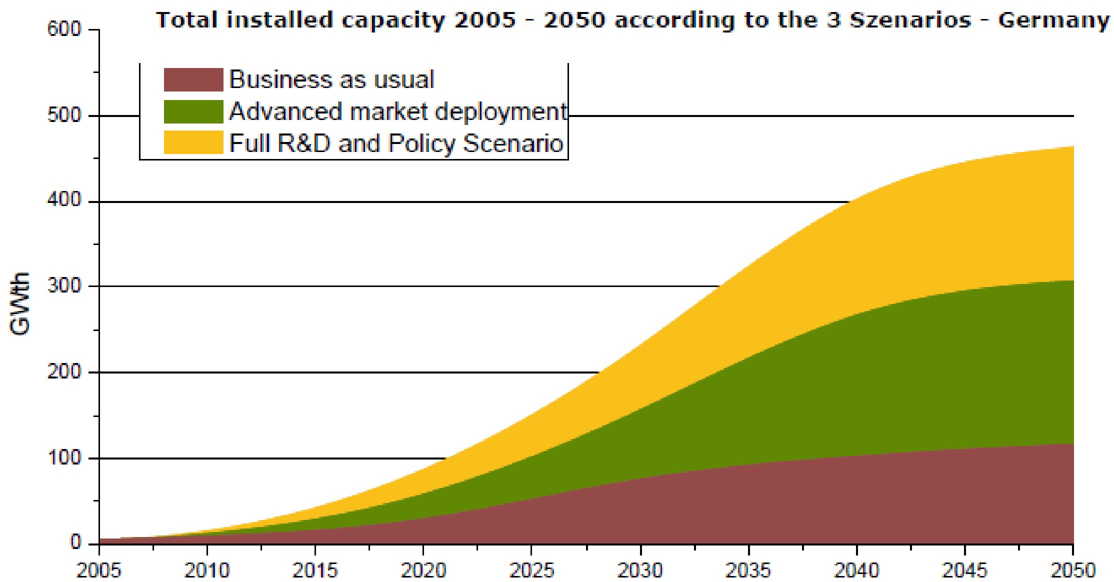


Figure 23: Solar thermal potential in Germany based on three scenarios (source: *[Weiss, Biermayr, 2009]*)

In Figure 24 the total heating and cooling demand of Germany and the contribution of solar thermal by sector according to the Full R&D and Policy scenario from 2006 to 2050 is illustrated.
In all scenarios it can be seen that the major application for solar thermal in Germany will be low temperature heat supply. Cooling has only a minor share of the contributions.

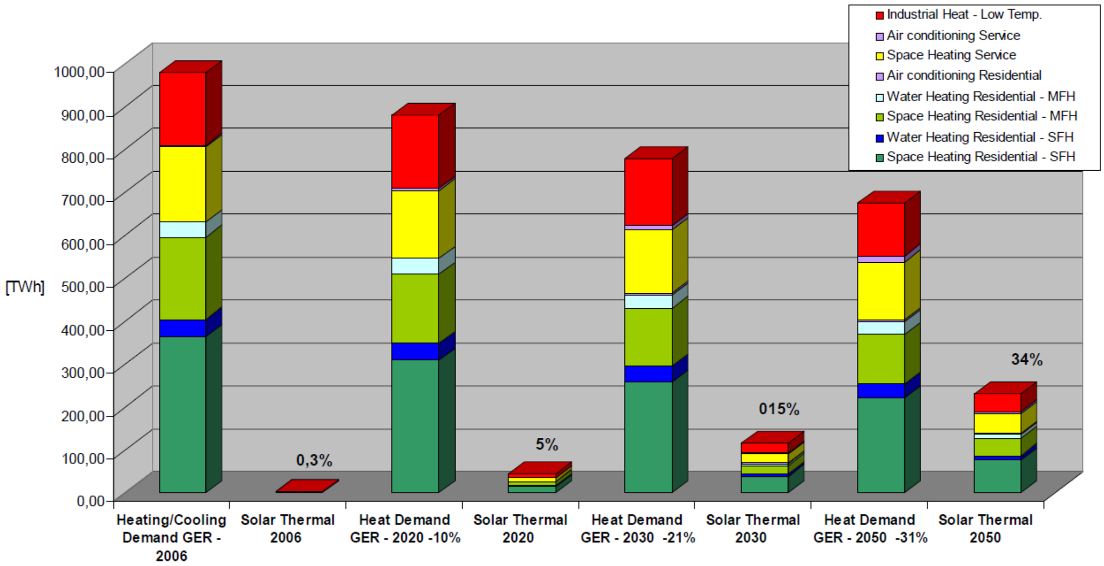


Figure 24: Total heating and cooling demand of Germany and contribution of solar thermal by sector according to the Full R&D and Policy scenario (source: *[Weiss, Biermayr, 2009]*)

According to the given figures the contribution of solar thermal energy to the total energy consumption in Germany will focus on the space heating and water heating demand with solar combisystems. As the energy demand for air conditioning is very low according to this study the potential for highcombi systems is limited in Germany.

3.3 Greek Market

3.3.1 Short term scenarios

The building construction activity in Greece counts an average of 52,500 buildings / year over years (1986 – 2000). Regarding the type of buildings, 2.400.000 refers to family buildings and dwellings as well, while 700,000 buildings refer to multifamily residential buildings with a corresponding dwellings number of 2.650.000. Another type of buildings concerns the

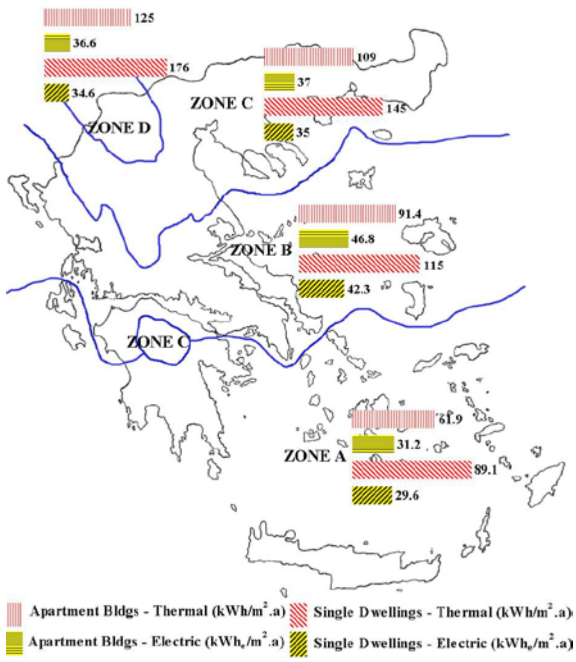
1.150.000 buildings for other uses (commercial etc.) out of which 1.050.000 corresponds to dwellings. Since 1980, all new buildings are well insulated. As a result of this, the buildings constructed before 1940 (~15% of the stock) should need to be refurbished; while the ones built before 1980 (~50% of the stock) should need maintenance. The newer buildings (i.e. ~35% of the building stock) should be in good condition *[Goumas, A., 2011]*.

The final energy consumption in Hellenic buildings was 7.5 Mtoe or about 34% of the total energy consumption in 2007, according to the National Information System for Energy. Hellenic buildings consumed about 67% of the produced electricity, resulting to total CO_2 emissions related to the building stock of about 43%.

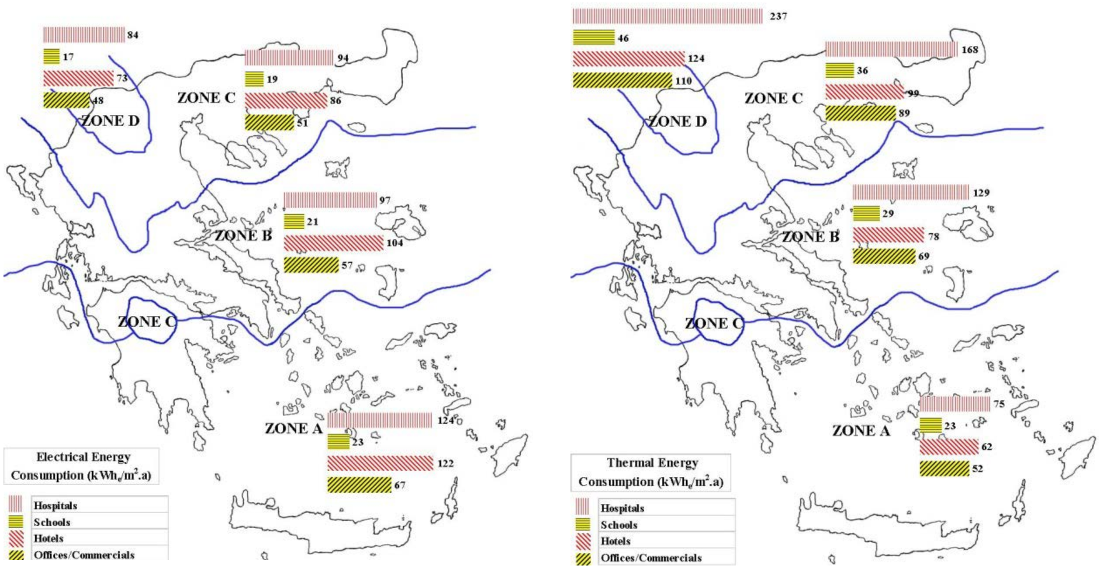
For a representative sample of Hellenic buildings, the annual final total energy consumption (operational data) for residential buildings ranges from 43 to 348 kWh/m^2-yr, while for non-residential buildings values range from 38 to 673 kWh/m^2-yr *[Dascalaki et al. 2010]*.
These large variations are due to different locations and weather conditions (referred to as climatic zones), operational characteristics and electromechanical installations, along with deviations from the desirable indoor environmental quality (i.e. sacrifice comfort conditions to maintain lower energy consumption).

Residential buildings consume over half of the electricity and over 90% of the thermal energy required by the Hellenic building sector. The great majority of Hellenic buildings are either not thermally insulated or poorly insulated; over 60% of exterior walls and 80% of windows of the existing building stock do not meet current minimum code requirements. The estimated average annual specific electric and thermal energy consumption (kWh/m^2) for residential and non-residential buildings is illustrated in Figure 25 for the four different national climatic zones *[Balaras et al. 2007]*.

The thermal energy consumption refers to buildings with central heating systems using fossil fuels (i.e., oil, gas).



(a) Residential buildings



(b) Non-residential buildings

Figure 25: Average annual specific electrical and thermal (for central heating) energy consumption of (a) residential and (b) non-residential buildings, for the four different national climatic zones.

In Greece, according to the national law N.3855/2010 on energy end-use efficiency and energy services the goal is to achieve by 2016 an overall national indicative target of 9% energy conservation. To reach this target, the overall final energy consumption should be about 19 Mtoe in 2016. Figure 26 illustrates the annual breakdown of the final energy consumption for the different end uses since 1960. The average annual growth rate over the last 3 years (2005-2007) is about 1.17%. Using this rate for the business as usual scenario (BaU) leads to an estimated final energy consumption of 22.7 Mtoe for 2010 and 24.4 Mtoe for 2016. Accordingly, the national indicative target of 9% for 2016 could be achieved provided that it is possible to reach an energy conservation of about 3.8 Mtoe over the coming years (2010-2016). For the building sector, this implies 16% energy savings or about 1.02 Mtoe from 2007 data.

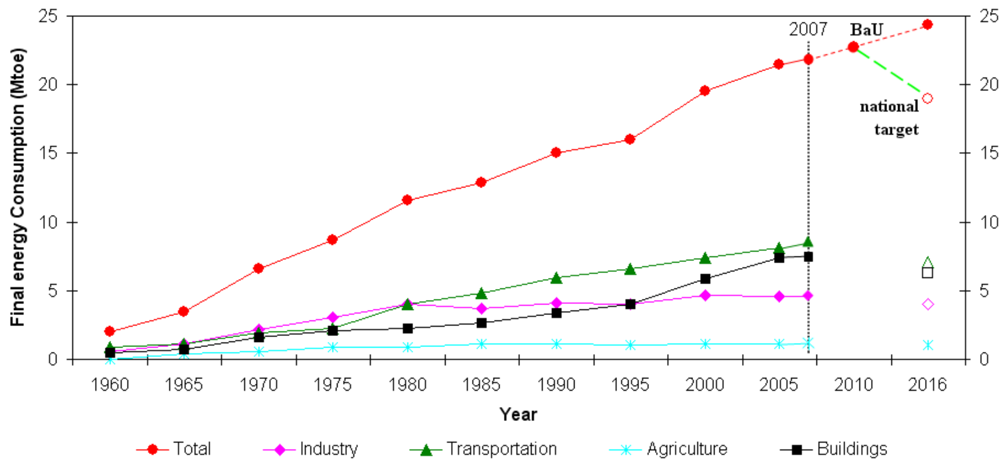


Figure 26: Final energy consumption by sector since 1960 and estimated for 2016 to reach the national indicative energy savings target of 9% in Greece.

Implementing various energy conservation measures in the residential building stock thermal energy demand can be reduced by 0.02-1.16 Mtoe and electrical energy demand by 0.08-1.32 TWh *[Balaras et al. 2007]*.

In non-residential buildings, thermal energy demand may be reduced by 2.8-51.9 ktoe in office/commercial buildings, 0.9-33.5 ktoe in hotels, 0.5-17.6 ktoe in schools and 1.6-16.2 ktoe in hospitals *[Gaglia et al 2007]*.

Electricity savings could average 18-682 GWh in office/commercial buildings, 15-407 GWh in hotels, 5-143 GWh in schools and 16-174 GWh in hospitals.

3.3.2 Medium term scenarios

The national targets for meeting the goals of the 20-20-20 national climate and energy package mandate the need for energy conservation measures - ECMs and the use of RES. According to the first national Energy Efficiency Action Plans - EEAP, the goal for energy conservation in buildings is 0.97 Mtoe by 2016 *[Lalas 2010]*.

This is a realistic target given the current energy performance and potential energy savings in Hellenic buildings.

3.4 Italian Market

3.4.1 Short term scenarios

DHW systems are currently the leading technology in Italy and it is likely that they will keep this leading role in the near future. Due to renewable ordinances at national level (implementing Directives 2002/91/EC and 2009/28/EC) new buildings will often have centralised heating systems, including DHW preparation, which will have positive consequences for the solar thermal market.

The market trend will also strongly depend on availability of a trustable, stable and economically interesting subsidy mechanism (e.g. thermal feed-in tariff).

An upcoming market for solar thermal is the district heating sector: following the development in some middle end northern European countries, indeed, a couple of Italian energy utilities are starting to build the fist solar fields for feeding heat in their district heating networks. These first systems are small size (100 – 1.000 m2) and are considered demonstration initiatives, but they might open a large market if results are positive.

Solar thermal market in Italy currently suffers from the competition with photovoltaic (for what concerns the volunteer investments in the existing building stock) and with heat pumps (for what concerns new buildings, for which renewables are mandatory and heat pumps are accepted for meeting the renewable targets).

3.4.2 Medium term scenarios

In the medium term scenario combisystems and combiplus systems (DHW, space heating and space cooling) may find their way in the Italian market (both, residential and tertiary), due to new national laws. The Italian implementation of the RES directive, indeed, obliges building constructors to realise the new buildings in such a way to cover a significant fraction of the energy demand of the whole building (DHW, space heating and space cooling) with renewables (20 % starting from 212, 35 % from 2014 and 50 % from 2017).

Solar district heating is also expected to play an important role in the medium term, considering that district heating is growing in Italy and that

solar thermal can much more easily be integrated in new networks, mainly due to low network temperature required by solar.
Another interesting area for solar thermal in the medium term is industry. So far no mandatory use of renewables in the industrial sector has been introduced, but as soon as it will, solar thermal may be one of the very few available technologies to reach medium temperatures usually needed in industrial processes. Concentrating solar collectors will possibly play an important role.
According to the National Action Plan, Italy plans for the future are quite ambitious: in 2020 Italy should be Europe's largest solar thermal market.

3.5 Romanian Market

According to Directive 2009/28/EC, Romania has to cover 24% of its primary energy consumption supplied from renewable sources by 2020.
At present, the primary energy consumption in Romania is used for:

- 70% heating and cooling;
- 15% transport;
- 15% power generation.

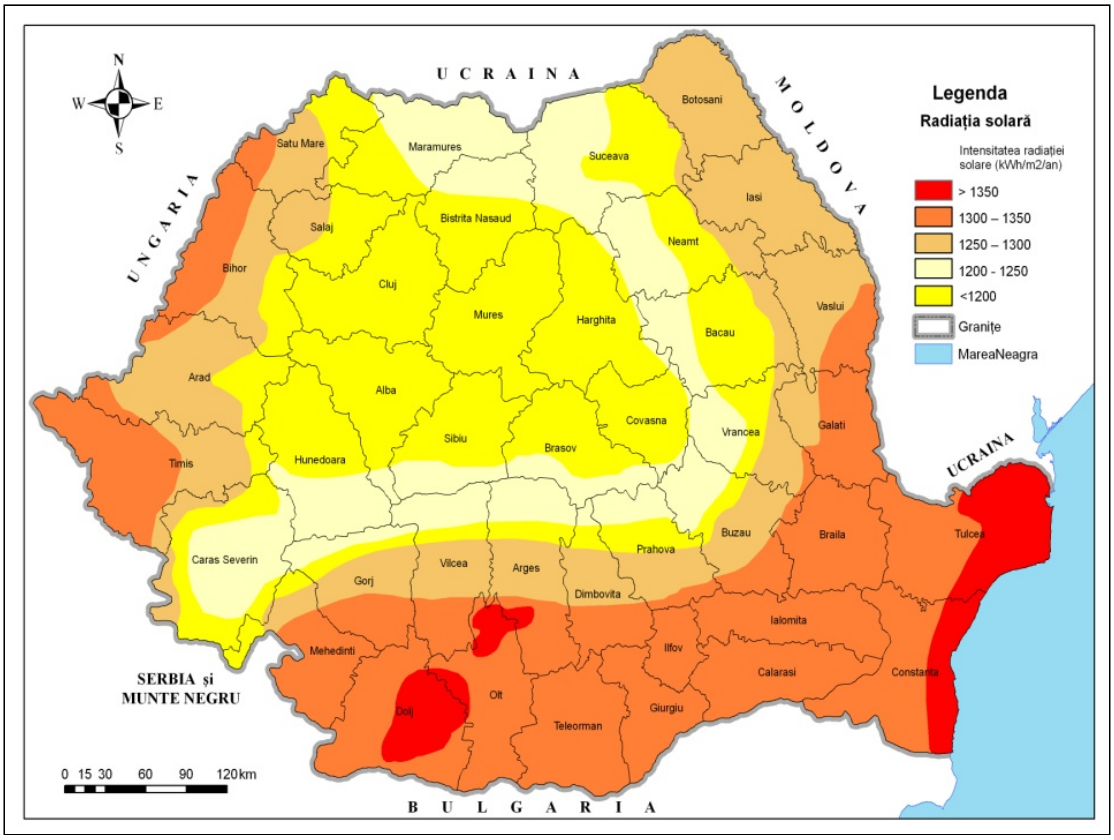


Figure 27: Solar map of Romania

The National Renewable Energy Action Plan (NREAP 2010) submitted by the Romanian Government in 2010, forecasts a decrease of the share of primary energy consumption for heating and cooling to about 60% by 2020 (about 18000 ktoe). In Chapter 5, according to NREAP's assessments, the solar thermal energy production is NOT even mentioned. The same NREAP estimates the total solar thermal annual energy potential of Romania at 60x106 GJ (1433 ktoe). The map of solar radiation potential is presented below.

The cooling demand in Romania is rather low and is needed mainly in July and August. In general, the use of cooling systems is still very low in Romania, almost not existing in rural areas, but very common is the tertiary sector buildings (public institutions, commercial buildings, etc.). Standard air-to-air split units are mainly used for space cooling with some exceptions for new large buildings. No solar thermal cooling system is currently in operation in Romania.
The highest solar potential is on the Black sea coast. For high-combi systems, the most important market should be represented by the large hotels in the sea side resorts, which are operated from spring to fall. The high-combi system can supply cooling and hot tap water, and also some heating (with short term storage) when needed (some colder nights in May, June and September). Other possible market for high-combi systems may be represented by large public buildings, if seasonal thermal storage will require acceptable volumes and will be available at reasonable costs.

3.6 Spanish Market

As a result of the previously mentioned study, four more potential penetration studies were analyzed, under economic criteria. They are, apart from the base scenario, previously mentioned:

- **Pb-15a sin ap**, cases with payback of less than 15 years without subsidies
- **Pb-15a ap 30%,** cases with payback of less than 15 years with 30% subsidies
- **Pb-15a ap 60%,** cases with payback of less than 15 years with 60% subsidies

- **Market**, cases in which the cost of Primary Energy Savings (CC_{EP}) was lower than 10 c€/kWh_{EP}, being that value the average for the reference cases studied.

The sectors in which it was studied were one-family houses, multi-family houses (with eight different types depending on surface and height), offices, hospitals and commercial centers.

The following table shows the total amount and the percentages of cases that could accomplish the criteria.

		Residencial					Terciario				
		base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado	base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado
ETC/FPC+AB1	2010	91 521	0	0	94	5 381	12 408	0	0	3 802	5 010
	2015	106 772	0	0	111	6 212	14 716	0	0	4 484	5 786
	2020	122 319	0	0	166	7 664	17 039	0	0	5 219	6 773
PTC+AB2	2010	-	-	-	-	-	0	0	0	0	0
	2015	-	-	-	-	-	0	0	0	0	0
	2020	-	-	-	-	-	681	8.9	17	294	389
FPC+DEC	2010	-	-	-	-	-	0	0	0	0	0
	2015	-	-	-	-	-	0	0	0	0	0
	2020	-	-	-	-	-	181	0	19	177	135

		Residencial					Terciario				
		base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado	base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado
ETC/FPC+AB1	2010	-	0.0%	0.0%	0.1%	5.9%	-	0.0%	0.0%	30.6%	40.4%
	2015	-	0.0%	0.0%	0.1%	5.8%	-	0.0%	0.0%	30.5%	39.3%
	2020	-	0.0%	0.0%	0.1%	6.3%	-	0.0%	0.0%	30.6%	39.8%
PTC+AB2	2010	-	-	-	-	-	-	-	-	-	-
	2015	-	-	-	-	-	-	-	-	-	-
	2020	-	-	-	-	-	-	1.3%	2.4%	43.1%	57.2%
FPC+DEC	2010	-	-	-	-	-	-				
	2015	-	-	-	-	-	-				
	2020	-	-	-	-	-	-	0.0%	10.7%	97.8%	74.5%

Figure 28: Summary of results of the potential

As we can see, the technical potential for flat plate or vacuum tube collector with single effect absorption machines (ETC / FPC + AB1) in the residential sector is very important, 11.33 million m^2 , but it is reduced to 166,000, 0.1%, if only we look at cases with less than 15 years amortization with a grant of 60%. To grant any case below this level, there are no viable cases. By contrast, from the point of view of cost per unit of primary energy saved, the potential rises to 7.6 million square meters.

For the tertiary sector, the situation is quite similar. The feasible scenarios request to have a minimum subsidy of 60%, but in these cases they represent a 31% of the technical potential and a total amount of 5,2 million m^2.

Non-standard technologies (DEC and double effect absorption machines), currently in development, are on the other hand, much more promising, since, although they are not so widely applicable, they can even present situations with lower level of subsidy (even, in some cases, without subsidy).

	superfície (m2)	número de plantas	ETC/FPC+AB1 base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado
Residencial unifamiliar			***63 508.0***	**-**	**-**	**-**	**-**
RU021	*100*	2	63 508.0	-	-	-	-
Residencial			***58 811.2***	**-**	**-**	***165.7***	***7 663.8***
RP022	*200*	2	16 350.5	-	-	-	-
RP052	*200*	5	7 415.8	-	-	-	-
RP024	*400*	2	16 455.9	-	-	-	-
RP054	*400*	5	7 724.4	-	-	-	847.6
RP084	*400*	8	1 278.3	-	-	8.5	544.6
RP058	*800*	5	7 808.7	-	-	-	4 674.9
RP088	*800*	8	1 383.1	-	-	-	1 202.0
RP128	*800*	12	394.7	-	-	157.2	394.7
Terciario oficinas			***3 468.3***	**-**	**-**	**-**	***0.2***
OF052	*200*	5	900.5	-	-	-	-
OF054	*400*	5	920.6	-	-	-	-
OF084	*400*	8	315.8	-	-	-	-
OF058	*800*	5	920.6	-	-	-	-
OF088	*800*	8	322.3	-	-	-	-
OF128	*800*	12	88.6	-	-	-	0.2
Terciario hospitales			***8 072.8***	**-**	**-**	***4 819.2***	***5 387.3***
HO033	*2 500*	3	2 214.6	-	-	-	-
HO075	*50 000*	7	2 337.6	-	-	1 854.7	2 064.9
HO078	*80 000*	7	3 520.6	-	-	2 964.5	3 322.4
Terciario c. comercial			***5 498.2***	**-**	**-**	***399.4***	***1 385.9***
CC010	*15 000*	1	4 417.7	-	-	1.0	910.5
CC015	*50 000*	1	963.1	-	-	397.0	428.1
CC019	*100 000*	1	117.4	-	-	1.4	47.2

	superfície (m2)	número de plantas	PTC+AB2 base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado
Residencial							
RU021	*100*	2					
Residencial							
RP022	*200*	2					
RP052	*200*	5					
RP024	*400*	2					
RP054	*400*	5					
RP084	*400*	8					
RP058	*800*	5					
RP088	*800*	8					
RP128	*800*	12					
Terciario			***154.7***	**-**	**-**	***0.7***	***0.4***
OF052	*200*	5	39.9	-	-	-	-
OF054	*400*	5	42.3	-	-	-	-
OF084	*400*	8	13.1	-	-	-	-
OF058	*800*	5	43.9	-	-	-	-
OF088	*800*	8	15.4	-	-	0.6	0.4
OF128	*800*	12	0.1	-	-	0.0	0.0
Terciario			***265.9***	**-**	***4.5***	***187.7***	***189.2***
HO033	*2 500*	3	78.1	-	-	-	1.5
HO075	*50 000*	7	100.9	-	0.9	100.9	100.9
HO078	*80 000*	7	86.9	-	3.6	86.9	86.9
Terciario c.			***260.3***	***8.9***	***12.1***	***105.2***	***199.7***
CC010	*15 000*	1	177.2	-	-	23.6	130.0
CC015	*50 000*	1	67.6	-	-	66.1	66.3
CC019	*100 000*	1	15.5	8.9	12.1	15.5	3.5

			FPC+DEC				
	superfície (m2)	número de plantas	base	pb<15a sin ap	pb<15a ap-30%	pb<15a ap-60%	mercado
Residencial							
RU021	*100*	2					
Residencial							
RP022	*200*	2					
RP052	*200*	5					
RP024	*400*	2					
RP054	*400*	5					
RP084	*400*	8					
RP058	*800*	5					
RP088	*800*	8					
RP128	*800*	12					
Terciario			***29.1***	***-***	***2.4***	***29.1***	***2.2***
OF052	*200*	5	6.4	-	-	6.4	-
OF054	*400*	5	8.0	-	2.4	8.0	2.2
OF084	*400*	8	3.2	-	-	3.2	-
OF058	*800*	5	6.4	-	-	6.4	-
OF088	*800*	8	2.9	-	-	2.9	-
OF128	*800*	12	2.1	-	-	2.1	-
Terciario			***94.4***	***-***	***8.6***	***90.4***	***77.6***
HO033	*2 500*	3	17.4	-	-	13.4	0.6
HO075	*50 000*	7	35.2	-	-	35.2	35.2
HO078	*80 000*	7	41.8	-	8.6	41.8	41.8
Terciario c.			***58.1***	***-***	***8.4***	***58.1***	***55.7***
CC010	*15 000*	1	32.7	-	8.4	32.7	30.4
CC015	*50 000*	1	25.3	-	-	25.3	25.3
CC019	*100 000*	1	0.1	-	-	0.1	-

Figure 29: Detailed results for the study

3.7 Market for the rest European countries

In Europe, final energy consumed for residential space heating accounts for 66% of total energy used in the sector, cooling for less than 1% (but is projected to grow at a fast pace in the future), water heating and cooking for 22%, electrical appliances for 6%, and lighting for 5%. For non-residential buildings, space heating accounts for 50.5% and other heat uses (sanitary hot water and cooking) for 22.5%, electrical appliances for 16.5%, lighting for 4% and cooling for 6.5%. On the other hand, more energy efficient building design, better materials and construction practices, and more energy efficient equipment and appliances (e.g. in 2004 the sales of certain high energy efficiency white appliances accounted for more than 70% of total sales), help alleviate some of the escalating trends for higher energy consumption *[Capros et al. 2008]*.

Current knowledge on the specific characteristics of the building stock is rather limited. The EU-27 building stock is estimated at 16.2·106 m^2 living area *[Uihlein, Eder 2010]*.

The number of European dwellings is about 200 million while detailed data for the non-residential building stock is even more abstract. About 70% of the residential building stock is over 30 years old and about 35% are more than 50 years old *[Balaras et al. 2007*].
Annual total operational energy use in European residential buildings expressed as energy per unit floor area per year, averaged 150-230 kWh/m2-yr in the '90s, while buildings in eastern and central Europe reach 250-400 kWh/m2-yr, often averaging about 2-3 times higher than that of similar buildings in western Europe. Well-insulated buildings in Scandinavia have an annual consumption of 120-150 kWh/m2-yr, while the so-called low energy buildings may even drop down to 60-80 kWh/m2-yr *[Balaras et al. 2007]*.

The passive house, a term commonly used in central Europe to refer to a standardised type of low energy buildings as developed in Germany [EC 2009], exhibits a typical space heating energy demand of about 15 kWh/m^2 and a total primary energy consumption of 120 kWh/m2-yr.In Switzerland, residential buildings bearing the Minergie quality label have a target value for an annual total energy consumption of 42 kWh/m2-yr. However, for southern European climates, where cooling is of primary concern, caution should be exercised when designing and implementing a standard passive house concept. On going work indicates that a passive house or equivalent has a combined heating and cooling demand between 15-20 kWh/m2-yr.

Best practice examples of low energy buildings in Europe are presented in EC 2009. At present, around 20,000 low energy houses have been built in Europe of which approximately 17,000 in Germany and Austria alone. Some EU Members States have introduced long-term strategies and targets for achieving low energy building standards, with an emphasis on new houses *[EC 2009]*.
For example, in the Netherlands the goal is to reach passive house standards and reduce energy consumption compared to the present building codes by 50% in 2015 through voluntary agreements. In the UK there is an ambitious goal to reach zero carbon homes by 2016. In France, all new buildings should comply with low-consumption standard by 2012 and be energy positive, i.e. produce energy, by 2020. Still, efforts are needed to remove practical market barriers (i.e. legislative, cultural,

financial and technical) facing house builders to deliver zero carbon homes in the near future *[Osmani & O'Reilly 2009]*.

4. Economic parameters for High Combi Systems implementation in each participating country

4.1 Analysis for Austria

Figure 30 shows the diversification of investment costs of a solar thermal absorption cooling system and Figure 31 of a solar thermal DEC system, both investigated for the Austrian market under the project ROCOCO. According to this project the frame conditions of this investigation are explained *[Preisler A., et al, 2008]*.

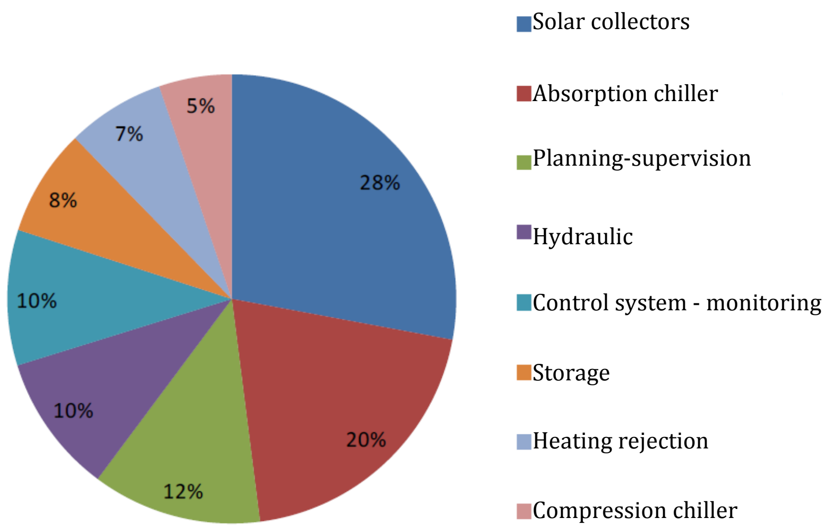


Figure 30: Solar thermal absorption cooling system - diversification of investment costs. (Source: Preisler A., et al., 2008)

For the solar thermal absorption cooling system following specific cost key figures were calculated:

1.724 €/m^2 Collector area
113 €/m^2 Cooled area
5.173 €/kW Cooling power

The investment costs are 245 % higher compared to a conventional cooling system considering the actual subsidy schemes of solar thermal systems in Austria. Regarding the energy-, operation- and maintenance costs for both technologies (sorption and compression), the costs for the sorption system are just 25 % higher for a period of 20 years. This is caused by an estimated primary energy saving factor of 40 %.

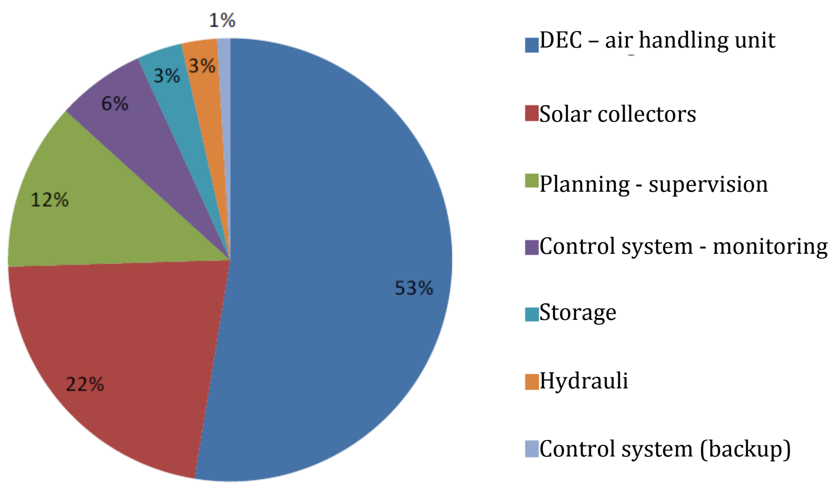


Figure 31: Solar thermal DEC system - diversification of investment costs (Source: Preisler A., et al., 2008)

The investment costs of a DEC system are 85 % higher compared to a conventional mechanical ventilation system. Considering the energy-, operation- and maintenance costs, both technologies show approximately the same costs for a period of 20 years – also calculated with an estimated primary energy saving factor of 40 %.

The subsidy schemes and the types of policy deployment instruments which have been used are introduced and grouped into categories *[Coulaud, C., et al., 2010]*.

Carrots: incentive schemes

Typically carrots act to entice a customer into utilizing RES to meet local heating needs and aims to address the cost gap between RETs and conventional technologies used for either direct or indirect heating. Such incentives schemes may be further categorized into financial incentives and fiscal incentives.

Considering three different fields, where solar panels can be applied. First, commercial buildings can be arranged with solar collectors, multi-family houses can be covered with solar collectors, but the most part of installed solar collectors is the field of detached houses, where about 50% provides the space heating. The subsidies for the buildings with commercial use were covered by the Kommunalcredit Public Consulting. These direct financial supports are available for each province in Austria. But it is cancelled when the solar plant is supported by the residential building subsidies. Target groups for this support are all private and legal persons, but the application needs to be connected with the exercise of some commercial activity, a confessional or non-profit institution, a public entity or a utility.

For solar thermal heating systems to supply warm water or space heating

- € 100/m^2 for standard collectors, € 150/m^2 for vacuum collectors
- For external energy consultancy services (at least 8 h) an allowance of € 300 is granted
- The support is granted "de-minimis" and is limited to 30% of the environmentally relevant costs at the max. We also consider the subsidies for solar collectors for multi-family houses and finally for detached houses.

In Austria, each of the 9 provinces has an own building law and therefore a large variety of regulations for subsidies in the field of residential buildings. In some provinces the solar thermal plants in new buildings are an obligation for loan eligibility (Wohnbauförderung), or increase the financial benefits. Most of all the so called ''eco-points'' improve the financial conditions for crediting the house construction. In order a project to be eligible in subsidizing, a band of certain criteria should be fulfilled.

The 3rd field of solar thermal subsidies is the field of detached houses. The rate of the direct subsidies ranges from approximately 8 to more than 30% of the investment cost. These direct grants are not depending on the circumstances (retrofit or new building). In case of a domestic solar system supplying sanitary hot water, the subsidies for solar energy varies from 600 € in Styria and Salzburg provinces (lowest end) and 1,550 € in Burgenland and Upper Austria provinces (highest end). For a solar plant which further provides space heating (Solar Combi system), the following subsidies can be credited: The house owner is subsidized by 1,050 € in

Salzburg, 1,250 € in Styria, 3,150 € in Tyrol and up to 3,325 € in Vorarlberg province. The criteria for these subsidies contain also minimum size for the collector area and the storage tank and in some provinces also include certifications for the components (mainly the collector), the installation of a heat meter and a minimum value for the specific solar gains.

Moreover to this direct support, loans for new or renovated buildings such as in the field of multi-family houses are in force under specific requirements. For instance, in Styria, it is obligated to install a solar plant or a heat pump in combination with photovoltaic cells in order to become eligible for this loan.

For all three types of buildings, additionally to the financial support in province level, many municipalities provide their own subsidy schemes for solar thermal plants installed in their borders.

<u>Tax-incentives:</u>

For retrofitting or for installing a heating system the householder can be profited by a corresponding income tax deduction. By this point of view, no limits exist for sustainability. For a solar plant on a detached house the average value for the tax deduction is 300 €.

Income tax-deduction can be associated with some additional incentives.

Three categories of incentives are applied to motivate the use of RES for heating & cooling.

1) The Value Added Tax (VAT) on the equipment for agricultural and forestry products is reduced by 10%, vis a vis the VAT on fossil fuels that is 20%.
2) The Austrian oil tax implies an additional tax cost on fossil fuels. This further increases the cost of heating oil by € 60 per 1.000 kg.
3) Since 1979, the Austrian income tax law considers the energy saving measures as special expenses for which tax allowances can be reclaimed. These measures also include expenses for heat pumps, solar thermal and bioenergy systems.

<u>Sticks: Regulatory schemes</u>

Several regulatory schemes and instruments are implemented by the state. One of this is the intervention in the solar market by placing requirements on specific sectors. This type of instrument forces REH deployment by directly requiring the development of specified technologies.

Based on the article 15a BVG (Federal Constitution) which provide the greenhouse emission reduction in line with EE directions, the regions regulate the loan for new and renovated buildings depending on the integration of a solar plant. The mandatory energy consumption for space heating is reduced in annual steps, e.g. the maximum value for 2010 is 45 kWh/m^2.

A law abstract launched by the province of Styria and still remaining unsigned by the European Parliament, refers to the condition of use a domestic hot water system based on solar or other renewable energies in order to get the building permission.

In line with the objectives and the requirements of the European building Council Directive the energy label is introduced in the sector of the new buildings and retrofits. The target for the energy consumption for space heating is reduced in annual steps, e.g. the maximum value for 2010 is 45 kWh/m^2*a (as a building surface to volume rate equal to 0.8 – an average value for detached houses).

<u>Guidance: education-based schemes</u>

Education to promote REH aims to enhance the awareness of the public by information campaigns and providing training to increase installer knowledge.

In 2004, the state department for life (which contains the fields of agriculture, forestry, environment and water) launched the program klima:aktiv to protect the climate. This program constitutes a part of the Austrian climate Strategy. In the context of this initiative, the program "solarwärme" was in operation from 2004 to 2009.

The targets of this project were to emerge the market of solar thermal energy, to spread know-how to the different kind of stakeholders (the householders, the installer, the building project organizer, the architects, the producer etc.) and to promote measures to guarantee the systems quality. To reach these targets many activities were done.

This project:

Creates and updates a homepage (www.solarwaerme.at) for all interested people to inform about events, actual subsidies, technical details, competent installers with experiences and added knowledge on solar thermal components and their costs and show a lot of pictures to give a wide overview of different kinds of integration of solar panels (about 1.35 Mio. visits between 2004 and 2009)

- Creates several specific courses for installers, manufactures, engineers, energy advisors and other solar thermal interested people since 2005. The installers and engineers of solar systems graduate their own certificate after successful pass of the final exams and after elaboration of plants as case studies. The results of four years are more than 500 installers and engineers to get the certificate of competency).
- Information of interested people by an own “solarwärme – hotline”, which was available on business time from Monday to Friday (more than 9.000 calls)
- Creates and offer many brochures and flyers for different stakeholders (distribution of about 145,000 brochures between 2004 and 2009)
- Organizes symposiums, workshops and various events in all provinces of Austria (more than 270 events were managed). Support “The Day of the Sun” in Austria and meanwhile this Day is organized in many European countries and takes place in the middle of May (1,630 events through the Day of the Sun in Austria)
- Improves and extends the existing networks of the pioneers.
- Offers engineering audits for more complex and bigger plants

In 2010, this project is substituted by the klima:aktiv program “erneuerbare wärme”, which combines the support of the 3 heating systems heat pump, biomass boiler and solar thermal plant. This project is also managed by AEE INTEC in cooperation with AIT, AEE GesmbH and AEE Niederösterreich.

4.2 Analysis for Germany

Different studies showed that investment cost (incl. design) for medium sized and large solar cooling systems in Germany are about 2 to 2.5 times higher compared to a conventional cooling system. For small systems this factor is even higher. Taking into account the savings in operation cost during the lifetime and calculating the lifetime cost of such plants still additional costs of between 20 and 40 % compared to conventional cooling systems occur. Even with a subsidy of 100 €/m² solar collectors this additional is still between 5 and 20 % *[Heinzelmann et.al., 2007]*. Nevertheless solar cooling is expected to become a standard technology in the close future and will be able to compete with conventional technologies.

Investment cost today for a size range between 7 and 105 kW cold are between 5500 €/kW for small systems and 2700 €/kW for the systems with medium size *[Jakob, 2010]*.

A big portion of the investment cost is caused by the solar thermal collector system. The economy of the systems thus strongly depends on the usability of the system and especially the solar collectors. As yearly cooling hours in Germany for normal air conditioning in residential and non-residential buildings are not very high due to the climatic conditions the system economy can be improved significantly by an additional usage of the solar collectors for heating purposes as it is intended by highcombi systems.

4.3 Analysis for Greece

In Greece, transposition of the European Directive 2006/32/EC on energy end-use efficiency and energy services, took effect in 2010 by the national law N.3855/2010, introducing various energy efficiency improvement measures, energy service companies – ESCOs, third party financing - TPF and other instruments, in order to achieve by 2016 an overall national indicative target of 9% energy conservation.

The key of success for improving the energy performance of Hellenic building stock and reaching some significant energy savings is:

- implementation of the energy performance of buildings directive and relevant regulations for new buildings,
- support implementation of win-win and financially attractive energy conservation measures in existing buildings,
- availability of different financial support instruments.

Transposition of the European Directive 2009/28/EC on the promotion of the use of energy from renewables took effect in 2010 by the national law on renewable energy sources - RES (L.3851/2010). The national target is to reach by 2020 a contribution of 20% from RES in the national gross final energy consumption (from 5% in 2007), 40% in gross electricity generation (from 4.6% in 2007), and 20% in final energy consumption for heating and cooling *[Lalas 2010]*. This law sets new requirements which stipulate that 60% of the need of new buildings for hot water should be covered by solar thermal systems as of 1 January 2011. Furthermore, L3851/2010 stipulates that by 31 December 2019, all new buildings will have to cover the total of their primary energy consumption needs with RES, CHP, district heating on a large area scale/block scale, as well as heat pumps. This requirement is extended to all new public buildings by 31 December 2014 at the latest *[A. Zervos et al., 2011].*

Specific incentives (financial, tax, and legal) are required for this target to be met, as well as development of market mechanisms (Energy Service Companies – ESCOs and Third Party Financing – TPF) and credit/loan schemes towards building owners. However, the planned obligatory installation of RES in every new building has not been implemented yet.

It is foreseen to develop specific national energy policies and to establish new financial incentives for the support of the heat production from biomass and geothermal energy, along with the implementation of the Energy Performance of Buildings Directive (EPBD). Solar thermal technologies should have a new fiscal framework. Furthermore, specific measures and actions that ensure that public buildings fulfill an exemplary role by 2012 are foreseen. Certification of installers does not exist for the moment. However, specific measures at regional/local levels are taken.

Heating and cooling targets will not be met if no additional measures are adopted. Proper technical requirements promoting especially the use of geothermal energy and of active solar systems should be enforced in practice. The large potential for RES-H&C in existing buildings needs to be tackled by incentives and administrative initiatives.
Favourable legislation for conventional energy sources should be removed (i.e. increase VAT to electricity and gas, remove tax credits and obligatory installation of gas in new buildings), *[A. Zervos, et al, 2011].*

4.4 Analysis for Italy

The construction of the High Combi plant in Italy entrusted via call for tender and included not only the plant itself, but also the refurbishment of the building. For this reason it is not possible to define the real investment cost of the plant. Nevertheless, some general considerations can be highlighted:

- solar thermal collectors are still expensive and represent a very high share in costs of any solar thermal installation. Significant decrease in collector's cost is not noticed in Italy so far, except for single cases;
- thermally driven chillers are also very expensive. Prices decreased quite significantly in the last years, but still heavily affect the total investment cost of a solar cooling plant;
- operation costs of solar heating and cooling systems are in fact very low and guarantee fixed expenses over 20 years.

One can finally draw the following conclusion: investment costs of solar heating and cooling plants are relatively high compared to standard solutions (e.g. heating boiler + compression chiller) and may be justified by high fossil fuel prices. As long as this is not the case, such systems are still not economically viable.

Looking at other new solutions, some simple calculation shows that a reversible air-water heat pump (or water-water heat pump) can basically satisfy the thermal needs of a building with just one machine and with lower investment costs. Operation costs would in this case be higher, but the overall economic evaluation with actual electricity prices is in favor of the latter solution.

Nevertheless, further considerations about the use of heat pumps should be included:

- producing hot water with heat pumps can push the machines to their limit, due to relatively high required temperature (e.g. 50 °C);
- producing hot water in the cooling period is possible, but requires either the use of condensing energy (which might often not meet the requirements), or stopping the cold production for preparing hot water;
- existing heat pumps on the market show a quite rapid decrease in energy efficiency, which might result in the substitution of the machines at least one or two times in i 20 years.

4.5 Analysis for Romania

Law 220/2008 (republished with significant modifications in 2011) provides financial support for power generation from renewable energy sources through a “green certificates” system. A similar law is expected in the future for thermal energy produced from renewable sources (“white certificates”).

A program called “Green House” carried out by the Environment Ministry provides financial support for renewable heating and cooling systems, including solar thermal systems, solar collectors for hot tap water production being specifically mentioned, but solar space heating and cooling are not even mentioned, which is also true for NREAP 2010.

Some other governmental programs are available for investments in large heating and cooling systems, including district heating, which may provide grants up to 95% of the project cost for public utilities and up to 60% for private companies.

There are a few ESCO’s operating in Romania (mainly multinational), but it is almost impossible to have a contract with a public institution because the financial rules are not flexible enough.

The requirements of Directive 2009/91/EC are transposed in the Romanian legislation by Law 372, which is not fully applicable yet! When this will happen, it should stimulate a market increase for the renewable heating and cooling systems, including High-Combi systems.

4.6 Analysis for Spain

The costs of solar thermal systems for heating, cooling and DHW are still high, well above reference installations. The Specific cost for the Spanish Project (Cibeles), counting only the equipment in the technical room, is around 2085 €/ installed m^2.

However, as it can be seen in the ROCOCO Project study (http://www.aiguasol.com/files/file219-3.pdf), this market situation will be improved in the next ten years, thanks to the reduction of costs of these systems. To evaluate the future costs, in this study a sensitivity analysis over different factors was done, under different climatic conditions and building types:

The analyzed variables were:

- Increased energy prices
- Expected improvement of energy efficiency equipment
- Reduced costs and engineering design activities
- Cost reduction in monitoring and control equipment
- Reduced maintenance costs.
- Reduced costs of sub-solar thermal system.
- Reduced costs of sub-thermally driven chiller system.
- Subsidies.

The results are illustrated in the following Figure 32.

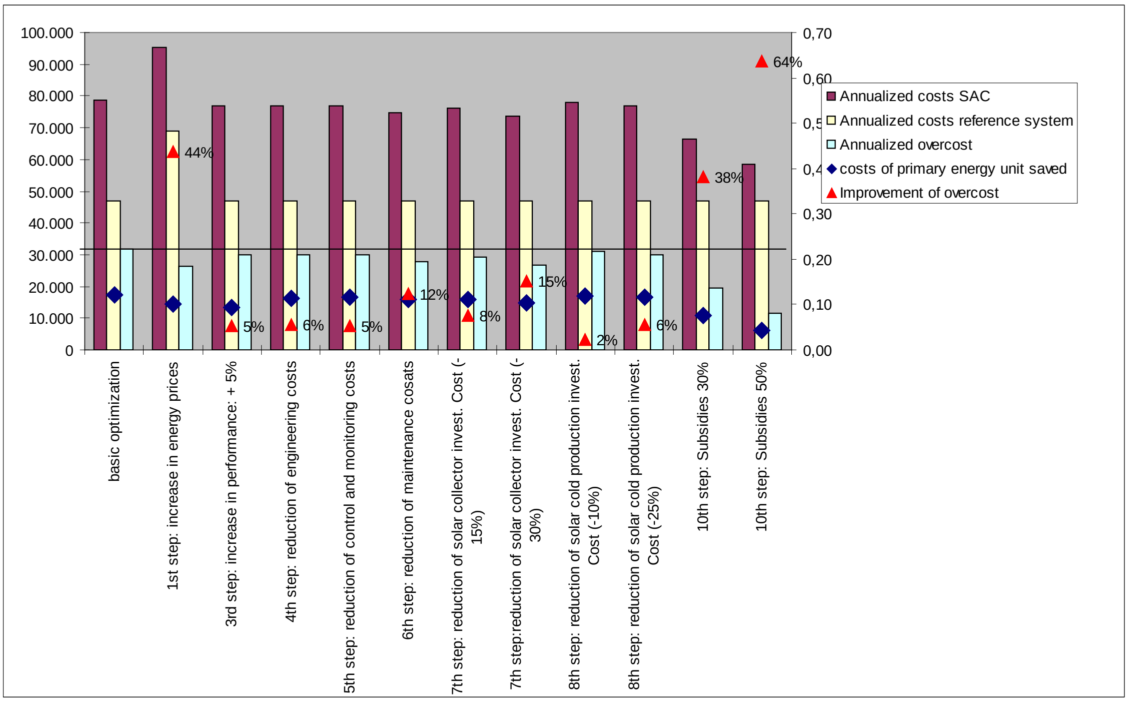


Figure 32: Influence of the different measures of cost reduction of solar cooling systems. Units of primary axis: €/year-Units of secondary axis: % (Source: ROCOCO European Project)

The factors with more "Improvement of overcost" (% - right axis) are the ones influencing more significantly in the cost reduction.

4.7 Analysis for the rest European countries

The European Commission has adopted an action plan aimed at achieving a 20% reduction in energy consumption by 2020 [EC 2006]. It includes measures to improve the energy performance of products, buildings and services, to improve the yield of energy production and distribution, to reduce the impact of transport on energy consumption, to facilitate financing and investments in the sector, to encourage and consolidate rational energy consumption behavior and to step up international action on energy efficiency. The biggest energy savings are expected in: residential and non-residential buildings (27% and 30%, respectively), the manufacturing industry (25%), and transport (26%).

The main legislative instrument for improving the energy efficiency of the European building stock is the European Directive 2002/91/EC on the energy performance of buildings (EPBD). This Directive forms part of the Community initiatives on climate change (commitments under the Kyoto Protocol) and security of supply. The EPBD recast (Directive 2010/ 31/EC) strengthens the energy performance requirements, clarifies and streamlines some of its provisions to reduce the large differences between Member States' practices. The key points of the EPBD recast include:

1. All new buildings must be nearly zero energy buildings after 31 December 2020, while new buildings occupied / owned by public authorities must be nearly zero energy buildings after 31 December 2018
2. All EU Member States implement a common methodology for calculating the integrated energy performance of buildings using common benchmarks for calculating cost-optimal levels, minimising the building's lifecycle cost
3. All existing buildings that undergo major refurbishment (25% of building surface or value) should meet minimum energy performance standards and not only for those above 1000 m2 foreseen in EPBD, while national policies and specific measures should stimulate the transformation of refurbished buildings into nearly zero energy buildings
4. All EU Member States introduce minimum energy use requirements for all HVAC technical building system.

The nearly zero or very low amount of energy required should to a very significant level be covered by renewable energy sources (RES) to satisfy most of their demand. This is going to be a major boost for the promotion of RES applications in buildings and their future exploitation. It will also contribute towards meeting the EU's goals set in the Europe 2020 Strategy [EC 2020] known as the 20-20-20 targets:

1. a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
2. an increase to 20% of RES contribution to EU's gross final energy consumption
3. a 20% reduction in primary energy use by improving energy efficiency, by 2020.

More energy efficient buildings may provide better living conditions and reduce operational costs. The estimated impact of the EPBD recast is energy savings of 60-80 Mtoe in 2020 or 5-6% reduction in total EU energy consumption, which equals the total current consumption of Belgium and Romania, and about 5% less CO_2 emissions. The European Commission will support efforts to increase the awareness of the whole chain from authorities, to construction industry and citizens on the saving opportunities, while new financing schemes are introduced to overcome investment barriers.

According to the European Directive 2006/32/EC on energy end-use efficiency and energy services, EU Member States shall adopt and aim to achieve by 2016 an overall national indicative energy savings target of 9% compared with the average final energy consumption for the five-year period of 2001-2005. This is to be reached by way of energy services and other cost-effective, practicable and reasonable energy efficiency improvement measures. The main areas for potential energy conservation include the building sector and especially energy end-use efficiency in the public sector, promotion of energy end-use efficiency and energy services (e.g. energy service companies – ESCOs and third party financing - TPF arrangements), and the implementation of EPBD. EU Member States submit to the Commission periodic Energy Efficiency Action Plans (EEAPs) to monitor progress.

Along the same lines, the European Directive 2009/28/EC on the promotion of the use of energy from renewables mandates an increase of RES use in an effort to reach the ambitious 20% share of energy from renewables by 2020. Specifically, each EU Member State is required to increase its share of RES by 5.5% from 2005 levels, with the remaining increase calculated on the basis of per capita GDP. For example, 10% in Malta up to 49% in Sweden. The Directive focuses on large scale RES installations, but also specify minimum levels for the use of energy from renewable sources in buildings.

Overall, experience has shown that support policies play a major role in kicking off the growth of national solar thermal markets, as demonstrated in several European countries. Once a critical mass of the market is reached, the intensity of incentives can be gradually reduced until the market is fully self-sustained *[ESTIF 2007]*.

5. Conclusions

The constant increasing of energy cost, due to the higher electricity & oil prices, raises the competitiveness of solar cooling systems against the conventional, considering the additional environmental benefits.
The survey conducted here, showed that the Solar Combi plus systems constitutes a promising technology for the exploitation of solar energy for a combined cooling, heating and sanitary hot water (SHW). The combination of solar heating, cooling and SHW systems (solar combi-plus) extending more the use of solar system throughout the year using seasonal energy thermal storage (High Solar Combi plus systems) is an ideal solution in most of the cases especially for southern areas.

High Combi plus system have a lot of advantages in terms of technology, being an innovative, reliable and efficient system, with further prospects of improvement, due to its current market phase. In combination with the environmental protection such systems might play a key role through the communication actions of more and more firms. Green credentials and corporate responsibility are becoming basic competitive issues of the majority on firms' agenda.

Although a limited number of applications have been realized, ongoing research and demonstration efforts are striving to achieve high solar fractions, thus enabling future market growth.

To play the High Solar combi-plus systems an integral role in the near future and support European and national efforts to meet the ambitious energy saving targets, a band of actions should be taken:

- Strengthening the research in deep for small scale installations (domestic systems) in order to produce highly efficient systems. Taking for granted that the large scale central systems are more cost effective, the research should focus on smaller systems capable to achieve same or better results on domestic sector. The penetration of small scale High Combi plus systems into air-conditioning market requires the fulfilment of the rising comfort standards taking into account that systems cost should remain in competitive level.
- Collaboration between commercial sector and educational institutes and research centers will assist the research and knowledge on new advanced technologic products.
- The optimization of High Combi plus systems in heating and cooling operations and controls, with an emphasis on operating conditions, coupling of the GHXs with the underground STES and the combined operation of the various system components will reduce the cost and will make these systems accessible for application to the public and house buildings.
- Collaboration with other market players and standardised institutes by validating specific procedures (i.e. simulations and design tools) so that a certified product to be the final outcome. The standardisation of the project's procedures will motivate further the market of solar thermal systems. Each partner's demo plant can play important role to increasing installations and its further recognition, while the work accomplished in the framework of the High Combi plus project regarding the definition of standard system configurations will be the first step for a European – international standardization.

The lessons learnt from the successful implementation of simple solar systems can be effectively transferred to High Combi plus emerging the solar market and motivate the customers and the end-users to select new environmental friendly and cost-effective products.

In conclusion, the goal is, with regard to five demo plants of High Combi plus project, characterized by high electrical COP and a total solar fraction (sometimes reaching over 90%), such systems to effectively compete not only conventional systems but also other sustainable technologies in order to evaluate the potential for future exploitation of high solar combi-plus systems in the European air-conditioning and SHW market.

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