SOLAR HEATING SYSTEMS - STATUS AND RECENT DEVELOPMENTS

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Abstract – The paper gives a worldwide overview of the dissemination and major markets for solar heating systems. It also shows the contribution of solar plants to the supply of energy and the CO_2 emissions avoided as a result of operating these plants.

Furthermore the paper gives an overview of recent system developments in the field of solar combisystems for hot water and space heating as well as in the field of large-scale solar heating systems for housing developments. Since the architectural integration of solar thermal collectors plays a major role concerning the broad acceptance of these systems, recent developments in façade integration are described. Finally promising new developments are presented in the field of solar heat for industrial applications.

1. INTRODUCTION

The increase of greenhouse gases in the atmosphere and the global warming and climatic change associated with it, represent one of the greatest environmental and in the future also one of the greatest social dangers of our time. The anthropogenic reasons for this impending change in the climate can for the greater part be put down to the use of energy and the combustion of fossil primary sources of energy, and the emission of CO_2 associated with this.

To set the course towards a sustainable energy future, it is necessary to look for solutions which are based on renewable energy.

Today, the world's energy supply is based on the non-renewable sources of energy: oil, coal, natural gas and uranium, which together cover about 82% of the global primary-energy requirements. The remaining 18% is divided into approximately 2/3 biomass and 1/3 hydropower.

According to many experts the effective protection of the climate for future generations will demand at least a 50% reduction in the worldwide anthropogenic emission of greenhouse gases in the next 50 to 100 years. With due consideration to common population growth scenarios and assuming a simultaneity criterion for CO_2-emissions from fossil fuels, an average per-capita reduction in the yield in industrial countries of approximately 90% will be required. This means 1/10 of the current per-capita yield of CO_2.

A reduction of CO_2 emissions on the scale presented will, however, demand conversion to a sustained supply of energy, which is based on the use of renewable energy with a high proportion of direct solar energy use.

If the direct use of solar energy for heating and cooling purposes via solar collectors is to make a significant contribution to the energy supply in future, it is necessary that a broad variety of different types of systems are developed and established in the market.

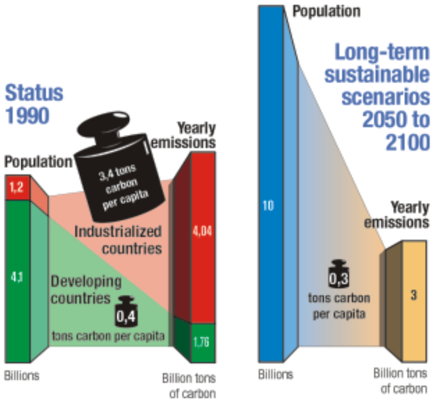

Figure 1: Per-capita emissions of carbon into the atmosphere required to meet climate stabilisation agreements with a doubling of the world population levels.

2. ACHIEVEMENTS - SOLAR THERMAL COLLECTOR AREA IN OPERATION

According to a study of the IEA Solar Heating and Cooling Programme (Weiss, W., Faninger, G., 2002) the installed collector area in the 22 IEA SHC member countries – including the USA, Canada, the European Union, Japan, Australia and Mexico - equalled around 58 million square meters at the end of the year 2000. Of this, 17 million square meters was accounted for by unglazed collectors, which are used mainly to heat swimming pools, and 40 million square meters of flat-plate and evacuated tube collectors, which are used to prepare hot water and for space heating. Air collectors were installed to an extent of 1 million square meters. These are used for drying agricultural products and to a lesser extent for space heating.

If one observes the use of solar thermal energy it becomes clear that it greatly varies in the different countries respective economic regions. In North America (USA and Canada) swimming pool heating is dominant with 15 million square meters of unglazed collectors while in Europe (9.7 million square meters) and Japan (11.7 million square meters) plants with flat-plate and evacuated tube collectors mainly used to prepare hot water and for space heating are dominant.

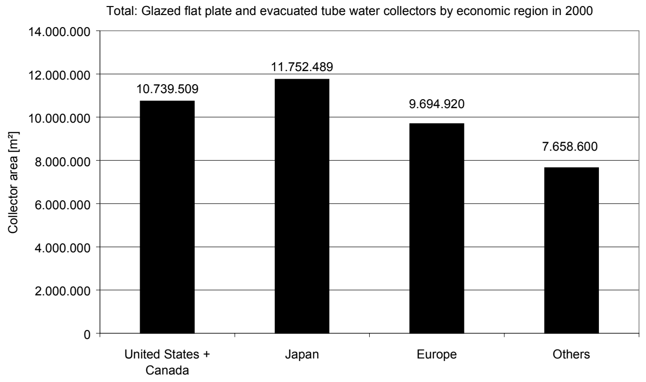

Figure 2: Glazed flat plate and evacuated tube collectors in operation by economic region in the year 2000 (Weiss, W., Faninger, G., 2002)

Focusing on the installed flat-plate and evacuated tube collectors through the year 2000, Greece, Austria and Turkey are in the lead with 264 m², 195 m², 113 m² per 1000 inhabitants respectively. They are followed by Japan, Denmark and Germany with collector areas between 93 and 34 m² per 1000 inhabitants.

With regard to the heating of swimming pools with unglazed collectors, Austria leads with 73 m² ahead of the USA with 52 m² and Switzerland with 31 m² per 1000 inhabitants. In fourth to sixth place we find Canada, Germany and the Netherlands with collector areas between 6 and 16 m² per 1000 inhabitants.

Analysing the market development from 1999 and 2000 in the field of plants for the preparation of hot water and space heating it can be seen that the market for flat plate and evacuated tube collectors grew from 2,025,384 m² in the year 1999 to 2,285,797 m² in the year 2000. This corresponds to a growth of 13%. The markets that underwent the greatest growth between 1999 and 2000 included Mexico at 226%, Sweden at 99%, Spain at 65%, Germany at 47% and France at 42%. The countries with stagnating markets were Japan, Italy, Norway and Turkey. Decreasing markets were recorded in Denmark at -16%, Switzerland at -11%, Portugal at -6%, and the USA and the Netherlands at -4%.

At this juncture it should be mentioned that huge solar thermal markets, which are not yet included in the IEA study, are to be found in China (4 mill. m²), India (2 mill. m²) and Israel (400.000 m²)[1] (Staiß, F., 2003).

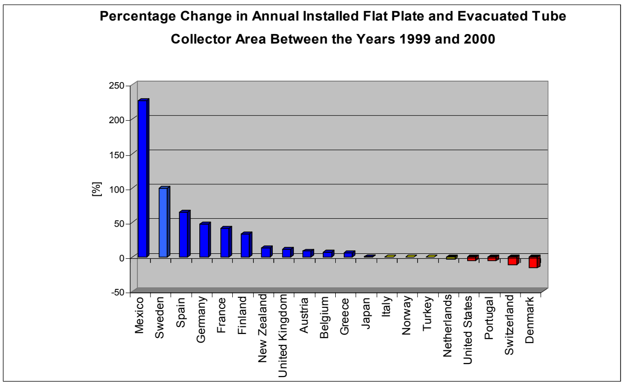

Figure 3: Percentage Change in Annual Installed Flat Plate and Evacuated Tube Collector Area Between the Years 1999 and 2000

The calculated annual collector yield of all recorded systems[2] in the 20 Member countries of the IEA SHC Programme is approximately 24,367 GWh (87,721 TJ). This corresponds to an oil equivalent of 3.9 billion litres and an annual avoidance of 10.7 million tons of CO_2.

2.1 The contribution of solar thermal energy to the overall heat demand in Europe

Since the beginning of the 1990s, the European solar market has undergone considerable development. As the figures from the IEA Solar Heating and Cooling Programme (Weiss, W., Faninger, G., 2002) and the German Solar Energy Association (Stryi-Hipp, 2000) confirm, sales of flat-plate collectors recorded a yearly average growth of 17% between 1994 and 2000. This meant that while 480,000 m^2 of collector area was installed across Europe during 1994, by 2000, the annual rate for installations was around 1.17 million m^2 collector area, meaning that the rate had more than doubled within a period of six years.

The installed collector area in Europe was around 11.4 million square metres at the end of 2000. Of this, 1.7 million square metres was accounted for by unglazed collectors, which are used in the main to heat swimming pools, and 9.7 million square metres by flat plate and evacuated tube collectors used to prepare hot water and for space heating.

Considering the installed flat-plate and evacuated tube collectors up to the end of 2000, then Greece and Austria are in the lead with 264 m² and 198 m² respectively per 1000 inhabitants. They are followed by Denmark with 46 m² per 1000 inhabitants, Switzerland with 37 m^2 per 1000

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[1] Figures from 1999

[2] All water based systems excl. air based systems. Since the dat abase of the applications of air collectors is insufficient, the contribution of air collectors to the energy supply and CO_2 reduction was not calculated.

inhabitants and Germany with 34 m² per 1000 inhabitants.

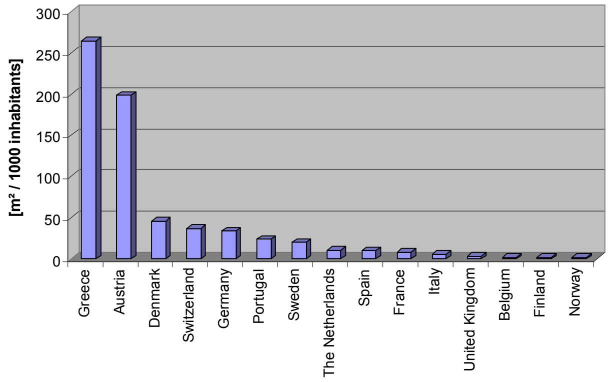

Figure 4: Total installed flat plate and evacuated tube collector area per thousand inhabitants in the year 2000

The markets that underwent the greatest growth in the period mentioned above included Spain, the Netherlands and Germany. In the main, this can be attributed to the fact that the dissemination of solar heating systems was very low in these countries, compared with Greece and Austria. In addition to this, deliberate state programmes of financial incentives also contributed to high growth rates.

The calculated annual collector yield of all recorded systems in Europe is approx. 4,600 GWh (17 PJ). Annually this saves the equivalent of 704 million litres of oil, thus avoiding the emission of 1.9 million metric tons of CO_2 into the atmosphere and covering around 0.14% of the overall requirements for hot water and space heating across the EU (Weiss, W., Faninger, G., 2002).

3. SOLAR COMBISYSTEMS FOR HOT WATER AND SPACE HEATING

The increase in the use of solar collectors since the early eighties for domestic hot water preparation has shown that solar heating systems are a mature and reliable technology. A broad variety of solar domestic-hot-water systems has been developed and adjusted to the needs and meteorological conditions around the world. Simple thermo-siphon systems are mainly used in low latitudes; whereas more advanced pumped systems are in use mainly in high latitudes.

Motivated by the confirmed success of these systems for hot water production, an increasing number of home builders are considering solar energy for space heating, as well.

Combining solar heating systems with short-term heat storage and high standards of thermal insulation in the building allows the heating requirements of a building to be met at acceptable costs.

Solar heating systems for combined domestic hot water preparation and space heating, called "solar combisystems" are essentially the same as solar water heaters when considering the collectors and the transport of the produced heat to the storage device. But solar combisystems are more complex than solar domestic hot water systems, as there is more interaction with extra subsystems. And these interactions deeply affect the overall performance of the solar part of the system. The general complexity of solar combisystems has led to a large number of widely differing system designs, which do not necessarily reflect local climate or local practice.

The solar contribution, that is, the part of the heating demand met by solar energy, varies from 10% for some systems up to 100% for others, depending on the size of the solar collector, the storage volume, the hot water consumption, the heat load of the building, and the climate.

Since December 1998, 26 experts from 9 European countries and the USA and 11 solar industries have worked together in the IEA Solar Heating and Cooling Programme's Task 26, *Solar Combisystems.* The objective of this Task was to further develop and optimise solar combisystems for detached single-family houses, groups of single-family houses and multi-family houses.

Figure 5: A French house with a direct solar floor system (Source: Clipsol, France). The daily storage for the space heating of the house is the concrete floor itself.

Task 26 showed that there are approximately 10 basic system concepts on the European market. The different system concepts can partly be put down to the different conditions prevailing in the individual countries (Suter, J.M. et.al., 2000). Thus, for example, the "smallest systems" in terms of collector area and storage volume are located in those countries in which gas or electrical energy are primarily used as an auxiliary form of energy. In the Netherlands, for example, a typical solar combisystem consist of 4-6 m² of solar collector and a 300 litre storage tank. The share of the heating demand met by solar energy is, therefore, correspondingly small, around 5 to 20%.

Figure 6: A Dutch house with a solar combisystem (Source: ATAG, The Netherlands)

In countries such as Switzerland, Austria and Sweden, where solar combisystems are typically coupled with an oil burner or a biomass boiler, larger systems with high fractional energy savings are encountered. A typical system for a single-family house consists of up to 15 - 30 m² of collector area and a 1 - 3 m³ of storage tank. The share of the heating demand met by solar energy is between 20% and 60 %.

Figure 7: Solar combisystem for a single-family house in Austria

The attention that is being given to solar combisystems is justified as these products will certainly hold a considerable share of the market in the future.

In 2001 the total collector area installed for solar combisystems in eight European countries, shown in figure 9, equalled 340,000 m². Assuming that the average collector area for a combisystem is 15 m², this means that about 22,600 solar combisystems were installed in 2001.

In Sweden the share of the collector area installed for solar combisystems in 2001 was already significantly larger than the collector area installed for solar domestic hot water systems. In Austria, Switzerland, Denmark and Norway, the collector area installed for solar combisystems and for solar domestic hot water systems was almost the same. In Germany, which installed a total of 900,000 m² collector area in 2001, the share of the collector area installed for combisystems was 25%.

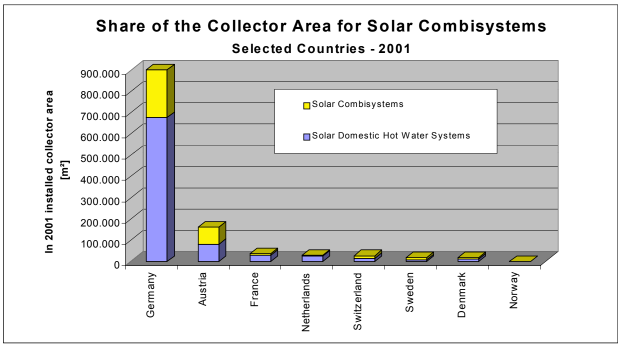

Figure 8: Share of collector area used for solar domestic hot water systems and for solar combisystems in selected countries in 2001

3.1 From Complex Designs to Compact Products

In recent years, combisystems have changed from complex single designs into more standardised and compact products.

Some years ago solar combisystems consisted of the following main separate components: the collector array, a space heating storage tank, a domestic hot water tank, an electronic control and a boiler. That means that there were a lot of components to be adjusted which could cause several problems for the hydraulic system and the controller. This complex design also reduced the overall efficiency.

Therefore a lot of effort has been put into optimising these components and to get a maximum integration of the solar parts of the system into the standard heating system.

The basic idea of this concept is a single stratified storage tank working as an energy manager. To make the system as compact as possible, the preparation of hot water via an external heat exchanger and the integration of the burner of the auxiliary energy source into this storage tank are also essential for advanced solar combisystems.

Each energy source (solar or auxiliary energy) is stored in the temperature layer inside the tank that corresponds to the temperature of the energy source. This avoids mixing the temperature layers.

It is equally important to draw the outgoing flows (space heating loop or domestic hot water preparation) from the correct temperature layer to avoid mixing and inject the return flows from the consumers in the temperature layer of the returning medium.

Figures 10 and 11 provide an excellent example of these developments. In the case of one industrial participant in Task 26 it was possible to optimise the system in several steps and to make it very compact. This is shown by the fact that that the number of pipe connections to be made by the plumber could be reduced from 17 to 8! The space requirement was reduced from 4.8 m² to 2.2 m² and the weight of the unit was reduced from 250 to 160 kg.

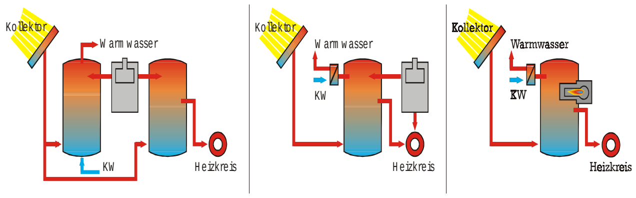

Figure 9: Complete integration of all components in one device (Source: SOLVIS)

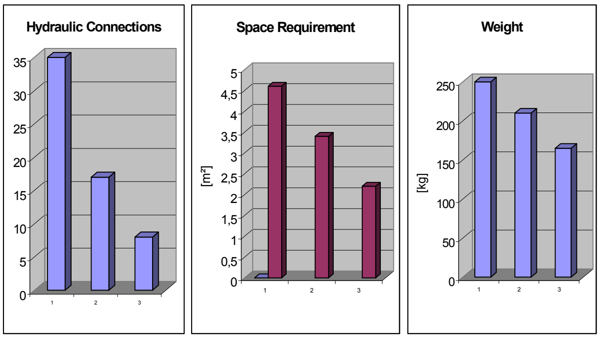

Figure 10: Reducing the number of pipe connections, the required floor space and the weight of the systems (Source: SOLVIS)

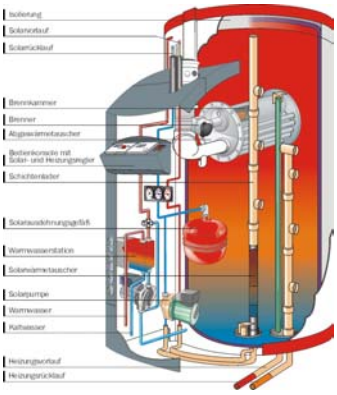

Figure 11: Cross section of the space heating storage tank (SolvisMax) with an integrated gas burner (Source: SOLVIS, D)

<u>This compact designs lead to:</u>

- Simplified hydraulic schemes
- Simplified controller
- Reduced space demand
- Less Weight
- Hygienic domestic hot water preparation without standby losses
- An increase in the performance of the solar combisystem

Figure 12: Pellets burner integrated in the space heating storage tank, (Source:Solarfocus, A)

3.2 Architectural Aspects – Building Integration of collectors

The usual range of collector areas of a solar domestic hot water system is between 4 and 8 m^2 and for a solar combisystem between 10 and 30 m² for a single-family house. It can range up to several hundred square metres, if the system is designed for hotels, hospitals or housing estates. With this size the collector array becomes a dominant architectural element. Therefore it is necessary to improve the appearance of collectors, which can be regarded as multifunctional building elements that provide both shelter and heat.

As solar collectors involve both technology and architecture, and also demonstrate social and ecological awareness, concerted professional efforts on behalf of engineers and architects are needed to make a success of the integration of solar collectors in the building envelope.

Building-integrated collectors have to fulfil the various demands of the building envelope and have to fit in with the overall concept of the building design. Except for the solar enthusiasts, the aesthetics of a building may be one of the most important aspects when solar collectors are integrated in the building envelope. The collectors have often been considered separate elements placed on the building and disregarding the architecture of the building itself. For architects the most common reasons for unacceptable solar energy systems are the disharmony with the design of the roof or façade. The placement of the architectonically ‘foreign’ components without any relation to the roof or façade scale leads to the fragmentation of homogenous spaces (Krippner, 2000; Herzog, 1998).

The integration of collectors should be consistent with the design of the roof and façade of a building. The first trends towards building integration show that ‘integration’ has been considered synonymous with ‘invisibility’. The aim was to maximise integration and to hide the fact that solar energy systems were different from other building elements. This practice has changed and architects have started to use solar energy systems in order to enhance the aesthetic appeal of a building by providing a variation or contrast (Hestnes, 2000).

3.2.1 Roof-integration of collectors

If the whole roof area is not needed for the collector array, the best aesthetical as well as the best economical solution may be to cover the remaining roof area with a dummy collector. This dummy consists of a glass cover and a black covered insulation layer. From the visual point of view it is very similar to the solar collector (see Figure 13)

Figure 13: Roof-integrated collectors. The far left and far right section of the roof is a dummy. As they are the same colour it gives a uniform look to the roof as a whole. In this case two roof windows have also been integrated in the collector roof.

3.2.2 Façade integration

Façade-integrated photovoltaic systems have become increasingly popular, but solar collectors are generally confined to rooftops. But where large collector areas provide energy for space heating as well as for hot-water production, façade-integration has much to offer – although it makes considerable demands on system manufacturers.

Solar irradiation on façade collectors

In central Europe the annual solar irradiation on the façade is about 30% less than the irradiation on a south-facing roof with a 45° slope. A characteristic of façade-integrated collectors is the regular profile of the solar irradiation, with just small peaks in spring and autumn (see Figure 14). This leads to a more or less balanced collector yield throughout the year.

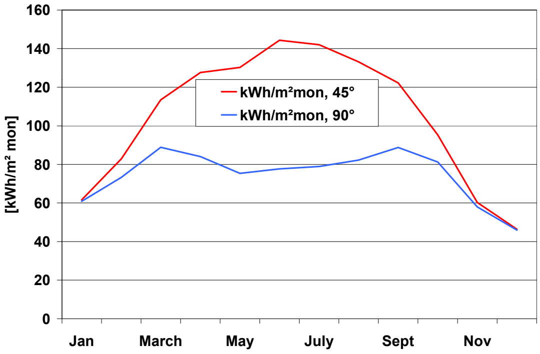

Figure 14: Solar irradiation on a surface of 45° and a surface with a 90° tilt angle, Graz, Austria, latitude: 47°

Façade integrated collectors – a good solution for solar combisystems

The energy demand has to be looked at in relation to the irradiation on the collector area – in the case of solar combisystems this is the demand for hot water and space heating. Whereas the domestic-hot-water demand is more or less constant over the year, the space heating demand varies very much depending on the season. However, most of the energy for space heating is needed when the irradiation is at its lowest.

Solar combisystems for hot water and space heating often have large collector areas – 15–30 m^2 for a single-family house. Depending on the location of a house, the standard of the building insulation, the passive solar gains, the air-tightness of the house and the room temperature preferred by the inhabitants, the heating season ends between March and May. During summer, when there is no, or just a very small, demand for space heating, more energy is available due to higher irradiation. This leads to the stagnation of the solar collectors.

Thus the irradiation on the façade meets the needs of combisystems rather well: during the heating season the irradiation falling on the façade and on a 45°-inclined surface are quite similar. During the summer, however, the advantage is on the side of the collector in the façade because the danger of overheating the solar heating system is significantly reduced due to the lower irradiation. Yet the relatively large collector area of a combisystem is sufficiently large to meet the hot water requirement.

Figure 15: In regions with snow, facade-integrated collectors for solar combisystems have several advantages. No snow cover on the collectors and high irradiation on the façade due to the reflection of the snow (Source: AKS DOMA, Austria)

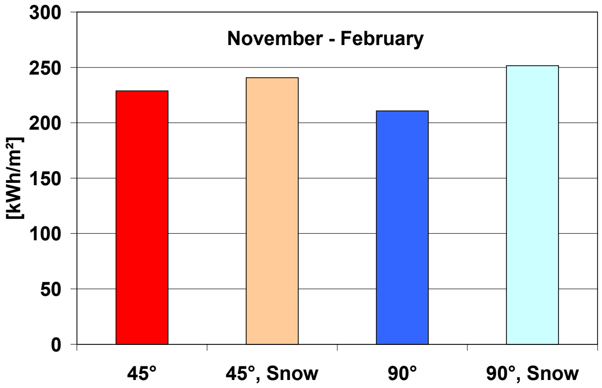

Figure 16: Increase in solar irradiation on a surface with a 45° and 90° tilt angle caused by the reflection of the snow on the ground from November to February; Graz, Austria

Solar radiation reflected on the collector from the ground increases the collector yield. The influence of reflection grows with the collector's tilt angle. Reflection is, therefore, important when it comes to the façade-integration of solar collectors. Simulations have shown that during the heating season the irradiation on the façade is higher than on a surface with 45° tilt angle, due to the reflection of the snow.

Direct façade integration

As with roof integration there are two ways of integrating a collector array in the façade: that is the collectors can be mounted with or without an air gap (ventilation gap) between the collector and the wall.

From the point of view of building physics, the installation with a ventilation gap is unproblematic.

In a collector element directly integrated in the façade, thermal insulation is a component of both the building and the collector – there is no thermal separation between the collector and the wall in the form of rear ventilation.

The direct façade-integrated collector helps reduce heat losses from the wall, and in periods of low irradiation, when the collector loop pump is switched off, the collector functions as a 'passive solar' element. Simulations showed that the U-value of a wall with a façade collector is reduced by up to 90% during cold winter days with high irradiation, and by up to 45% during days with low irradiation, because the temperature of the outer layer of the wall – the collector – is higher than the ambient temperature outside. Monitoring of the test façades confirmed the simulations.

Figure 17: Solar heating system with 22.7-m² façade-integrated collector area for domestic hot water and space heating in a new single-family house.

4 LARGE-SCALE SOLAR HEATING SYSTEMS

Since it has been possible to enter the market for thermal solar plants for single family houses as of the beginning of the 90's, for further dissemination it was important to develop and realize solar thermal systems on a larger scale for multi-family dwellings, housing estates and for whole villages as well.

4.1 Systems for Multi-Family Houses and Housing Estates

In recent years hundreds of solar heating systems have been realized all over Europe. By increasing the systems in size, an increase in system performance and a decrease in investment cost was anticipated. Measure for this behaviour is the cost/benefit-ratio (investment cost/energy savings per year). Figure 18 shows the cost/benefit-ratio for large solar systems compared to small systems. An improvement of up to 70% is feasible.

In general the system costs decrease with the size of the plant. Therefore, solar thermal systems for a housing estate connected to a district heating net are more cost effective than systems for one multi-family house. The results of the EU-sponsored project "Large scale solar heating systems for housing developments" have shown that large systems (> 150 m²) with a short term storage have an economic advantage compared to large systems with a seasonal storage (Mahler, B., Fisch, M.N., Weiss, W.; 2000).

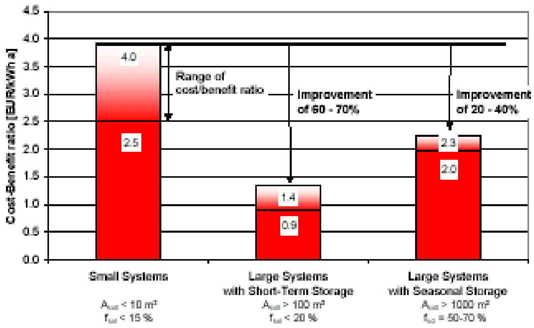

Figure 18: Cost/benefit ratio of solar heating systems

Three major system designs have been realized so far:

Systems with short-term storage

The typical storage volume referred to the installed collector aperture area is in the range of 50-75 l/m² for a system with short-term storage. With this design a short period of a few days with little sunshine can be bridged. In doing so, the solar fraction of the systems is limited to a maximum of about 20% of the total heat demand (space heating, domestic hot water preparation and net losses). Several of these systems have been realized in Germany, the Netherlands and Austria.

Systems with seasonal storage

For solar heating systems with seasonal storage the storage volume referred to the installed collector aperture area is about 2.000 l/m². With these large storages the solar heat produced in the summer months can be used for space heating in winter time thus leading to a substantially higher solar fraction of 50% to 70%. These systems have a long "tradition" in Sweden and also in Germany.

Medium-term storage

With the third approach, mainly realized so far in Austria, a high solar fraction is obtained by reducing the space heating demand of the buildings as far as possible and by optimising the district heating net to the needs of the solar heating system.

In the following two projects with medium-term storages are described in detail.

In Gleisdorf, Austria, six low energy terraced houses and one office building were erected in 1998/99. As a result of the high building insulation standard, thermal zoning and controlled air ventilation using ground heat exchangers, it was possible to reduce the heating energy requirement of these buildings by 60% compared to the present new building standard.

Domestic hot water and space heating requirements are mainly supplied by thermal collectors. The collector arrays, which cover 213 m², were integrated in the roofs of the conservatories. A wood pellets boiler meets the remaining residual heating requirement. Thus the provision of heat for the building is met 100% by renewable sources of energy. Energy is stored in a 14 m³ steel tank. The individual houses are supplied by a central storage tank via a local heating network, which is operated over 22 hours a day at a low temperature level (40°C) (space heating operation).

To prepare the hot water, the same local heating network is operated during the night for two hours at a higher temperature level (65 - 70 °C). In this time the heating is switched off and only the decentralised hot water storage tanks are loaded (see: Figure 19)

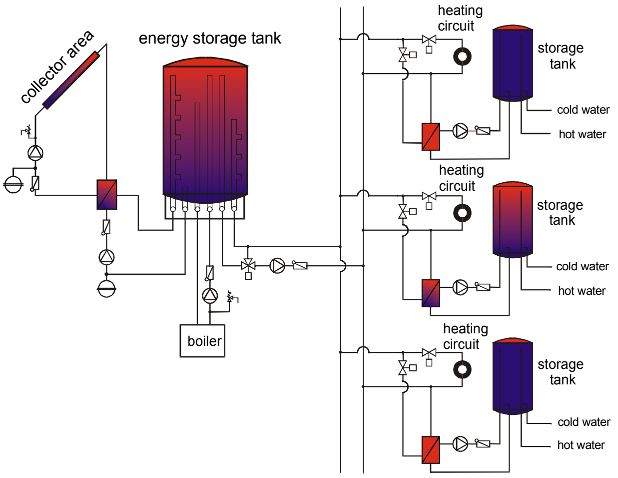

Figure 19: Hydraulic scheme of the system realized in Gleisdorf.

The monitoring results of the system have exceeded expectations based on the simulation. On average (1999 – 2001) 65.6% of the hot water and space heating demand was covered by solar energy.

The average annual space heating demand for the office building was 17.46 kWh/m² and the average annual space heating demand for the terraced houses was 34,57 kWh/m².

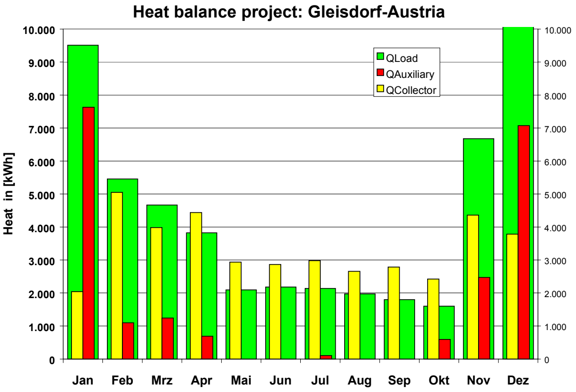

Figure 20: Heat balance for the year 2001

Figure 21: View of terraced houses

Another system realized with a slightly different approach is a housing estate on the outskirts of Salzburg. The housing estate Gneis-Moos was constructed on an overall area of 4.696 m².

The aim of the project was to design and install a new concept of a solar assisted district heating system, which provides both hot water and space heating. The new approach in Gneis –Moos was the usage of a small - weekly storage in combination with a two pipe network for the heat distribution and decentralised heat transmission stations in the flats.

Figure 22: General view of the housing estate Gneis-Moos

The energy supply to the apartments includes two special aspects:

- The collector was built in a size that a large part of the energy supplied by the collector can also be used to support the space heating. In particular with 100 m³ the energy storage tank was designed atypically in terms of its volume and in relation to the collector area. Until now it was common to design the energy storage tank for solar thermal systems for housing estates either as a long-term storage tank (seasonal storage) or as a short-term storage tank (storage for a number of hours).
  When it comes to the Gneis-Moos project the dimensioning of the energy storage tank was performed as an intermediate step between the concepts previously named. This aspect leaded to interesting results regarding the solar yield and solar fraction.

- The energy is distributed via a 2-pipe network with decentralised heat transmission stations in the individual houses. The design of the heat transmission stations and the radiators demands a constant network forward temperature of 65 °C throughout the year. On the one hand the heat transmission stations contain the external heat exchanger to heat up the water for domestic use on the basis of the throughput principle and on the other hand all the control elements such as differential pressure control units and backflow temperature limiting devices. The low network backflow temperatures which can be achieved with this heat transmission stations form the basis for a good collector efficiency rate and thus for corresponding solar yields.

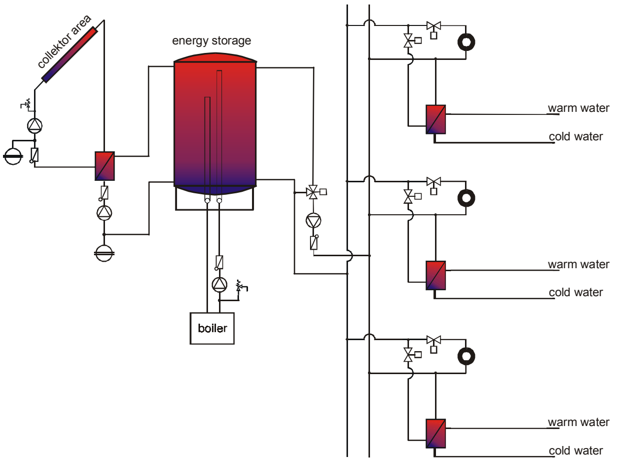

Figure 23: Heat distribution system: 2-pipe-network with decentralised heat stations in each apartment

Performance of the heat distribution network

For the depiction of the network operating temperatures of the heating unit in Gneis-Moos a day was taken in July and December 2001 as follows:

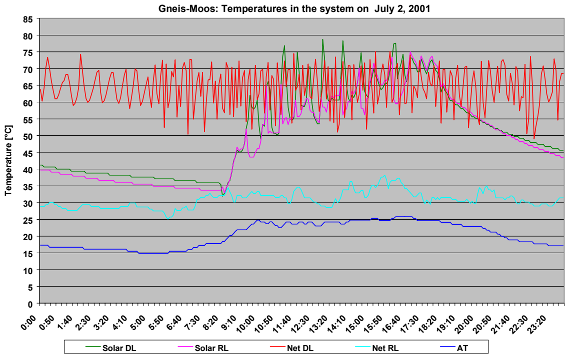

Figure 24: Network temperatures on July 2, 2000. The network backflow temperature (Net RL) equals between 25 and 36°C

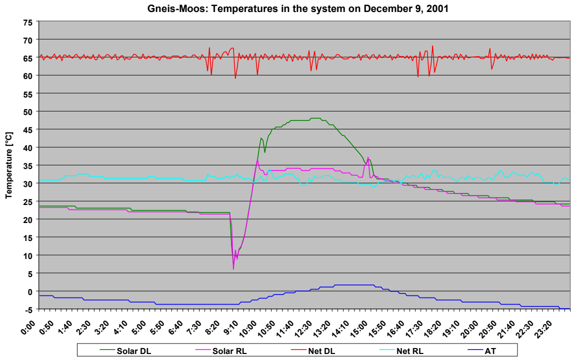

Figure 25: Network temperatures on December 9, 2001. The network backflow temperature (Net RL) equals 29 and 33°C.

Solar DL: Solar distribution line (from collector to the storage)
Solar RL: Solar return line (from storage to the collector)
Net DL: Net distribution line (from storage to the apartments)
Net RL: Net return line (from apartements storage to the storage)
AT: Ambient temperature

4.2 Solar Assisted Biomass District Heating

Since the beginning of the 1980s about 300 biomass district heating networks have been built in Austria and more and more of these types of plants are continuously being built and successfully operated. Especially due to the amount of wood available in Austria, these plants are considered to be interesting and also highly acceptable regarding the independence from energy imports.

Several of these central biomass plants have been equipped with solar collector arrays acting as an auxiliary heat supplier.

Up until now 18 solar assisted biomass district heating networks have been erected with collector areas of between 350 and 1250 m². These systems offer whole villages the possibility to switch to a heat supply based on renewable energies.

Figure 26: Solar assisted biomass district heating plant, Lienz, Austria

5 A NEW CHALLENGING MARKET - SOLAR HEAT FOR INDUSTRIAL PROCESSES

The use of solar energy in commercial and industrial companies is currently insignificant compared to the use in swimming pools and the household sector. Most solar applications for industrial processes have been on a relatively small scale and are mostly experimental in nature. In the Mediterranean countries Spain, Greece and Portugal several systems are in operation (POSHIP), but compared to other applications only a few large systems are in use worldwide.

On the other hand, if one compares the energy consumption of the industrial, transportation, household and service sectors, then one can see that the industrial sector has the biggest energy consumption in the OECD countries at approximately 30%, followed closely by the transportation and household sectors.

As a result of the fact that energy is available at low cost and without limitations, industry did not care too much about the energy efficiency and substitution of (fossil) fuels. The main activities in this field started in 1973 and 1979/80 following the two oil (price) crises. Later on, oil prices – and related to that the prices for natural gas and electricity – fell again. Today – even in the face of a critical political situation in the Middle East – energy prices are low.

On the other hand, it is obvious that fossil resources are finite and alternatives have to be found for any application, including the use in industrial and commercial applications.

The major share of the energy, which is needed in commercial and industrial companies for production processes and for heating production halls, is below 250°C. The low temperature level (< 80°C) complies with the temperature level, which can easily be reached with the solar thermal collectors already on the market. The principles of operation of components and systems apply directly to industrial process heat applications. The unique features of these applications lie on the scale on which they are used, system configurations, controls needed to meet industrial requirements, and the integration of the solar energy supply system with the auxiliary energy source and the industrial process.

A good example for an industrial application is shown by a system realized for a confectionery factory. The 2400 m² system was installed in 1996/1997 in Breda-NL.
The system load consisted of a daily use of 125.000 litre hot water of 65 ºC (26000 MJ/day). The factory is in operation 5 days a week. The solar contribution to cover the load was designed to meet 45%. This implied an almost full 100% contribution of the solar system in summer.

Figure 27: A 2400 m² collector array for an industrial application in the food industry.

To be able to make use of the huge potential for solar heat in industry and to open a new market sector for the solar thermal industry, it is necessary to integrate solar thermal systems in the industrial processes in a suitable way especially when it is necessary to further develop the solar thermal components so that they fulfil the requirements stipulated.

For applications where temperatures up to 250°C are needed the experience is rather limited and also suitable components and systems are missing. Therefore, for these applications the development of high performance solar collectors and system components is needed.

References:

Weiss, W., Faninger, G., (2002) Solar Thermal Collector Market in IEA Member Countries, IEA Solar Heating & Cooling Programme.

Staiß, F. (2003) Jahrbuch Erneuerbare Energien, Stiftung Energieforschung Baden- Würtemberg, Radebeul, Deutschland.

Striy-Hipp, G. (2000) Der europäische Solarthermiemarkt, German Solar Industry Association – DFS, Freiburg, published at the 5th international symposium Gleisdorf SOLAR , Gleisdorf, Austria.

Suter, J.M., Letz, T., Weiss, W., Inäbnit, J. (Ed.) (2000) Solar Combisystems in Austria, Denmark, Finland, France, Germany, Sweden, Switzerland, the Netherlands and the USA – Overview 2000, IEA SH&C Task 26 Solar Combisystems, ISBN 3-905583-00-3.

Krippner, R., Herzog, T., (2000) Architectural aspects of solar techniques – Studies on the integration of solar energy systems. Proceedings EuroSun 2000, 3rd ISES-Europe Solar Congress. 19-22.06., Copenhagen, Denmark.

Herzog, T., Krippner, R., (1998) Synoptic description of decisive subsystems of the building skin, Proceedings Building a New Century, 5th European Conference Solar Energy in Architecture and Urban Planning, Bonn, Germany.

Hestnes, A.G., (2000) Building integration of solar energy systems, Solar Energy, Vol. 67, Nos. 4-6, pp. 181-187.

Weiss, W (Ed.) (2003) “Solar Heating Systems for Houses – A Design Handbook for Solar Combisystems”, James & James Science Publishers, London, 2003

Streicher, W. (2000) Solar combisystems – from a small niche market to a standardized application, Proceedings Eurosun 2000 Conference, Copenhagen, Denmark.

Mahler, B., Fisch, M.N., Weiss, W. (2000) Large Scale Solar Heating Systems for Housing Developments, Proceedings Eurosun 2000 Conference, Copenhagen, Denmark.

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