SOLAR THERMAL SYSTEMS
STATE OF THE ART IN AUSTRIA

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1 Market development

Since the beginning of the 1980‘s the use of solar thermal collectors has continued to increase in Austria so that a total of 2.9 million m^2 of collector area – corresponding to an installed capacity of 2 GW_{th} - were installed by the end of the year 2004.
Of this, 607,000 square meters (425 MW_{th}) were accounted for by unglazed plastic collectors, which are used mainly to heat swimming pools, 2.25 million square meters (1,575 MW_{th}) of flat-plate and 33,000 square meters (23 MW_{th}) evacuated tube collectors. Flat-plate and evacuated tube collectors are applied for hot water preparation and for space heating.

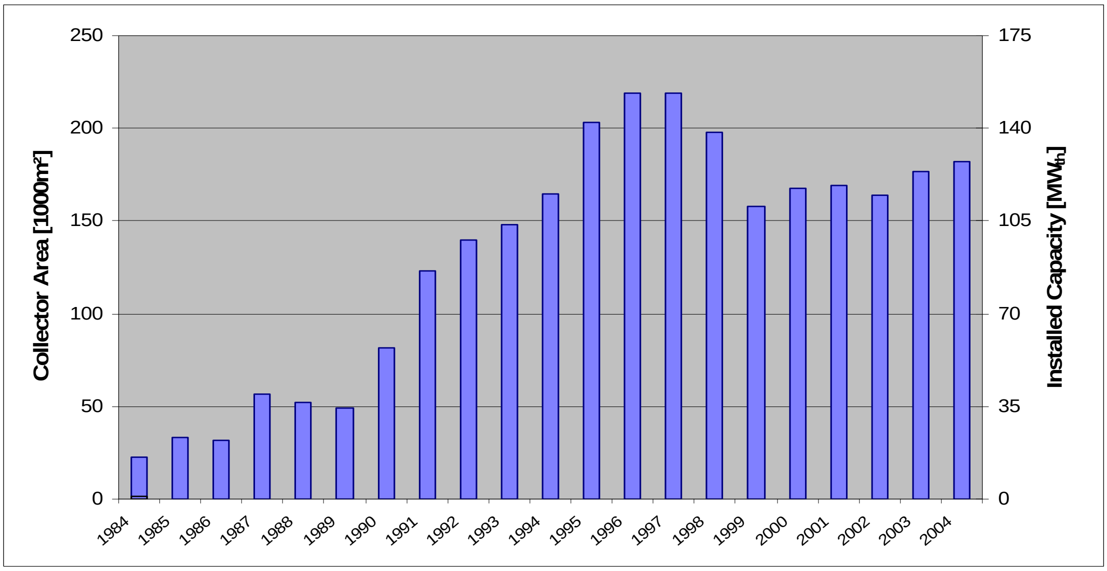

Fig. 1: Annual installed collector area and installed capacity in Austria

The annual collector yield of all solar thermal systems installed by the end of 2004 is 947 GWh. This corresponds to an oil equivalent of 150,000 tons and an annual avoidance of 443,000 tons of CO_2 /1/.
According to a recent study /2/, about 2,800 jobs have been created in the fields of production, trade and installation of solar thermal systems in Austria.

At the beginning of the development from 1975 - 1985, systems were predominantly used for the preparation of hot water in private houses on a small scale. However, the first plastic absorber areas on a larger scale were also erected to heat swimming pools.

The collectors were mainly manufactured by small companies who for the greater part only offered their products on a regional market. Other components, such as the storage tank and electronic controllers, were purchased and the plant as a whole was adjusted by the installer to suit the specific requirements of the customer. Only a very few companies took the step to become system suppliers.
This structure remained for years and motivated other small-sized companies to start to produce collectors as a result of the rise in demand and the subsidies offered by communities, the federal and provincial governments.
A change in these regional structures came as of the middle of the 1990's since specialisation began and since the establishment of nation-wide and in the recent years also international sales structures by some companies have been established. This is on the one hand reflected in industrial manufacturing technologies and in professional sales structures on the other hand.

2 Export and future market prospects

For a number of years now, these companies have also enjoyed considerable success in the field of exports. In 2004 the export share of flat plate and evacuated tube collectors manufactured in Austria equalled 65% or 320,000m² /1/.

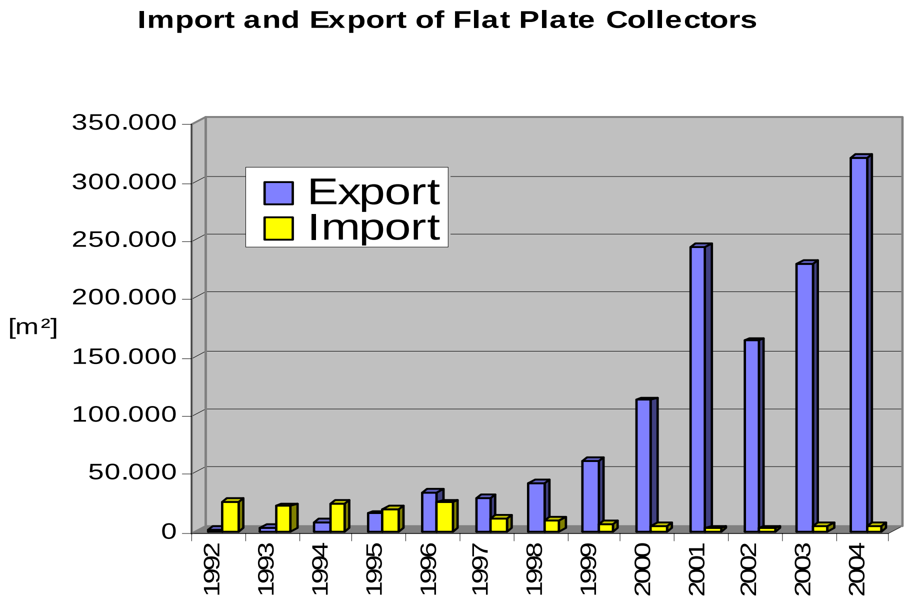

Fig. 2: Exports and imports of flat plate collectors in Austria 1992 - 2004 /1/

This new orientation towards larger markets, which extend beyond the borders of state boundaries, has also become noticeable in the fact that some companies are now also participating in European research and demonstration projects. This relates to the development of new storage tanks and collector technologies as well as to the development of system concepts for large-scale systems for the residential sector and for new applications like industrial heat.

As a result of specialising in new market niches some companies have been able to secure a place for themselves abroad and on the Austrian solar market. These companies manufacture exclusive solar façades, which have aroused the interest of Austrian and foreign architects alike.

Fig. 3: Facade integrated collector at a commercial building (Source: DOMA)

The conquering of new applications for thermal solar plants was also triggered off and supported by the research and development programmes initiated by the federal and provincial governments.
Above all the development of solar combisystems for hot water preparation and space heating initiated a series of innovations due to the larger collector areas required and new demands on storage tanks. The market share of these combisystems in the collector area already installed equalled 50 % in 1998. In this field Austria has without a doubt assumed a pioneering role.

3 Applications

3.1 Small-scale Systems for Hot Water Preparation

Under Austrian climatic conditions, double-circuit systems with forced circulation are almost exclusively used. A circulation pump drives the collector circuit. Characteristic to this system is the separation of the collector and the tank as the collectors are usually mounted on the roof and the tank is installed in the cellar of the house.

During summer the energy supplied by the sun is sufficient to cover between 80% and 95% of the hot water demand, depending on the dimensioning of the system. If the hot water consumption is matched with the solar radiation profile, it is fully possible to omit other forms of energy during the summer months.

During the interseasons and winter months, the solar energy supply is still sufficient to pre-heat the domestic water, i.e. the temperature of the inlet water has to be raised only by a small amount by the heating boiler or electric heating element. During the cold winter months, water temperatures between 30 and 50°C can still be reached on sunny days. Thus, the energy saving effect in winter may be still considerable.

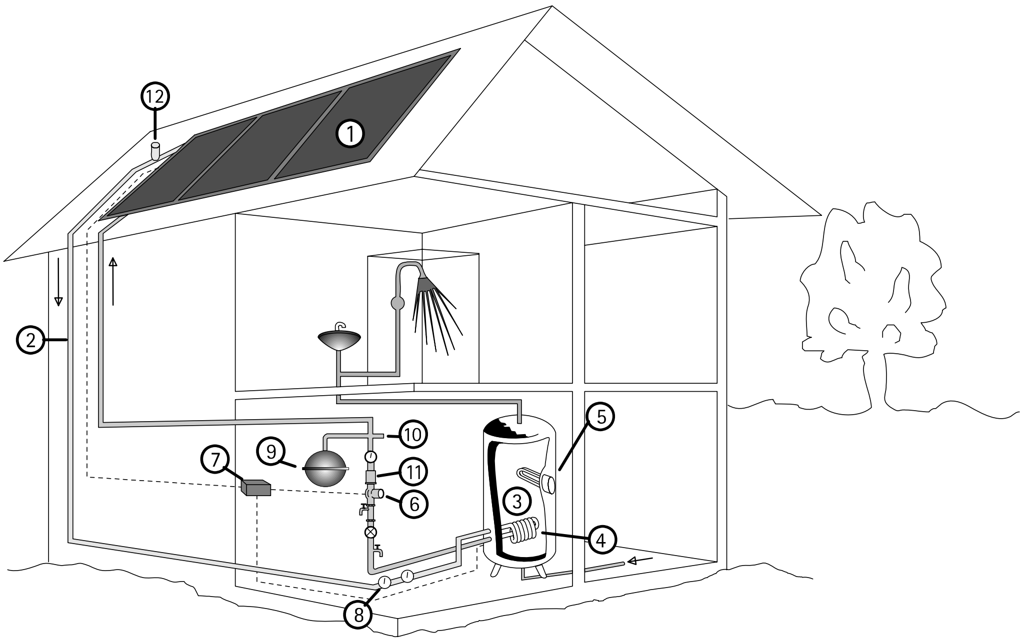

Fig. 4.: Solar hot water system with forced circulation

Description of a Domestic Hot Water System with forced circulation

The incoming solar radiation is converted by the collector (1) into heat. This heat is transported by a heat transfer medium (water/anti-freeze mixture) in pipes (2) to a storage tank (3). There, the heat is transferred through a heat exchanger (4) to the domestic water and thus becomes utilisable. The storage tank should be dimensioned in such a way that its volume corresponds to the hot water demand of one to two days.

The installation of an additional (e.g. electric) heater (5) ensures that sufficient amounts of hot water are available even during long and continuous periods of overcast weather.

The water, which has been cooled in the heat exchanger, flows then back to the collector. The heat transfer medium is circulated by a circulation pump (6). An electronic control (7) ensures that the pump is only turned on when an energy gain from the solar collector is expected, i.e. when the medium in the collector is warmer than the domestic hot water in the tank.

Both the storage tank and the pipes are well insulated to avoid unnecessary losses.

Additionally, thermometers (8) in the inlet- and outlet pipes belong to the basic equipment of the system. They are preferably installed close to the storage tank. Temperature dependent volume changes in the fluid are compensated by the expansion tank (9), keeping the operating pressure in the system constant.

The gravity brake (11) prevents the heat from flowing back to the top if a standstill in the system occurs. A pressure relief valve (10) allows fluid to escape if the system pressure becomes too high. An air escape valve (12) is installed at the highest point allowing air in the piping to escape. Inlet and outlet taps complete the system.

In general, the auxiliary heating of the domestic hot water is performed with a second heat exchanger by a boiler instead of, or in addition to, the electrical auxiliary heating.

Typical solar hot water systems in Austria consist of 5 – 6 m² of flat-plate collector and a 300 to 500 litre storage tank for the hot water.

3.2 Solar Combisystems

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. Motivated by the confirmed success of these systems for hot water production, an increasing number of home builders consider solar energy for space heating, as well.
Combining solar heating systems with a 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, so 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.
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.
In recent years, combisystems have changed from complex single designs into more standardised and compact products.
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.

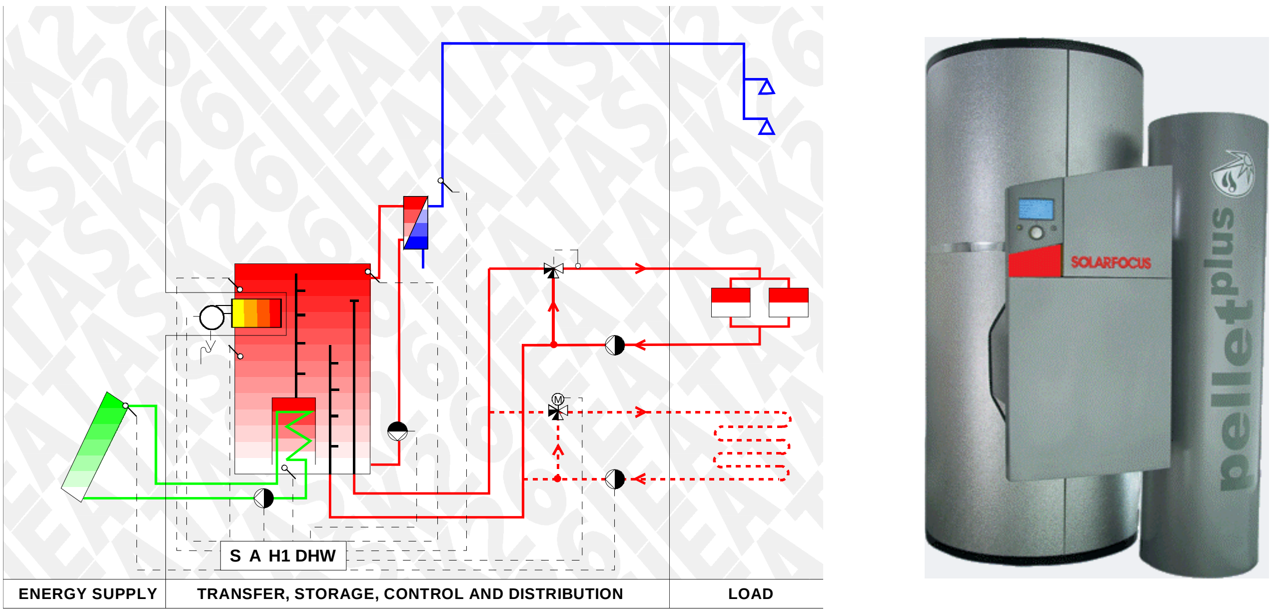

Fig. 5: Advanced solar combisystem with a pellet burner integrated in the storage tank. Hydraulic scheme (left) /3/ and storage tank with integrated pellet burner (right). Source: Solarfocus

The solar contribution of solar combisystems, 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.

From 1998 to 2003, 26 experts from 9 European countries and the USA and 11 solar industries worked together in the IEA Solar Heating and Cooling Programme's Task 26, Solar Combisystems, to further develop and optimise solar combisystems for detached single-family houses, groups of single-family houses and multi-family houses.
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. Thus, for example, the "smallest systems" in terms of collector area and storage volume are located in those countries in where 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%.
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%.
For more details on solar combisystems see: http://www.iea-shc.org/task26/

Fig. 6: Solar combisystems for single-family houses 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 2004 the total collector area installed for solar combisystems in Austria equalled 36,000 m². Assuming that the average collector area for a combisystem is 15 m², this means that about 2,400 solar combisystems were installed in 2004.

3.3 Systems for Multi-Family Houses and Housing Estates

In recent years hundreds of solar heating systems for multiple-family houses have been realized all over Europe. By increasing the systems in size, an increase in system performance and a decrease in investment cost were anticipated. Measure for this behaviour is the cost/benefit-ratio (investment cost/energy savings per year). Fig. 7 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-supported project “Large scale solar heating systems for housing developments” have shown that large systems (> 150m²) with a short term storage have an economic advantage compared to large systems with a seasonal storage /4/.

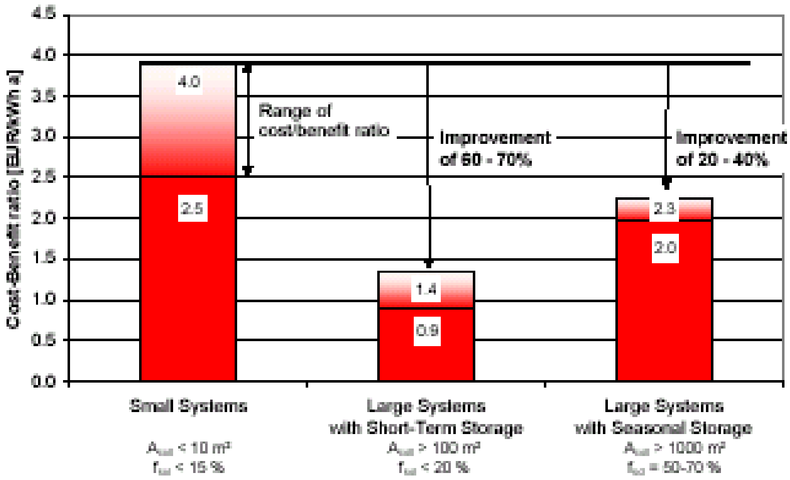

Fig. 7: Cost/benefit ratio of solar heating systems /4/

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 wintertime 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 in Austria so far, 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 a project with medium-term storage is described.
The housing estate Gneis-Moos was constructed on the outskirts of Salzburg 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.

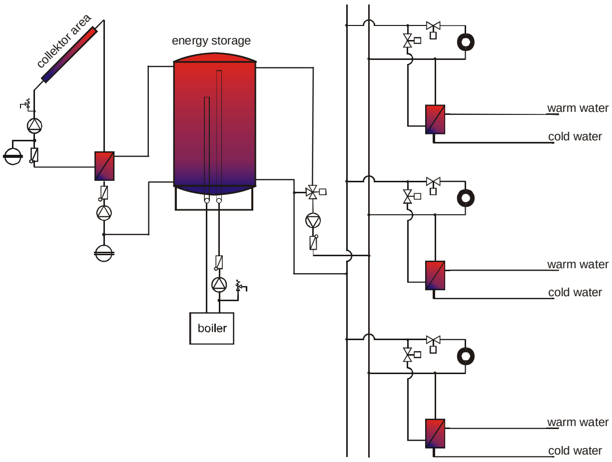

Fig. 8: General view of the housing estate Gneis-Moos (left) and the heat distribution system: Two-pipe-network with decentralised heat stations in each apartment (right).

The energy supply to the apartments includes two special aspects:

- The collector was built in a size so 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 lead 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.

3.4 Solar Assisted Biomass District Heating

Since the beginning of the 1980s about 300 biomass district heating networks have been built in Austria 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 fossil 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 1250m². These systems offer for whole villages the possibility to switch to a 100% heat supply based on renewable energies.

Fig. 9: Left picture: Solar assisted biomass district heating plant, Eibiswald with an installed capacity of 875 kW_{th}, (1250 m² collector array). Right picture: District heating plant in Graz with an installed capacity of 980 kW_{th}, (1400 m² collector array). Source: S.O.L.I.D.

4 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 residential 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 are several systems 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.

Fig. 10: Solar timber drying system

Installed capacity: 62 kW
Collector area: 88m²
Storage: 14,000 litres

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.

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