WATER SOLAR COLLECTOR SYSTEMS

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Abstract

In recent years the growth rate of the use of solar collectors for domestic hot water heating, has shown that solar heating systems are both mature and technically reliable. Every day, world-wide thousands of systems demonstrate the possibilities of this undisputedly ecologically harmless energy source. Motivated by the confirmed success of these hot-water systems, more and more house builders are also considering using solar energy for space heating. This can be realised in one or two family houses, in multifamily houses combined with medium or large (seasonal) storage and also in villages in combination with district heating networks mainly powered by biomass or fossil fuels supported by large central solar plants mainly in summer time for domestic hot water preparation.

Samenvatting

In de laatste paar jaar is het duidelijk geworden, door de toename van het gebruik van zonne collectoren voor de aanmaak van sanitair warm water, dat actieve zonnesystemen technisch op punt staan. Iedere dag, wereld-wijd, demonstreren duizenden systemen de mogelijkheden van deze ontegensprekelijke ecologisch onschadelijke energiebron. Gemotiveerd door het success van deze warm water systemen, overwegen meer en meer bouwheren het gebruik ervan in hun gebouwen. Dit kan zowel gerealiseerd worden in eensgezinswoningen als tweegezinswoningen, als in appartementsgebouwen gecombineerd met medium of grote (seizoens) opslag en ook in dorpen in combinatie met district verwarmingsnetwerken aangedreven door biomass of fossiele brandstoffen gesteund door grote centrale zonnesystemen voornamelijk in de zomer periode voor het bereiden van huishoudelijk warm water.

A) Solar systems for domestic hot water

Small sized solar systems "only" for domestic hot water preparation are built since almost 20 years, mainly in a similar technical (collector on the roof and tank inside the house, solar circuit is driven by a pump, see Fig. 1 and Fig. 2) way only the sizes are different.

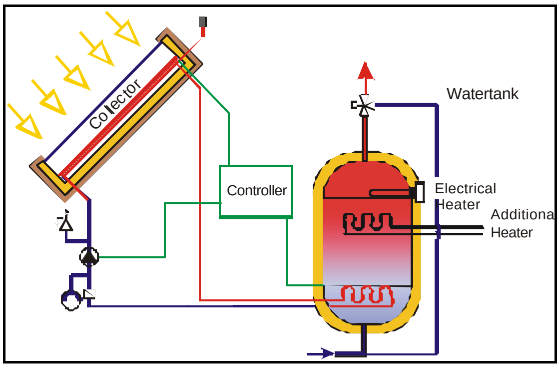

Fig. 1: standard solar system in northern europe

Fig. 2: Solar systems on several houses

In Austria for a one family house typically collector areas of 6 to 8 m² and about 500 litres water storage are built to get almost 100 per cent solar fraction in summer time. In Germany the systems are little smaller with about 4 m² and 300 litres, in Holland and Belgium are the smallest systems with "maximum" of economy which have 2 to 3 m² and 150 litres. Also in summer time solar fraction is maximum 50 per cent.

In southern Europe like Greece, Cyprus and also Israel mainly Thermosyphon systems are in operation what in this regions is definitely the best solution. System sizes are mainly about 4 m² and 200 litres for one family houses.
Developments are going on in technology fields of drain back systems (Holland) and "Kit-systems" with the goal to minimise the work the plumber has to do. Also new storage types are coming more and more which are not filled with domestic hot water but heating water and warming up the domestic hot water directly (by an external or internal heat exchanger) in that moment when the valve is open.

B) Combined systems for domestic hot water and space heating in one / two family houses, guest houses / hotels and industry

In several countries since about 5 to 8 years solar systems are growing and solar energy is also used for space heating more and more.

The combination of solar heating systems with short-term heat storage and thermally well insulated buildings, allows the heating requirements of a single- or multi-family dwelling to be met at acceptable costs. In comparison to systems with a seasonal storage, the costs of which are currently not justifiable for single-family houses, this combination provides a cost-effective system with high efficiency.

The demand for solar heating systems for combined domestic-hot-water preparation and space heating is increasing rapidly in several countries. In some countries, such as Austria, Denmark, Germany and Switzerland they have a noteworthy market- share.

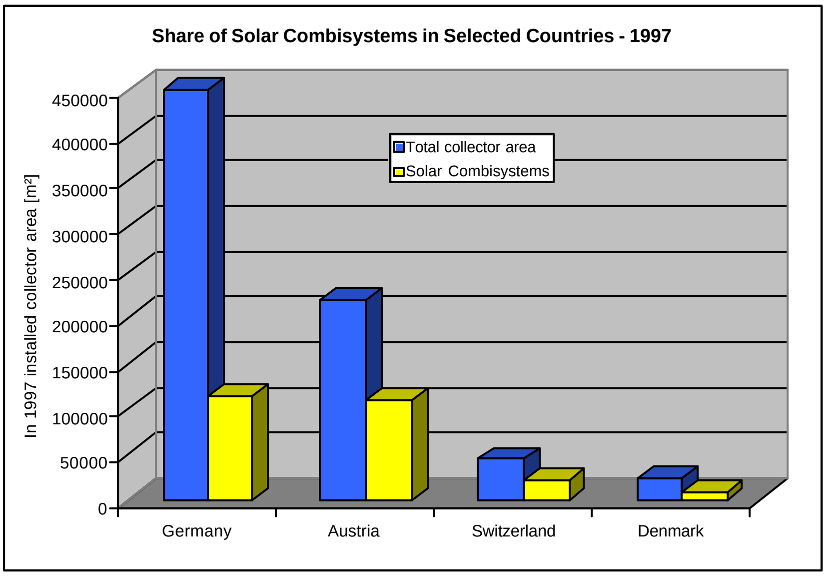

Fig. 3: In 1997 installed collector areas and share of collectors for solar combisystems in selected countries.

Since December 1998 25 experts from 8 European countries and the USA and 11 solar industries work together in Task 26 of the Solar Heating and Cooling Programme of the International Energy Agency (IEA) to further develop and optimise solar combisystems for detached one-family houses, groups of one-family houses and multi-family houses in the next two years. Furthermore, standardised classification and evaluation processes will be developed for these systems within the framework of this project. These serve as a basis for the elaboration of suggestions for the international standardisation of combisystem test procedures.

System designs

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

As mentioned before, there is broad variety of 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 which primarily gas or electrical energy are used as auxiliary energy. In the Netherlands for instance a typical solar combisystem consist of 4 to 6 m² of solar collector and a 300 l storage tank. The share of the heating demand met by solar energy is correspondingly small.
These are combisystems with just one storage tank, which is filled with domestic hot water. To store heat for subsequent delivery to the space heating loop the domestic hot water (DHW) is used. The DHW storage tank is provided with immersed heat exchangers to separate the different fluids and to load the tank and to deliver heat to space heating loop. In the Dutch systems the collectors are drained as soon as the circulating pump stops. The drained water is retained in a mantle heat exchanger or a drainback tank until the pump is turned on again by the control unit.

Fig. 4: Dutch solar combisystem (Source: ATAG)

Fig. 5: Solar combisystem for a one-family house in Austria (Source: AEE)

In countries such as Switzerland, Austria and Sweden in which solar combisystems are preferably coupled with a biomass boiler, larger systems with high fractional energy savings are encountered. Typical systems for a single family house consist of 15 up to 30 m² of collector area and a 1 to 3 m³ of storage tank. The share of the heating demand met by solar energy is between 20 and 60 %.
In contrast to combisystems using DHW to store heat for subsequent delivery to the space heating loop this systems store heat for space heating purpose in a different store. The medium, in most cases is the water of the space heating loop itself. Domestic hot water is heated up either in a separate DHW store or via a so-called load side heat exchanger.
Interesting developments for these systems are combined boiler-storage-systems where the gas/oil boiler is integrated in the tank what reduces place necessary in the cellar and also minimises the work of the plumber especially to adjust the system.

The same technology described above also can be used in guest houses and hotels. Many times advanteges because of different loads of the two seasons can be realized. High DHW consumption in summer time and heating load in winter time, so no oversizing problems occur.

Fig. 6: Hotel Bielerhöhe / Sylvretta (28 beds, 60 m² collector area, 14 ³m tank in tank system including 900 ltr DHW-tank)

Also industry buildings can be very interesting objects for solar systems. Especially production halls with air temperatures less then 20 degree are ideal for solar heating systems.

Fig. 7: Facade integrated collector, DHW preparation for showers and direct floor heating in winter time with lowest temperatures for high efficency (Source: DOMA)

C) Solar systems for domestic hot water and space heating in multifamily and terraced houses resp. housing estates

The systems described above are designed for one or two family houses. But there are also systems in operation which are designed for multi-family houses and terraced houses.
Apart from the market potential clearly apparent, almost half of the Austrian population lives in multiple family dwellings, these buildings favour the installation of large central solar plants since they are of a compact structure and have a large volume. Large plants offer greater potential to save CO2 than small-scale plants, which would mean a reduction in costs.
As per 31 January 1998, 232 multiple family dwellings in Austria were equipped with a thermal solar plant to prepare warm water and support heating.

Fig. 8: Multifamily building with 8 dwellings and a solar plant consisting of 60 m² collector area and 2,4 m³ storage tank only for domestic hot water preparation

The following two figures show some austrian statistical data which were collected in a national project. Figure 9 shows the solar fraction as a percentage of the overall energy requirements of 72 solar plants in multiple family dwellings.

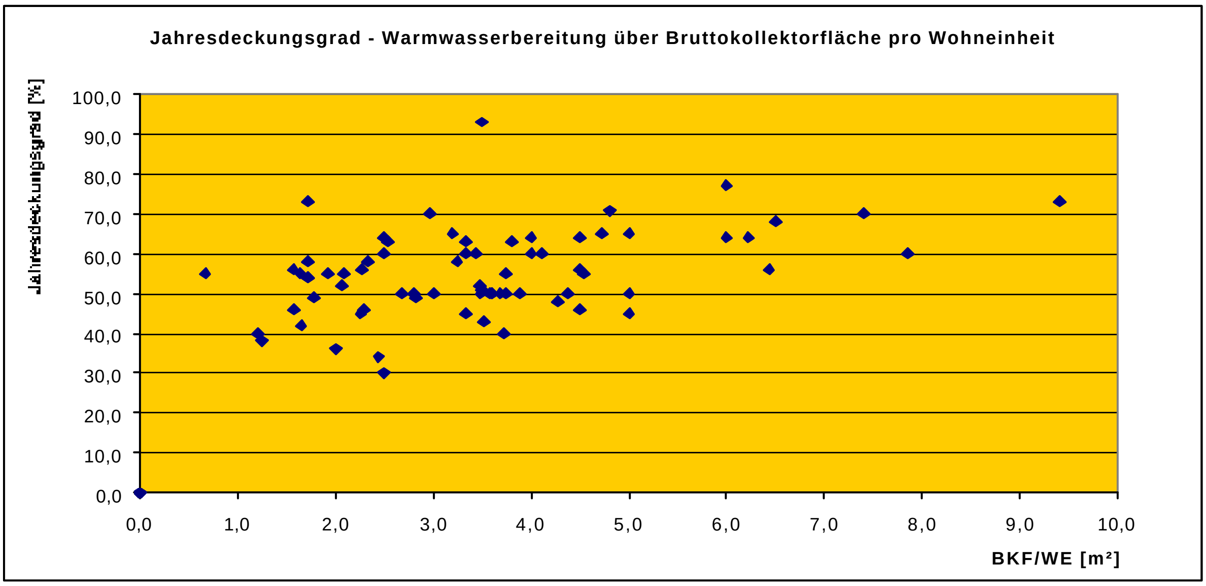

Fig. 9: Solar fraction [%] of solar plants for the preparation of warm water, in relation to the gross collector area (BKF) per residential unit (WE)

The specific yield describes the yield of the solar plant for each m² of gross collector area within one year. This represents a unit of measurement for dimensioning respectively the operatability of the plant and is the most important parameter apart from the solar fraction.

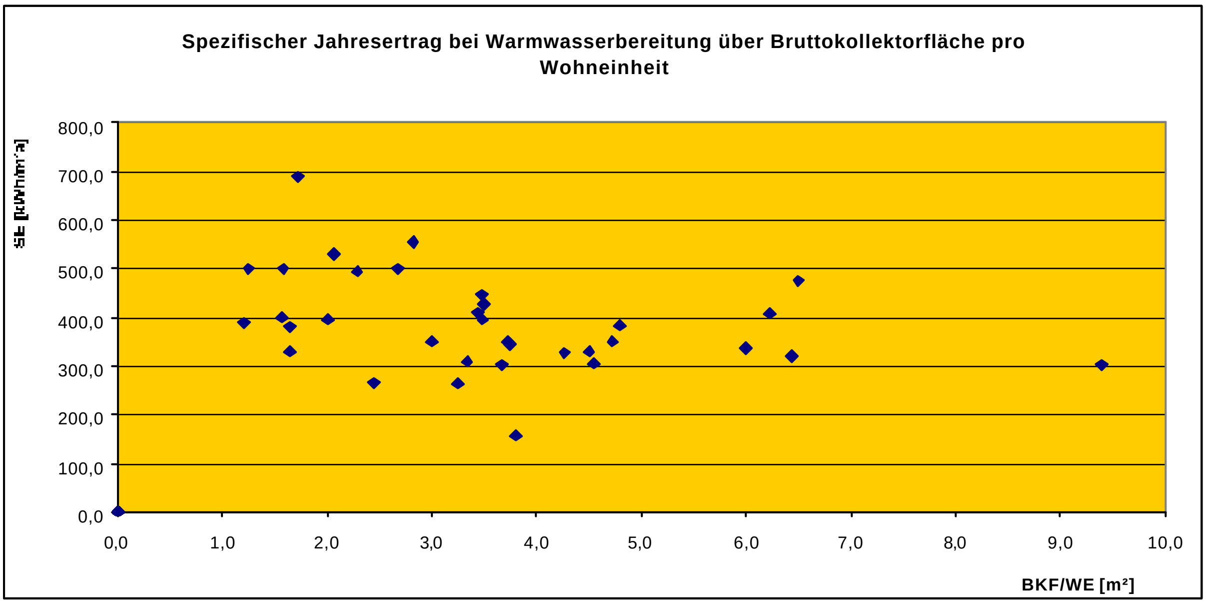

Fig. 10: Specific yields in kWh/m².a of solar plants for the preparation of hot water, in relation to the gross collector area (BKF) per residential unit (WE).

In Gleisdorf/Austria for example a system was installed in 1998 for a office building and 6 terraced houses. The collectors – spread on 3 construction parts – with an extension of 230 m² were integrated into the roofs of the winter gardens and cover 80% of the hot water and 60% of the space heating demand of the whole year. The remaining energy is provided by a biomass boiler. A local heating network connects the individual houses to the central 14 m³ storage tank.

The efficiency of a solar heating system is also determined by the temperature level of the heat release. For this reason the buildings were equipped with special low-temperature wall heating systems. The medium fluid temperature of low-temperature wall heating system is 35 C° during the heating period.

DHW is prepared and stored in a decentralised way. By night, the local heating network is operated for two hours at a higher temperature enabling the charging of all decentralised DHW stores.

In order to reduce the cost for the collector area "collector roof elements" were designed. These elements fulfil all conditions of a roof element, an insulator and a collector in one construction part. The collector roof elements are basically pre fabricated in a production hall and then installed on site with a crane.

Fig.11: 60% of the space heating demand of this terraced houses are covered by solar energy (Source: AEE INTEC)

Much greater systems with collector areas from several hundred m² up to 10.000 m² and storage volumes from 50 m³ to 12.000 m³ are realised (for further Information see also on Homepage: http://www.hvac.chalmers.se/cshp/). This systems are connected to new built housing areas with several hundreds apartments in very compact areas or integrated in existing district heating networks (Powered by special heating plants which are fired by biomass or fossil fuels.) of villages or little cities.
Main developing work in this field now is to find optimised heat delivering systems which guarantee a maximum of performance and a minimum of return flow temperatures at any time, also to reduce cost of the district heating network by reducing 4 pipe system to 2 pipe systems.

Fig. 12: Large-scale solar heating system, Salzburg Gneis-Moos (400 m² collector area, 100 m³ water tank, appr. 60 flats)

Existing or new district heating networks are ideal possibilities for integrating solar plants in a very efficient way. In Austria about 20 solar plants with appr. 200 m² up to 1.400 m² collector area are installed integrated in district heating networks.

Fig. 13: Solar-Biomass-Combiplant in Lienz/Austria (650 m² collector area)

Big scale solar systems and storages are built as pilot and/or demonstration projects in different ways. Several water storage are built special in Germany like Projects in Friedrichshafen (12.000 m³ and 5.000 m²) and Hamburg (4.500 m³ and 3.000 m²). Mixed stone/water storage are realised in Chemnitz/Germany and Lyckebo/Sweden. Also earth storage (25.000 m³ in Neckarsulm/Germany and about 2.000 m³ and 9.000 m² collector area in Marstal/Denmark) are realised.

Homepages with detailed Informations: www.hvac.chalmers.se/cshp/
www.aee.at