SOLAR COMBISYSTEMS FOR A SUSTAINABLE ENERGY FUTURE

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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. 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.

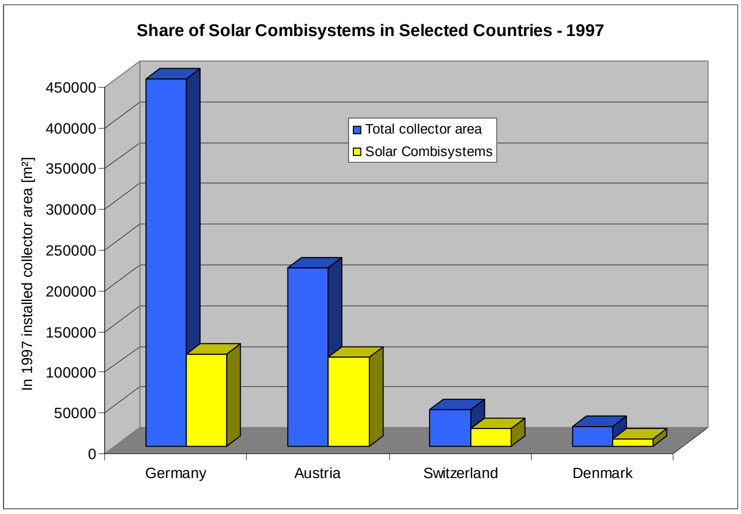

Figure 1: In 1997 installed collector areas and share of collectors for solar combisystems in selected countries.

Basically solar heating systems for combined domestic hot water preparation and space heating, so-called solar combisystems are similar to solar water heaters in what regards the collectors and the transport of the produced heat to the storage device. There is, however, one major difference: The installed collector area is generally larger for combisystems, as there are two different heat consumers to supply. Furthermore in a combisystem there are at least two energy sources to supply heat to these two heat consumers: the solar collectors, and the auxiliary energy source. The auxiliary energy sources are biomass, gas, oil or electricity.
This shows that solar combisystems are more complex as solar domestic hot water systems as there are more interactions with extra subsystems. These interactions profoundly 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.

The designs do not necessarily reflect local climate and local practice only. Several could be sold for example all over Europe, and some are in the process to be. Collaborative work in analysing and optimising combisystems is therefore a important action that can favour good systems on a more global market than the national one.

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.

Why solar space heating ?

The enrichment of gases inducing a greenhouse effect in the atmosphere and the potential global warming and climatic change associated with it, represent one of the greatest environmental dangers of our time. The reasons of 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.

Today, the world's energy supply is based in principle 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% divide approximately 2/3 into biomass and 1/3 into hydro power.

The effective protection of the climate which makes provisions for the future will, according to many experts, demand at least a 50% reduction in the world-wide anthropogenic emission of greenhouse gases in the next 50 years.
As a result of the climate conferences of the last decade and the discussion about sustainable development, the European Commission has laid down its goals with respect to future development in the field of renewable sources of energy in the White Paper [1] «Energy for the Future: Renewable Sources of Energy». In the Commission's "White Paper" the following is mentioned as a strategic goal: "... to increase the market share of renewable sources of energy to 12% by the year 2010." The yearly increase in the installed collector area named in the White Paper in the member states is estimated at 20%. Thus, solar heating systems in operation in the year 2010 would correspond to an overall installed collector area of 100 million m^2.

If the direct use of solar energy for heating purposes via solar collectors, as shown in the sustainable energy scenarios, is to make a relevant contribution to the energy supply, it is necessary that solar-heating technologies be developed and widely applied over and beyond the field of domestic-hot-water preparation only.

A realistic approach would be to assume that in the next ten years, about 20% of the collector area yearly installed in the European Union will be used for solar combisystems. This means

[1] Bulletin from the Commission Regarding Energy for the Future: Renewable Sources of Energy, White Paper for a Community Strategy and a Plan of Action

that in accordance with the "White Paper" of the European Commission, in the countries of the European Union alone per annum around 120’000 solar combisystems with 1,9 million m^2 of collectors have to be installed.

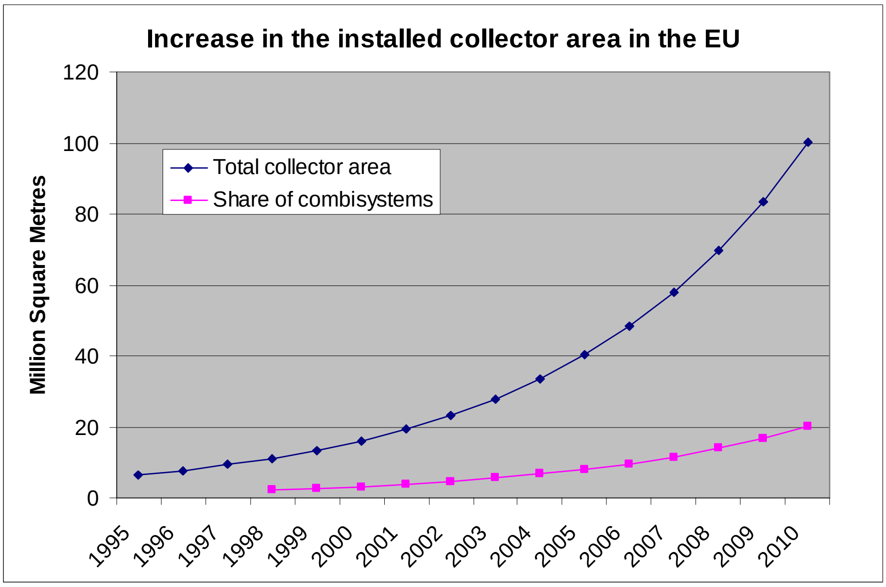

Figure 2: Objectives for the installed collector area until 2010 in the European Union’s member countries.

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.

Figure 3: Dutch solar combisystem (Source: ATAG)

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.

Figure 4: Solar combisystem for a one-family house in Sweden (Source: SERC)

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. Also this systems have shown promising results during the last years.
In Gleisdorf, Austria 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.

Figure 5: 60% of the space heating demand of this terraced houses are covered by solar energy (Source: AEE)

Boundary conditions and pre-requisites for solar space heating

Currently installed systems clearly show that solar space heating is possible even under mid- and northern European climatic conditions. However, before a solar-combisystem is installed, due attention must be paid to the boundary conditions and other requirements.

Solar energy availability

The solar energy available in summer is more than twice that available in winter. Virtually, the opposite applies to the energy demand for space heating. In comparison to hot-water supply, the heating load is dependent upon the outside temperature. Measurements of solar radiation and temperature in the transitional periods (September - October and March - May) clearly show that solar radiation availability is relatively high at the beginning and the end of the space heating season. Even on winter days, energy demand and solar radiation are partially related.

Figure **6** shows the solar radiation on a horizontal plane at Zurich, Switzerland. It can be seen that, under this latitude, there are not only strong seasonal variations in radiation throughout the year, but solar radiation also quite widely changes on a daily, or even hourly basis.

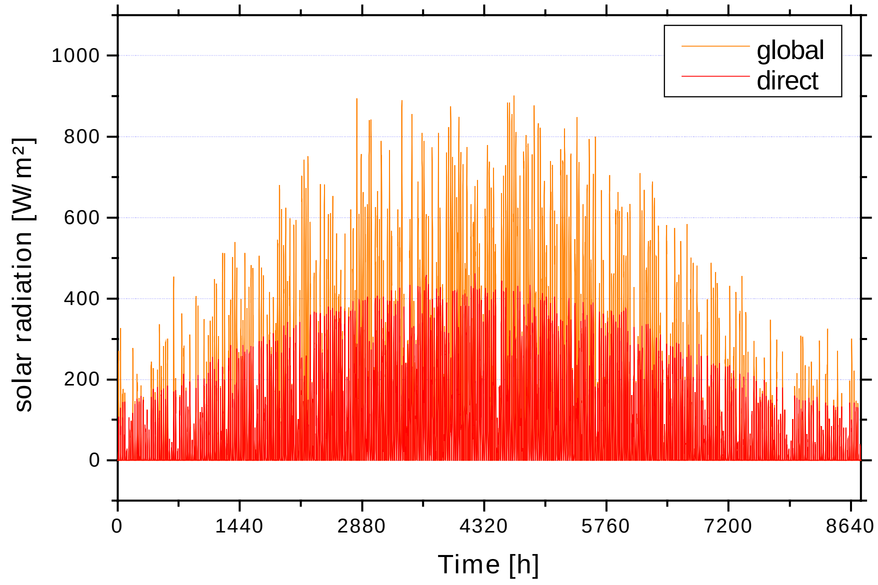

Fig.6: Solar radiation on a horizontal plane at Zurich, Switzerland

Heat storage

In order to make efficient use of the available solar energy supply, it is therefore necessary to even out these fluctuations, by means of storage systems, to be able to supply hot water continuously and to guarantee a constant room temperature. Basically, the following opportunities are available for balancing out the variations in energy supply and demand:

- Hourly, or even overnight, variations can be simply compensated by the inertia of the heat emission system (e.g., floor heating) or the storage mass of the building. This type of system is widely sold in France. In this system the collector array is directly connected to the heating floor, without any store or heat exchanger. A ramification in the hydraulic loop provides for solar domestic hot water (pre)heating, especially outside the heating season. The auxiliary heater for space heating is, e.g., a wood stove.

Figure 7: French house, equipped with a direct solar floor system (Source: Clipsol)

- If no or not enough solar radiation is available for several days, a small buffer storage volume can be used to make up the difference in solar radiation. In this case this heat storage may be combined with the domestic hot water storage or an additional storage is used for hot water. In most existing designs the auxiliary is outside the storage but a recent trend is to integrate a burner into the storage tank in order to market more compact and cheaper designs.

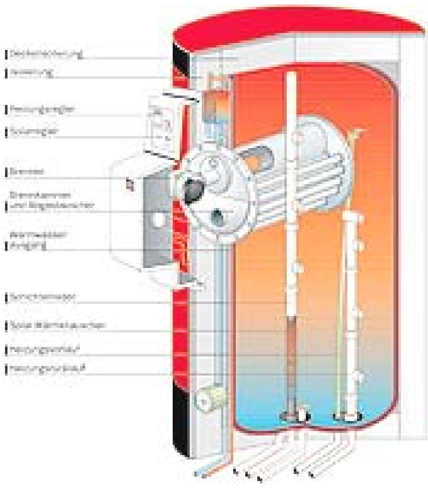

Figure 8: Storage integrated gas burner (Source: SOLVIS)

- Seasonal variations in solar energy supply can only be compensated for by the use of a seasonal storage. Several systems in recent years have shown that it is possible to store summer heat in large water reservoirs (60 - 130 m^3) for use later on in winter. In the interest of cost, solar systems with a seasonal storage will first be used in large systems in conjunction with district heating, on the basis that specific storage costs decrease drastically with increasing size. Examples from Sweden, Denmark and Germany indicate an interesting way forward.

Further Information: http://www.iea-shc.org/

A coloured brochure “Solar Combisystems in Austria, Denmark, Finland, France, Germany, Sweden, Switzerland, the Netherlands and the USA – Overview 2000” will be available in May 2000 and can be ordered at Büro n+1, Postfach 130, CH-3000 Bern 16, Fax: +41-31-3527756, e-mail: n+1@email.ch

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