Solar-Reports:

Large-scale solar systems: the sun supplies warm water and supports room heating

16.03.2009

Solar thermal systems for hot water supply and also for the support of heating are widely spread in single- or double-family homes. But many large buildings can also be supplied with solar heat. On many apartment buildings and high-residential complexes, on hotels, residences, hospitals and industrial buildings large roof surfaces are not utilised; and also façades and balcony balustrades or roofs of side buildings such as garages are available for generating heat.

While solar power systems (photovoltaics) are selling well in all sizes – right up to the Megawatt class – and also the sales of “small” solar heating systems increased by 120 percent in the past year, the market for very large solar systems still needs to be invigorated. This can be achieved in view of the fact that large solar thermal systems have certain distinct advantages: calculated on the basis of square metres of collector surface, they supply more heat and are more cost-efficient in comparison to smaller systems.
Solar Report as PDF Document

Solar thermics XXL: a whole lot more than just warm water. Photo: BSW-Solar

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After the last three Solar Reports looked into photovoltaics, the current Solar Report, in co-operation with the BINE Information Service, discusses systems with a collector surface of over 100 square metres and buildings of different types: cost-efficient systems only for generating hot water and so-called combination systems with which significantly more fossil fuels can be saved.

Good arguments in favour of solar heating

Large buildings often have extensive roof surfaces that can be used for the economically feasible implementation of solar thermics. When taking into consideration the benefits of scale, the heating costs of these systems are often less than in small standard systems. And losses can also be reduced, because heat can be better stored in large storage units. The utilisable solar heat gains can be maximised if the system is optimally adapted to the actual profile of heating demand. When they are well designed, carefully installed and regularly serviced, solar systems today run without hassles. Maintenance costs for large systems of annually approx. 1 to 1.5% of the investment costs are very similar to those of conventional boiler systems.

Thermal solar systems have a life expectancy of about 20 to 25 years and thus outlive conventional boiler systems that are generally allocated a life expectancy of about 15 years. Operating costs of solar thermal systems are low. In large-scale systems, about one kWh of electrical energy is required to generate about 40 to 50 kWh of heat. Of course, this largely depends on the complexity of the system.

Photo: Vacuum tube collectors enhancing the façade. Source: BSW-Solar; Viessmann.

During the course of the last years system technology was improved and at the same time economic competitiveness of solar systems in comparison to conventional boiler systems increased. Significant reductions in the emission of harmful substances as well as an improved image for the operator are further advantages of the use of solar systems.

Large solar-thermal systems for hot water

Generally, hot water is required in buildings throughout the year. When solar systems are designed for summer loads, the high radiation during the summer months can be fully utilised. The systems are cost-efficient and can attain high degrees of utilisation at especially high outputs. The contribution of drinking water systems only, however, is limited to a relatively small portion of the overall heating demand. If drinking water circulation is also included in the system, this portion can be increased. In large solar systems, the system structure should be kept as simple as possible in order to achieve high operative reliability and to minimise maintenance requirements. Because of the required storage masses and stipulations regarding water hygiene, large systems generally work with buffer storage units. Heat transfer, be it between the collector circuit and the storage unit or between the storage unit and drinking water, is generally achieved with external plate heat exchangers. In transferring heat from the buffer storage unit two different system types have developed – the flow concept and the storage-loading concept.

Left: Buffer storage unit of the solar system in the student village of Freiburg Vauban. Right: External heat exchanger. Photos: Hochschule Offenburg.

Both systems have proven their merits with the following advantages and disadvantages:

- Systems with the flow concept are somewhat simpler in their structure and are thus more cost-efficient. However, they require large, carefully proportioned heat transfer units as well as a steering component that fast reaction times. In the meantime fresh-water stations are offered in various sizes as complete solutions. In the event of largely differing tapping profiles and in very large buildings, this system reaches its limits. Solar coverage of circulation losses is difficult, because heat is only transferred when hot water is tapped.
- The pre-heating systems with the buffer storage concept are slightly more complex and thus more expensive. They require an additional pump and a further (or larger) storage unit, as well as a so-called legionella guidance. The drinking water heat exchanger can be smaller, but its size should nevertheless be carefully calculated. This option is particularly suitable for larger systems.

Cost and benefit

The energetic benefit of solar systems is measured by way of the output per year in Kilowatt-hours and usually has as its reference the square metres of collector surface. This specific collector output essentially depends on solar radiation at the specific location, the pitch and orientation, as well as a possible shading of the collectors and their average temperature level. Furthermore, the quality of components, the length of pipelines and storage losses play a role, albeit a minor role.

Within the framework of the programme Solarthermie-2000 system costs for installed systems ranged between 400 and 900 €/m2 of collector surface, on average they amounted to 673 €/m2 (incl. planning and VAT). The market incentive programme (2001 – 2005) also provides data for a number of systems of differing sizes, that prove a significant cost reduction when the size of systems is stepped up.

View of one of the two parts of the collector field of the solar system of the Albtherme Waldbronn. Photo: Hochschule Offenburg

For annual maintenance and repair costs an average of 1 to 1.5% of the investment costs should be allocated. Operating costs merely include electricity for pumps and steering. The pumps only run with solar radiation, a maximum of 2000 h per year. One of the most important facts is the solar coverage portion. With an increase in collector surface this portion in the heat demand of a building will increase and the absolute amount of utilisable solar heat will increase. Since a high degree of coverage is linked with higher collector temperatures and possibly even summer surplusses, the degree of utilisation of a system is contrary and the specific output decreases with an increase of coverage. While the specific costs per square metre of collector surface decrease as the surface area increases, the heating costs increase due to decreasing outputs per m2.

Combination systems – the next step

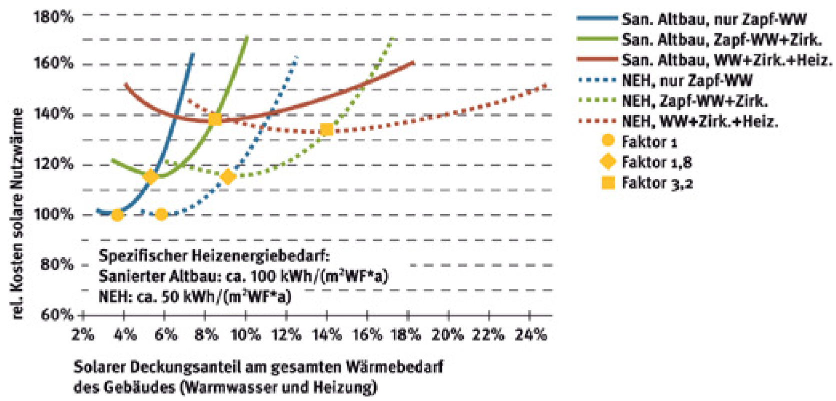
Merely one fifth of the heat required in an average residential building can be allocated to the preparation of hot water and its circulation. 80 percent are used for the heating of rooms. Solar systems that support heating besides heating the water, thus open up a large potential of saving. However, heating costs will also increase.

Large-scale collector of the "zero-emissions factory" Solvis GmbH in Braunschweig. Photo: Solvis; C. Richter

Because sunshine is scarce in winter when the heating requirement is high, solar systems that support heating require large-scale collector surfaces. This leads to a surplus of solar energy during the summer months that will be wasted, unless large-scale seasonal heat storage units are available. This is referred to as stagnation. Various strategies have been developed to reduce instances where too much heat is supplied and to reduce the stress on the collectors and the system.

- A fairly easy option is the installation of collectors at a very steep pitch or the vertical installation on a façade. Outputs when the sun rises to only slightly above the horizon are increased and surpluses when the sun rises higher are decreased. This also has a significant influence on the architecture of buildings.
- In the so-called "Aquasystem" water without antifreeze is utilised in the collector circuit. De-steaming of the collector can be more easily controlled with pure water and the antifreeze cannot be damaged. Protection against freezing in winter is given by energy being fed back into the collector during the night in order to keep it from freezing. This method can only be used with vacuum pipes.
- With the "Drain-Back" method the collector field empties itself as soon as the pump is switched off and is filled again when the pump is switched on. Water can be used in the collector circuit and can neither boil nor freeze in the collector while the pump is switched off.
- The solar storage unit is sized so that it can store summer surpluses and can make them available in winter (seasonal storage unit).
- Summer heat surpluses are used for solar air-conditioning (e.g. in hotels, office buildings, hospitals, institutions etc.).
- Surplus energy from the solar buffer storage unit is decreased by the pump being switched on during the night so that heat can be released through the collector.
- An additional heat consumption point (e.g. a swimming pool) utilises surplus energy.

Due to the higher return-flow temperatures in the heating system, the solar system will be working less efficiently when supporting the heating than when heating cold drinking water; and in winter the collectors work at a lower degree of efficiency because of the low outside temperatures. For these reasons the degree of efficiency of combination systems is less per annum than in pure drinking water heating. This is also reflected in higher specific heating costs. The performance of such a solar system can be increased by keeping the return-flow temperatures of the heating system as low as possible, e.g. by increasing the heating surfaces or by using under-floor heating.



[Wording of graph above: Relative. costs of utilisable solar energy; specific heating energy demand; renovated old building: approx. 100 kWh/(m2 res. surface *a); new building: approx. 50 kWh/(m2 res. surface*a); Degree of meeting the overall heating demand of the building (hot water and heating); ren. old building, only hot tap water; ren. old building, hot tap water+circ.; ren.old building, hot water+circ.+heating; new building, only hot tap water; new building, hot tap water +circ.; new building, hot water+circ.+heating; Factor 1; Factor 1.8; Factor 3.2] Optimisation of utilisable solar output and costs can be achieved by selecting a system and storage unit concept that is ideally suited for the respective application, as well as by calculating the exact size and version of the system. As in systems for the heating of water, various switching options exist to support heating. An essential distinguishing criteria is in-series connection to the heating system, where the solar storage unit, the boiler and the heating system are switched in series, or where the boiler and the upper part of the (solar) buffer storage unit from which the heating system is fed are connected in parallel.

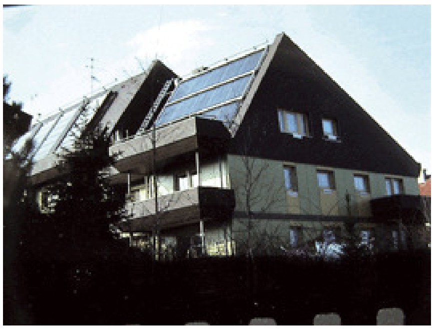
Solar heating system in the Rehabilitation Clinic Bad Frankenhausen. Source: Xtoday-Media Verlag; TU Ilmenau

Besides the optimisation of the solar systems themselves, the influence of the solar system on the operating characteristics of the boiler must be taken into consideration. In systems that are used to support solar room heating, it is important that the solar system as well as the conventional boiler and the heating system are synchronised.

For the large market of single residential houses, complete solutions are available that contain the solar system, the storage unit, the boiler, the heating of water and regulation and are, in some instances, integrated into one single apparatus. In pre-manufactured systems the components are ideally adapted to each other and the most important regulating parameters have been set. Thus possible errors during installation can be reduced to a minimum. But also for multi-party residential houses pre-manufactured modules, compact stations or solar energy centres for the support of heating are on offer.

Outlook

The solar heating of drinking water in large-scale systems is today general state of technology. In view of ever-rising energy costs, carefully planned systems can even compete economically with conventional systems. Even higher fuel savings than with hot-water preparation can be achieved with the combined generation of hot water and heating. Demonstration systems have proven that optimised combination systems in residential buildings, hospitals, residences, hotels, guest houses, sport and recreational facilities can make a significant contribution to the heating supply.

Left: Carefully planned collector systems enhancing architectural features. Right: Solar house in Freiburg: for 30 years hot water and room heating from the sun. Sources: ESG-Plan (left); ISFH, K. Vanoli (right).

The Federal Ministry of the Environment with its incentive programme Solarthermie2000plus places a research emphasis on large-scale combination systems as well as on heating systems supported by solar energy, on solar air-conditioning and on solar process heat systems. In all fields of applications the costs for the end-energy saved will further decrease if more cost-effective, more efficient system components with increased life expectancies are brought onto the market. Degression of system costs and higher prices for fossil fuels have become favourable framework conditions for large-scale solar systems.

In addition, subsidisation conditions have improved significantly: the market incentive programme of the German Federal Government was expanded, the application procedure was simplified and the subsidisation conditions for large-scale systems were improved. Attractive conditions are also offered by the programmes of the Credit Institute for Re-construction (Kreditanstalt für Wiederaufbau (KfW)). Last, but not least, the German act on renewable energies that came into force at the beginning of 2009 gives new impulses. It imposes an obligation to utilise renewable energies in all new constructions of residential and non-residential buildings from the beginning of 2009.

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The full Themeninfo I/2008 with ample background information and additional facts is available on the internet under www.bine.info

Solarserver wishes to thank BINE Information Services for the right to publish the abridged text.

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