Lots of sun and a little heat pump

The latest project of the Swiss solar pioneer Josef Jenni: an apartment building that is 100 % heated by the sun. The heat captured by 276 m² of solar collectors is stored in a 203 m³ tank. Photo: Jenni Energietechnik

The new solar house concepts are no longer just about solar collectors.

Since the oil price broke the 100 US$/barrel barrier for the first time, solar heating support systems have enjoyed increasing demand. More and more companies are developing building and heating concepts for houses that are mainly heated by solar energy. The Swiss solar pioneer Josef Jenni, who built a single-family house heated entirely by the sun as early as 1989 (Sun & Wind Energy 3/2007, page 18), and coined the term "solar house" for it, is still focussing on large-scale solar heating systems. In the more recent concepts, the solar collectors are sometimes only an embellishment.

100 % solar house in Sweden

One of the most exceptional concepts can be found in Sweden. In this country, with its low level of solar irradiation, solar thermal energy has not played a major role so far. Among the renewable energies, biomass and hydropower rank in the top positions. It was thus all the more astonishing when Göran Bolin in Täby, a place 10 km from Stockholm, took it into his head to heat his house using only the sun. This was not entirely without any self-interest: Bolin is the Executive Vice President and Chief Technical Officer of Climatewell AB in Hägersten. The company produces the solar cooling and heating machine Climatewell. "Our main market is Spain", says Bolin, "but I wanted to use the heat pump in Sweden as well." In his solar house concept, the cooling machine plays a crucial role.

Bolin and his family live in a house that was built in 1907. It is insulated on the outside and has 160 m² of living space. In addition to this, he built a new house with a living space of 80 m². On top of this guest house, 42 vacuum tube collectors (50 m² of gross collector area) from the manufacturer Philippine with direct flow tubes from Narva are installed. They are coated with Tinox absorbers on both sides. The reflective tin roof and the coating on both sides increase the peak capacity of the collectors by up to 20 %.

The special feature of Bolin's concept is that the solar collectors do not feed their energy directly into the heating system, neither in summer nor in winter. Instead, they supply it to the solar cooling engine, which acts as a heat pump here.

With a return flow temperature of 90 °C and a supply flow temperature of 120 °C, the collector array supplies about 34 to 40 kW to the Climatewell machine. In contrast to common practice, the heat pump

is not driven electrically, but thermally by hot water. All the year round, it extracts heat from a 300 metre borehole. During the summer, this energy is fed into a 200,000 litre storage tank. This is located underneath the new building and the associated terrace and consists of four tanks with a volume of 50,000 litres each. In this way, the energy can be stored at various temperature levels.

In winter, Bolin takes the heat from the part of the tank that is sufficiently hot and uses it to drive the cooling of the drill hole. With the waste heat from this drill hole cooling process – in the case of a solar cooling system, this would be the energy that would have to be removed by means of a cooling tower in the summer – the two houses are heated.

By using the Climatewell machine as a heat pump, the winter capacity is increased by a factor of 1.5 to 1.7, which results in a capacity of about 52 to 68 kW. This thermal energy is stored at a high temperature level of, for example, 90 °C.

During the summer, the heat pump increases the capacity 2.2-fold. This is possible because the heat pump process is passed through a second time, and thus the thermal energy is utilized a second time. In the course of this process, the temperature drops to about 60 °C. Therefore, any further passes at ever lower temperatures would not make sense.

The system has been in operation since May 2008. However, a few teething troubles had to be overcome. "Right from the beginning, I knew that the energy would not be sufficient", reports Bolin. Additionally, the system was not fully installed at the time of initial operation. Until December, he had enough thermal energy. From then onwards, the temperature was too low. This could be attributed, among other things, to the gravity heating circuit that is installed in his old building. "For this, high temperatures are required", explains Bolin. As a consequence, he had a floor heating system installed, for which the low temperature is sufficient. A second handicap was the insulation of the storage tanks. The buffer storage tanks are insulated by a one-metre layer of isofloc. "The insulation was not really completed", reports Bolin. Hence, rain water found its way in. In the meantime, however, the system is operating "very well", its operator claims.

The cooling engines from Climatewell are still quite new on the market. In 2005, the company started production in Spain. But sales activities have really been going on only since the beginning of this year. About 200 to 300 engines are already in operation, reports Bolin.

In Spain, Per Olofsson is in charge of the business. Also in that country, there are already several buildings that receive more than 50 % of their heating energy from the sun by means of the Climatewell machine. One example is a single-family house in Madrid. It has a heated floor area of 200 m². In this case, two pools with a surface area of 12 m² each serve as the heat sink for the absorption cooling machine. The solar energy comes from 34.2 m² of flat plate collectors, which are installed at an angle of 20°. The house has a radiating floor to supply both heating and cooling to the house. The solar fraction is 52.3 % for heating and 100 % for cooling.

Projects of the VKR Group

The heat pump also plays a major role in the building concept of VKR Holding A/S in the Danish town of Hoersholm. VKR is an industrial investor with the intention of "bringing daylight, fresh air and a better environment into people's everyday lives" with its companies. The group, with 15,000 members of staff in over 40 countries, is widely dispersed. Its lines of business are roof and façade windows, sunscreening, ventilation and solar thermal energy.

Distributed over several European countries, VKR wants to build eight houses that anticipate the construction standard of the year 2020. The most advanced projects are those in Denmark, Austria and Germany. "VKR wants to be involved in the creation of new building standards, and wants to be on the spot with its products", outlines Markus Staudigl, the Head of Engineering of the VKR subsidiary Sonnenkraft, referring to the aims of the holding company. The house design is not the same in all the countries. It is necessary to consider country-specific regulations, and the buildings should match the local architectural style.

This solar house in South Tyrol has been inhabited since this spring. On the single-pitch roof, 34.2 m² of solar collectors are installed. The inhabitants use firewood for auxiliary heating. The heat is stored in a 6,220 litre reservoir. The solar fraction is about 70 %.

Photo: Günther Gemassmer

In Regensburg, Germany, VKR is currently building a "house of the future", and the project is being managed by Sonnenkraft. The goal is to design a building that meets the zero-emission and zero-energy standards which are expected to be introduced, but that can be built already now from standard components and at affordable prices. As far as the components are concerned, it is planned, of course, to use the products from the VKR companies as far as possible. Additionally, the house is designed as an "alternative to the passive house". "Passive houses are too unattractive to live in because of the limited window areas and openings", says project manager Staudigl.

Instead of focusing primarily on insulation, it is planned that the house generates as much solar energy as possible. In order to allow the solar installations to harvest a maximum of solar energy even if they are not optimally oriented to the south, the architect Stephan Fabi of Fabi Architekten in Regensburg has planned the building in the shape of a crystal, with lots of corners. The orientation and inclination of the roof follow the course of the sun in the sky.

On the ground floor, the south-facing side of the house is completely glazed; the sides facing south-west and east are partly glazed in order to let solar energy enter the house. The wall areas above that slope at an angle of 75°. They provide space for 32 m² of solar collectors. Further up, the roof changes pitch sharply and tapers to a point with flattened angles of 20° and 30°, and is designed to carry 44 m² of photovoltaic modules.

Since March, the construction work has been proceeding at full speed. The single-family house has a living space of 175 m². The cellar is a rectangular masonry construction. "The interior of the house will also be built in masonry; outside, we will use a timber framework structure", reports Markus Staudigl. The

U-value of the outer walls will be 0.14 W/m²K, that of the roof 0.11 W/m²K. Staudigl estimates the building's heating load at 4.7 kW. Apart from the solar installations, the technical facilities include controlled living space ventilation, an under-floor heating system and a heat pump. The latter product was launched by Sonnenkraft only in March. The device with the name "Sonnenheizung" has a capacity of 6 kW and combines a solar thermal system with an air heat pump. A 1,000 litre storage tank and a fresh water station are connected to this.

The Fraunhofer Institute for Solar Energy Systems (ISE) has determined that the primary energy demand of the "house of the future" will range from 30 to 35 kWh/m² a. This is the requirement for heating, hot water and the energy needed to operate these systems, and does not include other household electricity.

Solar active house in Austria

Another project of the VKR Group is currently under construction in Carinthia, in the south of Austria. Here, it is known as a solar active house and is designed as a prefabricated house in three variants. The architect is Georg Reinberg from Vienna. Also in this case, the aim is to develop the idea of the passive house further. It is planned to halve the total energy consumption in comparison with the passive house, which has a primary energy demand of 120 kWh/m²a at most. Reinberg focuses primarily on the utilization of solar collectors as well as passive harvesting of solar energy by means of large windows and doors on the south side. The compact single-family house with 150 m² of living space has no cellar, and prefabricated technical facilities will be installed.

In the basic concept, for which the show house is currently being built, 16 m² of solar thermal collectors are combined with a 1,000 litre storage tank. The heat pump from Sonnenkraft meets the remaining energy demand. For research purposes, the ventilation is effected either by means of a ventilation unit with a heat recovery system or via automatically controlled windows. Wall heating systems distribute the heat within the house. Furthermore, earth-tube collectors (ground-to-water heat exchangers) are built in, and a PV system of about 30 m² is installed.

According to the architect, Reinberg, the solar fraction is 71.7 % of the total heat demand. The simulated heating energy requirement is 9.84 kWh per square metre of net useable floor space. The outer walls are double-leaf timber framework structures filled with cellulose for thermal insulation. On the outside, the walls are fitted with larch shuttering with a U-value of 0.136 W/m²K; on the inside, they are plastered with clay. The roof is also insulated with cellulose (U-value 0.091 W/m²K).

The most advanced among the VKR Group projects is the "Home for Life" in Denmark. This house was officially opened at the end of April. The occupiers will move into it at the end of July. This house also derives its energy primarily from the solar heat pump from Sonnenkraft. Beyond this, 50 m² of photovoltaic modules are installed. With 6.7 m², the solar thermal system is rather small. It heats only the drinking and showering water. On the basis of the figures, the target of realizing a zero-energy house has been met. "We have an energy overproduction during eight months of the year", says Rikke Lildholdt, project manager at Velfac A/S in Horsens.

Solar house in Italy

A concept that is primarily based on a heat pump is unthinkable for the advocates of the Jenni-concept of the solar house. The architects, planners, construction companies and installation firms that have joined forces in Germany in the Sonnenhaus-Institut e.V. (Solar house association) remain faithful to the ideas of Josef Jenni. Their construction and heating concept is based on three pillars: As effective a thermal insulation as possible, the utilization of passive energy gains by means of large windows and doorways, and above all a large solar heating system with big solar collectors and a solar storage tank of the corresponding dimensions.

The South Tyrolean building contractor Günther Gemassmer, who cooperates with the German

About half of the heating energy required by this house in Madrid is covered from solar energy. The solar collectors are installed separately on a rack next to the house. In the cellar there is a solar cooling machine, which is used as an absorption heat pump. The two pools serve as heat sinks. Photo: Climatewell

network, is currently building his first solar house in Goldrain in South Tyrol, in the north of Italy. The single-family house has a net living space of 150 m² and a heated area of 170 m². The building is a masonry construction, for which special insulating bricks are used. The building envelope surrounding the cellar and the insulation of the foundations are 10 cm thick. They are made of a thermal insulation composite system with EPS.

The annual heating energy requirement amounts to approximately 7,000 kWh. The solar heating system covers about 70 % of this. On the south-facing single-pitch roof of the house, 34.2 m² of solar collectors are mounted at an inclination of 70°. The heat is stored in a solar storage tank from the company Jenni with a volume of 6,220 litres and an integrated hot water boiler with a volume of 230 litres. The residents, Beate Pöder and Helmut Zöschg, use a wood gasification boiler with a rated capacity of 10 kW for auxiliary heating. The heat is distributed via an under-floor heating system. On average, 2.5 to 3.5 m³ of fire wood are needed annually as fuel. The occupiers can air the house at will, no ventilation system is installed.

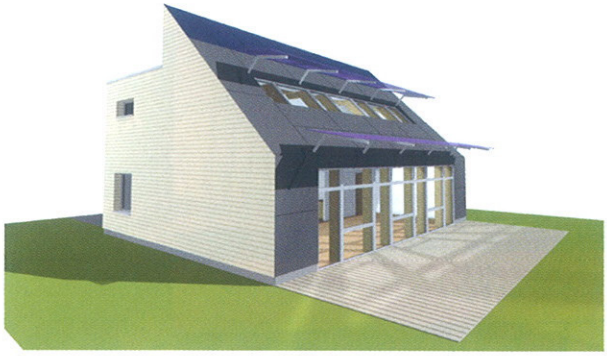
Günther Gemassmer is already planning the next solar houses. After the pilot project, he wants to begin the construction of the second solar house in the vicinity of Sterzing this spring. "Four are still in the planning phase", reports the head of a staff of twelve. He considers houses that are largely heated by the sun to be a promising field of business. "I think that the solar houses will be our main business", he says confidently. For this purpose, he is prepared to accept conditions that are more challenging than those in Bavaria, where his solar house network has its home.

Due to the multitude of narrow valleys, building land is scarce in South Tyrol. It is also difficult to obtain building permission. Gemassmer reports about lengthy administrative procedures. "If one owns the site already, it takes a further two years on average to get permission to build." That is the reason he wants to become increasingly involved in solar renovation projects. The first project is already in sight. In this field, quite considerable subsidies are available. For a solar house heating system that is worth € 40,000, the building owners receive a government grant of 55 %. This is laid down in the Italian framework law on the support of energy efficient buildings in the renovation sector.

Swiss apartment building heated 100 % by the sun

In South Tyrol, so-called "climate houses" are standard. In this construction type, a high level of insulation, a compact building style and the utilization of solar energy by means of insulated windows are the focus. Big solar heating systems are uncommon in Italy. Therefore, a house that is heated largely by the sun still attracts attention.

In Switzerland, things are different. In Josef Jenni's home country, where he continually promotes the idea of solar heating, he has to come up with something more special. And that is exactly what he has done with the first apartment building that is heated exclusively by solar energy. It was completed in September 2007. The building, which has eight rented flats, is located in the vicinity of the company building of Jenni Energietechnik AG at Oberburg in the heart of Switzerland. On 19th November 2005, Jenni caused a media spectacle when he had the 205,000 litre storage tank pulled from the workshop to the construction site "solely by muscle power".



This solar active house is currently under construction in Carinthia, Austria. 16 m² of solar collectors in a combination with a heat pump of 6 kW capacity achieve a solar fraction of 71.7 %. In addition, 44 m² of photovoltaic modules will be installed.

Graphic: Architekturbüro Reinberg

"The greatest challenge this building posed was the ventilation", reports Patrick Widmer, a member of the marketing division at Jenni Energietechnik. The heat recovery system had to comply with the strict Swiss fire protection regulations, which turned out to be difficult. "We had to install more fire protection devices than planned", says Widmer. Furthermore, they had to wait a long time for the ventilation system. This delayed construction.

In the autumn of 2007, the construction work was completed and the first tenants moved in. There are eight apartments in the building and it is certified according to the Swiss Minergie-P standard. The interior volume is 5,170 m³. The south-facing roof is completely covered by 276 m² of solar collectors. The floor space amounts to 1,344 m², of which 1,282 m² are heated.

The rental charges are comparable to those of other new buildings. "But in our building, the additional costs are lower", emphasizes Patrick Widmer. A three-person household can expect savings of about € 1,000 per year. Jenni Energietechnik has not evaluated the energy consumption since the tenants moved in. However, Widmer assumes that by means of the solar system, between 5,000 and 6,000 litres of fuel oil for hot water preparation and room heating are saved annually.

There is no auxiliary heating system in the solar house. So far, however, enough heat has been available at all times, the company spokesman points out. In May, the temperature in the storage tank is still about 80 °C; in the summer, it is cooled down. In the internet, any interested party can have a look at the storage tank temperatures since November 2007. Between the seasons, Jenni, who purchased one apartment in the building for the company, supplies heat to the family in the neighbouring house. "We blocked their mountain view", explains Widmer, "in return, they get solar heat."

Ina Röpcke

Further information:
Architekturbüro Reinberg: www.reinberg.net
Climatewell AB: www.climatewell.com
Gemassmer Günther & Co. KG: www.xsund-bauen.it
Intersolar: www.intersolar.de
Jenni Energietechnik AG: www.jenni.ch
Solar-Aktivhaus: www.solar-aktivhaus.com
Sonnenhaus-Institut: www.sonnenhaus-institut.de
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