100 % SOLAR HEATED MONOLITHIC CLAY BLOCK HOUSE


Georg Dasch **Katharina Liepach**

Summary

In summer 2006 the first 100 % solar heated one family house was completed in Regensburg, Germany. It is a monolithic house built with clay blocks (filled with perlite, λ = 0.08 W/(mK)) without extra insulation. The energy for hot water and space heating is completely provided by a 38,500 l hot water tank. The south facing roof is covered by 82 m² solar thermal panels. The terrace roof is covered by 35 m² photovoltaic panels. The house consumes less energy than it produces.

Keywords: Solar coverage, sunhouse, combined solar hot water tank, Poroton T 8, clay block, primary energy use, sustainability, living comfort, monolithic, passive house

1 Introduction

Since the past years energy consumption is rising dramatically world wide. This leads to a rising fossil energy consumption and consequently to rising CO_2-emissions. This development contradicts the objectives of the UN Convention on Climate Change. Also, the energy supply for the world economy is not secured in the long term. The world wide maximum in oil extraction is reached today and will be followed by a world wide maximum in natural gas extraction in 15 years, see **Fig. 1** and **2**. Consequently there will be a rise in coal and oil sand extraction to secure energy supply. Carbon capture and storage (often referred to as CCS) can't solve the problem. One the one hand, there are no reliable technologies and deposits, on the other hand in the long term there are not enough coal deposits.

Around 2010 there is supposed to be a maximum in fossil and nuclear energy production, see figure 2. A lack in fossil and nuclear energy will have adverse effects on the world's economy. A new strategy is needed to protect the climate and secure energy supply at the same time. Energy efficiency and renewable energies are commonly considered as key elements of the solution. Only then welfare can be secured in the long term. The sunhouse is a milestone on the way to an efficient, renewable and low carbon energy supply.

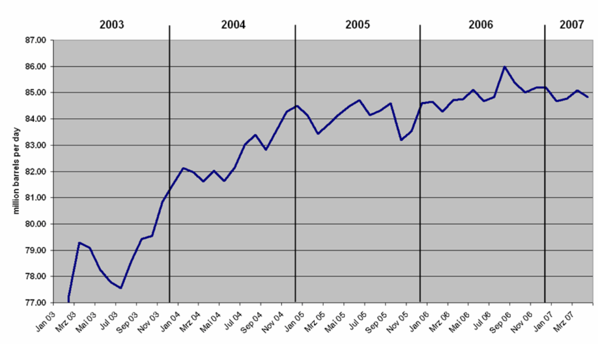

Fig. 1 Oil extraction in million barrel per day
source : IEA (International Energy Agency)

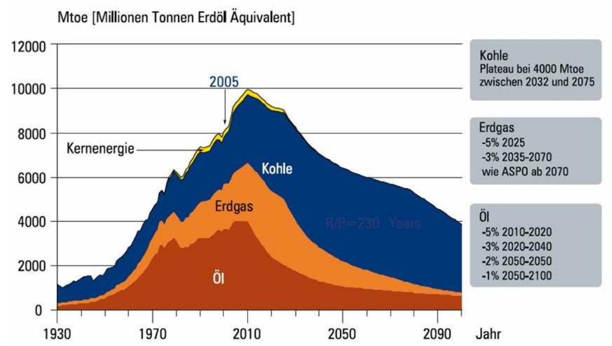

Fig. 2 Range scenario (oil: red, natural gas orange, coal: blue, nuclear energy yellow)
source: Ludwig Bölkow Systemtechnik

2 Monolithic Clay Block Sunhouse

The sunhouse is a well insulated house with an optimised active and passive solar energy use. The sunhouse „Lehner“ which is described here gets 100 % of the energy needed for space heating and hot water form the sun (solar thermal energy). The electricity is also provided to 100 % by photovoltaic. Therefore, the building does not consume any fossil energy for its operation and occupancy.

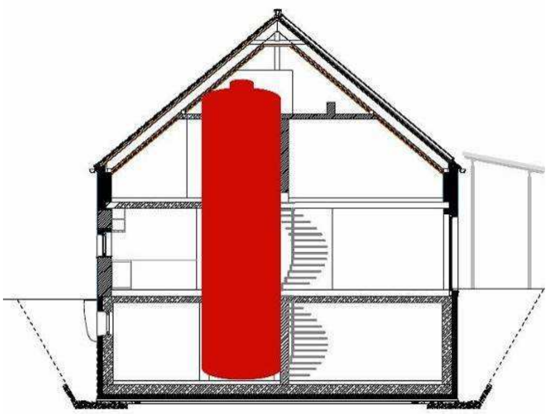

Fig. 3 Cross section of the sunhouse
source: Sonnenhaus-Institut

Fig. 4 Front view of the sunhouse
source: Sonnenhaus-Institut

Solar energy is collected via large solar thermal panels on the roof and in the facade and then stored in a large hot water tank, see **Fig. 3** and **4**. The heat loss of the tank is used as internal thermal load, so that efficient and loss free heat storage is secured.

The heat is distributed via a hydraulic low temperature heating system and is tailored to suit the room's needs.

The ventilation is disconnected form the heating system, therefore allowing an economical and comfortable control of the heat supply.

3 Technical details of the sunhouse

The sunhouse „Lehner“ is built with monolithic, highly insulating clay block masonry, see **Fig. 6**. The used clay block “Poroton T 8” has a λ = 0 .08 W/(mK). A stable structure of fired clay and is complemented with a perlite infilling to increase insulation, **Fig. 5**. Both, clay and perlite are minerals. Clay blocks have a very long lifetime and are water resistant, leading to durable, stable masonry with good insulation. The outer wall has an U-value of 0.18 W/m²K without extra insulation.

Fig. 5 Masonry with clay block „Poroton T 8“

Fig. 6 Outer wall with clay blocks „Poroton T 8“

The roof is insulated with hemp and has an U-value of 0.18 W/m²K. The triple glassed timber-aluminium-windows have an U_W-value of 0.90 W/m²K. Spiral stairs go around the large hot water tank and lead to the first floor.

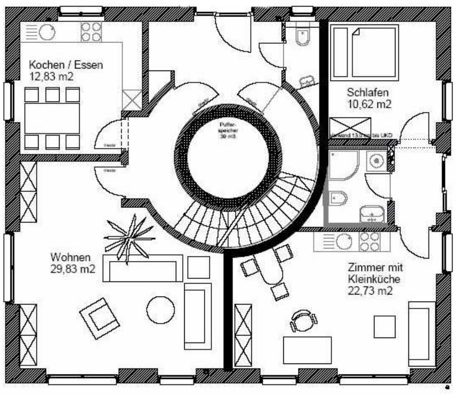

Fig. 7 Layout ground floor

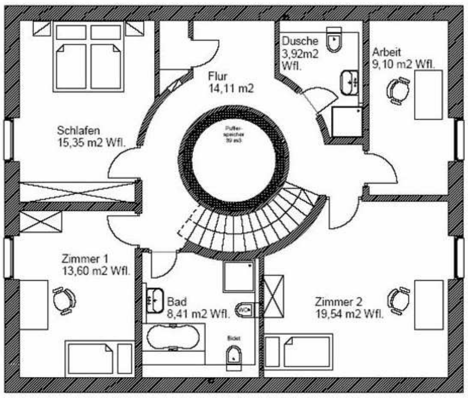

Fig. 8 Layout first floor

3.1 Solar technology in the sunhouse

Fig. 9 Swiss solar hot water tank
source: Sonnenhaus-Institut

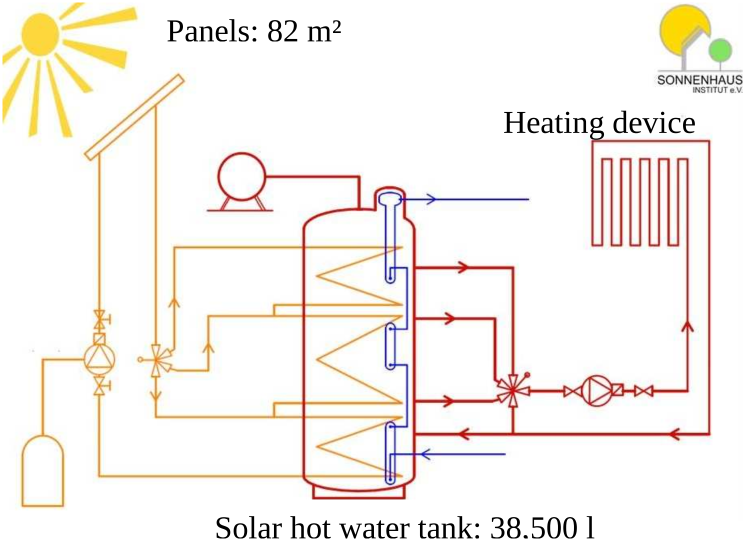

Fig. 10 Scheme solar technology
source: Sonnenhaus-Institut

The solar device has three components: solar thermal panels, the solar hot water tank and the heating devices. The solar hot water tank in the center (see **Fig. 9** and **10**) stores thermal energy and manages the energy flows in the house. The steel tank has a volume of 38,500 l. The heat collected by the solar panels is then transferred to the buffer water in the tank via a plain ended pipe heat exchanger. This buffer water is distributed via the heat circle and the heat is delivered as needed to the floors and walls. The incoming temperature of the heating system is approx. 25 °C. The hot water for consumption is produced with a stainless steel boiler which is heated by the buffer water. In October the buffer water in the tank is heated up to 100 °C. The minimal temperature in the top of the tank is approx. 40 °C. In the heating zone the tank can cool down to 22 °C. The solar heating system is powered by two circulation pumps. Two five-stage mixer form Esbe take care of the right loading and unloading of the hot water tank. There is a three-stage loading and unloading which leads to a good temperature layering in the tank. The volume of the tanks heavily depends on the climate, especially the sun shine duration of the particular house. The sunhouse "Lehner" was built in a foggy river valley of the river Donau. The solar panels were layouted especially for the south facing roof. They consist of copper plates with Tinox coating. Water carrying pipes are welded to the plates. In these pipes heat is transported to the tank. There is an easy temperature difference control.

3.2 The first winter in 100 % sunhouse

The first winter in sunhouse „Lehner“ was very interesting, since there was no experience for 100 % sunhouses in monolithic clay block masonry. Masonry leads to higher energy consumption in the first winter because of the drying process. **Fig. 11** shows the temperatures in the solar hot water tank and one can see the energy flows in the house. In mid October 2006 the water in the tank had 100 °C. The temperature could be held at nearly 100 °C, because a large radiator in the cellar was used to cool the hot water if needed. Because of this, also the masonry was used to store solar energy.

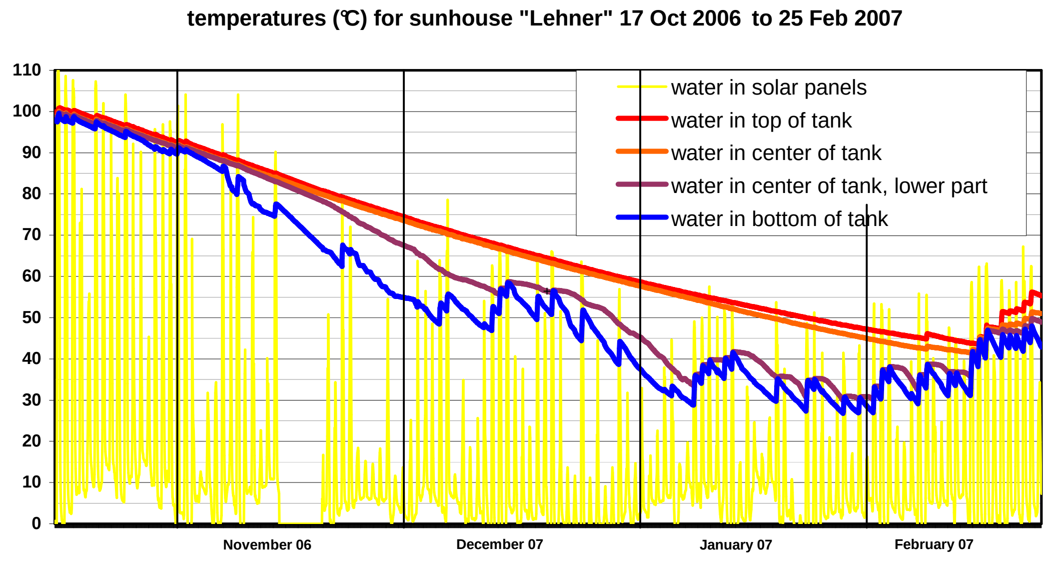

Fig. 11 Temperatures in the hot water tank

In November 2006 family Lehner moved in, when the temperature in the tank was still 90 °C thanks to the autumn sun. Despite good insulation of the hot water tank, its heat losses were sufficient to heat the rooms in the first weeks. In November there was very littlie sun in Regensburg and consequently the temperature in the tank sank slowly but surly. The heating circle in the lower storage area began to cool more and more. But as a consequence the sun could catch up for three heating days at only one sunny day.

Fig. 12 Sunhouse „Lehner“

Looking at the blue line in **Fig. 11** one can see that in December 2006 there were some sunny days, which made the temperature in the lower part of the tank rising for 5 to 7 °C. Around Christmas the hot water in the tank had only 64 °C, in the lower part still 52 °C. Family Lehner had a warm Christmas, because the “sun wall” space heating only needs 25 to 26 °C incoming temperature for comfortable temperatures in the room. Also the critical time between Mid-December 2006 and Mid-January 2007 was managed perfectly, although the ventilation with heat recovery was not yet working. The heat losses of the tank sank with falling temperatures, see flattening red line in Fig. 11. In the lower part of the tank the falling temperatures could be nearly compensated with sunny periods. The middle part of the tank did not need to be used, so there was great energy reserves left. Since Mid-February 2007 the temperatures in the tank began to rise steadily. Before, on February the 17th the minimum temperature with 44 °C in the top of the tank was reached. Since then, the solar device could heat up the tank from top to bottom.

The installation will be further optimised based on these experiences. In the next – possibly colder – winter, the masonry will be totally dry and the ventilation with heat recovery will be working, so that family Lehner can be totally relaxed. Then the only problem could be a several month long solar eclipse.

4 Conclusions

The 100 % sunhouse demonstrates that the sunhouse concept is an economic and ecologic concept at the same time. One-sided optimisations of only the building envelope, without taking into account the lifetime and the energy consumption of the building – i.e. the whole life cycle of a building from cradle to grave – don't lead to sustainable buildings. Additional synthetic insulation of the monolithic clay block masonry would lead to a significant drop in the overall life cycle assessment of the building. The combination of a well insulated monolithic wall and a solar thermal heating, possibly combined with additional biomass heating (only if needed) is a very sustainable solution for European climate. A very long lifetime, low maintenance and heating in winter and good thermal conditions in summer are guaranteed. Approx. 200 built examples in Central Europe demonstrate the potential of sun houses and show the way into a sustainable future.

References

[1] GEORG DASCH DIPL.-ING FH, WOLFGANG HILZ DIPL.-ING, PROF. DR. F. FELDMEIER, ROTHENWÜHRER SCHWARZ DIPL.-ING, PROF. KOHLER IFIB,. *Das Naturpark Informationshaus, Entwicklung eines Minimal-Energie-Hauses mit Solar-Heizung, Abschlußbericht Deutsche Bundesstiftung Umwelt. Zwiesel Deutschland* . <www.naturpark-bayer-wald.de>

[2] GEORG DASCH DIPL.-ING FH, WOLFGANG HILZ DIPL.-ING, ANDREAS SCHUSTER DIPL.-ING,THOMAS DIRSCHEDL DIPL.-ING FH , INA ROEPKE, *Das Sonnenhaus*, unabhängig und umweltbewußt Wohnen mit der Sonne, Straubing 05

[3] WOLFGANG HILZ DIPL.-ING, *Den ersten Winter gut überstanden*, Zwiesel 2007

Georg Dasch Dipl.-Ing. FH
✉ Augsburgerstraße 35
94315 Straubing, Germany
☎ +49 9421 71260
🗐 +49 9421 923307
☺ dasch@sonnenhaus-institut.de
URL www.sonnenhaus-institut.de

Katharina Liepach, Dipl.-Ing.
✉ Bundesverband der Deutschen Ziegelindustrie e.V.
Kochstr. 6-7
10969 Berlin, Germany
☎ +49 30 52 00 999 0
🗐 +49 30 52 00 999 29
☺ liepach@ziegel.de
URL www.ziegel.de