Zero and low energy houses in Waedenswil (Switzerland)

R. Stangier, G. Zweifel
EMPA, Building Equipment Section, CH-8600 Dübendorf, Switzerland

SUMMARY

As part of a project financed by the National Foundation for Energy Research (NEFF), the Building Services Section at the EMPA examined the thermal behaviour of one building, with zero energy demands, located in a low energy housing estate in Waedenswil on the border of the lake of Zuerich. The estate was initiated by Dr. R. Kriesi who also made the energy concept. The architect was R. Fraefel and the estate was financed also by the government of Zuerich. The measures taken in order to reach a minimal heating demand in the chosen zero energy test house were as following:

. Overall thermal insulation without any thermal bridges
. Complete air infiltration tightness of the building envelope
. Active solar energy use with 33m^2 of collector area
. Seasonal heat storage with a 20 m^3 water storage tank
. Passive solar energy use with 18 m^2 of windows facing south
. Heat recovery from air and waste water
. Saving with the latest electric energy saving appliances
. Occasional heating with a wood stove in the living room

Photo 1 shows the South/west view of four low energy and four zero energy houses in the background. One should note the slight northern sloping situation of the estate and the partially curved placement of the houses.

Photo 1: Low energy estate in Waedenswil.

1. Interior Room Temperatures and Humidity

During the past year of measurements, the temperatures in the living area of the measured house never went below 18°C for a long period of time. Even in the washroom and in the corridor on the cellar floor, the minimal measured temperatures were 16°C and 15°C respectively, due to the door to the unheated garage and the main door. A rather large temperature stratification only develops, of up to 8K temperature difference, between the different four floors. A small drop in temperature of 1K is also observed between the south and the north orientation, which produces however no reduction in the comfort. Refered to Dr. Kriesi, the average air humidity in the winter is quite constant at about 50 to 55%. At the beginning, the air humidity was found to be rather high by the occupants.

2. Tightness of the Building Envelope

Although the specially constructed roof framework was designed to be fully tight, considerable gaps in the air tightness, which exists especially in the rafter corners, were detected. A blower door measurement made in spring 1992 gave a forced ventilation with a pressure difference of 50 Pa n_{L50} of 0.4 to 0.5h^{-1} (normal: n_{L50} = 5 to 6 h^{-1}; uppermost SIA limit for buildings with an air supply installation n_{L50} = 1 h^{-1}). The measured house is therefore tight and meets the special requirements of a zero energy house. One should note, with respect to the measured value of 0.4 to 0.5h^{-1}, that not all the chimneys could be made tight around the periphery with a reasonable effort. (This is due to the complex HVAC installation and the fact that the two homes of the house are not totally air tight with respect to each other.) The influence was, however, estimated as small.

3. Water Storage

The temperatures were measured in the 8m high storage tank at five different heights and temperature levels. Figure 1 shows the four lower water temperature levels in the storage tank. Unfortunately, the highest and most interesting measuring probe gave incorrect values and could not be replaced up till now.

The storage tank is composed of a rubber container, which also did not stand the high water temperatures rising to over 80°C and began to leak quite early. In order to avoid a definite breakage of the rubber bag, which occurred in the other zero energy houses, the storage tank in the measured house had to be regularly cooled until the autumn. Due to the required cooling of the water, the remaining storage reserves were quickly used up. Hence, from the start of December 1991 to the start of February 1992, the reserve wood heating had to be used, consuming about 280 kg of wood, to guarantee the required comfort.

In figure 1, one notices clearly that the storage water temperature already starts to rise again in mid February, as the critical winter period for the energy consumption is already passed. It is easy to imagine that without leakage and emergency cooling, the period of December and January could have been covered by means of the storage reserves. One should note further that about 40% of the energy which the floor heating supplies is directly drawn from the collector, so that less heat is used from the storage.

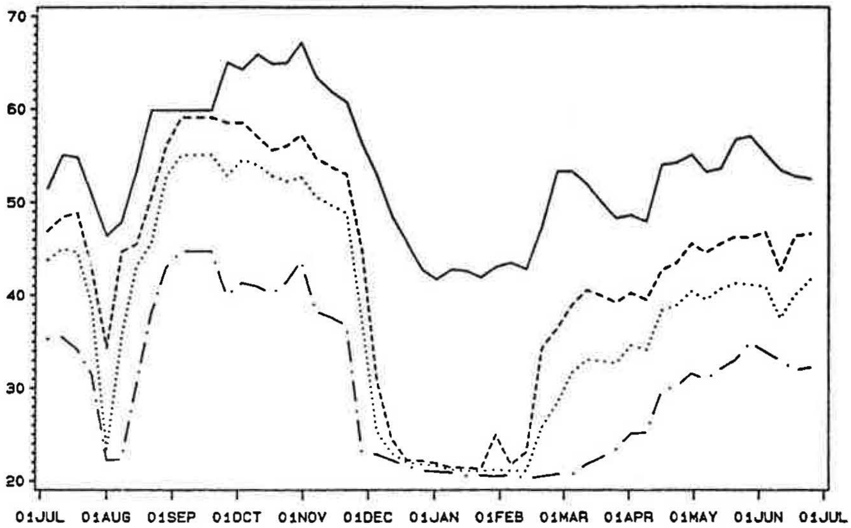

Fig. 1: Average weekly storage tank temperature at a level of —·— 0m, ····· 1.5m, – – – 3.5m and —— 5.5m

In August, the storage tank had to be partly emptied due to upkeep work and refilled with cold water. It is worth noting how fast the storage tank warmed up again.

At maximum the water storage contains about 3600 MJ useful storage energy. A storage water temperature of over 20°C is considered useful.

4. Solar Collectors

Using thermographic photographs of the collector, which were made in September 1991, the loss factor of the collector system and the quality of the transparent insulation (TI) were supposed to be determined. In order to do this, warm water, which was heated by an electric boiler especially installed for this purpose, had to be conducted through the collector. Performance measurements and thermographic photographs gave a heat loss factor of 0.95W/m²K (nominal value = 0.8W/m²K), whereby the thermal insulation proved to be about 19% worse than planned. Using the thermographic photographs, marked insulation breaches could be further localised. These developed due to installation and the effect of folding the TI. The TI will be completely replaced in the near future.

The monthly collector efficiency was determined from the summed collector energy, which was gathered, divided by the monthly solar radiation when the collector was

The temperature efficiency of the heat exchanger is practically 100%, as one must take into account that heat given out by the ventilator motor influences the temperature efficiency positively.

In mid summer, the ventilation system may have a cooling effect because of the connected ground heat collector. If this effect is used, then a yearly cooling off of the ground can be avoided at the same time. This was not done in Waedenswil.

6. Waste Water-Heat Recovery

The measured amount of warm water consumption in the test house amounted to 45'000 l (ca. 30 l/day*person) during the last heating period. The average preheating of the warm water totalled about 20 K, the energy recovery a respectable 3'960 MJ.

When working with the open container, which was only quickly rinsed, the workmen and measuring crew showed symptoms such as nausea. dizziness and strong headaches, which very probably arose from the produced biogas. Therefore, a 100% tightness is absolutely necessary and in future, a very thorough rinsing of the container is to be observed before repair and maintenance work.

7. Electricity Consumption

The annual power consumption amounts to about 3'500 kWh, the measuring equipment used by EMPA being responsible for 1'000 kWh of this quantity. An electrical energy index (without any measurement set-up) of 50 MJ/m^{2}a is obtained (compared to the SIA target value of 80 MJ/m^{2}a). The extra loads due to the pumps, ventilators and regulating systems are already included in this very low electricity consumption.

8. Emergency Oven

In the winter period 91/92 about 280 kg of softwood were burnt in the measured house. This leads to an energy consumption of 4'200 MJ and an energy index of about 23 MJ/m^{2}a. One should note that the storage tank was not fully and efficiently functioning. One can estimate that with normal operation and a standard climatic year no heating with wood should be necessary. If one takes into account the heat amount, which is fed into the storage tank via the wood oven, an estimated efficiency of the wood stove of 52% is obtained. An unknown amount of heat is directly passed over to the living room by radiation.

9. Passive solar energy usage

The large windows facing south (18m^2 of glazing), which cover 30% of the facade, contributed 10'800 MJ or 60 MJ/m^{2}a respectively during the past heating period.

10. Prospect

At the end of January 93, the thermal insulation of the collectors will be replaced and storage tank should be repaired and replaced by a steel tank in spring 1993. Therefore it has not been possible to measure a fully working system yet. The test house should be simulated as part of a separate project. Moreover, several parameters should be varied and their effect studied. Hence, via an optimisation of the separate measures, one should be able to quantify their influence. The first measurements on site show that although the aim of reaching a zero energy consumption was not achieved for technical reasons, it perhaps remains feasible if the components function irreproachably and if the inhabitants are trained and co-operative.