The Application of Renewable Energy for Prefab Houses in Germany

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Abstract - Within the framework of the REBUS project the German building industry has been investigated regarding their energy concepts. The intention was to evaluate the establishment of renewable energy sources on the German market for new built houses and prefab houses in particular. For this purpose the products of 85 manufacturers of prefab houses have been analyzed. Of special interest was the application of heating and hot water systems driven by solar energy and biomass. The results show that both techniques are well accepted and established. Almost 90% of the manufacturers offer solar systems on request and almost 70% heating systems based on Pellets. 24% offered solar and 7% as standard options in their range. From the achieved figures the potential of the Swedish market can be worked out. Strategies to introduce renewable energy to a greater extent to Swedish house manufacturers and builders might also be found.

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1 REBUS – Competitive solar heating systems for residential buildings
1. The German and Swedish market for single-family houses

The German building market for apartments is one of the largest in Europe. Compared to Sweden 17 times more apartments or equivalent are built every year. [6],[14] In the year 2000 approximately 340000 new apartments were constructed in Germany. Whereas 1997 the share of single-family-houses was still around 30% and 13% for two-family houses, three years later the shares have increased to 48% for single-family houses and 15% for two-family houses. Approximately 14% of these houses are prefabricated. In East Germany the rate of prefab houses is 30% higher than in the west part of Germany. [2]

In 2002 around 20000 apartments were built in Sweden. A construction company asserts that 50000 every year are necessary since 80 of 280 Swedish communities suffer a significant lack of adequate living spaces. [13]

![Number of new built apartments in Sweden](image)

Figure 1 Number of new built apartments in Sweden [6]

Figure 1 shows that the number of new apartments decreased to a minimum at the end of the nineties. For two years the market has been growing slightly again. The share of single-family houses has been relatively constant during the last 3 years, at between 40 and 50% of the total number of apartments. However, due to the lack of living space and the rather constant conditions in the Swedish economy including low interest rates an increasing building activity can be expected in the next years.

More than two-third of new single-family houses in Sweden are prefabricated (see fig.2). This is mainly due to the design and construction of Swedish houses. Swedish houses, as well as houses in other Scandinavian countries, are mainly constructed with wood. Many centuries of experience have led to houses, which don’t rank below massive built houses, but often have an even thermal insulation. The wooden construction and the light design encourage and simplify prefabrication.
2. Regulations for new built houses in Sweden and Germany

The international resolutions to restrict the emission of greenhouse gases according to the Kyoto protocol have forced the German government to spend more effort in energy conservation.

The private households account for more than a forth of the total German energy demand. [4] Most of this energy is needed for heating (65%) and hot water (16%). With advanced building techniques, houses with a very low energy demand for heating or even without any demand can be built. In order to use this large potential of energy conservation the regulations, which specify the maximal allowed energy demand for new built and reconstructed buildings, have been adopted to the state of art in building technique. Figure 3 illustrates the development in the last 20 years.

A reduction of the allowed heating demand is putting the use of solar energy in a more favorable situation. The smaller the heat demand the easier it is to cover a significant part of the load with a solar heating system without excessive costs (large collector area, seasonal storage).
The latest regulation (from 2002) limits the maximum heat demand to approximately 70 kWh/m², a for a standard house. Aside from these houses a number of manufacturers also offer low energy houses (3-liter house, 1.5 liter house) and also so called passive houses (10 to 15 kWh/m², year), which do not need any active heating system. The remaining demand is covered by internal and passive solar gains and the heat recovery of the ventilation system.

A passive house requires not only a drastically reduced heating demand but also a much lower energy need for hot water and a lower electricity consumption. Using a solar heating system will reduce the energy demand for the production of DHW. A lower electricity consumption may be achieved by the use of energy saving domestic appliances and/or the application of photovoltaic.

With the new German regulation - Energieeinsparverordnung (EnEV 2002) - the focus is not anymore only on the demand for heating. In fact the whole building is considered as one unit regarding the total energy consumption including the energy necessary for conversion from one energy form to another, e.g. gas to electricity. That means the primary energy input is the figure of interest. This gives an advantage for renewable energy sources and improves the chances for heat pumps. In the regulation the maximal primary energy use for a residential building is given per m² according to the ratio of the envelopment area to the heated volume of the building and other boundary conditions. Meanwhile a maximal heat transfer coefficient for the envelopment area is specified for these ratios.

Sweden had for many years much stricter requirements for heat insulation and energy demand of buildings. With the German EnEV both regulations are almost on the same level, but vary a lot regarding specific buildings. The reason is that the Swedish regulation “Energihushållning och värmeisolering” [5] contains only a maximal heat transfer coefficient, which depends on the ratio of windows area to living area. That means the heat demand is not limited to a certain value, rather it depends on the location of the house and the climate. Thus a house in the north of Sweden can consume more energy than the same type of house in the southern part.

These different concepts make it difficult to compare the requirements in general. Every case has to be investigated individually. Figure 4 shows the requirements for U-values for three different kind of buildings in some European countries in 2001, that is before the German EnEV 2002 came into force.

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1 Liter light fuel oil per m² and year (1 liter light fuel oil = 10.7 kWh, net calorific value)
Although Sweden’s regulation for heat insulation are demanding, no limitation is set for the energy use for production of domestic hot water. Moreover the efficiency of energy conversion (the primary energy use) is not used at all. In this way electricity, fossil fuels and renewable energy sources are equalized and a chance to promote environmentally friendly technologies is missed.

3. Development of the solar heating market in Germany and Sweden

In 2001 more than 900000 m² collector area was installed in Germany, including vacuum tube and flat plate solar collectors. In total 460 000 solar thermal systems with 3.8 million m² collector area have been built in Germany up till 2001. [1]

In Sweden the market has stagnated since 2000, on a rather low level. A high number of installations are large solar heating plants with more than 100 m² collector area, but in the recent years the share of systems with less than 15 m², typical system sizes for single-family houses, has increased from 54% in 2000 to 77% in 2002. [7]
After a clear decline in 2002 a further increase on the German market can be expected in 2003, since the German government has raised the subsidies again to 125 Euro per m² collector area. The high prices for fossil fuels will also push the number of new installations. Besides the economic reasons the confidence in the reliability of solar energy technique has taken a big step forward. Where not so long ago mostly environmentally interested people were buying domestic solar energy systems, today there is a much larger range of buyers.

4. Investigation on German prefab house manufacturers

The main task of this investigation was to analyze to what extent German manufacturers of prefab houses implement renewable and in particular solar energy technique. Are these techniques state of the art and are they offered in the same degree as conventional heat sources and how are they offered to costumers? What kind of system is offered and are combinations available? It was also of interest to evaluate the number of companies who offer the lowest heating demand houses like passive houses, since these houses are particularly suitable for renewable energy solutions.

The product ranges of in total 85 enterprises who produce prefab houses have been analyzed. First their web information was used to survey their supply of renewable products as standard options. The second way was to ask directly (by email) what products the house builders are offering on request. From 85 house builders 44 answered the direct request for information. The figures 6 and 7 show the result of the web survey and the direct questioning.

![Figure 6](image_url)  
*Figure 6 Offered solutions from the house builder’s web pages*

The web survey shows that a rather large number of companies already offer solar collectors and other environmental friendly solutions in their normal range of products. An even larger number can offer it on request (figure 7).
Almost 90% of the 44 house builders offer the installation of solar collectors if requested compared to only 24% that offer it as an alternative in their advertising. Even if those that did not reply, are not willing to integrate solar equipment it would still give a high number and shows how established this technique already is.

Companies who offer a solar heating system often also recommend a pellets boiler as backup. Heat pumps are also often available. PV is for many companies no problem, but most of them have only a little experience. That it is offered shows that the integration is easy and the installation is uncomplicated.

Generally most housing manufacturers are willing to integrate whatever the customer wishes as long as he pays for it. Many house builders distribute heating equipment only from one most large manufacturer like Buderus or Viessman. Due to the fact that these manufacturers have renewable heating equipment in their product line it is also offered to the house buyers.

As the results from the web survey show, the majority of the companies don’t promote renewable energy active, even if they have it in their product line. But there is also a growing number of exceptions, who offer renewable energy solutions rather actively. They deliver information brochures and other advertisement material in favor of renewables, provide information about state support programmes and campaign with their environmental friendly image. Good examples are the companies Carl-Platz GmbH, Haas Fertigbau GmbH & Co KG and Kaitel-Haus GmbH. Obviously they have realized that on the market an environmentally friendly image can be an advantage to compete with other players on the market.
Nevertheless the standard is still a gas or oil based solution, mostly high efficient boilers with condensing technique. Very seldom electrical heated boilers or electrical night storage radiators are still proposed.

The market for solar and renewable energy in Germany is not anymore a niche, but solar competes together with renewable solutions against the conventional energy techniques.

Figure 8  Installation roof integrated solar collector (Haas Fertigbau GmbH & Co KG)

The company Carl-Platz GmbH offers a low energy demand house (figure 9), which use several renewable and energy saving techniques. Beside a very good heat insulation the house integrates passive and active solar elements. A large roof window provides passive solar gains (3). To prevent overheating in the summer it is equipped with a modern shading devise. Furthermore solar collectors for hot water production (1) and photovoltaic panels for electricity (2) are installed. The heating load and the remaining hot water demand is covered by a pellets boiler (9), which is supplied with an automatic pellet support (10). The pellet boiler is an in-house development of Carl-Platz GmbH. The house has a ventilation system with heat recovery (5) and a ground pipe to preheat or precool the fresh air (4). 40 houses of this type have already been built in Germany.

Figure 9  Low energy house (Carl-Platz GmbH)
Another very active manufacturer regarding renewable energies is Haas Fertigbau GmbH & Co KG. Different levels of low energy houses are produced. Beside a large product range that covers all kinds of alternative energy equipment, Haas Fertigbau also propose interesting architecturally integrated solutions (figure 10), which is also an important factor to improve the acceptance of solar energy.

![Figure 9 Attractive architectural integration of solar collectors (Haas Fertigbau GmbH & Co KG)](image)

Kaitel-Haus GmbH offers houses with different degrees of heat demand. Their low energy houses are built as 4½ liter, 3 liter and 1½ liter (liter oil/m²,year) houses. A pellet burner or pellet stove in combination with a solar heating system is recommended. In 2002 two thirds of their houses have been built with an integrated solar heating system and 17% were equipped with a pellet heating system.

There are also companies on the German market who offer only low heating or passive houses with renewable energy sources. One example is the company Tetra Solar from Augsburg. They refuse to use any fossil heat sources like gas or oil for their houses.

The extra prices for a heating system based on pellets and solar including storage and automatic support for the pellets differ from company to company. The cheapest solution was offered for about 5000 Euro where admittedly all subsidies were already included. The average extra price for such a system including a combi-storage and up to 10m² collector area was around 8000 Euro.

5. Summary

Renewable energy solutions for hot water and heating in prefab houses like solar thermal systems or pellet boilers are already well established on the German market. The majority of the players on this market offer these techniques, but since higher in-
Installation costs must be accepted, mostly only as an option. However, with increasing prices for fossil fuels and electricity the extra investments can pay in the long run.

Due to the higher requirement for heat insulation the use of renewable heating technology is getting more and more favorable. Increasing prices for fossil fuels and electricity will improve the economical acceptance.

The total number of new built apartments in Sweden is significantly lower than in Germany, but on the other hand the share of prefabricated single-family houses is clearly higher. Renewable energy systems could be established here to a large extent if the lead of the German market is followed.

References