CADDET renewable energy

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Combined Solar Systems for Residential Buildings

Summary

Combined solar systems for domestic hot water and space heating, also called solar combi systems, have been installed in about 100 houses in Norway. This brochure focuses on an evaluation of five combined solar systems, carried out during 1998. These systems, which use polymer solar collectors, can provide 25–35% of the heating for a typical residential home in Northern Europe during the winter. Compared to the cost of traditional solar systems on the market today, the cost of the collector is low. Roof or façade integration requires an architecturally appealing solution, which needs collaboration with the building designer and the solar installer at an early stage.

Highlights

- **Low-cost polymer solar collectors with glazing**
- **Architecturally appealing, building-integrated systems**
- **Up to 8,000 kWh/year solar gain**

Side view of the house showing the polymer solar collectors.

Project Background

The development of a solar collector made from polymer materials, which can withstand a maximum temperature of 140°C, was carried out by the Norwegian solar energy company SolarNor AS, in collaboration with General Electric Plastics and the University of Oslo. The costs of the collector and revised solar system design were significantly lower than for a traditional solar system. The characteristic elements of the system are: roof-integrated solar collectors made of polymer plastics with glazing; a large heat store with typically 24 hours' storage capacity; and a low-temperature floor heating system. The combi systems are designed to convert enough solar energy to meet 25–35% of the total annual heating demand in a Northern European climate.

The Project

The aim of the project was to determine the performance of a modular, standardised solar combi system for single-family houses by carrying out energy measurements on five different houses in south-east Norway.

The five solar combi systems have the same basic design concept (see Figure 1). The solar collectors are part of a drain-back system with water as the heat transfer fluid. The heat provided by the solar collectors is used for low-temperature space heating and for preheating domestic hot water (DHW).

The active area of the collector fields for these residential buildings varies between 11 m^2 and 32 m^2. The solar collector is delivered as a modular roofing system consisting of low-weight panels of standard 60 cm building width in four different lengths (maximum 5.4 m). They are designed to replace conventional roofing materials, such as tiles, and mounting them is no more expensive.

In each case, the solar collector loop is linked directly to an unpressurised, stainless steel tank with a capacity of 1 m^3 to 3 m^3 which provides buffer heat storage. The heat store is equipped with a solar pump, a floor circulation pump and an integrated solar and temperature controller for the floor system. The controller has multi-zone regulation and controls the auxiliary heat supply, based on a dynamic thermostat level governed by the temperature outdoors.

The floor-heating loop is preferably directly connected to the heat store. The heated floor areas are in the range of 80 m^2 to 262 m^2. Domestic hot water is preheated by means of a 200 litre stainless steel tank immersed in the heat store.

Auxiliary heat is supplied directly to the heat store by an electric element (Norway has low-cost, "environmentally-clean" hydroelectricity). In one of the houses, a biofuel-pellet burner supplies additional heat to the buffer store.

In these systems, energy monitoring can be performed easily by calorimetric measurements in the heat buffer store.

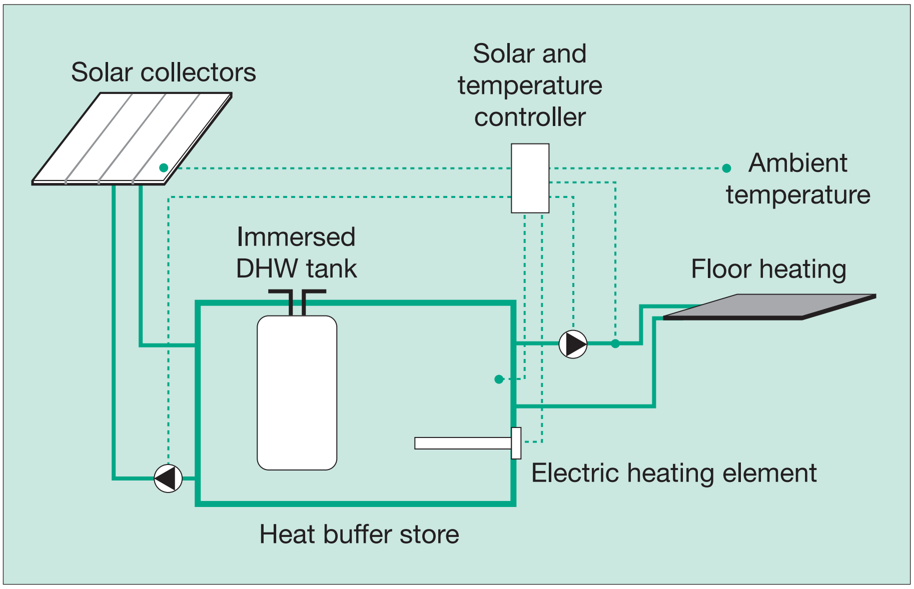

Figure 1: Schematic diagram of a typical system.

Performance

The performance of the solar systems is determined by measuring the dynamic temperature profile inside the heat store at 10-minute intervals, revealing the amount of energy delivered to, and consumed in, the heating system. Additional information is obtained by monitoring the return temperature in the floor system, the ambient air temperature and the solar irradiation.

Measurements were carried out between February and August 1998. The results were used to simulate the annual solar gain of the installed systems, which is estimated to be in the range 250–300 kWh/m^2 of collector area. The results for House A are given in Table 1, which gives a representative picture of the performance of the actual solar combi system.

Table 1: Analysis of energy performance, House A

System	Dimensions		
Solar collector area	31.7 m^2		
Heat store capacity	3.5 kWh/K		
Floor heating area	262 m^2		
Measuring Period	**27/02/98–26/03/98**	**27/03/98–25/04/98**	**26/04/98–24/05/98**
Total solar gain	799 kWh	801 kWh	1,442 kWh
Average solar gain/day	28.5 kWh	26.7 kWh	49.9 kWh
Max. solar output (daily)	2.18 kWh/m^2/d	2.49 kWh/m^2/d	3.11 kWh/m^2/d
System temperature (max/min)	45°C/24°C	47°C/24°C	56°C/25°C
Extrapolated net solar gain	**7,900 kWh/year**		
Solar fraction	**25%**		

Economics

As the solar collectors are integrated into the roof or façade, replacing conventional building materials, the total system costs are difficult to show without specifying the building. Three of the five houses analysed in spring 1998 were designed specifically for the integration of a solar system. In Norway, the solar collectors cost from €80/m^2 to €99/m^2 (where € is the euro), including manifold pipe framing and covers for roof integration.

The heat buffer store contains the pump station for the solar and floor heating systems and the domestic hot water preheating unit. The solar and temperature controller for the floor heating system is also an integral part of the buffer store. The concept, therefore, represents a complete central heating system, the cost of which should be compared with that of a complete conventional heating system providing the same comfort and functional flexibility.

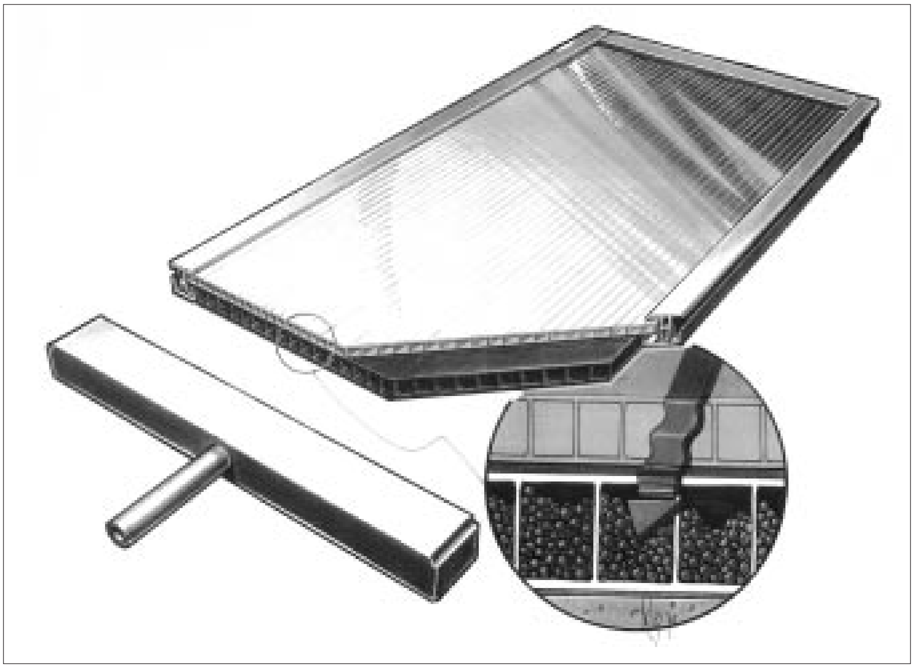

Figure 2: Diagram of a polymer collector module.

Typical additional costs for this type of solar combi system are in the range €2,500 to €3,700 in 1999 for installed systems providing 5,000 kWh to 8,000 kWh annually. The payback period is in the range of 8–12 years at the present low electricity price in Norway (0.05–0.06/kWh).

Environment

Electricity in Norway is generated by emission-free hydropower plants and, to some extent, imported from European countries. Consequently, these solar combi systems have little direct effect on reducing CO_2 emissions. However, widespread use of these systems could help to reduce the need for further large-scale hydroelectric installations in

Norway. If these projects were widely replicated in a country with mainly fossil fuel-based heat and power, significant savings in CO_2 emissions are possible. For example, just one solar combi system supplying 5,000 kWh/year in the Netherlands would save about 2 tonnes/year of CO_2 emissions.

Front view of the house.

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CADDET

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