SOLAR
District Heating

FRIEDRICHSHAFEN
(Germany)

In addition to solar water heating, more and more municipalities are launching projects to utilize solar energy for heating (or cooling), too. Such installations require a common storage tank that is able to feed hot water for a long period into the local district heating network. They may, depending on their size, meet as much as 40–70% of the annual heating needs of a residential estate. Moreover, these systems can use innovative techniques for interconnecting or feeding into a heat network, this providing huge energy savings compared to single installations. In Friedrichshafen, a residential estate with some 600 housing units has been supplied by a small-scale solar district-heating system since 1996.

THE CITY

Friedrichshafen lies on the shores of Lake Constance [Bodensee], in south-western Germany. It has 53,000 inhabitants, and is known both as a tourist attraction, and as the town where the zeppelins were built and tested. Today, Friedrichshafen is home to automobile, mechanical engineering, aerospace, and other high-tech companies.

Climatic Data:
Degree days (base 17 °C): 3,717
Annual mean temperature: 9.7 °C

CONTEXT

In Friedrichshafen, the town of trade fairs and zeppelins, climate protection and saving energy are becoming more and more the focus of energy policy. Together with the citizens of the town, concepts for implementing the Local Agenda 21 are drawn up and adopted. All interested parties receive important information and impulses for optimum energy use in their domestic or commercial facilities in the Town of Friedrichshafen's Bureau of Conservation and Environmental Protection, in the energy-advice offices of the municipal utility, the Technische Werke Friedrichshafen GmbH, and from many other partners in the "Campaign for Climate Protection by Saving Energy in the Lake Constance Region". Among the renewable sources of energy, solar thermal energy receives especially high priority in Friedrichshafen. The Wiggenhausen-Süd (4,300 m² when completed), Markdorf-Lichtenberg (230 m²) and Friedrichstraße (70 m²) plants, built and operated by the municipal utility, have provided important findings for the construction of other solar-assisted small-scale district-heating systems in Germany. Several years' practical operating experience have demonstrated the limitations and perspectives of this technology.

EXPERIENCE OF FRIEDRICHSHAFEN

The town planning concept

In a fundamental decision by the town council in August 1994, it was resolved to incorporate a solar-assisted district-heating scheme with long-term storage as a major component of the overall planning concept for the Friedrichshafen development "South Wiggenhausen", and to provide the groups doing the building with environmentally oriented guidelines for the planning and design of the individual quarters. At that time, it was thought that the medium-term demand for housing would best be met by blocks of flats built as complete or interrupted peripheral coverage. The overall South Wiggenhausen project is divided into three sections.

The first two sections are part of the solar-energy project, while the third section will be connected to the district-heating supply, but will not be fitted with solar collectors. The town planning aspects are supervised by the Friedrichshafen Municipal Planning Bureau. 250 housing units were planned for the four quarters of the first section. But upon completion of the first section in 1996, a total of 280 units were handed over to the clients. A kindergarten was added to the residential area afterwards, and also connected to the district-heating supply. The thermal insulation levels of the buildings erected go far beyond the requirements of the 1995 Thermal Insulation Ordinance [*Wärmeschutzverordnung* (WschVO 95)], so that the values are about 20% less than the prescribed standards.

1st section	**Building 1 StWB**	**Building 2 LEG**	**Building 3 KBG**	**Building 4 SW**	**Building 5 KiGa**	**Total for Buildings 1-4**
Number of housing units	72	63	83	62	-	**280**
Floor space	5,372 m²	4,761 m²	5,600 m²	5,652 m²	1,552 m²	**21,385 m²**
Space heat requirement	193 kW	200 kW	239 kW	290 kW	50 kW	**922 kW**
Hot water production	110 kW	135 kW	157 kW	115 kW	20 kW	**517 kW**
Average heat consumption 1997–2001	490 MWh	470 MWh	580 MWh	470 MWh	60 MWh	**2,010 MWh**

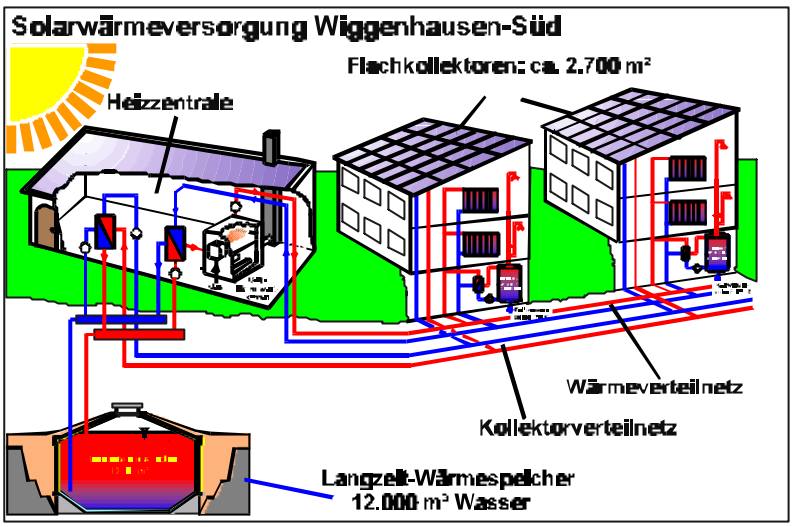
Table 1: South Wiggenhausen, building data for the first section

The financing concept

The Federal government ("Solarthermie 2000" research programme) subsidized the construction of the long-term storage and the district-heating system with a total of 53% of total costs. Other important supporters are the clients, with construction-cost subsidies of 24% of the total costs for connecting up to the district heating system and the solar-energy facility. The solar collectors of the first section were subsidized by the State of Baden-Württemberg with 9% of the total costs. The Technische Werke Friedrichshafen GmbH are the owners and operators of the entire solar-powered district-heating system and long-term storage facility, and have also assumed the builder's and operator's risk, including compensation in case of cost overruns.

The heat supply concept of the South Wiggenhausen solar estate

On the roofs of the multi-storey buildings of the first and second section, about 4,300 m² of solar collectors will be installed. The solar heat generated in summer will be fed into the storage recharging loop of the long-term storage unit in the heating plant via a separate solar-heat distribution network (solar network) and a heat exchanger.



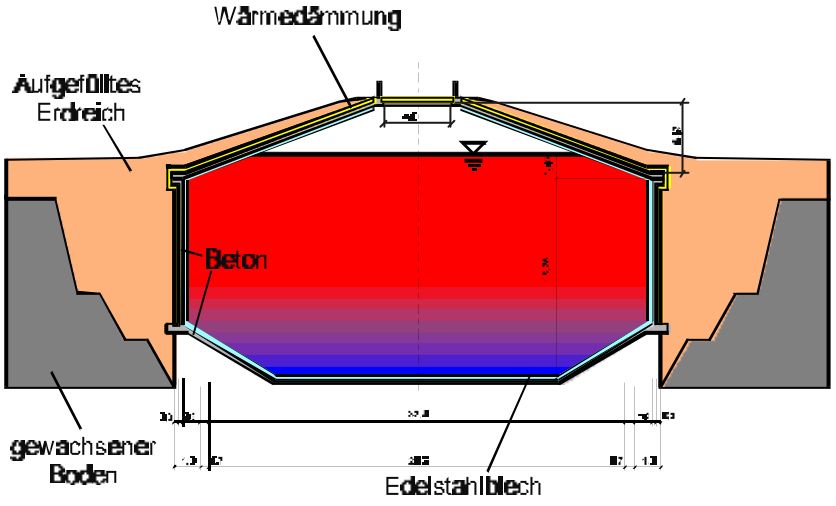
The long-term heat storage unit is heated by the solar network to temperatures ranging from 40°C to 90°C when the sun is shining. This heat is discharged into the district-heating distribution network (heat network) via another heat exchanger. The amounts of heat needed for heating and hot water in the individual quarters are, in turn, separated off via a heat exchanger in heat transfer stations. The goal of the South Wiggenhausen pilot project is to cover almost half the total heat demand for space heating and hot water supply of the 570 housing units with solar energy. The other half will be covered from gas-fired condensing boilers.

The solar collectors

The main component are the flat solar collectors, with a surface area of 2,700 m². The aperture of the individual modules ranges from 7.5 m² to 12.5 m², depending on the manufacturer. Some of the collectors are on elevated mountings on the roof, while others are integrated into the roof. The costs, including final assembly of the collector arrays, range from about EUR 175 to EUR 235 per square metre, depending on the model of collector.

The long-term heat storage unit

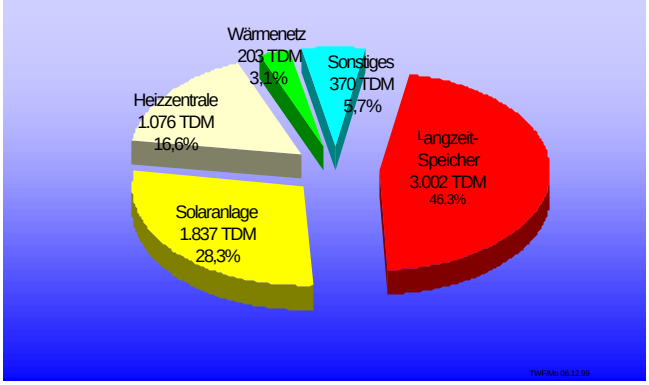
The long-term heat storage unit was designed as a cylindrical reinforced-concrete tank with a top and bottom having the form of truncated cones. This shape, with its optimum ratio of volume to surface area, enabled the construction costs of the long-term heat storage unit to be reduced considerably. The top and side wall of the cylindrical tank were lagged with 20 to 30 cm of rock-wool. The tank was lined with stainless-steel sheeting (1.25 mm) as protection against vapour diffusion. The long-term heat storage unit is entirely buried in soil.



Capital costs & commercial viability

The capital costs for the first section of the solar-district-heating system amounted to about EUR 3 million. For 280 completed housing units, this means an outlay of EUR 8,600 per unit. Total annual costs of EUR 90,000 and an annual heat output of 1,980 MWh result in a heat

price of about 45 EUR per MWh. In the first section, annual energy consumption per m^2 floor space averages 94 kWh/m^2.



EVALUATION AND OUTLOOK

The "Solarstadt Wiggenhausen-Süd" solar estate has become known far beyond the region as Germany's largest solar installation. This is illustrated eloquently by the large numbers of visitor groups coming to learn about the solar (and conventional) heat supply systems.

The first section was implemented to the extent planned, and documents that the concept works in principle. The operational experience now gained over several years has shown the limits of theoretical analyses and forecasts for some of the system components. On the other hand, it has shown the way forward for improved planning and construction of further solar installations. Seasonal heat storage technology needs to be refined in order to further reduce the presently high system costs. The predicted amounts of solar heat and the ability to store them were not fully realized. Nor were the planned return-leg temperatures of 25°C to 30°C in the heat network achieved. High return temperatures equal higher storage losses, and a reduction of the storage capacity of the long-term heat storage system and of the solar yield. The energy balance after five years of operation shows that, in particular, the expected 100% coverage of heat supply from the solar installation during the summer and early autumn months has not been achieved.

The experience gathered is already contributing to the building of the second section, whose urban planning aspects have also been reworked. The residential density of the first section is being supplemented by more scattered development, in the form of single-family houses, blocks of flats with fewer storeys, and types of town houses. In 2000, 24 terraced single-family houses and four multifamily buildings will be completed. Construction of the multifamily buildings will provide a collector area of just under 1,400 m^2. This will mean a much more efficient utilization of the long-term heat storage system.

FURTHER INFORMATION

Dipl.-Ing.(FH) L. Morgenbrodt
Technische Werke Friedrichshafen GmbH
Kornblumenstraße 7/1
D - 88046 FRIEDRICHSHAFEN
Tel: +49 7541 505-298
Tel: +49 171 142 04 28
Fax: 49 7541 505198
E-mail: ludwig.morgenbrodt@twf-fn.de

This case study was prepared by Energie-Cités in cooperation with Technische Werke Friedrichshafen GmbH as well as Steinbeis Transferzentrum in Stuttgart, and with the financial support of European Commission DG XVII within the scope of the ALTENER Programme. A 10-page full-length version (in German) is available from Mr Morgenbrodt and from Energie-Cités.