District heating – a precondition for efficient use of solar heating

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In the past 20 years, solar heating for district heating has been developed to be much more efficient, technically as well as economically. At the same time, small-scale solar heating applications have been developed. The efficency is high, the concept is well-known, and the technology is accepted as an obvious way of saving energy. Nevertheless, solar heating is still rather expensive compared to the fossil fuels.

The latest experience shows that large-scale solar applications for district heating are more profitable than small-scale plants and, moreover, can boost a significant increase in the market share of solar heating. The main reason is that the cost per m^2 solar panel of establishing a large-scale solar heating plant is dramatically lower than the cost of establishing a small-scale solar heating plant. At the same time, the performance tends to be better in the large-scale plant compared to the small-scale plant. The result is, all in all, that we see an improvement in the price/performance ratio by a factor 6 going from a 5 m^2 installation to a 20,000 m^2 installation.

Installation of the new panels for extension of the plant in Marstal, Denmark.

In case solar heating is part of the national energy policy, and the political aim is to supply a city with a significant fraction of solar heating energy, this can be achieved in the most efficient way if a citywide district heating system already exists and is in operation in the summer period. The only precondition is, of course, that the heat source to the district heating system in the summer period is based on fossil fuels and not on CHP or any other efficient heat sources.

We can point out following advantages of using solar heating from one large district heating solar plant compared to a large number of individual plants:

- The investments per m^2 installed panel are 5 times lower
- The efficiency is 1.2 times larger
- Low cost thermal storages become feasible, which will increase the utilisation of the solar heating
- The project is much simpler to implement
- The project can be implemented in a very short time
- The plant can be monitored and maintained more efficiently

Thus, both from an economic point of view as well as a technical/practical point of view, the large-scale solar plant is the best solution. Therefore district heating plays an important role for the utilisation of thermal solar heating on a large scale. The challenge for the district heating company is to operate the district heating network efficiently in order to maximize the benefits of the solar heating. This means first of all:

- To reduce heat losses and the supply temperature drop from plant to consumer in the summer period
- To reduce the requirement for maximal supply temperature in the summer period
- To encourage the consumers to lower the return temperature by tariff incentives
- To advice the consumers on how to improve the consumer installations

An efficient low-temperature network, which will increase the performance of the solar heating, will also allow the district heating company to use other heat sources more efficiently, e.g. economizers, CHP plants, geothermal energy, low temperature surplus heat and heat pumps.

In the following we present 4 cases of large-scale solar heating plants:

GJ Teknik assembles and installs panels for extension of the Marstal solar heating plant.

Case 1: Rise district heating plant Denmark

In the year 2000, a new small district heating plant was set in operation in Rise at the island Aeroe in Denmark. At the present the plant supplies 115 buildings, including the public school, an old peoples' home, the church, the inn, garages and the majority of the single family houses in the town close to the plant. (See also *News from DBDH* 2/2003).

The plant includes:

- 3,600 m^2 solar panels,
- one biomass boiler of 800 kW (wood pellets) and
- heat storage of 4,000 m^3 corresponding to 25 hours of max load of the boiler (steel tank).

The aim was to obtain a solar heating fraction of 50%, which requires a very large heat storage capacity. The capacity corresponds roughly to the heat demand, 24 hours, on a cold winter day. The storage is also in operation in wintertime, in order to balance the heat demand and the supply from the biomass boiler. As a matter of fact, the hourly peak load is 1,300 kW, which exceeds the capacity of the biomass boiler. By using the top half of the storage tank in the wintertime, the peaks from load fluctuations can be covered by supplying heat from the storage to supplement the biomass boiler. In case of a breakdown of the biomass boiler, the storage acts as emergency supply for a limited period.

From the planning of Rise district heating plant, special attention was paid to the return flow temperatures from the building installations. To ensure the lowest possible return flow temperature, all the heating installations were carefully balanced, fitting the necessary valves at each radiator etc. and setting these valves to the lowest possible flow. The result was a return flow in winter of 30 degrees C and 36–40 degrees C in the summer. These low temperatures made it possible to install smaller main pipes and to achieve a very high efficiency of the heat storage and the solar heating plant as well.

Case 2: Marstal, Denmark

The solar heating plant in Marstal has now been extended from 9,000 m² to 18,300 m². New types of panels are being tested, and an underground storage with a capacity of 10,000 m³ has been constructed. (See *News from DBDH* 3/2002).The design of the panels, which was used in Rise, has been improved even further in the latest project in Marstal.

A new developed type of heat storage was installed. It is a pit heat storage, dug into the ground and covered by a floating lid. For large-scale heat storages - above 50,000 m³ - this type is very promising. The price is less than 25 $ per m³ of storage, which is approx. 3 times less than the price of a pressure less steel tank accumulator. This opportunity will enlarge the potential market for large-scale solar heating plants significantly.

The storage type is, of course, also an option in other applications like combined heat and power plants, waste incineration plants etc. in which there is a need for storage of heat for levelling of load fluctuation on a weekly or even monthly basis.

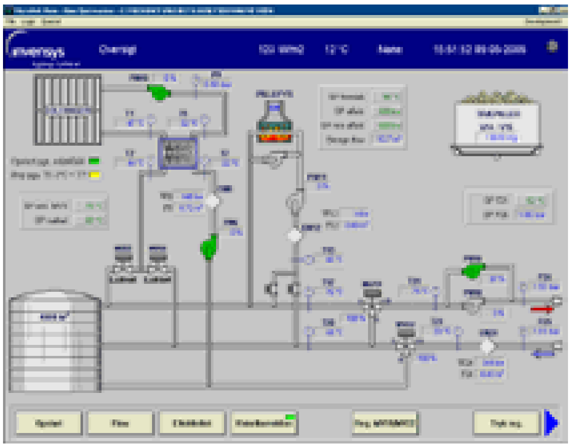

Figure 1. Principle diagram of the Rise district heating production plant.

Case 3: Tashkent, Uzbekistan

At the moment, a demonstration plant of 1,000 m² is in operation in the capital Tashkent at one of the gas-fuelled boiler houses (Vodnik). In this demonstration plant 8 different solar panels are in parallel operation, making it possible to compare the performance of different types from different countries and manufactures.

The first demonstration project, which was implemented in a Tacis project, included 820 m² panels. The second demonstration project, which was implemented in a UNDP project, included a local factory for manufacturing the panels based on the BATEC, CU-STRIP and mounting additional 200 m² of panels to the solar heating plant. Based on simulations of the solar radiation and temperatures, we have estimated that these panels will be capable of producing up to 3 times more heat per m² compared to similar panels in Northern Europe. Besides, the production costs of local manufactured panels adjusted to the local conditions should be lower than in Northern Europe. At this very boiler house it is possible to install 20,000–30,000 m², just for the summer load to replace heat produced by the natural gas-fuelled boiler. At other much larger gas-fuelled boiler houses, there is a potential for installing up to 200,000 m².

If we could combine the solar energy intensity in Uzbekistan with the larger fuel prices in Northern Europe, these plants would be very profitable. In the present situation it is necessary to consider the role of the solar heating in the national energy policy, taking into account the long term benefits and, if possible, use the benefits of CO_2 emission reductions.

Case 4: Romania

A feasibility study in Romania for a solar heating plant of up to 100,000 m², connected to a district heating network has recently been finalised. Included is a 30,000 m² storage tank. Due to technical and economic reasons at the present, the network is not operating from April to November. This situation is very uncomfortable for the residents, since no hot water is provided in this period. Consequently a number of residents have installed their own electric heater to ensure hot water. This solution is much more expensive and does in fact reduce the efficiency of the district heating system as well.

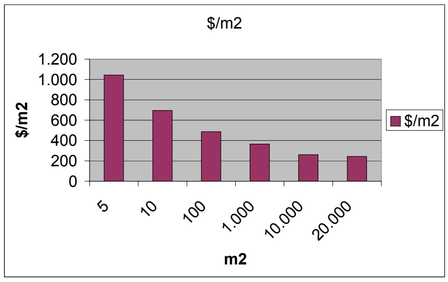

Figure 2. Price per m² of different sizes of solar heating plants, including heat storage. Moreover, the performance from the large plant is in general 20% higher than the performance of the small plants.

The feasibility study shows that the solar heating plant can compete with a district heating boiler plant fuelled with heavy oil. It also shows that the solar heating plant will have other benefits for the local society, in particular if the panels are constructed locally, and based on the technology used in the cases above.

One last aspect is that the heat accumulator will improve the operational conditions for the existing boiler plants, which shall supplement the solar heating and supply most of the heat in winter time.

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