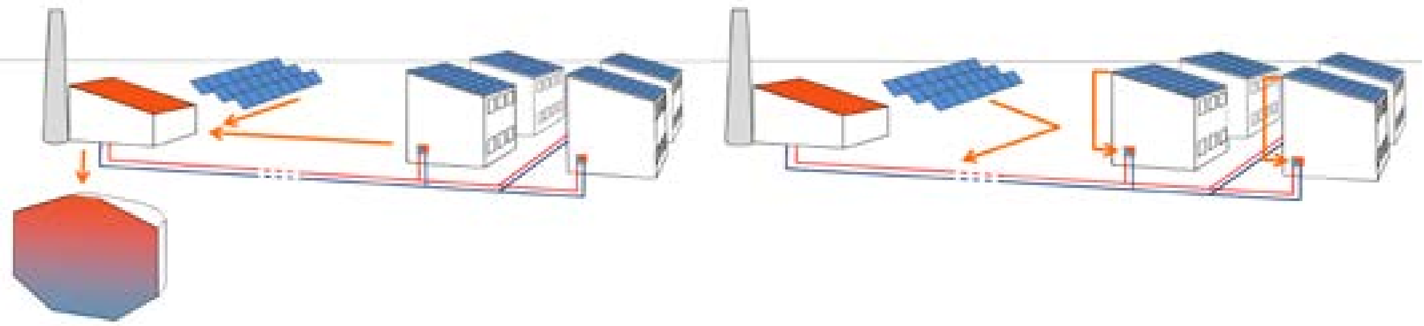
sweet swiss energy research for the energy transition
DeCarbCH

DeCarbCH

Grid integration of solar heat

Factsheet 7: Integration of solar energy in district heating grids

General Information

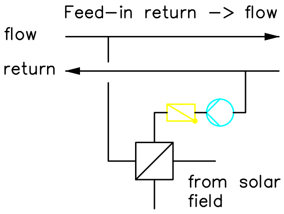


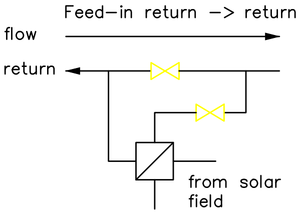
Centralized (left) and decentralized (right) integration of solar heat in district heating networks. *Source: Solites, via solar-district-heating.eu*

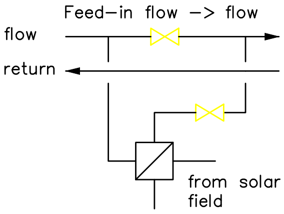
General

Solar collectors for district heating (DH) can be mounted on large roofs, carports, on existing structures such as walls or dams, or ground mounted in open fields. This is usually determined by space availability and distance to the DH network. Centrally integrated solar fields raise the temperature of the transfer fluid just upstream of the main heating point. The conventional heater then increases the temperature to the desired network temperature. This integration method requires a large seasonal thermal storage at the integration point if a high solar fraction is to be reached. This type of system is typically owned and operated by the owner of the DH system.
Decentralized solar thermal integration typically uses multiple smaller solar units, e.g. on small fields, carports, or by "prosumers": consumers that are able to feed in heat when the local production exceeds the local consumption. These systems typically do not require heat storage, as the grid is used as a heat store. These solar systems can be owned and operated by homeowners, companies, energy service companies (ESCOs) or the district heating provider.

Integration







Field integration can be accomplished using three feed-in principles. In the return->flow mode, the temperatures and pressure difference are defined by the heating grid and the solar field must be operated at flow rates matched to the required temperature. No valve is required in the grid line, but a pump is needed to overcome the pressure difference between return and flow.

The return->return principle uses the lowest operating temperatures resulting in higher solar yields. An additional valve is required in the grid line. This principle results in fluctuating return temperatures that must be balanced by other heat generators. A combination of return->flow integration in summer and return->return integration in winter can be favourable.

The flow->flow integration method results in the lowest solar yields and fluctuating grid temperatures. It is not normally used.

Control Strategies

The operation of a solar DH network includes the optimization of solar system yield, DH temperature, heat storage, heat consumption, electricity consumption, and so on.
For the solar system, variable flow rates in the range of 10-50 l/h per square meter of solar collector area are typically used to match temperatures to the DH flow temperature. These can be controlled using either the collector field temperature or an irradiance measurement. The latter does not suffer from thermal inertia, but cannot detect partial shading of the solar field.
In the case of a return->return integration a fixed "highflow"-rate around 50-70 l/h per square meter of solar collector area result in elevated efficiency.
Solar systems are usually switched off during the night and only operated when they are warm enough to provide heat to the DH system.

Heat transfer fluid

Solar thermal systems are usually operated with a mixture of antifreeze and water as heat transfer fluid to prevent freezing during cold winter nights. In these cases, it is necessary to separate the systems, which is typically done using plate heat exchangers. However, there are also manufacturers who propagate a constant flow of water through the collector field to prevent freezing. These systems must be actively maintained at temperatures above 0°C using energy from the heating network. The resulting energy loss can be kept low by using vacuum collectors and good thermal insulation, and accounts for only about 2% of the solar yield.

Avoiding stagnation

If the circulation pumps fail, or if the solar energy production exceeds the capacity of the grid and the available storage tanks, solar thermal systems face stagnation. Without a stagnation concept, solar thermal collectors can reach temperatures of more than 200°C during stagnation. In such emergency situations, stagnation is usually managed using stagnation cooling by air chillers.

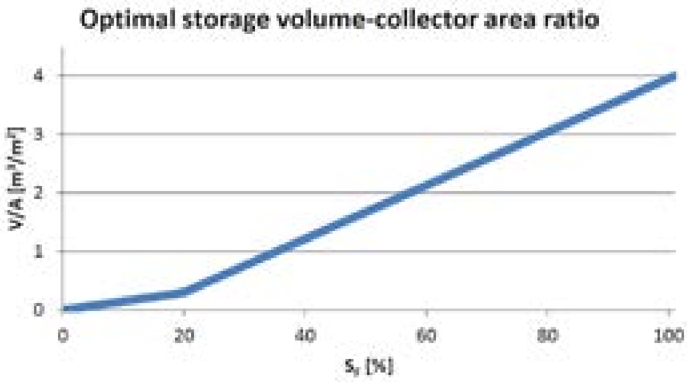
Nevertheless, an emergency concept is needed to drain the system at high temperatures and pressures in case of failure.

Combiantion with Thermal Energy Stores

Since the yield of a solar thermal system depends mainly on solar radiation and therefore cannot be controlled, in many cases a thermal energy storage (TES) system is needed. A TES can compensate for time differences in production and demand. The size of a storage tank depends largely on the coverage of the solar system. If the maximum solar yield is less than the minimum grid demand, no storage is required. In this case, the solar system can always supply all the energy to the grid and the difference to the demand is generated by an additional energy source. Depending on the summer demand, solar coverage rates of 5-10% can usually be achieved without additional storage.

If the solar system is to cover a higher fraction of the demand, the required storage volume increases disproportionately. The thermal storage then needs to cover increasingly longer periods of bad weather. In typical heating networks, a solar fraction of 15-20% is required to cover the entire summer demand with solar energy. This is particularly interesting in combination with biomass as additional heating source, as these boilers can then be completely switched off during the summer.

Higher solar coverage rates can also be achieved using seasonal storage. In Vojens (DK), for example, a solar system with 70,000 m² of collectors and a pit thermal energy storage (PTES) of 200,000 m³ achieves a coverage rate of almost 50% of the heating demand covered by the grid. The Drake Landing solar community in Canada even achieves solar fractions of 90-100% using a borehole thermal energy store (BTES).



Proposal from SDH (solar district heating) for the rough dimensioning of the storage tank for different solar coverage ratios.

Relevant sources & further information

- Webpage *on solar district heating*
- IEA-SHC Task68: *Efficient Solar District Heating Systems*
- BigStoreDH: *Grosse Wärmespeicher für Wärmenetze inkl. factsheets regarding large storages*
- Solites Rechner: *Rechner für solare Fernwärmeanlagen*

This sheet was produced by the DeCarbCH consortium, which is sponsored by the Swiss Federal Office of Energy's SWEET programme.

Pit thermal energy storage of Dronninglund (DK), the large solar thermal field installation can be seen in the background. Source: Solites

Situation in Switzerland

In Switzerland, there are some solar thermal plants that feed into thermal grids. However, these have low solar coverage rates of less than 10% and are therefore not dependent on large storage facilities.

On the other hand, Switzerland is a leader in the field of low-temperature or other energy grids, which are sometimes operated with ground storage. These networks can be supported with uncovered or PVT collectors due to the lower temperatures in the grid and the borehole thermal storage of approximately 5-30°C. Ground thermal energy storages that cool down during winter operation can be regenerated during summer using uninsulated collector technologies. For example, the world's largest PVT collector field regenerates the borehole thermal energy storage of the low-temperature grid in the Suurstoffi district in Risch-Rotkreuz. Low-temperature grids require integration concepts that differ from those presented in this fact sheet.

Contact
Florian Ruesch
OST – Ostschweizer Fachhochschule,
+41 58 257 48 31, florian.ruesch@ost.ch