SDHplus

Solar District Heating in Europe

WP3 – Case studies for changeover to SDH

Swedish SDH project activities

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Introduction to District Heating in Sweden	The majority of Swedish large and small cities and (large) villages have already district heating systems. More than 90% of the Swedish multi-family buildings are heated by district heat. The majority of the district heating systems have already large shares of RES (wood fuels and waste from RES), many close to 100%, in total about 70%. In those few cases where new DH systems are established in existing or new residential areas, it is commonly a bioenergy heating plant. The initiative to have a plant is commonly made by the municipality, in few cases a commercial developer. For further details about the Swedish framework, see D4.1 – Survey of framework and approaches in each participant country.
Short description of main SDH applications	Major opportunities to introduce solar heat in Swedish district heating systems appears in small existing or new district heating systems in combination with solid wood fuels (wood chips, wood pellets). The introduction of a solar collector array and a buffer storage will increase the investments in the heating plant, but will improve the efficiency of the wood boiler and reduce the use of wood fuel, i.e. reduce the operational costs. This application is named "**Bioenergy and Solar DH**" in the following text and is typically implemented by a municipal or private district heating operator or a municipal or a private housing owner. Another opportunity to introduce solar heat in Swedish district heating appears when a building owner wants to use solar collectors on the building in order to improve the energy performance of the building (as solar heat is defined as improving the energy performance in the Swedish building regulations, based on EPBD). This is often achieved with a so-called feed in system, i.e. the solar collectors are mounted on the building and the solar heat is fed into the DH system and the building owner is charged for the net use of DH. This application is named "**Solar heat EPBD**" in the following text and is typically implemented by a housing company in agreement with a district heating operator.

Bioenergy and Solar DH

Background

The first "**Bioenergy and Solar DH**" were built in the 80's. **EKSTA** (municipal housing company) built new residential areas in Åsa (1984-1992), Kullavik and Fjärås (1987) and Onsala (1995). All with roof-integrated solar collectors on new buildings in combination with wood briquette or wood pellet boilers for small DH systems in new residential building areas with low-energy buildings.

EKSTA has recently built a new DH system for the new residential area **Vallda Heberg** (2013). This system comprises a 250 kW wood pellet boiler, a number of buffer storage tanks and 700 m^2 of roof-integrated solar collectors and was realised during the course of SDH Plus (using Ritter XL collectors on the heating plant).

Falkenberg Energi (municipal district heating operator) built a new district heating system in Falkenberg in 1988-1989 and **Kungälv Energi** (municipal district heating operator) built a new district heating system in Kungälv in 1997-2000. Both with ground-mounted collectors in combination with wood chips boilers for DH in existing buildings. An existing oil fired small DH system at **Malmö Airport** (owned by Swedavia) was rebuilt with a wood pellet boiler and a solar collector array in 2008.

Orust municipality has recently built a new DH system in the village **Ellös** (2010). This system comprises a 4 MW wood chips boiler, a 200 m^3 buffer storage tank and 1 000 m^2 of (ARCON) solar collectors on ground and was realised during the course of SDH Take-Off. A national study tour to Ellös solar heating plant was organised within the SDH project in June 2015.

The map above shows the location of key projects for the development of "Bioenergy and Solar DH" on the Swedish west coast.

There is also a recent feasibility study for a large large collector array (10 000 m^2) in connection to bioenergy DH in **Värnamo**. See under "**Solar Heat and EPBD**".

Bioenergy and Solar DH **SDH related activities**	**Kungälv - New DH system** Main project partners: Kungälv Energi (municipal DH provider), Andersson & Hultmark (engineering consultant) and ARCON (contractor). CIT Energy Management AB was co-ordinator for the EC-project "Solar Heating Plant – 5 000 kW", in Kungälv, Sweden (REB 266/98, 1999-2001), at that time the largest solar district heating plant in Europe. **Ellös - New DH system** Main project partners: Orust municipality, Andersson & Hultmark (engineering consult) and Chalmers University of Technology. CIT Energy Management AB was involved as consultant in the design and the realisation and supervised the evaluation that was carried out as Master thesis by Halpin (2011). The MSc thesis also investigated the feasibility of a planned extension of the solar collector area. The original design comprised a system with 2 000 m^2 of ground mounted solar collectors and 200 m^3 of buffer storage, while only 1 000 m^2 were installed in 2010. CIT Energy Management AB is now involved as consultant in the redesign of plant. The main experiences from the operation of the plant the first years was that the connected heat load was less than predicted in the design and that the boiler installed was too large. The boiler has now (2015) been rebuilt to about half the power and it is possible to go on with the plans to extend the collector area. In parallel there is now also a feasibility study to use the reserved ground area for a Solar PV plant. **Värnamo – "Solar Heat and EPBD"** Main project partners: Finnvedsbostäder (municipal housing) and Andersson & Hultmark (engineering consultant). CIT Energy Management AB was involved as consultant in the feasibility study reported within EC- project SUNSTORE 4 (Dalenbäck, 2014). **Vallda Heberg – New residential area with DH system** Main project partners: EKSTA (municipal housing), Andersson & Hultmark (engineering consult), NCC (contractor) and Chalmers University of Technology. The project was initiated by EKSTA. CIT Energy Management AB was involved as consultant in the planning of the project carried out during the SDH Take-Off project. CIT Energy Management AB was further involved as consultant in the design, realisation and evaluation carried out during the SDH Plus project and supervised a master thesis by Olsson and Rosander (2014) where the thermal performance of the SDH system was evaluated. Here it should be noted that the solar heat cannot be used to "improve" the energy performance of the buildings according to the Swedish energy performance definition, as the solar collectors are mounted on sub-stations and the heating plant and not on the buildings! CIT Energy Management AB has prepared and presented the project at the SDH Plus Workshop in Braedstrup, DK, in 2012 and the initial evaluation was presented at the 2nd International conference on Solar District Heating in Hamburg in 2014 (Dalenbäck, et al, 2014), as well as at the Eurosun conference 2014 in Aix-Les-Bains (Nielsen et al, 2014). The project has further been presented as a **Case study within the SDH Plus project** (Pilot SDH, WP3).

Nacka - Fortum

Main project partners:

Swedish DH Association, Swedish Energy Agency, E.ON (Malmö), Göteborg Energi (Göteborg), AB Fortum Värme (Stockholm), Uppsala University.

SKANSKA initiated a study ”Säsongslagrad fjärrvärme via fjärrvärmenätet” (Seasonal heat via the district heating system” within the Swedish District Heating Associations R&D program “Fjärrsyn”. The study was carried out by WSP (Larsson and Håkansson, 2013). The intention with the study is to find out the possibilities to store excess heat from the Summer (waste heat, solar heat) to be used in the Winter, i.e. to replace heat from peak boilers (oil, natural gas, wood fuels).

The study is focused on the feasibility of large seasonal storages in Stockholm, Göteborg and Malmö and arrives at the conclusion that Malmö has the most favorable conditions to utilize solar heat in seasonal storages (infrastructure, space and ground conditions). The study is however based on the prerequisite that solar heat is an option that (only) could be used during the Winter as the Summer period is covered by “more favorable heat sources”, without considering other alternative system combinations.

CIT Energy Management AB was involved as a fact source and sounding board for the initial study and was later involved as a sounding board and for review of the feasibility study for a large solar heating systems, with water-filled rock caverns or boreholes in rock as seasonal storages, to be implemented in Nacka. The feasibility study was carried out at Fortum as a Master thesis by Tonhammar (2014).

The master thesis has the same narrow focus as the initial study and describes how large Swedish DH providers view the possibilities to use solar heat without a lot of interest to have a more holistic approach. The Nacka study has therefor been presented as a **Case study within the SDH Plus project** (Existing network, WP3) with a lot of lessons learned related to future project developments.

Other projects

Main project partners:

Swedish District Heating Association, Västra Götaland Region, Dalarna University, Chalmers University of Technology.

CIT Energy Management AB has disseminated results from the SDH project on misc. occasions (articles, presentations, etc.) and tried to initiate further projects. Some DH providers have shown interest in feasibility studies for “Bioenergy and Solar DH” in existing DH systems, but not strong enough to develop a study. Lack of incentives in the form of low wood chips prices and the abandoned investment subsidies are often mentioned together with increased interest for solar PV.

CIT Energy Management AB is involved as tutor for a PhD student at Dalarna University within Marie Curie project “SHINE” on the topic of solar district heating (Nielsen 2014).

CIT Energy Management AB participates in a new IEE project proposal (SDHp2m – Policy to market) with regional focus.

Solar heat EPBD

Background

The feed-in systems were pioneered by Sydkraft in 2001 in connection to "Bo01", a new residential area in Malmö with 100% renewable energy supply. The municipality wanted to support/allow solar heat used in the district heated buildings and Sydkraft designed, built and operates the systems.

Sydkraft rents the roofs were the collectors are mounted. A number of projects built and operated by the municipality followed in 2004. Sydkraft was later bought by E.ON. The feed-in systems in Bo01 were presented by E.ON during the 1st International conference of Solar District Heating in Malmö in 2013 (Rosén, 2013).

After the implementation of the EPBD directive in around 2006, "**Solar heat EPBD**" has been applied by a couple of municipal housing companies in cooperation with misc. DH utilities since 2009. These projects were further eligible for a governmental investment subsidy for solar systems (2000-2011).

All together 22 feed-in systems that were in operation in 2011 and/or 2012 were evaluated within the Swedish District Heating Associations R&D program "Fjärrsyn" and resulted in a published report in Swedish (Dalenbäck et al, 2013).

A number of feasibility studies and a number of projects have been implemented with the same approach as before the evaluation, i.e. by different stake holders using different incentives (often political). See "**Lerum municipality**" and "**Other feed-in projects**". All together there are more than 30 feed-in systems put in operation between 2001 and 2015, half of them based on Swedish building performance requirements and/or building certification (BREEAM, LEED, Miljöbyggnad) both based on the EPBD.

The feed-in systems is e.g. applied by **E.ON** in relation to EPBD requirements in new residential areas in Malmö in order to support DH in new building areas with 100% renewable energy supply. Feed-in systems using photovoltaics is also marketed by E.ON in new building areas.

There was also a feasibility study where a couple of large municipal and regional housing companies were interested to build a large collector array (10 000 m^2) in **Värnamo** and use the existing DH system to transfer the solar heat from the collector array to their buildings.

Solar heat EPBD

SDH related activities

Bo01 – Feed-in systems
Main project partners:
Swedish Energy Agency, Vattenfall, Sydkraft and misc. actors.

CIT Energy Management AB was involved as consultant within a national RD&D program where the implementation of feed-in systems in Bo01 (2001) was one of the development projects.

CIT Energy Management AB initiated the involvement of E.ON to take part in and present the Bo01 systems at the 1st International conference on Solar District Heating in Malmö, 2013 (Rosén, 2013).

Gårdsten – Feed-in system
Main project partners:
Gårdstensbostäder (municipal housing), Göteborg Energi (municipal DH provider), Andersson & Hultmark (engineering consultant), Armatec (prefab unit).

CIT Energy Management AB initiated a feed-in system demo on a multifamily building in Gårdsten, Göteborg, realised in 2010. The demo is now marketed within the Smart City project "Celsius" (Coordinator: Göteborg City).

Värnamo – "Solar Heat and EPBD"
Main project partners:
Finnvedsbostäder (municipal housing) and Andersson & Hultmark (engineering consultant).

CIT Energy Management AB was involved as consultant during the SDH project to a couple of large municipal and regional housing companies that were interested to build a large collector array (10 000 m^2) in **Värnamo** and use the existing DH system to transfer the solar heat from the collector array to their buildings. The background was that the companies had investigated the possibilities to install solar heating systems on their buildings and came to the conclusion that it would be easier and more cost efficient to build one large common solar system instead of a number of small systems on roofs.

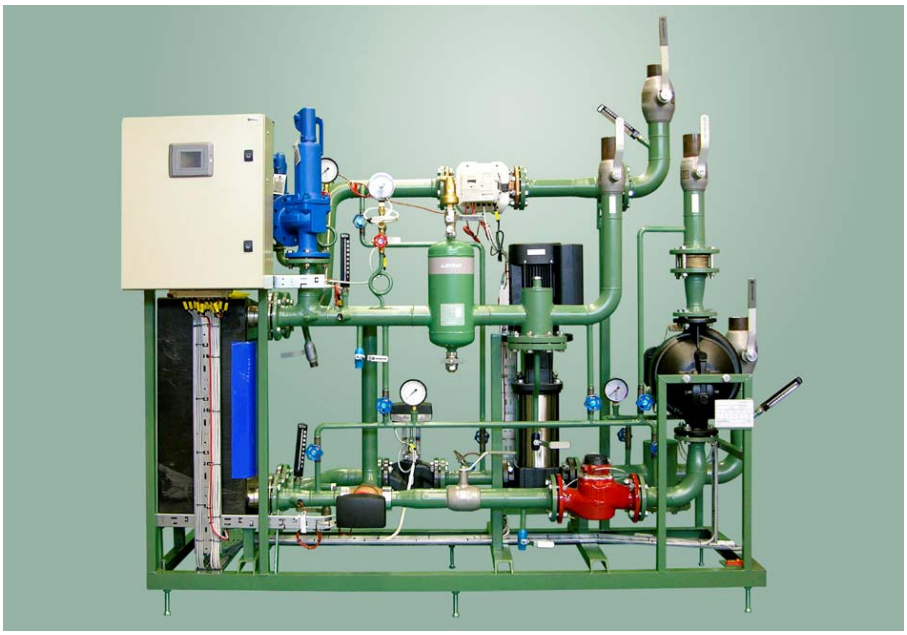
This study has been reported as a feasibility study within the SUNSTORE 4 project (FP7). The system was never realised as the project preparations (agreements between partners) were not finished when the investment subsidy expired (Dalenbäck, 2014).

Fjärrsyn - Solvärme i fjärrvärmesystem (Solar in District Heating Systems)
Main project partners:
Swedish DH Association, Swedish Energy Agency, E.ON, Fortum, Andersson & Hultmark and Energianalys (engineering consultants), Armatec (prefab unit), SP Technical Research Institute of Sweden and Chalmers University of Technology.

The development of Feed-in systems from 2001 and up till 2011 were based on different incentives (e.g. political) and involved a number of different stake holders (mainly different municipal housing companies). The main effort in connection to SDH was to carry out an evaluation of a number of systems with the aim to propose enhanced project development.

The evaluation was initiated by CIT Energy Management AB and carried out as a SDH co-financing project within the Swedish District Heating Associations R&D program "Fjärrsyn" and resulted in a published report in Swedish (Dalenbäck et al, 2013). The introductory chapter of the report describes further the development and the status of Swedish solar district heating.

The evaluation comprised 22 feed-in systems in different sizes (42 – 1 128 m^2 of solar collector area). The evaluation is based on the thermal performance in operation in 2011 and/or 2012. Bo01 and Gårdsten (above) are among the evaluated systems and Gårdsten was one of the systems with the best thermal performance. The main result from the evaluation was presented at the 1st International conference on Solar District Heating in Malmö in 2013 (Dalenbäck, 2013).



Prefab unit from Armatec used in a number of feed-in systems.

The result of the evaluation showed a number of problems, related to design as well as O&M, to be solved in order to have a positive development. See **D2.5** for more details. It was then the intention to form a national framework program for the continued development of feed-in systems or "Solar heat EPBD" systems, but the withdrawal of the investment subsidies for solar heating systems in 2012 made it difficult to gain a common interest for the approach.

Nevertheless, a number of feasibility studies and a number of projects have been implemented with the same approach as before the evaluation, i.e. by different stake holders using different incentives (often political).

The feed-in systems is now also applied by **E.ON** in relation to EPBD requirements in new residential areas in Malmö in order to support DH in new building areas with 100% renewable energy supply. Feed-in systems using photovoltaics is also marketed by E.ON in new building areas. One feasibility study has been carried out as a BSc thesis (Elofsson and Olofsson, (2014).

Lerum Minicipality – "Solar Heat and EPBD"

Main project partners:

Lerum municipality, Förbo (municipal housing), Energianalys (engineering consultant), Chalmers University of Technology.

CIT Energy Managament has been involved as advisor and consultant for a number of solar heating projects initiated by Lerum municipality.

Lerum municipality has a strong (political) ambition to be environment friendly. Lerum Fjärrvärme (municipal DH provider) runs three different heating plants in the municipality, all based on bioenergy. Lerum municipality is an example where (political) ambitions sometimes are in conflict with the required knowledge and experience.

The municipality board had decided that all new municipal buildings (e.g. schools) should have solar heating systems. The municipal office wanted to have an evaluation of a rather large solar heating system on one of the new schools (Rösalidskolan), where the system was designed by the contractor (within a total contract with the lowest bid according to LOU*). The evaluation (Lind and Nordmark, 2012) showed that the system was much too large in relation to the DHW load in the Summer and suggested to rebuild it and feed the solar heat into the local district heating. Lerum Fjärrvärme refused to have such a system as it would interfere with their boiler operation. The result is that the municipality board has changed their decision in favour of PV systems.

Rösalidskolan in Lerum with roof-mounted solar collectors.

Förbo (local municipal housing) planned to build a "PlusEnergyHouse" (in this case a "PlusHeatHouse", i.e. the annual yield from solar collectors on the building should exceed the heat used in the buildings during one year). Lerum Fjärrvärme accepted to make an agreement where Förbo could buy district heat when needed and feed solar heat into the local DH system when needed. The solar system went to an new contractor using a new type of collectors (lowest bid according to LOU*) and the contractor went out of business before the system was put in operation. The system is now up and running after a saving action among others supported by CIT Energy Management AB.

*LOU = Tendering procedure to be used by municipalities.

Two out of four “PlusHeatHouses” with roof-mounted solar collectors.

Lerum municipality initiated the Life-project “Noisun” with the intention to mount solar collectors as/on a sound barrier between the railroad and buildings in Lerum. The project is developed in cooperation with Trafikverket (national agency for roads, railroads, etc.), SP Technical Research Institute of Sweden (Sound and solar collectors) and Lerum Fjärrvärme, as it was the intention to connect the sound barrier to the local DH system. It was further the intention to develop a new type of sound barrier solar collector based on a local initiative. The project is presented at the web page www.noisun.eu.

Solar collectors mounted on a sound barrier in Lerum.

CIT Energy Management AB was initially involved in the reference group, but decided to stay out of the project based on previous experiences from working with Lerum municipality and Lerum Fjärrvärme.

Back side of the sound barrier and DH substation.

The project was redesigned and is now realised with established contractors, and in operation since Spring 2015 with traditional solar collectors (850 m^2) and the same sub-station as previously used in Gårdsten. It should however, be noticed that the system had to be equipped with a cooler, so that Lerum Fjärrvärme can close the connection in case they do not want to use the solar heat !

Other feed-in projects

Main project partners:

Energianalys and WSP (engineering consultants), Dalarna University, Chalmers University of Technology.

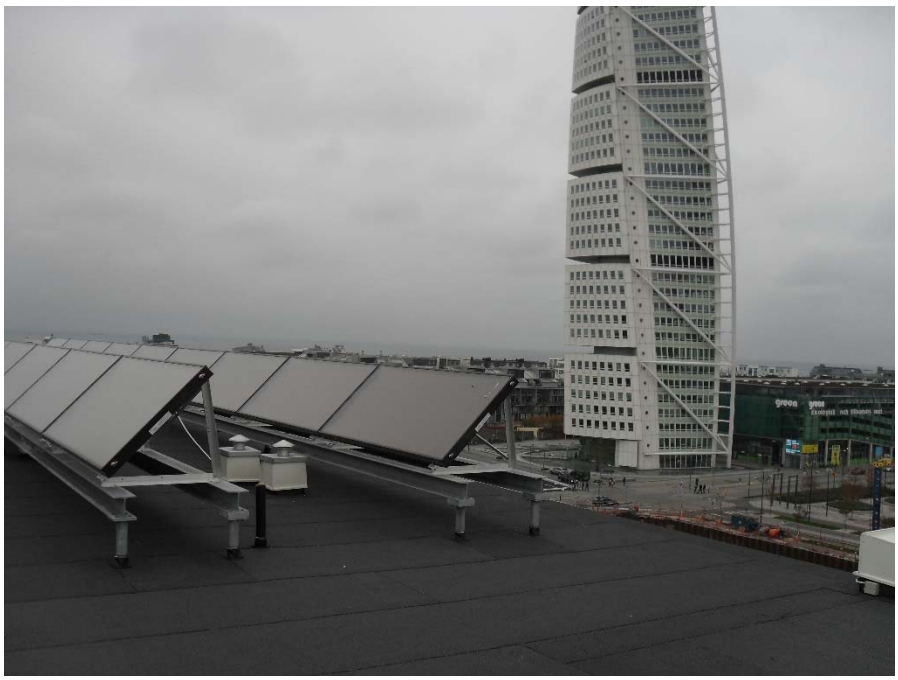
CIT Energy Management AB is used as sounding board by Energianalys in misc. project developments. There were a number of projects that did not meet the requirements to be included in the "Fjärrsyn" evaluation of the 22 feed-in systems, e.g. to have been in operation for more than 1 year in 2012, where Energianalys has been involved. These projects are described in ordinary contract documents and the performances of the plants have not yet been evaluated by a third party.

The "PlusHeatHouse" by Förbo (municipal housing company) with 430 m^2 of solar collectors on four new buildings (See "Leum municipality"). The solar collectors were installed already 2011, but Förbo had to find another contractor to finalize the installation. Sjöstadverken in Karlstad, a feed-in system partly used for heating in a biogas plant, was also put in operation in 2011.

Vattenfalls new head office in Solna (Stockholm) is equipped with a feed-in system with 430 m^2 of roof-mounted solar collectors in order to improve building energy performance according to the EPBD. WSP carried out a feasibility study, Energianalys designed the system, Norrenergi is the DH provider and the plant was put in operation in 2012.

Energianalys has recently been involved in the design of a feed-in system for a new building (Masten 3), in a block close to Bo01 in Malmö. The solar feed-in system is motivated by the requirements that the building should be certified according to BREEAM. Diligentia is the building owner, E.ON is the DH provider and the system is in operation since Spring 2015. Energianalys has also been involved in the "Noisun" project (See "Lerum municipality").

Solar collectors on one out of two roofs 60 m above ground – Vattenfall, Solna.



Solar collectors on new building close to “Turning Torso” – Diligentia, Malmö.

Energianalys has further initiated an R&D project about feed-in systems together with Dalarna University and Lund University, partly financed within the Swedish District Heating Associations R&D program “Fjärrsyn”. An initial article was presented at the 3rd International conference on Solar District Heating in Toulouse, June 2015.

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