Dronninglund Solar thermal plant

Solar thermal plant at Lunderbjerg, west for Dronninglund

Dronninglund Fjernvarme (Dronninglund District Heating)
PlanEnergi and Niras

The story

Dronninglund Fjernvarme is a consumer-owned cooperative. In 1989, it became the first Danish district heating company to install natural gas-driven engines for combined heat and power production.

Around 2005, the board and the general assembly of Dronninglund Fjernvarme realized that they should replace natural gas with renewable energy over time.

At that time, several Danish district heating companies had installed solar thermal plants that covered approximately 20 % of the yearly heat production. However, Dronninglund Fjernvarme wanted to take it a step further and aspired to cover up to 50 % of the yearly production with solar heat. In 2007, Nordjyllands Vækstforum subsidized a pre-feasibility study. The study showed that a solar thermal plant with seasonal storage could cover up to 50 % of the heat consumption. Furthermore, the heat production price would not be increased for the consumer with a subsidized investment. Therefore, Dronninglund Fjernvarme decided to continue the project and applied for subsidy from EUDP (Energy Technology Development and Demonstration Programme), a program financed by the Danish state. The application was approved and subsidy was granted for detailed design and for investments in long-term storage, piping, heat exchangers and a control system to connect the production units.

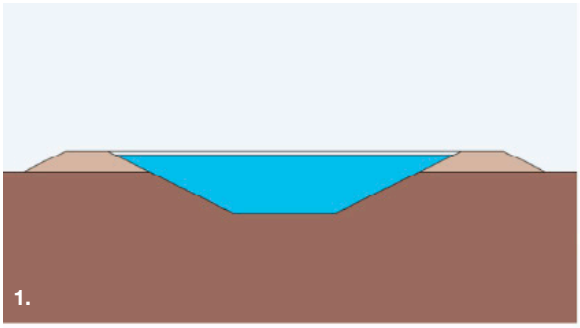
1. Cross-section of pit heat water storage
2. The water storage integrated in the surroundings
3. Situation of the water storage and the solar thermal plant.
4. Cross-section of the water storage and technique building with pipes, pumps and heat exchangers

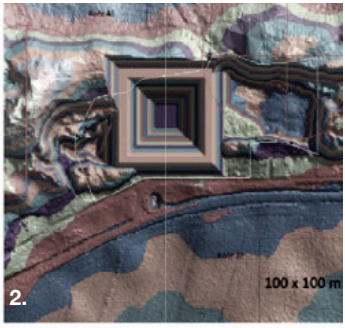
Why is the plant placed in a gravel pit?

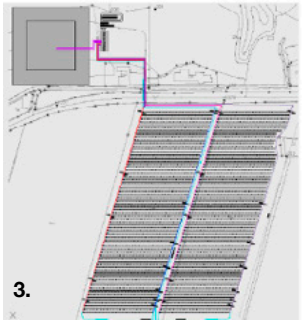
Pit heat water storage is made by digging a hole formed as an upside-down pyramid cone and use the soil as banks. It is ideal if the ground water level is below the storage.

Geotechnical investigations showed that it was impossible to find locations close to Dronninglund that fulfilled the above conditions. The ground water level was high and the soil was not usable for banks. The only place where the conditions could be met was in an abandoned gravel pit.

The solar thermal plant must be located near the water storage, but the area near the gravel pit was classified as “valuable cultural environment” in the regional plan. Besides that, distance to old viking tombs, distance to forest, protection of drinking water, etc. had to be taken into account. The last approvals for the project were given in October 2012, and call for tender and implementation could begin.

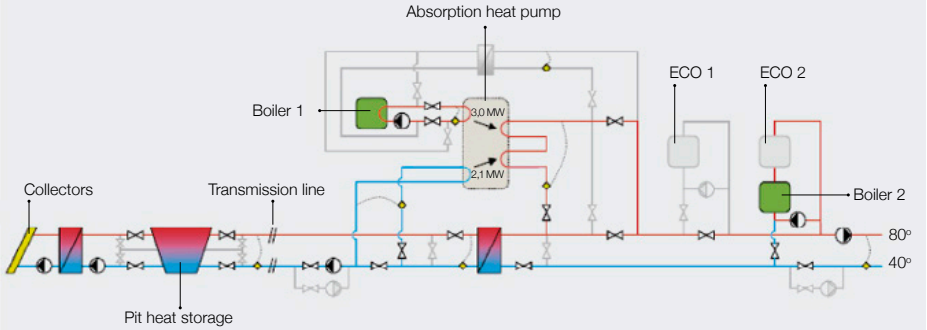






The new production plant

The main components in the new production plant are a large solar thermal plant and a pit heat water storage. In the summer, the solar thermal plant produces much more heat than Dronninglund consumes. The surplus is used to heat up the water storage. In the autumn, the storage is cooled down by adding water with district heating return temperature to the bottom of the storage and send hot water from the top of the storage to the city. The district heating return temperature is approximately 40º C. To utilize the storage further, it is cooled down from 40º C to 10º C as heat source for a heat pump. This will increase the storage capacity before the next summer, reduce the heat loss and increase the production from the solar collectors.



// Principle diagram. Yellow squares are flow/energy meters.

Placement of the components

The placement of the components can be seen below:

1. Solar panels in solar thermal plant
2. Pit heat water storage
3. Technique building with pipes, pumps and heat exchangers
4. District heating pipes
5. Søndervang with absorption heat pump

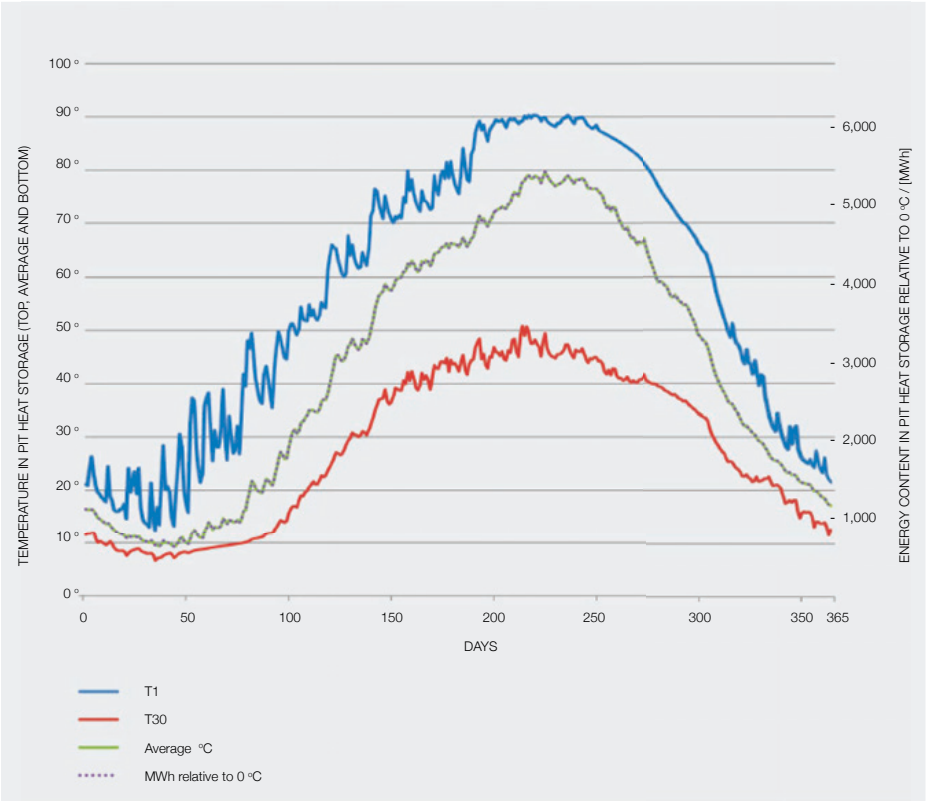
The solar thermal plant

The solar thermal plant consists of 2,982 solar panels or 37,573 m^2 from Arcon Solar. The panels are divided into fields, each connected to a heat exchanger in the technique building. Maximum power from the collector fields is 26 MW – this can be compared to the maximum consumption, which is 12 MW in the coldest winter periods. Each row in the collector fields has 21 solar collectors connected in sequence. The cold water is heated gradually through the 21 solar collectors. This ensures that the temperature in the last solar collector of the sequence is as decided in the control system. The solar collectors are mounted on galvanized steel profiles processed into the ground. At the opening in May 2014, the solar collector field was the largest in the world.

// Photos from construction showing foundation and mounting solar panels

The technique building

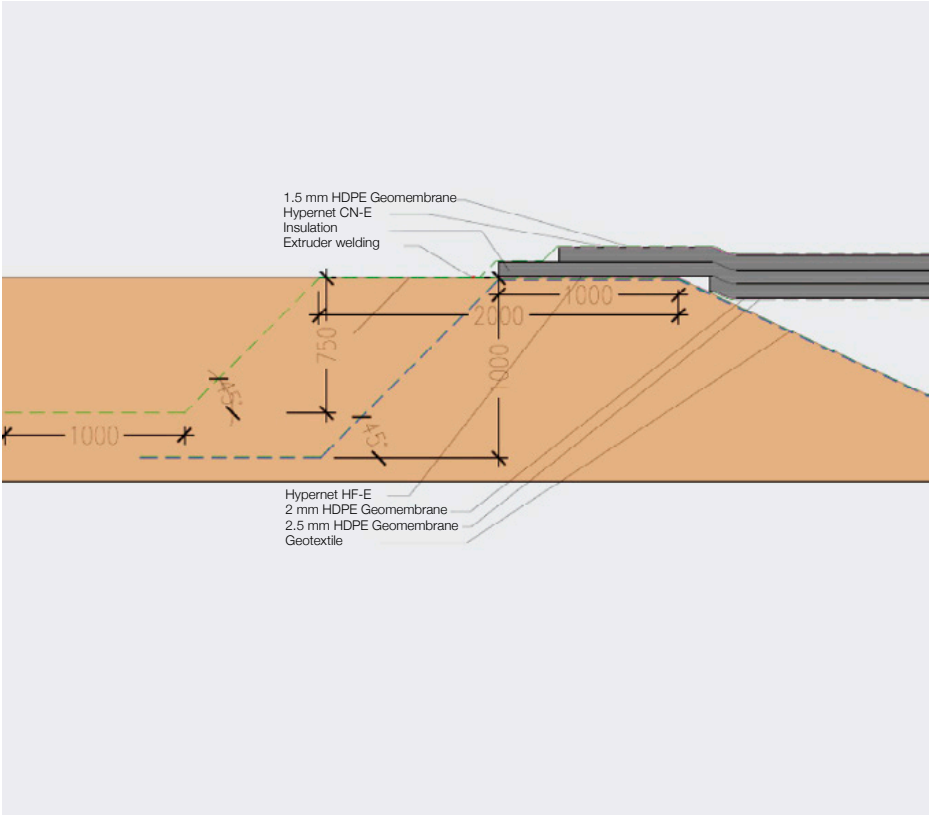
The technique building contains heat exchangers and pumps. If, during the winter, the solar collectors can produce water with temperatures beyond the bottom temperature in the storage, the solar collector pumps start and the storage is heated up. During the summer, the flow from the solar pumps is regulated to ensure that the production temperature exceeds the district heating flow temperature (approximately 75º C). When the production is higher than the consumption in the city, the storage is heated by adding hot water to the top of the storage and send cold water out of the bottom. The calculated storage temperatures during the year can be seen below (top, average and bottom temperatures).



The water storage

The water storage contains 60,000m3 water. Construction of the storage began in March 2003 and ended in November 2013. Inlet and outlet pipes run through the bottom, as the bottom of the storage lies at the same level as the technique building. The storage is tightened using a 2.5 mm welded polyethylene liner. Tightness of all of the welding is tested after welding is completed. The supplier of the liner has guaranteed a 20-year lifetime if the liner temperature does not exceed 90º C.

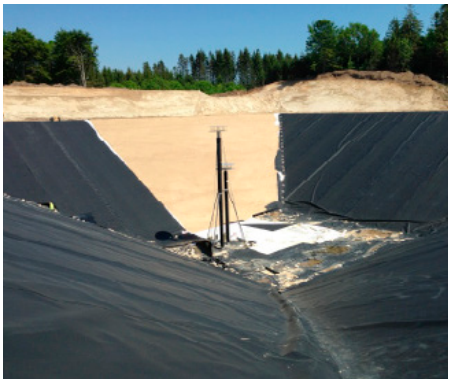
When the liner was implemented by the end of June, water filling could begin. Drinking



water from Dronninglund water company was used, but oxygen salts and calcium were removed from the water. The lid is constructed by welding a 2 mm polyethylene liner onshore and pulling it gradually over the water. Thereafter, the insulation is constructed on top of the liner, floating on the water.

On the inside and on the surface of the lid, weight pipes (plastic pipes with concrete) are mounted in order to create a slope towards the middle of the lid, where rainwater is collected and pumped away.

The top of the lid is a roof foil with vacuum vents removing moisture coming from the storage through the polyethylene liner.



// Photos from construction of the pit heat water storage

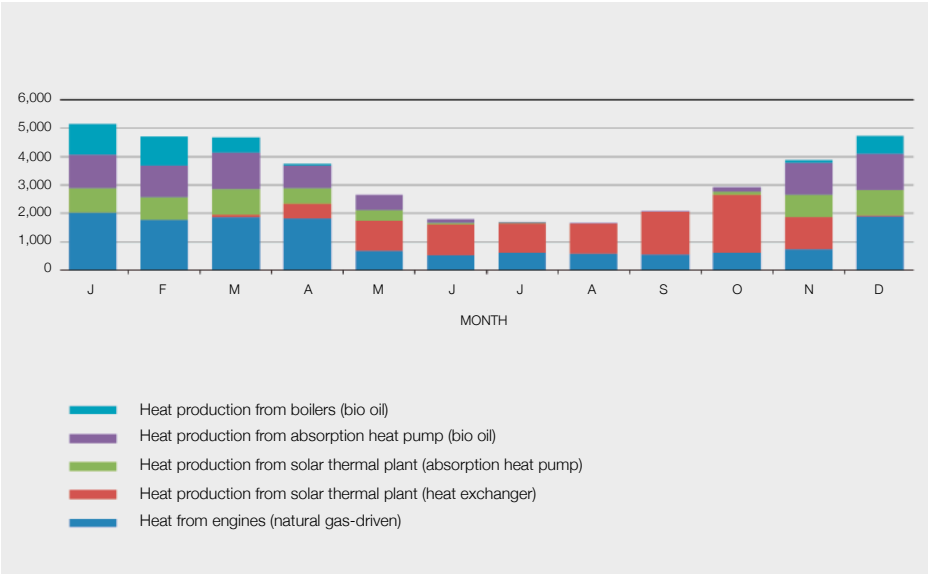
The heat pump

The heat pump is an absorption heat pump driven by heat from a bio oil boiler placed at Søndervang in Dronninglund. The bio oil boiler heats up the water to 160º C. The hot water runs the absorption heat pump. The heat pump uses the storage water as heat source and produces district heating at flow temperature.

Heat production

The future heat production from solar collectors to the water storage is calculated to 17,453 MWh/year.

The monthly production from the different plant components is expected to be as illustrated below:



List of suppliers

Consultant:
CVR 74038212
PlanEnergi

Consultant:
CVR 37295728
NIRAS

Solar collectors supplier:
CVR 10778530
ARCON SOLAR

Main entrepreneur:
CVR 28098197
AEA
Averhoff Energi Anlæg A/S

Excavation, storage:
CVR 18458144
JAKOBSEN & BLINDKILDE
ENTREPRENØRFIRMA

Liner work, storage:
CVR 35051473
PBJ Miljø

Pipes supplier:
CVR 21330248
LOGSTOR

Entrepreneur, transmission pipes:
CVR 86503417
L&H-Rørbyg
Vi gør det nemt for dig

Electrical installations:
CVR 32272843
DRONNINGLUND EL-SERVICE A/S

Control system:
CVR 12047495
DME
Dansk Miljø- & Energistyring A/S

Building:
CVR 30533704
JE BYG APS
MURER & ENTREPRENØR

Boiler and heat pump:
CVR 16147249
danstoker

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eUDP

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PlanEnergi and Niras