Market uptake of small modular renewable district heating and cooling grids for communities

Project No: 691679

CoolHeating Study Tour in Denmark

WP 2 – Task 2.3 / D 2.3

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Authors: Linn Laurberg Jensen, PlanEnergi, Denmark

Contact: Linn Laurberg Jensen
PlanEnergi
E-mail: llj@planenergi.dk
Vestergade 48H
8000 Aarhus
www.planenergi.dk

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CoolHeating website: www.coolheating.eu

Content

1 Introduction

The objective of the CoolHeating project, funded by the EU's Horizon2020 programme, is to support the implementation of "small modular renewable heating and cooling grids" for communities in South-Eastern Europe. This is achieved through knowledge transfer and mutual activities of partners in countries where renewable district heating and cooling examples exist (Austria, Denmark, Germany) and in countries which have less development (Croatia, Slovenia, Macedonia, Serbia, Bosnia-Herzegovina). Core activities, besides techno-economical assessments, include measures to stimulate the interest of communities and citizens to set-up renewable district heating systems as well as the capacity building about financing and business models. The outcome is the initiation of new small renewable district heating and cooling grids in 5 target communities up to the investment stage. These lighthouse projects will have a long-term impact on the development of "small modular renewable heating and cooling grids" at the national levels in the target countries. A key objective of the project is to exchange information on best practices for small modular district heating and cooling systems.

CoolHeating organises three study tours for target country stakeholders and project partners to best practice (BP) examples in Germany, Denmark and Austria (http://www.coolheating.eu/map/). The objective of the study tours is to show project partners and stakeholders from the target countries examples of small renewable district heating and cooling grids and to facilitate networking among the relevant partners.

The first study tour was organised for the project participants on occasion of the Kick-off-Meeting in Germany on 26/27 January 2016. The second study tour was organised on 21-23 September 2017, on occasion of the project meeting in Denmark. The present report is a summary of the study tour in Denmark. A third study tour is planned for January 2018 in Austria.

2 Acknowledgements

The consortium would like to thank the persons from the site visits of the study tour in Denmark for their time and efforts to guide the participants through their facilities: **Jan Jantzen** and **Michael Kristensen** for their presentation on local ownership at Samsø Energy Academy and **Jim Larsen** for the guided tour at Brædstrup DH. Also, great thanks to the SDHp2m Conference and the persons involved in the organized study tours in relation to the conference.

3 Overview on the study tour

The CoolHeating consortium met for the first progress meeting in Denmark in September 2016. The progress meeting took place in Billund, giving the CoolHeating partners the opportunity to participate in the SDHp2m conference[1], which is relevant in the context of renewable DH solutions. The overall schedule for the stay in Denmark is shown in Table 1. The detailed flyer from the study tour in Denmark is seen in presented in ANNEX A.

Table 1: Schedule and logistics for the first progress meeting and study tours in Denmark.

	Monday 19 September	Tuesday 20 September	Wednesday 21 September	Thursday 22 September	Friday 23 September
Morning		Project meeting	SDHp2m-conference	SDHp2m-conference	Check out Hotel 8:15 Ferry and bus Study tour: Brædstrup
Afternoon	Travelling	Project meeting	SDHp2m-conference Study tour	Bus and ferry to Samsø. Study tour: two DH-plants	Brædstrup Bus to Billund
Evening	Arrival, check in	Joint project dinner with the SDHp2m-project partners	SDHp2m-conference dinner	Dinner Seminar Samsø Energy Academy	
Hotel	Billund	Billund	Billund	Samsø	

Please see information in e-mail 20 May 2016 on hotels.

Please see information in e-mail 20 May 2016 on registration to the SDHp2m-conference.

The internal CoolHeating progress meeting took place on Tuesday the 20st of September, followed by the SDHp2m conference, where the CoolHeating was represented with a stand and two presentations. Furthermore, the first site visit of the CoolHeating project included a visit to the Gram Solar district heating plant, organised by the SDHp2m conference.

On Thursday morning, the SDHp2m conference continued and at lunch time, the CoolHeating study tour officially started. The study tour participants travelled to Samsø to see some of the local DH plants at the island and to participate in a seminar at the Samsø Energy Academy. Samsø is famous renewable energy island due to its various renewable energy projects and as its goal is to be fossil free by 2030.

On the way home from Samsø, a visit at the Brædstrup DH plant was arranged. Brædstrup DH is one of the Danish guiding examples.

[1] **SDHp2m** stands for **S**olar **D**istrict **H**eating (SDH) and actions from **P**olicy **to** **M**arket. The project addresses market uptake challenges for a wider use of district heating and cooling systems (DHC) with high shares of RES, specifically the action focuses on the use of large-scale solar thermal plants combined with other RES in DHC systems. See more at http://solar-district-heating.eu/SDHrelatedprojects/AboutSDHp2m.aspx and http://solar-district-heating.eu/NewsEvents/SDHConference2016.aspx, where it is possible to download the presentations from the conference and the book of papers.

4 Study tour visits

4.1 SDHp2m Conference

The participation in the SDHp2m Conference gave the CoolHeating Consortium the opportunity to get a more comprehensive understanding of the use of solar thermal applications in district heating (and cooling) systems. Solar thermal applications were represented at different technical levels at the conference. This gave the participants an opportunity to learn more about the technical aspects of solar thermal heating, the potential of using the technology as well as an understanding of how solar thermal can be combined with other technologies such as biomass[2].

At the conference, that CoolHeating project was represented by a stand with dissemination material from the project.

The CoolHeating project applied for presentations at the conference by submitting abstracts. The project was finally represented by two presentations:

- Small, modular and renewable district heating and cooling grids for communities in South-Eastern Europe by Dominik Rutz, WIP Renewable Energies

  In the category of “RES and solar district heating in your country – market aspects”

- Local approach to renewable district heating: case study Croatia by Borna Doracic, University of Zagreb in the “Poster session”.

The presentations and the book of papers are available at http://solar-district-heating.eu/NewsEvents/SDHConference2016.aspx.

4.2 Gram District Heating

The visit at Gram DH was part of the program of the SDHp2m Conference and took place on Wednesday, 21st of September 2016. Gram DH is an interesting plant to see due to the new established large scale solar field combined with seasonal storage. An overview of the technical data of the DH plant in Gram is shown in ANNEX B.

Figure 1: Left: The visitors walking on the top of the seasonal storage, right: part of the solar field (Photos by Kristina Bozhkova).

Gram District Heating Company was until 2009 based on natural gas with a CHP unit and two boilers. The heat capacity of the CHP unit is 6.5 MW and the heat capacity is 5.0 MW for each boiler. The annual heat demand is around 30,000 MWh.

[2] The program from the SDHp2m Conference can be found at: http://solar-district-heating.eu/Portals/0/SDH%20Conference%202016/SDH%20Program_2016.pdf

The first phase of the solar field was established in 2009 and covers more than 10,000 m^2 with a maximal output capacity of 6.5 MW. The solar field could cover around 15 % of the heat demand and was connected to the existing storage, a steel tank of 2,300 m^3. The solar collector field is connected to the plant by a transmission line (DN200) that is approximately 200 m long. The construction cost of the first solar field was around 2.4 million EUR. The solar collector field was expanded in 2015 to have an area of 44,800 m^2 in total. After the expansion, the system is expected to be able to cover about 60 % of the heat production. The high penetration rate is only possible through the establishment of a seasonal pit storage, an absorption heat pump and an electric heat pump which allows the collectors to operate at a lower temperature, whereby the efficiency increases significantly.

The purpose of the electrically-powered heat pump is to cool the bottom of the seasonal heat storage. By cooling the bottom of the heat storage, the operating hours of the solar plant is increased and thus the utilization of the solar system is increased. The CHP unit delivers the driving energy to the absorption heat pump. This is done by replacing the high temperature flue gas heat exchanger with an approved exchanger for heated water above 150 °C. To utilize energy from the CHP unit's exhaust gases an additional low-temperature flue gas exchanger is implemented to cool the exhaust gas down to about 20 °C. This results in an excess of cooling water that can be recovered for further optimization of gas boilers, solar heating and an electric driven heat pump. A performance of 450 – 500 kWh/m^2/year is expected from the total solar system.

Figure 2: The seasonal pit storage and the solar field under establishment. To the right is the existing 10,000 m^2 and at left and front is seen the area where the new solar panels installed together with the seasonal pit storage, picture by Gram Fjernvarme

Gram DH is close to a carpet factory. The carpet factory currently has two processes that have delivered surplus heat to Gram District Heating since June 2016. The surplus heat is supplied at a temperature of 69 °C, so they only needed to establish a service line between the plant and the factory. To retrieve the excess heat, two new heat exchangers were installed in the processes. It is expected that 2,000 MWh/year can be optained. To deliver excess heat from the factory is part of the factory´s commitment to the concept of cradle to cradle.

Figure 3: The new solar system established in 2015 including solar voltaic panels on the south side of the seasonal pit storage, picture by Gram Fjernvarme

4.3 Jelling District Heating

As an alternative to the site visit to Gram, the participants could also chose to visit the district heating of Jelling.

Figure 4: Jelling DH plant (http://www.jelling-varmevaerk.dk/).

Data from the DH plant can be found at the Jelling DH plant's webpage: http://www.jelling-varmevaerk.dk/ (only in Danish). From here, it can be seen that Jelling DH was founded in 1960, and there are 999 consumers affiliated as of May 1st 2017.

The plant consists of approximately 15,000 m^2 of solar panels, a natural gas-powered boiler as well as a cogeneration plant based on natural gas and a woodchip boiler. This means that 51 % is "green" energy production.

The Board of Directors of Jelling DH formulated the vision and strategy: "Jelling DH ensures attractive and sustainable heat!! This is achieved through strategic goals with environmentally friendly operations, business and development-oriented management in openness. Jelling DH should not appear as an island in modern energy production, but rather engage in and identify potential relationships and networks within the industry" (translated from Danish).

Figure 5: Right: The two new accumulation tanks in relation to the solar field under construction, right: view of the solar field (http://www.jelling-varmevaerk.dk/solvarme).

4.4 Samsø: Nordby/Mårup District Heating

The Nordby-Maarup DH plant supplies district heating to the villages of Nordby and Maarup. The heat is mainly generated by the combustion of wood chips in a 900 kW boiler. The plant has also a field of solar panels (app. 2,500 m^2) as a supplementary source of heat. During the summer-period the solar field supplies all energy in extended periods of time. For more details, please see technical data in ANNEX B[3].

Figure 6: Photos from Nordby/Mårup Varmeværk with solar DH and biomass (L. Laurberg Jensen)

The energy company NRGi owns and operates the plant. According to the original master plan, this plant was to be the last to be built. But a local group of citizens managed to accelerate the project and finish it five years before the final deadline. Some points on the history of the plant are given below:

1998: After a citizens meeting, a local work group asks the energy company NRGi to design a district heating plant. Meanwhile the work group walks from door to door to talk to the potential consumers, and the group is highly active in all respects.

1999: NRGi submits the first project proposal end of November 1999.

[3] More information about the plant can found at
http://seacourse.dk/wiki/tiki-index.php?page=District+Heating+Plant%2C+Nordby-Maarup and
http://www.solarge.org/fileadmin/media/docs/danish/DKGPAnlaegseksempler/Samsoe_gpsheet.pdf

2000: After negotiations — with the national authority (the Danish Energy Agency), the municipality, and the Samsø Energy Company — the energy company NRGi submits its second revised proposal in October 2000.

2001: The municipality pre-approves the proposal, then the Danish Energy Agency approves. The municipality gives its final approval on the following conditions: that all municipal buildings connect to the distribution net, that at least 70 % of all houses with own central heating agree to connect, that all new buildings are obliged to connect, and that the owner tries to utilize local energy crops such as elephant grass. The wood-chip boiler was in operation in November this year.

2002: Start-up of solar array in April.

4.5 Samsø: Ballen – Brundby District Heating

The district heating plant between the villages of Ballen and Brundby runs on shredded straw. The boiler has a heat capacity of 1.6 MW. See more technical details in ANNEX B and on the following website: http://www.bbf-veo.dk/.

The plant supplies DH to the two villages by transporting the hot water through seven kilometres of highly insulated pipes. The consumers own the plant through a cooperative. It is the only heating plant on the island of Samsø, which is owned entirely by the consumers.

Figure 7: Left: The group outside Ballen-Brundby DH plant, right: the group inspecting the plant (photos: L. Laurberg Jensen).

How the plant was initiated is shortly described in the following points[4]:

1998: The original plan was to build a district heating system for four villages: Ballen, Brundby, Ørby and Permelille. At a meeting with the citizens of this area in Brundby, a work group of local people was defined. The meeting particularly aimed to define this group of people representing the four villages.

1999-2002: The group asked the energy company NRGi to establish a district heating plant for the four villages. Calculations soon showed that the economy was not sound. The villages Ørby and Permelille were too far away, causing large heat losses in the distribution system. Furthermore, the number of potential district heat consumers was relatively small in these two villages. The group accepted this verdict, and the group was reduced to citizens from Ballen and Brundby. NRGi proposed several plans for the area of Brundby and Ballen, but the potential heat consumers rejected all. In October 2002 NRGi gave up looking for an acceptable economic model for the project, and they withdrew from the planning.

[4] Taken directly from:
http://seacourse.dk/wiki/tiki-index.php?page=District+Heating+Plant%2C+Ballen-Brundby&structure=REE

2003: The remaining members of the group and the Samsø Energy Company decided to try one more time. First all potential district heat consumers were asked to say whether or not they were interested in joining the district heating system. The consumers were promised heat prices similar to those in Onsbjerg, the cheapest on the island. The group then decided to work for a cooperative model, whith the consumers owning a straw fired plant. The workgroup held 11 meetings and 2 public metings. They distributed a folder to the villages. Finally they conducted a general assembly meeting which elected six board members from the villages. The six were later supplemented by a seventh board member from the municipality, and the municipality must approve the energy price asked from the consumers.

2004: Plant construction and commissioning.

2005: In operation.

4.6 Samsø: Energy Academy

In 1997, the island of Samsø Island with almost 5,000 permanent inhabitants decided to become 100 % renewable energy based. Later, a new vision was formed for a fossil fuel free island, and this is now promoted by the ”Samsoe Energy Academy” that was formed during the development of the renewable energy island.

Samsø began to inform island citizens about the potential and perspectives in the Energy Island project in 1998. There was a “Ten Year Plan” to guide the project[5].

Samsø is now looking at the plan ‘Samsø 3.0’ with the following steps on the way:

- 100 % self-sufficient when it comes to energy. In 2011 the “Version 2.0 from best to next praxis”, began a new conceptual process where the goal was being able to be called “Denmark’s renewable energy island”.
- Targeting being independent of fossil fuels. Headings in 2011 also referred to all the work that had to be scheduled in the process of the island to be fossil fuels independent by 2030.

It’s has been a success for Samsø energy Academy and Samsø municipality. Therefore, the island moves forward towards “Version 3.0” that includes circular bio economy, which can be crucial in small and medium-sized enterprises on the island.

A great deal of the success for Samsø is due to the involvement of citizens. The focus of the presentation at the visit to the Energy Academy was therefore on citizen involvement.

[5] https://energiakademiet.dk/en

Figure 8: Photo from the seminar at Samsø Energy Academy on local ownership (L. Laurberg Jensen)

Samsø has worked with local ownership to ensure local involvement and support of the projects. Some examples that can be mentioned in relation to energy production are wind turbines and the DH plants;

- Eleven 1 MW wind turbines makes the island self-sufficient with electricity. They were erected in 1999-2000. The wind turbines are owned by a windmill cooperative and by individual owners.
- Samsø's district heating systems are also owned in different ways. The DH plants based on straw, woodchip and solar thermal heating have diverse forms of ownership;

The cooperatively owned regional utility, NRGi, owns and operates the straw based heating plant in Tranebjerg and the combination woodchip/solar heating plant in Nordby/Mårup on normal commercial terms. The straw-based plant in Ballen/Brundby is a consumer owned heating system owned exclusively by the consumers themselves. The DH system is run by a locally elected committee. Every consumer is eligible for election and the elected members are the governing body for the heating plant. The heating plant in Onsbjerg is organized as a limited company owned by a local contractor, the Kremmer Jensen brothers. The plant is run by a local committee with consumer and municipal representation. The former have two seats, while the island municipal council has one seat. There is also several smaller, so-called neighbourhood district heating plants, systems set up to heat some few houses, a school or an institution as examples together with the straw based boilers at Samsø Jr. College and Brattingsborg Castle, and the wood pellet furnace at the Samsø Folk High School[6].

An overview of the ownership model in each DH plant at Samsø:

[6] Text based on: https://energiakademiet.dk/en/vedvarende-energi-o/

- Tranebjerg: Run on normal commercial terms
- Nordby/Maarup: Run on normal commercial terms
- Ballen/Brundby: Consumer owned
- Onsbjerg: Private company ltd

The involvement in the different projects at Samsoe can be set up by a triangle consisting of:

- The Municipality
- The citizens
- (Local) Entrepreneurs

The municipality supports the ideas in terms of planning and to provide the opportunity to invest in the projects. The citizens have the opportunity of local ownership. Local entrepreneurs are involved. The development was ensured by the motivation of driving citizens (known as ildsjæle in Danish, directly translated to "firesouls") to change things. The creation of local jobs has been a great driver at Samsø, where the project combined has created 35-40 jobs today – and more in the process and under the establishment of e.g. the DH plants[7].

4.7 Brædstrup District Heating

The group visiting Denmark in September 2016 visited Brædstrup District Heating on the way back from Samsø. Brædstrup DH is a consumer owned company with many different technologies. Brædstrup DH is owned by almost 1,500 consumers and started as a traditional co-generation plant including CHP and boiler units. The first step towards increasing the plants efficiency was taken in 2006 where one of the boiler units was replaced by a new unit with an efficiency of 104 %. Today, the plant is producing heat by various technologies:

- 18,600 m^2 solar collectors established by 8,000 m^2 in 2007 and 2012 10,600 m^2
- Electric boiler, 10 MW, 2012
- Heat pump (high pressure screw compressor), 1.2 MW, 2012
- Boiler 1, natural gas, 13.5 MW, 2006
- Boiler 2, natural gas, 10 MW
- Engine 1, natural gas, 4.1 MW (8.7 MW fuel)
- Engine 2, natural gas, 4.1 MW (8.7 MW fuel)

The plant also has a cylindrical buffer tank for daily heat demand variations and a borehole storage used for seasonal variations in demand and production. See more technical information in ANNEX B.

The visit started by an introduction at the plant by the daily manager of the plant, Jim Larsen. He could among other things tell that Brædstrup DH over the last 10 years has been a frontrunner in Denmark in how to make district heating efficient, cheap for the consumers and environmentally friendly at the same time. This is done through activities in the electricity market, smart metering and introduction of service visits and support to improvement of house installations. Increasing the efficiency and optimizing the production and distribution

[7] Information from the presentation at Samsø Energy Academy

facilities in terms of technical economic and environmental aspects are central parts of the district heating company´s future policy.

After the presentation, all visitors were invited to join Jim Larsen on a guided tour of the plant, seeing all the production units at the plant. Brædstrup DH made design calculations in 2005 showing that solar DH combined with CHP in an open electricity market could be a feasible solution. The electricity prices are in periods so low, that the engine is stopped and the heat production takes place on natural gas boilers, making solar district heating a feasible solution. Based on these calculations a total of 8,000 m² of solar collectors were commissioned in 2007.
Brædstrup DH was the world's first solar thermal plant in combination with natural gas fired CHP. In 2008 Brædstrup DH decided to take the second step towards 100 % renewable energy (RE). It was decided to implement another 10,600 m² of solar panels, 5,500 m^2 buffer tank, 19,000 m^3 pilot borehole storage, 1.2 MW_{th} heat pump and a 10 MW electric boiler. The solar collector installation was the biggest in Europe at that time, but there is still a need for natural gas boilers as peak load.

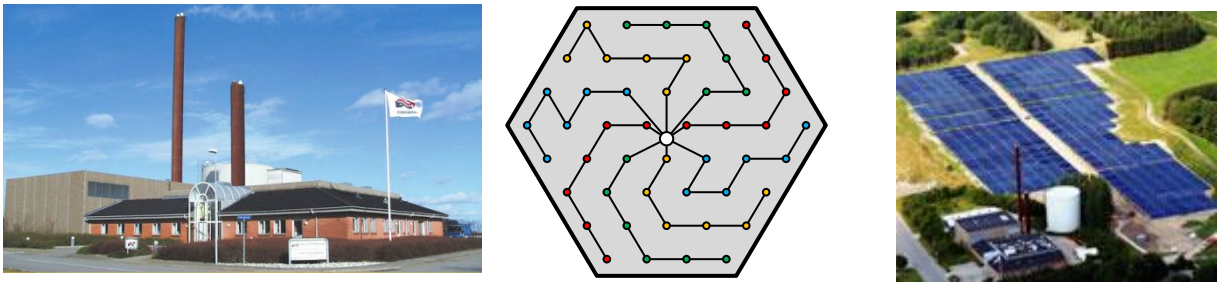


Figure 9: Facilities in Brædstrup: district heating facility building (left), design of the borehole storage (middle) and solar field (right) (Source: www.braedstrup-fjernvarme.dk)

Brædstrup DH is among the 25 % cheapest DH plants in Denmark. The consumers benefit from the activities by less pollution from reduction in natural gas consumption and low heat prices. More points of the successful operation is for instance, that all house installations are checked every second year by the utility and all consumers can find key figures for their own consumption at Brædstrup DH´s homepage via a personal link.

The tour ended by lunch at the DH plant, where it was possible to ask questions to the manager and Jim Larsen told more about the management of the plant. Since it is a consumer owned DH plant, all large decisions are taken on the annual general assembly, where all consumers are invited and have a vote. Project preparation with local plan and landscaping has been carried out in co-operation with Horsens Municipality to integrate solar plants in the landscape and utilize them as recreation areas. A presentation of the plant can be seen at: http://dkfilm.jsmediatools.com/dk/200902/braedstrupfjernvarmeUK/.

Figure 10: Site visit at Brædstrup DH (L. Laurberg Jensen)

5 ANNEX A: Study Tour Flyer

Invitation to:

Renewable District Heating
Three study tours to Danish cases

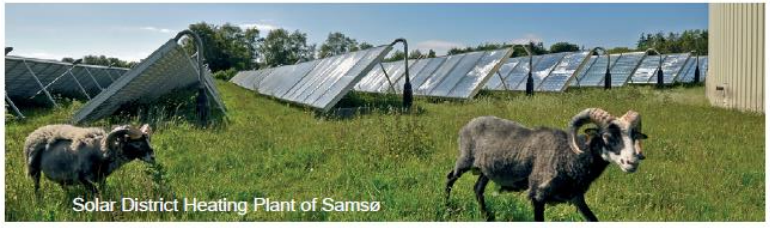
Wednesday 21 September 2016

09.00 - 15.00 SDHp2m-conference in Billund
15.00 - 18.00 Study tour to Gram
- Solar District Heating Plant
19.00 - Dinner at Knight's Restaurant, Legoland, Billund


Solar District Heating Plant of Gram

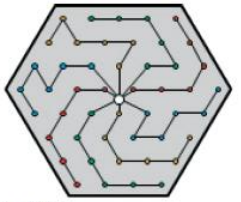
Thursday 22 September 2016

08.00 - 12.00 SDHp2m-conference in Billund
12.00 - 22.00 Study tour to Samsø
- two district heating plants and Energy Academy
19.00 - Dinner and hotel in Samsø


Solar District Heating Plant of Samsø

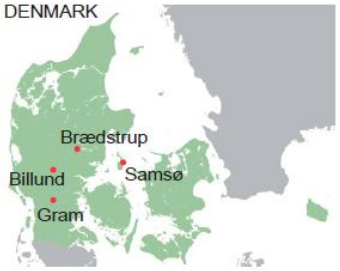
Friday 23 September 2016

09.00 - 14.00 Study tour to Brædstrup
- Solar District Heating Plant
15.00 Billund Airport

Solar District Heating Plant of Brædstrup

Location: Denmark, Central Jutland
Language: English
Participants: CoolHeating project partners, external representatives
Participation fee: The three study tours are free of charge. The SDHp2m conference is 222 euro. Other expenses are covered by the participants, but partly financed by the project CoolHeating.
Registration: Deadline July 1st 2016.
E-mail: mh@planenergi.dk and your local CoolHeating partner



European Commission | Horizon 2020 European Union funding for Research & Innovation

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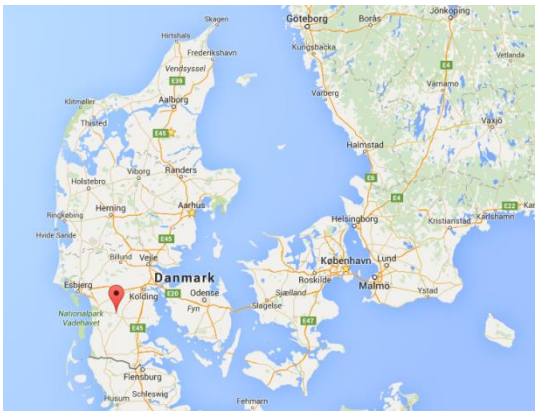
For further information, please visit:
www.solar-district-heating.eu/NewsEvents/SDHConference2016.aspx
www.coolheating.eu/en
www.planenergi.eu/
www.energiakademiet.dk/en/

PlanEnergi

6 ANNEX B: Technical Details of the visited projects

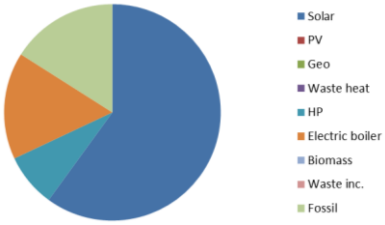
Gram District Heating

Location: Southern part of Jutland, Denmark
Google maps
http://www.gram-fjernvarme.dk/



Technical data

Heat production technology // Fuel // heat capacity // year of installation	10,073 m^2 solar collectors, 6.5 MW, 2009 34,727 m^2 solar collectors, 31 MW in total for all 44,800 m^2 solar collector field (3,556 panels), 2015 2 Boilers, natural gas, 10 MW Engine, natural gas, 6.5 MW (8.7 MW fuel) Electric boiler, 8 MW Electric driven heat pump, 900 kW, 2015

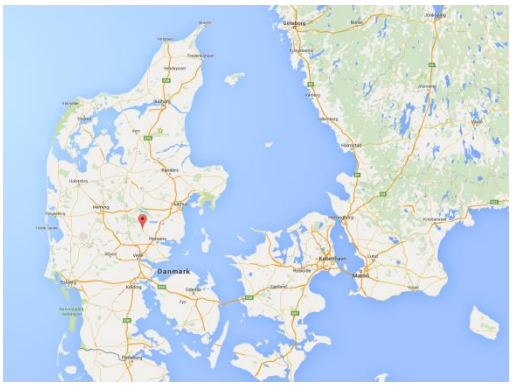


Cooling	No
Efficiency of plants	Boiler 1: 100 % Boiler 2: 100 % Engine: η(heat) 50 %, η(el) 41.2 %
DH network	21.1 km main network 13.3 km service pipes
Storage	Steel tank (in connection to CHP and first solar collectors) 2,300 m^3 Seasonal storage 122,000 m^3
Consumers // total annual heat sales	Around 1,200 consumers 25,000 - 30,000 MWh
Heat price, fixed, variable, total (standard house)	80 EUR/MWh 1,925 EUR/year (standard house 18.1 MWh; 130 m^2 incl. tax, excl. capital costs)
Ownership	Private/consumer owned

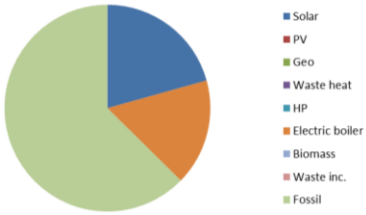
Brædstrup District Heating

Location: Middle of Jutland
Google maps
http://www.braedstrup-fjernvarme.dk/

Video:
http://www.braedstrup-fjernvarme.dk/firmaprofil/billedegalleri/video



Technical data

Heat production technology // Fuel // heat capacity // year of installation 	18,600 m^2 solar collectors, 2007 (8,000 m^2) and 2012 (10,600 m^2) Electric boiler, 10 MW, 2012 Heat pump (high pressure screw compressor), 1.2 MW, 2012 Boiler 1, natural gas, 13.5 MW, 2006 Boiler 2, natural gas, 10 MW Engine 1, natural gas, 4.1 MW (8.7 MW fuel) Engine 2, natural gas, 4.1 MW (8.7 MW fuel)
Cooling	No
Efficiency of plants	Boiler 1: 104% Boiler 2: 100 % Engine 1: η(heat) 47%, η(el) 42% Engine 2: η(heat) 47%, η(el) 42%
DH network	27.9 km distribution and 21.1 km service pipes. Network age of 17 years.
Storage	Bore hole – seasonal storage: 48 bore holes Probes lowered to a depth of 45 meters 5 x 60 meters deep holes for temperature sensors 19,000 m^3 soil is heated Steel-tank, in total 7,500 m^3 2,500 m^3 in connection to CHP 5,500 m^3 in connection to solar collectors, electric boiler
Consumers // total annual heat sales	2015 numbers: 1,481 consumers 296,378 m^2 connected floor area 39,633 MWh heat produced 31,100 MWh heat sold
Heat price, fixed, variable, total (standard house)	63 EUR/MWh Total 1,721 EUR/year (standard house 18.1 MWh; 130 m^2 incl. tax, excl. capital costs)
Ownership	Private (consumer)

Nordby-Maarup District Heating

Energy	
Power rating	1.4 MW
Heat generators	0.9 MW wood chip boiler with flue gas heat exchanger (Weiss) + 2.2 MW solar collector array (ARCON)
Auxiliary generator for reserve and peak load	1.4 MW oil burner, delivers about 4 % of the energy
Hot water accumulation tank	800 cubic meters
Fuel	3 200 MWh/year wood chip + 96 MWh/year oil at design capacity.
Storage	Wood chip: 7 days of peak load. Oil: 14 days of peak load.
Design capacity	90 % of the potential heat consumption
Potential heat consumption	3.7 MWH/year
Initial consumer connections	72% of the potential heat consumption
Production by solar array	1 090 MWH/year or 430 KWH/sq m,
Solar array coverage	21% of the energy (May 2002 - Apr 2003)
Environment	
Buildings	- One boiler room with 130 cubic meters of chip storage, - one accumulation tank, diameter 8.5 m and 300 mm insulation, - 2 500 square meters of solar panels, and - a 25 000 liter oil tank underground
Solar array	20 rows of 10 panels at 12.5 sq meters, bearing 167 degrees, inclination 40 degrees. Max power rating: 2 200 kW.
Fuel savings	1 000 MWh/year compared to individual oil boilers
Fuel source	Primarily from the woods of Brattingsborg at Samso
Economy	
Owner	NRGi
Construction costs	20.4 mill DKK (2.7 mill EUR)
Subsidies	9 mill DKK (1.2 mill EUR) from the Danish Energy Agency
Construction cost of solar array	4.7 mill DKK (0.63 mill EUR)
Calculated consumer price of solar energy	0.29 DKK/kWh or 0.15 DKK/kWh with subsidies
Consumers connected	180 households corresponding to 80 %
Consumer's annual fee (2010)	2817 DKK/year (376 EUR/year), VAT tax (25%) included
Consumer's heat price (2010)	755 DKK/MWh (101 EUR/MWh), VAT tax (25%) included
Consumer's connection fee	25,000 DKK + 1,200 DKK/m piping (3,330 EUR + 160 EUR/m)

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Ballen Brundby District Heating

Energy

Power rating	1.6 MW
Heat generator	1.6 MW straw boiler (LIN-KA)
Auxiliary generator for reserve and peak load	2.0 MW oil burner
Fuel	Straw: 1 500 tons/year, one big-bale weighs 600 kg. Oil: 4 700 liters/year
Storage coverage	Straw: 750 tons. Oil: 1.5 days at peak load
Potential heat demand	5 500 MWh/year
Current heat demand (2009)	4 900 MWh/year
Design capacity	80 % of the potential heat demand
Current consumer load (2009)	89 % of the potential heat demand
Initial consumer load (2005)	57 % of the potential heat demand

Environment

Heat transmission net	7 km of twin pipes (STAR PIPE)
Buildings	one for straw storage + one for the boiler room
CO2 savings (2009)	1 600 tons/year (expected 1 100 tons/year)

Economy

Start-up year	2005
Ownership	The consumers, through a cooperative with limited liability (amba)
Consumers connected initially (2005)	187
Consumers connected (2009)	258 (161 houses + 82 summer houses + 7 large consumers + 8 properties without buildings)
Consumer's annual subscription fee (2010)	4 050 DKK/year (540 EUR/year), VAT (25 % tax) included
Consumer's heat price (2010)	735 DKK/MWh (98 EUR/MWh), VAT (25 % tax) included
Price of straw to farmer (2013)	0.69 DKK/kg (0.092 EUR/kg) +/- 10 % depending on humidity
Plot and buildings	1.8 million DKK (240,000 EUR)
Boiler system	2.69 million DKK (359,000 EUR)
Distribution net + house installations	11.2 million DKK (1,490,000 EUR)
Consultants + other costs	0.485 million DKK (65,000EUR)
***Total construction costs* (2005)**	16.2 mill DKK (2.2 mill EUR)
Subsidies (2005)	2.5 mill DKK (0.33 mill EUR)
Consumer's price of a new connection (2009)	45,000 DKK (6,000 EUR)

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7 ANNEX C: Participants

- Dominik RUTZ, WIP
- Rita MERGNER, WIP
- Morten HOFMEISTER, PLAN
- Linn LAURBERG JENSEN, PLAN
- Kristina BOZHKOVA, PLAN
- Kanau TAKAHASI, PLAN
- Christian DOCZEKAL, GET
- Tomislav PUKSEC, UNIZAG
- Neven DUIC, UNIZAG
- Borna Doračić, UNIZAG
- Blaž SUNKO, SKUP
- Natasa MARKOVSKA, SDEWES
- Meri KARANFILOVSKA, SDEWES
- Nikola RAJAKOVIC, ETF
- Ilija BATAS BJELIC, ETF
- Anes KAZAGIC, EPBIH
- Alma ADEMOVIC-TAHIROVIC, EPBIH
- Slobodan JEROTIC, SABAC
- Bojana MLADENOVIĆ, SABAC
- Mitja KOLBL, LJUTOMER
- Olga KARBA, LJUTOMER
- Damijana BELCL, LJUTOMER
- Nemanja PAJIĆ, President of the City Assembly of the City of Šabac
- Gordana LIPŠINIĆ, City of Ozalj, Croatia
- Boris GUŠTIN, Serbia
- Milon STOŠIĆ, City of Šabac, Serbia
- Ljupco DIMOV, Municipality of Karposh, Macedonia
- Vladimir GJORGIEVSKI, Municipality of Karposh, Macedonia

Figure 11: Participants of the CoolHeating study tour in Denmark