solar district heating

SDHp2m

… from policy to market

Advanced policies and market support measures for mobilizing solar district heating investments in European target regions and countries

IMPLEMENTATION OF SOLAR DISTRICT HEATING COMBINED WITH BIOMASS IN VILLAGES WITHOUT DISTRICT HEATING

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691624.

Document Information:

Authors:	Per Alex Sørensen, PlanEnergi
Contact:	PlanEnergi Nordjylland Jyllandsgade 1, DK- 9520 Skørping T: +45 9682 0402 E: pas@planenergi.dk

Last update:	January 2018
Deliverable:	WP 4: Mobilization of projects and investments
Task:	4.1-4.4
Deliverable:	D4.5: Manuals with standardized (plug and play) organizational processes and technical solutions (1)
Status:	Public
Project Website:	www.solar-district-heating.eu

solar district heating

TABLE OF CONTENTS

1. INTRODUCTION

In the SDHp2m (Solar District Heating, policy to market) project, the purpose is to rollout Solar District Heating in three “A-regions” (Thuringia in Germany, Styria in Austria and Auvergne-Rhône-Alpes in France) and six “B-regions” (Hamburg in Germany, Mazovia in Poland, Varna in Bulgaria, Västra Götaland in Sweden, Aosta and Veneto in Italy) in Europe.

The boundary conditions for such a rollout differ from region to region. Nevertheless, we have found three standard solutions, that can be utilized in nearly all regions. The solutions are the following:

- Solar district heating combined with biomass in villages without district heating.
- Solar district heating combined with existing district heating using biomass as primary fuel.
- Solar district heating integrated in existing district heating systems in cities.

This manual describes how to **develop and establish solar district heating and biomass in villages without district heating.**

The main problems in villages without district heating stem from the planning and implementation of the district heating network, and not from the implementation of solar thermal panels. Nonetheless, the fact that solar thermal energy can completely displace the use of fossil fuels during the summer period, makes it a possible driver for the establishment of new district heating.

Solar thermal energy can be combined with other sources, different from biomass, when implementing new district heating systems (e.g. heat pumps). However, economic feasibility is often of high importance to consumers during the decision-making process for shifting from individual to district heating, and biomass has until now been the cheapest backup alternative. Hence, biomass is expected to be the most attractive solution at present.

Another advantage of biomass is the fact that it is often available locally. Consequently, a change away from fossil fuels will strengthen the local economy and reduce the dependence on import.

The manual is divided into steps following the decision-making process. After each step, a decision has to be made by the process stakeholders whether or not to continue the process.

The manual is a “living” document, meaning that new experiences and ideas are always welcome and can be integrated.

2. INITIAL REQUIREMENTS

Future heating of houses in villages with individual heating will not be based on oil or gas if the transition to low carbon societies in the EU is realized as planned. The main possibilities for the future are individual biomass boilers or heat pumps. Biomass, however, may be a limited resource, since there will be a necessity for it as a fuel in the transport sector. Biomass is also less convenient if the house owners are away for long periods. The main solution for the future might therefore be the use of individual heat pumps.

Nevertheless, if the heat density of a village is high enough, common solutions e.g. district heating might be more attractive, due to the following reasons:

- The house installation for a district heating system consists of a compact heating unit that saves space within the house and is easy to regulate.
- Nearly no maintenance is necessary.
- The house installation does not emit any smoke nor make any noise, unlike e.g. oil boilers, biomass boilers and heat pumps.
- Heat production can be CO_2 neutral and can create local job openings.
- The costs of district heating per house can be lower than of individual heat production.

The last argument is often the most important. Thus, it is strongly recommended that a screening of the feasibility is made before an implementation process is initiated. For example, some Danish municipalities systematically screen DH possibilities using a simple methodology, as shown in Appendix 1. This methodology can also be applied to a single village. Before starting a process for implementation of new DH with solar thermal panels, some additional conditions need to be in place.

<u>Positive stakeholders</u>

A **group of inhabitants of the village** have to be willing to use time on forming a local working group and to take the responsibility of informing neighbors and discussing a possible SDH project with them.

Moreover, the **local authorities** need to back the project up and support the process by for instance:

- Financing the screening of SDH feasibility.
- Making a "one stop" contact with the municipality for obtaining permissions and support with expertise.
- Making a municipal-owned heat supply company or including heating purposes in an existing supply company (e.g. waste, drinking water, sewage water).

<u>Possible areas for placement of the solar thermal panels</u>

Lack of sufficient area appears to be a major obstacle around Europe when placing a SDH plant. Hence, the possibilities for placing solar thermal panels must be investigated at an early stage. The solar collectors can be placed on buildings (rooftops) or on the ground. Placing solar collectors on rooftops is more expensive[1], and is often competing for space with PV systems. Therefore, ground-mounted collectors are the most common solution used for villages.

The simplest solution is to place the solar collectors on farmland. As an example, Denmark has a target of replacing 10% of existing DH production with solar by 2030. The latter would present the necessity for establishment of ca. 8 mio. m^2 solar collectors. If each collector takes 2-4 m^2 of farmland, and we calculate with 3.5 m^2/m^2 collector area they will cover a total of 2,800 ha. The total amount of farmland in Denmark is approx. 2.65 mio. ha. Hence, the solar collectors would cover approx. 0.1% of the farmland. In comparison, golf courses in Denmark cover more than 10,000 ha. Moreover, if an area of the same size, as the one to be used for establishing solar collectors, is used for growing crops, the energy yield would be much lower. See Table 1.

[1] See for instance [1], factsheet 2.3, Fig 2.3.6 and 2.3.7

Landscape integration:

Figure 1: "Collector Island" (SUNMARK), Almere, Holland. [1], Fact sheet 2.2

Double utilization:

Figure 2: On a slope (Schüco), Crailsheim, Germany (by Stadtwerke Crailsheim GMBH). Notice the size compared to the car on top and the man in the background. [1], Fact sheet 2.2

Landscape integration:

Figure 3: Alternative placement of solar collectors, Example from Brædstrup, Horsens Municipality [4]

	Solar thermal	Photovoltaics	Biomass/ bioethanol
Annual yield range	133 to 167 kWh_{th}/m^2	50 to 69 kWh_{el}/m^2	2 to 5 kWh_{th}/m^2
Average annual yield	150 kWh_{th}/m^2	59.5 kWh_{el}/m^2	3.5 kWh_{th}/m^2
Increase over solar thermal (multiplying factor)		3	43

Table 1: Annual energy yield per square meter for different renewable energy Sources in Northern Europe: Fraunhofer ISE, PlanEnergi and Chalmers University, [2]

Table 1 is for Northern Europe, but the multiplying factor is similar in Southern Europe. But even if farmland should not be a limiting factor, it sometimes is, and that will have its reflection on the price. Thus, double utilization of areas and utilization of e.g. polluted or wet areas can be a solution. There will also arise a demand for integration in the landscape and visualization of the solutions during the planning process. Examples of collector placement can be seen in [1], [3] and [4], as well as in Figure 1, Figure 2 and Figure 3 on page 4.

Areas for solar collectors can be bought or rented. It is important to keep in mind that there almost always has to be more than one alternative area, in order to avoid having the price decided by a monopolist.

Resources needed

Before starting the implementation of new DH with solar panels, one must be aware of the resources needed in the process to:

- Coordinate all activities
- Arrange and participate in meetings
- Elaborate basis for decisions
- Inform about the project and take care of contracts
- Write, print and distribute information letters to building owners
- Create advertisements and information in local media

A working group consisting of people living in the village can take care of the daily contact and information. However, unless they are fully dedicated to the project and willing to spend a huge number of hours working on it, they would need an existing municipal utility or private company specialized in implementing new DH e.g. SolarComplex in Germany (www.solarcomplex.de) to take care of the project.

Gudhjem, Bornholm. Picture of the village and a map defining the DH supply area.

3. BASIS FOR DECISIONS

To convince investors, municipalities and future consumers, a “Basis for decisions” i.e. a business plan needs to be set up.

Content for investors could be:

- Description of possible heating solutions (district heat and reference with individual heating with different fuels)
- Choice of district heating solution and description of access to fuel
- Definition of supply area (area where the DH utility is obliged to supply).
- Where to place the biomass plant, the solar plant and the accumulation tank
- How to organize and finance the district heating
- Economic consequences for reference and project (Net Present Value, Internal Rate of Return, yearly costs for consumers). Sensibility analyses.
- Environmental consequences (emissions to soil, water and air)
- Time schedule
- Discussion on possible barriers for realisation of the project
- Draft customers contract
- Draft Statute for members

Content for the municipality could be:

- Economic consequences for the municipality as an “island”
- Consequences for employment in the municipality
- Environmental consequences (emissions)
- Consequences for the municipal planning (effect on environmental protected landscape, effect on neighbours to the production plant)
- Social economy

Content for the consumers could be:

- Price for heat from district heating and sensitivity calculations
- Installation costs and financing possibilities
- Description of the house installation
- Maintenance the customer has to take care of
- Maintenance the utility takes care of
- Pollution in and around the house
- Statutes including description of obligations and possibilities to change to individual heating again

3.1. Comments to “Basis for decisions”

<u>Description of possible heating solutions</u>

For biomass and solar based DH to be able to compete with individual heating, the individual heating normally has to be based mainly on oil. That is unless there are high taxes on fossil fuels, raising the price of natural gas, as e.g. in Denmark. Additionally, if there is local access to cheaper heat than the one from solar collectors (e.g. excess heat from industrial processes or unused heat from a biogas engine), SDH will be less feasible and probably not attractive. These possibilities/obstacles have to be described when considering a SDH implementation process. See also [1], Fact sheet 2.1 "Solar heat combined with other fuels."

Choice of DH solution and description of access to fuel

The DH solution is solar thermal combined with biomass, but biomass can be straw, wood chips or wood pellets. Wood pellets are easy to handle but pellet solutions cannot compete economically in larger boilers (>500 kW). The choice between wood chips and straw depends on the local conditions and traditions. For instance, access, quality, price and security of supply for the fuel.

A map showing the supposed supply area, possible placement of solar collectors and district heating utility must be a part of the basis for decisions.

How to organize and finance DH

The district heating company can be:

- A consumer owned coop
- A consumer owned Ltd.
- A part of a public (municipal owned) Ltd.
- A part of a private owned Ltd.

The ownership is important for investors and consumers. For the investors, the business case (security of investment) is important. For the consumer, some of the important factors are the price, confidence in the utility owner and transparency and security of supply. See also [1], Fact sheet 2.4 "Ownership and financing".

Economic and environmental consequences for the reference and the project

To calculate the economic consequences of the project, the plant has to be designed and it is necessary to know:

- The annual heat consumption divided on the buildings (can be standard m^2 figures)
- DH pipe sizes, temperature level, heat losses and prices. A pipe calculation software can be found in [5] and [6]. Prices for pipes can be estimated from [7]. Sometimes pipe suppliers are willing to calculate a price for a given network.
- Investment, operation and maintenance costs for connection pipes and house installations.
- Investment, operation and maintenance costs for the solar panels and the biomass boiler. Prices can be found in [8] and [9]. Nonetheless, suppliers are often willing to give estimates on prices.
- Cost of utility administration.
- Efficiency of biomass boiler, efficiency curve for solar collectors and grid temperatures over the year.
- Financing conditions

Technical design includes size of biomass and solar plant and pricing of the plant. The most feasible solution is normally to let the solar part, including an accumulation tank, cover the summer load and to let the biomass part cover 75% of the peak load, assisted by a peak load and reserve load boiler using oil or gas. The principle diagram might look as in Figure 4.

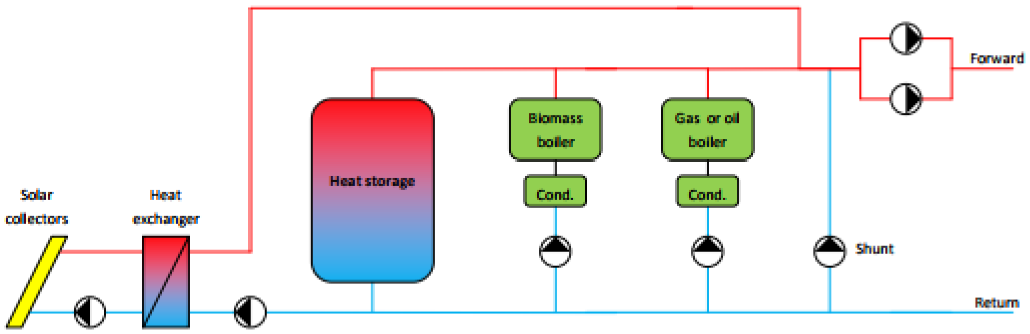


Figure 4: Principle diagram for solar thermal combined with biomass [1], Fact sheet 2.1 "Solar heat combined with other fuels".

From the above stated conditions, total cost for investment, annual costs of heat production and heat losses can be calculated. Afterwards, annual costs for heating a standard house can be calculated and compared to the costs for individual heating.

Environmental consequences (emissions) for biomass boilers can be found in [8].

Possible calculation tools are energyPRO (https://www.emd.dk/energypro/), Polysun (http://www.velasolaris.com/english/home.html), T*Sol (http://valentin.de/calculation/thermal/start/en), TRNSYS (http://www.trnsys.com/), etc.

Guidelines for detailed design can be found in [1], Chapters 6,7 and 8.

An example of a calculation of economic consequences for SDH and for new district heating (pipes) can be found in Appendix 2.

Time schedule

A time schedule showing the stages in the planning period (connection campaign, authority permissions), detailed design, call for tenders, contracting, building the plant and commissioning has to be a part of the basis for decisions document.

Possible barriers

Possible barriers that need to be considered and complied with when situating the solar thermal field and the biomass production plant include the effect on environmental protected landscape (e.g. Natura 2000), noise and integration in the landscape. But compared to traditional farming, solar thermal plants will increase biodiversity and plants sourrounding the collector field open possibilities of green corridors between for instance forest areas.

Moreover, the economic consequences for the municipality and consequences for employment can be calculated. This is done by estimating the local share of investment, fuel and maintenance costs, and dividing them with the total annual costs of employees, then comparing them to the corresponding figures for individual heating.

Finally, sensitivity calculations showing how robust SDH is to changes in the most volatile preconditions have to be carried out. For instance, connection % to DH is an important precondition – is 60% enough or is 75% necessary?

4. CONNECTION CAMPAIGN

If the Basis for decisions is accepted by the stakeholders including the local working group, the connection campaign can start. The campaign might be organized as follows:

An information leaflet and a preliminary connection agreement is distributed to all building owners.

The leaflet includes:

- information about the needed connection %
- invitation to an information meeting
- the economy for the building owner with district heating, oil heating and electrical heating
- arguments for district heating
- a map of the area, where new district heating is offered to the house owners
- a hot line where questions can be asked and answered

An example of the leaflet is shown in Appendix 3.

Information in the preliminary connection agreement can include:

- Signing means that regulations for connection to district heating are accepted
- The value of energy savings belongs to the utility
- This agreement will be dropped if the project is not realised because of few connections
- Connection including connection pipe, a standard district heating substation with hot water tank and shunt regulation, heat meter with leakage alert, removal of oil boiler and oil tank cost 2,200 € (50% of the normal price) for house owners who have signed the agreement before pipework has passed the house
- For electrical heated houses, the price is 0

The preliminary connection agreement can be delivered to members of the working group.

An example of a preliminary connection agreement can be seen in Appendix 4.

Interviews with the working group and information in local media. Public information meeting with presentation of the project and information about connection conditions.

The arguments for district heating are:

- The house installation in a DH system is a compact heating unit, which is easy to regulate. Saves m^2 in the house
- Nearly no maintenance is needed
- There is no smoke and no noise from the installation (in contrast to oil boilers, wood boilers and heat pumps)
- Heat production is CO_2 neutral and creates local work places
- The costs are lower than for heat production from oil boilers and individual heat pumps
- Service for the house installation and leakage alert is included in the heat price

When the connection % is reached, the preliminary connection agreements are changed to contracts and implementation can start. If it is a new consumer owned district heating company, a general assembly is arranged to formally establish the company. The local working group will then be replaced by an elected board. During implementation house owners are contacted before the pipe work has passed the house to give them a last chance to get 50% off the price.

An example of conditions for DH connection can be found in Appendix 5.

An example of a district heating unit is visible in Appendix 6.

5. BUILDING THE PLANT

When the connection % is reached, tendering, contracting and building the plant can take place. This work needs to be carried out by professionals, but it is important that the implementation company and the local working group (or the elected board of a coop) continuously inform people in the village about the project. This is because the implementation of DH pipes in the streets causes a lot of troubles with traffic that need to be explained beforehand. See also [1] Fact sheet 3.2 “Tendering and contracts” and Fact sheet 4.1 “Supervision of construction and commissioning”.

REFERENCES

[1] Solar district heating guidelines Collection of fact sheets. http://solar-district-heating.eu/Documents/SDHGuidelines.aspx

[2] http://www.solarthermalworld.org/content/solar-thermal-shows-highest-energy-yield-square-metre

[3] Best-practice guide and policy recommendations for SDH land area development and double usage of space. http://solar-district-heating.eu/

[4] Illustrative Prospective of Solar Energy in Urban Planning http://task51.iea-shc.org/publications

[5] www.calc.logstor.com

[6] www.isocalc.isoplus.dk

[7] Technology Data for Individual Heating and Energy Transport. Danish Energy Agency and Energinet.dk. 2013. https://ens.dk/en/our-services/projections-and-models/technology-data

[8] Technology Data for Energy Plants. Danish Energy Agency and Energinet.dk. May 2012. Updated 2015. https://ens.dk/en/our-services/projections-and-models/technology-data

[9] Technology Data Catalogue for Energy Plants. Danish Energy Agency and Energinet.dk. August 2016. Updated June 2017. https://ens.dk/en/our-services/projections-and-models/technology-data

APPENDIX 1: SCREENING OF DH POSSIBILITIES

Author: Max Guddat, PlanEnergi, Denmark, August 2017

The screening of a new district heating plant can be initiated as a top-down process, by having a municipality or other authority initiate a screening, eventually together with a small local workgroup. Other stakeholders are involved, after the screening shows a potential (e.g. socioeconomic benefits). This reduces the frustration of possible stakeholders, if the screening does not result in a project, as well as it does include the stakeholders from crucial project phases until the establishment of the project.

Th general aim of the described process is to follow a comprehensible process that facilitates the possibility to analyse a larger number of cases under comparable conditions. The result is a powerful tool for e.g. energy planners to address evident cases for district heating grids in his or her area of responsibility. The steps in the process for screening are illustrated on page 4, in the brochure at hand.

Step 1: Initially, possible project areas are identified. A Danish database for existing heating supply areas (individual natural gas or district heating) makes it possible to point out villages and towns that are yet not supplied by any collective heat supply system. A best-choice approach can be applied to evaluate the projects, most likely to be carried out first.

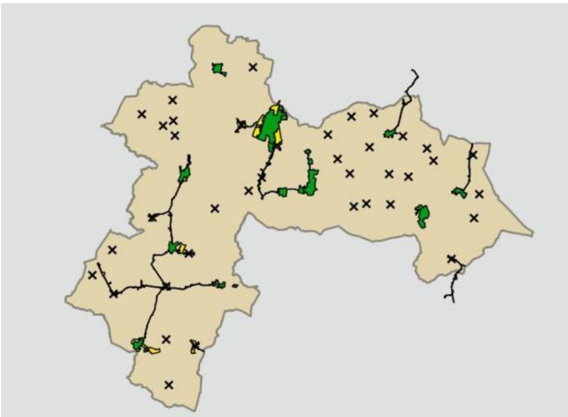


Figure 5: Heat supply areas in a Danish municipality (green: district heating, yellow: natural gas)

Figure 6: Buildings in an example town. Data based on available Danish databases.

Step 2: The heat demand of the given geographical location must be identified. Two sources are crucial:

1. A building-database, containing basic information regarding the buildings in an area, such as year of construction, heat supply form, size and use (in Denmark: BBR).
2. A database, describing the heat demand in building categories, e.g. based on age and use of the building (in Denmark: regular study by the National Building Research Institute, SBi)

This information can be combined in a geographic information system (GIS) to estimate heat demand in a normal year for the buildings in an area – a so-called heat-atlas. With this heat-atlas, the heat demand in an area can easily be estimated with acceptable accuracy. To not overestimate the heat demand in the area, the estimation of the heat atlas should be limited to residential buildings and alike and possibly be supplemented by the demand of larger consumers, known to the authors.

Besides the net heat demand, a future district heating system will have to cover heat losses from the grid. These can be estimated, based on the necessary grid. The suppliers of district heating pipes provide calculation tools for this purpose. Input for these consist of the previously found heat demand along the designed heating grid. In a more superficial screening, the heat losses can be estimated as a simple percentage of the net heat demand, which however should be adjusted to the heat density in the given case.

Step 3: With an estimation of the gross heat demand that needs to be supplied, a load curve can be prepared. This step is used to estimate the needed thermal capacity for base and peak loads. Furthermore, based on the base load, first estimates for size of an SDH-plant can be carried out.

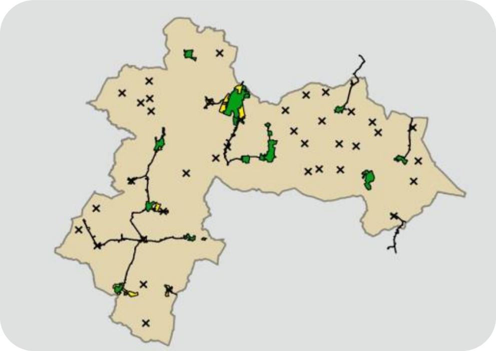
Step 4: In step 4, available heat sources for a district heating system are to be evaluated; The surrounding areas should be screened for available space for a SDH-plant. Other renewable resources include excess industrial heat or heat pumps. The combination of the different heat sources can be analysed in modelling software for the purpose, e.g. energyPRO. These models can after slight adjustments be reused for similar projects or other cases in the same project. The most time-consuming part of design of a model is the basic setup of external conditions (i.e. climatic data and electricity spot prices), the estimated heat demand, the heat generating capacities, taxation, operation subsidies etc. Once a generic reference model is setup, these models can easily be adjusted to variation in e.g. gross heat demand and heat generating capacity in order to model a similar district heating system for a different town under other similar conditions. Depending on the setup of the given energy modelling software, the output typically consists of fuel consumption, composition of heat sources and the resulting operational costs that can be exported to Excel.

Step 5: Investment budgets must be set for the chosen scenarios. Depending on the chosen energy model, this step is carried out in the model directly or alternatively in Excel (e.g. to avoid re calculation of operation results). As with the energy models, this is to some extent a generic step, as e.g. the investment costs in district heating grids follow a comparable unit price, as long as the project dimensions are comparable in size. Estimations of CAPEX for other units such as SDH-plants, boilers and technical sheds can be provided by suppliers in the field, preferably for the sizes relevant to the project.

Step 6: Based on the investment overviews, average down payments are calculated. Together with the operation costs that were calculated in the energy model software, a resulting balancing heat price is calculated. This heat price is then compared to the alternatives, i.e. predominant individual heating sources or existing district heating technology.

When relevant scenarios are identified and prices furthermore validated, the calculations are presented to the stakeholders, after which possible developments of a possible district heating grid are discussed and eventually the planning phase begins, based on the early stages in the process.

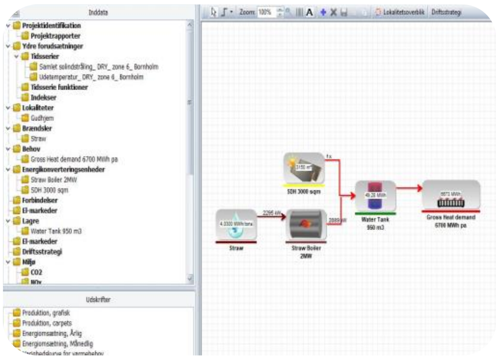
Example of screening procedure (Denmark)



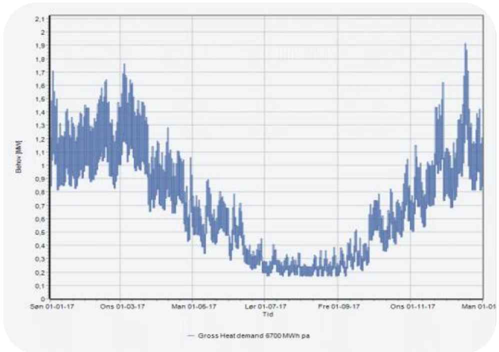
Step 1: Identifying possible cases

(Green: existing district heating, yellow: natural gas)

Step 2: Estimation of heat demand in case area (based on building category and age) in a GIS, basic design of DH-grid.



Step 4: Modelling of relevant alternatives for heat supply in e.g. energyPRO. Once a reference system is designed, the generic model can be reused for other cases and alternative heat supply technologies.



Step 3: Calculation of heat loss, distribution of heat demand over the design year, estimation of needed capacity.

		0 Gudhjem Reference	1 Gudhjem Ref + Sol 25%
Estimated investment in solar thermal panels[1], incl. storage tank, technology building, pipe work, control, etc.			
Solar system including foundations and piping, at ca. 175 EUR per m²	EUR		551.000
Heat exchanger, pumps, glycol tank, etc.	EUR		50.000
Storage tank, 945 m^3	EUR		240.000
Nitrogen plant	EUR		10.000
Pipe work	EUR		20.000
Technology building (solar panels)	EUR		50.000
Power supply, connection fees	EUR		10.000
Fences, planting and earthworks	EUR		10.000
ICS, PLC and control	EUR		50.000
Purchase of land at ca. 7 EUR per m^2	EUR		55.000
Energy savings (ca. 55 EUR per MWh produced in the first year)	EUR		-94.000
Total investment in solar thermal panels	**EUR**		**952.000**
Project planning, supervision, regulatory procedures	EUR	1.500.000	30.000
Contingencies (5%)	EUR	2.029.000	49.000
…al	**EUR**	**44.103.771**	**1.031.000**

Step 5: Estimation of investment plans for the chosen alternatives and calculation of fixed costs pr. annum for the system.

Selskabsøkonomi, Halm 650 Kr./ton = 27 EUR/MWh		0 Gudhjem Reference	1 Gudhjem Ref + Sol 25%	1 Sensitivity
Investering, Solvarmeanlæg inkl. jordkøb	EUR	0	952.000	712.000
Samlet investering	EUR	0	1.031.000	791.000
Samlede kapitalomkostninger	EUR/år	0	69.300	35.917
Driftsomkostninger	EUR/år	187.434	142.963	142.963
Driftsbesparelse	EUR/år	0	44.471	44.471
Nettobesparelse (driftsbesparelse - kapitalomk.)	EUR/år	0	-24.829	8.554
Simpel tilbagebetalingstid	år	-	23,2	17,8
Varmeproduktionspris	EUR/Mwh	28	32	27
…eduktion i varmeproduktionspris	EUR/MWh	-	-4	1

Step 6: Calculation of a budget and resulting heat prices, incl. downpayments. After this: comparison of alternatives, e.g. individual heating reference.

The screening method as described here follows a generic model and can easily be adjusted to local circumstances and thus other cases. Furthermore, the generic form makes it possible to efficiently screen a large number of cases within an area, e.g. all (individually heated) towns in a municipality.

The steps in the screening process are elaborated in Appendix 1.

APPENDIX 2: EXAMPLE OF A CALCULATION OF DH ECONOMY

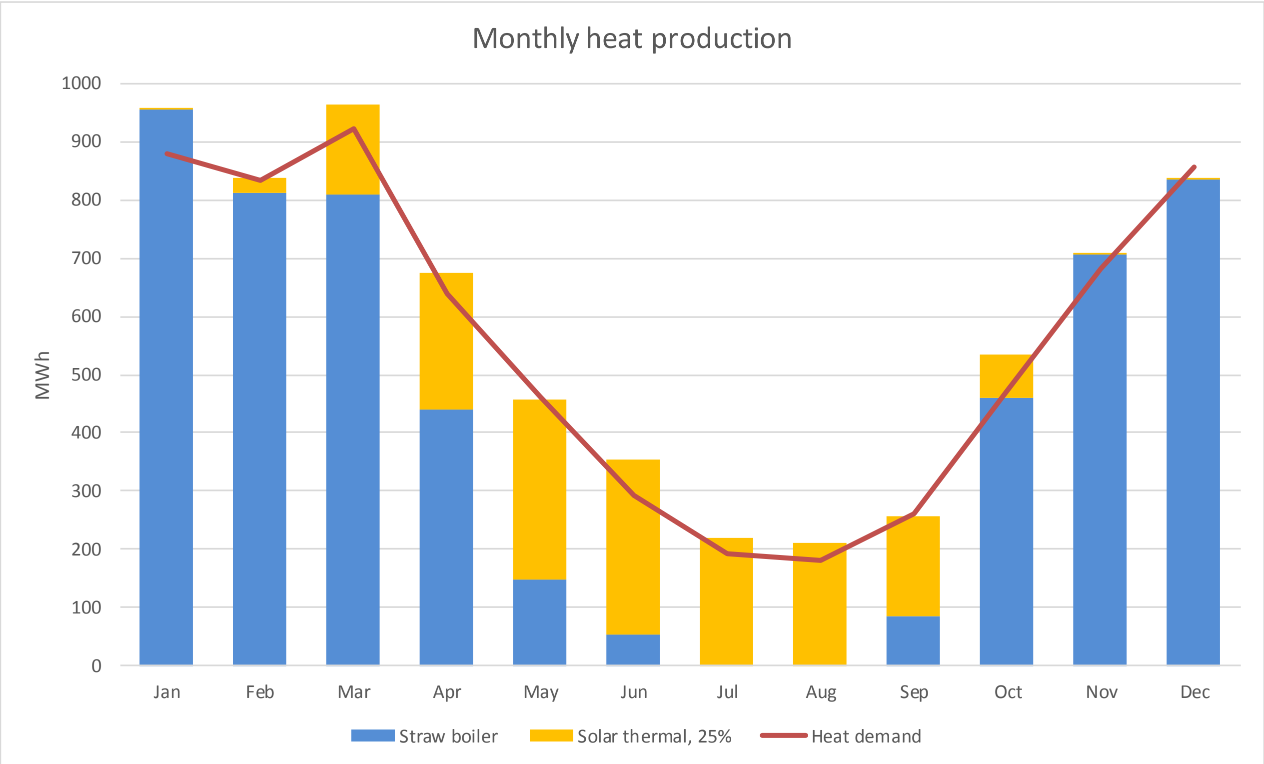
Gudhjem is a village with 358 heat consumers, at present primarily using oil. The neighbor city Østerlars has a quite new district heating network, supplied with heat from a straw fired boiler. The plant in Østerals (and several other DH plants on the island of Bornholm) is owned and ran by Bornholms Forsyning. It is a non-profit Ltd, 100% owned by the municipality of Bornholm. Apart from running the district heating plants, Bornholms Forsyning also takes care of waste water from 17,000 households and 5,500 septic tanks, while also providing drinking water for 11,000 households.

Bornholms Forsyning offers to provide the citizens of Gudhjem with a basis for decisions and to run the process of connecting customers to a new DH system. A local working group has been established to follow the work and inform about the project.

Moreover, it is worth mentioning that the municipality of Bornholm has screened the island for DH possibilities and decided on a heat plan, where Gudhjem is planned to have DH.

The plan is to connect Gudhjem to Østerlars. The connection pipe will be a 4,300m long DN 100 twin pipe, while the price for heat from Østerlars will be around 28 €/MWh.

To investigate if it is a good idea to add solar thermal panels to the DH in Gudhjem, a calculation in the energyPRO software is carried out. The calculation result in a collector area of 3,150 m^2, covering 25% of the annual heat production can cover the summer load most of the time. A graphical representation of the calculations is visible in the figure below.



Monthly heat production from straw and solar thermal, relative to the heat demand

The solar production is calculated to approx. 1,700 MWh/year, corresponding to 47,600 €/year saved heat purchase. The investment costs for solar thermal panels are shown in the table below.

Estimated investment in solar thermal panels[1], incl. storage tank, technology building, pipe work, control, etc.		**1 Gudhjem Ref + Sol 25%**
Solar system including foundations and piping, at ca. 175 EUR per m²	EUR	551,000
Heat exchanger, pumps, glycol tank, etc.	EUR	50,000
Storage tank, 945 m³	EUR	240,000
Nitrogen plant	EUR	10,000
Pipe work	EUR	20,000
Technology building (solar panels)	EUR	50,000
Power supply, connection fees	EUR	10,000
Fences, planting and earthworks	EUR	10,000
ICS, PLC and control	EUR	50,000
Purchase of land at ca. 7 EUR per m²	EUR	55,000
Energy savings (ca. 55 EUR per MWh produced in the first year)	EUR	-94,000
Total investment in solar thermal panels	**EUR**	**952,000**
Project planning, supervision, regulatory procedures	EUR	30,000
Contingencies (5%)	EUR	49,000
Total	**EUR**	**1,031,000**

[1]) Estimated by PlanEnergi based on similar projects

The technical lifetime of solar collectors is between 25-30 years. The annual capital costs could therefore be calculated for a loan with the same length. Nevertheless, the economic lifetime might be shorter, so a 20-year loan period is used. If the real interest rate is 3%, the yearly capital costs will be 69,300 € plus 1 €/MWh in maintenance and electricity for pumps. Altogether, the costs amount to approx. 71,000 €/year, or a total of approx. 23,400 €/year extra for the solar thermal panels.

The annual sale of heat is expected to be 5,818 MWh/year, so the extra cost of solar thermal will be 4.02 €/MWh, or 56.3 €/year for a standard consumer using 14 MWh/year.

In addition, it is worth performing a sensitivity calculation for the establishment of solar thermal panels. Based on the projected lifetime of solar panels of 25-30 years, a loan period of 25 years is chosen instead, together with a real interest rate of 1% (3% nominal interest rate – 2% inflation). Moreover, an assumption is made that the DH plant in Østerlars already has a storage tank that goes together with the straw boiler, which is a usual practice in such plants. The storage tank can therefore be used by the solar panels. Hence, the investment costs for the storage tank are excluded from the investment.

A calculation under the sensitivity conditions results in capital costs of 36,000 €/year or a total of 37,700 €/year including maintenance and electricity costs. The establishment of solar thermal panels presents savings of approx. 9,900 €/year. This corresponds to a cost reduction of 1.70 €/MWh, or 23.8 €/year for a standard consumer.

All-in-all, solar thermal plus straw is slightly more expensive than straw alone, but the advantages of adding solar thermal include the reduction of emissions in the summer period (Bornholm has a lot of tourists in the summer period.), along with the fact that 25% of the fuel price is fixed for the next 25-30 years. In addition, the sensitivity calculation shows that under certain conditions the investment in solar panels has the potential of reducing the overall heat price. Moreover, the lifetime of the straw boiler might be prolonged by stopping it during the summer, in case its production during that period is replaced by a solar thermal plant.

New district heating

When implementing new district heating, the investments in pipes and house installations are huge and can be a main barrier, if financing is too expensive. In the example from Gudhjem another problem is that Gudhjem is situated partly on rocks and therefore excavation is expensive.

Pipes in "rock cities" on Bornholm are implemented following these principles:

- Large dimensions are placed in areas with place and distributed to smaller dimensions in areas with less place because of rocks.
- Use of existing pipetracés where possible.
- Flexible pipes as distribution and service pipes, 12-16 mm.
- Highest possible difference pressure and decentralized pumping for reduction of the pipe dimension.
- Accumulation tank (110 l) for hot water in units in buildings.
- Intelligent control of units (consumption pattern and simultaneity) for further reduction of pipe dimensions and heat losses.

For Gudhjem the budget for 75% (269 out of 350 buildings) connection was in 2014:

Length **m**	**Dimension** **DN mm**	**Investment** **€**	**Heat losses** **MWh**
5,200 (service pipes)	16	665,000	196
2,100	20	423,000	103
1,900	25	384,000	98
2,450	32	508,000	142
2,401	40	500,000	160
920	50	234,000	60
400	65	105,000	30
800	80	172,000	67
16,171		**2,991,000**	**855**
Transmission pipe			
4,300	100	471,000	339
Rock, extra		1,346,000	
House installations (269)		821,000	
Income: 269 buildings at 1,830 € per building		-429,000	
Total		**5,137,000**	**1,194**

The lifetime of DH pipes is 30-40 years, but in Gudhjem they used a loan period of 25 years.

The yearly capital costs with a real interest rate of 3% are 295,000 €. With an annual heat sale of 5,818 MWh, this corresponds to 50.7 €/MWh.

APPENDIX 3: EXAMPLE OF INFORMATION LEAFLET ON DISTRICT HEATING

Information about district heating Svaneke, Aarsdale og Listed

The district heating project for Svaneke, Aarsdale and Listed are now approved by the Regional Municipality of Bornholm. Bornholms Forsyning (Supply) is along with the local associations working to realize the project as soon as possible.

A high connection rate is necessary!
For the project to be implemented, it requires that the majority of the properties, which now has oil-fired boilers, connect: At least 60 % should connect (of the residential / commercial area that are heated with oil).

Call for a quick sign up!
- as soon as there is a sufficient registration, the project is implemented as soon as possible. The district heating will be produced at the heating plant in Nexø, starting with the establishment of transmission line from Nexø to Aarsdale. It is the hope to convert the first houses to district heating at the end of 2014 (Aarsdale), then Svaneke and Listed during 2015.

A preliminary schedule is available on the website www.bornholmsforsyning.dk, which has much more information on district heating etc. Later a detailed timetable will be published, which shows when excavation work takes place for individual roads, and when the houses convert to district heating.

Bornholms Forsyning has through already implemented district heating projects collected a lot of experience, most recently in Gudhjem / Melsted. These experiences will be used to make the project as efficiently as possible, and to reduce the cost of rock blasting. Bornholms Forsyning already operates the water and sewerage networks in Svaneke, Aarsdale and Listed.

Houses with oil boilers, biomass boilers, etc.
Houses with oil-fired boilers, wood pellet, or solid fuel boiler will be offered a complete package solution with service line and installation of only 17,000 dkr. incl. VAT (to be paid before the property converts to district heating). This very advantageous price is reserved for properties that are connected from the start - at least simultaneously with the implementation of the distribution network.

The terms of commercial and larger installations must be agreed individually.

Houses with electric heating or heat pump.
If the house is heated with electricity, you get free service pipe + delivery of the unit
- but you must pay for the connection of the unit and possible radiators etc. An offer from a plumbing company can be a solution that is attractive.

It is possible to get up to 5 years of postponement to district heating usage and pay the regular taxes.

What you can save
The district heating price is significantly cheaper than equivalent heating with oil or electricity.

The example below shows what district heating costs per year compared to oil or electric heating. The example is based on a house with a living area of 120 m², and a consumption of heating of 14 MWh (megawatt hours), corresponding to approximately 2,000 liters of oil.

All prices are incl VAT and is from 2014

Annual district heating costs		
Variable costs:		
14 MWh, 640 dkr./MWh	8,960 dkr.	
BRK tax, 31.25 dkr./MWh	438 dkr.	(1)
Basic costs:	2,794 dkr.	
Floor tax, 26.25 kr./m²	3,150 dkr.	(2)
El. to shunt pump, 50 kWh	110 dkr.	
Service	0 dkr.	
Total (annually)	15,452 dkr.	

(1) New municipal tax from 2014 for loan guarantee
(2) Maximum charge of 175 m² per housing

Annual oil boiler costs	
Oil:	
2,000 l, 11.5 dkr./l	23,000 dkr.
Electricity, pump etc.:	700 dkr.
Chimney service	400 dkr.
Serviceand maintenance	1,000dkr.
Total (annually)	25,100 dkr.
(Savings app.	10,000 dkr.)

Annual costs for electric heating	
Electicity:	
14 MWh, 1,600 dkr./MWh	22,400 dkr.
Serviceand maintenance	0dkr.
Total (annually)	22,400 dkr.
(Savings app.	7,000 dkr.)

An easy and reliable solution
It is fairly simple to implement district heating in private homes. The supply line is decided by Bornholms Forsyning after discussion with the owner. The boiler must be replaced with a consumer unit, and radiators and pipes can be reused. The installation work is carried out within one day of local plumbers.

When district heating is installed in the house there are, in addition to a brand new heating system, also following advantages:
- Easy adjustable and compact heating system
- Minimal maintenance
- No noise and smoke from oil boilers
- CO_2 neutral heating from local biomass.
- Low heating bill.
- Service and leakage monitoring is included in the heating price, and:
- weather compensation unit:

Electrical controlled regulation of the district heating temperature, adjusting this to the outside temperature. This reduces loss in the network and optimizes the cooling. At the same time, the system can even shut off when the outdoor temperature is sufficiently high over 3 days, and open the plant again when the temperature drops. This results in considerable savings, especially for one-string systems. Possibility of night-lowering, if the property is suitable for this.

Service for district heating consumers at Bornholms Forsyning
Service applies to all regular households, and shall ensure that the household is offered a service check at least every third year to the benefit of both consumers and the district heating company. The service check covers the visit of a plumber and instructions to consumers on the use of district heating, as well as information about energy savings and green initiatives.

The price of 17,000 dkr. incl. VAT includes:
- Establishment of the service pipe and insertion to the house. All excavation work, restoration, etc.
- Heat meter including leakage monitoring.
- Consumer unit including hot water tank and weather compensation.
- Plumping- and electricity work.
- Disposal of oil-fired boilers, hot water tank as well as above-ground oil tank.
- Emptying / blanking of underground oil tanks.

The price does not include:
- Sealing holes in the floor and wall after the old combustion units, feeding tube, etc.
- Blanking of the chimney

More information
This information material is prepared by Bornholms Forsyning, tlf. +45 5690 5600, email: post@bornholmsforsyning.dk. in cooperation with the local group, that represents the civic associations in Svaneke, Aarsdale and Listed.

Bornholms Forsyning A/S
Industrivej 1
DK-3700 Rønne
Tlf. +45 5690 5600
post@bornholmsforsyning.dk
www.bornholmforsyning.dk

APPENDIX 4: EXAMPLE OF PRELIMINARY CONNECTION AGREEMENT, BORNHOLM, DENMARK

Agreement on District Heating Supply

Returned to Bornholms Forsyning with owner's signiture.

There are between the owner of the following property and Bornholms Forsyning signed an agreement on connecting district heating to the property located:

Land registry no. ______________________

Street name/no. ______________________

Zip code/City ______________________

- By signing this contract, the owner of the property agrees to the implementation of the connection to district heating under the conditions listed below, as well as the then-current general conditions, see Tariff sheet and Regulations (General and technical regulations for district heating supply).
- Tariffs and regulations, etc. can always be found on the website www.bornholmsforsyning.dk and can be obtained from Bornholms Forsyning. The website also contains a more detailed description of the elements of this agreement.
- When the property is converted to district heating, it constitutes an energy saving activity under the Heat Supply Act. By signing this Agreement, the energy saving accrues to Bornholm Varme A / S, and is reported to the Danish Energy Agency, or transferred / sold.
- This agreement is annulled if the project cannot be implemented due to insufficient enrollment.

Connection: Service pipe through the main valves in ground wall is free in the current construction campaign.
Connection also includes a standard district heating installation unit and direct connection for 17,000 dkr. incl. VAT (offers in relation to our energy-saving activities).

Offer of free service pipe applies to contracts signed before the excavation work is passed property.
Total price: 17,000 dkr. incl. VAT
– due <u>before</u> installation of Unit.

Living area according to BBR ________ m² (basic to calculation of floor area tariff, cf.tariff sheet)

Business area according to BBR ________ m² (basic to calculation of floor area tariff, cf.tariff sheet)

Property no. ________

Owner of the property	Bornholms Forsyning
Name:	Company: Bornholms Varme A/S, CVRnr. 3158 2148
Street name/no.:	Street name/no.: Toftelunden 1A
Zip code/City:	Zip code/City: 3790 Hasle
Telephone:	Telephone: +45 60 26 24 10
E-mail:	Date: 31st of May 2013
Date /Signature:	Signature:

VAND VARME SPILDEVAND

APPENDIX 5: EXAMPLE OF CONDITIONS FOR DH CONNECTION

Example of conditions for DH connection technical description, April 2013

Standard offer to properties in existing district heating areas and new district heating areas.

Bornholms Forsyning offers connection to the then-current rate, as per tariff sheet.
Note that there is a common tariff for properties in the existing district heating areas, as well as a "promotional rate" in areas where new district heating network are implemented.

1) The tariff covers in general the establishment of service pipe entering the property and ends with the main valves and meter.
2) In areas where new district heating network are established, the tariff also covers installing the consumer unit including hot water tank, and direct connection for properties with service pipes up to maximum d 20 mm (up to 350 m^2 heated area). The new district heating unit belongs to the owner of the property after installing. Removal of existing oil-fired boilers, and removal / blanking of the oil tank are also included in this offer.
3) For properties with electric heating (with a non-water-borne system) are offered free connection, which includes the free service pipe, and supply of consumer unit for properties with service pipe up to maximum d 20 mm. This particular advantageous offer is because the owner needs to invest in a radiator/heating system that is water borne, etc.
4) Bornholms Forsyning determines whether the property is under category 1), 2) or 3)

Bornholms Forsyning recommends using direct connections where possible, as it provides better cooling and is a simpler system with less maintenance. Since the district heating water in a direct system circulates through the building's radiators, the direct systems are established with two flow meters so that any leaks can be detected. Bornholms Forsyning uses units with a mixing loop to get a reasonable distribution of heat and cooling in one-stringed systems – there is seen good experience in connection to these systems.

Bornholms Forsyning's offer of implementation of domestic installation with the unit, as per 2), is an offer that is part of the company's energy saving efforts (all heating companies are required to meet an individual quota of energy savings):

A pressure test is carried out during installation, where a pressure of approximately 6 bars is used. When Bornholms Forsyning installs units with direct connection, it rarely happens that a radiator leak as related to pressure test - if the insurance does not cover the damage, then Bornholms Forsyning will cover. Those who wish, will have the old boiler, tank etc. removed as part of the offer. If the owner wishes - our plumber dispose the oil tank (including emptying of oil residues). There will be no payment for oil residue. Sealing of holes in the floor and wall from the old combustion units, feeding tube, etc. and blanking the chimney is not included in the offer.

Note that the consumer owns the new unit / installation just as if it was purchased privately. The heating-company's plant ends as previously at the main valves where district heating is led into the house, see the Regulative section 2.11. The new unit / installation is covered by the usual warranty rules, generally two years, and inquiries about possibly defects must go to the district heating company. There is generally very little maintenance of the unit, and our general service scheme involves a visit every third years, where the installation is reviewed and adjusted.

APPENDIX 6: DESCRIPTION OF DISTRICT HEATING UNIT

District heating unit

A standard unit has the following measurements (as shown in the picture)

110 l tank and unit directly above one another H: 1835 W: 615, D: 595

If you instead choose to place the two devices side by side - also called split system - is the height of the 110 liters tank 1185 and unit 650

Note: A demo of the model can be seen at the green warehouse (furniture factory) and in Allinge at our office; Kirkeplads 6 th. (open Wednesday from 2 am). A unit will also be at display at Industrivej 1a in Rønne.

Heat Control

Danfoss Comfort ECL 210

All units with a hot water tank are delivered with an electronic heat control type Danfoss ECL Comfort 210.

This device has control of the heating and domestic hot water system collected into one, easy to use solution.

This device ensures a weather compensated flow temperature of the building's heating circuit (radiator circuit). It simultaneously controls the temperature of the hot water tank and utilize this most effectively, on order to achieve both a reduction in heat loss in the service pipe and an intelligent control of the domestic hot water circuit.

By using this control device a range of advantages are achieved, that will ensure optimal use of energy and operation: With the "Auto-save"-function the flow temperature is regulated by the outside temperature, to achieve optimum energy usage all year round.

The controller provides a "summer lock-down" function where the heating circuit is closed and the circulation pump is switched off during summer time when the outdoor temperature reaches above a certain value. It re-opens by itself and turn on the pump when it gets colder outside. The use of domestic hot water is not affected by this feature.

There is normally no need for additional options of this control, only if one wishes to change the room temperature or the like.

Danfoss Comfort ECL 310

It is possible to replace the above type ECL 210 with a model ECL 310 by paying an additional price. This type of control goes via a modem connected to the internet, and can be set via a PC or smartphone. It allows you to turn on and off the heat in the house and monitor the heating system no matter where you are.