SDH 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 EXISTING DISTRICT HEATING USING BIOMASS AS PRIMARY FUEL

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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 the integration of **solar district heating with existing district heating using biomass as primary fuel.**

DH networks using a biomass boiler as a primary heating source often have problems in the summer period due to the low level of the heat demand. If there is only one boiler installed, the summer load corresponds to 20% or less of the peak output of the boiler. The biomass boiler is therefore turned off in some plants during the summer period and replaced by an oil boiler. In other plants, the biomass boiler runs at a lower load, corresponding to the heat demand in the summer, which results in higher emissions and lower efficiency. Sometimes, an accumulation tank is installed, which enables turning off the biomass boiler in periods.

Instead of the above-mentioned solutions, a solar thermal plant covering large parts of the summer load could be added to the DH system.

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

There are several distinct advantages of integrating SDH in a biomass DH system:

- There will be much lower to none emissions from the biomass boiler in the summer period.
- If the SDH system replaces an oil boiler, which is used for summer production, fossil fuels (and the emissions from them) can be avoided.
- SDH plants can run nearly without supervision. This would enable the DH personnel to engage in other activities, e.g. have holidays/ carry out customer service/ clean the biomass boiler, etc.
- If the biomass boiler can be turned off in longer periods, its lifetime can be prolonged.
- Less transport of biomass during summer

Nonetheless, there are also a few disadvantages:

- The solar collectors need a suitable area near the utility (or near a suitable DH pipe)

- An accumulation tank of 50-300 l/m^2 solar collectors needs to be added, if it is not already implemented. However, this will also be advantageous for the biomass boiler. An accumulation tank will equalize the winter production from the boiler, thus making it easier to cover the peaks in heat demand. Moreover, it will enable running the boiler at a fixed load, thereby prolonging its lifetime.
- The establishment of SDH would reduce the market for biomass, since it is a local product. This can be solved by extending the coverage of the DH system or by finding an additional biomass market. In the long run, biomass is expected to be a limited resource, due to the demands for biomass in the transport sector.

All the above-mentioned advantages and disadvantages have a value depending on the DH system. However, in all cases a rough feasibility calculation is necessary in the early stage of the project, with the purpose of estimating a heat production price from the SDH plant, which is then compared to the one of the existing biomass DH system. This can be done by asking a solar thermal supplier to give a price estimate of the solution or by using [1], Fact sheet 2.3 “Feasibility study”. A calculation of the estimated heat production price from the solar production plant can also be done by using an online calculation tool, developed by Solites [2] or Excel-tool scenocalc Fernwärme (in German).

Before starting a process for implementation of new DH with solar thermal panels, some additional conditions need to be in place.

Ownership and financing

The solar collector field can be owned and financed by the existing district heating utility or by an external supplier. For the communication in the decision-making process, it is important to know the model of ownership and financing from the beginning of the project.

Read more about:

- Utility as an owner
- Private ownership of roof mounted collectors
- Private ownership and third-party financing
- Solar collectors in cooperative ownership

In [1], Fact sheet 2.5 “Ownership and financing”.

Positive stakeholders

Whether the SDH plant will be owned and financed by the existing DH utility or some third-party, the **utility** has to be willing to implement the project/ buy the heat if their conditions for taking part in the project are met. For instance, if the DH price would not be higher than in the reference situation (or not more than X % higher). In this case the price calculation model has to be confirmed by the partners.

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

- Elaborating a heat plan for the municipality. In the European projects Hotmaps http://www.hotmaps-project.eu/ and Planheat http://planheat.eu/ tools for heat planning are under development.
- Making a “one stop” contact with the municipality for obtaining permissions and support with expertise.

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 [5]

Possible areas for placement of the solar thermal panels

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 SDH.

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 farm-land, and we calculate with 3.5 m^2/m^2 solar collector 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.

	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, [3]

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], [4] and [5], as well as in Figure 1, Figure 2 and Figure 3 on page 4.

Areas for solar collectors can be bought, leased 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, and that the solar thermal system can be established as distributed systems as an alternative.

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

Solar heating systems can be centralized or distributed systems.

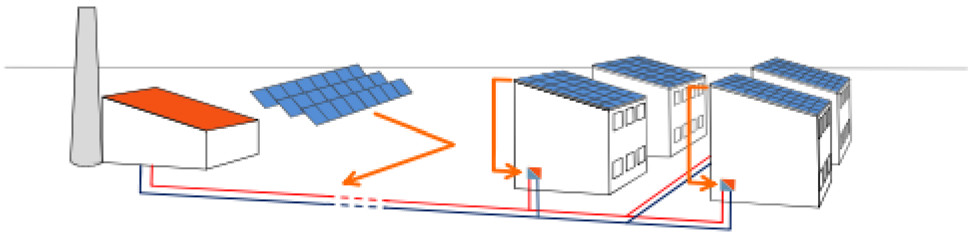

Figure 4: Distributed solar district heating system. [1]

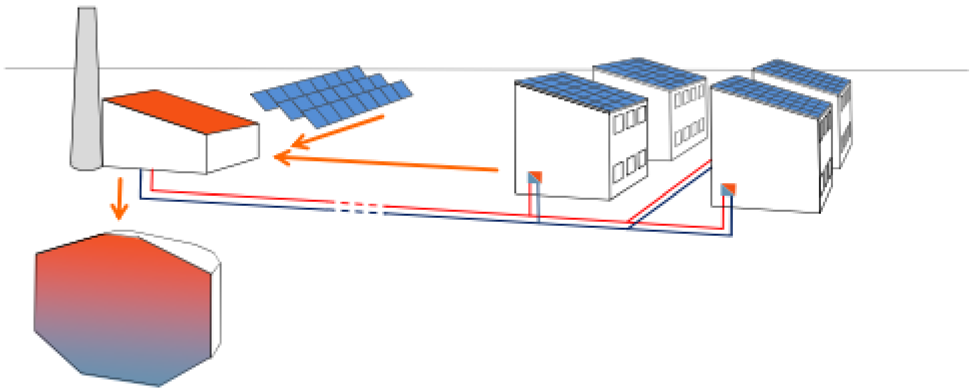

Figure 5: Centralized solar district heating system [1]

<u>Resources needed</u>

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
- Create information in local media

The DH utility can take care of this, however if the supplier is external it has to be done in cooperation.

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 (different future DH solutions)
- Why integration of solar heat in the present DH system
- Where to place the solar plant and the accumulation tank
- How to organise and finance the solar plant
- 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 contract between the utility and external investors (if the investor is external)
- Draft contract between the utility and the supplier of the SDH plant (if the utility invests)

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:

- Consumer price for district heating with and without SDH
- Pollution around the house

3.1. Comments to “Basis for decisions”

Description of possible heating solutions

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, industrial processes, waste incineration and heat pumps utilizing cheap electricity and producing power-to-heat), 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”.

Why integration of solar heat in the present DH system

The choice of solar thermal and the plant design have to be justified. Moreover, the SDH coverage of the annual heat demand has to be stated, to clarify if it will be possible to turn the biomass boilers off over longer periods and to determine if the SDH plant(s) is central or decentral connected to the existing DH grid.

Where to place the solar plant

A map showing the possible placement of solar collectors and connection to the district heating utility or pipe grid must be a part of the basis for decisions.

How to organize and finance DH

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.

Ownership of the SDH plant can be the utility or an external investor. The ownership model has to be described and the choice of ownership justified. See also [1], Fact sheet 2.5 “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:

- Investment, operation and maintenance costs for connection pipes.
- Investment, operation and maintenance costs for the solar panels. Prices can be found in [7]. Nonetheless, suppliers are often willing to give estimates on prices.
- Efficiency curve for solar collectors and grid temperatures over the year.
- The annual production from the SDH plant
- Saved costs in the existing DH system
- Financing conditions

Technical design includes size of 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. The principle diagram for a centralized system might look as in Figure 6.

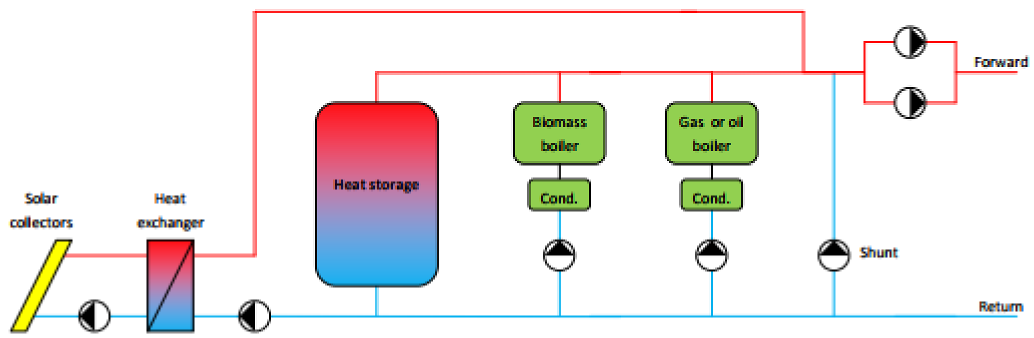

Figure 6: Principle diagram for solar thermal combined with biomass [1], Fact sheet 2.1 "Solar heat combined with other fuels".

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 the existing DH system.

Environmental consequences (emissions) for boilers can be found in [6] and [7].

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 an utility-owned and financed SDH plant can be found in Appendix 1.

Draft contract between utility and external plant owner/supplier of the SDH plant

If a SDH plant is owned by others than the utility, a contract has to be agreed upon between the parties. In [1], Fact sheet 2.5 "Ownership and financing", there is a list of important issues that need to be included in the contract:

1. Subject of the contract

Fixes the basics of the solar energy supply:

- Who is the plant owner, who is the utility?
- General information on the system integration of the solar thermal plant
- Start of the energy supply, usually fixed within a certain period of time or with a latest starting date.

2. Duration of the contract

Fixes the beginning and the end of the energy supply, and additionally:

- Exit clauses and exit terms for contracting out of the agreement for both contractual parties. This can be a tricky paragraph, and it is important to negotiate conditions which assure long-term stability for selling the solar energy!

3. Installation of the solar plant, property line

- Who is responsible for the installation of the technical equipment?
- Describes in all detail where the limits of performance are drawn, in particular the utilities responsibilities are defined. Moreover, the energy delivery point (usually position and integration of heat exchanger) is specified.
- Certifications requested
- Who pays the electrical energy for pumps and other equipment?
- Who cares for the ongoing service and maintenance of the solar plant?
- Property structure of the areas which are going to be affected by the solar plant in some way (tech room, roof, space for piping, …)

4. Details on the energy supply and the operation of the plant

Fixes all details between the plant owner and the utility that are related to the solar energy supply service:

- For the plant owner, is there a right to deliver the system's energy output to the utility? Required forward temperature, pressure and max flow? Obligation of backup?
- For the utility, is there an obligation or a right to buy the solar energy? How about required return temperature?
- All the risks concerning damage of the solar plant and damages or consequential damages that are due to some improper operation of the plant are for the plant owners' account.
- Date for earliest and / or latest begin of the energy delivery to the utility.

5. Solar energy price

This part specifies all questions related to the tariff model of the solar energy. It is completely arbitrary for both contract parties to agree upon a model which serves both sides' interests.

- Same price for the whole year or difference between summertime and wintertime?
- Price reduction for lower temperatures than required?
- Solar energy indexed to consumer price index / some other energy (be careful with risk of fluctuating prices) / any other reasonable factor?
  What's the effective date that serves as a basis for the indexing calculations?

- What happens if one of these factors changes drastically? New definition of this part of the contract?
- What happens if solar energy prices are related to other fossil fuel prices?

6. Metering and charging of the solar energy

- How is the solar energy metered?
- Any prerequisite for the metering facilities or the metering system in general?
- How is the solar energy going to be metered and charged to the customer?
- Who calibrates the metering equipment?
- Term of payment for the solar energy invoices

7. Other contract clauses

- How are withdrawals from the energy supply contract handled? States all circumstances under which one of the contract parties could exit the contract without legal consequences.

8. Legal venue

- Fixes the legal venue for any misconceptions between the contract parties
- Usually, there are appendices to the energy supply contract. Most commonly, the following appendices are included:
    - Hydraulic scheme of the energy delivery station with integration of the solar plant
    - Hydraulic scheme of the solar thermal plant.

If an utility owns the SDH plant, they have to make a contract with the supplier of the SDH plant. If it is a total contractor, a checklist for contract content can be found in [1] Fact sheet 3.2 “Tendering and contracts” p.4. A model for setting up performance guarantees can be found in [1] Fact sheet 3.3 “Performance guarantees”.

<u>Time schedule</u>

A time schedule showing the stages in the planning period (information 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.

<u>Possible barriers</u>

Possible barriers that need to be considered and complied with when situating the solar thermal field include the effect on environmental protected landscape (e.g. Natura 2000) and integration in the landscape. But compared to traditional farming, solar thermal plants will increase biodiversity and plants surrounding 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 the existing heating system.

Finally, sensitivity calculations showing how robust SDH is to changes in the most volatile preconditions have to be carried out. For instance, financing conditions and calculated lifetime of the SDH plant and biomass boilers, as well as development of biomass prices, are important.

4. PUBLIC ACCEPTANCE AND AUTHORITY PERMISSIONS

If the Basis for decisions is accepted by the stakeholders, information and involvement of the population of the city, along with the process of acquiring public permissions, can start. Usually it is not difficult to get public acceptance of a SDH plant.

However, experience from wind power and biogas planning says that the investor(s) has to be proactive to gain public acceptance. If a strategic energy plan and/or a heat plan is elaborated for the municipality, it can be of great help in gaining public acceptance, as long as people have been involved in the planning process, because lack of information and inclusion gives a feeling of powerlessness and can cause huge frustrations, angry feelings and resistance against projects.

On the Danish island Samsø, several energy projects have been implemented in the period from 1996 until now with public perception and acceptance. One of the experiences from the implementation projects is that careful preparation in the first steps is a must. In the project “Implement” supported by the EU Interreg program, Samsø Energy Academy described the implementation process in “A manual on citizen involvement” [8]. The manual is described for a biogas project but is useful for other projects as well.

The steps in the manual are:

- Elaboration of baseline study including collection of information about local social habits.
- Engagement of people that know local habits and conditions.
- Identify the directly involved project stakeholders.
- Find “what’s in it for me” for the involved stakeholders.
- Define objectives for involvement and a strategy for how to reach the stakeholders.
- Involve the local authorities in the project.

The process (must be carried out from the bottom and controlled from the top)

- Communication must be clear and proactive. Communication channels must be defined.
- Objective of meetings must be clear, and meetings prepared by contacting key stakeholders before the meeting and discuss possible scenarios of what might happen.
- Between the meetings the project can contact key stakeholders, arrange working groups, arrange sightseeing to similar projects.

This method of involvement has created local ownership to all kinds of energy projects on the Island of Samsø. It is also important that there is a master plan for transition to renewable energy for the island and that this masterplan is broadly discussed and politically approved.

5. BUILDING THE PLANT

When authority permissions are obtained, 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 continuously inform people about the project. If the project includes implementation of DH pipes in the streets, this can cause 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

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

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

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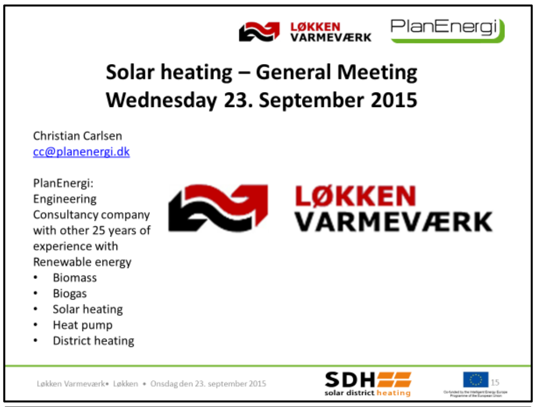
[6] Technology Data for Energy Plants. Danish Energy Agency and Energinet.dk. May 2012. Updated 2015. https://ens.dk/en/our-services/projections-and-models/technology-data

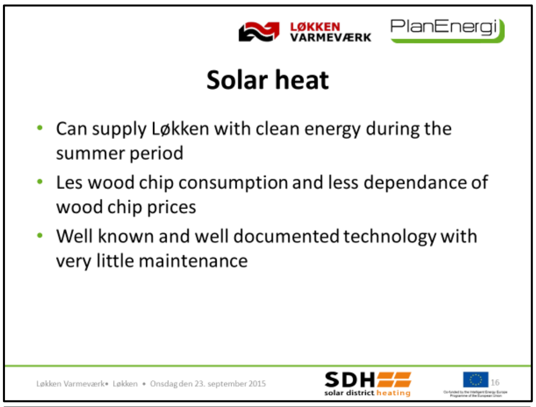
[7] Technology Data Catalogue for Energy Plants. Danish Energy Agency and Energinet.dk. August 2016. Updated June 2017. https://ens.dk/en/our-services/projections-and-models/technology-data

[8] People and Biogas. A manual on citizen involvement. www.peopleandbiogas.com

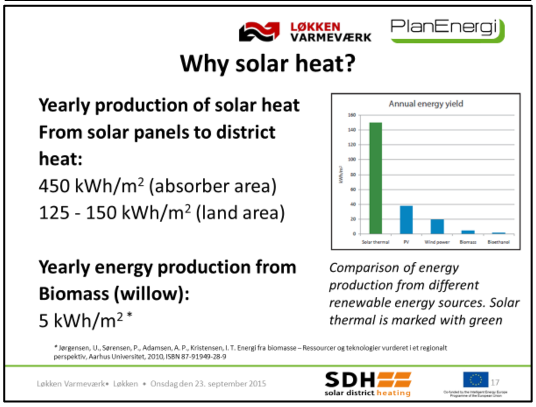
APPENDIX 1: PRESENTATION OF BASIS FOR DECISIONS, LØKKEN DENMARK



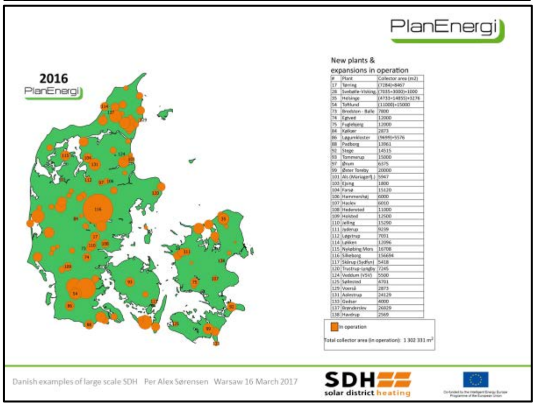
The presentation was made for the General Meeting. Løkken Varmeværk is a consumer owned co-operative. The presentation is made from the "Basis for decisions" report



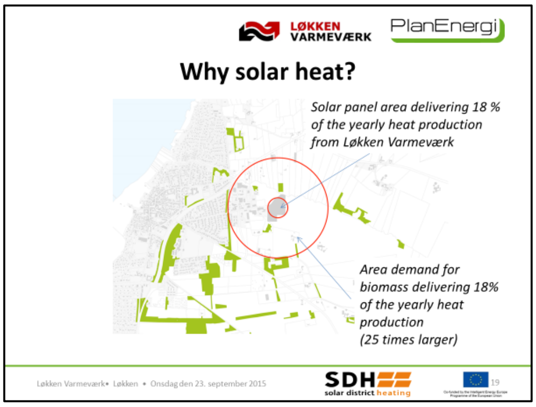
Why solar heat (1)



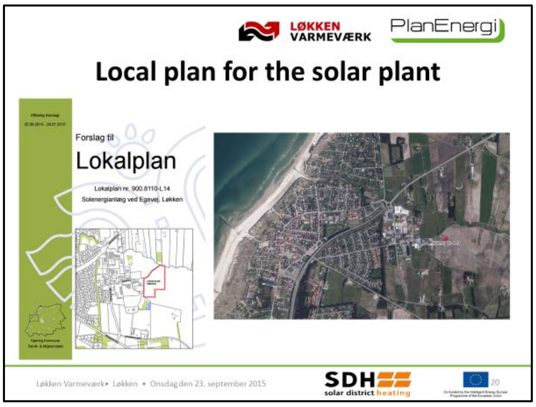
Why solar heat (2)



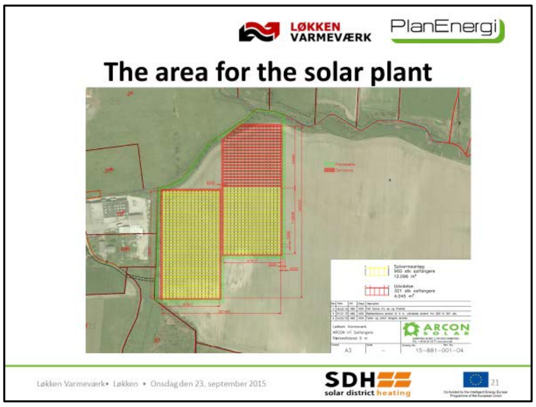
Map of already implemented Danish plants



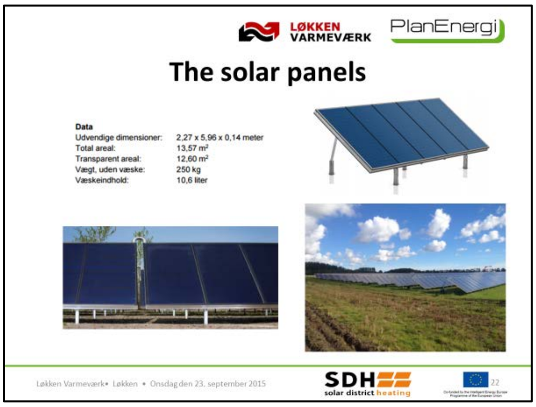
Calculation of area necessary for solar heat and biomass



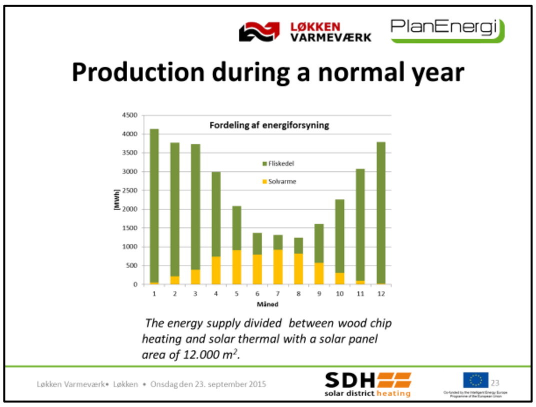
A local plan was already made by the municipality



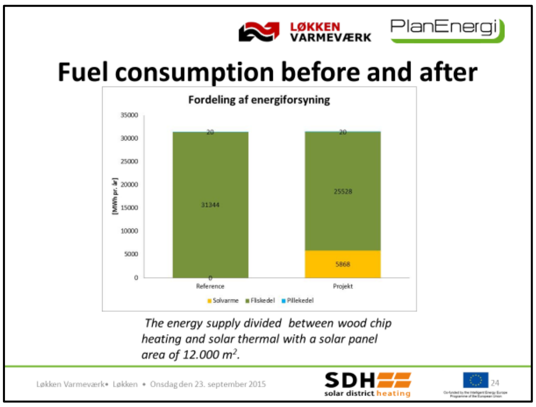
And the area for the plant and for a possible extension was pointed out in the local plan



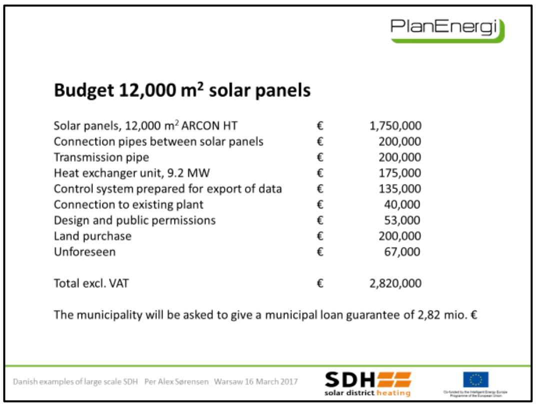
Description of the chosen solar panel



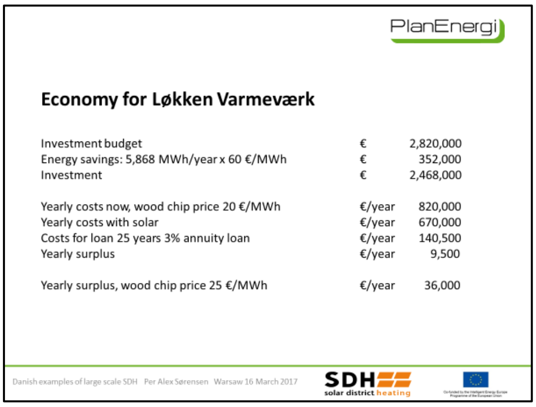
Result of calculation in energyPRO with 12,000 m²



Yearly result



Budget for the plant and financing



Consequences for the heat price with two different wood chip prices. The 3% is the real interest rate and the result is the average for 25 years