SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Checklist Solar Thermal District Heating

Subtask C report RC2

IEA SHC TASK 68 | Efficient Solar District Heating Systems

Technology Collaboration Programme
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SOLAR HEATING & COOLING PROGRAMME
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Checklist Solar Thermal District Heating

This is a report from SHC Task 68: Efficient Solar District Heating Systems

Subtask C: Business Models

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Solar Heating and Cooling Technology Collaboration Programme (IEA SHC)

The Solar Heating and Cooling Technology Collaboration Programme began its work in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency.

Our mission is: *To bring the latest solar heating and cooling research and information to the forefront of the global energy transition.*

IEA SHC members carry out cooperative research, development, demonstrations, and exchanges of information through Tasks (projects) on solar heating and cooling components and systems and their application to advance the deployment and research and development activities in the field of solar heating and cooling.

Our focus areas, with the associated Tasks in parenthesis, include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54, 69)
- Solar Cooling (Tasks 25, 38, 48, 53, 65)
- Solar Heat for Industrial and Agricultural Processes (Tasks 29, 33, 49, 62, 64, 72)
- Solar District Heating (Tasks 7, 45, 55, 68)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59, 63, 66)
- Solar Thermal & PV (Tasks 16, 35, 60, 73)
- Daylighting/Lighting (Tasks 21, 31, 50, 61, 70)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, Test Methods and LCA/LCoH (Tasks 14, 24, 34, 43, 57, 71)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46)
- Storage of Solar Heat (Tasks 7, 32, 42, 58, 67)

In addition to our Task work, other activities of the IEA SHC include our:

- SHC Solar Academy
- *Solar Heat Worldwide*, annual statistics report
- SHC International Conference

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1 Executive Summary

Solar thermal energy generates heat for space heating, sanitary warm water production and industrial processes. With heat making up 50% of the global energy demand, solar-thermal technology plays a significant role in the future energy mix regarding heat generation and reducing carbon emissions.

However – as with other technologies – good standards in designing, constructing, and operating solar-thermal plants are key to create cost-efficient solutions and maximize the usable energy output over their long lifetime. Providing consistent high quality system performance will also increase the image and utilization of the solar-thermal technology.

Hence, this report aims to help plant designers and operators by providing checklists with critical aspects and questions for each stage of a solar-thermal plant's lifetime (from project idea to decommissioning). The report is aimed at different actors for each phase, from project developers to plant operators.

2 Lifetime stages of solar thermal district heating

The following six lifetime stages of a solar thermal plant have been considered in this report. This breakdown has been made to highlight important aspects and decisions in each phase. Moreover, different actors are addressed in each step. A short descriptive text is given below for each stage.

Project idea – In this stage, the aim is to identify customers and locations with potential for solar-thermal plants and to assess their energy needs. It is the very first step to roughly analyse the feasibility, understand customer requirements, and to decide whether more time should be invested into a project.
(Main Actor: Project Developer)

Planning phase – As a next step, the feasibility of the project needs to be assessed in more detail and a final design for the plant needs to be identified. Customer requirements are refined, heat potentials and technologies are analysed in more detail, and system components need to be sized and dimensioned techno-economically. Permits, costs, funding, legislations, local-standards, and other topics need to be addressed as well.
(Main Actor: Plant Designer)

Project preparation – In this phase, the plant design is fixed. Allowing costs to be finalized, yield, components and other topics discussed in the planning phase like permits and financing. Finally, components are bought and manufactured, and logistics need to be addressed.
(Main Actor: Engineering)

Construction phase – In this phase the plant is built, installing the thermal collectors, connecting pipes and connecting to the customer (e.g. a district heating grid or perhaps an industrial client). Finally, the plant needs to be commissioned.
(Main Actor: Construction Team).

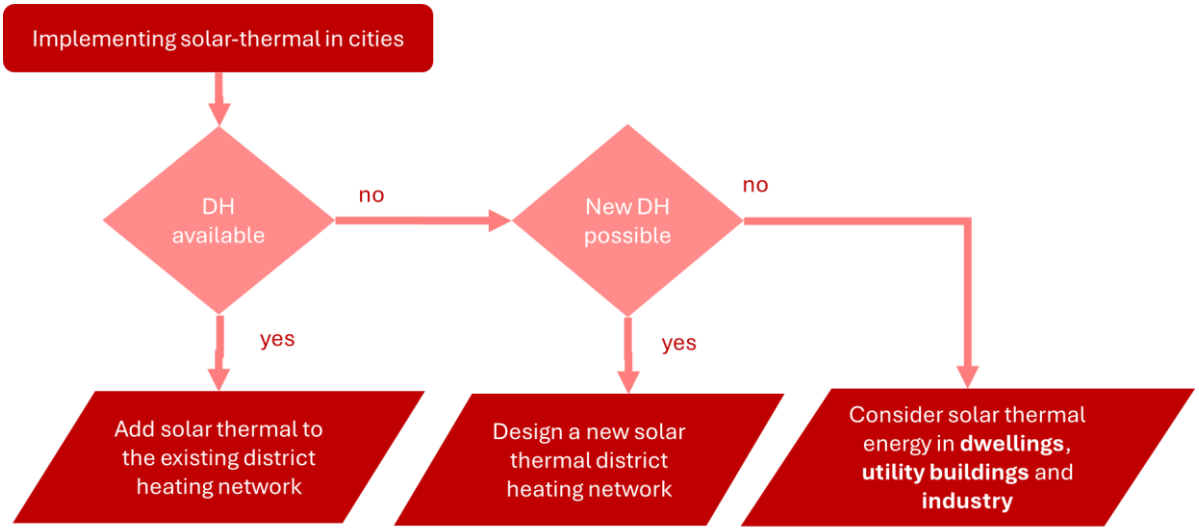
Operation – During plant operation, the operator needs to ensure that the plant is running at optimal performance and align production with other heat sources in the system. Main tasks are monitoring, fault detection, scheduling and carrying out repairs and services, and communicating with stakeholders.
(Main Actor: Operator).

Decommission – Finally, the last phase in the lifetime of a solar-thermal plant is its decommissioning. Broken parts need to be reassembled or refurbished. Parts which cannot be used anymore need to be recycled.
(Main Actor: Operator)

The consecutive stages will be discussed in the separate sections following on the next pages.

3 Checklist for the stage of project idea

The flow chart below gives a basic approach to start considering solar thermal energy. The first question is whether a district heating system is already available, which could be a starting point for adding a new solar thermal source. An alternative option is to design a new district heating network, in which solar thermal is an integral part of the design. If both options are not possible, stand-alone installations are still worthwhile to consider.



DH = District Heating

In case of an existing district heating network:

Checklist for Project Idea phase		
Question	**Description / Context**	
Why decarbonize?	What is the ultimate goal for decarbonising the heat supply of the existing district heating network? Full decarbonisation, or is it a first and partial step towards decarbonisation? Is it important to make the energy supply regionally self-sufficient as far as possible? This will impact the design in the early project idea phase.	☐
Are alternative sources available?	Are there other renewable energy sources, which can be used to supply the district heating? For example, industrial waste heat, which cannot be avoided by energy efficiency measures, environmental heat from water bodies (aqua thermal energy) that can be harvested using heat pumps.	☐
Financial boundary conditions?	What framework conditions exist regarding economic efficiency? Who is initially paying the investment and how is it remunerated?	☐
Technical boundary conditions?	Are there framework conditions regarding the technical components?	☐
Solar fraction?	Is a small solar share enough (roughly <10%, with or without diurnal heat storage) or targeting large solar shares (up to 50% or higher, including seasonal storage)?	☐
Temperature level?	Does the temperature level of the district heating system match the technical possibilities of solar thermal? Supplying district heating by solar thermal at >90°C is technically doable with certain collectors, 60-90°C is doable, <60°C is relatively easy.	☐
Climate conditions?	Identify characteristics of the average solar irradiation in the region. What share of the demand can realistically be covered by solar thermal regarding local climate, heat storage and other available heat sources? Is a small solar share enough (roughly <10%, with or without diurnal heat storage) or targeting large solar shares (up to 50% or higher, with seasonal heat storage, either aquifer thermal storage, borehole storage or pit storage)?	☐

Available Space?	Is space available for solar thermal collectors, either on roofs or on the ground?	☐
Available Storage?	Is there a heat storage already available in the district heating? If not, is there an option to install one?	☐
Demand (temporal distribution)?	Identify characteristics of the (optimised) heat demand: minimal heat demand in summer, maximum heat demand in winter. Ideally heat demand including a future projection should be available for each hour of a typical year.	☐
Pre-selection	Which of the rough technical variants is the most economical according to an initial assessment?	☐
Optimization for solar-thermal?	Is it possible to optimise the operation of the DH system for better integration of solar thermal? For example, reduce energy demand by applying insulation to houses and piping and lowering the operational temperatures. On average, heat losses in district heating networks is around 20%.	☐
Future Demand changes?	Is a densification (further compacting cities by increasing the population density in already developed urban areas) of the connected buildings planned or necessary?	☐

In case of a *new district heating network*, the following additional questions might be considered:

Addition to Checklist (in the case of a new district heating network)		
Question	**Description / Context**	
Low Temperature possible?	Is it possible to design the system as a low temperature system? For example, <60°C or <30°C.	☐
Network scale?	What is the right scale for a DH system? Large (city, neighbourhood) or small (street or a number of houses). Where is the heat demand density high enough for district heating?	☐
Seasonal storage?	In case of low temperature seasonal heat storage district cooling could be an option, thus providing additional service.	☐
Energy savings?	Has energy saving been applied as far as reasonably achievable?	☐

In case of district heating is not an option or not the preferred solution some general questions to be addressed:

Checklist in case district heating is not an option or not the preferred solution		
Question / Topic	**Description / Context**	
Is solar supported space heating possible?	How are the buildings heated (heat source, indoors heat emitting system) and is it necessary to change it?	☐
Sanitary Warm Water supply?	Consider stand-alone solar thermal for sanitary warm water.	☐
Check options for solar space heating	Consider stand-alone solar thermal for space heating (in combination with a heat pump).	☐

4 Checklist for the stage of planning phase

Checklist		
Question / Topic	**Description / Context**	
Collector orientation?	Is the location fine (oriented south, no shading)? Rule of thumb: 10 m² collector surface needed to supply 20% of annual heat consumption for a household (depends on climate region). *Source: IEA-SHC Task 55 flyer*	☐
Combination with other technologies?	How do other energy sources influence the design of the solar-thermal plant? Is there another renewable technology that should be considered? Formulate ideas on thermal storage: no storage, diurnal storage in a water tank or seasonal storage.	☐
Dimensioning?	What is a reasonable size for the collector area?	☐
Area cost?	Is the required area available at low cost (land lease, roof rent)? In case of roof areas: is the roof strength adequate?	☐
Required Permits?	Which permits are required for constructing the plant?	☐
Dual land use?	Is it possible to enable dual use of the collector field (e.g., sheep herding, farming, etc).	☐
Funding available?	Are there any support measures or subsidies available from municipal, regional or national governments?	☐
Heat supply contract	What type of heat delivery contract is a convenient choice?	☐
Local Support?	Can neighbours and heat clients be involved in the planning and can they provide feedback to the plans?	☐
Stakeholders?	Who will invest, who will construct, who will own and who will operate the plant? Is it an option to have heat clients invest and co-own the solar thermal plant? May the project be accompanied by an energy saving campaign? Is an energy co-operative an option?	☐
Partners?	What manufacturers and EPC[1] companies exist and how do they perform? Can a company assist in the planning phase?	☐
Connection to district heating grid?	Is the district heating grid connection available? Is a new heat transport line needed? Depending on design factors, such heat transport line may be up to 15 km (but preferable shorter).	☐
Biodiversity	A ground-based collector field should be designed in such a way that biodiversity still can flourish. Usually this means enough space between the collectors, but also attention for flora (native plants) and fauna (nest-building).	☐

[1] EPC: contractor planning and executing all **E**ngineering, **P**rocurement, and **C**onstruction activities needed to complete a capital project

5 Checklist for the stage of project preparation

Checklist		
Question / Topic	**Description / Context**	
Yield calculation	Make a detailed yield [MWh/year] calculation.	☐
Cost estimation	Make a detailed estimate for the total system investment costs [€/m²].	☐
LCOH calculation	Make a detailed calculation for the cost of heat [€/MWh] from the solar thermal plant, including costs like land or roof lease, insurance. This cost value is relevant for the district heating network owner.	☐
Communicate costs	Communicate to the client what the effect will be on the price level of the supplied heat. One advantage is that the price level is expected to remain constant, since fossil fuel price increases do not affect the end-user heat price (depending on the system layout).	☐
Transparency to customer	Communicate transparently about the heating system. Also mention the network losses and compare the costs, prices and price risks to the consumers.	☐
Prepare financing	Financing: benefit from smart financing based on loans which are fully guaranteed by the municipality. *Source: IEA-SHC Task 55 flyer*	☐
Manage funding	Ensure that energy saving agreements with government can be fulfilled with solar district heating. *Source: IEA-SHC Task 55 flyer*	☐
Coordinate with other energy sources	Between May and August, a solar field can meet all hot water needs, so that the district heating company running the field can shut down boilers to significantly extend their useful lifetime. *Source: IEA-SHC Task 55 flyer*	☐
Exchange knowledge	Synergy in the sector: take a non-profit approach, so that there is no need to keep good ideas under wraps and exchange information on the latest technologies, cost-saving methods and efficiency improvements. *Source: IEA-SHC Task 55 flyer*	☐
Detailed engineering and logistics	Perform a detailed simulation to verify the final design. Perform detailed engineering for dimensioning all components. Prepare hydraulic schematics and plans for construction. Identify and select suitable components from manufacturers. Plan logistics (apart from timetable and cost flow this also includes checking for available space for construction vehicles and parts, and making sure components can be delivered to the location regarding size). Consider local norms and standards.	☐
Use high-quality components	Quality of the components (collector, heat exchangers, piping, insulation, etc) should be good, preferable independently checked by a quality seal.	☐
Is pressure drop, OK?	Are the requirements for pressure drop in the system met?	☐
Structural design	Design the construction in such a way that it withstands wind and precipitation loads.	☐
Insulation	Apply insulation with high insulation value, for piping, components, and energy-efficient fluid pumps.	☐
Maintenance plan	Decide on operation and maintenance strategies and contracts [€/m²/year]	☐
Required measurements	Decide on metering and control strategies, consider publishing real-time yield data through an open data platform.	☐
Data gathering	Ensure that data from the plant are accessible from a distance, and that the plant can be controlled remotely.	☐
Data security	Ensure that all data connections are secure.	☐
Prepare manuals	What will the client see (temperatures in the system, generated heat, consumed heat)	☐
User dashboard	User interface: what will the plant owner see and what are control options? What will the client see (temperatures in the system, generated heat, consumed heat)	☐

6 Checklist for the stage of construction phase

Checklist		
Question / Topic	**Description / Context**	
On-Site preparation	What on-site preparatory works need to be performed?	☐
Inform neighbours	Will there be inconvenience for the neighbours?	☐
Select machinery	What equipment and machines are needed on the site, and can nuisance be reduced?	☐
Consider environmental aspects	For healthy soil life it shouldn't be compressed, can heavy machinery be prevented?	☐
Insurance	Organize insurance (e.g. for personnel, transportation or other damages, delays, etc.).	☐
Safety	Ensure safety of personnel and surroundings. Provide and check safety instructions. Construction such that fire risk is reduced	☐
Logistics	Handle logistics and make sure there is available area on site to temporarily store components and parts.	☐
Accessibility	Can collectors be easily replaced or repaired? Is there enough space to move around, install, maintain, and repair critical components?	☐
Coordination	Manage and coordinate different contractors, perform quality assurance, gather required construction reports, and handle claims	☐
Public relations	Maintain relationship to customer and locals during construction. Keep people informed and motivated.	☐
Commissioning	Prepare and perform commissioning and handle funding.	☐
Guarantees	Product guarantee of minimal 5 years should be given on components and 10 years on collectors.	☐

7 Checklist for the stage of operation

Checklist		
Question / Topic	**Description / Context**	
Monitoring	Periodically check the performance of the plant and its components.	☐
Maintenance	Is maintenance guaranteed? Are there regular services and checks? Predictive/preventive maintenance?	☐
Repairs	What is the expected remaining lifetime of components? Is replacement/repair necessary?	☐
Data utilization	Is there demand for digitalization and maintenance? (data extraction and validation, live-monitoring, fault detection, accounting, research, customer dashboard, etc.)	☐
Optimization	Can operation and control be optimized? For example, in case of changes in customer requirements or demand. Or in case heat and electricity prices change. Does it make sense to increase the solar field or other components?	☐
Public relations	Maintain relationship to customers.	☐
Site visits	Is there demand for site visits?	☐
Safety measures	Are there any risks and are all required safety measures in place?	☐
Frost protection	Is frost protection available? How (chemical or by emptying the collectors)?	☐
Environment aspects	Use maintenance products (i.e. antifreeze) with lower environmental impact.	☐

8 Checklist for the stage of decommissioning

Checklist		
Question / Topic	**Description / Context**	
Continued use?	Can existing permits be prolonged or are new permits to be purchased?	☐
Refurbishing?	Can part of the installation still be used or be repaired?	☐
Early replacement?	Anticipate to next generation solar thermal: cheaper, more performant. Compare the option of major revision with recycling costs.	☐
Evaluate recycling options	Are the collectors designed in line with a circular economy and ready for recycling? Are the various materials easily separated and are all materials pure and ready for recycling (such as glass, coatings, insulation, solder).	☐
Perform recycling	Where to recycle the parts that cannot be reused? Organise logistics for transportation and calculate costs and revenue.	☐

9 Literature references / further reading

Main reference:

IEA SHC Task 55 flyer: download at https://task55.iea-shc.org

Additional information and further reading:

S. Alexopoulos, S. A. Kalogirou: *Solar Thermal Energy* (Encyclopedia of Sustainability Science and Technology Series), 2022, Springer Nature, New York, ISBN 978-1-0716-1421-1, https://doi.org/10.1007/978-1-0716-1422-8

A. K. Provasnek, S. Putz: *Design Handbook* - Installation, Commissioning and Operation of Large Scale Solar Thermal Plants (report from IEA SHC Task 45), available on https://task45.iea-shc.org/publications and as https://nachhaltigwirtschaften.at/resources/iea_pdf/endbericht_201603_iea_shc_task45_anhang03_handbook.pdf

Further Fact Sheets from IEA SHC Task 45 (https://task45.iea-shc.org/publications) and from IEA SHC Task 55 (https://task55.iea-shc.org/publications)