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IEA-SHC Task 45: Large solar heating/cooling systems, seasonal storage, heat pumps

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Abstract

Large solar thermal systems have proven to be cost effective in several cases - and the combination of a large solar system with long term storage and also heat pump seem to be very attractive in an efficient modern energy system due to:

- flexibility when supplying combined heat and power production in a liberal market for electricity
- potential for obtaining very high solar and renewable fractions of supply.

The use of solar thermal in connection with district heating is far behind (relatively only one tenth of) the use of solar thermal in individual houses - even though it is in most cases much cheaper to supply solar energy centrally to a district heating network, than to supply solar energy to individual houses.

In Denmark right now "an explosion" in numbers of large scale solar district heating systems is seen. Not because of special subsidy schemes - but simply because the systems in many cases are competitive with gas and biomass based district heating systems.

The main overall objective of the IEA-SHC[i] Task 45 is to assist in a strong and sustainable market development of large solar heating and cooling systems. The task will focus on the "MW-size" systems for district heating and cooling applications.

The general outcome of the Task will be increased use of cost effective, well designed and well operated large scale solar thermal systems throughout the world - and a strong network of experts and professionals in the field.

Main deliverable will be a "Design Handbook for Large Solar Heating/Cooling Systems"

Keywords: Large solar systems; solar district heating; seasonal storages; heat pumps; IEA-SHC Task 45

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1. Introduction

The main objective of this task is to assist in the development of a worldwide strong and sustainable market of large solar heating and cooling systems by focusing on cost effectiveness, high performance and reliability of systems. The work's main focus is on solar assisted district heating (and cooling) systems dealing especially with the system level and how to match a system configuration to the local needs and conditions.

2. Background

The background for starting the Task is the recent growing interest around the world for this kind of systems and an even dramatic development in a few markets.

Large solar thermal systems have proven to be cost effective in several cases - and the combination of a large solar system with long term storage and also heat pump seem to be very attractive in an efficient modern energy system due to:

- flexibility when supplying combined heat and power production in a liberal market for electricity
- good potential for obtaining very high solar and renewable fractions of supply (almost 100 % solar fraction is achieved a system in Canada!)

The use of solar thermal in connection with district heating is far behind (relatively only one tenth of) the use of solar thermal in individual houses - even though it is in most cases much cheaper to supply solar energy centrally to a district heating network, than to supply solar energy to the individual houses.

The Task should serve the need for development in the following fields:

Solar collectors for large systems:

- Improve cost / performance ratio
- Secure long life time

Seasonal storages:

- Reduce cost of the “expensive concepts”
- Increase durability / maintenance cost / performance of the “cheap concepts”

Systems:

- Optimize performance of such systems through analyzing control strategies and the right combination of solar thermal, heat pump, seasonal storage and others
- Optimize such systems with respect to integration in the surrounding regional / national energy system
- Minimize maintenance and operation cost

Apart from developing the technology there is also a big need for spreading out existing success stories and best practice in order to inspire people to utilize the huge potential of this cost effective energy supply - and in order to avoid “re-inventing the wheel”.

As almost half of our total energy use is low temperature heating and cooling it is obvious and essential to utilize this possibility for very cost effective solar heat and cold production and save fossil fuels and biomass resources.

The Task 45 was proposed from Danish side. In Denmark we see right now “an explosion” in numbers of large scale solar district heating systems see fig.1 below. Not because of special subsidy schemes - but simply because the systems in many cases are competitive with gas and biomass based district heating systems.

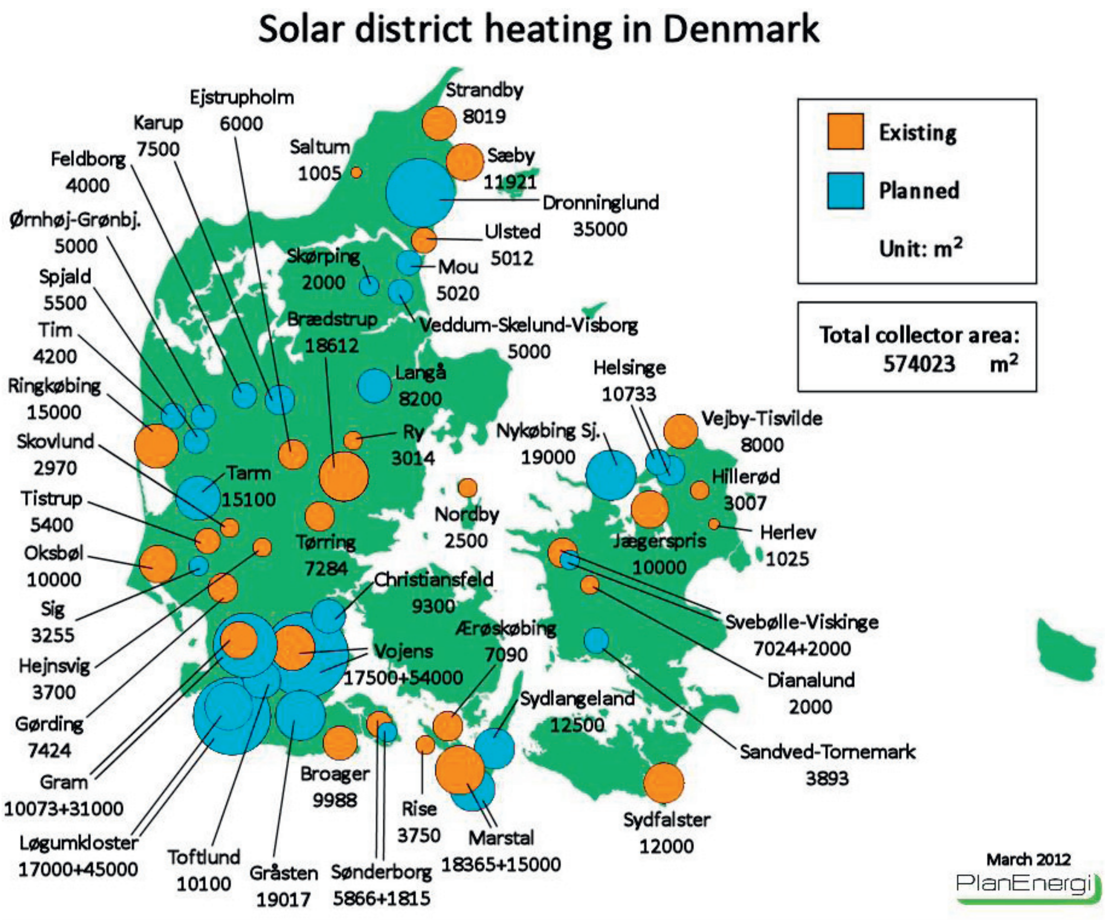

Fig. 1. Existing and planned solar district heating systems in Denmark - it is seen that a lot of new very large systems are underway

Some of these Danish projects already include:

- large scale seasonal thermal storage
- combination with heat pumps
- combination with combined heat / power production (gas motor)

If large scale solar systems are so popular in Denmark - this could also be the case in other countries.

The European projects: “Solar district heating - Take-off” and “Solar District Heating PLUS” (www.solar-district-heating.eu) dealing with solar district heating, are supporting the Task 45.

3. Objectives and scope

The main objective of the Task 45 is to assist in a strong and sustainable market development of large solar district heating and cooling systems. The systems can include seasonal storages and/or heat pumps/chillers.

The main focus is on the system level: How to match the actual system configuration to the actual needs and local conditions including the surrounding regional energy system (free electricity market). Or in other words: For the given conditions of load and energy prices, which system type and size to choose to have a competitive heat price and a large solar fraction. It is important that the systems are installed and controlled/operated properly in order to perform well. To secure that, guidelines and standards have to be updated and developed and recognized performance guarantee procedures established.

To push the market development, a strong effort will be done in promoting the benefits of the technologies and results from the Task to the decisions makers in the sectors of district heating and cooling and process heating and cooling. The issue of financing the “upfront investment in 25 years of heat production” will be dealt with - and models for services of Energy Service Companies (ESCo’s) will be proposed and sought tried out.

The scope of the Task covers large-scale solar thermal systems – preferably with a collector area larger than 700 m² (0.5 MW). Included are pre-heat systems as well as any combination with storages, heat pumps, CHP-units, boilers, etc. for the supply of block and district heating & cooling.

4. Subtasks

The work is organized in the following subtasks:

- Subtask A: Collectors and collector loop (Subtask leader DTU/DK)
- Subtask B: Storages (Subtask leader SOLITES/DE)
- Subtask C: Systems (Subtask leader S.O.L.I.D./AT

4.1. Subtask A: Collectors and collector loop

The general objectives of Subtask A are:

- to assure use of suitable components
- to assure proper and safe installation - including compatibility with district heating and cooling network to assure the performance of the collector field

The following activities are proposed:

<u>A1: Improve use and accuracy of collector test results</u>

- Investigate and describe influence from operation conditions on the collector field performance - and draft an amendment to EN 12975 and/or EN 12977 on how to correct standard test results.

<u>A2: Define requirements and test methods for collector loop pipes</u>

- Investigations on requirements and test methods on durability of pipes for solar collector loops will be carried out. Among other things, thermal expansion, corrosion and boiling behaviour with different solar collector fluids will be studied.

<u>A3: Requirements to hydraulic design of collectors and collector fields</u>

- Parallel theoretical and experimental investigations on the flow distribution for different rows of serial connected solar collectors will be carried out for differently designed solar collector fields with different piping systems and circulation pumps. Includes:
    - applicable hydraulic design of collectors
    - flow distribution in parallel absorber pipes, collectors and collector groups
    - uniform distribution of flow rates in overall collector area with less regulation valves
    - pipe heat losses
- Guidelines for design, control and operation of solar collector fields will be worked out.

A4: Precautions for safety and expansion

- Thermal expansion and stagnation behaviour and measures to handle stagnation.
- The solar collector loop design will also be investigated with focus on air escape, thermal expansion of solar collector fluid.

A5: Guaranteed performance of the collector loop

- A procedure for how to guarantee and check the performance of collector field and heat exchanger will be elaborated and tried out on existing plants.

A6: Cost/performance improvement

- Investigations with focus on reduction of the cost/performance ratio for building integrated solar collector fields inclusive the applied control and operation strategies will be carried out.

4.2. Subtask B: Storages

The following activities are proposed in subtask B:

B1: State of the art – Evaluation of existing projects

- Definition of selected pilot and research projects to be evaluated by national participants.
- Evaluation based on questionnaire
- Overview analyses of pilot projects and storage developments: main findings, constructions and materials to be recommended, problems found.
- Cost analyses of construction technologies and materials.
- Cost for operation and maintenance.
- System interaction.

B2: Technical improvements

- Identification of necessary developments / improvements.
- Collection of possible improvements, new concepts, materials, investigations …
- If possible: investigations on identified technical improvements.

B3: Quality management

- Definition of technical requirements and procedure(s) for checking the performance of storages (materials, thermal losses, stratification, …).
- Definition of characteristic parameters for comparison of storages (equivalent storage volume, equivalent heat capacity, usability of stored thermal energy etc.).

B4: Knowledge transfer / dissemination

- Preparation of design guidelines for seasonal storages.
- Review of design / simulation tools.
- Database on seasonal storages: Gather data on large seasonal thermal storages - present via web (co-op. with the IEA storage group: IEA ECES / www.energy-storage.org).

4.3. Subtask C: Systems

The general objective of this subtask is to provide decision makers and planners with a good basis for choosing the right system configuration and size. More specifically the objectives are:

- provide an overview of applications and system configurations
- see the large solar systems in the context of the surrounding regional/national energy system (competition with waste heat, integration in the free market for electricity, …)
- provide a good basis for decision makers to decide on investment in large solar systems
- provide state of the art of simulation tools and simulation models
- provide general design requirements for DH networks
- define parameters to identify suitable existing DH networks
- give models for ESCo services (contracting)
- give procedures for performance guarantee - and check
- give recommendations for monitoring and checking system output
- define criteria to adapt solar systems to the DH networks (existing and new)
- sensitivity analysis of SDH systems, considering different parameters such as DH distribution temperature, solar fraction, storage size, load, economics
- give recommendations for operating strategies
- give design guidelines for "substations units" (units controlling the in- and output of heat for buildings with collectors fields on e..g. the roof)

The following activities are proposed:

C1. Overview

- Overview of system categories (systematic categorization of large solar systems with respect to applications, components, component types,
- Detailed description of (all) existing systems with (seasonal) storage and/or heat pump by each national representative
- Updated database for all large solar systems > 0.5 MW

C2. Feasibility

- Does a large solar system fit into the surrounding regional/national energy system (competition with waste heat, integration in the free market for electricity, …) (each national representative)
- Tools for feasibility studies: overview on calculation tools providing strong and weak points and users' categories
- Develop a dedicated pre-feasibility tool
- Written guidelines (including requirements from DH IEA task and parameters to identify existing suitable DH networks and sensitivity analysis) Examples: Economy for realized systems
- Case studies; different application; different countries (comment: 20 case studies will be carried out within FP7 Sunstore4)
- Guidelines for environmental assessment

C3. Models for ESCo services

- Financing models, financial risks, ownership, system maintenance
- Existing examples
- Case studies; different application; different countries

C4. Performance check/monitoring/surveillance

- Procedures for performance check
- Recommendation for monitoring and verification / surveillance of systems

C5. Guidelines for planning, installation, commissioning, operation

- Give inputs for Design Handbook
- Give inputs for handbook in subtask E for the overall installation, commissioning and operation of solar district heating

C6: Guidelines for connection of decentralized solar thermal systems

- Give inputs for handbook for direct and indirect connection of decentralized solar thermal systems distributed in the district heating supply network and handling both solar production and user load (e.g. in building with a large collector field on the roof. The accreditation bodies are checking the certification bodies, test labs and inspectors (and they are checking each other too)

5. More information

The results already obtained are so far only available as draft reports/documents for task participants in the restricted area of the website: www.iea-shc.org/task45. By the end of 2012 some of these results will be public available.

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Next meeting: September 10-11, 2012 - Gleisdorf, Austria

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Participating countries:

- Austria
- Canada
- Denmark
- France
- Germany
- Italy
- Spain

China and Sweden will join the task during 2012

Abbreviations used

IEA-SHC:	International Energy Agency - Solar Heating and Cooling, www.iea-shc.org
ECES:	Energy Conservation through Energy Storage - IEA implementing Agreement, http://www.iea-eces.org
ESCo:	Energy Service Company
DH:	District Heating
SDH:	Solar District Heating