



## **IEA SHC Task 55**

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# **Towards the Integration of Large SHC Systems into DHC Networks**

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**ANNEX SHC TASK 55**

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This Annex text was prepared by Sabine Putz – SOLID  
and Anna Katharina Provasnek – SOLID

## Annex 55

### Towards the Integration of Large SHC Systems into DHC Networks

#### 1. Introduction

Solar District Heating (SDH) plays an increasing role in the District Heating sector. As of today, the commercial viability of Solar District Heating is under closer investigation in several countries. One particular market is Denmark, where SDH is a considerable market driver at feasible heat costs and the realization of plants had started *booming* years ago. Projects to realize SDH networks are already in development in Austria, and are also currently in a pre-implementation phase in e.g. Germany, Italy, France, Spain, and Norway. Still, SDH is in an early market development stage. Large solar thermal plants feeding into district heating networks represent only about 1% of the installed capacity of solar thermal systems, despite the fact that competitive prices lower than 40 €/MWh can be reached. In the long run, SDH could represent 4-15 % of the total potential of solar thermal energy technologies.

SHC Task 55 is one of the first major projects and a platform to focus specifically on the integration of solar thermal large scale applications into district heating and cooling networks. It aims to identify technical and economic requirements for a scalable, commercial market introduction of solar district heating and cooling (DHC) in a broad range of countries. Activities will lead to increasing and widespread know-how on technologies, markets, and boundary conditions, providing experts sophisticated information developed at an international platform for project realization, implementation, training structures, and dissemination opportunities such as events. SHC Task 55 is *the* platform for know-how transfers between experienced and newcomer countries.

One key element will be the direct cooperation of SDH experts with associations and companies of the district heating sector in order to bridge the current gap between different institutions and technologies working towards the same objectives. Hence, SHC Task 55 and the IEA Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power (IEA DHC) officially established a moderate cooperation to complement and support each other's efforts and multiply the outputs of the platforms.

#### 2. Scope

In recent years, megawatt-scale solar supported district heating systems have gained increasing attention all over the world. Several ambitious projects have been successfully implemented. Large scale SDH systems and their large-sized seasonal

storages have become an attractive solution for district networks' cost effective and low carbon heat supply at the same time. In the next big step, large systems will become even bigger, and will grow from existing and new coming MEGA to almost GIGA-sized to meet the increasing energy demand of districts and whole cities. Projects and concepts of large scale solar thermal systems and seasonal storages are well scalable and transferable to existing and upcoming district networks, independent of their age, but expertise and transformational projects are limited and clustered.

The effective operation of a SDH network and its combined seasonal storage both guarantee a primary energy consumption reduction of >70% in thermal needs (compared to conventional heat generation systems). Depending on the waste heat available and the district's energy demand, it is possible to reduce the primary energy consumption of up to 100%.

The new IEA SHC Task 55 is a subsequent follow up from the IEA SHC Task 45, where a lot of opportunities for the integration of large solar thermal systems into district heating networks were identified. Task 45 focused on components and collector performances of large-scale (>0.5 MW) solar thermal systems. Beyond emerging pressing research questions from various experts, SHC Task 55 will focus on several fields for further research and technical development from Task 45:

- 1) Characteristics of solar thermal systems for DH and DC > 0.5 MW up to GW systems
- 2) Technical and economic specifications of district heating networks which are relevant for the integration of solar thermal systems and hybrid technologies
- 3) Analyses of system components and their integration: system temperature requirements, optimization of hydraulic systems, interdependences between large collector fields and seasonal storages, control strategies, self-learning controls, large collector field performances, assessment and design of large seasonal storages (>50.000 m<sup>3</sup>), system performance guarantees, system ratings and certificates
- 4) Modular design of large SDH/SDC systems
- 5) Up-scaling potential of existing medium/large SDH/SDC systems to up to GWth systems
- 6) Economic requirements of large SDH/SDC systems and market analyses of global and country developments

### **3. Objectives**

Objectives of SHC Task 55 are:

- 7) Description of low cost and high performance large-sized SDH/SDC systems, their main components, hybrid technologies (large scale storages, industrial waste heat, heat pumps, etc.) and guidelines for their construction
- 8) Simulation of the integration of large seasonal storages, hybrid technologies and large collector arrays into different district heating networks
- 9) Description of crucial components of modular conception and construction of SDH/SDC systems
- 10) Elaboration of business and financing calculation models

- 11) Validation of measurement methods of tests on field collector performances and singular collector tests in the laboratory
- 12) Country reports, license requirements, feasibility studies and a database on large SDH/SDC systems in established and new markets
- 13) Expert and industry workshops and presentations to communicate task findings
- 14) Cooperation on a moderate level with the IEA Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power (IEA DHC), focusing SDH/SDC network designs and analyses

#### **4. Activities**

Main activities in SHC Task 55 are grouped into the following Subtasks.

##### **4.1 Subtask A: Network Analyses and Integration**

Subtask A focuses on the operation of district heating networks and the integration of solar thermal technologies. It analyses DHC network supply strategies, including: transition strategies from no to 100% solar thermal supply, hydraulics within networks and at transmission stations, heat demand management, storage charging/discharging, control strategies and energy price scenarios as well as potentials and barriers for the integration of solar thermal systems. A main focus of the analyses will further be on return temperatures and their reduction within the district heating network. Technical characteristics of existing, newly integrated and planned SDH and SDC systems of > 0,5MWth up to GWth will be assessed (typical network temperatures, summer/winter load ratio, pressure level, collector fields, seasonal storages, hybrid-technology implementation, hydraulics, control strategies).

Activities in this subtask will be performed in collaboration with other SHC Tasks and Implementing Agreements such as the DHC Implementing Agreement. The IEA DHC will give expert input in Subtask A and reviews publications and major outputs. Also interactions with Subtask B, C and D are given.

##### **Activities:**

- Activity 1 Assessment of technical characteristics of district heating networks
- Activity 2 Assessment of technical characteristics of district cooling networks
- Activity 3 Economic analysis of district heating networks
- Activity 4 Economic analysis of district cooling networks
- Activity 5 Identification of control strategies for district heating networks
- Activity 6 Identification of control strategies for district cooling networks
- Activity 7 Providing information material and results to IEA DHC (reports, publications, etc.)

##### **4.2 Subtask B: Components Testing, System Monitoring and Quality Assurance**

Subtask B focuses on system components. It targets tests, performance guarantees, monitoring, and control strategies of main solar thermal system elements. Methods for hybrid elements in in-situ collector tests at existing installations (6 different collector types approx. 2.500m<sup>2</sup>) as well as methods for simple thermal power and energy performance proofs will be elaborated. Of interest are also validated performance guarantees for key components such as collectors, storages, piping, heat exchangers,

etc. The subtask will also provide data on automated monitoring and failure detection software for key components. In a next step, control strategies and self-learning controls will be developed and described. Finally, results from IEA SHC Task 43 on solar ratings and certification procedures will be implemented in Subtask B as well.

**Activities:**

- Activity 1 Development of methods for the efficient measurement of outputs at in-situ collector fields
- Activity 2 Evaluation of existing performance guarantees for components and further development of existing measurement standards (methodology for describing performance guarantees have been elaborated within IEA SHC Task 45)
- Activity 3 Design of control strategies and self-learning controls of key components
- Activity 4 Implementation of IEA SHC Task 43 work results

### **4.3 Subtask C: Design of the Solar Thermal System and of Hybrid Components**

Subtask C focuses on simulation and design of solar thermal systems and components (storage, piping and others like e.g. heat pumps). The subtask elaborates on characteristics of collector array units, large and seasonal storages, hydraulics, and heat pumps within system operations. Large scale collector fields will be simulated and compared to the measurements in Subtask B. If needed, the simulation tool will be corrected. Parameters of seasonal storages will be calculated and guidelines for the design and construction of different storage types updated. Hydraulics within systems are sensitive to a variety of parameters. These parameters will be optimized. Piping within large systems will be investigated as well and options for a modular conception and construction for very large systems.

**Activities:**

- Activity 1 Simulation of an existing SDH installation
- Activity 2 Assessment and design of large scale seasonal storages
- Activity 3 Simulation and verification of hydraulics and piping via an existing installation for modular concerted system units

### **4.4 Subtask D: Economic Aspects and Promotion of Solar Thermal and Hybrid Technologies**

Subtask D elaborates on economic aspects and the promotion of results from SHC Task 55. Large scale solar thermal systems require sophisticated financing models due to high initial investment costs. Different business models are already in place and facilitate the realization of large systems. The subtask will assist practitioners, architects, system designers and district heating providers in their efforts for the integration of DHC applications. Stakeholders face several economic challenges and risks and will benefit at large from the deliverables of this Subtask. A database will collect information on different system types already in place and their global distribution. Country regulations such as licenses and permissions are also central for business cases of different markets. Moreover, the subtask will assist the other subtasks in the promotion and dissemination of project results, the organization and execution of events, workshops, and trainings.

**Activities:**

- Activity 1 Collection of currently applied financing models of SDH and SDC systems
- Activity 2 Compilation of favorable and challenging macroeconomic conditions for solar DHC systems in existing and new markets
- Activity 3 Accumulation of data on existing and new global large scale solar DHC systems in Best Practice Examples (based on Task 45 Subtask C database)
- Activity 4 Promotion of solar DHC systems in different cities, countries, regions
- Activity 5 Assessment of developments within the solar DHC technology on a global scale in different regions and countries
- Activity 6 Organization and execution of expert and training events, workshops and presentations

**5. Expected Deliverables****Subtask A:**

- A-D1 Assessment of technical requirements of existing and newly integrated large scale SDH/SDC
- A-D2 Economic analyses of overall DHC network supply strategies, transition strategies, heat demand and energy price scenarios
- A-D3 Analyses of DHC network hydraulics and evaluation of hybrid technologies and possible supply points for large ST plants
- A-D4 Overall DHC network control strategies and other measures for increasing solar thermal fractions

**Subtask B:**

- B-D1 In-situ collector tests
- B-D2 Draft Standards and Performance Guarantees for key components
- B-D3 Automated monitoring, failure detection of key components, control strategies and self-learning controls of key components

**Subtask C:**

- C-D1 Simulation and design of collector array units within large systems
- C-D2 Assessment and design of large scale seasonal storages
- C-D3 Optimized hydraulics and piping in large solar systems
- C-D4 Modular conception and construction

**Subtask D:**

- D-D1 Business Models of Solar Thermal and Hybrid Technologies
- D-D2 Beneficial and challenging environments for SDH/SDC systems including hybrid technologies in new and existing markets
- D-D3 Identification and preparation of Best Practice Examples
- D-D4 Evaluation of diverse global market development and country reports
- D-D5 Dissemination of expertise through education and training

**6. Rights and Obligations of Participants**

In addition to the obligations enumerated in Article 4 of this Implementing Agreement:

- (a) Each participating institution/company shall provide the Operating Agent with reports on the results of the work carried out for each Subtask.
- (b) Each participating institution/company shall collect, assess and report to the Operating Agent data on solar district heating and cooling systems in its country.
- (c) Each participating institution/company shall participate in the editing and reviewing of draft reports of the Task and Subtasks.
- (d) The IEA SHC shall participate in the reviewing of draft reports of the Task and Subtasks.
- (e) Each participating institution/company shall send in a progress report prior to every meeting of the SHC Task 55 members at least one week in advance of SHC Task 55 meetings.
- (f) Each country/Participant will bear the costs of its own participation in the Task, including travel costs. Each participant applies for own for funding, if available in his country. The cost of organizing meetings will be borne by the host country.
- (g) The Participants agree on the following funding commitment:
  - 1) Each Participant (country) will contribute to this Task a minimum of 3-person months per year of the Task, i.e. a total minimum of 1 person years.
  - 2) Participation in the Task requires participation in at least one of the Subtasks.
  - 3) The Operating Agent will contribute with a minimum of 2-person months per year to the Task.
  - 4) The Subtask leader shall commit a minimum of 2-person months per year to the Task.
  - 5) Participation may partly involve funding already allocated to a national (or international) activity that is substantially in agreement with the scope of work outlined in this Annex. Aside from providing the resources required for performing the work of the Subtasks in which they are participating, all Participants are required to commit the resources necessary for activities that are specifically collaborative in nature and that would not be part of activities funded by national or international sources. Examples include the preparation for and participation in Task meetings, co-ordination with Subtask Participants, contribution to the documentation and dissemination work and Task related R&D work which exceeds the R&D work carried out in the framework of the national (or international) activity.
  - 6) The level of effort to be contributed by each country will be specified in a "Letter of National Participation" which is signed by the Operating Agent and the Executive Committee representative within 3 months from the start date of the Task.

## **7. Management**

### **7.1 Operating Agent**

Austria, acting through Sabine Putz from S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH is designated as Operating Agent.

The Operating Agent's rights, obligations and responsibilities in addition to those indicated in the main body of the Implementing Agreement and the organization of the

work under this Annex are enumerated in Articles 5 of this Agreement. The Operating Agent shall:

- 1) Prepare and distribute the results mentioned in paragraph 5 above (List of Deliverables).
- 2) Prepare a workplan including objectives, deliverables, milestones, activities and a GANTT time schedule under consultation of subtask leaders (for the SHC Executive Committee voting/approval).
- 3) Prepare and organize half-year task meetings, at least 2 experts or industrial workshops, individual seminars, conferences and other meetings.
- 4) Provide semi-annually reports on progress and work performed to the SHC Executive Committee.
- 5) Provide a final report to the SHC Executive Committee within six months after completion of all Task deliverables for its approval.
- 6) In co-ordination with the Participants, use its best efforts to avoid duplication with activities of other related programmes and projects implemented by or under the auspices of the Agency or by other competent bodies.
- 7) Provide the Participants with the necessary guidelines for the work they carry out with minimum duplication.
- 8) Gather documents from Subtask Leaders, edit and distribute the output of the Task either as a printed handbook, electronically or on the SHC website.
- 9) Manage the Cooperation with the IEA DHC:
  - a. Provide a progress report (MS PowerPoint presentation) for every meeting of the IEA DHC Executive Committee (ExCo meeting) at least one month in advance of the Executive Committee meeting.
  - b. Supervise the integration of input provided by IEA DHC in SHC Task 55 publications and communication.
  - c. Supervises that SHC Task 55 Subtask A uses the IEA DHC logo on its publications that have been reviewed and endorsed on behalf of IEA DHC.
  - d. Send major outputs of subtask A for review to the IEA DHC
  - e. Participate at each IEA DHC meeting, if possible (Expert of Subtask A or OA)
  - f. Communicate with the IEA DHC representatives to ensure that projects do not cover significant research that is already performed under IEA SHC Task 55 Subtask A

## **7.2 Subtask Leaders**

A Subtask Leader for each of the foregoing Subtasks will:

- 1) Co-ordinate the work performed under that Subtask.
- 2) Assist the Operating Agent in preparing the detailed Programme of Work.
- 3) Direct technical workshops and provide the Operating Agent with written summaries of workshop results.
- 4) Edit technical reports resulting from the Subtask and organize their publication.
- 5) Subtask leaders may arrange meetings in between or in association with Experts meetings of the Task.

- 6) The Subtask Leaders shall be a Participant that provides to the Subtask a high level of expertise and undertakes substantial research and development in the field of the Subtask. The Subtask Leaders shall be proposed by the Operating Agent and designated by the Executive Committee, acting by unanimity of the Participants. Changes in the Subtask Leaders may be agreed to by the Executive Committee, acting by unanimity of the Participants.
- 7) The Subtask Leaders shall attend each semi-annual Task meeting as well as expert or industrial meetings.
- 8) Subtask A Leader shall Co-ordinate the work performed under Subtask A and exchange findings for review with IEA DHC.

### **7.3 Task Meetings**

There will be Experts meetings of SHC Task 55 at intervals of approximately 6 months. Subtask Leaders may arrange meetings in between or in association with Experts meetings of the Task. It's intended to organize expert / industry workshops every year, directly linked to Task meetings.

Additionally, the Operating Agent supervises Meetings with the IEA SHC under the cooperation agreement.

### **7.4 Dissemination**

The overall scope and objectives of the Task and the different Subtasks will be described on the SHC website for the Task. The server should be able to process an automatically distributed electronic newsletter. Newsletter shall be sent out semi-annual.

In addition to publications of scientific results in conferences, seminars, trainings, journals and magazines we would like to distribute printed leaflets to describe the scope of the Task, if funding therefore is available.

SHC Task 55 will integrate the input provided by IEA DHC in its publications and communication, and Subtask A will use the IEA DHC logo on its publications that have been reviewed and endorsed on behalf of IEA DHC.

## **8. Admission, Participation and Withdrawal of Participants**

The rules of the Implementing Agreement will guide through admission, participation and withdrawal of the Participants. Share of results produced will be subject to the active contribution of each Participant. Participants support the Task with own financed efforts (parallel projects or national funding). The Operating Agent will collect, promote and distribute all Task results, also to the IEA SHC.

The Participants will support these activities by contributing respective papers on time and by dissemination activities financed by the individual Participants.

## **9. Information and Intellectual Property**

For purposes of this Annex, in case of conflict with the provisions of the Agreement, the following provisions shall prevail:

- a) For arising information regarding inventions, the following rules shall apply:
- 1) Arising information regarding inventions shall be owned in all countries by the inventing Participant. The inventing Participant shall promptly identify and report to the Executive Committee any such information along with an indication whether and in which countries the inventing Participant intends to file patent applications, and
  - 2) Information regarding inventions on which the inventing Participant intends to obtain a patent protection shall not be published or publicly disclosed by the Operating Agent or the other Participants until a patent has been filed, provided, however, that this restriction on publication or disclosure shall not extend beyond twelve months from the date of reporting of the invention. It shall be the responsibility of the inventing Participants to appropriately mark Task reports that disclose inventions that have not been appropriately protected by filing a patent application.

(b) The inventing Participant shall license proprietary information arising from the Task for non-exclusive use as follows:

- 1) To Participants in the Task:
  - i. a. On the most favorable terms and conditions for use by the Participants in their own country; and
  - ii. b. On favorable terms and conditions for the purpose of sub-licensing others for use in their own country.
- 2) Subject to sub-paragraph above, to each Participant in the Task for use in all countries, on reasonable terms and conditions; and
- 3) To the government of any Agency Member country and nationals designated by it, for use in such country in order to meet its energy needs. Royalties, if any, under licenses pursuant to this paragraph shall be the property of the inventing Participant.

## **10. Entry into Force**

This Annex shall enter into force on the 1st of September 2016 and shall remain in force for a period of 4 years until the 31st of August 2020. At the conclusion of that period, this Annex can be extended by at least two Participants, acting in the Executive Committee, for a period to be determined at that time, provided that in no event shall the Annex continue beyond the current term, or actual termination, of the Implementing Agreement.