



## **Task 55**

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

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**ANNEX 55**

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## Annex 55

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

#### 1. Introduction

Solar District Heating (SDH) already arrived in the District Heating sector. Today, the commercial application of Solar District Heating is spreading to several countries. In particular in Denmark, where SDH is operated at feasible heat costs, the realization of plants is booming. SDH activities are already developed in Austria and are currently in the first implementation phase in e.g. Germany, Italy, France, Spain and Norway. The Task aims to develop technical and economic requirements for a commercial market introduction of solar district heating and cooling (DHC) in a broad range of countries. The actions aim to improve know-how on technologies, market know-how and boundary conditions, providing expert know-how for project realization, implementation, training structures and dissemination activities, such as events, as well as know-how transfers between experienced and newcomer countries. A key element will be the direct cooperation of SDH experts with associations and companies of the district heating sector in order to bridge the gap between these sectors.

Solar district heating still 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, solar district heating could represent 4-15 % of the total technical potential of solar thermal energy.

#### 2. Scope

In recent years, megawatt scale solar supported district heating systems have gained increasing attention all over the world. Several ambitious projects were successfully implemented in the past. Large scale solar thermal district heating systems and their large-sized seasonal storages have become an attractive solution for districts' cost effective and low carbon heat supply. In a next step, large systems will become even bigger and likely grow from existing and new coming MEGA to almost GIGA-size, to meet increasing energy demands of districts and cities. These concepts of large scale solar thermal and seasonal storages are well scalable and transferable to other district networks, independent of their age.

The effective operation of a SDH network and its seasonal storage 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 districts' energy demands, it is possible to reduce the primary energy consumption of up to 100%.

The new IEA SHC Task is a subsequent follow up from the IEA SHC Task 45. The IEA SHC Task 45 focused on components and collector performances of large-scale (>0.5

MW) solar thermal systems. As the previous Task identified several fields for further research and technical development, the new IEA SHC TASK will subsequently focus on:

- Solar Thermal System characteristics of very large SDH (solar district heating) and SDC (solar district cooling) installations > 0.5 MW up to GW systems.
- District heating network analysis and assessment of solar thermal and hybrid technology integration.
- The Task will focus on technical possibilities to reduce return temperatures of district heating grids.
- Modular design requirements of large solar thermal district heating and cooling systems: Focus on the optimization of SDH/SDC systems, their modular units and the units' sizes.
- Optimizations of hydraulic systems in existing and new SDH/SDC systems are at the core of investigation, since these connect the different components and modular units. The interdependences between large collector fields' seasonal storages, control strategies and the main thermal grids are investigated.
- Control strategies and self-learning controls.
- The Task uncovers the up-scaling potential of existing medium/large SDH systems, and requirements for the installation of SDH systems with up to GWth systems in large communities and cities.
- Large collector field performances:
- The performance of large collector fields is of higher significance than the performance of singular collectors (e.g. Solar Keymark certified collectors). The evaluation of performance results will lead to collector fields' standardized field measurements, the optimization of collector fields' hydraulic concepts and the minimization of the fields' heat losses.
- Simulation and design of collector array units within large systems.
- Assessment and design of large seasonal storages (>50.000 m<sup>3</sup>):
- The Task will evaluate system integration requirements, the durability of large storages, possibilities to optimize current materials, and control strategies of storages. Furthermore, strategies to lower operation and maintenance costs of large storages will be elaborated.
- Evaluation of the potential to integrate hybrid technologies (biomass and solar) in existing SDH/SDC systems and networks.
- Evaluation of state-of-the art SDH/SDC system performance guarantees (based on Task 45 performance guarantee sheets). Data will be accumulated from launched Danish and Austrian district heating systems.
- Development of automated monitoring systems: The Task focuses on automated failure detection of monitoring systems and self-learning control functions for automated large SDH/SDC system surveillance.
- Evaluation and further development of SDH/SDC system ratings and system certificates (out of Task 43).
- Analyses of economic requirements for large solar thermal and district heating/cooling:
- The Task will provide cost-effective business models and investment projections for large solar thermal systems as well as for centralized and

decentralized SDH/SDC systems. Furthermore, pricing frameworks for the prediction of district heat and cold prices will be elaborated.

- Development of standard technical criteria of large solar systems for policy makers from diverse industries: Decision makers, city planners, architects and municipal utilities will be able to evaluate the relevance of specific large SDH and SDC projects.
- Promotion of large solar thermal systems through the continuation of a database, developed within the Tasks 45, 48 and 49.
- Market analyses on global and country specific developments within the SDH community, based on the existing DHC database of large solar thermal systems.

### **3. Objectives**

Objectives of the Task are:

- System description and design of low cost and high performance large-sized SDH and SDC systems as well as the design and evaluation of large scale seasonal storages and hybrid technologies.
- Further, technical analyses of findings will be presented within a report for city district planners, dealing with the integration of solar thermal and seasonal storages. Additionally, a specific report for planners will focus on system requirements for SDH and SDC, modular conception and construction as well as the minimization of piping and losses.
- Established business and financing models: Objectives here are reference calculation models of SDH and SDC as well as economical requirement definitions for new systems and markets.
- Guidelines to secure low operation and maintenance efforts for very large systems including automated operational surveillance.
- Advanced control systems for large-sized solar and hybrid systems.
- A comparison of measured collector performances in the field, and singular collector tests in the laboratory. Results will be the basis for a validated measurement method of solar collector fields and the validation of performance guarantee procedures.
- Data for the optimization of very large collector fields' performances based on adjusted hydraulics and minimized system losses.
- Promotion and technology spread of large systems in new markets through the continuation of the existing database from the IEA SHC Task 45, 48 and 49.
- Country reports including case studies and feasibilities.

### **4. Activities**

The main activities in Task 55 are grouped in the following Subtasks.

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

Subtask A deals with district heating network analyses of the overall district heating and cooling (DHC) network supply strategies, including: transition strategies, hydraulics, heat demand management, storage charging/discharging, control

strategies and energy price scenarios as well as potentials and barriers of SDH projects. A main focus of the analysis and adaption measures will be set on the return temperature reduction of the district heating network. Technical requirements of existing, newly integrated and planned SDH and SDC systems of > 0,5MWth up to GWth size will be assessed (typical network temperatures, summer/winter load ratio, pressure level, collectors, seasonal storages, hybrid-technology implementation).

Activities in this subtask will be performed in collaboration with IEA SHC Task 52 and the IEA District Heating and Cooling Implementing Agreement. Interactions with Subtasks B and C and D are given.

**Activities:**

- Activity 1 Assessment on district heating and cooling characteristics
- Activity 2 Control strategies for DHC

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

Subtask B describes testing, system monitoring and quality assurance of solar thermal system components. Among solar thermal components, hybrid component methods for in-situ collector tests at an existing installation (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. Validated performance guarantees for key components like collectors, storages, piping, heat exchangers, etc. will be elaborated as well. Also, automated monitoring and failure detection software for key components will be provided. Control strategies and self-learning controls will be developed and described. Finally, results from IEA SHC Task 43 will be implemented in this Subtask.

**Activities:**

- Activity 1 Method development and efficiency output measurements at the in-situ collector field
- Activity 2 Validation of performance guarantees (methodology for describing performance guarantees have been elaborated within IEA SHC Task 45)
- Activity 3 Software development of automated monitoring and failure detection
- Activity 4 Design of control strategies and self-learning controls of key components
- Activity 5 Implementation of IEA SHC Task 43 work results

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

Subtask C deals with the system design of solar thermal components and hybrid technologies as well as storages, seasonal storages, and heat pumps. Large-scale collector array fields will be simulated and the simulation output will be assessed and compared to the measurements in Subtask B. If needed, a correction of the simulation has to be done. Seasonal storages will be assessed and a design guideline for design and construction of seasonal storages will be elaborated. Optimized hydraulics and piping will be investigated and described for modular conception and construction of the system (except district heating, this will be treated in Subtask A).

**Activities:**

- Activity 1 Tansy's Simulation of an existing SDH installation
- Activity 2 Assessment and design of large scale seasonal storages

- Activity 3 Optimization of hydraulics and piping via simulations and verifications at an existing installation for modular concerted system units

#### **4.4 Subtask D: Economic Aspects and Promotion**

Subtask D elaborates on economic aspects and promotion activities of the Task. Large scale solar thermal systems require sophisticated financing models due to high initial system costs. Different business models are already in place and facilitate the spread of large systems. The subtask will assist practitioners, architects, system designers or district heating providers in their efforts for the integration of DHC applications. These stakeholders face different challenges and risks, but also chances, which will be focused on in the deliverables. A database will collect information on different system types and their global distribution. The subtask will also assist the other Tasks in the promotion and dissemination of project results, the organization and execution of events, workshops and trainings.

Activities of Subtask D will focus on the dissemination and promotion of results from the previous subtasks.

##### **Activities:**

- Activity 1 Collection of currently applied financing models
- Activity 2 Creation of a reference calculation tool on solar thermal district heat and cold price scenarios
- Activity 3 Compilation of favorable and challenging macroeconomic conditions for solar DHC systems in existing and new markets
- Activity 4 Accumulation of data on existing and new global large scale solar DHC systems in a database (based on Task 45 Subtask C database)
- Activity 5 Promotion in different communities and information events on Task activities
- Activity 6 Assessment of development on a global scale in different regions and countries
- Activity 7 Organization and execution of expert and training events, workshops and presentations

## **5. Expected Results/Deliverables**

### **Subtask A:**

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

### **Subtask B:**

- B-D1 In-situ collector tests
- B-D2 Further development of validated performance guarantees for key components
- B-D3 Automated monitoring and failure detection of key components
- B-D4 Control strategies and self-learning controls of key components
- B-D5 Integration of solar ratings and certification procedures

**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
- D-D2 Beneficial and challenging macroeconomic environments for SDH/SDC systems in new and existing markets
- D-D3 Identification and preparation of large SDH/SDC systems in a database
- D-D4 Promotion and dissemination of SDH/SDC technologies in new markets
- D-D5 Evaluation of divers global market development and country reports
- D-D6 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 his country.
- (c) Each participating institution/company shall participate in the editing and reviewing of draft reports of the Task and Subtasks.
- (d) 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.
- (e) 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 work plan 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 programs 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.

### **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 Work Plan.
- 3) Direct technical workshops and provide the Operating Agent with written summaries of workshops 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.

### **7.3 Operating Agent's Meetings**

There will be Experts meetings of the Task 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.

### **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.

## **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.

The Participants will support these activities by contributing respective papers 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. On the most favorable terms and conditions for use by the Participants in their own country; and
  - ii. 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 1 July 2016 and shall remain in force for a period of 4 years until 30 June 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.