SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 45

Large Systems

Large solar heating/cooling systems,
seasonal storages, heat pumps

Work Plan, revision 5 (incl. prolonged period)

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1 Background

1.1 *Why proposing this Task*

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.

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 analysing 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 practise in order to inspire people to utilise 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 utilise this possibility for very cost effective solar heat and cold production and save fossil fuels and biomass resources.

The issue of large solar thermal systems with heat pumps and seasonal storage is not included in the IEA SHC Task 44 ”Solar and heat pump systems”. The scope of Task 44 is limited to small systems for one-two family houses.

1.2 *Other background*

This task is proposed from Danish side. In Denmark we see right now[1] "an explosion"- see figure below - in numbers of large scale solar district heating systems. Not because of special subsidy schemes - but simply because the systems in many cases are competitive with gas and biomass based district heating systems.

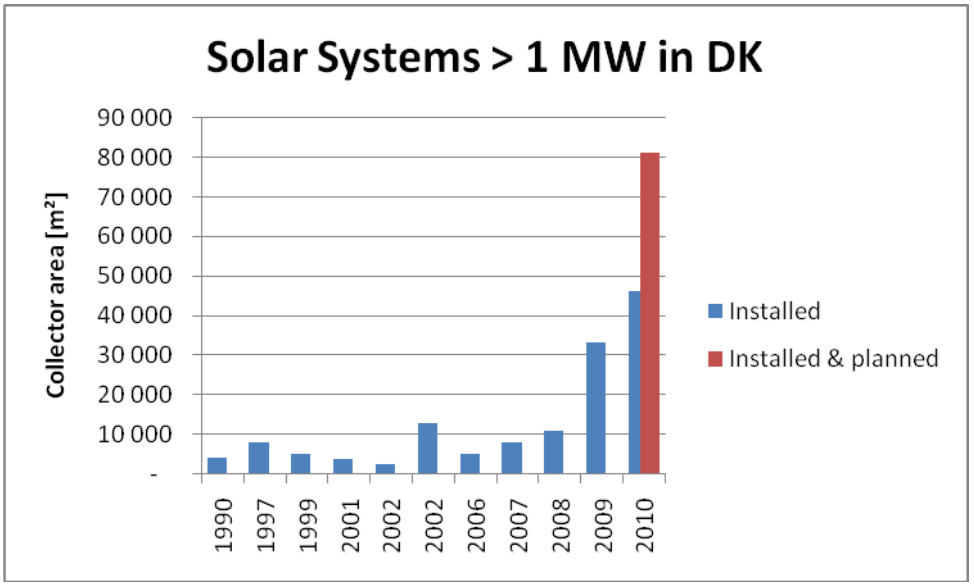

Fig.1. Installed large scale solar systems in DK.

Some 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.

An European project: "Solar district heating - Take-off" has just been initiated - participants in this project already have shown interest in participation in the proposed task.

The proposed task will utilise results from other finalised IEA-SHC tasks, especially

- Task 7: Central Solar Heating Plants With Seasonal Storage (1979 - 1988)
- Task 33: Solar Heat for Industrial Processes (2003 - 2007)

and will be coordinated with the ongoing task:

- Task 44: Systems Using Solar Thermal Energy in Combination with Heat Pumps (2010-2013)

Note: Co-ordination also with other relevant IEA implementation agreements: IEA-DHC, IEA ECES, IEA Heat Pump Centre.

[1] This "now" is referring to 2011 – but the "explosion" is still ongoing: In 2012 more than 100 000 m² was installed and in 2013 it is expected that more 150 000 m² will be installed.

2 Objective

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

This is done by optimizing system configurations and components:

- component level: improve costs, performance and lifetime
- system level: using the best relative sizes and combinations of solar thermal, heat pump, seasonal storage and others, control strategies - taking into account the local framework conditions.

3 Scope

3.1 *Size*

The task will focus on the “MW-size” systems

- Systems with a total solar thermal capacity of > 0.5 MW (collector area > 700 m²) - unless special reasons for dealing with smaller systems are present (could be demonstration projects demonstrating principle and operation of a large system)

3.2 *Applications*

The task will focus on district heating (and cooling) applications

3.3 *System types*

- Solar preheating

- Solar in combination with other energy sources and technologies like e.g.:
  - Heat pumps
  - Boilers
  - Motors/turbines for combined heat and power production / ORC systems
  - Waste heat

- Systems with storage:
  - Short term storage (daily - weekly)
  - Long term storage (seasonal storage)

- Collector fields
  - Central collector fields
  - Distributed collector fields (e.g. on roofs of houses)
  - Combination of central and distributed collector fields

- Direct / indirect:
  - Systems with heat exchanger
  - Systems without heat exchanger (for non-freezing locations)

4 Process

A 3 year task was approved initially; starting 1.January 2011 and running until 31.December 2013 – in June 2013 a prolongation of 1 year – until 31 December 2014 was approved.

In the beginning of the Task an overview of existing systems and projects will be made, including individual evaluations - to give state of the art of systems and technologies.

It will be investigated when large solar thermal systems are feasible - and in which configurations.

An overview and analysis of existing models and tools for performance estimation will done and improvements proposed and implemented where relevant.

Recommendations use for existing/improved performance models and tools will be given.

Based on best practice from existing systems and new systems - and using recommended/improved models and tools, guidelines for planning, dimensioning, installation and operation will be drawn up.

Where possible procedures for guaranteeing - and checking - performance will be elaborated.

The main results of the Task will be published in “Fact Sheets for large solar systems”.

The work will be carried out within the framework of three Subtasks:

- Subtask A: Collectors and collector loop (DTU, Denmark)
- Subtask B: Storages (SOLITES, Germany)
- Subtask C: Systems - configurations, operating strategies, financing issues (SOLID, Austria)

Experts will meet in two annual regular task meetings where their work in between the meetings will be discussed.

It will be considered to extend the expert meetings with one extra (half) day for a workshop targeting the country of the task meeting. If necessary subtask groups can organise special meetings in connection with the task meetings - or in between.

Intermediate web conferences will be organized if necessary for detailed discussions in a subtask in between the expert meetings.

5 Outcome

The Task aims at the following outcomes:

- Increased use of cost effective, well designed and well operated large scale solar thermal systems throughout the world
- Less use of resources for heating (fossil fuels and biomass)
- Better and more cost effective integration of solar energy in the energy system
- Increased energy supply security
- Increased employment
- Network of experts and professionals in the field

6 Participants

Contributors and participants in this task will be:

- Market players (industry, utilities and others) in the heating/cooling sector - including consultant engineers and planners
- Universities and research institutes active in the building sector

7 Subtasks

7.1 *Subtask A: Collectors and collector loop*

Lead: DTU, Denmark

Countries AT, DK, AT, CA, IT, AT, DE, ES

Objectives: The general objectives of Subtask A are:

- Use of suitable components for solar collector fields
- Good designs of solar collector fields
- Proper and safe installations of solar collector fields
- Good interplay between solar collector fields and district heating and cooling networks
- High thermal performance of solar collector fields

Results: The deliverables of Subtask A are seen in table 1.

Subtask A Deliverables	**2011**				**2012**				**2013**				**2014**			
A-D1: Models for correction of collector efficiency parameters depending on collector type, flow rate, tilt and fluid type														D	R_1	R
A-D1-1 Collector type														D	R_1	R
A-D1-2 Flow rate														D	R_1	R
A-D1-3 Collector tilt														D	R_1	R
A-D1-4 Solar collector fluid														D	R_1	R
A-D2 If possible: Proposal for an informal annex to be included in EN 12975 / ISO 9806-1 describing how to make the above mentioned corrections																D
A-D3 Proposal for requirements and test methods for collector loop pipes (safety, durability, heat loss, thermal expansion) - pre-normative work - to be proposed to the relevant ISO/CEN TC's																R
A-D4 Guidelines for requirements for collector loop installation, hydraulic scheme including precautions for safety and expansion including check list for checking installation accordingly							D	R_1				R				
A-D5 Detailed simulation models for solar collector fields (thermal performance)														D	R_1	R
A-D6 Control and operation strategies for solar collector fields																

A-D7 Procedure for guaranteeing performance of collector field installation - including how to check the guarantee - and including validation on existing fields								D				R1				R
A-D8 Procedure for guaranteeing performance of solar loop heat exchanger - including how to check the guarantee - and including validation on existing fields								D				R1				R
A-D9 Input to Task web site																
A-D10 Input to "Fact sheets"															D	R
A-D11 Subtask A Summary Report															D	R
Milestones: D: Draft reports(s); R Final reports(s); R_1: First Report; D_1: First Draft																

Table 1. Time- and Milestone plan for Task 45 Subtask A (updated October 2013)

Approach: The following activities are proposed:

A1: Improve use and accuracy of collector test results
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.

A2: Define requirements and test methods for collector loop pipes
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. Consider EN 13941, EN 235, which changes are needed?

A3: Requirements to hydraulic design of collectors and collector fields
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: Model for thermal performance of collector field with evacuated tubes will be worked out.

A6: Until October 2013 no input to "Control and operation strategies for solar collector fields"

A7-8: 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.

7.2 *Subtask B: Storages*

Lead: Solites, Germany

Countries: CA, DE, DK, AT

Objectives: The general objectives of Subtask B are:

- improving the economy of (seasonal) storage technologies
- increasing knowledge on durability, reliability and performance of (seasonal) storage technologies
- demonstrating cost effective, reliable and efficient seasonal storage of thermal energy

Results: The deliverables of Subtask B will be:

B-D1. State of the art report with best practise examples (in the beginning of task)
B-D2. Design guidelines for seasonal storages
B-D3. Report on research requirements
B-D4. Database on large seasonal storages
B-D5. Input to Task web site
B-D6. Input to "Fact Sheets"
B-D7. Subtask B Summary Report

Approach: The following activities are proposed:

B1: State of the art – Evaluation of existing projects

B1.1. Definition of selected pilot and research projects to be evaluated by national participants.
B1.2. Evaluation based on questionnaire
B1.3. Overview analyses of pilot projects and storage developments: main findings, constructions and materials to be recommended, problems found.
B1.4. Cost analyses of construction technologies and materials.
B1.5. Cost for operation and maintenance.
B1.6. System interaction.

B2: Technical improvements

B2.1. Identification of necessary developments / improvements.
B2.2. Collection of possible improvements, new concepts, materials, investigations …
B2.3. If possible: investigations on identified technical improvements.

B3: Quality management

B3.1. Definition of technical requirements and procedure(s) for checking the performance of storages (materials, thermal losses, stratification, …).
B3.2. Definition of characteristic parameters for comparison of storages (equivalent storage volume, equivalent heat capacity, usability of stored thermal energy etc.).

B4: Knowledge transfer / dissemination

B4.1. Preparation of design guidelines for seasonal storages.
B4.2. Review of design / simulation tools.
B4.3. Database on seasonal storages: Gather data on all large seasonal thermal storages - present via web (co-op. with the IEA storage group: *IEA ECES*).

Time Plan and Milestones - subtask B

Subtask B Deliverables	2011				2012				2013				2014			
B1: state of the art report with best practice examples						D						R				
B2: identification of necessary R+D							D			R1		R				

B3: procedures for checking the performance of the storage and definition of characteristic parameters for comparison of storages → simple tool											R1					R
B4: design guidelines for seasonal storages and review of design/ simulation tools. Internet-database in cooperation of IEA ECES → English version of www.saisonalspeicher.de														R		
Milestones: D: Draft reports(s); R Final reports(s)																

Table 2. Time- and Milestone plan for Task 45 Subtask B (updated October 2013)

7.3 *Subtask C: Systems - configurations, operating strategies, financing issues*

Lead: **S.O.L.I.D.**,

Countries AT, CA, DE, DK, ES, IT, SE

Objectives:
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 (comment: material is available from IEA DH task, EIE SDH take off, Swedish DH association)
- 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)

Results:
The deliverables of Subtask C are seen in table 3:

Subtask C Deliverables	2011				2012				2013			
C-D1: Overview system categories			D		R							
C-D1.1 Systematic categorization of large solar systems with respect to applications, components, component types												

C-D1.2 Detailed description of (all) existing systems with (seasonal) storage and/or heat pump by each national representative													
C-D2: Updated database large systems >0.5MW				D	R_1								R
C-D2.1 Investigation and selection of adequate installations													
C-D2.2 Preparation of template and data fill in													
C-D2.3 Maintenance of the data base													
C-D3: Guidelines and tools for feasibility incl. sensitivity analysis								D					R
C-D3.1 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)													
C-D3.2 Tools for facilitating feasibility studies: overview on calculation tools providing strong/weak points and user categories													
C-D3.3 Develop a dedicated pre-feasibility tool													
C-D4: Models for ESCo services			D		R								
C-D4.1 Financing models, financial risks, ownership, system maintenance, barriers (!), funding conditions, policy support													
C-D4.2 Description of existing examples													
C-D4.3 Case studies; different application; different countries, potential end users													
C-D5: Procedures for performance check/monitoring/surveillance													R
C-D5.1 Procedures for performance check											D		R
C-D5.2 Recommendation for monitoring and verification / surveillance of systems (automated failure detection);Level a, b, c of Task 38													R
C-D6: Guidelines for planning, installation, commissioning, operation						D_1			D				R
C-D6.1 Inputs for Fact Sheets													
C-D6.2 Inputs for Fact Sheets for the overall installation, commissioning and operation of SDH													

C-D6.3 Guideline for Connection of decentralized solar thermal systems												
C-D6.4 Inputs for Fact Sheets for direct and indirect connection of decentralized solar thermal systems distributed in the district heating/cooling supply network and handling both solar production and user load												
C-D7: Inputs for fact sheets						D_1			D			R
C-D8: Input to task website												
C-D9: Subtask C Summary Report												R
Milestones: D: Draft reports(s); R Final reports(s); R_1: First Report; D_1: First Draft												

Table 3. Time- and Milestone plan for Task 45 Subtask C (updated October 2013)

Approach:

The following activities are proposed:

C1. Overview

- C1.1. Overview of system categories (systematic categorisation of large solar systems with respect to applications, components, component types,
- C1.2. Detailed description of (all) existing systems with (seasonal) storage and/or heat pump by each national representative
- C1.3. Updated database for all large solar systems > 0.5 MW

C2. Feasibility

- C2.1. 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)
- C2.2. Tools for feasibility studies: overview on calculation tools providing strong and weak points and users' categories
- C2.3. Develop a dedicated pre-feasibility tool
- C2.4. Written guidelines (including requirements from DH IEA task and parameters to identify existing suitable DH networks and sensitivity analysis) Examples: Economy for realised systems
- C2.5. Case studies; different application; different countries (*comment: 20 case studies will be carried out within FP7 Sunstore4*)
- C2.6. Guidelines for environmental assessment

C3. Models for ESCo services

- C3.1. Financing models, financial risks, ownership, system maintenance
- C3.2. Existing examples
- C3.3. Case studies; different application; different countries

C4. Performance check/monitoring/surveillance

- C4.1. Procedures for performance check
- C4.2. Recommendation for monitoring and verification / surveillance of systems

C5. Guidelines for planning, installation, commissioning, operation

- C5.1. Give inputs for Fact Sheets

C5.2. Give inputs for Fact Sheets for the overall installation, commissioning and operation of SOLAR DH

C6: Guidelines for connection of decentralised solar thermal systems

C6.1 Give inputs for Fact sheets for direct and indirect connection of decentralised 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.

8 Information Plan

The outcome and results shall be disseminated to the target groups:

- Utilities / heating companies / ESCos
- Planners
- Installers
- Operators
- Technical Schools and Universities
- Authorities
- Producers of the relevant components

The dissemination activities will be:

Fact sheets for large solar thermal systems

Write and publish fact sheets for large solar thermal systems, proposal for list of contents:

Number	Subject	Corresponding deliverable
45.A.1	Correction of collector efficiency parameters depending on variations in collector type, fluid type, collector flow rate and collector tilt.	A-D1
45.A.2	Requirements & guidelines for collector loop installation	A-D4
45.A.3.1	Performance guarantee - Collector field power output	A-D7 & A-D8
45.A.3.2	Performance guarantee - Collector field annual output	A-D7 & A-D8
45.B.1	Seasonal storages - Best practise examples	B-D1
45.B.2	Seasonal storages - Monitoring	B-D3
45.B.3	Seasonal storages – Guidelines for materials & construction	B-D4
45.C.1	Categorization of large solar heating and cooling systems	C-D1
45.C.2.1	ESCo models - General	C-D4
45.C.2.2	ESCo models - Best practice	C-D4
45.C.2.3	ESCo models - Energy performance contracts	C-D5

National experience exchange groups (participant to be chosen from each country)

Establish/participate in national experience exchange groups. The groups should meet e.g. twice a year and exchange experience from operation of systems and discuss new ideas. Experts could be invited for special issues. Participants could be:

- Plant operators
- Planners / consultants
- Suppliers
- Researchers
-

Lists of suppliers of systems, components and services

Make on-line lists of suppliers of components and services. Sorted country by country.

Task website

Make website; make available from here the guidelines, tools, databases, reports, papers, presentations, list of suppliers of components, systems and services plus other materials produced in the task. Also project participants, relevant links and upcoming event will be listed.

Make "educational packages"

Make editable " educational packages" for the target groups:

- Universities / technical schools
- Associations

Workshops

Arrange workshops on thematic themes (heat pumps, thermal cooling; seasonal heat storage, collectors, …) (could be in cooperation with IEA-HP and IEA-ECES). 1 international workshop per year. Optionally also national workshops (in connection with "experience exchange group meetings")

Newsletters and thematic leaflets

Issue 1 - 2 newsletters/leaflets per year

Presentations & papers

Give presentations at international conferences - at least one per year

Participate in meetings/events arranged by the target groups (e.g. associations of district heating and municipalities) (national participants)

White paper

Write "White paper" on policy position using the model from Task 38

9 Future meetings

Two meeting are planned in the prolonged period (2014), proposed locations:

- Denmark
- China