SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

TASK 52

Solar Heat and Energy Economics in Urban Environments

ANNEX

December 2013

Prepared by Sebastian Herkel (Fraunhofer ISE, DE), Hans-Martin Henning (Fraunhofer ISE, DE), Brian Vad Mathiesen (Aalborg University, DK), Paul Bourdoukan (Sorane, CH) and Franz Mauthner (AEE INTEC, AT), Miguel Amado (FCT UNL, PT), Marcus Hummel (EEG TU Wien, AT)

Annex 52
Solar Heat and Energy Economics in Urban Environments

1 Description of Technical Sector

This Task focuses on the analysis of the future role of solar thermal in energy supply systems in urban environments. Based on an energy economic analysis - reflecting future changes in the whole energy system - strategies and technical solutions as well as associated tools will be developed. Good examples of integration of solar thermal systems in urban energy systems will be developed and documented.

Recent discussions questioning the role of solar thermal systems in urban areas are being raised at different levels, which have to be considered when developing new energy supply concepts for the urban environment:

(a) Building Level:

Retrofit of buildings towards low energy standards like passive house is state of the art - even if it's not yet economically feasible (IEA SHC Task 37 and Task 47). For residential buildings this leads to a higher share of heat needed for domestic hot water consumption in relation to the heating energy demand. Heating energy demand remains in the central winter months (at least in the moderate climates).

The concept of Net Zero Energy Building (NZEB) is and will be deeply analyzed and developed in SHC Task 40. Four main results thus far are:

- The need for a systematic approach for energy balancing and rating in relation to the energy supply system of the built environment,
- The domination of concepts using photovoltaic as main local renewable source,
- The limits of such concepts in dense urban quarters due to missing areas in higher buildings, and
- The need to extend the NZEB concept to the level of quarters or cities.

Compared to other renewable-based energy supply systems (e.g. PV, wind) the cost reduction (learning curve) of solar thermal systems at consumer level is small. In addition, there will be a competition regarding the use of solar exposed building surface area between electricity production and heat production.

(b) District Level:

The heat demand in districts will be lowered while the electricity demand will remain stable. This will put force on the expansion of existing or the establishment of new district heating networks. To date, solar thermal combi-systems are predominantly used in housing quarters, especially in single-family houses, detached and row houses. These types of buildings are especially common in rural areas and suburbs. The same is true for large systems as can be seen in SHC Task 45. Most large-scale solar thermal systems connected to energy supply networks are realized in new settlements where land is relatively cheap. Within the solar community there is a broad knowledge and understanding of storage in different scales.

(c) Energy supply system

The increasing share of renewable-based, but intermittent energy in the electrical grid lead to an increasing need of storage either electrical, chemical (Power to Gas) or thermal (using heating technologies connected with the electrical grid).

Heating systems interacting with the electric grid thus have to match the availability of electricity; the main technologies are heat pumps and CHP. This affects the heat supply of buildings in an urban environment in different ways. The operation of CHP will be more and more controlled by the prices for fed-in electricity at the stock exchanges resulting in the need for larger thermal storage capacity.

Solar thermal is traditionally seen in competition with other net-based heat supply technologies like CHP, however this may not be the case. Taking the above mentioned change in operation conditions into account, new opportunities for feeding-in solar thermal energy may arise.

Biomass-based boilers as back-up systems are limited due to the restriction of resources and the need for use in other sectors like transport or chemistry.

2 Purpose and Objectives

The Task focuses on the analysis of the future role of solar thermal in energy supply systems in urban environments. Based on an energy economic analysis - reflecting future changes in the whole energy system - strategies and technical solutions as well as associated tools will be developed. Good examples of integration of solar thermal systems in urban energy systems will be developed and documented.

The main objective of Task 52 is to better understand the future role of solar thermal systems in urban energy supply systems. To achieve these objectives, work is needed in the following three areas:

Energy Scenarios
The role of solar thermal in the energy system of urban environments will be identified with a horizon of 2050 and a 100% renewable energy goal at the national or international level, but not necessarily 100% on a city or regional level solely.

The scenarios will reflect the combined view of electricity and heat as well as other key heat supply technologies, such as electrical and thermal heat pumps and CHP. Different district structures will be taken into account and different scenarios regarding the development of the energy system (e.g. IEA Energy Perspectives)[1]. The Scenarios will reflect all sectors including mobility. They will be based on detailed time-series in order to reflect the dynamic of the solar energy availability and will use space-discretized data.

Integrating Design Tools for Urban energy supply systems
Existing tools for estimating the solar potential based on geographical information systems (GIS) are not yet linked to existing design tools for optimizing the structure of urban energy systems. Up to now, they do not take into consideration the spatial and time resolution and variability of energy production and energy consumption induced by local

[1] http://www.iea.org/w/bookshop/add.aspx?id=425 (ETP2012)

renewable resources. The forecast of such fluctuations is observed especially in decentralized energy infrastructure, both energy production and energy consumption not only in time will also vary greatly in the future in space.

A key approach to stabilizing the operation is the use of energy storage – in the Task's scope heat storage, in particular, fed by cogeneration and solar thermal systems that are indirectly helping to operate the electricity grid stable. Existing local energy management tools for heat supply systems – in this case district network with solar thermal - have to be further developed in order deal with the change from demand driven energy supply systems towards production driven systems.

Tools and techniques for the transition process of the energy system towards a renewable one will be addressed and case studies will be documented.

Demonstration and Operation
The implementation of solar thermal in existing and new urban districts as part of an integrated energy supply system will be demonstrated and monitored. A focus will be on the integration of solar systems in district heating systems addressing technical and economic aspects and operation schemes governed by the link to the electrical grid. Tools for operation will be analyzed. Existing sites will be included as base for identifying bottlenecks, good practices as base for further analysis.

Based on these boundary conditions, observations, statements and a critical review of the goal "Solar thermal energy systems will provide up to 50% of low temperature heating and cooling demand by 2030" – as stated in the IEA SHC Strategic Plan – is planned within the proposed Task. Further on technically and economically feasible solutions will be identified and best practice examples will be documented.

3 Activities

(a) Main activity
In order to facilitate this, questions in three main R&D areas have to be answered and compiled in a common structure:

Subtask A: Energy Scenarios
Subtask B: Methodologies, Tools & Case Studies for Urban Energy Concepts
Subtask C: Technology and Demonstrators

The participants shall share the coordinated work to be carried out.

(b) Subtasks

Subtask A: Energy Scenarios
The objective of Subtask A is to analyze the role of solar thermal in the energy system of urban environments with a horizon of 2050. The analysis will be based on the development of scenarios for selected countries taking into account modeling results with different analytical approaches. The scenarios should reflect the combined view of electricity, heat and transport and should take into account the dynamics of changes in the energy systems, focusing on the parts of the system that directly link to solar thermal energy. The competition between solar thermal and other key heat supply technologies like electrical and thermal heat pumps and CHP as well as PV are major issues in the analysis. Different

district structures should be taken into account and different scenarios regarding the development of efficiency, costs and prices. The scenarios will also take into account selected key differences in current configurations of national energy systems, that is, levels of renewable energy, nuclear, hydro etc. and the potential developments in the future as for example a high share of renewable energy, fossil fuel or nuclear energy. Particularly the role of solar thermal in future smart energy systems with integrated electricity, heat and transport supplies will be addressed. The barriers and drivers in the transition of current energy systems towards high shares of solar energy will be addressed in the analysis and conclusions and recommendations for policy and other stakeholders will be developed in discussion with the outcomes of the other Subtasks

Subtask A will have to elaborate scenarios based on a common methodology developed within the first phase of the Task work.

Objectives of Subtask A

- Using energy system analyses with different analytical approaches in combination with spatially disaggregated data for creating scenarios focusing on the use of solar thermal in future energy systems
- Identifying balances between heat or cooling savings and supply systems with relation to solar thermal
- Identifying balances between building level solar thermal and solar thermal in local district heating networks
- Identifying the role of solar thermal in integrated renewable energy systems and in particular the interrelation with combined heat and power (CPH) and heat pump production.

The main activities of Subtask A

A1 Identification of relevant solar thermal concepts and establishing energy system models for enabling energy system analysis of key solar thermal concepts

A2 Development of energy system scenarios for selected countries focusing on the analysis of the role of solar thermal with a time horizon of 2050

A3 Analyses of the role of solar thermal concepts in future energy systems including sensitivity analyses regarding cost developments, national and international system integration and the influence of climate change

Based on existing work and experiences of all partners in the Task relevant concepts for the integration of solar thermal energy in urban areas will be identified. In order to allow for a comprehensive representation of the identified concepts in the different models the used approaches in each model will be discussed and further elaborated. There will be two main outcomes: on the one hand this will lead to a common understanding of how to qualify the results of the different modeling approaches regarding the use of solar thermal energy, on the other hand a common methodology for the development of scenarios within the Task will be defined. The existing models will partly be extended if it shows to be necessary in order to reflect the common methodology.

For selected countries we will develop energy system scenarios with the target of 100% renewable energy supply in 2050. Main focus of the analysis is to identify the role of solar thermal energy in the overall energy system and the barriers and drivers related to different solar thermal energy concepts. Therefore the parts of the energy system that are directly linked to solar thermal energy will be investigated in detail mainly based on existing scenarios and ongoing projects. In order to deepen the understanding of barriers and drivers

as well as technological and economic potentials of different concepts on the national level selected further scenarios will be developed within the Task. Highly important scenario settings will be defined in accordance with the main partners of the Subtask/Task. The partners within the Task will provide the necessary data for the calculations and if necessary further data research will be undertaken.

In order to identify promising configurations of future energy systems, the role of solar thermal energy and the barriers and drivers in the transition to such systems sensitivity analyses will be calculated. The barriers and drivers in the diffusion of different technologies in the transition to such systems will be elaborated based on existing scenarios for the selected countries. Parameters that have shown to be highly important will be analyzed in the context of the new findings within the Task.

Subtask B: Methodologies, Tools and Case studies for Urban Energy concepts
Subtask B aims at providing methodologies to support technical and economical calculations for successful integration of solar thermal in urban environments. Depending on energy scenario the use of solar thermal may or may not be energetically rational or economically viable. The intention is to identify urban planning methodologies and calculation techniques capable to ensure an objective evaluation of the role of solar thermal in urban energy scenario's reflecting future regional, national and international boundary conditions.

Objectives of Subtask B
- Development of methodologies with focus on performance indicators
- Energy planning tools and toolboxes (from Urban planning to neighborhoods)
- Case studies analysis of different regions

The main activities of Subtask B
B1 Development of methodologies and performance criteria
B2 Review on existing tools and development of tool chains
B3 Case studies

In order to develop energy concepts in the urban environment methods will be develop which allows the characterization of different urban morphologies in different climate regions. The methods should be able to identify patterns of consumption in regions (actual and long term development) and should be able to reflect and quantify effects of urban environment on consumptions and identify determinant factors. Key indicators to describe different situations will be developed (e.g. heat density; solar potential, building typology).
A survey will be conducted on the available simulation and design tools integrating solar thermal modeling in urban planning and energy-economic calculations. A Guideline will be elaborated to document the use of tools, method/toolboxes for each particular case. This guideline will help identifying types of answer each tool is able to provide for each situation.

The use of the solar thermal can be differently weighted depending on the size and the boundary of the energetic systems considered. Case studies for energy concepts of integration of solar thermal systems into urban and regional energy systems will be performed reflecting different typologies of structures and integration configurations of solar thermal into the urban energy systems, different climates and the evolution of the energy scenarios in the horizon of 2050 (up to 100 % renewable). Based on the results of

these four case studies Key findings will be documented in guidelines and solution sets specific to different regions and contexts.

Subtask C: Technology and Demonstrators

In Subtask C best practice examples of solar systems with direct linkage to urban, sub-urban but also municipal energy supply systems are investigated in more detail. Interaction between heating supply and electrical or gas grid should be reflected.
The investigation is limited to the following conditions:

- Solar thermal systems with direct connection to heat and, more general, to energy supply networks (urban, suburban and municipal level)
- Solar-assisted building blocks (micro-grids) in urban environments (urban level only)
- Renewable heating and cooling systems like Heat pumps in combination with PV

The objectives of Subtask C

- Classification of relevant (renewable-based) technologies and demonstrators in urban environments
- Screening of best practice examples
- Analysis and documentation of selected best practice examples
    - Technological and economic analysis
    - Analysis of bottleneck's and success factors, lessons learned
    - Analysis of monitoring data (subject to data availability)

The main activities of Subtask C

C1 Screening and survey of Best Practice examples
C2 Identification of Technical and economic performance figures of Best Practice examples and describing success factors
C3 Further development of (existing) business opportunities with regard to future energy supply systems

Subtask C aims to give an overview over the market availability of the above mentioned kinds of solar thermal systems in a European and worldwide context. Based on this overall market overview selected best practice examples will be identified together with the task participants and subsequently analyzed by techno-economic aspects.
Practical experiences on solar thermal system financing, design, construction, commissioning and operation will be documented and present as well as possible future business opportunities will be documented. Depending on data availability detailed monitoring data on the performance of relevant demonstrators will be analyzed. Further on present as well as possible future business opportunities with regard to changing conditions in the future (as assumed in Subtask B and Subtask C) will be discussed.

(c) Workshops and seminars

Industry workshops, during the Task duration, in conjunction with every Task meeting, will be organized in the host country of the meeting. All relevant target groups will be invited.
National industry workshops will be organized by Task participants using the information gathered during Task workshops and the material produced by the Task. This will be performed once a year.

(d) Publications/Newsletters

The overall scope and objectives of the Task and the different Subtasks will be described on the SHC website, and possibly linked to another site. Apart from the publication of scientific results at conferences and in journals and magazines, a Task brochure will be distributed to describe to the scope of the Task.

4 Expected Results/Deliverables

The products of work performed in this Task are designed for the solar heat industry (manufacturers of components and systems) for prescriptors, such as urban planners, energy service companies and utilities, and finally, for the end-users, such as owners of buildings that have to choose a heating system either for a new building or a renovated one.

The main deliverables allocated to the three Subtasks, will be:

Subtask A:
- Report on advanced energy system analyses of solar thermal concepts: Methodology report
- Report on future scenarios highlighting recommended uses of solar thermal and sensitivity analysis of important parameters
- Contribution to the Task 52 common publications

Subtask B:
- Report on methodologies, and existing planning tools
- Report on case studies
- Development of a guideline analyzing case studies and solutions sets with performance indicators (which solution fits to which situation including the interpretation of the outcome of the scenarios (Subtask A) and including no go's)
- Contribution to the Task 52 common publications

Subtask C:
- Report on technical and economical evaluation of best practice examples
- Report on existing and adapted business opportunities and success factors
- Contribution to the Task 52 common publications

Operating Agent in collaboration with Subtasks:
- Website with all major reports and papers
- 2 international conferences participation
- 4 newsletters
- Position Paper as required by the SHC Programme

5 Rights and Obligations of the Participants

In addition to the obligations enumerated in Article 4 of the Implementing Agreement each Participant shall commit himself in actively working in the Task and to provide:

(a) Operating Agent with detailed reports on the results of the work carried out in each Subtask.

(b) Each Participant shall participate in the editing and reviewing of draft reports of the Task and Subtasks.

(c) Each Participant shall participate in the editing and reviewing of the final publications of Task 52 “Solar Heat and Energy Economics”.
(d) Attendance at Experts meetings of the Task will be mandatory. Task meetings will be carried out at intervals of approximately six months. Experts meetings may be accompanied by national workshops dedicated to target audiences of the Task, mainly from the national industry of the host country of the Experts meeting.
(e) Publications.
In addition to the specific obligations, the Operating Agent will produce, promote and distribute the results of the Task. The Participants will support these activities by contributing respective papers and by dissemination activities financed by the individual Participants.
(f) Individual Financial Obligations.
Each country will bear the costs of its own participation in the Task, including reporting and necessary travel costs.
(g) Task-Sharing Requirements.
The Participants agree on the following funding commitment:
(1) Each Participant (country) will contribute to this Task a minimum of 0,5 person year per year of the Task, i.e. a total of more than 2 person year over the period;
(2) Participation in the Task requires participation in at least one of the Subtasks A, B, C; and
(3) The Operating Agent will contribute with a minimum of 0.3-person year per year to the Task.

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 which are specifically collaborative in nature and which 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 Management

6.1 Operating Agent

The German Ministry for Environment, acting through Sebastian Herkel, Fraunhofer Institute for Solar Energy Systems, is designated as Operating Agent.

In addition to the obligations enumerated in Articles 4 of this Implementing Agreement, the Operating Agent shall:

(a) Prepare and distribute the results described above.
(b) At the request of the Executive Committee organize workshops, seminars, conferences and other meetings.
(c) Prepare the detailed Programme of Work for the Task in consultation with the Subtask Leaders and the Participants and submit the Programme of Work for approval to the Executive Committee.
(d) Provide, at least semi-annually, periodic reports to the Executive Committee on the progress and the results of the work performed under the Programme of Work.

(e) Provide to the Executive Committee, within six months after completion of all work under the Task, a final management report for its approval and transmittal to the Agency.
(f) 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.
(g) Provide the Participants with the necessary guidelines for the work they carry out with minimum duplication.
(h) Perform such additional services and actions as may be decided by the Executive Committee, acting by unanimity.

6.2 Subtask Leaders

(a) A Subtask Leader shall be a Participant that provides to the Subtask a high level of expertise and undertakes substantial research related to the Subtask.
(b) 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 SHC Executive Committee, acting by unanimity of the Participants.
(c) In addition to the obligations enumerated in Section 5 of this Annex, the Subtask Leader for each of the Subtasks shall:
  (1) Assist the Operating Agent in preparing the detailed Programme of Work.
  (2) Co-ordinate the work performed under that Subtask.
  (3) Actively participate in the dissemination activities.
  (4) Subtask leaders may arrange, direct and provide summarizes of Subtask meetings and workshops in between or in association with Task meeting.
  (5) Provide the Operating Agent with timely written summaries of Subtask work, action items and results after each Task meeting.
  (6) Edit technical reports resulting from the Subtask and organize their publication.
  (7) Collaborate with the Operating Agent and other Subtasks and contribute to the preparation, production and distribution of the results described in Section 4 in this Annex within the framework of the Task dissemination plan.

6.3 Meetings

Experts meetings of the Task will be carried out at intervals of approximately 6 months. Subtask leaders may arrange meetings in between or in association with Experts meetings of the Task. Attendance at the Experts meetings of the Task will be mandatory. The cost of organizing meetings will be borne by the host country.

7 Admissions, Participation and Withdrawal of Participants

In addition to the specific obligations, the Operating Agent will produce, promote and distribute the results of the Task. The Participants will support these activities by contributing respective papers and by dissemination activities financed by the individual Participants.

8 Information and Intellectual Property

(a) Executive Committee's Powers

The publication, distribution, handling, protection and ownership of information and intellectual property arising from this Task shall be determined by the Executive Committee, acting by unanimity, in conformity with the Agreement.

(b) Right to Publish

Subject only to copyright restrictions, the Participants shall have the right to publish all information provided to or arising from this Task, except proprietary information.

(c) Proprietary Information

The Participants and the Operating Agent shall take all necessary measures in accordance with this paragraph, the laws of their respective countries and international law to protect proprietary information provided to or arising from this Task. For the purposes of this Task, proprietary information shall mean information of a confidential nature such as trade secrets and know-how (for example computer programs, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments) which is appropriately marked, provided such information:

- *Is not generally known or publicly available from other sources.*
- *Has not previously been made available by the owner to others without obligation concerning its confidentiality.*
- *Is not already in the possession of the recipient Participant without obligation concerning its confidentiality.*

It shall be the responsibility of each Participant supplying proprietary information and of the Operating Agent for appraising proprietary information, to identify the information as such and to ensure that it is appropriately marked.

(d) Arising Information

All information developed in connection with and during activities carried out under this Task (arising information) shall be provided to each Participant by the Operating Agent, subject only to the need to retain information concerning patentable inventions in confidence until appropriate action can be taken to protect such inventions.

For arising information regarding inventions the following rules shall apply:

- 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.
- 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, which disclose inventions that have not been appropriately protected by filing a patent application.
- The inventing Participant shall license proprietary information arising from the Task for non-exclusive use to participants in the Task:
  - (1) On the most favorable terms and conditions for use by the Participants in their own country.
  - (2) On favorable terms and conditions for the purpose of sub-licensing others for use in their own country.
  - (3) Subject to sub-paragraph (1) above, to each Participant in the Task for use in all countries, on reasonable terms and conditions.
  - (4) 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.

(e) Production of Relevant Information by Governments

The Operating Agent should encourage the governments of all Agency Participating Countries to make available or to identify to the Operating Agent all published or otherwise freely available information known to them that is relevant to the Task.

(f) Production of Available Information by Participants

Each Participant agrees to provide to a Subtask Leader or to the Operating Agent all previously existing information, and information developed independently of the Task, which is needed by a Subtask Leader or by the Operating Agent to carry out its functions under this Task and which is freely at the disposal of the Participant and the transmission of which is not subject to any contractual and/or legal limitations:

(1) If no substantial cost is incurred by the Participant in making such information available, at no charge to the Task.

(2) If substantial costs must be incurred by the Participant to make such information available, at such charges to the Task as shall be agreed between the Operating Agent and the Participant with the approval of the Executive Committee.

(g) Use of Confidential Information

If a Participant has access to confidential information which would be useful to a Subtask Leader or to the Operating Agent in conducting studies, assessments, analyses, or evaluations, such information may be communicated to a Subtask Leader or to the Operating Agent but shall not become part of the reports, handbooks, or other documentation, nor be communicated to the other Participants, except as may be agreed, between the Subtask Leader or the Operating Agent and the Participant.

(h) Reports on Work Performed under the Task

The Operating Agent shall, in accordance with paragraph 7 above, provide reports of all work performed under the Task and the results thereof, including studies, assessments, analyses, evaluations and other documentation, but excluding proprietary information.

(i) Copyright

The Operating Agent may take appropriate measures to protect copyrightable material generated under this Task. Copyrights obtained shall be the property of the SHC Programme for the benefit of the Participants provided, however, that the Participants may reproduce and distribute such material, but if it shall be published with a view to profit, permission should be obtained from the Executive Committee.

(j) Authors

Each Participant will, without prejudice to any rights of authors under its national laws, take necessary steps to provide the co-operation from its authors required to carry out the provisions of this paragraph. Each Participant will assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

9 Entry into Force, Term and Extension

This Annex shall enter into force January 1, 2014 and shall remain in force for a period of four years until December 31, 2017. 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.