SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Heating and Cooling Technology Collaboration Programme

2016 Annual Report

with feature article on solar certification

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INTERNATIONAL ENERGY AGENCY

2016
Annual report

June 2017

The contents of this report do not necessarily reflect the viewpoints or policies of the International Energy Agency (IEA) or its member countries, the IEA Solar Heating and Cooling Technology Collaboration Programme (SHC TCP) members or the participating researchers.

Table of Contents

1. Message from the Chairman

In 2016 the IEA SHC Technology Collaboration Programme (TCP) increased our activities to disseminate the knowledge that we have developed through the decades to a wider audience and thereby to enhance the expertise available to the sector. We initiated the Solar Academy to share our work and support R&D and implementation of solar heating and cooling projects worldwide. We formed a partnership with the International Solar Energy Society (ISES) to hold the International Solar Heating and Cooling Conference together with the Solar World Congress in 2017. We started three new Tasks and completed one Task.

We welcomed two new members in 2016, the Slovak Republic as a Contracting Party and ISES as a Sponsor. And, we approved the withdrawal of Singapore from the TCP.

2016 also was a year of growing interest in this field in part due to the call to action from the Paris Climate Agreement and the Mission Innovation Challenge on the "Affordable Heating and Cooling of Buildings". This global call to action will provide an opportunity for the SHC TCP to expand our impact as it will provide a much-needed focus on heat energy that is missing from many countries' priorities for renewable energy supply. Consequently, we expect that greater resources should become available for collaborative research of the types undertaken in the SHC TCP.

Significant progress has been made toward delivering the objectives our 2014-2018 Strategic Plan to move us toward our 2050 vision of solar thermal energy meeting 50% of low temperature heating and cooling demand. Some details of our work can be found in this report and more details are available on our website, www.iea-shc.org.

In 2016, we continued our collaborations both within the IEA with the Secretariat in Paris and other IEA Technology Collaboration Programmes that cover Renewable Energy and End Use Technologies, and externally with industry to better understand industry needs and with information and academic organizations to improve the information flow and dissemination of our research results.

I would like to acknowledge the work of the TCP Vice Chairs, Ricardo Enríquez, Daniel Mugnier and He Tao, the members of the Executive Committee, the Operating Agents of the Tasks as well as all the experts working in the TCP's projects. I'd also like to particularly note the support of the Secretariat, Pamela Murphy, and the Webmaster, Randy Martin.

In 2017 we will continue to work productively as I coordinate the Programme's work from Australia.

Ken Guthrie, *SHC Executive Committee Chairman*

2. Solar Heating and Cooling Technology Collaboration Programme

IEA

Established in 1974, the International Energy Agency (IEA) carries out a comprehensive programme of energy co-operation for its 29 member countries and beyond by examining the full spectrum of energy issues and advocating policies that will enhance energy security, economic development, environmental awareness and engagement worldwide. The IEA is governed by the IEA Governing Board, which is supported through a number of specialized standing groups and committees.

The IEA RD&D activities are headed by the Committee on Research and Technology (CERT), supported by the IEA secretariat staff, with headquarters in Paris. In addition, four Working Parties on End Use, Renewable Energy, Fossil Fuels and Fusion Power, are charged with monitoring the various collaborative energy agreements, identifying new areas of cooperation and advising the CERT on policy matters. The Renewable Energy Working Party (REWP) oversees the work of ten renewable energy agreements and is supported by a Renewable Energy Division at the IEA Secretariat in Paris. For more information on the IEA, see http://www.iea.org.

SHC TCP

The Technology Collaboration Programme on Solar Heating (SHC TCP) was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency. The Executive Committee agreed upon the following for the 2014-2018 term:

The SHC Programme's **vision**…

> *By 2050 a worldwide capacity of 5kWth per capita of solar thermal energy systems installed and significant reductions in energy consumption achieved by using passive solar and daylighting: thus solar thermal energy meeting 50% of low temperature[1] heating and cooling demand.*

The SHC Programme's **mission**…

> *To enhance collective knowledge and application of solar heating and cooling through international collaboration in order to fulfill the vision.*

The SHC Programme's mission assumes a systematic approach to the application of solar technologies and designs to whole buildings, and industrial and agricultural process heat. Based on this mission, the Programme will carry out and co-ordinate international R&D work and will continue to cooperate with other IEA Implementing Agreements as well as the solar industry to expand the solar market. Through international collaborative activities, the will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data and market approaches, and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for industrial and agricultural process heat applications.

The Programme's target audience is the design community, solar manufacturers, and the energy supply and service industries that serve the end-users as well as architects, cities, housing companies and building owners

1 Low temperature heat up to 250°C

The primary activity of the SHC Programme is to develop research projects (Tasks) to study various aspects of solar heating and cooling. Each research project (Task) is managed by an Operating Agent who is selected by the Executive Committee.

A total of 57 projects have been initiated to date. The Tasks running in 2016 were:

- Solar Resource Assessment and Forecasting (Task 46)
- Solar Heat Integration in Industrial Processes (Task 49)
- Solar Energy in Urban Planning (Task 51)
- Solar Heat and Energy in Urban Environments (Task 52)
- New Generation Solar Heating and Cooling (Task 53)
- Price Reduction of Solar Thermal Systems (Task 54)
- Towards the Integration of Large SHC Systems into DHC Networks (Task 55)
- Building Integrated Solar Envelope Systems for HVAC and Lighting (Task 56)
- Solar Standards & Certification (Task 57)

To support the work in our Tasks, the *SHC Solar Academy* was established to facilitate the dissemination of Task results and to support R&D and implementation of solar heating and cooling projects worldwide. The main activities will be webinars (hosted by ISES), videos, national days in conjunction with Executive Committee meetings, and onsite training in member countries.

In addition our other activities continue – SHC International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2017 will be held jointly held with ISES Solar World Congress 2017 on October 29 - November 2 in Abu Dhabi), Memorandum of Understanding with solar thermal trade organizations, annual Solar Heat Worldwide statistics report, organization and participation in seminars, industry workshops and conferences.

Members & Membership

The overall management of the Programme rests with the Executive Committee comprised of one representative from each Contracting Party organization and Sponsor organization.

Members

Australia	Contracting Party	**Mexico**	Contracting Party
Austria	Contracting Party	**The Netherlands**	Contracting Party
Belgium	Contracting Party	**Norway**	Contracting Party
Canada	Contracting Party	**Portugal**	Contracting Party
China	Contracting Party	**RCREEE**[5]	Sponsor
Denmark	Contracting Party	**Singapore***	Contracting Party
ECI[1]	Sponsor	**Slovakia***	Contracting Party
ECREEE[2]	Sponsor	**South Africa**	Contracting Party
European Commission	Contracting Party	**Spain**	Contracting Party
France	Contracting Party	**Sweden**	Contracting Party
Germany	Contracting Party	**Switzerland**	Contracting Party
GORD[3]	Sponsor	**Turkey**	Contracting Party
ISES[4]*	Sponsor	**United Kingdom**	Contracting Party
Italy	Contracting Party		

1 ECOWAS Centre for Renewable Energy and Energy Efficiency
2 European Copper Institute
3 Gulf Organization for Research & Development
4 International Solar Energy Society
5 Regional Centre for Renewable Energy and Energy Efficiency

**Slovakia and ISES joined in 2016 and Singapore withdrew in 2016*

Benefits of Membership

The SHC Programme is unique in that it provides an international platform for collaborative R&D work in solar thermal. The benefits of membership are numerous.

- ***Accelerates*** the pace of technology development through the cross fertilization of ideas and exchange of approaches and technologies.
- ***Promotes*** standardization of terminology, methodology and codes & standards.
- ***Enhances*** national R&D programs thorough collaborative work.
- ***Permits*** national specialization in technology research, development, or deployment while maintaining access to information and results from the broader project.
- ***Saves*** time and money by sharing the expenses and the work among the international team.

How to Join

To learn how your government agency or your international industry association, international non-profit organization or international non-governmental organization can join please contact the SHC Secretariat *(*secretariat@iea-shc.org*).*

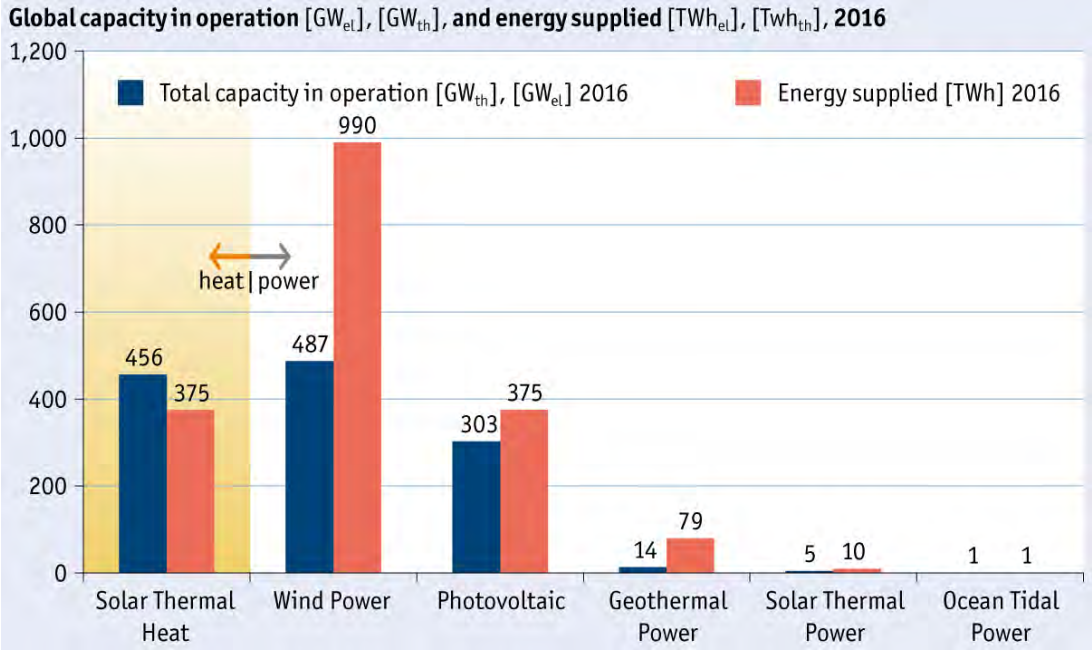
3. 2016 Recap

Solar Thermal Outlook

The SHC Programme publishes the only annual global solar thermal statistics report, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply*. The 2017 edition reports that in 2016, solar thermal technologies produced 375 TWh – which corresponds to an energy savings equivalent of 38.4 million tons of oil and 123.8 million tons of CO_2.

For the 2nd year, the report includes data on solar thermal cost and levelized costs of heat (LCOH). This data is valuable because it analyzes economic performance indicators and cost ranges at the system level in major solar thermal markets worldwide.

This report is the most comprehensive of its kind and is referenced by many international organizations including the IEA, REN21 and IRENA and national governments. The report is free to download at http://www.iea-shc.org/solar-heat-worldwide.



Global capacity in operation and energy supplied in 2016.

TOP FIVE LIST 2015
New installed water collectors (MWth)
China (30,450), Turkey (1,467), India (1,089), Brazil (982), United States (704)
New installed water collectors (kWth/1,000 inhabitant)
Israel (37), Denmark (31), Barbados (28), China (22), Turkey (18)
Total water collectors in operation (MWth)
China (309, 470), United States (17,307), Turkey (13,637), Germany (13,226), Brazil (8,669)
Total water collectors in operation (kWth/1,000 inhabitant)
Barbados (489), Austria (421), Cyprus (400), Israel (397), Greece (287)

SHC Tasks

New

The Programme continues to push forward on cutting edge topics in solar thermal as well as in the field of solar buildings, architecture, and lighting, all of which support our strategic focus on market deployment and R&D.

In 2016, the following Tasks began:

- Task 55 Towards the Integration of Large SHC Systems into DHC Networks
  (Lead Country: Austria)
- Task 56 Building Integrated Solar Envelope Systems for HVAC and Lighting
  (Lead Country: Italy)
- Task 57 Solar Standards & Certification
  (Lead Country: Denmark)
- Task 58 Material and Component Development for Thermal Energy Storage
  *(Lead Country: Austria) *Approved November 2016 and started January 2017.*

Completed

In 2016, the following Tasks ended:

- Task 46 Solar Resource Assessment and Forecasting
  (Lead Country: United States then Australia)
- Task 49 Solar Heat Integration in Industrial Processes
  (Lead Country: Austria)

SHC Activities

Each of the activities below serve as a means to inform policy and decision makers about the possibilities of solar thermal as well as the achievements of our Programme.

You can learn more about these activities and our work on our website, http://www.iea-shc.org.

Solar Heat Worldwide

This report is a primary source for the annual assessment of solar thermal. The report is the leading data resource due its global perspective and national data sources. The installed capacity of the 61 documented countries represents 95% of the solar thermal market worldwide.

International Conference on Solar Heating and Cooling for Buildings and Industry

Our international conference provides a platform for experts to gather and discuss the trending topics and learn about the work others are doing in the field. The next conference, SHC 2017, will be held jointly with the International Energy Agency's Solar World Congress on October 29 – November 2 in Abu Dhabi, UAE.

SHC Solar Award

Our prestigious award recognizes individuals, companies and institutions that have made significant contributions to the growth of solar thermal. The 11th SHC Solar Award will be presented at SHC 2017 in Abu Dhabi, UAE. The award will recognize a successful program or policy measure that supports solar heating and cooling.

SHC Book Series

This growing collection of books on Task results is published by Wiley-VCH. To date it includes three books: *Modeling, Design, and Optimization of Net-Zero Energy Buildings, Solar and Heat Pump Systems for Residential*

Buildings and *Polymeric Materials for Solar Applications.* In 2017 two additional books will be published, ***Solar Cooling Design Guide*** and *Solution Sets for Net-Zero Energy Buildings.*

SHC Collaboration

To support our work, the SHC Programme is collaborating with other IEA Technology Collaboration Programmes and solar organizations.

Within the IEA

IEA Photovoltaic Power Systems TCP collaborated in *SHC Task 46: Solar Resource Assessment and Forecasting* and is collaborating in *SHC Task 53: New Generation Solar Cooling and Heating Systems.*

IEA SolarPACES TCP collaborated in *SHC Task 46: Solar Resource Assessment and Forecasting* and *SHC Task 49: Solar Heat Integration in Industrial Processes.*

IEA District Heating and Cooling TCP is collaborating in SHC Task 55: *Towards the Integration of Large SHC Systems into DHC Networks*

IEA Buildings Coordination Group is represented by the Spanish Executive Committee, Ricardo Enriquez, who attends the semi-annual meetings.

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC Programme to increase national and international government agencies and policymakers awareness of solar thermal's potential and to encourage industry to use solar thermal R&D results in new products and services. To support this collaboration meetings are regularly held. The 11th meeting will be held in conjunction with SHC 2017 in Abu Dhabi, UAE.

European Solar Thermal Industry Federation (ESTIF), the SHC Programme has a close working relationship with ESTIF.

ISO TC 180, the SHC Programme, specifically through Tasks, is supporting the work of ISO TC 180. For example, Task 43: Rating and Certification Procedures defined the revisions needed to standard ISO 9806 for solar collector testing and Task 57: Solar Standards & Certification will continue to support the work of ISO TC 180.

Executive Committee Meetings

2016 MEETINGS	
79th ExCo Meeting June 1 - 3	Almeria, Spain (including Technical Tour)
80th ExCo Meeting November 9 - 10	Doha, Qatar (including Technical Tour and National Day/GORD's Green Expo)
2017 MEETINGS	
81st ExCo Meeting June 7 - 10	London, England *(Includes Joint Meeting with EBC TCP, Strategic Planning Session, Technical Tour)*
82nd ExCo Meeting November 30 – December 1	Melbourne, Australia

4. Feature Article

Solar Standards and Certification

Mr. Jan Erik Nielsen
PlanEnergi
Operating Agent for SHC Task 57, Solar Standards and Certification

Harmonizing Collector Testing and Inspection

Building on the success of the national/regional certification schemes in China, Europe, North Africa/Middle East and the United States, the Global Solar Certification Network (GSCN) was established to streamline the testing and certification of collectors between these national/regional schemes and thus increase the global sales of solar thermal products. Before the GSCN, if a manufacturer wanted to sell their product somewhere else in the world they would in most cases need to re-test and re-certify their products - a time consuming and costly step many chose not to do.

The concept of opening up cross-border trade of solar thermal products for manufactures and suppliers was widely supported, but has had its challenges. Originally, encouraged by the success of Solar Keymark in Europe, the ambition was to have a single Global Mark that would be valid and accepted all over the world. But it proved impossible to agree on the use of one global certification mark. Not to be discouraged, those involved looked at harmonizing existing certification schemes to the extent that it would be possible to use test and inspection reports from one certification scheme to another certification scheme in a different country/region.

Potential savings are huge when using the "Global Solar Certification Network" concept. A manufacturer selling 8 different collector types in 3 different parts of the world could save up to almost 200,000 € in testing and inspection costs the first year!

On the Road to Harmonization

THE FIRST STEP – GLOBALLY ACCEPTED STANDARD

To avoid multiple re-testing the ISO technical committee ISO/TC 180 issued an international standard for testing solar collectors (ISO 9806). Recognizing the importance of this standard, the SHC Programme supported the work through Task 43: Solar Rating & Certification Procedures and Task 57: Solar Standards and Certification is now promoting the use of this standard through out the world – and the good news is that most countries with the largest markets have implemented ISO 9806, but there is still work to do.

THE SECOND STEP – HARMONIZED TESTING AND INSPECTION PROCEDURES AND REQUIREMENTS

The "Global Solar Certification Network" is working on harmonizing the testing and inspection procedures and requirements in the existing certification schemes around the world. ISO 9806 is the obvious choice for the common test procedure. Concerning inspection procedures, the GSCN has outlined common procedures, which are now agreed on by several certification schemes. This is a critical step because it will make it possible to have test and inspection reports from one certification scheme accepted by another certification scheme.

The reuse of test and inspection reports in different certification schemes is becoming possible this year! GSCN industry members can use a collector test report or a production inspection report from one of the GSCN schemes to apply for a certificate in another part of the world that is also part of GSCN. This procedure is a critical step for expanding the solar thermal market because it removes the need for collector retesting or a second site inspection and thus saves manufacturers time and money.

How the Global Solar Certification Network Works

The GSCN is a cooperative agreement between solar certification bodies around the world. Its members represent industry, certification bodies, test labs and inspection facilities. It is governed by a board of directors and operates under the “Global Solar Certification Network Working Rules.” Once a member what next depends on who you are:

Manufacturer

- A GSCN manufacturer that has already received a certificate from a certification body member of the network applies directly to the “new” certification body (also GSCN member) to receive a certificate for its product(s).
- The manufacturer shows the existing certificate to the "new" certification body and asks the test lab and inspection body that did the testing and inspection to provide both reports to the "new" certification body. The test lab and inspection facility must be recognized by the “old” as well as the “new” certification body.
- The “new” certification body lets the manufacturer know if any additional testing or inspection is needed.
- If additional testing is not required – or when additional tests have been completed – the manufacturer will be granted a license to label the product with the “new” certificate.

Certification Body

- Certification bodies must show that they fulfill the requirements for membership and sign an agreement with the GSCN to participate. Signing the agreement means that the certification body will recognize the certifications done by other GSCN participating certification bodies if they both recognize the involved test labs and inspection bodies.
- Must be accredited for certification of solar collectors.

Test Lab and Inspection Facility

- Test labs and inspectors must show that they fulfill the requirements for membership and sign an agreement with the GSCN to participate. Test labs and inspectors need recognition by the certification bodies they work with.
- Test labs must be accredited for testing solar collectors according to the latest version of ISO 9806.
- Inspection bodies must be accredited for certification of solar collectors.

GSCN Certification Scheme applying for membership of GSCN as of April 2017.

What's Next

In 2017 some of the very big solar collector companies will be using this concept. And the implementation and promotion of the GSCN will continue to be supported by the members of SHC Task 57, Solar Standards and Certification.

For more information contact Jan Erik Nielson, GSCN Manager, manager@GSCN.SOLAR and visit the GSCN website.

5. Completed Tasks

Task 46 – Solar Resource Assessment and Forecasting

Dr. David S. Renné
Senior Consultant, Clean Power Research (USA)
Operating Agent for Task 46

Task Overview

The goal of SHC Task 46: Solar Resource Assessment and Forecasting was to provide the solar energy industry, the electricity sector, governments, and renewable energy organizations and institutions with the means to understand the "bankability" of data sets provided by public and private sectors. A major component of the Task was to provide this sector with information on how accurately solar resources can be forecast in the near future (sub-hourly, 1-6 hours ahead, and 1-3 days ahead) so that utilities can plan for the management of large-scale solar systems operating within their systems. Another major component of the Task was understanding short-term (1-minute or less) resource variability associated with cloud passages that cause power "ramps", an important concern of utility operators with large penetrations of solar technologies in their system. Although solar heating and cooling technologies are not, in themselves, "grid-tied" systems, the use of these technologies also impacts grid operations since they offset the use of conventional fuels or electricity, thereby impacting the electricity load profile.

The objectives of the Task were to:

- Evaluate solar resource variability that impacts large penetrations of solar technologies;
- Develop standardized and integrating procedures for data bankability;
- Improve procedures for short term solar resource forecasting; and
- Advance solar resource modeling procedures based on physical principles to provide improved evaluation of large-scale solar systems using both thermal as well as PV technologies.

Participating Countries

	Research Institutes	Universities	Companies
Australia	2	1	0
Austria	1	0	2
Canada	0	0	1
Denmark	1	1	0
France	1	2	1
Germany	1	2	3
Netherlands	1	0	0
Singapore	1	0	0

Spain	2	3	2
Switzerland	0	1	1
UK	0	0	1
Norway (guest participant)	1	0	0
Slovakia (guest participant)	0	0	1
USA (guest participant since 2014)	2	3	3
Chile (observer)	0	1	0
Greece (observer)	0	1	0
UAE (observer)	0	1	0
TOTAL	**13**	**16**	**15**

Task Duration

The Task started in **July 2011** and ended in **December 2016**. The Task will continue as PVPS Task 16: Solar Resource for High Penetration and Large-Scale Applications under the IEA PVPS Technology Cooperation Programme, beginning in July 2017.

Collaboration with Other SHC Tasks and Outside Organizations/Institutions

Task 46 worked closely with PVPS Task 14, and Jan Remund of Meteotest served as the Task 46 liaison to PVPS Task 14. Task 46 also remains as Task 5 in the SolarPACES operational plan. Dr. Richard Meyer (Suntrace) and Dr. Lourdes Ramirez (CENER) represented Task 46 in SolarPACES and coordinated WP8 on meteorological input in the SolarPACES-guiSmo-project, as well as another SolarPACES project on DNI-benchmarking.

Task 46 also maintained collaboration with the IRENA Global Atlas and with Global Earth Observation programs such as ConnectinGEO, a project funded by the European Union to support the exchange of information on in-situ earth observation networks such as pyranometric networks.

Task 46 had joint collaborations with the COST ES1002 WIRE (Weather Intelligence for Renewable Energy), notably:

Collaborative work about DNI inter-comparison in the high quality platform of pyranometric sensors in Payerne (Meteoswiss) between alternative sensors measuring DNI (Rotating Shadowband Irradiometers from different manufacturers and SPN1 sensors)

Collaborative work on the impact assessment of AOD uncertainty on clear-sky surface solar irradiance.

Collaboration With Industry

Several small companies involved in solar resource data production and services were directly or indirectly participating in the Task: Green Power Labs (Canada), Suntrace GmbH (Germany), Black Photon Instruments GmbH (Germany), CSP Services (Germany), Meteotest (Switzerland), Blue Sky Wetteranalyzen (Austria), GeoModel. s.r.o. (Slovakia), IrSOLaV (Spain), Meteotest (Switzerland), Irradiance Corp. (USA), Augustyn and Co. (USA), Clean Power Research (USA), Solar Consulting Services (USA), and Peak Design (UK).

The audience for the results of Task 46 includes the technical laboratories, research institutions, and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, and building and

system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and have been informed through numerous targeted reports, presentations, webinars, handbooks and journal articles.

Task Accomplishments

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 46 webpage.

The following is a brief summary on the key accomplishments of each single work activity within the Subtasks.

Subtask A: Solar Resource Applications for High Penetrations of Solar Technologies
(Subtask Leader: Dr. Richard Perez, SUNY/Albany ASRC, USA)

A1: Solar Resource Variability Fundamentals and Grid Integration
This subtask initially included three activities – A1: Short-Term Variability, led by Hans Georg Beyer, A2: Integration of solar with other RE technologies, led by Martin Gaston and A3: Spatial and Temporal Balancing Studies of the Solar and Wind Energy Resources, led by David Pozo. At the 6th Task Expert meeting in Almería in January 2015, it was decided to combine the three activities into a single activity: Solar Resource Variability Fundamentals and Grid Integration. The main reason was the small amount of ongoing activity in A2 and A3 relative to A1.

The subtask covered three major areas of research: (1) very short-term variability and over-irradiance measurement and modeling, (2) space and time characteristics of solar resource variability, and (3) application to grid interaction and balancing. Areas 1 and 3 resulted in several conference and peer-reviewed publications led respectively by Hans Georg Beyer and David Pozo. The second area led to by a review monograph, jointly authored by several subtask experts that should serve as a reference to the understanding, characterization and modeling of solar resource variability. This monograph was published as the inaugural volume/issue of Now Publishers' Foundations & Trends in Renewable Energy journal. This work offers an effective scientific background and complement to the applied findings of IEA PVPS Task 14 undertaken by Jan Remund.

Subtask B: Standardization and Integration Procedures for Data Bankability
(Subtask Leader: Dr. Stefan Wilbert, DLR/PSA, Almería, Spain)

B1: Measurement Best Practices
Detailed measurement best practices for solar radiation measurements (Sengupta et al., 2015) and measurement with RSIs (Wilbert et al., 2015) have been documented and published.

B1 participants contributed to drafts and updates for several international standards that will be published in 2017 or in the next years. The DNI definitions related to circumsolar radiation were discussed in a task workshop in 2013 and published as Blanc et al. 2014 and are now used in the IEC draft "117/27/NP: 2014-01 – Future IEC 6xxxx TS Ed.1: Solar Thermal Electric Plants – Terminology". For radiometer classification a draft has been created for ASTM and an update of the existing ISO 9060 "Solar energy - Specification and classification of instruments for measuring hemispherical solar and direct solar radiation" has reached the stage of a draft international standard. Silicon sensors, correction functions and shading types for diffuse radiation measurement will be considered.

Further results in B1 are related to the determination of circumsolar irradiance (Wilbert et al., 2013, Wilbert, 2014), solar extinction in tower plants (Hanrieder et al, 2016; Polo et al, 2016), and soiling (Wolfertstetter et al, 2013).

B2: Gap-Filling, QC, Flagging, Data Formatting
Task participants have defined a new meteorological data format for information from one single site. The format can be used for modeled or measured data, TMYs and forecasts. The format is described in an IEA report that is now under review by the SHC review committee. The data format was also used as the basis for an IEC committee draft that has been submitted.

A report on quality control and gap filling was published (Espinar et al., 2011) and flagging and data QC methods were documented in joint publications (Geuder et al., 2015).

B3: Integration of Ground Measurements with Model-derived Data
During the task a review and discussion on methodologies for site adaptation of model-derived data with short-term ground data have been performed. Different methodologies and approaches arose from the input supplied by the participants. So far no clear recommendations had been developed from this work. A specific webinar was organized by CIEMAT in July 2015 for discussing this topic, where general consensus was achieved about the need of preparing a further benchmarking exercise about site adaptation methods. A report about methodologies for integration of model-derived data with measurements was delivered and available for downloading from the task website. In addition a paper on the survey of models for site adaptation was published in the Journal of Solar Energy (Polo et al., 2016).

B4: Uncertainty of Model-derived Solar Radiation Data
In B4 the method for benchmarking model derived solar irradiance data was documented and published (Meyer et al., 2014). The benchmarking for various models was performed and documented in Ineichen et al., 2013. The benchmarking covered various geographic regions and twelve different radiation models.

B5: Yearly and Long-term Meteorological Data Sets
The use of meteorological data sets for solar resource assessment has been reviewed. Typical Meteorological Years (TMYs) and other yearly meteorological data sets can be used for rough studies of renewable energy conversion and site feasibility studies. Often yearly data sets are designed for specific solar technologies. Care should be taken to use a data set that is suitable for the specific purpose of interest. It is not feasible to make yearly data sets with untypical or extreme meteorological data; rather long-term measured or modeled data sets should be used to account for general meteorological conditions. From such data sets the annual performance variability of solar energy conversion systems can be quantified. This can be done with the probability that a level of annual energy production will be reached or exceeded. For instance the production level exceeded in 90% of the years can be used. This is referred to as the P90 value. To determine this, the statistical distribution must be correctly assessed, and the uncertainties of the data used properly accounted for. The effects of long-term trends and rare events such as Plinian or ultra-Plinian volcanic eruptions on P90 values are currently not accounted for and are important to investigate further. The task participants contributed to an IEC committee draft on TMY creation for concentrating solar power.

Subtask C: Solar irradiance Forecasting
(Subtask Leader: Dr. Elke Lorenz, Fraunhofer ISE, Freiburg, Germany)

C1: Short Term Forecasting, Up to 7 Days Ahead
The development and improvement of methods to forecast GHI and DNI has been a major subject of activity C1. Different forecast horizons, ranging from minutes up to several days ahead are addressed using specific methodology and data. Considerable progress was achieved in sub activities C1.1 to C1.5 covering different forecasting approaches, characterized by the used data sources, corresponding methods and time scales.

Key accomplishments under this Activity can be summarized as follows:

Time series models with advanced statistical methods using on-site measured irradiance data as input are applicable for the very short-term time scale ranging from minutes up to few hours. Task 46 participants have been continuously working on time-series forecasting and published a number of journal articles as well as conference papers (e.g. Grantham et al. 2016, Boland and Soubdhan, 2015, Huang et al 2013, Wolff et al 2016).

Solar forecasting with sky imagers has been a focus of the development of several participants. Irradiance forecasting using information on the temporal development of clouds from ground-based sky imagers has a high potential for the sub hourly range with a very high spatial and temporal resolution. The University of California San Diego (UCSD) has investigated the impact of high PV penetration using solar resource assessment with sky imager and distribution system simulations (Nguyen et al. 2015) and a sky camera geometric calibration using solar observations (Urquhart et al. 2015). They have proposed a new method to estimate cloud optical depth by coupling sky images with three-dimensional radiative transfer models (Mejia et al 2015) and a new approach for cloud base estimation (Guang et al 2015). U of Oldenburg has presented an evaluation of the spatial-temporal performance of sky imager based solar irradiance analysis and forecasts for a dense network of irradiance sensors located in area of 10 km x 12km (Schmidt et al. 2015). DLR has presented requirements for nowcasting systems that can be applied for concentrating solar technologies (Hirsch et al. 2015). The application of voxel carving to derive 3D cloud coordinates from four all sky imagers were published by Prahl et al, 2015 and Oberländer et al., 2015.

Forecasts based on cloud motion vectors from satellite images show a good performance for a temporal range of 30 minutes to 6 hours. We have investigated further development of existing approaches. Müller and Remund, 2014 have proposed a method that combines cloud index values retrieved from MSG satellites with wind fields from a NWP model. Hammer et al., 2015 developed a nighttime cloud index based on Meteosat-SEVIRI data for short-term forecasting of surface solar irradiance also in the early morning hours.

NWP models provide the basis to forecast irradiance up to several days ahead. We have investigated new parameterizations for aerosols, clear sky irradiance and clouds. Furthermore we have analyzed new options for irradiance forecasting (rapid update cycle models, cloud resolving models, ensembles prediction systems, aerosol forecasts using chemical transport models). Mathiesen et al., 2013 have introduced a high-resolution, cloud-assimilating numerical weather prediction model for solar irradiance forecasting. Ruiz-Arias el al., 2014 propose a simple parameterization of the short-wave aerosol optical properties for surface direct and diffuse irradiances assessment in a numerical weather model. Gleeson et al., 2015 have performed shortwave radiation experiments in HARMONIE and tested the cloud inhomogeneity factor and a new cloud liquid optical property scheme compared to observations. Hong et al. (2016) propose corrections to the New Goddard Shortwave Scheme based on dissecting surface clear sky irradiance bias in numerical weather prediction. Schroedter-Homscheidt et al. (2013) have assessed ECMWF/MACC aerosol forecast in the context of concentrating solar electricity production forecasts.

Statistical post-processing methods have the potential to combine different data sources in an optimum way, to reduce systematic forecast errors and to adjust forecasts for local conditions or specific weather conditions. In particular we have investigated multi-NWP model forecasts and Model Output Statistics (MOS) systems. Diagne et al. (2104) have proposed post-processing methods of solar irradiance forecasts from WRF Model at Reunion Island. Lauret et al. 2014 have compared different machine learning techniques for solar radiation forecasting in an island context. Lorenz et al. (2012) have introduced a short term forecasting approach of solar irradiance by combining satellite data and numerical weather predictions. Wolff et al. (2016) have compared support vector regression for PV power forecasting to a physical modeling approach using measurement, numerical weather prediction, and cloud motion data. Perez et al. (2014) have introduced a solar resource forecast service for PV fleet simulation integrating different NWP models as well as satellite-based forecasts.

As a second focus of activity C1, addressed in Subactivity C1.6, we have compared different forecasting approaches in several benchmarking studies focusing on different models and regions.

A comparison of numerical weather prediction solar irradiance forecasts in the US, Canada and Europe' is presented in Perez et al. (2013).

For Deliverable C1.2 “Benchmarking of NWP model irradiance forecasts for central and northern Europe” we have compare solar global horizontal irradiance forecasts based on numerical weather predictions for a variety of different models (Lorenz et al, 2016). These include direct model output of several numerical weather prediction models, a rapid update cycle model assimilating satellite derived cloud products as well as radar data, the multi model ensemble prediction system GLAMEPS, and two MOS systems, as shown in Figure 1. In order to allow for a transparent and comparable analysis of the different methods we have set up a joint, consistent framework of evaluation. As a basis for the comparisons we have compiled a common data set of hourly measured solar irradiance values for Denmark, Germany, and Switzerland. Local and regional forecasts are analyzed with respect to different properties. In particular we show that spatial and temporal averaging effects have a strong impact on the RMSE when comparing solar irradiance forecasts of NWP models with different output resolutions. Furthermore we investigate a new approach to evaluate the model’s ability to represent and forecast solar irradiance and cloud variability. The benefit of high-resolution mesoscale models in this respect is demonstrated.

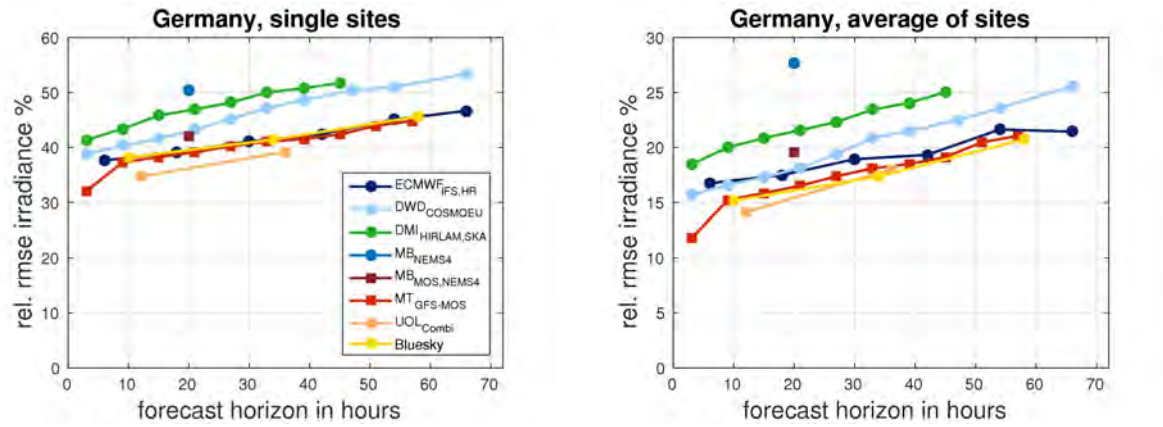


Figure 1. Forecast error (rel. RMSE) in dependence of forecast horizons for single site predictions (left) and regional forecasts (right).

A chapter was prepared as part of a final report to the Danish Energy Agency that compiles the work of DTU in the Task, using the IEA SHC Task 46 annual and semi-annual reports plus some additional outcomes. Global and regional Numerical Weather Prediction (NWP) outputs have been benchmarked against ground-based stations measuring GHI. For intraday site-specific forecasts (6-24 hours) the models typically have relative RMSEs of 35%-45%. For regional averages of the measurements the relative RMSEs are approximately halved. The relative RMSE increases with the forecasting horizon. Thus, for the best of the models tested - the IFS model of ECMWF - the relative RMSE increases from approx. 39% for a 7 hour forecast in Germany to approx. 47% for a 67 hour forecast.

RMSE is the root square sum of the forecast bias and the standard error. For the different models tested it varies to which extend the RMSE is a result of biases in the GHI forecasts. The models with the largest bias gain most from corrections based on model output statistics (MOS). Thus, it was demonstrated by Bacher et al. (2012) that the RMSE of the HIRLAM SKA GHI forecasts can be lowered with 15% by applying MOS. Different MOS approaches are discussed and demonstrated in section 7.3 of the task mid-term report (Sengupta et al. 2015). The biases also vary over the course of the year tested. On a monthly basis this is shown in Figure 2 for Danish GHI stations. It can also be seen that the biases vary on a per model basis from month to month. In general it can be recommended to apply MOS when using NWP forecasts of GHI or combinations of different forecast types.

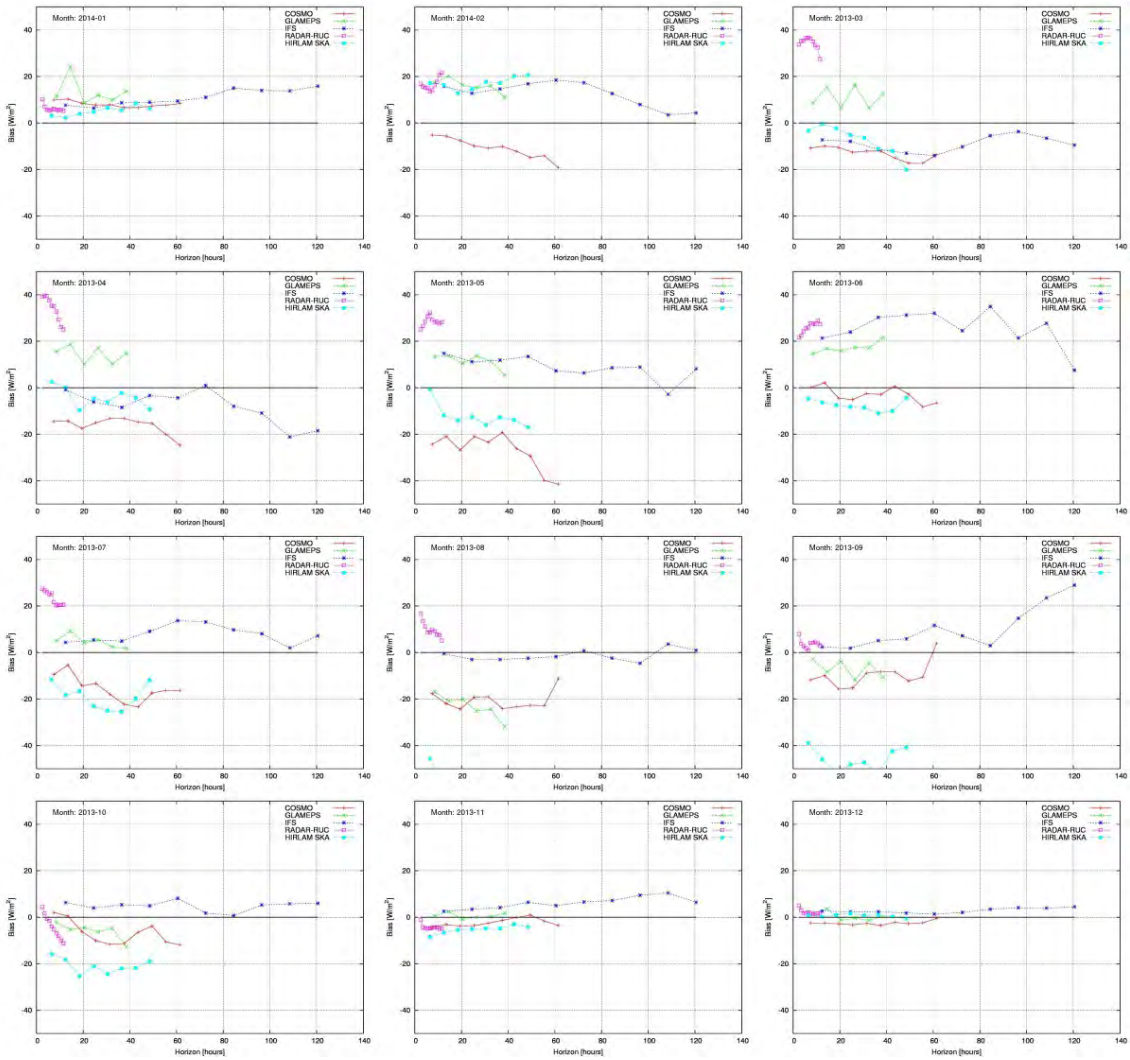


Figure 2. Average GHI monthly biases in W/m^2 as a function of forecast horizon for selected Danish GHI stations for the models: COSMO-EU (red curves), GLAMEPS (green curves), IFS (blue curves), RADAR-RUC (magenta curves) and HIRLAM SKA (cyan curves). The 12 subplots show the months from January (upper left) to December (lower right) from the test period (source: DMI).

For Deliverable C1.3 “Irradiance forecasts for Southern Europe and La Reunion” we focused on the accuracy assessment of different solar forecasting methods for La Reunion (Lauret et al 2016), which is a particular challenge due to the meteorological conditions. Réunion Island is a tropical island with a complex orography where cloud processes are mainly governed by local dynamics. As a consequence, Réunion Island exhibits numerous microclimates. Two sites representative of the challenging character of solar forecasting in the case of a tropical island with complex orography were chosen. The work focuses on day-ahead and intra-day solar forecasting. Day-ahead solar forecasts are based on numerical weather prediction with the Integrated Forecast System (IFS) provided by the European Center for Medium-Range Weather Forecast (ECMWF). Different post-processing techniques are applied to refine the output of the IFS model for day-ahead forecasting. Statistical models like a recursive linear model or a nonlinear model such as an artificial neural network are used to produce the intra-day solar forecasts. It is shown that a combination of the IFS model and the neural network model further improves the accuracy of the forecasts.

Deliverable C1.4 “Benchmarking of short term forecasting algorithms based on cloud motion vectors” addresses the comparison of satellite-based forecasts with numerical weather prediction (Remund et al., 2016). Two investigated satellite based forecasting methods showed significantly better results than NWP based methods up to three hour ahead for irradiance and variability forecasting (Lorenz et al, 2015).

In the context of forecast evaluation we also have developed several new metrics. In Lorenz et al. (2016) a new approach to assess the model's ability to forecast solar irradiance and cloud variability is proposed. The Temporal Distortion Index" (TDI), and its use in a bi-dimensional forecast analysis is presented in Frías-Paredes et al. 2016. Perez et al. (2016) introduce new financial metrics to account for the economic impact of forecast accuracy.

C2: Integration of Solar Forecasts into Operations
This activity examines the important issue of how solar forecasts are used for different applications, including utility operations, management of PV or CSP power plants, and thermal management of buildings.

Linking to industry has been accomplished through designated workshops and numerous conference presentations. IrSOLaV and CIEMAT organized and hold a "Workshop on Applications of solar forecasting" on 11th June 2013 at Ciemat (Deliverable C 2.1) with more than 100 participants joining the workshop. A joint workshop on solar forecasting of IEA SHC 46 and IEA PVPS 14 (Deliverable C 2.3) organized by Meteotest was held on 1 October 2013, 13:30 - 17:00 as a parallel event of the EU PVSEC 2013 conference in Paris.

Several Task members are applying their forecasting algorithms to PV power forecasting (e.g. Kuehnert, 2016, Wolff et al 2016, Lipperheide, et al., 2015). Forecast evaluations with respect to solar electricity production forecasts and respective user needs are given e.g. in Schroedter-Homscheidt and Oumbe, 2013, Schroedter-Homscheidt et al 2016 and Kraas et al 2013 for both CSP and PV applications.

Subtask D: Advanced Resource Modeling
(Subtask Leader, Prof. Philippe Blanc, MINES-ParisTech, France)

D1: Improvements to Existing Solar Radiation Retrieval Methods
Consensus peer-reviewed paper on DNI definitions. The direct normal irradiance (DNI) is of particular relevance to concentrated solar technologies, including concentrating solar thermal plants and concentrated photovoltaic systems. The observed disagreement between the various interpretations and definitions of DNI has been discussed in the framework of D1 and other additional international experts, some from SolarPACES. Following these discussions, a peer-reviewed collaborative paper has been published in Solar Energy, available in Open Access (Blanc, et al., 2014). The terms of reference related to DNI are specified in this paper. The important role of circumsolar radiation is evidenced, and its potential contribution is evaluated for typical atmospheric conditions, conceptualized in Figure 3.

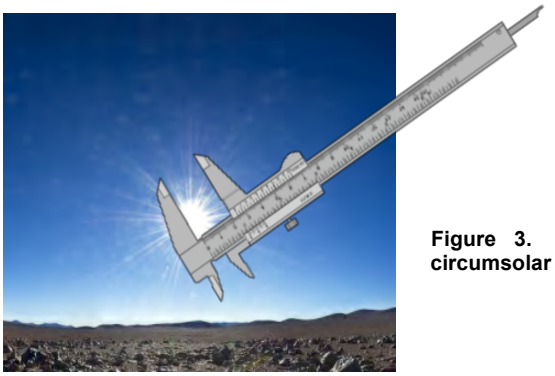


Figure 3. Expert consensus about DNI definitions related to the circumsolar normal irradiance and the angular aperture to be considered.

Towards an expert-based reference worldwide dataset of identified cloudless and cloudy conditions in 1-min measurements of surface solar irradiance. Several models predicting the solar irradiance at surface (SSI) in clear-sky conditions, i.e. cloud-free conditions, are developed and must be tested and assessed. To that goal, a worldwide reference database must be established that will comprise measurements of 1 min global SSI (GHI) and its diffuse component (DHI) as well as the direct irradiance measured on a plane always normal to the sun rays (DNI) for clear-sky instant.

In addition, this reference database may be used to assess the performance, e.g. probabilities of false alarm, detection, error, etc., of automatic algorithms of detection of clear-sky instant based solely on time series of pyranometric measurements of the SSI. These automatic algorithms may be "offline" and dedicated to the analysis of historical pyranometric time series for example in order to extend a reference database of SSI under clear-sky condition or create a new one. Among other applications, such offline algorithms may be used for the fusion of satellite-based SSI time series with in-situ measurements, which may be adapted for clear-sky or cloudy

situations. Automatic algorithms may be “in-line”, with as possible application the detection in real time of clear-sky conditions for solar forecasting purposes.

For all these reasons, in the framework of D1, a web-based survey[2] was setup as an initial step towards the creation, in a collaborative way, of a first reference database of high-quality measurements of GHI, DHI and DNI under clear-sky and cloudy conditions. The underlying concept is that experts are still better than computers and algorithms for detecting cloudless and cloudy situations using time-series of pyranometric measurements. A first database has been then created by visual inspection by experts who classified measurements in ”clear-sky”, “cloudy” and “don’t know” classes (see Figure 4 as an example). The possibility of human failure is recognized. To mitigate the adverse effects of scoring errors, each case will be seen by many experts. The possible divergence in opinion between experts will be analyzed to reach a consensus, which will be noted in the database.

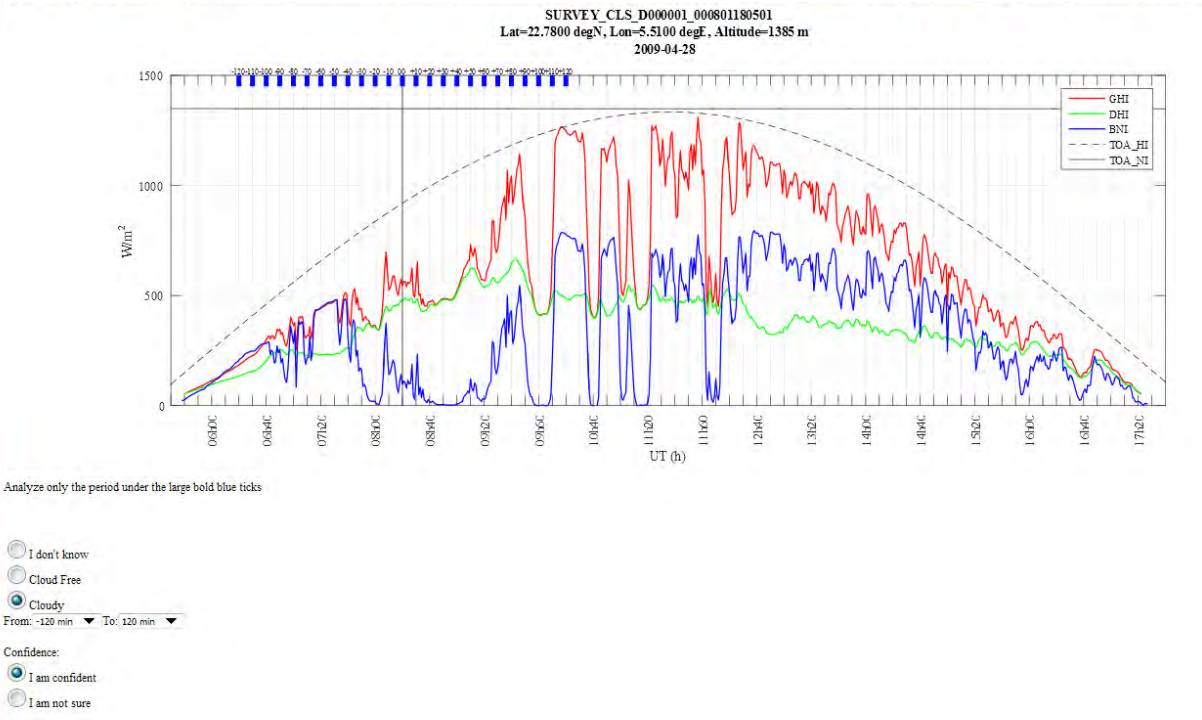
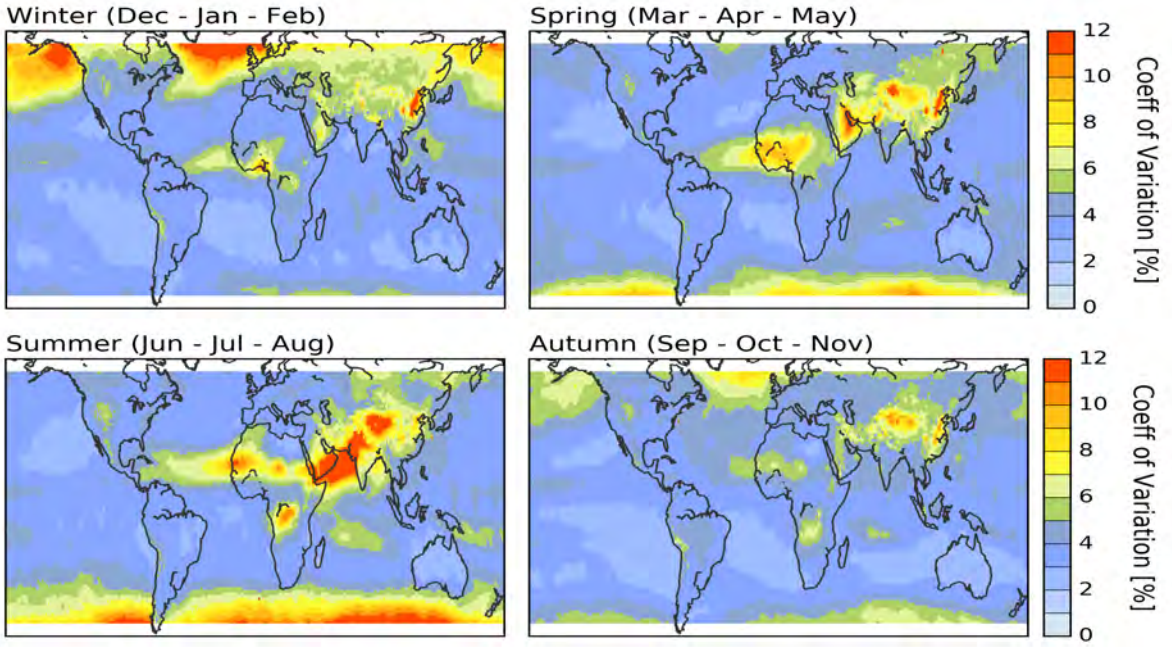


Figure 4. Snapshot of the web-based survey to collect expert-based decisions for a first reference database of high-quality measurements of GHI, DHI and DNI under clear-sky and cloudy conditions

2 http://survey-cls.oie-lab.net/Ref_dataset_SSI_measurements_cloudy_clearsky_decisions_v1.pdf

Worldwide intercomparison of clear-sky solar irradiance models. Accurate modeling of solar radiation in the absence of clouds is highly important because solar power production peaks during cloud-free situations. The conventional validation approach of clear-sky solar radiation models relies on the comparison between model predictions and ground observations. Therefore, this approach is limited to locations with availability of high-quality ground observations, which are scarce worldwide. As a consequence, many areas of interest, for example solar energy development, still remain sub-validated. Within subtask D, a worldwide inter-comparison of the global horizontal irradiance (GHI) and direct normal irradiance (DNI) calculated by a number of well-known and new clear-sky solar radiation models is being conducted, without direct intervention of any weather or solar radiation ground-based observations. The model inputs are all gathered from atmospheric reanalysis covering the globe. The model predictions are compared to each other and only their relative disagreements are quantified as shown in Figure 5. The largest differences between model predictions are found over central and northern Africa, the Middle East, and all over Asia. This coincides with areas of high aerosol optical depth and highly varying aerosol distribution size. Overall, the differences in modeled DNI are found about twice larger than for GHI. The models do not appear to parameterize adequately the prevailing weather regimes (most importantly, aerosol conditions) over regions exhibiting substantial divergences. Further validation and scrutiny using conventional



methods based on ground observations should be pursued in priority over those specific regions to correctly evaluate the performance of clear-sky models, and select those that can be recommended for solar concentrating applications in particular.

Figure 5. Seasonal coefficient of variation of DNI calculated with 13 different clear-sky models.

D2: Long term analysis and forecasting of solar resource trends and variability

MINES ParisTech published a paper in Renewable Energy Journal about the use of re-analysis data (ERA-Interim and MERRA) for solar energy applications (Boilley and Wald, 2014). The comparison, which also includes ground measured and satellite based data, shows that a very large part of the variability in irradiation is not captured by the re-analyses. MERRA and ERA-Interim should only be used with no correction in solar energy with proper understanding of their limitations and uncertainties. In regions where clouds are rare, e.g. North Africa, MERRA or ERA-Interim may be used to provide a gross estimate of monthly or yearly irradiation. Satellite-derived data sets offer less uncertainty and are preferred.

Following this paper, J. Remund has incorporated a working paper on the “use of re-analysis data for long term trends and adaptation” into the publication by Polo et al, (2016). To compensate for potential high monthly and yearly biases, it is recommended to calibrate —using for example MCP technics (Measure-Correlate-Predict) — the long-term SSI data from the re-analysis products with the nearest satellite-based estimated over a shorter overlapping time period.

Publications

Task Reports

Report No.	Authors & Report Title	Publication Date	Target Audience	Bibliographic Reference
A1	Perez, Richard, Mathieu David Tom Hoff, Mohammad Jamaly, Sergey Kivalov, Jan Kleissl, Philippe Lauret, Marc Perez, 2016: **Spatial and Temporal Variability in Solar Energy**	2014	Solar data users and data providers	Published in "Foundations and Trends in Renewable Energy" 1, 1, pp. 1-44, 2014
B1.1	Wilbert, S, N. Geuder, M. Schwandt, B. Kraas, W. Jessen, R. Meyer, and B. Nouri: **Best Practices for Solar Irradiance Measurements with Rotating Shadowband Irradiometers**	August 2015	RSI measurement practitioners and RSI data users	http://task46.iea-shc.org/publications
B3.1	Polo, J., S. Wilbert, J. A. Ruiz-Arias, R. Meyer, C. Gueymard, M. Šúri, L. Martín, T. Mieslinger, P. Blanc, I. Grant, J. Boland, P. Ineichen, J. Remund, R. Escobar, A. Troccoli, M. Sengupta, K. P. Nielsen, D. Renne, and N. Geuder: **Integration of ground measurements with model-derived data**	November 2015	Solar data users and data providers	http://task46.iea-shc.org/publications
Task 46 Interim Report	Sengupta, M., A. Habte, S. Kurtz, A. Dobos, S. Wilbert, E. Lorenz, T. Stoffel, D. Renné, D. Myers, S. Wilcox, P. Blanc, and R. Perez: **Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications**	February 2015	Solar data users and data providers	http://task46.iea-shc.org/publications
B5	Nielsen, K. P., P. Blanc, F. Vignola, L. Ramirez, M. Blanco, and R. Meyer: **BeyondTMY – Review of Currently Used Practices for Creation of Meteorological Data Sets for CSP Performance**	Late 2016	Researchers, developers and data providers	Will be published as a IEA SolarPACES report

	Simulations			
D1	Blanc, P., B. Gschwind, L. Wald. **Towards an expert-based reference worldwide dataset of measurements of 1-min solar irradiance at surface in identified cloudless and cloudy conditions**	April 2016	Solar data experts	Restricted access: http://survey-cls.oie-lab.net/Ref_dataset_SSI_measurements_cloudy_clearsky_decisions_v1.pdf
D2	Remund, J. **Use of re-analysis data for long-term trends and adaptation, Working paper**	January 2015	Solar data users and data providers	

Members of SHC Task 46 contributed a major share of the book “Solar Resource Assessment and Forecasting”, edited by Jan Kleissl of UCSD and published in August 2013:

- R. Perez, T Cebecauer, and M. Suri: Semi-Empirical Satellite Models
- S.D. Miller, A.K. Heidinger, M. Sengupta: Physically Based Satellite Models
- R. Perez, T.D. Hoff: Solar Resource Variability
- M. Clave, J. Kleissl, and J. Stein: Quantifying and Simulating Solar-Plant Variability using irradiance data
- C.F.M. Coimbra, J. Kleissl, R. Marquez: Overview of Solar- Forecasting Methods and a Metric for Accuracy Evaluation
- B. Uruquart, M. Ghonima, D. Nguyen, B Kurtz, C.W. Chow, and J. Kleissl: Sky-imaging Systems for Short-Term Forecasting
- R. Perez, T.D. Hoff: SolarAnywhere Forecasting
- J. Kühnert, E. Lorenz, And D. Heinemann: Satellite-Based Irradiance and Power Forecasting for the German Energy Market
- P. Mathiesen, J. Kllessl, C. Collier: Case Studies of Solar Forecasting with the Weather and Research Forecasting Model at GL- Garrad Hassan

Journal Articles, Conference Papers, etc. for 2015 – 2016

Author(s)	Title	Publication / Conference	Bibliographic Reference
Aga, Vipluv, Bubolz, Konstantin, Hirsch, Tobias, Gaston, Martin and Schroedter-Homscheidt, Marion	Weather Forecasting and Dispatch Requirements for Predictable and Flexible Molten Salt CSP plants of the Future	SolarPACES 2016 conference, 11-14. October 2016, Abu Dhabi, UAE	
Albarelo, Tommy, Marie Joseph Isabelle, Primerose Antoine, Seyler Frédérique, Laurent Linguet, Lucien Wald	Optimizing the Heliosat-II method for surface solar irradiation estimation with GOES images	Canadian Journal of Remote Sensing, 41, 86-100, July 2015	http://doi.org/10.1080/07038992.2015.1040876
Andersen, E., K. P. Nielsen, J. Dragsted, and S. Furbo	Measurements of the angular distribution of diffuse irradiance	Energy Procedia 70: 729-736, 2015	http://orbit.dtu.dk/files/110866645/elsevier_36.pdf
Andre, M, S. Dabo_Niang, ..T Soubdhan and H. Ould-Baba	Predictive spatio-temporal model for spatially sparse global solar radiation data	Energy 111, 599-608, 2016	http://www.sciencedirect.com/science/article/pii/S0360544216307769

Antonanzas J., Osorio N., Escobar R., Urraca R., Martínez-de-Pison F.J. and Antonanzas-Torres F.	Review of photovoltaic power forecasting	Solar Energy, 136, 78–111, 2016	
Arbizu-Barrena, C., D. Pozo-Vázquez, J. A. Ruiz-Arias, and J. Tovar-Pescador	Macroscopic cloud properties in the WRF NWP model: An assessment using sky camera and ceilometer data, J. Geophys. Res. Atmos., 120, 10, 297–10,312	J. Geophys. Res. Atmos. 120:1-16, Oct. 2015	http://doi.org/10.1002/2015JD023502
Bachour, D., D. Perez-Astudillo, and Luis Martín Pomares	A novel method for calibration of aod databases with lidar-ceilometer measurements	Presented at ISES SWC 2015, Daegu, Korea, November 2015	
Bachour, Dunia, Daniel Perez-Astudillo, and Luis Martín Pomares	Study of soiling on pyranometers in desert conditions	Presented at Eurosun 2016, Palma de Mallorca, Spain, September 2016	
Beyer H.G.	Handling of small scale structures of the irradiance field for solar energy system analysis – a review	Energy Procedia 97 (2016) 141 – 148	http://dx.doi.org/10.1016/j.egypro.2016.10.039
Boland J. and Soubdhan T.	Spatial-temporal forecasting of solar radiation	Renewable Energy, 75, pp. 607-616	http://dx.doi.org/10.1016/j.renene.2014.10.035
Cebecauer, T. and M. Suri	Typical Meteorological Year data: SolarGIS approach	Energy Procedia 69:1958-1969, May 2015	http://www.sciencedirect.com/science/article/pii/S1876610215005019/pdf?md5=49d93f51d3544d3f7fb50db1b1d58969&pid=1-s2.0-S1876610215005019-main.pdf
David, M., F. Ramahatana, P.J. Trombe, and P. Lauret	Probabilistic forecasting of the solar irradiance with recursive ARMA and GARCH models	Solar Energy 133, 55-72	http://dx.doi.org/10.1016/j.solener.2016.03.064
Dragsted, J., S. Furbo, E. Andersen, B. Perers, and K. P. Nielsen	Calculated thermal performance of solar collectors based on measured weather data from 2001-2010	Energy Procedia 70: 49-56, 2015	http://orbit.dtu.dk/files/102242094/Paper_Janne_Dragsted_China_2014.pdf
Eissa, Y., Blanc, P., Ghedira, H., Oumbe, A., Wald, L.	A fast and simple model to estimate the contribution of the circumsolar irradiance to measured broadband beam irradiance under cloud-free conditions in	Solar Energy, under review, 2017	

	desert environment		
Eissa, Yehia, Mohamed Korany, Youva Aoun, Mohamed Boraiy, Magdy Abdel Wahab, Stephane Alfaro, Philippe Blanc, Mossad El-Metwally, Katja Hungershoefer , Hosni Ghedira and Lucien Wald	Validation of the surface downwelling solar irradiance estimates of the HelioClim-3 database in Egypt	Remote Sensing, 7,9269-9291, July 2015	http://doi.org/10.3390/rs70709269
Eissa, Y., P. Blanc, L. Wald, and H. Ghedira	Can AERONET data be used to accurately model the monochromatic beam and circumsolar irradiances under cloud-free conditions in desert environment?	Atmos. Meas. Tech. 8(12): 5099-5112, December 2015	http://doi.org/10.5194/amt-8-5099-2015.
Eissa, Y., S. Munawwar, A. Oumbe, P. Blanc, H. Ghedira, L. Wald, H. Bru, D. Goffe	Validating surface downwelling solar irradiances estimated by the McClear model under cloud-free skies in the United Arab Emirates	Solar Energy, 114, 17-34, 2015	http://dx.doi.org/10.1016/j.solener.2015.01.017
Eissa, Yehia, Mohamed Korany, Youva Aoun, Mohamed Boraiy, Magdy Abdel Wahab, Stephane Alfaro, Philippe Blanc, Mossad El-Metwally, Hosni Ghedira, Katja Hungershoefer ,and Lucien Wald	Comparison between estimates of the surface downwelling solar irradiances under cloud-free skies extracted from the McClear and HelioClim-3 services over Egypt	3rd International Conference Energy & Meteorology (ICEM), 22–26 June 2015, Boulder, Colorado, USA	http://www.wemcouncil.org/wp/wp-content/uploads/2015/07/1710_YehiaEissa.pdf
Eissa, Y., P. Blanc, L. Wald, H. Ghedira	Preliminary results on modelling the monochromatic beam and circumsolar radiation under cloud-free conditions in desert environment	3rd International Conference Energy & Meteorology (ICEM), 22–26 June 2015, Boulder, Colorado, USA	http://www.wemcouncil.org/wp/wp-content/uploads/2015/07/1750_YehiaEissa.pdf
Escobar, Rodrigo A., Cristian Cortes, Alan Pino, Marcelo Salgado, Enio Bueno Pereira, Fernando Ramos Martins, John Boland, Jose Miguel Cardemil	Estimating the potential for solar energy utilization in Chile by satellite-derived data and ground station measurements.	Solar Energy 121:139-151, November 2015	
Fernandez-Peruchena, Carlos, Gaston, Martin, Schroedter-Homscheidt, Marion, Martinez Marco, Isabel and Garcia-Moya, Jose Antonio	Increasing the Temporal Resolution of Direct Normal Solar Irradiance Forecasted Series	AIP Proceedings. SolarPaces 2016, 11 -14, October 2016, Abu Dhabi, UAE	
Fernández-Peruchena,	Screening and Flagging	Energy Procedia	http://dx.doi.org/10.1016/j.

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Fernández-Peruchena, Carlos M., Martín Gastón	A simple and efficient procedure for increasing the temporal resolution of global horizontal solar irradiance series	Renewable Energy 86:375-383, February 2016	http://doi.org/10.1016/j.renene.2015.08.004.
Fernández-Peruchena, Carlos M., Martín Gastón, Marcelino Sánchez, Javier García-Barberena, Manuel Blanco, Ana Bernardos	MUS: A multiscale stochastic model for generating plausible meteorological years designed for multiyear solar energy yield simulations	Solar Energy 120: 244-256, October 2015	http://doi.org/10.1016/j.solener.2015.07.037
Fernández-Peruchena, Carlos M., Manuel Blanco, Martín Gastón, Ana Bernardos	Increasing the temporal resolution of direct normal solar irradiance series in different climatic zones	Solar Energy 115:255-263, May 2015	http://doi.org/10.1016/j.solener.2015.02.017.
Frías-Paredesa, Laura, Fermín Mallorb, Teresa Leónc, Martín Gastón-Romeo	Introducing the Temporal Distortion Index to perform a bidimensional analysis of renewable energy forecast	Energy, 94: 180-195 2016	doi: 10.1016/j.energy.2015.10.093
Gleeson, E., K. P. Nielsen, V. Toll, L. Rontu, E. Whelan	Shortwave Radiation Experiments in HARMONIE Tests of the cloud inhomogeneity factor and a new cloud liquid optical property scheme compared to observations	ALADIN-HIRLAM Newsletter 5: 92-106, 2015.	
Grantham, Adrian, Yulia R. Gel, John Boland	Nonparametric short-term probabilistic forecasting for solar radiation	Solar Energy 133:465-475, 2016	http://www.sciencedirect.com/science/article/pii/S0038092X16300342
Guang, W., B. Kurtz, J. Kleissl	Cloud base height from sky imager and cloud speed sensor	Solar Energy 131: 208-221, June 2016	http://dx.doi.org/10.1016/j.solener.2016.02.027
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Boland, John	Synthetic generation of climate data sets at Colloque Martinique	Energy Environment, April 2014 and the International Federation of Operations Research Societies Forum, Barcelona July, 2014	
Boland, John	Spatial-Temporal Forecasting of Wind and Solar on Various Time Scales	World Renewable Energy Congress, London August 2014	
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Schwandt, M., K. Chhatbar, R. Meyer, I. Mitra, R. Vashistha, G. Giridhar, and A. Kumar	Quality check procedures and statistics for the Indian SRRA solar radiation measurement network	Accepted for publication in Energy Procedia, 10, 2013	
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Vindel, J.M., Polo J.	Markov processes and Zif's law in daily solar irradiation at earth's surface	J. of Atmospheric and Solar-Terrestrial Physics, 107, 42-47, 2014	
Vindel J.M., Polo J	Intermittency and variability of daily solar irradiation	Atmospheric Research, 143, 313-327, 2014	
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Yang, Handa, Ben Kurtz, Dung Nguyen, Bryan Urquhart, Chi Wai Chow, Mohamed Ghonima, and Jan Kleissl	Solar irradiance forecasting using a ground-based sky imager developed at UC San Diego, California	Solar Energy 103: 502-524, May 2014	ISSN 0038-092X, http://dx.doi.org/10.1016/j.solener.2014.02.044. (http://www.sciencedirect.com/science/article/pii/S0038092X14001327
Zhang, T., P.W. Stackhouse, Jr., W. S. Chandler and D.J. Westberg	Application of a global-to-beam irradiance model to the NASA GEWEX SRB dataset: An extension of the NASA Surface meteorology and Solar Energy datasets	Solar Energy, 110:117-131, December 2014	

Conferences and Workshops

Task participants presented Task work and results at approximately 30-35 conferences and workshops over the course of the Task.

Task Meetings

To develop the Task, the following Task Definition Workshops were held:

1. Paris, France (IEA Headquarters) March, 2010
2. Graz, Austria (in conjunction with Eurosun 2010) September 2010

Over the entire term of the Task a total of eight Experts meetings plus two informal meetings and one joint workshop.

Meeting	Date	Location	# Participants
Expert Meeting #1	2 September 2011	Kassel University, Kassel, Germany	30

Informal Task Meeting	24 September 2011	T46B1 Workshop, Almeria, Spain (Hosted by DLR, Germany)	20
Expert Meeting #2	18 May 2012	National Renewable Energy Laboratory, Golden, CO (USA)	25
Expert Meeting #3	21-23 January 2013	Mines Paris-Tech, Sophia Antipolis, France	35
Joint Workshop with PVPS Task 14	1 October 2013	28th EU PVSEC, Parcs des Expositions, Paris Nord Villipinte, France	80
Expert Meeting #4	7-8 October 2013	University of Oldenburg, Oldenburg, Germany	40
Expert Meeting #5	15-16 April, 2014	University of La Reunion-PIMENT Laboratory, La Reúnion Is., France	25
Expert Meeting #6	27-28 January, 2015	Plataforma Solar Almería (PSA), Spain	35
Informal Task Meeting	24 June 2015	Boulder, Colorado (US) in conjunction with the 3rd International Conference on Energy Meteorology	20
Expert Meeting #7	22-24 September, 2015	Bern, Switzerland (Hosted by Meteotest)	35
Exert Meeting #8	6-8 April 2016	MINES ParisTech, Sophia Antipolis, France	35
Informal Task Meeting	21 June 2016	PVSEC, Intersolar Munich, Germany	~20

SHC Task 46 Participants

Country	Name	Institution / Company	Role
USA	**David Renné**	**Senior Consultant, Clean Power Research**	**Operating Agent**
AUSTRALIA	Ian Grant	Bureau of Meteorology	National Expert
AUSTRALIA	Jing R. Huang	CSIRO	National Expert (replaced Robert Davy)
AUSTRALIA	Alberto Troccoli	CSIRO	National Expert
AUSTRALIA	John Boland	University of South Australia	National Expert
AUSTRALIA	Ian Muirhead	Bureau of Meteorology	Guest Participant
AUSTRIA	Gerald Steinmaurer	Austria Solar Innovation Center (ASiC)	National Expert
AUSTRIA	Philipp Rechberger	Austria Solar Innovation Center (ASiC)	National Expert
AUSTRIA	Klaus Reingruber	Blue Sky Wetteranalysen	National Expert
AUSTRIA	Wolfgang Traunmüller	Blue Sky Wetteranalysen	National Expert
AUSTRIA	Robert Höller	FH OÖ Studienbetriebs GmbH	National Expert
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CANADA	Vlad Kostylev	Green Power Labs	National Expert
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DENMARK	Elsa Andersen	DTU	National Expert
FRANCE	Philippe Blanc	Mines ParisTech	Subtask D Leader
FRANCE	Lionel Ménard	Mines ParisTech	Guest Participant
FRANCE	Lucien Wald	Mines ParisTech	National Expert
FRANCE	Philippe Lauret	Laboratoire PIMENT/Université Réunion	National Expert
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FRANCE	Nicolas Schmutz	Reuniwatt SAS	National Expert

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GERMANY	Marion Schroedter-Homscheidt	German Aerospace Center (DLR)	National Expert
GERMANY	Steffen Stoekler	German Aerospace Center (DLR)	National Expert
GERMANY	Stefan Wilbert	German Aerospace Center (DLR)	Subtask B Leader
GERMANY	Natalie Hanrieder	German Aerospace Center (DLR)	Observer
GERMANY	Richard Meyer	Suntrace	National Expert; SolarPACES Representative
GERMANY	Joachim Jaus	Black Photon Instruments GmbH	National Expert
GERMANY	Norbert Geuder	CSP Services GmbH	National Expert
GERMANY	Bernhard Reinhardt	Ludwig-Maximilians-Universitaet	National Expert
GERMANY	Gerd Heilscher	University of Applied Sciences, Hochschule Ulm	National Expert
GERMANY	Holger Ruf	University of Applied Science	National Expert
GREECE	Andreas Kazantzidis	University of Patras	Observer
NETHERLANDS	Alexander Los		National Expert
NORWAY	Hans Georg Beyer	University of Agder	Guest Participant
SINGAPORE	Wilfred Walsh	Solar Energy Research	National Expert

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SLOVAKIA	Tomáš Cebecauer	GeoModel s.r.o.	Guest Participant
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SPAIN	Luis Martín	IrSOLaV	National Expert
SPAIN	Diego Bermejo	IrSOLaV	National Expert
SPAIN	Marco Cony	Universidad Complutense de Madrid	National Expert
SPAIN	Jesús Polo	CIEMAT	National Expert
SPAIN	Lourdes Ramírez	CIEMAT	National Expert
SPAIN	Luis F. Zarzalejo	CIEMAT	National Expert
SPAIN	Ana A. Navarro	CIEMAT	National Expert
SPAIN	Vicente Lara Fanego	University of Jaén	Guest Participant
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SPAIN	Jose-Antonio Ruiz-Arias	University of Jaen	National Expert
SPAIN	Martin Gastón	CENER	National Expert
SPAIN	Inigo Pagola	CENER	National Expert
SWITZERLAND	Pierre Ineichen	University of Geneva	National Expert
SWITZERLAND	Jan Remund	Meteotest	National Expert; PVPS Task 14 Representative
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UAE	Yehia Eissa	Masdar Institute	Observer
UAE	Hosni Ghedira	Masdar Institute	Observer
UAE	Mercedes Ibarra	Masdar Institute	Observer
UAE	Arttu Tuomiranta	Masdar Institute	Observer
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USA	Paul Stackhouse	NASA Langley Research Center	Guest Participant
USA	Jan Kleissl	University of California at San Diego (UCSD)	Guest Participant
USA	Chris Kern	Irradiance Corp.	Guest Participant
USA	Jim Augustyn	Augustyn and Co.	Guest Participant
USA	Frank Vignola	University of Oregon	Guest Participant

6. Ongoing Tasks

Task 51 – Solar Energy in Urban Planning

Prof. Maria Wall
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Operating Agent for the Swedish Energy Agency

Task Overview

The main objective is to support urban planners, authorities and architects to achieve architectural integration of solar energy solutions (active and passive) in urban areas, and eventually whole cities, thus creating cities with a large renewable energy supply. The types of support being developed in this Task include processes, methods and tools capable of assisting cities in developing a long term urban energy strategy, including heritage and aesthetic issues and solar integration in sensitive landscapes. As part of this work, participants will work to strengthen solar energy in urban planning education at universities by testing and developing teaching material for programs in architecture, architectural engineering and urban planning. The material will also be appropriate for postgraduate courses and continuing professional development.

To achieve these objectives, work is needed in four main topics:

1. Legal framework, barriers and opportunities for solar energy implementation
2. Development of processes, methods and tools
3. Case studies and action research (implementation issues, test methods/tools/
4. processes, test concepts for example NZEB, NZEC)
5. Education and dissemination

Task 51 will require a dialogue and cooperation with municipalities in each participating country. This ensures good communication with different key actors, gives the possibility to develop and test methods and tools, to document good examples of how to work (methods and processes) with solar energy in urban planning, and to show inspiring examples of urban planning with solar energy integration. The municipalities are also a target group in the dissemination phase.

Task experts at meeting in Stockholm, Sweden.
Photo: White Arkitekter

The main objectives of the Task are subdivided into four key areas and involve the following work.

Subtask A: Legal Framework, Barriers and Opportunities *(Lead Country: Australia)*

- Investigate current legal and voluntary frameworks, barriers and urban planning needs of specific relevance to solar energy implementation.
- Review existing targets and assess the practical potential of solar energy in urban environments to support urban planning design and approval processes.
- Recommend areas in need of attention to improve the uptake of solar energy in urban planning.

Subtask B: Processes, Methods and Tools *(Lead Country: Sweden)*

- Identify factors among existing processes and supportive instruments (knowledge/ methods/tools) that enable decision processes for solar energy integration in urban planning, and to elucidate development needs.
- Develop new and/or improve urban planning processes in order to facilitate passive and active solar strategies in urban structures, both in new and existing urban area developments as well as in sensitive/protected landscapes.
- Develop new and/or improve supportive instruments (knowledge/methods/tools) and show how guidelines along with existing and new supportive instruments regarding active and passive solar energy can be incorporated and at what stage in the planning process.

Subtask C: Case Studies and Action Research *(Lead Country: Norway)*

The main objective is to facilitate replication of successful practice. Complementing objectives are to:

- Coordinate a database of best practice case studies and stories across Subtask topics.
- Establish and manage action research in each participating country.
- Facilitate and document the development and testing of supportive instruments and process models in at least one city in each participating country, in cooperation with local decision makers.

Subtask D: Education and Dissemination *(Lead Country: Germany)*

- Strengthen the knowledge and competence in solar energy and urban planning of relevant stakeholders such as universities and professionals.
- Develop and make available education material based on e.g. results from the Task. Give information on where to find relevant courses.
- Provide for dissemination and education by developing an e-learning platform, integrating methods, tools and case studies.

Scope

The scope of the Task includes solar energy issues related to:

1. New urban area development
2. Existing urban area development
3. Sensitive/protected landscapes (solar fields)

In all three environments listed above, both solar thermal and photovoltaics will be taken into account within the Task. In addition, passive solar will be considered in the urban environment (1 and 2). Passive solar includes passive solar heating, daylight access and outdoor thermal comfort.

In order to achieve a substantial contribution to increased use of solar energy, Task 51 focuses on how to improve and accelerate the integration of solar energy in urban planning that respects the quality of the urban context. The main work will be on active solar strategies due to a great need of development in this area, related to urban planning. The Task will not cover the whole complex context of urban planning.

Subtasks A to C reflect different stages in the urban planning process. Subtask A sets the current boundary conditions for solar integration, deals with the assessment of available potential and elucidates opportunities. Subtask B deals with processes, methods and tools and developments for the applied phase related to specific situations (new development areas, existing urban areas, landscapes). Subtask C focuses on implementation issues; tests of processes, methods and tools, tests of concepts (e.g. NZEB/NZEC) through case stories and showing good examples as case studies. Finally, Subtask D covers the dissemination focused on tertiary education and continuing professional development (CPD).

Main Deliverables

Subtask A: Legal Framework, Barriers and Opportunities

D.A1. Review on existing urban planning legislations and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B) in participating countries.

D.A2. Report on the barriers, challenges and needs of urban planning for solar energy implementation.

D.A3. Report on current solar energy targets and assessment of solar energy potential in urban areas from participating countries.

Subtask B: Processes, Methods and Tools

D.B1. Review on existing urban planning legislations and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B) in participating countries.

D.B2. Improved and/or new supportive instruments (knowledge/methods/tools).

D.B3. Guidelines: Presentation of developed generic process models with recommendations and guidelines on how to use them when adjusting for local planning, based on lessons learnt from Subtask C, as well as recommendations of needs for improved or new supportive instruments (knowledge/methods/ tools).

D.B4. Report on Multi-Criteria Decision Making. NEW!

Subtask C: Case Studies and Action Research

D.C1. Database of best practices.

D.C2. Documentation of activities supporting the creation and management of action research in each participating country: exhibitions, public hearings, quality programmes, jury work, presentations to decision makers, interviews, legislation work, creation of incentives etc.

D.C3. Documentation reports of testing of supportive instruments in partner cities: preparation, implementation and assessment of results (link to Subtask B).

Subtask D: Education and Dissemination

D.D1. Report on the state-of-the-art in education regarding urban planning with solar energy, for countries participating in the Subtask.

D.D2. Make available and inform about teaching material/packages for tertiary education and for CPD.

D.D3. Carry out seminars, workshops, summer schools and symposia, which support the knowledge exchange.

D.D4. A web-based learning platform.

D.D5. Website on innovative solar products.

D.D6. Best practice guidelines for urban planning with solar energy based on, and referring to, developed processes, methods, tools, strategies and case studies/stories – presented in an “umbrella document” with links to Task results and deliverables (joint with all Subtasks).

Task Duration

This Task started on May 1, 2013 and will end April 30, 2017.

Participating Countries

Australia, Austria, Canada, China, Denmark, France, Germany, Italy, Norway, Sweden and Switzerland.

Luxembourg is also participating, while waiting to become a formal member of the IEA SHC Programme. See the list of the participants at the end. Updates on participation and results from the Task are available on the website http://task51.iea-shc.org/.

Work During 2016

It has been an intense year with many reports to write and prepare for reviews. The experts have worked on documenting existing urban planning legislation and voluntary initiatives (Subtask A) and urban planning processes (Subtask B). Barriers, challenges and needs have also been studied. Development needs regarding methods and tools have been described. Reports on this work are now drafted and will soon be reviewed and published. Subtask A will also finalize the report on "Solar Energy Targets and Assessment of Potential in Urban Planning". Subtask B is working on their added report "Approaches, Methods and Tools for Solar Energy in Urban Planning". This report will give a theoretical background to the complex decision making context in urban planning, present ways on how to inform and support decision making in urban planning regarding solar, and give examples of how new and developed approaches, methods and tools fit into this context. Subtask C focused on analyzing and documenting case studies into an extensive report. This report has been reviewed and approved. After final editing, it will soon be published on the SHC website. In addition, the case studies will be published as separate brochures on the website, linked to a map. Work is also ongoing to compare cases, which then will be compiled into another report. In Subtask D, the Task experts have approved the state-of-the-art report on education regarding urban planning with solar energy and final layout of the report is ongoing before the final review process starts. Subtask D also carried out a summer school in Berlin in connection to the Task meeting in September. Work has also been done on a state-of-the-art report on solar tools in education. New innovative solar products have been described and uploaded on the webpage http://solarintegrationsolutions.org/.

During the Task meeting in Stockholm in March, three seminars were arranged. One on solar energy and heritage, one on natural and hybrid ventilation in tropical climates and one symposium on solar energy in urban planning including Task 51 experts and local actors.

As the last part of the work in Task 51, an interactive webpage will be created with condensed information about results and conclusions from the task, with links to different deliverables.

The summer school "City in Transformation: Energy and the Urban Environment" brought students together with researchers and teachers, linked to our Task 51 meeting in Berlin. Over the course of a week, students from different fields and German universities developed a master plan for solar optimized buildings in an area of Berlin's Adlershof district and then publically presented project designs. Photo: K.Simon, Wuppertal University, Urban Institute

Work Planned For 2017

Since the Task is ending in 2017, many reports and deliverables will be finalized. Below are the main activities and planned results.

- Finalize the report on existing urban planning legislation and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B).
- Review and publish the "State-of-the-Art of Education on Solar Energy in Urban Planning. Part 1: Approaches and Methods in Education" (Subtask D).
- Finalize the report "State-of-the-Art of Education on Solar Energy in Urban Planning. Part 2: Solar Tools in Education" (Subtask D).

- Finalize the reports D.A2 on the barriers, challenges and needs of urban planning for solar energy implementation, and D.A3 on current solar energy targets and assessment of solar energy potential in urban areas (Subtask A).
- Finalize the report on Approaches, Methods and Tools for Solar Energy in Urban Planning (Subtask B).
- Publish the approved report “Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies” (Subtask C).
- Work on finalizing some additional case studies and finalize brochures, to publish all cases on the webpage, linked to a map (Subtask C).
- Compile and finalize the report on “Lesson Learnt from Case Studies of Solar Energy in Urban Planning” (Subtask C).
- Final tests and make public the web-based learning platform (Subtask D).
- Publish booklet on “Summer Schools on Solar Energy in Urban Planning- Teaching Methodologies and Results” (Subtask D).
- The innovative solar products webpage is continuously updated until end of the Task (Subtask D; EPFL, Lausanne).
- Continue to develop the structure and content of the common guideline (umbrella document) that will be designed as an interactive webpage at the end of the Task (Subtask D with support from all Subtasks).
- A workshop on solar energy in urban planning will be arranged in conjunction to the final Task meeting in Sydney (March 2017).

Task Reports/Results Published In 2016

Main Task Deliverables

No main deliverables were published in 2016, but reviews on reports have been done and are ongoing. All reports will be published in 2017. News articles have been published describing our activities, see further http://task51.iea-shc.org/publications.

Reports, Published Books

Author / Editor	Title	Bibliographic Reference
Émilie Nault	PhD Thesis: Solar Potential in Early Neighborhood Design - A Decision-Support Workflow Based on Predictive Models	Thèse No 7058 (2016), École Polytechnique Fédérale de Lausanne, Switzerland

Journals Articles, Conference Papers, etc.

Author / Editor	Title	Publication / Conference	Bibliographic Reference
Siems, T. & Simon, K.	Summer School with a Twist	Solar Update Newsletter	Vol.64/ December 2016
Solarthermalworld.org / Bärbel Epp	IEA SHC Task 51: German Summer School Educates Students on Solar Urban Planning	Newsletter in Solarthermalworld.org	October 2016
Solarthermalworld.org / Bärbel Epp	IEA SHC: Attractive Solar Solutions for Urban and	Newsletter in Solarthermalworld.org	September 2016

	Landscape Planning		
Paparella, R. & Caini, M.	The recovery project of a proto-industrial building: the case study of the former Galvani-Rizzardi paper mill in Vittorio Veneto	CESB16. Prague, 22–24 June 2016	In CESB16 proceedings, ISBN 978-80-271-0248-8
Paparella, R. & Caini, M.	The school building in the period between the unification of Italy and the first world war: intervention methodology applicable to a stock property of national significance	CESB16. Prague, 22–24 June 2016	In CESB16 proceedings, ISBN 978-80-271-0248-8
Paparella, R. & Caini, M.	Nearly zero energy multifunctional modules for public use	Back To 4.0: Rethinking The Digital Construction Industry. June 2016	In volume: “Back To 4.0: Rethinking The Digital Construction Industry, ISBN 8891618078
Lobaccaro, G., Chatzichristos, S. & Leona, V. A.	Solar Optimization of Housing Development	Energy Procedia	Energy Procedia, Volume 91, Pages 868–875. June 2016
Polo López, C. S. & Bonomo, P.	Gli effetti della densificazione urbana nello sfruttamento delle risorse energetiche solari. L'impatto della densificazione urbana sul patrimonio edilizio esistente e sugli edifici storic”i. Un caso-studio in Svizzera	Online publication	Published in: infobuildenergia .it, posizione di rilievo. 14 June, 2016
Munari Probst, M. C. & Roecker, C.	Promoting Solar Energy While Preserving Urban Context	Solar Update Newsletter	May 2016
Hachem, C.	Environmental impact of various neighborhood designs	7th annual symposium on Simulation for Architecture and Urban Design; SimAUD.	2016, London
Kanters, J., & Wall, M.	A planning process map for solar buildings in urban environments	In Journal: Renewable and Sustainable Energy Reviews	57 (2016), 173-185. doi: http://dx.doi.org/10.1016/j.rser.2015.12.073
Nault ,E., Rey, E. & Andersen, M.	Urban planning and solar potential: assessing users' interaction with a novel decision-support workflow for early-stage design	Submitted to SBE16. (abstract accepted, full paper submitted)	Zürich, 2016
Nault, E., Rey, E. & Andersen M., 2016.	A multi-criteria performance-based decision-support workflow for early-stage neighborhood design	Submitted to PLEA 2016. (abstract accepted, full paper submitted)	Los Angeles, 2016

Peronato, G., Bonjour, S., Stoeckli, J., Rey, E. & Andersen M.	Sensitivity of calculated solar irradiation to the level of detail: insights from the simulation of four sample buildings in urban areas	Submitted to PLEA 2016. (abstract accepted, full paper submitted)	Los Angeles, 2016
Scognamiglio, A.	'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision	In Journal: Renewable and Sustainable Energy Reviews	55 (2016), pp 629–661. http://dx.doi.org/10.1016/j.rser.2015.10.072

Conferences, Workshops, Seminars

Conference / Workshop / Seminar	Activity & Presenter	Date & Location
Summer School on "City in Transformation: Energy and the Urban Environment"	Course for students in architecture, urban planning, spatial planning and energy management Results presented at seminar with teachers, local actors and Task 51 experts. Hosted by the Institute for Urban Design & Studies - University of Wuppertal, HTW University of Applied Sciences Berlin, IBUS Berlin	In conjunction to Task 51 meeting, 19 – 26 September 2016, Berlin
Austrian national event 'IEA Vernetzungstreffen', organized by the Austrian Ministry for Transport, Innovation and Technology	Presentation of IEA SHC Task 51 activities and results by Daiva Jakutyte-Walangitang	20 October 2016, Vienna
Summer course on "Sustainable Energy in Cities". Students worked together in order to develop a Sustainable Research Facility at Wetland island in Jiuduansha (Shanghai)	Master students from SJTU (China), NTNU (Norway), Tsinghua University THU (China), University of Maryland (USA), University of Hamburg (Germany), Korea University. Organized by NTNU and Shanghai Jiao Tong University SJTU	July 2016, Shanghai, China
Summer course on "Sustainable Energy in Cities". Students worked together in order to develop a Sustainable Research Facility at Wetland island in Jiuduansha (Shanghai)	Master students from SJTU (China), NTNU (Norway), Tsinghua University THU (China), University of Maryland (USA), University of Hamburg (Germany), Korea University. Organized by NTNU and Shanghai Jiao Tong University SJTU	July 2016, Shanghai, China
Energy Systems Day	Poster presentation of IEA SHC Task 51, by the Austrian Task 51 team	16 June 2016, Graz
Multidisciplinary Congress 2016,	Co-organizer and chairing by	30 May 2016. Calgary, Canada

Energizing by Design	Caroline Hachem, University of Calgary Presentation on solar energy in buildings and communities by Caroline Hachem	
Conference organized by the Swedish Energy Agency; “Solar energy in dense cities”, + following 4 presentations for municipalities in the Stockholm region	Presentations of work and results from Task 51. By Johan Dahlberg and Marja Lundgren, White Arkitekter	May 2016. Stockholm, Sweden
Conference on: Sustainable Design” – From Sustainable Buildings to Smart Cities – Approccio alla progettazione sostenibile	Presentation by Mauro Caini (Padua University) and Gabriele Lobaccaro (NTNU, Norway)	18 April 2016, Padua, Italy
	Presentation by EPFL-LESO of the LESO-QSV method to CRDE (Commission Romande des Déléguées à l'énergie)	Maison des Canton, Berne, 26 April 2016
	Presentation by EPFL-LESO of the LESO-QSV method to SIREN (Energies Renouvelables de la Ville de Lausanne)	Lausanne, 29 January 2016
Seminar on Solar Energy in Urban Planning	Presentations by Task 51 experts and local architects and urban planners.	In conjunction to Task 51 meeting, 11 March, 2016, Stockholm
Seminar on Natural and Hybrid Ventilation	Key note: Francois Garde, University of La Réunion, France	In conjunction to Task 51 meeting. 10 March, 2016, Stockholm
Seminar on Solar Energy and Heritage	Key note: Maria Cristina Munari Probst, EPFL, Switzerland	In conjunction to Task 51 meeting. 9 March, 2016, Stockholm

Task Meetings 2016 and 2017

Meeting	Date	Location
Experts Meeting #7	7-11 March 2016	Stockholm, Sweden (plus 3 seminars)
Experts Meeting #8	28-29 September 2016	Berlin, Germany (preceded by Summer School, September 19-26)
Experts Meeting #9	20-24 March 2017	Sydney, Australia (plus workshop)

SHC Task 51 Participants

Country	Name	Institution / Company	Role
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		EURAC	
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Task 52 – Solar Heat and Energy Economics in Urban Environments

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Fraunhofer ISE
Operating Agent for Forschungzentrum Jülich GmbH

Task Overview

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 chains for energy system analysis will be developed. Good examples of integration of solar thermal systems in urban energy systems will be assessed and documented.

Scope

Subtask A: Energy Scenarios (Lead Country: Denmark)
The content of subtask A is about:

- Using energy system analyses and GIS based data for creating scenarios highlighting the use of solar thermal in future energy systems in different types of 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 (smart energy systems) and in particular the interrelation with combined heat and power (CPH) and heat pump production.

Subtask B: Methodologies, Tools and Case Studies for Urban Energy Concepts (Lead Country: Switzerland)
The content of subtask B is about:

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

Subtask C: Technology and Demonstrators (Lead Country: Austria)
The content of Subtask C is about:

- 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)
- Further development of (existing) business opportunities with regard to future energy supply systems

Task Duration

This Task started on January 2014 and will end December 2017.

Participating Countries

Austria, Denmark, Germany, Portugal, Sweden, Switzerland

Work During 2016

Subtask A: Energy Scenarios

The third year's activities in Subtask A were on the performance of energy scenarios. For four selected countries an overall energy scenario reflecting the role of solar heat in four countries were identified including Austria, Denmark, Germany and Italy. The following modeling approaches and tools were chosen.

Model	EnergyPLAN	REMod-D	Invert/EE-Lab
Organization	AAU	Fraunhofer ISE	EEG/TUV
Scenarios	100% renewable energy in 2050 Solar thermal share	100% renewable energy in 2050 Solar thermal share	100% renewable energy in 2050 Solar thermal share
Countries	AT,DE,DK,IT	DE	AT

The comparison of different scenarios of the contribution of solar thermal to the heat production show that applying the EnergyPLAN methodology and as boundary condition, 35% of the buildings connected to solar thermal will lead to a share of solar heat of 5-7% for individually supplied houses and 3-10% for solar heat in district heating. The absolute amount of heat produced will decrease due to lower overall heat demand due to energy savings.

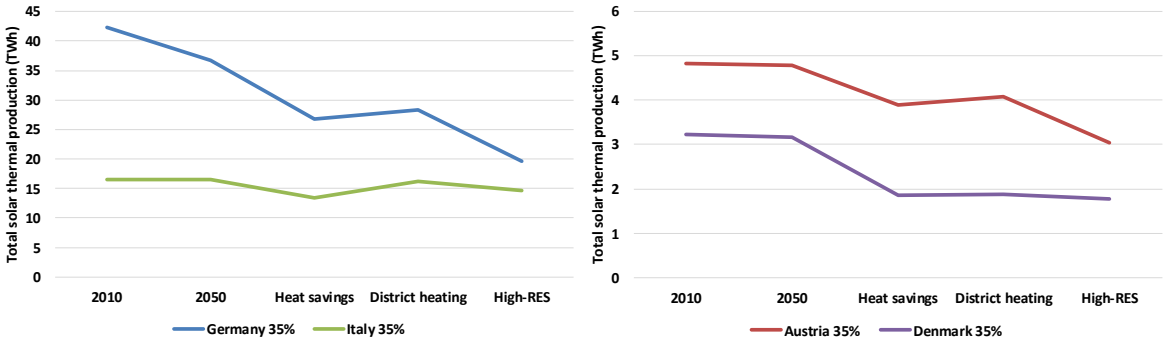

Figure 1. Total solar thermal production potentials for the four countries in the various scenarios with a solar penetration rate of 35%. Source K. Hansen, AAU Copenhagen

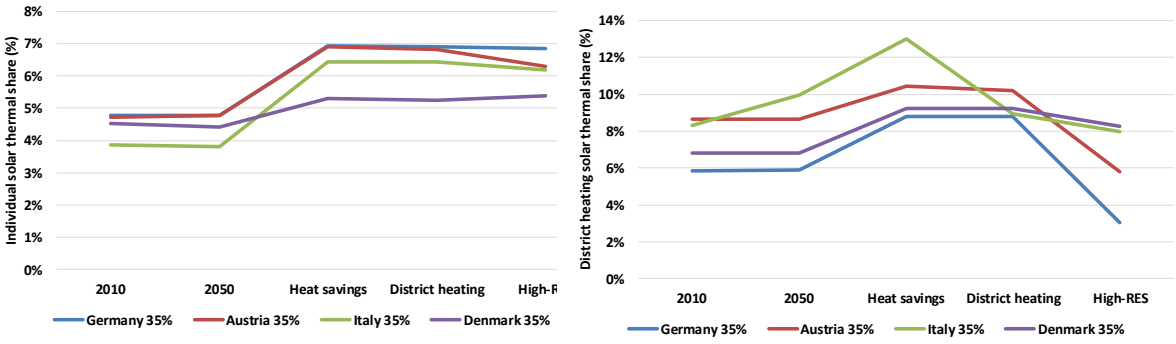

Figure 2. Solar thermal share potentials for individual heating and district heating in the four countries with a solar penetration rate of 35%. Source K. Hansen, AAU Copenhagen

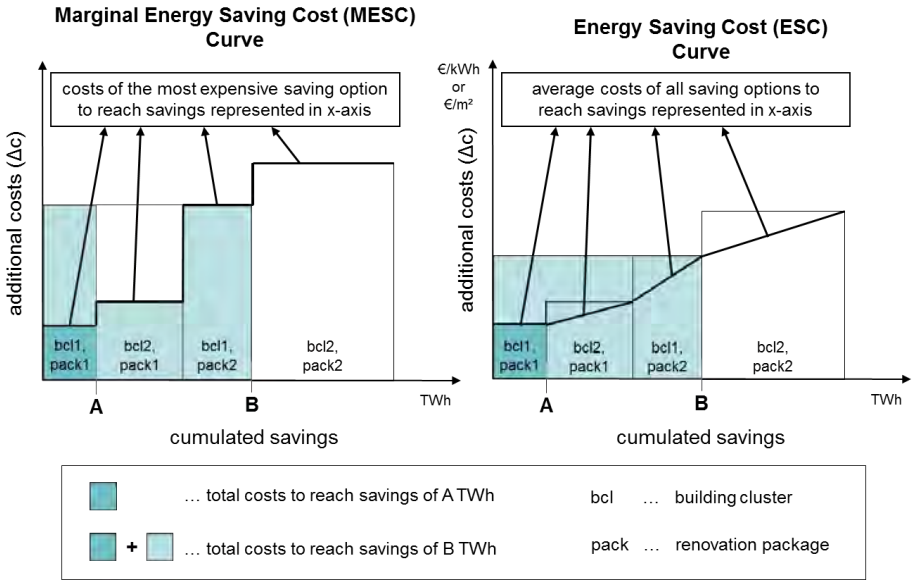

Figure 3. Different methods to evaluate cost of renovation packages. Source M. Hummel, TU Wien

For the marginal energy saving cost, the cost curves for six different European countries show that due to higher labor cost the costs are highest in Denmark followed by Austrian and Germany.

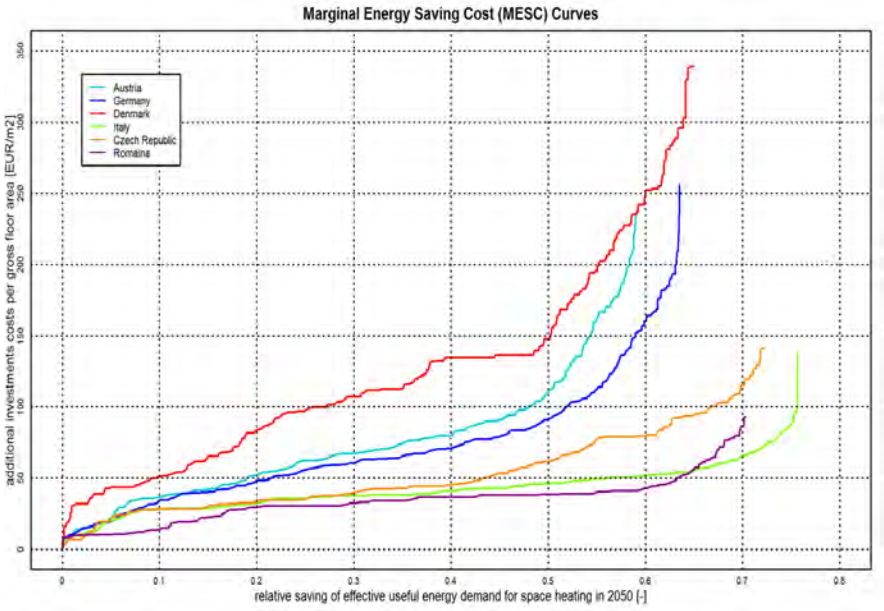

Figure 4. Marginal Energy Saving Cost for Retrofit. Source M. Hummel, TU Wien

Subtask B: Methodologies, Tools and Case Studies for Urban Energy Concepts

B1 Methodology

In Subtask B the focus was on the development of a pre-design tool to asses the solar heat potential in a district.

An Excel-tool was elaborated on to calculate solar indicators. Based on the heated floor area and available area for solar panels, some relevant indicators can be calculated at a very early stage of the project. The tool can provide a valuable estimation of the solar fraction, cost evaluation of the solar system and gains in the CO2 emissions. Moreover, in order to help the stakeholder in his choices, adapted commercial tools are proposed to address some specifics questions.

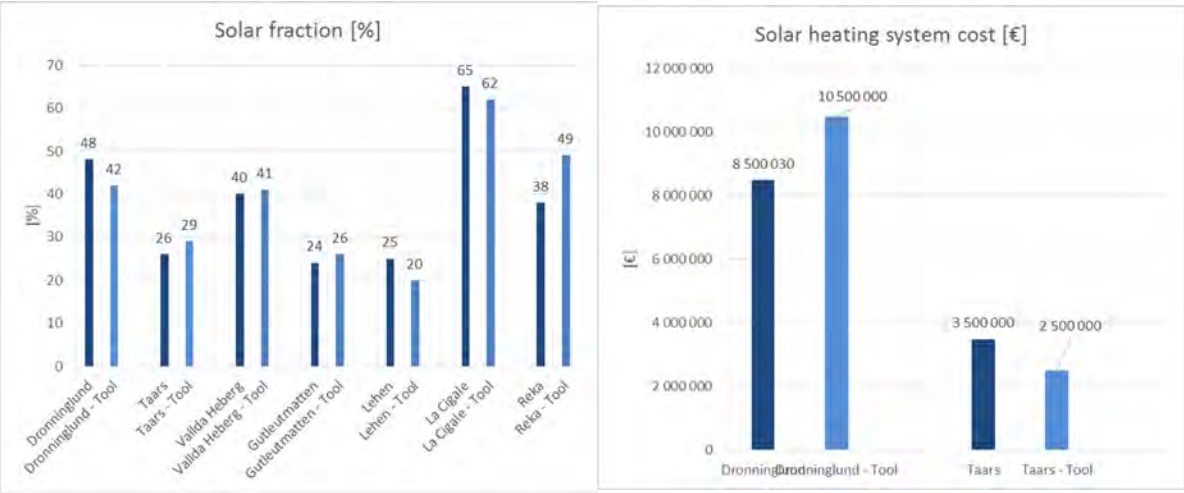

Figure 5. Comparison of Task 52 predesign tool results and detailed data from different case studies.
Source M. Joly, Sorane

Subtask C: Technology and Demonstrators

In 2016 the main activities were on documenting and analyzing. A detailed documentation of seven different larger solar case studies from Denmark, Sweden, Germany, Austria and Switzerland were described and both technical and socio-economical aspects documented.

Case Studies of Solar Thermal Best Practices

Hybrid solar district heating in the city of Taars, DK (top left)

Solar district heating with seasonal storage in the city of Dronninglund, DK (top right)

Solar assisted residential area Vallda Heberg in Kungsbacka, SE (bottom left)

Solar assisted urban quarter Lehen in Salzburg, AT (bottom right)

Solar assisted urban quarter Gutleut-matten in Freiburg, DE (top left)

Solar assisted apartment blocks La Cigale in Geneva, CH (top right)

Solar assisted mountain holiday resort “Reka Feriendorf” in Naters, CH (bottom left)

(Source: F. Mauthner, AEE Intec)

Work Planned For 2017

In the three subtasks the following work is planned for 2017:

Subtask A: Energy Scenarios

- Finalization of Reporting of Scenario analysis and Executive summary

Subtask B: Methodologies, Tools and Case Studies for Urban Energy Concepts

- Finalization of analysis for installed capacity of large solar systems and their potential

Subtask C: Technology and Demonstrators

- Identification of the success factors and cross analysis of the documented case studies regarding technical performance and socio-economic processes

Reports Published In 2016

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
K. Hansen	The role of solar thermal in European high-renewable energy systems	2nd International Conference on Smart Energy Systems and 4th Generation District Heating 26-29 September 2016, Aalborg	
J.-B. Eggers	Energy economical perspectives of solar heat in urban energy supply systems	2nd International Conference on Smart Energy Systems and 4th Generation District Heating 26-29 September 2016,	

Aalborg

Reports Planned for 2017

Report A1: “Report on advanced energy system analyses of solar thermal concepts: Methodology report”

Report A2: “Report on advanced energy system analyses of solar thermal concepts: Results report”

Report B: “URBAN ENERGY CONCEPT Solar heat district – Methodology and tools”

Report C2: “Analysis of built best practice examples and conceptual feasibility studies”

Report C3: “Success factors”

Task Meetings 2016 and 2017

Meeting	Date	Location
Experts Meeting #5	15-16 April 2016	Vienna, Austria
Experts Meeting #6	20-21 September 2016	Aalborg, Denmark
Experts Meeting #7	6-7 April 2017	Gothenburg, Sweden
Experts Meeting #8	18-19 September 2017	Freiburg, Germany

SHC Task 52 Participants

Country	Name	Institution / Company	Role
GERMANY	**Sebastian Herkel**	**Fraunhofer ISE**	**Operating Agent**
AUSTRIA	Franz Mauthner	AEE Intec	Subtask C Leader
AUSTRIA	Marcus Hummel	TU Wien EEG	National Expert
DENMARK	Brian Mathiesen	Aalborg University	Subtask A Leader
DENMARK	Keneth Hansen	Aalborg University	National Expert
DENMARK	Bengt Perers	DTU	National Expert
DENMARK	Daniel Trier	Planenergi	National Expert
GERMANY	Jan-Bleicke Eggers	Fraunhofer ISE	National Expert
SWEDEN	Martin Andersen	Dalarna University	National Expert
SWEDEN	Chris Bales	Dalarna University	National Expert
SWITZERLAND	Paul Bourdoukan	Sorane	Subtask B Leader
SWITZERLAND	Martin Joly	Sorane	National Expert
SWITZERLAND	Gabriel Ruiz	CREM	National Expert
SWITZERLAND	Christine Weber	BKW	National Expert

Task 53 – New Generation Solar Cooling & Heating Systmes (PV or Solar Thermal Driven Systems)

Daniel Mugnier
TECSOL SA
Operating Agent for the French Energy Agency (ADEME)

Task Overview

A tremendous increase in the market for air-conditioning can be observed worldwide, especially in developing countries. The results of the previous SHC Tasks and work on solar cooling (for example, SHC Task 38: Solar Air-Conditioning and Refrigeration) showed on the one hand the great potential of this technology for building air-conditioning, particularly in sunny regions, and showed on the other hand that solar thermal cooling has had difficulty emerging as an economically competitive solution. There is therefore a strong need to stimulate the solar cooling sector for small and medium power sizes, which this Task focusing on.

Objective and Scope

The Task objective is to create a logical follow-on to the IEA SHC work already carried out by finding solutions to make the solar driven heating and cooling systems cost competitive. This major target should be reached thanks to five levels of activities:

1. Investigate new small to medium size PV & solar thermal driven cooling and heating systems and develop best suited cooling & heating system technology focusing on reliability, adaptability and quality.
2. Prove cost effectiveness of the above-mentioned solar cooling & heating systems.
3. Investigate life cycle performances on energy and environmental terms (LCA) of different options.
4. Support market deployment of new solar cooling and heating systems for buildings worldwide.
5. Support energy supply safety and influence virtuous demand side management behaviors.

The Task is focusing on technologies for the production of cold/hot water or conditioned air by means of solar heat or solar electricity. That is the Task will start with the solar radiation reaching the collector or the PV modules and end with the chilled/hot water and/or conditioned air transferred to the application. Although the distribution system, the building and the interaction of both with the technical equipment, is not the main topic of the Task this interaction will be considered where necessary. The main objective of this Task is to assist with the development a strong and sustainable market for solar PV or new innovative thermal cooling systems. It is focusing on solar driven systems for both cooling (ambient and food conservation) and heating (ambient and domestic hot water).

The Task is divided into four Subtasks:

Subtask A: Components, Systems & Quality

- A1: Reference systems
- A2: New system configurations for cooling and heating
- A3: Storage concepts and management
- A4: Systems integration into buildings, micro grid and central Grid
- A5: LCA and techno-eco comparison between reference and new systems

Subtask B: Control, Simulation & Design

- B1: Reference conditions
- B2: Grid access conditions and building load management analysis
- B3: Models of subcomponents and system simulation
- B4: Control strategy analysis and optimization for ST and PV
- B5: System inter-comparison

Subtask C: Testing and Demonstration Projects

- C1: Monitoring procedure and monitoring system selection criteria
- C2: System description for field test and demo project
- C3: Monitoring data analysis on technical issues & on performances
- C4: Best practices / feedback

Subtask D: Dissemination and Market Deployment

- D1: Website dedicated to the Task
- D2: Handbook and simplified brochure
- D3: Newsletters, workshops and conferences

Main Deliverables

The following documentation or information measures are planned during the course of the Task (corresponding the Subtask in brackets).

- State of the art of new generation commercially available products (A)
- Techno-economic analysis report on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Ecolabel sensibility (A)
- Technical report on optimized control strategies for solar cooling & heating systems (B)
- Design tool including a country- and climate-sensitive economic analysis (B)
- Technical report on monitoring data analysis (technical issues + performances) (C)
- Technical report presenting a draft testing method for a quality standard on new generation cooling & heating systems (C)
- Website dedicated to the Task (D)
- Industry workshops addressing target groups (related to Experts meetings) (D)
- Handbook for new generation solar cooling and heating systems (D)
- Simplified short brochure (D) jointly edited by the Subtask Leader and IEA SHC program

Task Duration

The Task started in March 2014 and will be completed in June 2018 (one year extension from original date). This is a collaborative Task with the IEA PVPS Programme.

Participating Countries

Australia, Austria, China, France, Italy, Netherlands, Spain, Sweden, Switzerland

Work During 2016

Task 53 held its 4th Expert meeting in April 2016 and its 5th Expert meeting in October 2016 just before the EUROSUN conference organized in Palma de Majorca.

Year 2016 has been dedicated to:

- Progress on the first activities of the Task's Subtasks A, B and C, and
- Successful dissemination actions in Madrid and Palma de Majorca during several workshops and the EUROSUN conference just after the 4th and 5th Task expert meetings.

Task 53 Logo Project

A logo was created to use on all Task communications and publications.

Collaboration with IEA PVPS

This Task is collaborating with the IEA PVPS Programme through several means:

- Task Liaison Officers (mainly PVPS Task 1 and SHC Task 53)

- Joint Task Meetings when possible
- Meetings at the same place & time when possible
- Joint Workshops at conferences

Conference Presentations

ARFREE : Arab Forum for Renewable Energy and Energy Efficiency (ARFREE)

An important communication activity towards industry and a specific target market has occurred on 01-02 June 2016 in Cairo in Egypt with the participation of TECSOL to the ARFREE Forum. Daniel Mugnier, Operating Agent of Task 53 presented the latest developments on Solar cooling and especially the ongoing work of Task 53 to a panel of decision makers in the field of energy in the Middle East region.

CIEMAT Workshop

The workshop, Jornada sobre" Sistemas solares de calor y frío aplicados a la edificación. La participación Española en la AIE y Smart Cities" was organized by CIEMAT and held in Madrid in May 2016.

Intersolar Europe / GÜNDER Side-Event: Turkey`s Sun

Thursday, June 23, 2016 in München Intersolar

Daniel Mugnier, Operating Agent of Task 53 and Vice Chair of IEA SHC presented the SHC Programme to Turkey's invited panel with a particular focus on tsolar cooling technology, which is a key technology for developing solar energy in Turkey in the next years.

PUSCH Worskhop on Solar Cooling Roadmapping in Australia

This workshop was held during the 6th Task Experts meeting in Palma de Mallorca with COOLGAIA and CSIRO in May 2016.

CSIRO in Australia has been awarded funds from ARENA for Promoting the Use of Solar Cooling and Heating (PUSCH) in Australian Buildings. This three year project (July 2016 to May 2019) is being executed along with partners AIRAH and Coolgaia. The project will consist of three work packages.

- WP1. Industry roadmap
- WP2. Case studies
- WP3. Knowledge dissemination

Task 53 experts actively contributed to provide information and advice for the PUSCH team during this workshop.

EUROSUN 2016

During this conference, six oral speeches and posters were presented on behalf of Task 53:

- Design and testing of a latent heat storage for solar cooling applications (Author: Andrea Frazzica; Institution: CNR ITAE, Italy)
- Energy saving benefits of predictive control approaches for high temperature Solar Cooling (SC) systems (Author: Subbu Sethuvenkatraman; Institution: CSIRO)
- Assessment of solar heating and cooling – comparison of best practice thermal and PV driven systems (Author: Neyer D; Institution: University of Innsbruck)
- Smart Grid and PV driven Heat Pump as Thermal Battery in Small Buildings for optimized Electricity Consumption (Author: Alexander Thür; Institution: University of Innsbruck)
- A quality-labeling scheme for solar heating and cooling systems (Author: Sonia Longo/ Daniel Mugnier; Institution: UNIPA
- Results of solar PV air conditioner testing (Author: Vicente Quiles, Institution: UMH)

Green Expo Forum

This conference was held in Doha, Qatar in November 2016. Daniel Mugnier, on behalf of SHC Task 53, gave two presentations during the session on Technology Context for Climate - Friendly Solar Energy 1) Solar cooling situation in the World and perspectives underlining and 2) New generation of solar cooling for MENA region & worldwide: situation and challenges. In addition, YAZAKI China presented the following presentation in line with Task 53's work on Medium to Large Solar cooling Systems for Sustainable Future.

greenexpo FORUM 2016

Task Training Seminars and Workshops

During the seven events mentioned below, nearly 450 persons have been reached through the Task's communication.

Conferences, Workshops, Seminars

Workshop/Conference/ Seminar	Activity	Date & Location	# of Participants
SHC Task 53 / PVPS Task 1 Joint Workshop	Presentations	April 2016 Madrid, Spain	35
IEA SHC Task 53 Industry Workshop	Presentations	April 2016 Madrid, Spain	50
ARFREE Forum	Presentation	June 2016 Cairo, Egypt	200
CIEMAT Workshop	Presentation	May 2016	50

		Madrid, Spain	
Side-Event GÜNDER: Turkey`s Sun	Presentation	June 2016 Munich, Germany	50
IEA SHC Tasks sessions in EUROSUN	Presentation	October 2016 Palma de Majorca, Spain	30
PUSCH /IEA SHC Task 53 Expert workshop	Workshop/ Brainstorming	October 2016 Palma de Majorca, Spain	23

Reports Published In 2016

Several draft reports were completed. The final versions will be posted on the Task webpage when completed.

- Draft state of the art of new generation commercially available products including costs, efficiency criteria ranking and performance characterization
- Draft technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's)
- Draft Monitoring procedure for field test & demo systems (depending on size and application)
- Draft report on a new and universal classification method "new generation solar cooling square view" for generic systems
- Draft technical report on the Reference conditions for modeling
- Draft Technical report on components and system models validation
- Draft Technical report on simulations results and systems intercomparison

Work Planned For 2017

According to the Work Plan, the following deliverables should be available in 2017.

Subtask A: Components, Systems & Quality

- Definition of the existing cooling reference systems
- State of the art of new generation commercially available products including costs, efficiency criteria ranking and performance characterization
- Technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's)
- Report on a new and universal classification method "new generation solar cooling square view" for generic systems

Subtask B: Control, Simulation & Design

- Technical report on optimised control strategies for solar cooling & heating systems
- Technical report on components & system model validation
- Technical report presenting the reference conditions for modelling (reference load profile and comfort conditions in case of living / office room AC/cooling)

Subtask C: Testing and Demonstration Projects

- Monitoring procedure for field test & demo systems (depending on size and application)
- Catalogue of selected systems (with full description)

Links With Industry

Industry representatives participating in Task Experts Meetings as observers or as Task participants include: SOLABCOOOL (Netherlands), CLIMATEWELL (Sweden), ATISYS (France), SOLARINVENT (Italy), VELASOLARIS (Switzerland), HYUNDAI (South Korea), SUNOYSTER (Germany) and YAZAKI (China).

They represent primarily engineering companies and solar cooling system manufacturers. The results of Task 53 are profitable for their business and their involvement consists of supporting and analyzing the Task work.

Task Meetings 2016 and 2017

Meeting	Date	Location
Experts Meeting #5	12-13 April 2016	Madrid, Spain *Side event: Task 53 / PVPS Task 1 Join Workshop / IEA SHC Task 53 Industry Workshop*
Experts Meeting #6	10-11 October 2016	Palma de Majorca, Spain *Side event: EUROSUN 2016 conference in Palma*
Experts Meeting #7	19-20 April 2017	Messina, Italy *Workshop:* For Italian installers and planners (especially from Sicilia)
Experts Meeting #8	27-28 October 2017 (to be confirmed)	Abu Dhabi, UAE *Side event: SHC 2017 Conference*

SHC Task 53 Participants

Country	Name	Institution / Company	Role
FRANCE	**Daniel Mugnier**	**TECSOL SA**	**Operating Agent & Subtask D Leader**
AUSTRALIA	Subbu Sethuvenkatraman	CSIRO	
AUSTRALIA	Stephen D. White	CSIRO	Subtask A Leader
AUSTRIA	Bettina Nocke	AEE Intec	National Expert
AUSTRIA	Tim Selke	AIT Vienna	National Expert
AUSTRIA	Daniel Neyer	University of Innsbruck	National Expert
AUSTRIA	Alexander Thür	University of Innsbruck	National Expert
CHINA	Yanjun Dai	Shanghai Jiao Tong University (SJTU)	National Expert
CHINA	Wei Zheng	YAZAKI China	National Expert
FRANCE	Paul Byrne	University of Rennes	National Expert
FRANCE	Philippe Esparcieux	ATISYS	National Expert
GERMANY	Richar Schex	ZAE Bayern	National Expert
GERMANY	Carsten Heinrich	ILK Dresden	National Expert
GERMANY	Mathias Safarik	ILK Dresden	National Expert
GERMANY	Felix Loistl	University of Applied Sciences Munich	National Expert
GERMANY	Timo Korth	University of Applied Sciences Munich	National Expert
ITALY	Roberto Fedrizzi	EURAC	Subtask B Leader
ITALY	Anton Soppelsa	EURAC	National Expert
ITALY	Marco Beccali	University of Palermo	National Expert
ITALY	Sonia Longo	University of Palermo	National Expert
ITALY	Salvatore Vasta	CNR ITAE	National Expert
ITALY	Pietro Finocchiaro	SOLARINVENT	National Expert
NETHERLANDS	Henk De Beijer	SOLABCOOL	National Expert
SWITZERLAND	Elena-Lavinia Niederhaeuser	HEFR	National Expert
SWITZERLAND	Andreas Witzig	VELASOLARIS	National Expert
SWITZERLAND	Lukas Omlin	SPF	National Expert

SPAIN	Pedro Vicente Quiles	UMH	National Expert
SWEDEN	Richard Thygesen	MDH	Subtask C Leader

Task 54 – Price Reduction of Solar Thermal Systems

Michael Köhl
Fraunhofer ISE
Operating Agent for Forschungzentrum Jülich GmbH

Task Overview

Task 54 aims at the purchase price reduction for end-users of installed solar thermal systems by evaluating and developing sustainable means to reduce production and/or installation costs on material, sub-component, system-component and system level. Special emphasis is placed on the identification and reduction of post-production cost drivers such as e.g. channels of distribution and installation. An extensive market research and the definition of reference systems, cost analyses, and the study of socio-political boundary conditions for solar thermal prices in selected regions will provide the basis for the evaluation of cost-structures and the cost reduction potential. Additionally, ways to make solar thermal more attractive by improved marketing and consumer-oriented design will be explored.

The Task's work is divided into four subtasks:

Subtask A: Market success factors and cost analysis (Norway)

Subtask B: System design, installation, operation and maintenance (Germany)

Subtask C: Cost-efficient materials, production processes and components (Austria)

Subtask D: Information, dissemination and stakeholder involvement (Germany)

Subtask A: Market success factors and cost analysis

Objectives
Investigation of costs for regionally typical solar thermal systems and cost analyses of optimized systems as well as the development of suitable and innovative marketing measures.

Activities
- Definition of solar thermal and conventional reference systems:
- Cost analysis of post-production cost drivers for reference systems
- Comprehensive cost-analysis (cradle-to-grave) for reference systems
- Cost analysis of post-production cost drivers for optimized systems
- Comprehensive cost-analysis (cradle-to-grave) for optimized systems
- Political, legal and social boundary conditions
- Market success factors

Subtask B: System design, installation, operation and maintenance

Objectives
Optimization of system designs through standardized and/or prefabricated components and investigation cost-reduction potential though standardized installation.

Activities
- Definition of standardized components
- Manufacturing costs
- Technical after sales costs
- Cost optimization of reference systems
- New proposals for a 40% price reduction

Subtask C: Cost-efficient materials, production processes and components

Objectives
Evaluation of cost efficient and reliable materials and components for solar thermal systems.

Activities

- Identification of major cost drivers
- Material substitution and functional integration
- Innovative, cost-efficient processes and components

Subtask D: Information, dissemination and stakeholder involvement

Objectives

Disseminate Task 54's results to the interested public and its stakeholders through online publications (homepage, newsletters, articles), presence on conferences and scientific publications. Involve stakeholders through suitable dissemination events, e.g. workshops, expert rounds, presentations.

Activities

- Industry liaison
- Information and dissemination

Task Duration

The Task started on October 1, 2015 and will end on September 30, 2018.

Participating Countries

Australia, Austria, China, France, Germany, Italy, Norway, Switzerland

Work During 2016

Subtask A: Market success factors and cost analysis

- Definition of collaboration with Editors of Solar Heat Worldwide for collection of cost data.
- Preparation of cost questionnaire for individual markets.
- Memo on procedure for publication of cost figures (when, where and by whom) early 2016.
- Distribution of responsibilities for acquiring cost data for the individual markets.

Subtask B: System design, installation, operation and maintenance

Promising developments in collector design were presented by the following participants: KBB Kollektorbau, Viessmann, ISFH, University of Kassel, HTCO, HSR-SPF, Fraunhofer ISE, University of Florence and Sunlumo.

Discussed was the need for more industrial partners and know how for installation and maintenance for the acquisition of these partners, Subtask B works in close cooperation with Subtask D and plans an industry workshop in the first quarter of 2016.

Subtask C: Cost-efficient materials, production processes and components

Project C1: Identification of major cost drivers

- Info-sheet on Cost Reduction in other Industries (D-C1)
- Info-sheet on Cost Drivers and Saving Potentials (D-C2)

Project C2: Material substitution and functional integration

- Global aging characterization methods for pre-qualification and lifetime assessment of cost-efficient materials
- Multi-functional polypropylene and polyamide absorber materials

Project C3: Innovative, cost-efficient processes and components

- Design for a pumped-controlled valve for fully overheating controlled collectors (using the backcooling principle)
- Designs and manufacturing concepts for polymer based integrated collector storages
- System testing of polymeric solar thermal collectors

Subtask D: Information, dissemination and stakeholder involvement

Project D. 1: Industry Liaison

New industry contacts

Definition of core stakeholders for Task 54:

- Solar thermal manufacturers (preferably representatives from management and marketing)
- Installers for solar thermal applications and heating
- Participants from the building industry incl. architectural offices who work with solar thermal installations

The following contacts could be established:

- **Conico Valves,** Netherlands (new participant)
- **GreenOneTec,** Austria (new participant)
- **Selektif Teknoloji**, Turkey (interested in joining, presentation sent to 3rd Experts Meeting, no expert present)
- **ForSun – Solartechnik**, Germany (interested in joining, presentation sent to 3rd Experts Meeting, no expert present)
- **BAXI,** Spain (interest in joining)
- **BUILD UP SKILLS,** European Initiative to train craftsmen in the energy sector (contact with coordinator of German initiative, Dr. Iris Pfeiffer, Zentralverband des Deutschen Handwerks)
- **Thermondo,** Germany (contact desired; shall be established by May 2017 Experts Meeting)
- **SOVISA,** Germany (interested in participation, will probably join in May 2017)

Data collection on installation

For the collection of data on installation costs and a better understanding of obstacles or time-consuming factors with current systems, a questionnaire for distribution amongst these contacts was developed in the framework of a dedicated task force (ISE, ITW; TECSOL, SPF). The questionnaire is available in English, German and French and will also be distributed at the ISH 2017 fair, the biggest fair for sanitary installations and heating in Europe. The data collection is ongoing till the fourth Experts Meeting in Rapperswil in May 2017.

D 1.1 Industry Workshop

The first SHC Task 54 workshop was held within the framework of the ESTTP workshop, *Solar Thermal Energy for Europe* (24-25 May 2016) in Brussels, Belgium. Jointly organized with the European Solar Thermal Industry Federation (ESTIF). The workshop included a presentation and discussion of the reference systems to be defined in Subtask A and the installation questionnaire launched as part of the Task's D.1 work. Input was gathered and published in summer 2016.

In addition, Task 54 was presented at Gleisdorf Solar 2016 (8-10 June, Austria).

D 1.2 National Dissemination Workshop

Planning for the National Dissemination Workshop at the 3rd Experts Meeting in Stuttgart, Germany. The next workshop will be organized by the Austrian Task 54 partners around JKU Linz, and will most probably be held in Vienna, Austria in the third quarter of 2017 in close connection with a Task 54 Experts Meeting.

Project D.2: Dissemination and Information

- Public website is set up and maintained by ISE (http://task54.iea-shc.org/)
- First press release on the start of Task 54 was distributed by ISE and taken up by solarthermalworld.org, which released an online article in early October 2015. (http://solarthermalworld.org/keyword/iea-shc-task-54)
- An announcement of the Task 54 workshop was published in May 2016 via solarthermalworld.org http://www.solarthermalworld.org/content/brussels-travel-where-politics-and-funding-meet
- Another article on the workshop was published in the ESTIF newsletter edition June / July 2016 and in the Solar Update (December 2016 edition)
- e-newsletter was published in November 2016 containing articles by the partners Fraunhofer ISE, University of Kassel, Conico Valves, ISFH Hameln, Sunlumo
- Further articles and a webinar by Task 54's main actors are planned

- Task 54 Flyer for distribution at SPF Industry Day in March 2017, ISH 2017 in April 2017, OTTI Symposium in May 2017 and Task 54 National Dissemination Workshop in 3rd quarter of 2017 in Austria.
- Task 54 created a twitter account to be accessed via @IEA_SHC_Task 54

Conferences, Workshops, Seminars

Workshop/Conference/ Seminar	Activity	Date & Location	Number of Participants
Task 54 Dissemination Workshop, ESTTP Event, Solar Energy for Europe	Presentation	May 2016 Brussels, Belgium	
TEWIsol and KoST Workshop	Presentation	October 2016 Stuttgart, Germany	

Task Meetings 2016 and 2017

Meeting	Date	Location
Experts Meeting #2	3-4 May April	Florence, Italy *25 participants from research and industry*
Experts Meeting #3	6-7 October 2016	Stuttgart, Germany *25 participants from research and industry*
Experts Meeting #4	3-4 May 2017	Rapperswil, Switzerland
Experts Meeting #5	October 2017 (to be confirmed)	Austria

Funded Projects Of Task 54 Partners

(February 2017, updates can be found at http://task54.iea-shc.org/funded-projects.

KoST: Kostenreduktion in der Solarthermie durch Standardisierte Komponenten und Schnittstellen / Cost Reduction in Solar Heat by Standardized Components and Interfaces (04/2016 - 03/2019)
Funding: *BMWi Bundesministerium für Wirtschaft und Energie*
Partners: *Institut für Thermodynamik und Wärmetechnik (ITW) der Universität Stuttgart, Fraunhofer-Institut für Solare Energiesysteme (ISE), Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO), CitrinSolar GmbH, emz-Hanauer GmbH & Co. KGaA, Ernst-Schweizer AG, Metallbau, GREENoneTEC Solarindustrie GmbH, KBB Kollektorbau GmbH, Ritter Energie- und Umwelttechnik GmbH und Co. KG, Solvis GmbH und Co. KG, WIKORA GmbH SolarSpeicherSysteme, Bundesverband für Solarwärme e.V. (BSW), Deutsches Institut für Bautechnik (DIBt), Zentralverband des Deutschen Dachdeckerhandwerks e.V. (ZVDH)*

TEWISOL: Technisch-Wirtschaftliche Optimierung von Solarthermischen Kombianlagen (01/2016 - 12/2018)

Funding: *BMWi Bundesministerium für Wirtschaft und Energie (Projektträger PTJ)*
Partners: *Fraunhofer-Institut für Solare Energiesysteme ISE*

IEA SHC Task 54: Preisreduktion von thermischen Solaranlagen (11/2015 - 09/2018)
Funding: *Bundesministerium für Verkehr, Innovation und Technologie BMVIT/ Österreichische Forschungsförderungsgesellschaft FFG*
Partners: *AEE INTEC, Johannes Kepler University Linz - Institute of Polymeric Materials and Testing,* Universität Innsbruck*, Sunlumo*

SolPol-4/5: Solar Energy Technologies Based on Polymeric Materials - Novel Pumped and Non-Pumped Collector-Systems (05/2014 - 04/2018)
Funding: Klima- und Energiefond*/ Österreichische Forschungsförderungsgesellschaft FFG*
Partners: *AEE INTEC,* APC Advanced Polymer Compounds*, Johannes Kepler University Linz - Institute of Polymeric Materials and Testing,* Universität Innsbruck*, Sunlumo*

HP-Koll: Kostengünstige und zuverlässige Solarsysteme durch neuartige Wärmerohr- Kollektoren / Cost Efficient and Reliable Solar Thermal Systems by Novel Heat Pipe Collectors (09/2014 - 08/2017)
Funding: *BMWi Bundesministerium für Wirtschaft und Energie (Projektträger PTJ)*
Partners: *Institut für Solarenergieforschung (ISFH), KBB Kollektorbau*, *Narva Lichtquelle GmbH Co. KG*

SolStream: Solarthermie – Hydroblock (05/2015 - 07/2016)
Funding: *Basisprogramm der Österreichischen Forschungsförderungsgesellschaft FFG*
Partners: *Sunlumo*

Untersuchungen zur Fertigungstechnik und Kollektorkonstruktion für Vollkunststoff-Kollektoren (runs until mid-2016)
Partners: *Technische Hochschule Ingolstadt - Institut für neue Energie-Systeme (InES)*

SolarPipe: Solarthermie – Kunststoffrohre (05/2015 - 02/2016)
Funding: *Land Oberösterreich*
Partners: *Sunlumo*

Wirtschaftlichkeit mit System (03/2015 - 12/2015)
Funding: *Hessisches Ministerium für Umwelt, Energie, Landwirtschaft und Verbraucherschutz, Hessen Agentur*
Partners: *Universität Kassel*

Solar Thermal Systems without Controllers / Sensors Using the Thermo-Differential Bypass Valve (04/2016 - 09/2017)
Funding: *Smart Energy Regions, Eindhoven Energy Institute*
Partners: *Conico Valves bv, Technische Universiteit Eindhoven*

NORDIC BUILT - Active Roofs and Facades in Sustainable Renovation (2014 - 2017)
Funding: *Nordic Innovation*
Part*ners:* Cenergia (DK) (coordinator), Copenhagen Real Estate (DK), KAB (DK), WSP Group (DK), VTT (FI), ZED Consulting (FI), University of Iceland (ISL), AVENTA AS (NO), *Høyer Finseth (NO), Ecovent (DK), Gate21 (DK) and Demos (DK)*

Bio - New Solution for Combining Bio and Solar Energy for Heating of Low Energy Houses (2016-2018)
Funding: *Research Council of Norway*
Part*ners:* AVENTA AS (NO) (coordinator), *Stansefabrikken Fredrikstad, Frost Produkter AS, Jøtul AS (NO), Dalarna University (SE)*

ProTASK - Prozesstechnik, Qualitätssicherung und Systemlösungen für Thermochrome Absorber in Solarthermischen Kollektoren / Process Technology, Quality Assessment and System Solutions for Thermochromic Absorbers in Solar Thermal Collectors (02/2016 – 01/2019)
Funding: *BMWi Bundesministerium für Wirtschaft und Energie (Projektträger PTJ)*
Part*ners: ISFH (GER), Viessmann (GER)*

SHC Task 54 Participants

Country	Name	Institution / Company	Role
GERMANY	**Michael Köhl**	**Fraunhofer Institute for Solar Energy Systems**	**Operating Agent**
AUSTRALIA	Harry Suehrcke	Sunspin Pty Ltd	National Expert
AUSTRIA	Patrick Bradler	JKU Linz	National Expert
AUSTRIA	Robert Buchinger	Sunlumo	National Expert
AUSTRIA	Harald Poscharnig	GREENoneTEC Solarindustrie GmbH	National Expert
AUSTRIA	Michael Grabmann	JKU Linz	National Expert
AUSTRIA	Thomas Ramschak	AEE Intec	National Expert
AUSTRIA	Karl Schnetzinger	Advanced Polymeric Compounds	National Expert
AUSTRIA	Nataliya Schnetzinger	Advanced Polymeric Compounds	National Expert
AUSTRIA	Alexander Thür	UIBK	National Expert
AUSTRIA	Max Wesle	Sunlumo	National Expert
CHINA	Ma Guangbai	Linuo-Paradigma Company	National Expert
CHINA	Jiao Qingtai	Sunrain	National Expert
DENMARK	Simon Furbo	University of Denmark (DTU)	National Expert
FRANCE	Daniel Mugnier	TECSOL	National Expert
GERMANY	Sebastian Barg	WZL RWTH Aachen	National Expert
GERMANY	Mathias Ehrenwirth	INES	National Expert
GERMANY	Stephan Fischer	ITW	National Expert
GERMANY	Sebastian Föste	ISFH	National Expert
GERMANY	Federico Giovanetti	ISFH	National Expert
GERMANY	Bernd Hafner	RHC-Platform	National Expert
GERMANY	Steffen Jack	KBB Kollektorbau GmbH	National Expert
GERMANY	Wolfgang Kramer	Fraunhofer ISE	National Expert
GERMANY	Yoann Louvet	University of Kassel	National Expert
GERMANY	Axel Oliva	Fraunhofer ISE	National Expert
GERMANY	Andreas Piekarczyk	Fraunhofer ISE	National Expert

GERMANY	Norbert Rohde	KBB Kollektorbau GmbH	National Expert
GERMANY	Sandrin Saile	Fraunhofer ISE	National Expert
GERMANY	Bert Schiebler	ISFH	National Expert
GERMANY	Karl-Anders Weiss	Fraunhofer ISE	National Expert
ITALY	Maurizio De Lucia	University of Florence	National Expert
NETHERLANDS	Nico van Ruth	Conico Valves	National Expert
NORWAY	Michaela Meir	Aventa	National Expert
NORWAY	John Rekstad	Aventa	National Expert
SWITZERLAND	Andreas Bohren	HSR-SPF	National Expert
SWITZERLAND	Michel Haller	HSR-SPF	National Expert
SWITZERLAND	Daniel Philippen	HSR-SPF	National Expert

Task 55 – Towards the Integration of Large SHC Systems into DHC Networks

Sabine Putz
S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH
Operating Agent for the Republic of Austria

Task Overview

IEA SHC Task 55 elaborates on technical and economic requirements for the commercial market introduction of solar district heating and cooling systems in a broad range of countries. The Task activities aim to improve technological and market know-how, as well as to develop tools for the network integration of solar thermal systems and the implementation of other renewable energy technologies for maximum energy coverage. A key element is the direct cooperation of SDH experts with associations, companies, and institutions from the DHC community to bridge the gap between the research fields and organizations.

The Task's work is divided into four subtasks:

- Subtask A: Network Analyses and Integration (Austria)
- Subtask B: Components Testing, System Monitoring, and Quality Assurance (China)
- Subtask C: Design of the Solar Thermal System and of Hybrid Technologies (Denmark)
- Subtask D: Promotion and Economic Aspects of Solar Thermal and Hybrid Technologies (Spain)

Subtask A: Network Analyses and Integration

Objective: The main research questions of Subtask A are how to integrate significant shares of ST, what the impact on other generation units is, how to solve the integration technically, and what measures are suitable to maximize the share of solar thermal applications.

Outcomes aimed are best practice examples and case studies, energetic, ecologic and economic assessments of the overall system, transformation strategies of DHC networks considering high share of ST, guidelines on challenges and benefits of ST integration, control strategies and hydraulic options for the integration of SHC systems into district heating and cooling networks.

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

Objective: The main research objectives of Subtask B are to elaborate on methods for in in-situ collector tests, hybrid elements, and provide methods for simple thermal and energy performance proofs. Furthermore, it will provide data on automated monitoring and failure detection software for key components, and develop and describe control strategies for self-learning control systems.

Subtask C: Design of the Solar Thermal System and of Hybrid Technologies

Objective: Subtask C focuses on the simulation and design of solar thermal systems and components (storage, piping and others, 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.

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

Objective: Subtask D elaborates on economic aspects to assist practitioners, architects, system designers, and district heating providers in their efforts to integrate SHC-applications. Aims are to find currently applied financing models for SDH and SDC applied, and new investment models, the creation of a reference calculation tool on solar thermal district heat and cool price scenarios, the identification of types of hybrid technologies that can be

coupled with solar thermal, to maintain a database to collect information on different systems, and to disseminate Task project results.

Task Duration

The Task started in September 2016 and will be completed in August 2020.

The IEA Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power (IEA DHC) officially cooperates with the SHC Task 55 on a ***moderate*** level as defined by the IEA SHC.

Participating Countries

	Research Institutes	Universities	Companies	Observer
Austria	2	1	3	
Canada	1	0	1	
China	0	1	1	
Denmark	0	1	2	
Finland*	0	0	1	
France	0	0	1	
Germany	3	5	1	
Italy	1	0	1	✔
Israel	0	0	1	✔
Spain	0	1	1	
Sweden	0	0	1	✔
Switzerland	0	0	1	✔
Turkey	0	0	1	✔
TOTAL	**7**	**9**	**16**	**5**

*Through IEA DHC

** Pending Observer Countries: Australia, UK, UAE, Slovakia, Poland

Collaboration with other SHC Tasks and Outside Organizations/Institutions

IEA SHC Task 55 will collaborate with IEA SHC Task 57 on selected findings of economic analyses of overall DHC network supply strategies and transition strategies, in-situ collector tests, and the integration of solar ratings and certification procedures.

Further collaborations are planned with HPT Annex 47 (Heat pumps in DHC systems), ECES Annex 28 (Energy Conservation through Energy Storage), EBC Annex 60 (Energy in Bulidings (new generation tools), EBC Annex 64 (Optimized urban energy systems) and DHC Annex 12 (currently built and focused on DH system optimization).

Collaboration with Industry

1. Task 55 has started to collaborate with the following industry partners:
2. Bioenergy 2020+ GmbH
3. CanmetENERGY
4. Cim-Mes
5. Jiangsu Sunrain Solar Energy Co., Ltd
6. KBB Kollektorbau GmbG
7. MGR GEORG SIMA E.U.
8. Savo-Solar Oy
9. SOLID
10. Tecnalia
11. Absolicon Solar Collector AB
12. PlanEnergi
13. TVP Solar
14. NewHeat
15. Alcor Energy

Work During 2016

Main activities since the last report are shortly highlighted below. More details and specific deliverables can be found on the SHC Task webpage.

SHC Task 55 Newsletter

The 1st Task 55 Newsletter was sent out to report on the Task 55 Kick-Off Meeting in November 2016. The newsletter further announced the next Task 55 meetings, the SHC 2017 conference, and motivated readers to join Task 55 and IEA SHC activities. In total, 62 recipients were in the Newsletter Task 55 group. Nobody unsubscribed from the mailing list, 40% opened the newsletter (industry average are 14%), with 138 total opens. Top links clicked were http://task55.iea-shc.org/ and http://www.shc2017.org/ and top five countries with most openings were Austria, Germany, Spain, China, and Denmark.

New Partners

After the Task 55 Kick-Off Meeting, activities to integrate new partners continued. Up until the 2nd Task 55 Meeting in Aalborg, Denmark, the following partner institutions joined Task 55 activities and meetings:

1. Absolicon Solar Collector AB (Sweden)
2. New Heat (France)
3. TVP Solar (Italy)
4. TU Dresden (Germany)
5. Alcor Energy

Preparation of the 2nd Task 55 Meeting in Aalborg

The 2nd IEA SHC Task 55 Meeting takes place from the 14th - 16th of March 2017 in Aalborg/Denmark. Several invitations and a short newsletter were sent out to promote the meeting. Next to the meeting, a technical tour illustrates an installation in (1) Taars: The first combi solution 4.000 m^2 Parabolic trough and 6,000m^2 flat panels with Glycol/Water, and the installation of (2) Brønderslev: 29,600m^2 Parabolic trough with oil working through a ORC. This plant is in commissioning. More than 20 international experts and industry partners join the 2nd Task 55 Meeting.

Funded Projects: Overview Of Projects Of Task 55 Partner

1. **Project "SOLFW"**
   - Project is currently in implementation; 2,100m² of solar thermal installations; DH 70/40 low temperature systems; 1,000m³ storage; solar fraction of 11%
   - Partner: Fraunhofer ISE
2. **EMS Energy Management simulation tool**
   - Developed within FP7 Smart City project PITAGORAS and contributed by CIM-MES from Poland
   - Partner: CIM-MES
3. **ZEKON In-Situ**
   - Partner: Fraunhofer ISE
4. **MEQUSO**

- Dealing with measurement methods on field collector performances (including quasi dynamic simulation); installed in Graz/Austria
- Partner: SOLID, AEE INTEC

5. **Spanish project**
   - Integration of TES and waste heat into DH and DC Systems to increase the solar fraction and renewable energy sources –
   - Partner: University of Zaragoza
6. **Store4grid**
   - Partner: University of Innsbruck/Austria
7. **Drake Landing**
   - A tri-generation concept including seasonal storages and a study about ST and seasonal storage, 100% solar fraction reached
   - Partner: CanmetEnergy
8. **CHEST in Smart District Heating**
   - Flexible thermal and electrical energy storage and supply system
   - Partner: DLR, German Aerospace Center, Institute of Engineering Thermodynamics
9. **DHC Projects** (details to be confirmed in 2017)

Reports Published In 2016

Reports & Published Books

No reports were published in 2016 as the Task just started.

Journal Articles, Conference Papers, Press Releases, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Barbel Epp	IEA SHC Task 55	Solarthermalworld.org	http://www.solarthermalworld.org/keyword/iea-shc-task-55
Sabine Putz Anna K. Provasnek	Schwerpunkte des neuen IEA SHC Task 55: Towards the Integration of Large SHC Systems into DHC Networks	OTTI Symposium “Thermische Solarenergie“	Abstract Submitted
Sabine Putz Anna K. Provasnek	IEA Solar Heating and Cooling Programme; Task 55: Towards the Integration of Large SHC Systems into District Heating and Cooling (DHC) Networks	SOLAR TR2016, Istanbul, Turkey	Poster

Conferences/Workshops/Seminars

Conference / Workshop / Seminar	Activity & Presenter	Date & Location	# of Attendees	Organized by
SOLAR TR Turkish Solar Conference	TASK 55 poster	6-8 December 2016, Istanbul, Turkey		Günder & UFTP

Task Meetings in 2016 and 2017

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting #1	19 – 21 October 2016	Graz, Austria	25 (8)
Experts Meeting #2	14 -16 March 2017	Aalborg, Denmark	21 (8)
Experts Meeting #3	27-28 October 2017	Abu Dhabi, UAE *(Inconjunction with SHC 2017)*	

SHC Task 55 Participants

Country	Name	Institution/Company	Role
AUSTRIA	**Sabine Putz**	**SOLID**	**Operating Agent**
AUSTRIA	Ralf-Roman Schmidt	AIT/Austrian Institute of Technology	Subtask A Leader National Expert Cooperation Leader
AUSTRIA	Christian Fink	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Fabian Ochs	University of Innsbruck	National Expert
AUSTRIA	Daniel Tschopp	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Markus Gölles	Bioenergy 2020+ GmbH	National Expert
AUSTRIA	Christian Engel	Thermaflex Int Holding	National Expert
CANADA	Lucio Mesquita	CanmetEnergy	National Expert
CANADA	James Bererton	Naked Energy	National Expert
CHINA	Qingtai Jiao	Jiangsu Sunrain Solar Energy Co., Ltd	Subtask B Leader
CHINA	Wenjing Qiao	Architectural Engineering Institute of Xi'an Technological University	National Expert
DENMARK	Jan Erik Nilsen	PlanEnergi	Subtask C Leader
DENMARK	Bengt Perers	Technical University of Denmark	National Expert
DENMARK	Christian Kok Nielsen	MOE A/S	National Expert
DENMARK	Jes Donneborg	Aalborg CSP	National Expert
FINLAND	Kaj Pischow	Savo-Solar Oy	National Expert
FRANCE	Pierre Delmas	NewHeat	National Expert
GERMANY	Dan Bauer	DLR	National Expert
GERMANY	Norbert Rohde	KBB Kollektorbau GmbG	National Expert
GERMANY	Nirendra-Lal Shrestha	TU Chemnitz	National Expert
GERMANY	Roman Marx	ITW University of Stuttgart	National Expert

GERMANY	Axel Gottschalk	Bremerhaven University of Applied Sciences	National Expert
GERMANY	Carles Ribas Tugores	Universität der Künste Berlin	National Expert
GERMANY	Karin Rühling	TU Dresden	National Expert
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
GERMANY	Andrej Jentsch	Operating Agent IEA IA on District Heating and Cooling including the integration of CHP	National Expert
ITALY	Luca Degiorgis	Politecnico di Torino	National Expert
ITALY	Marco Scarpellino	TVP Solar	National Expert
ISRAEL	Zvika Klier	TIGI Solar	National Expert
POLAND	Armen Jaworski	Cim-Mes	National Expert
SPAIN	Patricio Aguirre Múgica	Tecnalia	Subtask D Leader
SPAIN	Luis M. Serra	University of Zaragoza	National Expert
SWEDEN	Joakim Bykström	Absolicon Solar Collectors AB	National Expert
SWITZERLAND	Vittorio Palmieri	TVP Solar	National Expert
TURKEY	Deniz Kazanci	Alcor Energy	National Expert

Task 56 – Building Integrated Solar Envelope Systems for HVAC and Lighting

Roberto Fedrizzi
EURAC Research
Operating Agent for ENEA

Task Overview

This Task focuses on the critical analysis, simulation, laboratory test and onsite monitoring of envelope systems entailing elements that use and/or control incident solar energy, having one or more of the following uses:

- To deliver renewable thermal or/and electric energy to the systems providing heating, cooling and ventilation to buildings
- To reduce heating and cooling demands of buildings, while controlling daylight

Technologies are considered that account for the specificity of the intervention on residential and tertiary buildings, both new-built and retrofitted.

Integration of Solar Envelope solutions into the building's HVAC and lighting systems through a systemic approach is central in this task.

Energy performance, indoor comfort and architectural integration are addressed all along the Task elaboration.

Subtask A: Solar Envelope Systems Classification and Communication

Lead Country: Norway; *Subtask Leader: Michaela Meir – AVENTA*

Objective
An overview of products and solutions of solar envelope systems, which are presently available on the market, will be made available in Subtask A as a preparatory work for Subtask B and C. In particular, the conditions for the effective deployment of solar envelope systems will be analysed in this Subtask. In addition, the communication of such factors and of the overall results will be tackled here.

Subtask B: Performance Characterisation of Solar Envelope Elements

Lead Country: Germany; Subtask Leader: Christoph Maurer – Fraunhofer-ISE

Objective
Subtask B aims to develop tools and strategies to foster the market penetration for industrialised solar envelope systems. In particular, it focuses on the solar envelope elements intended as the sub-systems, strictly incorporated in the building envelope.

Subtask C: Assessment of Solar Envelope Systems at Building Level

Lead Country: Austria; Subtask Leader: Fabian Ochs – University Innsbruck

Objective
In Subtask C complete solar envelope systems are defined based on active and passive components and integrated into the HVAC system of reference buildings. This buildings are considered as virtual case studies, which the specific envelope elements proposed by the industrial partners are integrated into.

The solutions will be evaluated based on reference conditions assessed in Subtask A, and sub-systems and KPIs defined in Subtask B.

Task Duration

The Task started in February 2016 and will be completed in January 2020.

Participating Countries

Participants are requested to deliver the NPL until the second meeting. The list reported below refers to the organisations participants from the kick-off to the third meeting.

	Research Institutes	Universities	Companies
Austria	-	1	1
Canada	-	-	1
Denmark	-	1	1
Germany	3	-	1
Italy	1	1	1
The Netherlands	-	1	-
Norway	-	1	1
Slovakia	-	1	-
Spain	1	-	-
Sweden	-	1	-
TOTAL	**5**	**8**	**6**

Work During 2016

Key Results

The strategic objective of the Task is to coordinate the research and innovation effort taking place within the scientific community and the private sector, towards the utilization of envelope integrated technologies.

Specific objectives of the Task are:

- To gather relevant information on market available and “under-development” solar envelope systems both in terms of performance and costs
- To assess and develop test methods for the performance characterization of solar envelope elements (thermal, electric and daylighting performance characterization)
- To assess and develop simulation models for the performance characterization of solar envelope elements (thermal, electric and daylighting performance characterization)
- To develop design, manufacturing and installation guidelines for industrialised solar envelope systems, accounting for technological, architectural/aesthetical, economic, financing and customer acceptance viewpoints
- To assess and develop business models for solar envelope systems
- To enhance awareness of the public and private sector on the treated technologies.

Task 56 has had its 3rd Expert Meeting in March 2017 in Dublin. The location has been selected in order to allow the participation of relevant stakeholders in the sector of the active envelope systems, both from the research side and from industry.

Moreover, since Ireland is participating as an observer through DIT, an official partnership is sought. SEAI (Sustainable Energy Authority of Ireland), who is the organisation who can accept Ireland to be officially represented, participated to the meeting.

The Task has been focused mainly on the definition of the activities and share of work among interested participants and on the dissemination of the project objectives:

- 2 newsletters have been released, together with 1 article on Solarthermalworld.org.
- In addition, EURAC and UIBK have organised a session on Solar Active Envelopes within the Advanced Building Skins Conference held in Bern 11-13.10.2016. Bartenbach, Cenergia, AEE-INTEC, EURAC and UIBK participated to the session.
- In Dublin an industry workshop has been organised with local experts (industry and architects) with the objective of gathering feedback of barriers and strategies for solar envelope systems market uptake.
- In addition to SEAI, also NEDO (New Energy and Industrial Development Organisation, Japan) participated in the meeting.

Subtask A: Solar Envelope Systems Classification and Communication

A market analysis has started assessing existing solutions through a literature review and the advice of the experts participating.

Different specific products and solutions will be evaluated all along 2017 through a SWOT analysis based on the market analysis, accounting for technical and non-technical issues, which in the past have determined the success or the failure of solar envelope systems.

A major activity of Subtask A is to attract and involve central actors, decision makers, planners, builders, architects, experts from research and industry. This is achieved by the exchange of information generated in all Subtasks through local workshops, newsletters and an updated public website. As above mentioned, during the first year of activity this consisted of:

- 2 newsletters and 1 article on Solarthermalworld.org.
- 1 session on Solar Active Envelopes within the Advanced Building Skins Conference held in Bern 11-13.10.2016.
- 1 industry workshop in Dublin.
- Clustering activity with SEAI and NEDO.

Subtask B: Performance Characterisation of Solar Envelope Elements

In order to analyse the barriers for solar envelopes, two meetings with industry have been held. The aim of the activity is to develop strategies for companies with innovative concepts for solar envelopes to be successful in the market. The industry partners provided valuable insight into the challenges they face.

Publications on simulation models for solar envelopes have been collected and the elaboration of a journal review paper on these models is ongoing. The paper is planned to be helpful for all target groups of Task 56 in finding the best and therefore most cost-effective simulation models to be used for their innovative technologies.

Standards have been collected useful to rate and to evaluate solar active envelope components. The understanding is that a very large number of standards which can be used when dealing with solar envelopes.

On the one hand they are seen as a barrier to the diffusion of the technology since functional requirements differ strongly from country to country, on the other, more standards are felt as necessary relating on the performance of these solutions.

So far, the agreement is that Subtask B will analyse some of these standards to understand whether they are directly/easily applicable for solar envelopes or their application to solar envelopes is unclear: in the latter case, recommendations will be provided how to use them with respect to a number of envelope typologies. First standards have been examined and are being analysed.

Subtask C: Assessment of Solar Envelope Systems at Building Level

A preliminary study on different building simulation methodologies has been discussed with regard to the scope of analysing Envelope integrated HVAC systems. Further work is necessary to understand how the different simulation studies can be compared and what the requirements for a benchmark are.

The case studies will be collected and organized using a template that has been developed and send out. The project will be classified according to building type and application and a final suggestion will follow before the next meeting. Several simulation projects are actually ongoing, which could be source of information to the Task, while only few sources of monitoring data are available so far.

Links with Industry

Twenty-eight experts from 24 different institutions participated in the kick-off meeting at EURAC in Bolzano. The majority were from universities and research centres. However, we have had good participation by industry (7 companies), which expressed their intention to actively participate in the project.

During the second meeting held in Darmstadt, 25 experts attended out of which 5 were from industry. Two observers from BASF and MERCK glasses presented their developments in the sector of advanced solutions for the active solar gains control. The China International Investment Promotion Agency also participated disseminating their activates and seeking possible collaboration in China.

During the third meeting held in Dublin, again 23 experts where involved out of which 5 were from industry. 3 experts from Kingspan, FenestraPRO (an add-on software for BIM software Revit) and an architect (O'Donnell & Tuomey) were "external" speakers at the industry workshop.

Reports Published in 2016

Reports & Published Books

No Task reports were published as the Task only began in February 2016

Journal Articles, Conference Papers, Press Releases, etc.

Author(s) / Editor	Title	Publication / Conference	Bibliographic Reference
Baerbel Epp	IEA SHC: Task 56 Kick-Off Meeting on Building Integrated Solar	Solarthermalworld.org	http://www.solarthermalworld.org/content/iea-shc-task-56-kick-meeting-building-integrated-solar
D. Venus, B. Nocke, C. Fink, K. Höfler	Facade integrated HVAC systems for the renovation of residential buildings – results from Austrian research projects	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications//aee_intec_abstract_dv_v2.pdf
Peter Veisig	Nordic Built Active Roofs and Facades and Living in Light urban renewal in Valby, Copenhagen	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/20161003_abstract_bern_10_oct_peder_vejsig.pdf

Bonato P., D'Antoni M., Fedrizzi R.	Integration of a sorption collector coupled with a decentralized mechanical ventilation unit in curtain wall modules	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/eurac_abstract_dm.pdf
Wilfried Pohl, David Geisler-Moroder	Daylight-driven and user-centered lighting and energy management	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/20160701_bartenbach_abstract.pdf

Conferences/Workshops/Seminars

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	# of Attendees	Oraganized By
12th Conference on Advanced Building Skins	Presenations, abstracts, papers *(1 session hosted by Task 56)*	Oct. 02-03, 2016, Bern, Switzerland	5 Task 56 partners	Advanced Building Skins GmbH

Task Meetings in 2016 and 2017

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meetiing #1	21-22 March 2016	EURAC - Bolzano	28
Experts Meetiing #2	13-14 September 2016	Darmstadt University - Darmstadt	25
Experts Meetiing #3	02-03 March 2017	Dublin Institute of Technology – Dublin	26
Experts Meetiing #4	20-21 September 2017	Eindhoven Institute of Technology – Eindhoven	-

SHC Task 56 Participants

Country	Name	Institution / Company	Role
Italy	**Roberto Fedrizzi**	**EURAC**	**Operating Agent**
Austria	Fabian Ochs	University Innsbruck	Subtask C Leader
Austria	David venus	AEE-INTEC	National Expert
Austria	Andreas Ampenberger	Bartenbach GmbH,	National Expert
Canada	John Hollick	Solar Wall	National Expert
Canada	Zissis Ioannides	Concordia University	National Expert
Denmark	Vickie Aagesen	Cenergia	National Expert
Germany	Christoph Maurer	Fraunhofer ISE	Subtask B Leader
Germany	Paul Rouven Denz	Facade-Lab GmbH	National Expert
Germany	Tomas Mikeska	Passive House Institute	National Expert
Germany	Carolin Hubschneider	Fraunhofer IBP	National Expert
Italy	Matteo D'Antoni	EURAC	National Expert
Italy	Alessio Passera	EURAC	National Expert
Netherlands	Roel Loonen	Eindhoven University of Technology - Department of the Built Environment, Unit Building Physics and Services	National Expert
Norway	Michaela Meir	Aventa	Subtask A Leader
Norway	Ellika Taveres-Cachat	NTNU, Felles fakturamottak	National Expert
Slovakia	Stanislav Darula	Institute of Construction and Architecture Slovak Academy of Sciences	National Expert
Spain	Roberto Garay	Tecnalia	National Expert
Sweden	Ricardo Bernardo	University Lund	National Expert

Task 57 – Solar Standards and Certification

Jan Erik Nielsen
SolarKey International
Operating Agent for the Danish Energy Agency

Task Overview

The purpose and objectives of the Task are to develop, improve and promote ISO standards on test procedures and requirements for solar thermal products and to harmonize at international level certification schemes in order to increase in general the level of quality and at the same avoid the need for re-testing and re-inspection.

Subtask A: Kick-off of operation of Global Solar Certification Network (GSCN)

(Leader: Harald Drück, Germany)

Subtask A will support the operation of the Global Solar Certification Network.

Subtask B: Improvement of test procedures – support and input to ISO

(Leader: He Zinian, BSERI, China)

Subtask B will elaborate specific proposals for new and improved test procedures. Initiating new "ISO work items" for revisions of existing standards and for elaborating new standards.

Subtask C: Promotion and capacity building with respect to ISO standards and state-of-the-art certification schemes

(Leader: Ashraf Kraidy, RCREEE)

The ISO standards for solar thermal products are becoming increasing popular throughout the globe; but still some countries stick to old national standards or even make new national standards. Subtask C will work to convince stakeholders in such countries that the ISO standards are very well proven and useful – and give guidance for implementation.

Main Outcome

The purpose and objectives of the task are to develop, improve and promote ISO standards on test procedures and requirements for solar thermal products - and to harmonize at international level certification schemes in order to increase in general the level of quality and at the same avoid the need for re-testing and re-inspection.

Duration

The Task started in January 2016 and will end in December 2018.

Work During 2016

Subtask A: Kick-off of Operation of Global Solar Certification Network (GSCN)

- 5 Global Solar certification Network (GSCN) Board meetings (web meetings)
- Approval of working rules for GSCN
- Call for applications for membership (incl. “application package”)
- Processing applications started
- Plan for promotion of GSCN
- New website

Subtask B: Improvement of Test Procedures – Support and Input to ISO

- Chinese – German cooperation on collector durability / accelerated ageing testing: Chinese plan for long term testing of evacuated tubular collectors planned

- Translation of 3 Chinese standards for systems done

Subtask C: Promotion and Capacity Building with Respect to ISO Standards and State-Of-The-Art Certification Schemes

- Supporting documents uploaded
- Work on guideline for ISO 9806:2017 started, so the guideline will be ready when the standard is published around July 2017
- Draft questionnaire on ISO 9806:2017 made
- Outline of "model certification schemes" done. Three levels are proposed see table below:

Level	3rd party sampling	Initial testing	Initial inspection	Surveillance inspection	Surveillance testing	Accred. level	Ex.
Low	From producer	ISO 9806				C	-
Medium	From producer	ISO 9806	Other	Annually	Bi-annually --- Special test	C	SHAMCI
High	From producer	ISO 9806	Other	Annually	Bi-annually --- Special test	AAA	KEYMARK

Links with Industry

- Applications from three very large collector manufacturers received.
- Involvement of relevant stakeholders in North Africa / Middle East (workshop in Cairo).

Dissemination/Presentations

Presentations given at:

- ESTIF webinar February
- Solar Keymark Network meetings March and October, JE Nielsen
- ISO TC 180 meeting in October, JE Nielsen
- Danish Technical University for Chinese delegation, JE Nielsen
- ESTIF general assembly, H Drück

Website

- New extended web site for "Global Solar Certification": WWW.GSCN.SOLAR

Other

Article by solarthermalworld.org: http://www.solarthermalworld.org/content/global-solar-certification-network-facilitating-international-high-quality-collector-trade

Connected meetings

- Global Solar Certification Network meetings, Berlin, March

Work Planned for 2017

Subtask A: Kick-off of operation of Global Solar Certification Network (GSCN)

- Continue operation of the Global Solar Certification Network (GSCN) – including 4-5 board meetings and one plenary meeting
- Continue promotion of the Global Solar Certification Network (GSCN)
- Process aplications

Subtask B: Improvement of test procedures – support and input to ISO

- Make final draft set of requirements for participating bodies
- Publish approved version of the harmonized requirements
- Continue Chinese – German cooperation on collector durability / accelerated ageing testing
- Make first initial draft proposals for new standards for:
  - ✓ Test methods for mechanical load on support of close-coupled solar water heating systems
  - ✓ Test methods and requirements for building integrated collectors and systems
  - ✓ Test methods for close-coupled solar water heating systems- reliability and safety

Subtask C: Promotion and capacity building with respect to ISO standards and state-of-the-art certification schemes

- Finish work on guideline for ISO 9806:2017; the guideline will be ready when the standard is published around July 2017
- Make final questionnaire on ISO 9806:2017; send out and analyze respons
- Describe in more detail “model certification schemes”.

Reports Published In 2016

No reports were published in 2016.

Reports Planned for 2017

No reports planned to be published in 2017

Task Meetings in 2016 and 2017

Meeting	Date	Location
Experts Meetiing #1	March 2016	Berlin, Germany
Experts Meetiing #2	October 2016	Cairo, Egypt
Experts Meetiing #3	March 2017	Freiburg, Germany
Experts Meetiing #4	November 2017	Abu Dhabi, UAE

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