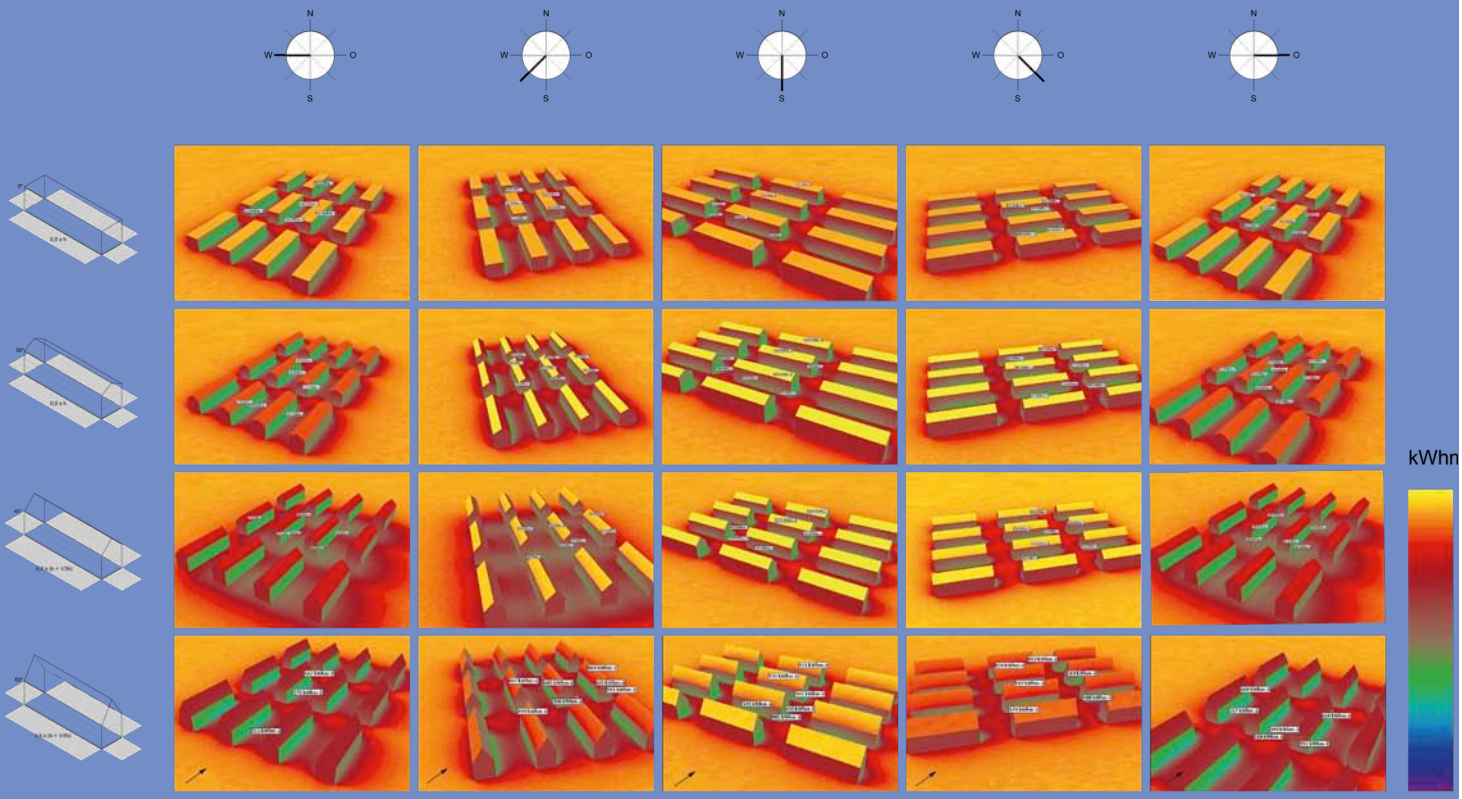
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Heating and Cooling Technology Collaboration Programme



2017 Annual Report

with feature article on solar in urban planning

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2017
Annual report

March 2018

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.

Cover: Graphic comparison of solar irradiation for different roof types and orientations for the case study of Øvre Rotvoll, Norway. Credit: Katharina Simon, PhD thesis, University of Wuppertal.

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1. Message from the Chairman

The IEA SHC Technology Collaboration Programme (TCP) continued to be the leading international collaborative research program that produces high quality data and research on solar heating and cooling in 2017.

The Solar Academy initiated in 2016 to share our work and support R&D and implementation of solar heating and cooling projects worldwide, delivered a webinar series on our work and a training program in South Africa in 2017. Through our partnership with the International Solar Energy Society (ISES) and supported by Masdar Institute, we held our International Conference on Solar Heating and Cooling for Buildings and Industry together with the ISES Solar World Congress in Abu Dhabi in November 2017. Our partnership with solarthermalworld.org also continued to broaden the reach of our work through their news service, the leading news service in this field. And, we published the 21st edition of our statistics report, Solar Heat Worldwide. 2017 ended with the start of two new Tasks and the completion of one Task.

Our Tasks continue to address the big issues for solar thermal deployment. For example, large systems are becoming more important as economies of scale improve the financial attractiveness of solar thermal technologies providing heat. And urban planning can be a barrier to implementation if the planning processes and strategies used aren't informed by methods and tools that are suitable to account for solar deployment.

2017 also saw the Mission Innovation Challenge on the "Affordable Heating and Cooling of Buildings" get underway, and the SHC TCP facilitated the organization of one of its meeting in conjunction with our conference in Abu Dhabi. This Challenge arose from the recognition and acknowledgement that heat is more than 50% of global final energy consumption and 38% of CO2 emissions. Consequently, greater resources will become available for collaborative research of the types undertaken in the SHC TCP.

In 2017, we held joint Executive Committee meetings with the IEA Energy in Buildings and Communities Technology Collaboration Programme (TCP) and with the Photovoltaic Power Systems TCP. We continue to collaborate in joint Tasks with four IEA TCPs that cover Renewable Energy and End Use Technologies TCPs and with the IEA Secretariat in Paris. We also worked to strengthen our relationship industry associations in order to better understand their perspective and issues and to disseminate our research results to them as well as academic organizations.

I would like to acknowledge the work of the TCP Vice Chairs, Daniel Mugnier, Ricardo Enríquez 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 thank the Secretariat, Pamela Murphy for her proactive approach to the administration of the TCP, and the Webmaster, Randy Martin for his support of the Programme.

2018 is on course to be another year of significant achievements from our Task work and valuable collaborative work with Industry and other TCPs. During this year, the Executive Committee will also look to the future as they develop a new strategic plan to implement starting in 2019.

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 program 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.

1 Low temperature heat up to 250°C

1 Lobaccaro, G., Lindkvist, C., Wall, M., Wyckmans, A. (eds.), 2017. Illustrative Prospective of Solar Energy in Urban Planning. Collection of International Case Studies. IEA SHC Task 51/Report C1. DOI: 10.18777/ieashc-task51-2017-0002.

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

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.

The Tasks running in 2017 were:

- 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)
- Material and Component Development for Thermal Energy Storage (Task 58)
- Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO2 Emission (Task 59)

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 was held jointly held with ISES Solar World Congress 2017 on October 29 - November 2 in Abu Dhabi, UAE), 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	**Italy**	Contracting Party
Austria	Contracting Party	**Mexico**	Contracting Party
Belgium	Contracting Party	**The Netherlands**	Contracting Party
Canada	Contracting Party	**Norway**	Contracting Party
China	Contracting Party	**Portugal**	Contracting Party
Denmark	Contracting Party	**RCREEE**[5]	Sponsor
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

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

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.

81st ExCo Meeting – June 2017, London

82nd ExCo Meeting – November 2017, Melbourne

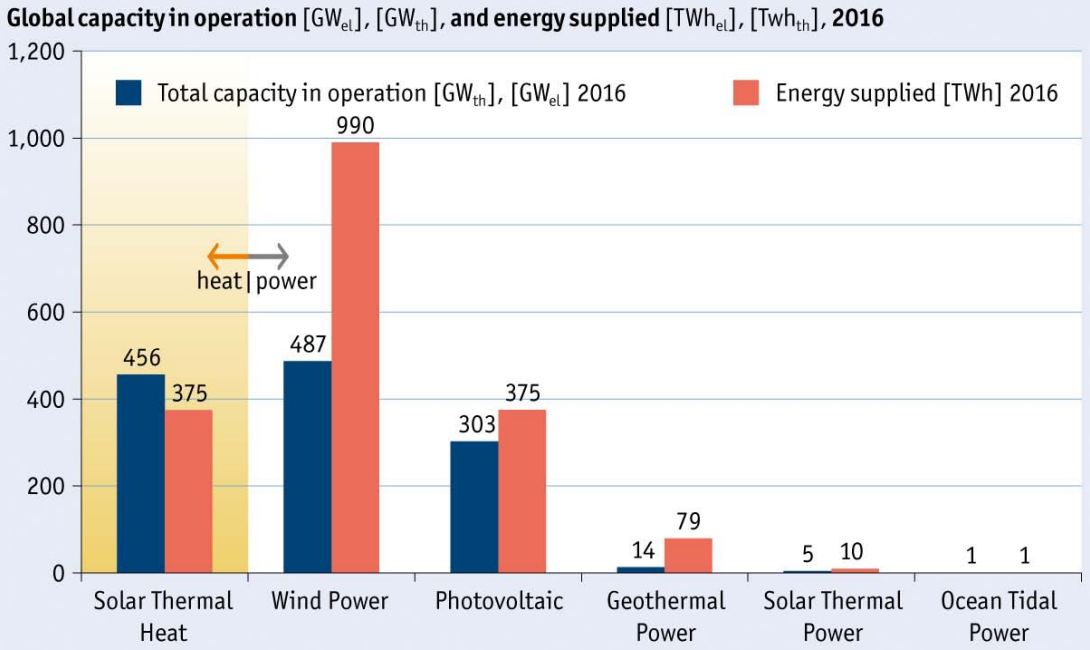
3. 2017 Recap

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 2017, the following Tasks began:

- Task 58 Material and Component Development for Thermal Energy Storage *(Lead Country: Austria)*
- Task 59 Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO2 Emission *(Lead Country: Italy)*

Completed

In 2017, the following Tasks ended:

- Task 51 Solar Energy in Urban Planning *(Lead Country: Sweden)*

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 66 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. SHC 2017 was held jointly with the International Energy Agency's Solar World Congress on October 29 – November 2 in Abu Dhabi, UAE. Approximately 500 people attended representing 58 countries.

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 was presented at SHC 2017 in Abu Dhabi, UAE and recognized a successful program or policy measure that supports solar heating and cooling. The 2017 Solar Award recipient was Austrian Climate and Energy Fund. A total of 10 nominations were received in total.

SHC Book Series

This growing collection of books on Task results is published by Wiley-VCH. In 2017 two books were added to the series: *The Solar Cooling Design Guide: Case Studies of Successful Solar Air Conditioning Design* and *Solution Sets for Net-Zero Energy Buildings: Feedback from 30 Net ZEBs Worldwide*

Books already published in the series are: *Modeling, Design and Optimization of Net-Zero Energy Buildings, Solar and Heat Pump Systems for Residential Buildings,* and *Polymeric Materials for Solar Applications.*

SHC Collaboration

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

Within the IEA

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

IEA Energy in Buildings and Communities TCP is collaborating in Task 59: Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO2 Emission.

IEA Energy Conservation and Energy Storage TCP is collaborating in Task 58: Material and Component Development for Thermal Energy Storage.

IEA Photovoltaic Power Systems TCP is collaborating in SHC Task 53: New Generation Solar Cooling and Heating Systems, and Task 59: Renovating Historic Buildings Towards Zero Energy.

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

Future Buildings Forum the 2017 meeting held in Singapore on 24-25 October 2017 was attended by the SHC Chairman, a SHC Vice Chairman and Australia's Alternate Executive Committee member.

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC TCP 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 was held during SHC 2017 in Abu Dhabi, UAE.

Solar Heat Europe (formally ESTIF), the SHC Programme has a close working relationship with this organization and they supported SHC 2017 and the conference's industry session.

ISO TC 180, the SHC TCP, specifically through Tasks, is supporting the work of ISO TC 180. For example, Task 57: Solar Standards & Certification will continue to support the work of ISO TC 180 and ISO Standard 9806.

Executive Committee Meetings

2017 MEETINGS	
81st ExCo Meeting June 7 – 10	London, England (included Joint Meeting with EBC TCP, special Strategic Planning Session, Technical Tour)
82nd ExCo Meeting November 30 – December 1	Melbourne, Australia (included Joint Meeting with PVPS TCP, Technical Tour)
2018 MEETINGS	
83rd ExCo Meeting June 19 – 21	Stockholm, Sweden (will include National Day, Joint Meeting with EBC TCP, Technical Tour)
84th ExCo Meeting November 13 – 15	Lisbon, Portugal

4. Feature Article

Solar Energy in Urban Planning

Maria Wall
Energy and Building Design, Lund University
Operating Agent for the Swedish Energy Agency

Solar Energy – An Important Part Of Urban Planning

Local energy production by integrating solar energy systems in the built environment is a key ingredient towards sustainable buildings and cities. The built environment accounts for over 40% of the world's total primary energy use and 24% of greenhouse gas emissions. A combination of making buildings more energy efficient and using a larger fraction of renewable energy is therefore a key issue.

How to integrate solar energy systems into buildings is important, but when we worked on this in SHC Task 41: Solar Energy and Architecture, we realized in order to ensure long term solutions, that urban planning also needed to take solar issues into account; What's the purpose of integrating solar systems into a building if in the future it will be shaded by another building across the street? Long term solar strategies including, for example, legal considerations need to be taken into account in urban planning. Therefore, we needed to strengthen solar energy research and development in urban planning and work on how to spread knowledge into education and to professionals.

The main objective of SHC Task 51: Solar Energy in Urban Planning was to support urban planners, authorities and architects by providing guidance for urban planners and policy makers on a large fraction of renewable energy supply. This included developing approaches, methods and tools capable of assisting cities in developing a long term urban solar energy strategy. Heritage and aesthetic issues were carefully considered. Also, the goal was to prepare material and suggest teaching methodologies to strengthen education.

Planners are increasingly calling for more sophisticated decision support tools to assess active solar energy potential and measures to determine the impacts of future development. This also allows building owners to utilize their solar access assets to harvest energy and reduce their exposure to external energy price variability and supply constraints.

The scope of the Task included solar energy issues related to 1) new urban area development, 2) existing urban area development and 3) sensitive and protected landscapes (solar fields). Both solar thermal and photovoltaics were taken into account. In addition, passive solar—as passive solar heating, daylight access and outdoor thermal comfort—was considered in the urban environment. Solar energy integration in existing and in new city districts are two different contexts with different opportunities and constraints. Furthermore, ground based active solar applications are interfacing with urban environments, creating solar landscapes that juxtaposition with the existing urban form with varying levels of aesthetic acceptance. In open landscapes, solar fields need to harmonize with the rural landscape and nature. Understanding these types of existing parameters and challenges under which planners operate is critical.

Action Research Through Case Studies – Resulting In Case Stories

Through action research the participants actively took part in urban planning processes, creating arenas for mutual interaction between researchers and city managers. More than 30 case stories from 10 countries were analyzed and compared in extensive reports[1,2] and the lessons learnt were condensed into guidelines for solar

1 Lobaccaro, G., Lindkvist, C., Wall, M., Wyckmans, A. (eds.), 2017. Illustrative Prospective of Solar Energy in Urban Planning. Collection of International Case Studies. IEA SHC Task 51/Report C1. DOI: 10.18777/ieashc-task51-2017-0002.
2 Lobaccaro, G., Lindkvist, C., Wall, M. (eds.), 2018. National and International Comparison of Case Studies on Solar Energy in Urban Planning. IEA SHC Task 51/Report C2. DOI: 10.18777/ieashc-task51-2018-0001.

energy in urban planning.

One example of the lessons learnt was the importance of raising awareness on how to implement solar energy into an urban area. One holistic approach is to involve all relevant stakeholders of urban planning. This involvement extends to citizen engagement, which is crucial in building agreements, creating understanding and achieving solutions. This approach ensures wide representation of stakeholders and increases the chances of reaching ambitious goals by overcoming barriers in developing solar energy in urban planning through an open communication forum.

The research also illustrated the importance of introducing solar with systematic respect to the urban context to preserve heritage and avoid unnecessary aesthetic conflicts. There is a risk if these aspects are not taken seriously that the social acceptance of solar technologies may decrease and in the long run slow down the pace of solar utilization.

The Urban Planning Process And Supportive Approaches, Methods And Tools

Urban planners are typically generalists who have to consider many different aspects. It is important that methods, tools and approaches are designed to aid urban planners in their work rather than increasing their workload. To structure and describe supportive methods and tools related to different urban planning stages, a generic planning process was developed in SHC Task 51. This involves four stages; 1) comprehensive/strategic planning, 2) urban and landscape design, 3) detailed development plans and 4) architectural design (Figure 1).

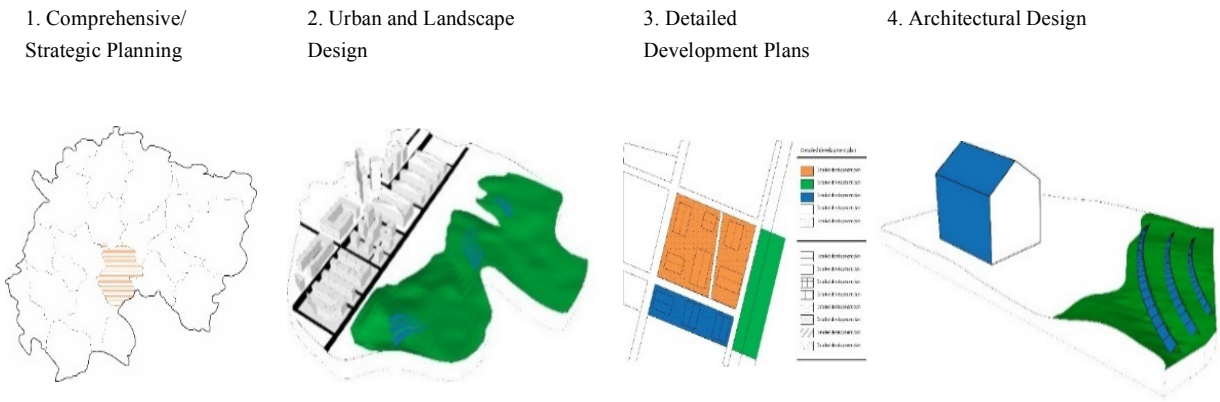


Figure 1. Illustration of four stages of urban planning (source: Marja Lundgren & Johan Dahlberg)

Approaches, methods and tools (AMTs) have been described related to which specific stage of the urban planning process they are relevant. The AMTs can be divided into four types; 1) regulatory, policy and governance approaches, 2) integrated design and planning support, 3) assessment methods and tools, and 4) awareness and consultation methods.

Many software tools exist today where solar insolation of an urban area can be calculated and visualized. However, there is a lack of approaches and methods of how to integrate the results from these tools into traditional urban planning processes. Available software tools also vary in complexity, user friendliness and quality of end result. Extensive work has been carried out in developing approaches, methods and tools that aid in understanding solar potential in an urban planning context as well as defining which level of detail such studies need to be at in different phases of urban planning.

Planners are increasingly calling for more sophisticated decision support tools to assess active solar energy potential and measures to determine the impacts of future development. This also allows building owners to utilize their solar access assets to harvest energy and reduce their exposure to external energy price variability and supply constraints.

Solar Rights Are Needed!

Legal aspects are crucial to highlight in order to ensure the long term access to solar radiation onto buildings and other collecting areas, and will be increasingly important to handle. Historically, solar access rights focused on daylight. Today, with increased local solar energy production, there is a need to revisit the legal framework to identify to which extent it enhances or hinders deployment of solar energy technologies. The analysis carried out from national perspectives shows that the law is still unsatisfactory. There is considerable scope for legal reform in many countries and the typical subjective judgment that a lack of solar access only is a 'nuisance', creates significant investment uncertainty and barriers that could be solved by more informed decision-making processes.

Ultimately, the research found that active solar systems have a critical role to play and their deployment will conflict with future development heights if there is not a more cohesive relationship between planning approval processes and building innovation.

Education Is Important

A review of education on solar energy in urban planning showed that solar energy as it relates to urban planning was rarely part of the curriculum at universities. The identified courses were instead mostly offered in other disciplines[3]. The identified gaps and barriers in existing courses and pedagogy provide knowledge that can be implemented in relevant seminars, lectures and tools for educating the next generation of architects, urban planners and specialist planners. Supporting material and reports are accessible via the SHC Task 51 website[4]. For example, a tool called Solar Potential Analysis was developed for both students and life-long learners[5].

Outlook

As the number of sustainable developments continues to grow it is inevitable that the demand for solar technologies in both urban environments and open landscapes will also continue to grow. And, with this growth comes the need for more work on ways to help urban planners and designers understand the complexities when dealing with daylight, active solar and energy performance in cities with rapidly densifying populations. The role of the urban planner is to design areas that can be built to last. Urban design that addresses the need for daylight and sunlight will not only contribute to a healthier urban environment, it will also enable solar thermal technologies and photovoltaics to be implemented if not now, in the future. Action research related to planning and designing solar neighborhoods will be an important activity ahead, enabling researchers, professionals and municipalities, including their inhabitants, to jointly develop and test concepts and solutions for sustainable use of solar resources in the built environment.

Increasing global population growth means that cities will require more resources while at the same time renewable energy sources are expected to rapidly expand and the land needed to support cities is expected to increase. Renewable energy systems are set to be a major land user in the near future and more research is needed to understand the environmental and social impacts of these systems and how rapidly growing cities affect the land use in the immediate surroundings. In this respect, also large scale solar systems in sensitive landscapes need further attention.

Finally, education and dissemination need to be strengthened to rapidly ensure that knowledge and support are offered for present and future professionals and educators. The work of SHC Task 51 will hopefully support such developments and knowledge transfer.

Parts of this article are based on the following more comprehensive conference paper: Urban Planning for Solar Energy – IEA SHC Task 51. Wall, M., Snow, M., Dahlberg, J., Lundgren, M., Lindkvist, C., Lobaccaro, G., Siems, T., Simon, K. & Munari Probst, MC. SHC 2017 / SWC 2017 Conference. Paper to be published online in 2018.

3 Siems, T., Simon, K., Wall, M. (eds.), 2017. State-of-the-Art of Education on Solar Energy in Urban Planning. Part I: Approaches and Methods in Education. IEA SHC Task 51/Report D1 Part 1. DOI: 10.18777/ieashc-task51-2017-0001.
4 See http://task51.iea-shc.org/publications.
5 Hendel, S. & Voss, K., 2017. Urban-based solar potential analysis – A teaching and learning tool for determining the solar energy use at the district scale. User manual and online tool. IEA SHC Task 51.

5. Completed Tasks

Task 51 – Solar Energy in Urban Planning

Prof. Maria Wall
Energy and Building Design, Lund University
Operating Agent for the Swedish Energy Agency

Task Overview

The main objective was 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 developed in this Task included 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 worked 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 is also appropriate for postgraduate courses and continuing professional development.

To achieve these objectives, work was focused 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/processes/concepts)
4. Education and dissemination

Task 51 required a dialogue and cooperation with municipalities in each participating country. This ensured good communication with different key actors, gave 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 were also a target group in the dissemination phase.

Participating Countries

	Research Institutes	Universities	Companies	Municipalities
Australia		1		Yes
Austria	1	2	1	Yes
Canada		2	1	Yes
China			1	Yes
Denmark			4	Yes
France		3	1	Yes
Germany	1	2	1	Yes
Italy	2	2		Yes
Luxembourg (observer)	1			Yes
Norway		1		Yes
Sweden		1	1	Yes
Switzerland		2		Yes
TOTAL	**5**	**16**	**10**	

Task Duration

This Task started in **May 2013** and ended in **December 2017**. Final deliverables will be published during the first part of 2018.

Collaboration with Other SHC Tasks and Outside Organizations/Institutions

Mostly in the first phase, information exchange was carried out with the SHC Task 52: Solar Heat and Energy Economics in Urban Environments, EBC Annex 63: Implementation of Energy Strategies in Communities, and EBC Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles. All these projects were running in parallel and ending in 2017. The purpose of this collaboration was mainly to ensure that there was not (much) overlap of work. As OA, I have sent short semi-annual status reports to the PVPS Executive Committee.

Collaboration With Industry

For SHC Task 51, "industry" represents actors like municipalities (e.g., urban planners), architects, energy consultants, building owners and real estate developers. The collaboration and communication was mainly carried out in two ways. One way was the organization of public workshops, seminars etc. in conjunction with Task Expert Meetings. Another way was the local and regional activities in different countries, based on the action research applied in SHC Task 51. This long term collaboration with local municipalities, urban planners, architects, consultants, energy suppliers and real estate developers was shaped around local urban developments. Such developments were, for example, planning of new urban areas, infills and active solar integration in existing urban areas, and landscape planning. Through this collaboration, Task experts learned about real challenges, needs and opportunities, and could test methods and tools and get feedback. The municipalities and other actors got support from the Task regarding knowledge, methods and tools as well as detailed support regarding the actual case. In this way, it was also indirectly a way to disseminate Task results and served as a "wake-up" call for municipalities.

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 51 webpage and in the activities of the specific Subtasks:

- Subtask A: Legal Framework, Barriers and Opportunities
  (Subtask Leader: Mark Snow, University of New South Wales, Australia)

- Subtask B: Process, Methods and Tools
  (Subtask Leaders: Johan Dahlberg and Marja Lundgren, White Arkitekter AB, Sweden)

- Subtask C: Case Studies and Action Research
  (Subtask Leaders: Carmel Lindkvist and Gabriele Lobaccaro, Norwegian University of Science and Technology (NTNU), Norway)

- Subtask D: Education and Dissemination
  (Subtask Leaders, Tanja Siems and Katharina Simon, Bergische Universität Wuppertal)

Action Research

The "engine" of SHC Task 51 was its action research. Action research involves the process of actively participating in an organization change situation whilst conducting research. In SHC Task 51, this was reflected in the participants' collaboration with urban planners and other key actors within local urban planning developments in each participating country. In this way information about important issues to address was identified. The goal was to develop knowledge that is useful for practicing urban planners and for education of architects and planners.

Case Studies and Case Stories

In total 34 case studies and stories were documented from the Task (Subtask C), showing different applications focusing on new urban areas, existing urban areas and landscapes. Active solar systems (solar thermal and PV) and passive solar strategies (daylighting) were key aspects in these studies. The three reports based on the case studies are useful both to learn from and adapt to new project developments, and as inspiration for urban planners, architects, developers and other actors to continue this important development process.

Legislation and voluntary initiatives

Although we cannot directly make changes to legislation and regulations, we could have an impact on highlighting the barriers and challenges in present and future planning and influence decision makers to improve

the decision-making process and secure solar access rights. The survey of legal cases concerning installation of solar energy systems into buildings identified the barriers and need for legal reform and for more informed decision-making processes. These findings were important and something that needs further consideration in new projects and developments.

Methods and tools

New as well as developments of existing methods and tools were tested in real planning situations as well as within the Task. Not only the methods and tools are important results but also guidelines how and when they are suitable to use in the planning process. This is reported in Subtask B: Approaches, Methods and Tools for Solar Energy in Urban Planning. Many different examples are described. One example of a very important tool for SHC Task 51 and the developments within existing urban areas is the LESO-QSV tool. This has been used within the Task for the case studies on active solar system integration into existing urban environments, but are also used in new situations when cities are mapping urban areas to identify where active solar systems may be implemented and which level of integration quality is needed for different situations (industry area, old city centre, etc.). There is also a possibility to use the method in the process when cities are evaluating and giving building permits for solar integrations. An example of this success is that the City of Malmö, Sweden, invited Maria Cristina Munari Probst to discuss the use of the method for Malmö and arranged a workshop for local key actors to test and discuss solar energy integration at a local perspective. Malmö wishes to continue working with this method, and apply it on the local situation in the region. Maria Cristina Munari Probst and Christian Roecker, EPFL, also received the Swedish prize “innovation of the year” in 2016 (75,000 Euro), for their innovative work on this method.

Education

To highlight education gave us information about the (low) status on education on solar energy related to urban planning. This became an important basis for identifying needs for developments, both in courses and in teaching tool developments. The development of supporting teaching materials, for example, the Solar Potential Analysis tool and the report on Summer schools showing teaching methodologies and results from a summer course in Germany will be useful in further teaching situations. As an example, a university in China after reading the results from Subtask D on education and want to develop course(s) on solar energy in urban planning since it is presently missing in their environment. Also, they will consider using the report on summer schools to adopt and use locally.

Umbrella platform

The platform will serve as a vehicle for disseminating key information and finding by linking the different Task results – reports, other web platforms, tools, etc. This will be tested as a development of the standard way to present results on the SHC website.

Publications

Task Reports & Online Tools

Author(s)/ Editor	Title	Report No. Publication Date	Target Audience
Snow, M., Dahlberg, J. & Lundgren. M. (Eds)	Current Status of Solar Energy in Urban Planning. A Review of Urban Planning Legislation, Voluntary Initiatives and Urban Planning Processes	Task 51/Report A1.B1 *To be published in 2018*	
Snow, M. (ed.)	Barriers, Challenges and Needs of Urban Planning for Solar Energy Implementation	Task 51/Report A2 *To be published in 2018*	
Snow, M. (ed.)	Solar Energy Targets and Assessment of	Task 51/Report A3	

	Potential in Urban Planning		
Dahlberg, J. & Lundgren, M. (eds)	Approaches, Methods and Tools for Solar Energy in Urban Planning	Task 51/Report B2 *To be published in 2018*	Practitioners
Lobaccaro, G., Lindkvist, C., Wall, M. & Wyckmans, A. (eds)	Illustrative Prospective of Solar Energy in Urban Planning: Collection of International Case Studies	Task 51/Report C1 June 2017 *DOI:10.18777/ieashc-task51-2017-0002*	Urban planners, architects, energy engineers, etc.
Lobaccaro, G., Lindkvist, C. & Wall, M. (eds)	National and International Comparison of Case Studies on Solar Energy in Urban Planning	Task 51/Report C2 January 2018 *DOI:10.18777/ieashc-task51-2018-0001*	Urban planners, architects, energy engineers, etc.
Lobaccaro, G., Lindkvist, C. & Wall, M. (eds)	Lesson Learnt from Case Studies of Solar Energy in Urban Planning	Task 51/Report C3 *To be published in 2018*	Urban planners, architects, energy engineers, etc.
Siems, T., Simon, K. & Wall, M. (eds)	State-of-the-Art of Education on Solar Energy in Urban Planning. Part 1: Approaches and Methods in Education	Task 51/Report D1 Part 1: May 2017 *DOI:10.18777/ieashc-task51-2017-0001*	Educators
Siems, T., Simon, K. & Voss, K. (eds)	State-of-the-Art of Education on Solar Energy in Urban Planning. Part 2: Solar Irradiation Potential Tools in Education	Task 51/ Report D1 Part 2 *To be published in 2018*	Educators, students
Siems, T. & Simon, K	Stadt im Wandel- Solarenergie im städtebaulichen Kontext Lehrmethoden und Resultate (German version)	Task 51/Report D2 June 2017 *DOI:10.18777/ieashc-task51-2017-0004*	Educators
Siems, T. & Simon, K.	Summer Schools on Solar Energy in Urban Planning- Teaching Methodologies and Results (English version)	Task 51/Report D2 June 2017 *DOI:10.18777/ieashc-task51-2017-0003*	Educators
Händel, S. & Voss, K.	Urban-based solar potential analysis – A teaching and learning tool for determining the solar energy use at the district scale. User manual.	Task 51/User Manual December 2017	Educators, students
Online Tool: Umbrella “Solar energy in urban planning” showing main results and linking to deliverables	Task 51 leaders and experts	SHC Task 51 website *To be posted in 2018*	
Online Tool: Case	Editors: Gabriele Lobaccaro, Carmel	SHC Task 51	

Studies on Solar Energy in Urban Planning	Lindkvist	website *To be posted in 2018*	
Online Tool: Solar Potential Analysis on District Level	Hendel, S. & Voss, K.	https://projektinfos.energiewendebauen.de/en/project/werkzeug-fuer-die-staedtebauliche-solarpotenzialanalyse/ December 2017	
Online Tool: LESO-QSV method	MC Munari Probst, C Roecker	http://leso.epfl.ch/leso-qsv March 2017	
Online Tool: Collection of Innovative Solar Products for building integration	Task 41 / Task 51: coordinated by MC Munari Probst, C Roecker. Product updates: P. Florio, EPFL-LESO, Lausanne	www.solarintegrationsolutions.org (continuously updated since 2012)	
Online Tool: Solar Planning: Guidelines for Urban Planners	Kanters, J., & Wall, M. Division of Energy and Building Design, Lund University	www.solarplanning.org/ (2014 – ongoing)	

Journal Articles, Conference Papers, etc.

Author(s)/Editor	Title	Publication / Conference	Bibliographic Reference
Wall, M., Snow, M., Dahlberg, J., Lundgren, M., Lindkvist, C., Lobaccaro, G., Siems, T., Simon, K. & Munari Probst, MC.	Urban Planning for Solar Energy – IEA SHC Task 51	Joint Conference SHC 2017 and SWC 2017 UAE, 30 Oct 30 – 2 Nov 2017	To be published in Conference Proceedings
Nault, E., Moonen, P., Rey, E. & Andersen, M.	Predictive models for assessing the passive solar and daylight potential of neighborhood designs: A comparative proof-of-concept study	*Building and Environment*, 116, 1-16.	2017 https://doi.org/10.1016/j.buildenv.2017.01.018
Nault, E., Aguacil Moreno, S., Rey, E. & Andersen, M.	Energy performance analysis in interdisciplinary education – Lessons learned from a simulation-based teaching approach	33rd International Conference on Passive and Low Energy Architecture (PLEA)	Edinburgh, 2017
Peronato, G., Kaempf J.H., Rey, E., Andersen,	Integrating urban energy simulation in a parametric environment: a Grasshopper	33rd International Conference on Passive and Low	Edinburgh, 2017

M.	interface for CitySim	Energy Architecture (PLEA)	
Paparella, R. & Caini, M.	Comparison among environmental certification systems. Relationships between systems and project. Case study: the recovery of a RSA	*Valori e valutazioni*, N. 17	Nov. 2017, ISSN:2036-2404, Dei Tipografia del Genio Civile, pp. 39-58
Polo López, C. S.	Densificazione e patrimonio storico-culturale	*Archi*, Nr. 3/2017	June 6, 2017 Publisher: espazium SA, Zurich ISSN 1422-5417
Lobaccaro, G., Carlucci, S., Croce, S. Paparella, R. & Finocchiaro, L.	Boosting solar accessibility and potential of urban districts in the Nordic climate: A case study in Trondheim	*Journal of Solar Energy*	Vol. 149, pp 347-369 http://dx.doi.org/10.1016/j.solener.2017.04.015
Kanters, J., Johansson, J. & Fossum, T.	Designing a solar neighbourhood in Malmö Hyllie	Sustainable City Development – UN conference	In proceedings of Sustainable City Development, 30.11-02.12, 2016
Siems, T., Simon, K.	Sommerakademie „Stadt im Wandel“ Universitäre Lehre, Forschung und Praxis- Hand in Hand	*PlanerIn*, SRL	Heft 6_2016
Siems, T. & Simon, K.	Summer School with a Twist	Solar Update Newsletter	Vol.64/ Dec. 2016
Florio, P., Roecker, C., Munari Probst, MC. & Scartezzini, JL.	Visibility of building exposed surfaces for the potential application of solar panels: a photometric model	Eurographics UDMV	Liège, (Belgium) 8 Dec 2016
Solarthermalworld.org/ Bärbel Epp	IEA SHC Task 51: German Summer School Educates Students on Solar Urban Planning	Solarthermalworld.org online newsletter	October 2016
Solarthermalworld.org/ Bärbel Epp	IEA SHC: Attractive Solar Solutions for Urban and Landscape Planning	Solarthermalworld.org online newsletter	September 2016
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 conference 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	CESB16. Prague, 22–24 June 2016	In CESB16 proceedings, ISBN 978-80-271-

	applicable to a stock property of national significance"		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
Solarthermalworld.org/ Bärbel Epp	IEA SHC TASK 51: "Integrate Energy Perspectives into Spatial Planning of Urban Areas". Based on material presented at Task 51 seminars	Solarthermalworld.org online 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	*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. &	Sensitivity of calculated solar irradiation to the level of detail: insights from the	Submitted to PLEA 2016 (abstract	Los Angeles,

Andersen M.	simulation of four sample buildings in urban areas	accepted, full paper submitted)	2016
Scognamiglio, A.	'Photovoltaic landscapes': Design and assessment. A critical review for a new transdisciplinary design vision	*Renewable and Sustainable Energy Reviews*	55 (2016), pp 629–661 http://dx.doi.org/10.1016/j.rser.2015.10.072
Polo López, C. S., Sala, M., Tagliabue, L. C., Frontini, F. & Bouziri S.	Solar Radiation and Daylighting Assessment Using the Sky-view Factor (SVF) Analysis as Method to Evaluate Urban Planning Densification Policies Impacts.	SHC 2015 conference, Istanbul, 2-4 December 2015	*Energy Procedia* Volume 91, June 2016, Pages 989–996. DOI:10.1016/j.egypro.2016.06.266
Sala, M., Polo López, C. S., Frontini, F., Tagliabue, L. C., & De Angelis, E.	The energy performance evaluation of buildings in an evolving built environment: an operative methodology	SHC 2015 conference, Istanbul, 2-4 December 2015	*Energy Procedia* (2016) Volume 91, June 2016, Pages 1005-1011. DOI:http://dx.doi.org/10.1016/j.egypro.2016.06.268
Lobaccaro, G., Chatzichristos, S. & Leona, V.A.	Solar optimization of housing development, (full paper and poster)	SHC 2015 Istanbul, 2-4 December 2015	
Siems, T., Simon, K. & Voss, K.	State-of-the-Art: Solar Energy in Urban Planning Education	Solar Update Newsletter	November 2015
Solarthermalworld.org/ Bärbel Epp	IEA SHC Task 51: Urban Planners Know Little about Solar Energy Potential (Interview with M.Wall)	Solarthermalworld.org online newsletter	November 2015
MC Munari Probst, C Roecker	Solar energy promotion & urban context protection: LESO-QSV (Quality - Site - Visibility) Method	PLEA2015 Bologna, 9-11 Sept 2015	
C. S. Polo López, F. Frontini, S. Bouziri.	Urban densification and energy performance of existing buildings: a case study	CISBAT 2015: Future Buildings and Districts - Sustainability from Nano to Urban Scale 9-11 September 2015, Lausanne	ISBN Electronic version: 978-2-9701052-2-0. ISBN Print-version: Vol.I 978-2-9701052-0-6, Vol.II 978-2-9701052-1-3
Polo López, C. S., Sala, M., Frontini, F., Tagliabue, L. C. & De Angelis, E.	Solar energy availability in urban densification process impact on existing buildings in a Swiss case study	Sustainable Built Environment Conference, SBE Switzerland, 13-17	In proceedings, published by vdf ISBN: 978-3-7281-3774-6 (ebook),

		June 2016	DOI:10.3218/3774-6
Maurer, C., Cappel, C., Kuhn, T. E.	Modelling building-integrated solar thermal systems	BPSA (Hg.): Building Simulation Conference India, 7-9 December 2015	http://publica.fraunhofer.de/dokumente/N-382850.html
Paparella, R. & Caini, M.	Approccio Metodologico per il Recupero Sostenibile del Patrimonio Edilizio Esistente: Applicazione in casi studio significativi	Colloqui.AT.e, Conference Convegno Ar.Tec Italy, 26-28 November, 2015	
Gobbi, M., Bortolato, M., Caini, M. & Paparella, R.	Innovative solar thermal concentrating roof-integrated collector: technological and formal issues	10th Conference on Advanced Building Skins Switzerland, 3-4 November 2015	ISBN: 978-3-98120538-1, pp. 183-192
Maurer, C., Cappel, C., & Kuhn, T. E.	Simple models for building-integrated solar thermal systems	*Energy and Buildings*	103 (2016), pp. 118–123. DOI:10.1016/j.enbuild.2015.05.047 http://publica.fraunhofer.de/dokumente/N-354587.html
Maurer, C., Sprenger, W., Lämmle, M. & Kuhn, T. E.	Simple models for architecture with BIPVT or BIST	*Energy Forum on Advanced Building Skins*	2015 http://publica.fraunhofer.de/dokumente/N-435545.html
Nault, E., Rey, E., & Andersen, M.	Towards a predictive model for assessing the passive solar potential of neighborhood designs	The Building Simulation 2015 India, 7-9 December 2015	2015, in print
Nault, E., Rastogi, G., Rey, E., & Andersen, M.	The sensitivity of predicted energy use to urban geometrical factors in various climates	PLEA2015 Bologna, 9-11 Sept 2015	http://www.plea2015.it/book/download.php?id=458
Peronato, G., Rey, E., & Andersen, M.	Sampling of building surfaces towards an early assessment of BIPV potential in urban contexts	PLEA2015 Bologna, 9-11 Sept 2015	http://www.plea2015.it/book/download.php?id=642
Nault, E., Peronato, G., Rey, E., & Andersen, M.	Review and critical analysis of early-design phase evaluation metrics for the solar potential of neighborhood designs	*Building and Environment*	92, 679–691, 2015 http://doi.org/10.1016/j.buildenv.2015.

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Jakutyte-Walangitang, D.	Tapping Solar Energy in Urban Areas as significant means to Climate Change Mitigation	1st International Academic Conference on Climate Change and Sustainable Heritage 2015, Austria	
Hachem, C.	Design of a base case mixed-use community and its energy performance	6th International Building Physics Conference 2015, Italy	
Hachem C., Cubi, E. Bergerson, J.	Energy performance of a solar mixed-use community	4th Climate Change Technology Conference 2015, Canada	
Hachem, C.	Integrated design considerations for solar communities	*Green Buildings*	V. 10, N2.2015
Hachem C., Cubi, E. Bergerson, J.	Energy performance of a solar mixed-use community	*Sustainable Cities and Communities* (Special issue)	2015
Peronato, G., Nault, E., Cappelletti, F. Peron, F. & Andersen, M.	A parametric design-based methodology to visualize building performance at the neighborhood scale.	Proceedings of BSA 2015	In print
Eicker, U., Nouvel, R., Duminil, E., Coors, V.	Assessing Passive and Active Solar Energy Resources in Cities Using 3D City Models	*Energy Procedia*	Volume 57 (2014) 896 – 905. DOI:10.1016/j.egypro.2014.10.299
Good CS., Lobaccaro G., Hårklau S.	Optimization of solar energy potential for buildings in urban areas – a Norwegian case study	*Energy Procedia*	Volume 58, 2014, pp 166-171
Dahlberg, J., Lundgren, M., Dahman Meyersson, S., Lindkvist, C., Wyckmans, A., Snow, M. & Wall, M.	Solar Energy in Urban Planning. Task 51	Solar Update Newsletter	November 2014
Dahlberg, J., Kanters, J.,Lundgren, & Wall, M.	Solar energy on the urban scale (solenergi i stadsbyggnadsskalan)	*PLAN*	Nr.6 Energi. 2014
Kanters, J., & Wall, M.	The impact of urban design decisions on net zero energy solar buildings in Sweden	*Urban, Planning and Transport Research*	2014, pp 312-332 doi:10.1080/21650

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Kanters, J., Wall, M. & Dubois, M.-C.	Development of a Façade Assessment and Design Tool for Solar Energy (FASSADES)	*Buildings*	4(1), pp 43-59.2014
Scognamiglio, A., Garde, F., Ratsimba, T., Monnier, A. & Scotto, E.	Photovoltaic Greenhouses: A Feasible Solution For Islands? Design, operation, monitoring and lessons learned from a real case study	Technical Digest 6th World Conference on Photovoltaic Energy Conversion Japan, November 2014	In proceedings
A. Scognamiglio, A. & Garde, F.	Photovoltaics architectural and landscape design options for Net Zero Energy Buildings, towards Net Zero Energy Communities: spatial features and outdoor thermal comfort related considerations	*Progress in Photovoltaics: Research and applications*	2014 http://dx.doi.org/10.1002/pip.2563
Paparella,R. & E. Saretta, E.	Photovoltaics in Italian historical city centers: do PV products and building codes have a meeting point?	World Sustainable Buildings Conference, Spain 2014	In Proceedings
MC Munari Probst, C Roecker	Innovative solar products for architectural integration: a joint Task 41 and Task 51 IEA website	Eurosun 2014 France, September 2014	
Scognamiglio, A., Garde, F., Ratsimba, T., Monnier, A. & E. Scotto, E.	Photovoltaic greenhouses: a feasible solution for islands? Design, operation, monitoring and lessons learned from a real case study	The 6th World Conference on Photovoltaic Energy Conversion (WCPEC-6) Japan, September 2014	
Scognamiglio, A & Garde, F.	Photovoltaics' architectural and landscape design options for Net Zero Energy Buildings, towards Net Zero Energy Communities: spatial features and outdoor thermal comfort related considerations	*Progress in Photovoltaics*	29th EUPVSEC, 22-27 September 2014, Netherlands
Good, C. S., Lobaccaro, G. & Hårklau, S.	Optimization of solar energy potential for buildings in urban areas – a Norwegian case study	Renewable Energy Research Conference (RERC) Centre for Renewable Energy (SFFE) Norway, June 2014	
Hachem, C., Fazio, P. &	Design of curtain wall facades in	ISES Conference	

Athienitis, A.	multistory buildings for improved solar potential and daylighting distribution	Mexico, November 2013	
Hachem, C., Fazio, P. & Athienitis, A.	Effect of Housing Density on Energy Performance of Solar-optimized Residential Configurations	CISBAT Conference Switzerland, September 2013	
Hachem C., Fazio, P., and Athienitis, A.	Solar optimized residential neighborhoods: Evaluation and design methodology	*Journal of Solar Energy*	Vol. 95, pp. 42–64, 2013
MC Munari Probst	Technologies Solaires et Architecture - une Synthèse delicate (opening article for the special issue "Construction Solaire" of the Swiss journals *Tec 21* and *Tracé and Archi*, (translated in French, German, Italian)	*Tec 21* *Tracé and Archi*	May 2013

Conferences and Workshops

Task participants presented Task work and results at approximately 77 conferences and workshops over the course of the Task.

Task Meetings

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

1. Lisbon, Portugal March 2010
2. Lund, Sweden September 2012

Over the entire term of the Task a total of nine Experts Meetings were held and all included an additional workshop, symposium or other event.

Meeting	Date	Location	# Participants
Experts Meeting #1 (kick-off meeting)	29-30 May 2013	Stuttgart, Germany	30 (8 countries)
Experts Meeting #2 (in conjunction with SHC 2013)	26-29 September 2013	Freiburg, Germany	32 (10 countries)
Experts Meeting #3 (plus workshop and bilateral meetings with industry)	25-28 March 2014	Naples, Italy	41 (11 countries)
Experts Meeting #4 (plus symposium)	25-29 September 2014	Toronto, Canada	34 (12 countries)
Experts Meeting #5 (plus symposium)	17-20 March 2015	Trondheim, Norway	37 (11 countries)
Experts Meeting #6 (plus symposium)	28 September-2 October 2015	Saint-Pierre, Tampon and Saint-Denis, Reunion	26 (12 countries)

		Island, France	
Experts Meeting #7 (plus 3 seminars)	7-11 March 2016	Stockholm, Sweden	24 (11 countries)
Experts Meeting #8 (plus workshop on tools and Summer School on 19-26 September)	28-29 September 2016	Berlin, Germany	33 (11 countries)
Experts Meeting #9 (plus public seminar, Urban practitioner workshop on Solar Energy in Urban Planning	20-24 March 2017	Sydney, Australia	21 (10 countries)

SHC Task 51 Participants

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AUSTRIA	Michael Malderle	University of Technology Graz	
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CANADA	Elisa Bernier	Ryerson University	National Expert
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CANADA	Miljana Horvat	Ryerson University	National Expert
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CANADA	John Crace	Green Power Labs Inc.	National Expert
CANADA	Marlene Moore	Green Power Labs Inc.	National Expert
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DENMARK	Stig Mikkelsen	Mikkelsen Arkitekter A/S	National Expert
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ITALY	Andrea Giovanni Mainini	Politecnico di Milano	National Expert
ITALY	Rossana Paparella	Padua University	National Expert
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NORWAY	Lene Lad Johansen	Oslo Municipality	National Expert
NORWAY	John Paloma Nwankwo	Oslo Municipality	National Expert
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NORWAY	Gabriele Lobaccaro	Norwegian University of Science and Technology (NTNU)	Subtask C Leader
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SWEDEN	Sara Dahman Meyersson	White Arkitekter AB	National Expert
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SWITZERLAND	Francesco Frontini	University of Applied Sciences and Arts of Southern Switzerland (SUPSI)	National Expert
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SWITZERLAND	Cristina S. Polo Lópes	University of Applied Sciences and Arts of Southern Switzerland (SUPSI)	National Expert
SWITZERLAND	Maria Cristina Munari Probst	Ecole Polytechnique Fédérale de Lausanne (EPFL)	Working Group Leader – Existing Urban Areas
SWITZERLAND	Christian Roecker	Ecole Polytechnique Fédérale de Lausanne (EPFL)	Working Group Leader – Existing Urban Areas
SWITZERLAND	Pietro Florio	Ecole Polytechnique Fédérale de Lausanne (EPFL)	National Expert
SWITZERLAND	Emilie Nault	Ecole Polytechnique Fédérale de Lausanne (EPFL)	National Expert
SWITZERLAND	Guiseppe Peronato	Ecole Polytechnique Fédérale de Lausanne (EPFL)	National Expert

6. Ongoing Tasks

Task 52 – Solar Heat and Energy Economics in Urban Environments

Sebastian Herkel
Fraunhofer ISE
Operating Agent for Forschungzentrum Jülich GmbH

Task Overview

IEA SHC Task 52 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 neighborhoods)
- 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 2017

Subtask A: Energy Scenarios

The fourth year's activities in Subtask A were the finalization of energy scenarios. For four selected countries an overall energy scenario reflecting the role of solar heat in the four countries were identified for 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	Austria, Denmark, Germany, Italy	Germany	Austria

A detailed scenario analysis for Germany using the energy system analysis model ReMod-D gives the amount of heat produced by different technologies for different ambition levels of CO_2-reduction. The share of solar heat varies from 2% to 5% (2030) and 7% to 17% (2050). The higher the ambition level is, the higher the share of solar thermal might be in the scenarios. With rising costs for solar thermal, the share will be lower, as well with a higher availability of biomass. The use of solar thermal in district heating will be approximately 20% in 2050 and grow up to 40% of the heat produced by solar thermal. It can be seen that solar thermal could ease the pressure on scarce renewable resources, such as biomass,but will be competing with other renewable sources as biomass in a high-renewable energy system in saving CO_2.

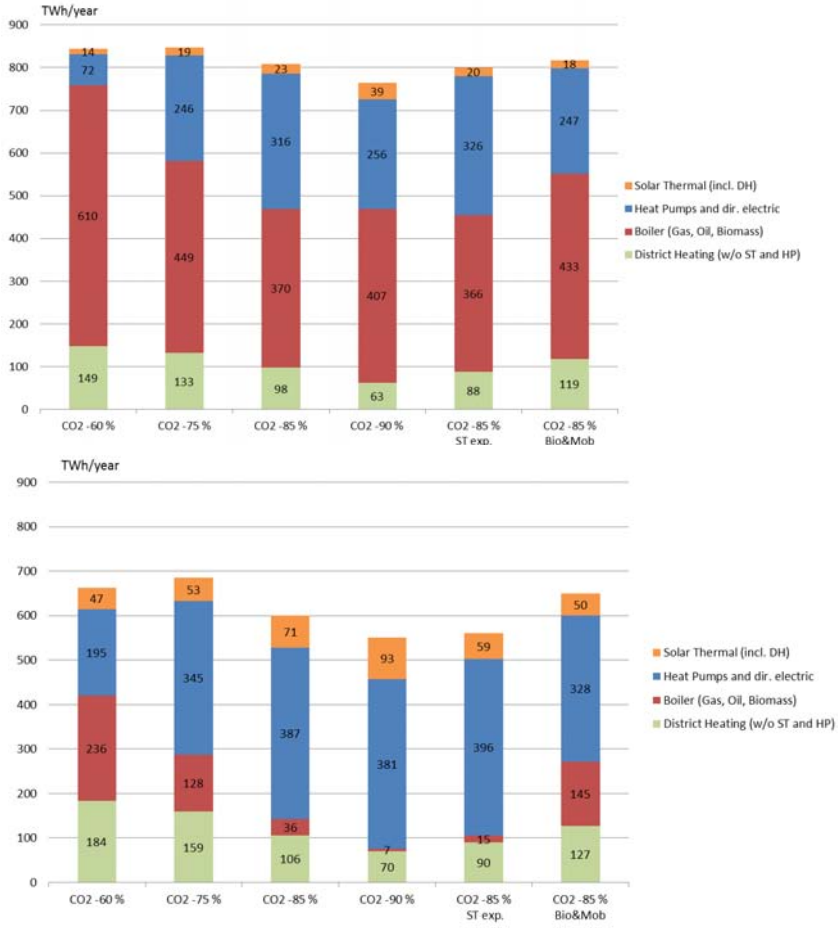


Figure 1. Scenario of contribution of different technologies for low temperature heat production in 2030(upper graph) and 2050 (lower graph) for different scenarios. Source A. Palzer, Fraunhofer ISE

The development of cost curves for heat savings in buildings by the application of measures on the building envelope showed remarkable saving potentials in existing buildings for the analyzed countries Austria, Denmark, Germany and Italy. While the overall potentials for heat savings as well as the costs for these savings differ between the countries, the shape of the cost curves is similar. In the first part of the cost curves, reflecting the cheaper saving options, the increase of costs with increased level of savings is relatively low. In the second part of the cost curves, reflecting cumulated savings of more than 60-80% of the overall saving potential, the costs increase remarkably. This is due to the lower effect of the same insulation applied to an already insulated surface compared to a non-insulated surface.

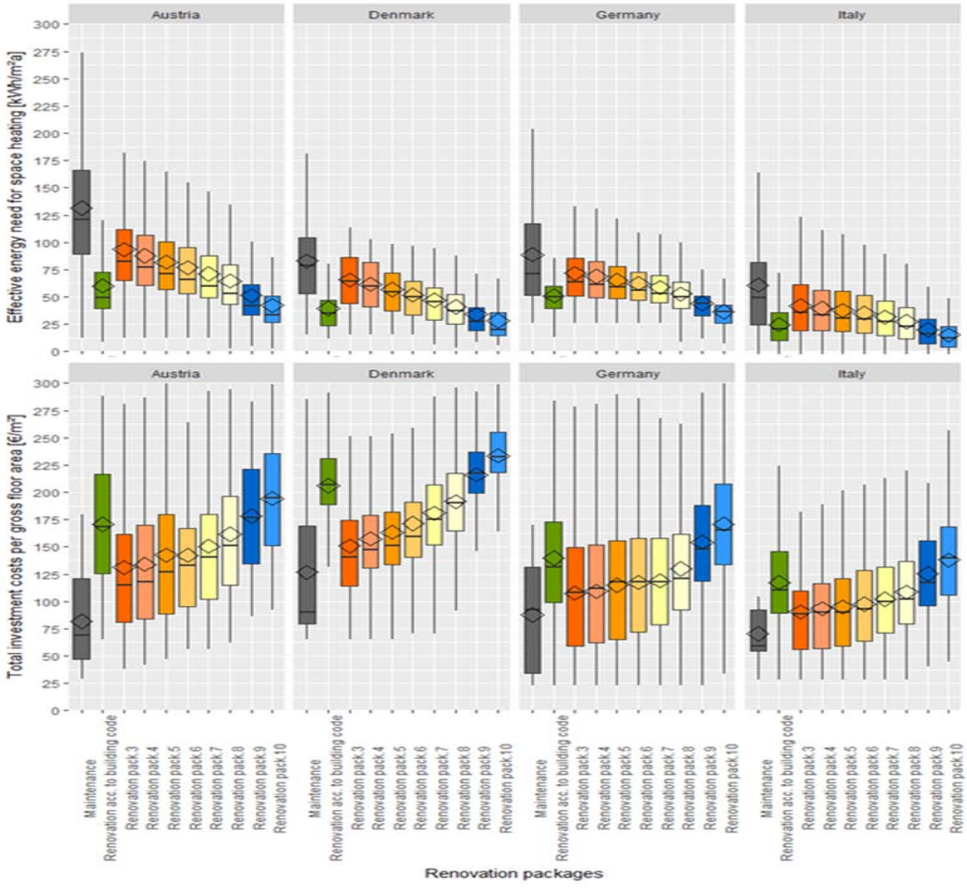


Figure 2. Box plots of effective energy needs and total investment costs for all building classes in the different countries when implementing the maintenance and renovation packages as defined for this analysis. Source M. Hummel, eeg TU Wien

The analysis showed the following highly influencing factors on the additional costs of heat savings in buildings: high shares of window area in the building envelope leads to remarkably higher investment costs for reaching similar amounts of savings. This is due to the fact that the investment costs in for windows per square meter of surface area are around three times higher than for the insulation of opaque surfaces. More external surface area increases the investment costs and therefore higher surface-to-volume ratios lead to higher renovation costs. Renovation measures on the building surface are more cost effective in places with higher space heating needs. This is because applying the same measure leads to lower savings in warmer places or in places where buildings already contain higher levels of insulation. The additional costs for heat savings are remarkably higher if a maintenance action is assumed as reference action compared to assuming e.g. a standard renovation as the reference action.

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

B1 Methodology

In Subtask B the focus was on the assessment of the solar heat potential using GIS-data. A three-step methodology was developed as follows:

1. Step 1 – Database with most suitable networks
    a. Database of district heating grids
    b. The “DH city” does not have access to excess heat from excess heat activities (EHA)
    c. The “DH city” does not have access to Waste-to-Energy (WtE) incineration facilities
2. Step 2 – Availability of suitable land close to the city/town areas
    a. Radius from DH networks
    b. Available agricultural area within this “corridor”/”zone”
    c. Required area for solar collector fields
3. Step 3 – Add cost assumptions
    a. Costs for collectors, storage, transmission pipe, land, electricity costs
    b. Assuming max. accepted heat price

Based on this map with the potential for solar thermal use in a district can be elaborated.

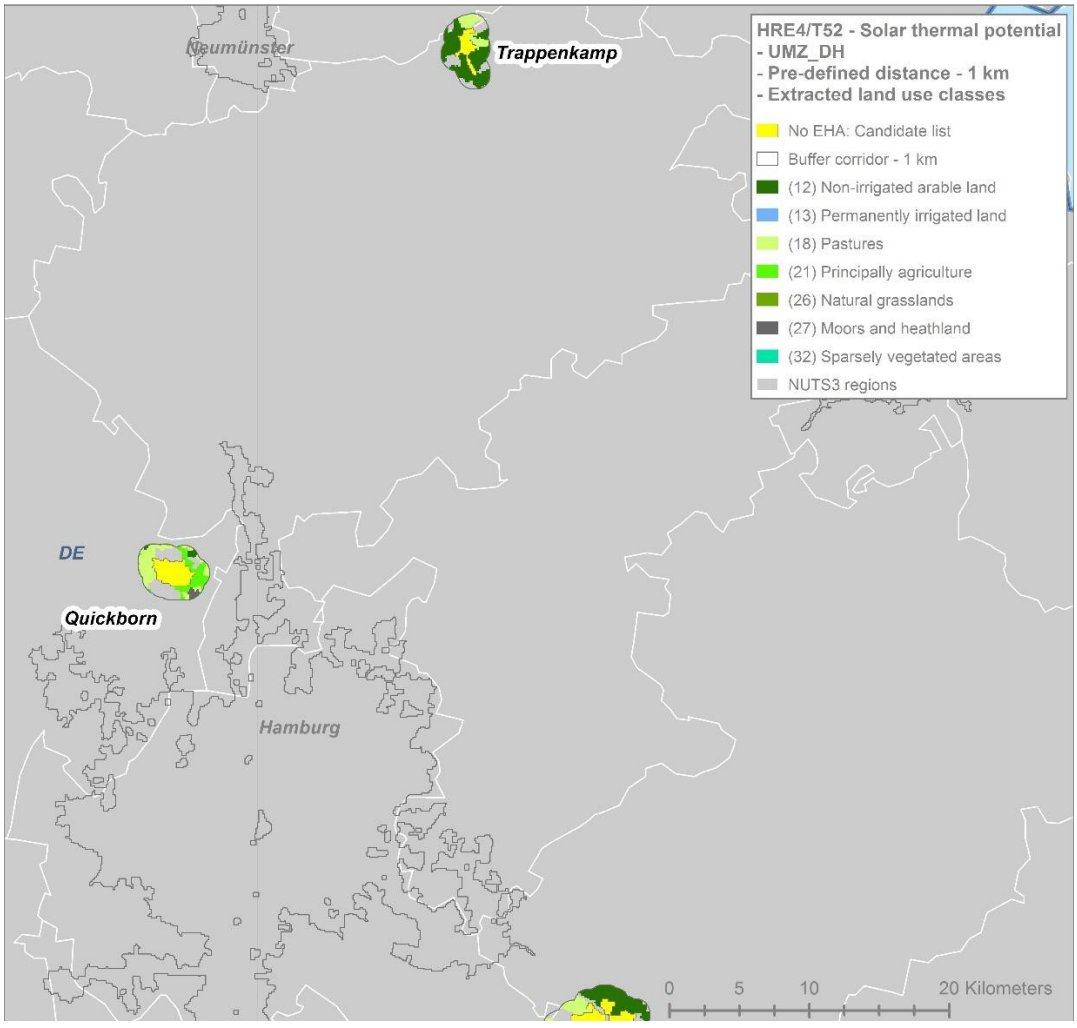


Figure 3. Different methods to evaluate cost of renovation packages.
Source M. Hummel, TU Wien

Subtask C: Technology and Demonstrators

In 2017 the main activities were on documenting and analyzing. The leaflet, “Solar Thermal Applications in Urban Environments”, highlighting the Task’s case studies was published.

Work Planned For 2018

The Task ended December 2017 so work in 2018 will be focused on finalizing and publishing reports and presenting results at conferences, etc.

Dissemination Activities In 2017

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Martin Joly, Gabriel Ruiz, Franz Mauthner, Paul Bourdoukan, Morgane Emery, Martin Anderson	A methodology to integrate solar thermal energy in district heating networks confronted with a Swedish real case study	Cisbat 2017, Lausanne	

Dissemination Activities Planned For 2018

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

Report B1: "URBAN ENERGY CONCEPT Solar heat district – Methodology and tools"

Report B2: "Analysis of built best practice examples and conceptual feasibility studies"

Task Meetings 2017

Meeting	Date	Location
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 Systems (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.

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).

Scope

Subtask A: Components, Systems & Quality (Lead Country: Australia)

- 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 (Lead Country: Italy)

- 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

Subtask C: Testing and Demonstration Projects (Lead Country: Sweden)

- 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 Eco label sensibility (A)
- Technical report on optimized control strategies for solar cooling & heating systems (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)
- Position paper for new generation solar cooling and heating systems (D)
- Simplified short brochure (D) jointly edited by the Subtask Leader and IEA SHC program

Collaboration with Other IEA TCPs

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

Collaboration 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), WALDSCHUETZ (Germany), Thomas NOLL (Germany), SUNOYSTER (Germany) and YAZAKI (China).

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

Task Duration

The Task started in March 2014 and will be completed in June 2018 (one year extension from original date).

Participating Countries

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

Work During 2017

Task 53 has had its 7th Expert meeting in April 2017 just before a specific Industry Workshop on Solar Cooling organized in Messina in Italy (Sicily) and its 8th Expert meeting in October 2017 just before a specific Solar Cooling Workshop organized in Abu Dhabi during the SHC/SWC 2017 Conference (UAE)..

Year 2017 was dedicated to:

- Progress on the first activities of the Task's Subtasks A, B and C, and D
- Successful dissemination activities:
    - Industry Workshop in Messina, Italy following the Task Experts meeting
    - Task presentations at special SAC workshop during SHC 2017 in Abu Dhabi, UAE (8 of the 14 presentations) following the Task Experts meeting

Dissemination Activities In 2017

Conference Presentations

IEA SHC Task 53 - Industry Workshop – Messina, Italy
20 April 2017

Presentations included:

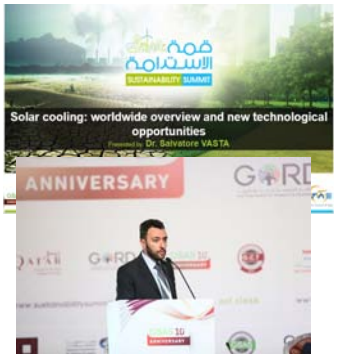
- Presentation to Italian industry a/c player of latest R&D development on solar cooling
- Overview of SHC Task 53
- Latest results and developments in PV and thermal solar cooling phase change materials (PCMs) for energy storage in thermal solar cooling systems
- Solar cooling by pleion: a case study in Sicily, Italy
- Freescoo, a new idea of solar air conditioning
- Solar thermal cooling with adsorption chillers – experiences and consequences for future projects
- PV solar cooling for air conditioning and DHW
- Investigation on advanced batteries for PV electric cooling and building energy demand
- An innovative HCPV/T collector and its potential SHC applications
- High temperature shc systems with lfr collectors and molten salts thermal storage
- Package label for promoting solar thermal in energy systems in EU countries
- Technical, economical and environmental aspects of the new generation solar cooling systems
- Bilateral discussions on technical, economical and environmental aspects of the new generation solar cooling

7th Solar Air Conditioning Workshop – SHC 2017, Abu Dhabi, UAE
31 October 2017

The Solar Air Conditioning Workshop highlighted the latest innovative solar cooling developments throughout the world. The focus was on the new generation of solar cooling systems based on the coupling between PV and air conditioning systems as well as the diversification of usage of the solar heat beyond simply cooling: domestic hot water, space heating, process heat, heating for networks. At this event, Daniel Mugnier, Operating Agent of SHC Task 53, gave a keynote presentation on the "Solar Cooling Potential in the MENA region."

Further information on the Conference is available at
www.solaircon.com/hom.html

Sustainability Summit 2017 – Doha, Qatar
26-27 November 2017



This is the leading annual sustainability event in the MENA region. The summit was organized by the Gulf Organization for Research and Development (GORD), and practitioners, experts, regulators and researchers from all over the word came together to discuss various topics on sustainability and climate change.

On behalf of SHC Task 53, Dr. Salvatore Vasta gave a presentation on "Solar Cooling: Worldwide Overview and New Technological Opportunities." The presentation topic ranged from solar cooling market foresight up to 2050 to a technical focus on hybrid chillers and advanced heat/cold storage systems for the

next generation solar cooling plants. As expected, the solar cooling topic had a good response on social media, such as Facebook and LinkedIN.

During the three events mentioned above, nearly 285 persons were reached through the Task's communication.

Reports Published In 2017

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

- 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)
- Monitoring procedure for field test & demo systems (depending on size and application)
- Catalogue of selected systems (with full description)
- Report on a new and universal classification method "new generation solar cooling square view" for generic systems
- Technical report on optimized control strategies for solar cooling & heating 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 2018

Subtask A: Components, Systems & Quality

- Update of the report on state of the art
- Technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's)

Subtask B: Control, Simulation & Design

- Technical report presenting the reference conditions for modeling (reference load profile and comfort conditions in case of living / office room AC/cooling)
- Overview on peak demand & demand side management possibilities
- Technical report on components & system model validation
- Technical report on system dimensioning

Subtask C: Testing and Demonstration Projects

- Technical report on monitoring data analysis (technical issues + performances)
- Technical content (best practices) for a part of the Handbook on efficient new generation cooling and heating systems

Task Meetings 2017 and 2018

Meeting	Date	Location
Experts Meeting #7	19-20 April 2017	Messina, Italy *Workshop:* For Italian installers and planners (especially from Sicilia)
Experts Meeting #8	29-30 October 2017	Abu Dhabi, UAE *Side event: SHC 2017 Conference*
Experts Meeting #9 (final Experts Meeting)	10-11 April 2018	Dresden, Germany *Side event: SAC German Workshop (12 April, Dresden)*

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	Rebekka Koell	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	Yajun 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	Carsten Corino	SUNOYSTER	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	Maurizio Cellura	University of Palermo	National Expert
ITALY	Salvatore Vasta	CNR ITAE	National Expert
ITALY	Alessio Sapienza	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	Dimitri Torregrossa	HEFR	National Expert
SWITZERLAND	Andreas Witzig	VELASOLARIS	National Expert
SWITZERLAND	Lukas Omlin	SPF	National Expert
SPAIN	Pedro Vicente Quiles	UMH	National Expert
SPAIN	Asier Sanz	TECNALIA	National Expert
SWEDEN	Chris Bales	HOGSKOLA DARMANA	National Expert
SWEDEN	Björn Karlsson	MDH	Subtask C Leader

Task 54 – Price Reduction of Solar Thermal Systems

Michael Köhl
Fraunhofer ISE
Operating Agent for Projektträger Jülich

Task Overview

IEA SHC 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
- Subtask B: System design, installation, operation and maintenance
- Subtask C: Cost-efficient materials, production processes and components
- Subtask D: Information, dissemination and stakeholder involvement

Scope

Subtask A: Market Success Factors and Cost Analysis (Lead Country: Norway)

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.

The main activities are:

- 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 (Lead Country: Germany)

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

The main activities are:

- 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 (Lead Country: Austria)

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

The main activities are:

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

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

Disseminate SHC 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.

The main activities are:

- 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, Denmark, France, Germany, Italy, Netherlands, Norway, Switzerland

Work During 2017

Subtask A: Market Success Factors and Cost Analysis

Input collection for infosheet on "Political, legal and social boundary conditions" finished, publication of infosheet in progress.

During the 4th Experts meeting in Rapperswil, Switzerland, May, 2017, valuable input for Deliverable D A.5 was collected (collaborative effort with Subtask D):
Key decision factors for European consumers – Five market studies (S. Lambertucci, ESTIF) and New business strategies for solar thermal (S. Saile, ISE)

Subtask B: System Design, Installation, Operation and Maintenance

Project B.1: Definition of standardized components

A standard collector design with respect to size, dimensions, connections and mounting interface was evaluated based on the investigation of 212 collectors certified with Solar Keymark. The design was discussed with manufactures and a first standard flat plate collector was defined.

A standard 300l-hot water storage for solar domestic hot water application was defined. The standard is related to dimensions and sizes as well as location and dimensions of the connections.

B.2: Manufacturing costs

The mean production cost of a flat plate collector with a gross area of 2.5 m² was determined to 68 €/m² (70% material costs, 15% labor costs, 15% other costs) based on the input of 4 collector manufacturers.

B.3: Technical aftersales costs

Analysis of the impact on installation and maintenance costs when the maximum collector temperature is limited to 120 °C and no steam is produced was performed.

B.4: Cost optimization of reference systems

The sensitivity analysis and LCoH calculation on improved (compared to the reference system) SDHW systems in Germany showed the major impact parameters.

B.5: New proposals for a 40% price reduction

A water-based vacuum-tube solar systems with automated thermosiphon (back-up) frost protection, using Thermo-Differential Valve technology was introduced resulting in a significant reduction of the investment and operation costs because no controller and no solar heat exchanger are required.

LCoH Calculations were performed by using the thermal performance parameters of the heat pipe flat plate collector developed by ISFH/KBB. The result showed that the costs for the kWh solar heat could be reduced by 38%.

Subtask C: Cost-Efficient Materials, Production Processes and Components

The major cost drivers for solar-thermal systems and cost saving potentials (Project C1) were identified in 2016. Hence, the main focus of work in Subtask C was on Projects C2 and C3.

Project C2: Material substitution and functional integration

Polypropylene with carbon black modification offers a high potential for the absorber of fully overheat protected collectors (operating temperature: up to 95°C). Such collectors are of high relevance for domestic hot water preparation in moderate and warm climate zones.

Glass-fiber reinforced polyamides exhibit a superior long term performance compared to stainless steel for integrated storage collectors.

Project C3: Innovative, cost-efficient processes and components

Cost-efficient all-polymeric collector systems are preferentially manufactured by extrusion, injection molding and welding. Mass-production of more than 500.000 systems/a (s. Figure below) is needed for being cost-efficient.

A significant cost-reduction of pressurized, single loop ICS can be achieved by employing polymeric components reducing the parts from more than 100 to less than 10 pieces per collector. The most cost-efficient process for manufacturing of the absorber is long-fiber thermoplastic molding.

Subtask D: Information, Dissemination and Stakeholder Involvement

Project D. 1: Industry liaison

National dissemination workshop by Task partners held at the University of Linz, Austria in connection with the 5th Task Experts meeting plus an Industry Round Table, October 2017.

SHC Task 54 promotion at the ISH 2017 trade fair in Frankfurt, Germany from 14-18 March 2017 where Task 54 was represented at the booth of Fraunhofer ISE and through the Operating Agent and Leader of Subtask D in various halls. For dissemination purposes a flyer (see Figure 1) was designed to inform about Task 54 and to attract new contacts, especially installers, building planners and new partners from the solar thermal industry. The promotion was successful in terms of gaining new contacts for the SHC Task 54 info list. The general impression was that price reduction is one of the most important topics in the sector but industry partners are hesitant to join the Task due to IP related issues and skepticism. The big players, for example, Viessmann and Vaillant are already one step ahead as they are heavily expanding their digital offers, thus improving sales, distribution and maintenance.

For targeted outreach to customers and consumers of solar thermal, SHC Task 54 is collaborating with Solar Heat Europe (former ESTIF) who presented relevant results of their project FROnT at the 4th Experts Meeting in Rapperswil.

Figure 2. Left: German Task flyer for promoting Task 54 and gaining new contacts with reply card (distributed at ISH 2017 trade fair and national dissemination WS in Austria. Right: Flyer for distribution at Fraunhofer ISE booth.

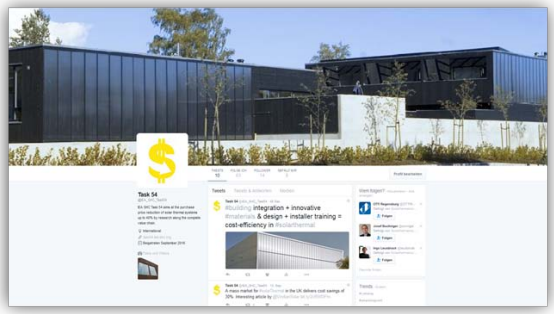
For the collection of data on installation costs and a better understanding of obstacles or time-consuming factors with current systems, a questionnaire was distributed to installers and planners of solar thermal systems. The questionnaire is available in English, German and French. The results provide good and valuable insights into the realities of the installation business in different European countries. The results will be published as Info Sheets towards the end of the Task. It is also intended to include installer's feedback as recommendations in a Position Paper at the end of SHC Task 54.

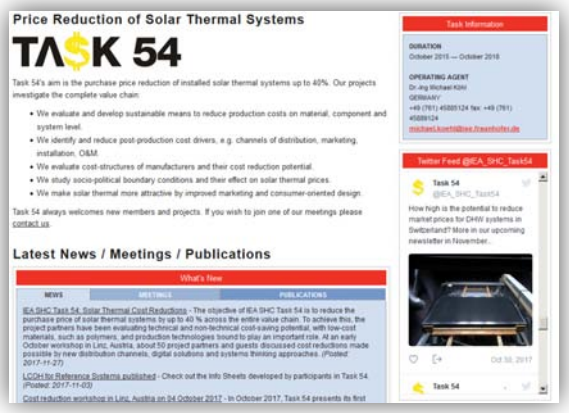
Project D.2: Dissemination and Information

Published an e-newsletter in Nov 2017.

Twitter
For dissemination beyond the sphere of IEA SHC and Task 54 experts a twitter account was created **@IEA_SHC_Task 54**.

For easy access to its contents (for partners without access to twitter) a live feed was implemented on the SHC Task 54 homepage, mirroring the information exchanged in real time.





Twitter allows live feeds from Task 54 events, links to Task 54 related articles or cross references to Task 54 partners, e.g. Solar Heat Europe. An impression of Task 54's twitter initiatives 2017 is given below.

Dissemination Activities In 2017

Reports, Published Books

Author / Editor	Title	Bibliographic Reference
Yoann Louvet (University of Kassel), Stephan Fischer (ITW Stuttgart), Simon Furbo (Technical University of Denmark), Federico Giovanetti (ISFH), Franz Mauthner (AEE Intec), Daniel Mugnier (Tecsol), Daniel Philippen (SPF)	Info Sheet A01: LCOH for Solar Thermal Applications - Guideline for levelized cost of heat (LCOH) calculations for solar thermal applications	SHC website
Thomas Ramschak, François Veynandt (AEE INTEC)	Info Sheet A02: Reference System, Austria Conventional heating system for single-family house	SHC website
Thomas Ramschak, François Veynandt (AEE INTEC)	Info Sheet A03: Reference System, Austria Conventional heating system for multi-family house	SHC website

Thomas Ramschak, François Veynandt (AEE INTEC)	Info Sheet A04: Reference System, Austria Solar domestic hot water system for single-family house	SHC website
Thomas Ramschak, François Veynandt (AEE INTEC)	Info Sheet A05: Reference System, Austria Solar Combisystem for single-family house	SHC website
Thomas Ramschak, François Veynandt (AEE INTEC)	Info Sheet A06: Reference System, Austria Solar domestic hot water system for multi-family house	SHC website
Stephan Bachmann, Stephan Fischer (ITW Stuttgart), Bernd Hafner (RHCPlatform)	Info Sheet A07: Reference System, Germany Conventional heating system for single-family house	SHC website
Stephan Bachmann, Stephan Fischer (ITW Stuttgart), Bernd Hafner (RHCPlatform)	Info Sheet A08: Reference System, Germany Solar domestic hot water system for multi-family house	SHC website
Stephan Bachmann, Stephan Fischer (ITW Stuttgart), Bernd Hafner (RHCPlatform)	Info Sheet A09: Reference System, Germany Solar Combisystem for single-family house	SHC website
Daniel Philippen, Marco Caflisch (SPF)	Info Sheet A11: Reference System, Switzerland Solar domestic hot water system for multi-family house	SHC website
Simon Furbo, Janne Dragsted (Technical University of Denmark)	Info Sheet A12: Reference System, Denmark Solar domestic hot water system for single-family house	SHC website
Karl Schnetzinger (Advanced Polymer Compounds), Gernot M. Wallner (University of Linz)	Info Sheet C01: Cost Drivers and Saving Potentials (1): Material substitution	SHC website
Alexander Thür (University of Innsbruck)	Info Sheet C02: Cost Drivers and Saving Potentials (2): Production, installation, design	SHC website
Max Wesle, Robert Buchinger (Sunlumo)	Info Sheet C03: One-World-Solar-System	SHC website

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Martin Frey	Innovationen für die Solarthermie	Heizungsjournal	ISH 2017 issue, 7 April 2017 https://www.heizungsjournal.de/innovationen-fuer-die-sonnenwaerme_12032?p=

			1
Bärbel Epp	Investigating cost factors along the value chain	Solarthermalworld	22 May 2017 http://www.solarthermalworld.org/content/iea-shc-task-54-investigating-cost-factors-along-value-chain
Bärbel Epp / Eva Augsten	Solar thermal cost reductions		26 November 2017 http://www.solarthermalworld.org/content/iea-shc-task-54-solar-thermal-cost-reductions

Conferences, Workshops, Seminars

Workshop/Conference/ Seminar	Activity	Date & Location	Number of Participants
Industry Round Table	Meeting	October 2017 Linz, Austria	

Task Meetings 2017 and 2018

Meeting	Date	Location
Experts Meeting #4	3-4 May 2017	Rapperswil, Switzerland *25 participants from research and industry*
Experts Meeting #5	5-6 October 2017	Linz, Austria *30 participants from research and industry* Plus a workshop 25 participants from research and industry
Experts Meeting #6	24-26 April 2018	Sophia Antpolis, France
Experts Meeting #7	18-19 September 2018	Oslo, Norway

Funded Projects Of Task 54 Partners

(January 2018, 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 (2016 – 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 (2016 - 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 (2015 - 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 (2014 - 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 (2014 - 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 (2015 - 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 (2015 - 2016)
Funding: *Land Oberösterreich*
Partners: *Sunlumo*

Wirtschaftlichkeit mit System (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 (2016 - 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 (2016 - 2019)**
Funding: *BMWi Bundesministerium für Wirtschaft und Energie (Projektträger PTJ)*
Part*ners: ISFH (GER), Viessmann (GER)*

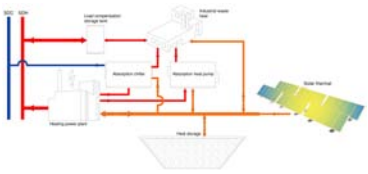
SHC Task 54 Participants

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	Gernot Wallner	JKU Linz	Subtask C Leader
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	Subtask B Leader
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	Subtask D Leader
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	Subtask A Leader
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)

Scope

Subtask A: Network Analyses and Integration (Lead Country: Austria)

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 (Lead Country: China)

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 (Lead Country: Denmark)

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 (Lead Country: Spain)

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.

Collaboration with Other IEA TCPs

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

Collaboration with Industry

Sixteen companies are participating in SHC Task 55.

Task Duration

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

Participating Countries

Austria, Canada, China, Denmark, Finland*, France, Germany, Italy, Israel, Poland, Spain, Sweden, Switzerland, Turkey, United Kingdom

*Through IEA DHC

Work During 2017

Subtask A: Network Analyses and Integration

During the first year, the work in Subtask A focused mainly on the set-up of the overall structure as well as analyzing and consolidating the international activities and projects from the Task 55 participants. Following general achievements can be noted:

- A table of contributing projects and partners was created and currently up-to-date. Here, all projects, the concrete input to each deliverable and the timing are described.
- New partners joined Subtask A: EURAC, DTU, Solites and TVPSolar. During the last Task meeting in Abu Dhabi, first input and contributions to subtask A were discussed.

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

The work in Subtask B focused on structuring efforts and the identification of suitable projects, their timelines and input possibilities. First results of the project MEQUSO were presented. A new ISO standard draft was developed and the potential for efficiency increase by model based control strategies were evaluated. Additionally, basic information about a planned, very large SDH project in Tibet was gathered. Following general achievements can be noted:

- Worldwide first in-situ testing for assessing system performance and certification
- The world's first high altitude large solar space heating project in Tibet to be built
- New ISO standard and global solar certification
- Optimized control strategy for large solar district heating systems

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

Analyses based on measurements in Denmark show that it makes sense to combine flat plate (FP) and concentrating solar collectors (CSP). FP collectors have a good performance in cold regions, CPCs have a good performance in hot sections and an effective control of overheating. A CFD model for a detailed study on FP collectors' modules has been made by DTU, DK. Following general achievements can be noted:

- Report on measurements on combined FP / CSP collector field
- CFD model for FP collector type available – CFD modeling of pit storage
- First results (not detailed interpreted) of the field test in the research framework of MeQuSo

Subtask D: Promotion and Dissemination of SDH/SDC And Hybrid Technologies in New Markets

Subtask D got a new Subtask Leader. The new Subtask lead focused on the structuring and gathering of data on each deliverable. A first draft of a best practice template was presented and discussed at the 3rd expert meeting. Country reports presented latest developments in different regions. As the quality of education material is essential for good results in capacity building, a first draft of a handbook was created which all partners will review. Following general achievements can be noted:

- Country reports of Austria, Germany, Sweden, Demark, France
- First draft of the template for best practice installations
- First draft of a handbook

Work Planned For 2018

Subtask A: Network Analyses and Integration

- Setup a detailed deliverable structure
- Continuous update of the table of contributing projects
- Discussion on the process and timing to consolidate and integrate the partner input
- Possible shared session at the next SDH conference in Graz (9. / 10. April 2018)

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

- Fraunhofer ISE will install collector plants with ETC and Fresnel collectors for in-situ test; Fraunhofer ISE is open to integrate collectors of Task participating partners
- MEQUSO will present its findings and provide insights into its methods of measurements
- Sunrain will begin to construct the project in Tibet

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

- Recommendations for monitoring
- Conversion of horizontal radiation to direct/diffuse on collector plane
- CFD model for CSP collector type
- Update of storage fact sheets
- Survey on storage models
- Evaluated test results will be presented and the analysis method will be discussed

Subtask D: Promotion and Dissemination of SDH/SDC and Hybrid Technologies in New Markets

- There is information and material available for D-D1, which can be prepared in the next half year. First results can be presented at the next meeting in April 2018
- First draft of D-D5 is planned to be prepared and presented at the next meeting in April 2018
- First short article on Solarthermalworld.com will be published
- Final template for best practice examples will be ready for application

Dissemination Activities In 2017

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
Ralf-Roman Schmidt, Paolo Leonie, Markus Gölles, Sabine Putz, Anna Katharina Provasnek	Measures and enablers for integrating significant shares of solar thermal energy into urban district heating networks – preliminary results from	SDH Conference 2018 April 2018, Graz, Austria	

	SHC Task 55, Subtask A		
Putz, Sabine, Provasnek, Anna Katharina	Towards the Integration of Large SHC Systems into DHC Networks - Contributing Projects and Results	SDH Conference 2018 April 2018, Graz, Austria	
Anna Katharina Provasnek, Sabine Putz	Towards the Integration of Large SHC Systems into DHC Networks	SHC 2017 / SWC 2017 Conference October 2017, Abu Dhabi, UAE	
Ralf-Roman Schmidt, Markus Gölles, Anna Katharina Provasnek, Paolo Leoni, Sabine Putz	Barriers and opportunities to maximize the share of solar thermal energy in district heating networks – approaches within the IEA SHC Task 55, Subtask A and selected preliminary results	SHC 2017 / SWC 2017 Conference October 2017, Abu Dhabi, UAE	
Anna K. Provasnek, Sabine Putz	2nd SHC Task 55 Expert Meeting in Aalborg, Denmark	Task 55 Newsletter	30 March 2017
Baerbel Epp	IEA SHC Task 55	Solarthermalworld.org	http://www.solarthermalworld.org/keyword/iea-shc-task-55
Anna K. Provasnek, Sabine Putz	Large Scale Solar Installations – The Actors & Activities	Solar Update Newsletter	December 2017, Vol. 66
Sabine Putz Anna K. Provasnek	Towards the Integration of Large SHC Systems into DHC Networks	OTTI Symposium, Thermische Solarenergie	Poster presented (short oral presentation) in May 2017
Sabine Putz	IEA SHC Task 55 – Akteure und Aktivitäten	Presentation at Dresder Fernwärme Kolloqium	Presentation, September 2017
Sabine Putz, Patrick Reiter	IEA SHC Task 55	4th Generation District Heating Conference	Presentation, September 2017

Dissemination Activities Planned For 2018

First reports for selected deliverables will be published.

Task Meetings in 2017 and 2018

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting #2	14 – 16 March 2017	Aalborg, Denmark	
Experts Meeting #3	27 – 28 October 2017	Abu Dhabi, UAE In conjunction with SHC 2017/SWC 2017	

		Conference	
Experts Meeting #4	9 – 10 April 2018	Graz, Austria Plus an Industry Workshop)	

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 + 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
AUSTRIA	Carles Ribas Tugores	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Viktor Unterberger	Bioenergy 2020+ GmbH	National Expert
AUSTRIA	Werner Doll	SOLID	National Expert
AUSTRIA	Christian Holter	SOLID	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	Daolin Xu	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Gang Xu	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Jinliang Yang	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Kaichun Li	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Shai Li	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Shuhuai Wang	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert

DENMARK	Jan Erik Nilsen	PlanEnergi	Subtask C Leader
DENMARK	Andreas Zourellis	Aalborg CSP	National Expert
DENMARK	Bengt Perers	Technical University of Denmark	National Expert
DENMARK	Christian Kok Nielsen	PlanEnergi	National Expert
DENMARK	Jan Birk	Arcon Sunmark	National Expert
DENMARK	Jianhua Fan	Technical University of Denmark	National Expert
DENMARK	Junpeng Huang	Technical University of Denmark	National Expert
DENMARK	Morten Vang Bobach	Arcon Sunmark	National Expert
DENMARK	Povl Frich	Danish Energy Agency	National Expert
DENMARK	Tian Zhiyong	Technical University of Denmark	National Expert
DENMARK	Torsten Malmdorf	Danish Energy Agency	SHC ExCo
DENMARK	Zhiyong Tian	Technical University of Denmark	National Expert
FINLAND	Kaj Pischow	Savo-Solar Oy	National Expert
FRANCE	Alexis Gonnelle	New Heat Directeur technique / CTO	National Expert
FRANCE	Nicolas Lamaison	CEA/INES	National Expert
FRANCE	Pierre Delmas	NewHeat	National Expert
GERMANY	Andrej Jentsch	OA for District Heating and Cooling TCP	National Expert
GERMANY	Axel Gottschalk	Bremerhaven University of Applied Sciences	National Expert
GERMANY	Bärbel Epp	Solrico	National Expert
GERMANY	Dominik Bestenlehner	ITW/TZS University of Stuttgart	National Expert
GERMANY	Karin Rühling	TU Dresden	National Expert
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
GERMANY	Magdalena Berberich	Steinbeis Research Institute for	Subtask D Leader

GERMANY	Nirendra Lal Shrestha	Technische Universität Chemnitz	National Expert
GERMANY	Norbert Rohde	KBB Kollektorbau GmbG	National Expert
GERMANY	Roman Marx	ITW University of Stuttgart	National Expert
GERMANY	Sven Fahr	Fraunhofer ISE	National Expert
ITALY	Luca Degiorgis	Politecnico di Torino	National Expert
ITALY	Marco Scarpellino	TVP Solar	National Expert
ITALY	Roberto Fedrizzi	Eurac Research	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
SPAIN	Javier Mazo	University of Zaragoza	National Expert
SWEDEN	Joakim Bykström	Absolicon Solar Collectors	National Expert
SWEDEN	Peter Kjellgren	Absolicon Solar Collector	National Expert
SWITZERLAND	Vittorio Palmieri	TVP Solar	National Expert
TURKEY	Deniz Kazanci	Alcor Energy	National Expert
UNITED KINGDOM	Eamon Clarke	Kingspan Environmental Ltd.	National Expert
UNITED KINGDOM	Finbarr McCarthy	Kingspan Environmental Ltd.	National Expert

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

Roberto Fedrizzi
EURAC Research
Operating Agent for ENEA

Task Overview

In the residential sector, solar thermal and PV systems are typically mounted on building roofs with limited attempt to incorporate them into the building envelope, creating aesthetic drawbacks and space availability problems. On the contrary, the use of facades is highly unexplored. Daylight control is delegated to the individuals' management of blinds and curtains, leading to high thermal loads, both during midseason and summertime.

In the tertiary segment (offices, schools, hospitals), the roof is again, most of the times, the only surface devoted to the installation of solar thermal and PV technologies. While daylight control nowadays is here state of the art in terms of shading effect, the utilization of shading devices to also redirect natural light into the room, improving visual comfort at the same time, has still to be deepened.

When energy efficient technologies are installed together with traditional ones, frequently they are just "added on top" of the main systems, resulting in high investment costs and low performance optimization. An interesting option to overcome this competition is to combine multiple functions in envelope components thus enabling hybrid systems to simultaneously cover different energy, comfort and aesthetic needs.

SHC Task 56 focuses on simulation, laboratory tests and monitoring of multifunctional envelope systems that use and/or control solar energy, influencing thermal energy demand, thermal energy consumption and comfort of the building.

The strategic objective of SHC Task 56 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 by:

- Gathering relevant information on market available and "under-development" solar envelope systems both in terms of performance and costs
- Assessing test methods and simulation models for the performance characterization of solar envelope elements
- Developing design and installation guidelines for solar envelope systems, accounting for technological, architectural/aesthetical, economic, financing and customer acceptance viewpoints
- Assessing and elaborating on business models for solar envelope systems

Scope

Subtask A: Solar Envelope Systems Classification and Communication (Lead Country: Norway)

An overview of products and solutions of solar envelope systems, which are presently available on the market, will be made available in Subtask A. First, a market analysis will be carried out (Activity A.1) to assess existing solutions through a literature review and the advice of the experts participating. Moreover, standards, test methods and numerical tools will be categorized. Different products and solutions will be evaluated through a SWOT analysis, accounting for technical and non-technical issues, which in the past have determined the success or the failure of solar envelope systems (Activity A.2).

A major activity of Subtask A will be to attract and involve central actors, decision makers, planners, builders, architects, experts from research and industry. This will be achieved by the exchange of information generated in all Subtasks through local workshops, newsletters and an updated public website (Activity A.3).

Subtask B: Performance Characterization of Solar Envelope Elements (Lead Country: Germany)

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

Solar envelope elements need to be integrated in the construction process at the early planning stage. To this purpose, planners need to be provided with the necessary information – integration parameters, performance measurements and modeling, etc. – when starting their task. The end target of the Subtask is a successful construction process that includes the transfer of knowledge and models, for example, between the component manufacturers and the planners of the building.

The key, therefore, is the involvement of an industrial partnership from the very beginning of the program. The activities reported next will be elaborated only with reference to the specific elements suggested by the manufacturers involved in the Task.

Subtask C: Assessment of Solar Envelope Systems at Building Level (Lead Country: Austria)

In Subtask C complete solar envelope systems are defined based on active and passive components and integrated into the HVAC system of reference buildings. Buildings will serve as virtual case studies with the specific envelope elements proposed by the industrial partners integrated into them.

The Subtask is performed in two parallel and interacting activities:

- Solutions that are technically and economically meaningful will be identified by means of building and HVAC simulations. A decision support instrument (pre-design tool) will be developed as part of this activity, allowing simplified calculations to be performed.
- Existing systems will be evaluated by monitoring demonstration systems installed.

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

Collaboration with Industry

Of five of the 24 experts at the Task Experts Meeting were from industry. Three additional industry representatives participated in the first industry workshop. Task industry partners presented their solutions together with invited speakers:

- COST 1205 project
- Kingspan
- Aventa
- FenestraPro
- O'Donnel & Tuomey architects
- Solarwall

Sixteen experts from the well-established group of participating entities have actively contributed to the Task Experts Meeting in Eindhoven. Overall, eight external manufacturers participated with different levels of contribution to the meeting. The meeting started with a confidential industry workshop led by Fraunhofer-ISE. Six international experts met to discuss one each of their most innovative technologies. Three directors, one professor and two R&D experts presented their favorite technology and received feedback from others who experienced the barriers and opportunities of innovative solar building envelopes. The presented technologies came from all areas of solar building envelopes. From building-integrated photovoltaics and solar thermal to innovative daylighting concepts and technical building plant, many interesting components and systems were discussed. Four additional manufacturers attended as observers.

Task Duration

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

Participating Countries

Austria, Canada, Denmark, Germany, Italy, Netherlands, Norway, Slovakia, Spain, Sweden

Work During 2017

Subtask A: Solar Envelope Systems Classification and Communication

Subtask A activities focused again on the dissemination of the project objectives on the website and in other news sources. The website has been updated with the projects and papers around solar envelope systems led by the participating partners. Two newsletters has been released, together with one article on Solarthermalworld.org.

The analysis of the state of the art in terms of solar active envelopes available on the market and under development has taken off, and is based on a template to gather relevant information. The document provides a methodological framework to assess strengths, weaknesses, opportunities and threats of solar active façade technologies. This assessment is carried out on the one hand by evaluating product-related intrinsic features, such as unique selling points or possible improvements of a specific product/technology, and on the other hand by looking at the market for identifying existing competitors and stimulate strategies for future developments.

Particular care is given to analyze the building integration from two perspectives, 1) the architectural and technological integration into the façade, ranging from visual acceptance aspects to installation and maintenance problems and 2) the effects on the indoor comfort and the modifications required on HVAC or lighting system compared to traditional system.

The analysis of the solar envelope systems ends with the lessons learned. The detail here varies according to the maturity level of the product/technology. Based on the inputs gathered, the ultimate aim of this document is to draw common conclusions on solar envelope systems. This task is not easy to tackle since products/technologies are very different one from another (in terms of concept and aim) and the number of products evaluated is quite high.

Subtask B: Performance Characterization of Solar Envelope Elements

Industry workshops were organized at the Experts Meetings in Dublin, Ireland and Eindhoven, The Netherlands. The aim of the workshops was to deepen the SWOT analysis of specific market available products and to gather feedback useful for developing market strategies (activity B1).

Good progress was made reviewing the initial draft of the report (DB.1) on the development of strategies for market penetration. The mid-term draft delivery is foreseen in January 2018.

Regarding activity B2, a journal review paper on simulation models availability and purposes was delivered to a peer reviewed journal. The paper is planned to be helpful for all target groups of SHC Task 56 in finding the best, and therefore, most cost-effective simulation models to be used for their innovative technologies.

In activity B3, standards have been collected useful to rate and evaluate solar active envelope components. The understanding is that a very large number of standards are available that can be used when dealing with solar envelopes. The deliverable reporting on such norms analysis and recommendations for improvement and for avoiding barriers to market development is under review by the contributing partners and a first draft is foreseen in January 2018.

Subtask C: Assessment of Solar Envelope Systems at Building Level

In the last months of 2017, substantial effort was put into the definition of a common set of boundary conditions required in order to consistently assess solar envelope systems by means of transient simulations. This task ended with the elaboration of the Task Report DC.1, where a detailed description of suitable reference residential and tertiary buildings is provided. The performance of solar envelope system will be analyzed in different locations, ranging from heating- to cooling-dominated climates. Additionally to geometrical and user-behavior boundary conditions, a set of Key Performance Indicators have been defined for the energy, environmental and comfort assessment of solar envelope systems.

Dissemination Activities In 2017

Reports & Published Books

No Task reports were published in 2017.

Journal Articles, Conference Papers, Press Releases, etc.

Author(s) / Editor	Title	Publication / Conference	Bibliographic Reference
Roberto Garay Martineza, Julen Astudillo Larraza	Performance assessment of façade integrated glazed air solar thermal collectors	AREQ 2017, Alternative and Renewable Energy Quest, February 2017, Spain	http://task56.iea-shc.org/publications
Roberto Garay Martinez, Beñat Arregi Goikolea, Ignacio Gomis Paya, Paul Bonnamy, Saed Raji, Jerôme Lopez	Performance assessment of an unglazed solar thermal collector for envelope retrofitting	AREQ 2017, Alternative and Renewable Energy Quest, February 2017, Spain	http://task56.iea-shc.org/publications
Roel Loonen, Fabio Favoino, Jan Hensen, Mauro Overend	Review of current status, requirements and opportunities for building performance simulation of adaptive facades	Journal of Building Performance Simulation, 10(2), 205-223	http://www.tandfonline.com/doi/full/10.1080/19401493.2016.1152303
Mohammad Ghasempourabadi, Kostas Sinapis, Roel Loonen, Roland Valckenborg, Jan Hensen, Wiep Folkerts	Towards simulation-assisted performance monitoring of BIPV systems considering shading effects	IEEE 43rd Photovoltaic Specialists Conference (PVSC), Portland, Oregon, USA	http://ieeexplore.ieee.org/document/7750241
Bärbel Epp	IEA SHC Task 56: Cooperation on Energy Balance and Building Design Tools	Solarthermalworld.org	http://www.solarthermalworld.org/content/iea-shc-task-56-cooperation-energy-balance-and-building-design-tools

Conferences, Workshops, Seminars

Workshop/Conference/ Seminar	Activity	Date & Location
International Conference – Alternative and Renewable Energy Quest, AREQ 2017	Presentations, abstracts, papers	1-3 February 2017 Barcelona, Spain

Task Meetings in 2017 and 2018

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting #3	2-3 March 2017	Dublin Institute of Technology Dublin, Ireland	23

Experts Meeting #4	20-21 September 2017	Eindhoven Institute of Technology Eindhoven, The Netherlands	22
Experts Meeting #5	6-7 March 2018	University of Innsbruck Innsbruck, Austria	

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	David Geisler-Moroder	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	Paolo Bonato	EURAC	National Expert
ITALY	Pietro Finocchiaro	University Palermo - Solarinvent	National Expert
NETHERLANDS	Roel Loonen	Eindhoven University of Technology	National Expert
NORWAY	Michaela Meir	Aventa	Subtask A Leader
NORWAY	Ellika Taveres-Cachat	NTNU, Felles fakturamottak	National Expert
NORWAY	Francesco Goia	NTNU, Felles fakturamottak	National Expert
SLOVAKIA	Michal Krajcik	Slovak University of Technology	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 SHC Task 57 are to:

- Harmonize at international level certification schemes, in order to increase in general the level of quality and at the same time avoid the need for re-testing and re-inspection
- Develop, improve and promote ISO standards on test procedures and requirements for solar thermal products
- Assist establishing certification schemes in new areas

Scope

Subtask A: Kick-off of operation of Global Solar Certification Network (Lead Country: Germany)

Subtask A will support the operation of the Global Solar Certification Network (GSCN) with the aim to harmonize certification schemes and have mutual accept of test and inspection reports.

Subtask B: Improvement of test procedures – support and input to ISO (Lead Country: 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 (Lead Sponsor: 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.

Collaboration with Industry

Four large manufacturers now members:

- GREENoneTEC
- TiSUN
- Beijing Tus-Clean Energy Technology Co. Ltd.
- Savosolar
- Indication of interest from: Kingspan

Support given to assist manufacturers in new markets.

Duration

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

Participating Countries/Sponsors

Austria, Australia, China, Denmark, France, Germany, RCREEE (plus member Algeria), Portugal, Spain, Switzerland

Work During 2017

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

- Now 12 members:
  - 4 industry members
  - 2 test labs
  - 2 inspectors
  - 1 certification body
  - 3 supporting
- Two Global Solar certification Network (GSCN) Board meetings (web meetings)
- One Global Solar certification Network (GSCN) plenary meeting
- Updated website

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

- Chinese / German cooperation on collector durability / accelerated ageing testing ongoing. Considerations if draft proposal for standard could be elaborated in this field
- Second version draft proposals for new ISO standards on:
  - "close-coupled systems"
    - mechanical load
    - reliability and safety
  - building integrated collectors and systems
- First version draft proposal for new ISO standard on:
  - Performance check of large collector fields

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

- Final "Guideline on ISO 9806"
- Draft version on "Guideline for Implementing Certification Schemes for Solar Heating and Cooling Products"
- Survey on new ISO 9806 planned

Work Planned For 2018

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

- Continued operation of the Global Solar Certification Network (GSCN) – included 4-5 board meetings and one plenary meeting
- Continued promotion of the Global Solar Certification Network (GSCN)
- Processing applications
- Maintaining website

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

- Continue Chinese – German cooperation on collector durability / accelerated ageing testing
- Make final 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
  - Performance check of large collector fields

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

Send out questionnaire on ISO 9806:2017 and analyze responses

- Finalize "model certification schemes".

Dissemination Activities In 2017

Report Published In 2017 - Guide To Standard ISO 9806, K. Kramer

Conferences, Workshops, Seminars

Workshop/Conference/ Seminar	Activity	Date & Location
ESTIF	Webinar	February 2017
Solar Keymark Network meetings	Presentation	March and October 2017
CEN TC 312 meeting	Presentation	October 2017
ISO TC 180 meeting	Presentation	December 2017
Asian Pacific Solar Research Conference	Presentation	December 2017
SHC 2017	Interview with Task OA, Jan Erik Nielsen https://www.youtube.com/watch?v=zEe8NkeNt0U	November 2017

Dissemination Activities Planned For 2018

Reports Planned For 2018

Final Task Report: Guideline for Implementing Certification Schemes for Solar Heating and Cooling Products

Task Meetings in 2017 and 2018

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meetiing #3	March 2017	Freiburg, Germany	
Experts Meetiing #4	November 2017	Abu Dhabi, UAE	
Experts Meetiing #5	March 2018	Madrid, Spain	
Experts Meetiing #6	November 2018	TBD	

SHC Task 57 Participants

Country	Name	Institution / Company	Role
DENMARK	**Jan Erik Nielsen**	**SolarKey International**	**Operating Agent**
ALGERIA	Abdelkrim Chenak	CEDR	National Expert
AUSTRALIA	Ken Guthrie	Sustainable Energy Transformation Pty Ltd	National Expert
AUSTRALIA	Jeremy Osborne	Energy Analysis & Engineering	National Expert
AUSTRIA	Harald Poscharnig	GREENoneTEC	National Expert
CHINA	He Zinian	Beijing Solar Energy Research Institute	Subtask B Leader
CHINA	Zhou Xiaowen	Tsinghua Solar Energy Co. Ltd.	National Expert
CHINA	Tong Xiaochao	CABR Certification Centre	National Expert
CHINA	Lin Jiali	China General Certification Centre	National Expert
CHINA	Zhang Lei	China National Engineering Research Center for Human Settlement	National Expert
CHINA	Shen Bin	Zhejiang Provincial Center for Quality Inspection & Testing of Solar Products	National Expert
CHINA	Gu Xiuzhi	Beijing Building Materials Testing Academy Co, Ltd	National Expert
FRANCE	Pierre Delmas	Newheat	National Expert
FRANCE	Alexis Gonnelle	Newheat	National Expert
GERMANY	Harold Drück	ITW, University of Stuttgart	Subtask A Leader
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
GERMANY	Arnulf Knorr	GIZ/RCREEE	Observer
RCREEE	Ashraf Kraidy	RCREEE	Subtask C Leader
PORTUGAL	Maria Joao Carvalho	LNEG	National Expert

SPAIN	Julian David Hertel	University of Balearic Islands / Solar Optics	National Expert
SPAIN	Ramon Pujol Nadal	University of Balearic Islands / Solar Optics	National Expert
SWITZERLAND	Andreas Bohren	SPF, Rapperwil	Observer

Task 58 – Material and Component Development for Thermal Energy Storage

Wim van Helden
AEE INTEC
Operating Agent for the Austrian Government

Task Overview

The key objectives of this joint Task with the IEA ECES TCP are:

- Development and characterization of storage materials to enhance TES performance
- Development of materials testing and characterization procedures, including material testing under application conditions
- Development of components for compact thermal energy storage systems
- Mapping and evaluating the TES application opportunities concerning the requirements for the storage material

Scope

This joint Task deals with advanced materials for latent and chemical thermal energy storage, Phase Change (PCM) and Thermo Chemical (TCM) materials. The Task deals with these materials on three different scales:

- Material properties, focused on their behavior from molecular to bulk scale, including material synthesis, micro-scale mass transport and sorption reactions
- Material performance within the storage system, focused on the materials behavior and when they are implemented in the storage itself, including heat, mass, and vapor transport, wall-wall and wall-material interactions, and reactor design
- Storage system implementation, focused on the performance of a storage within a heating or cooling system, including for instance economical feasibility studies, case studies, and system tests

Because seasonal storage of solar heat for solar assisted heating of buildings is the main focus of the IEA SHC TCP, this will be one of the primary focus areas of this Task. However, because there are many more relevant applications for TES, and because materials research is not and cannot be limited to one application only, this Task will include multiple application areas.

Collaboration with Other TCPs

This is a fully joint Task with the ECES TCP (Annex 33). Each TCP has its own Operating Agent, Wim van Helden for SHC TCP and Andreas Hauer for ECES TCP.

Task Duration

The Task started on January 2017 year and will end December 2019.

Participating Countries

Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, France, Italy, Netherlands, Sweden, Slovenia, Czech Republic, Turkey, United Kingdom.

Work During 2017

Subtask 1: Energy Relevant Applications for an Application-oriented Development of improved Storage Materials

A starting table for the possible applications for thermal energy storage was made at the Lyon Task Kick-off meeting. This will be the basis for a short list of applications for which the boundary conditions for system, component and material derived.

Work on the List of Applications was continued in the second Task Experts meeting. A further detailing and inventory of the different application aspects was discussed: operating a condition, who is working on which application, and Key Performance Indicators.

For five applications, more than five organizations showed interest in working on the aspects and one expert was appointed as the lead for the specific application:

- Domestic heating and cooling (short term and seasonal): EMPA, Benjamin Fumey
- Industrial batch processes: HSLU, Anastasia Stamatiou
- Combined heat and power (also decentralized, solar): EHU, Gonzalo Diarce
- Integration in district heating system: ITW, Henner Kerskes and KTH, Viktoria Martin
- TES in HVAC systems (including ice storage as reference): ISE, Stefan Gschwander

Subtask 2P: Development & Characterization of improved Phase Change Materials

Presentations on PCM development given at the Task Kickoff meeting in April 2017 showed a wide range of activities in the field of PCM development. The main activities are on the development of new compounds (e.g., microencapsulation of PCMs), the development of new binary and ternary material mixtures and on the improvement of PCM stability. The first objective of the subtask is here to develop a template to collect relevant information on these approaches including thermophysical properties relevant for application.

For the material database, new masks for further properties are under development. In a first step the database will be extended to feed in viscosity data.

The round robin test (RRT) for determining the heat capacity Cp and the material density will use the same material that were used in the previous RRT on thermal conductivity, namely RT70HC. Additional material is Parafol 18-97.

Four organizations will participate in the RRT with a T-history method, and three with a thermal hot bridge method. A procedure for the measurement of the heat capacity was discussed and agreed upon. For the determination of the material density, a number of temperatures both in the solid and the liquid state were agreed upon.

The group will also work on a Wiki on PCM. The different terms that will be described are, amongst others are the DSC method, supercooling, nucleation, hysteresis, and T-history.

The scope of this working group is to develop and characterize new and improved TCM materials as powders: chemical reactants and sorption materials and composites. The investigated materials are part of different European and national projects. Novel chemical reactions and composite materials were developed and identified in thermochemical heat storage materials: sorption materials: MOFs, SAPO-34 on heat exchanger, mesoporous zeolites, aluminophosphate, chemical reactants ($CuCl_2$, $SrBr_2$, $SrCl_2$, K_2CO_3) and oxides (MgO, CaO); redox reactions and composites (hydroxides with expanded graphite or carbon nanotubes; salts in silica gels; vermiculite with LiCl; $CaCl_2$ in CaX). A few laboratories are also working on absorption in solutions like LiBr or LiCl.

It was decided that the TCM database should be divided into three parts:

1. Solid materials based on sorption
2. Materials based on chemical reaction
3. Liquids based on absorption.

Experts defined which materials properties should be included in the database for sorption materials (adsorbent material, adsorbate, adsorbent density, density measurement technique, density measurement temperature, density source, material cost, desorption temperature, desorption adsorbate partial pressure, desorption pressure, adsorption temperature, adsorption adsorbate partial pressure, adsorption pressure, sample mass, measurement method, adsorbate uptake, heat of adsorption, specific heat of “dry” material, cycling stability (optional), reference, comments, contact) and for materials based on chemical reaction. The latter will be divided to starting materials properties (name, chemical composition, % active part, surface area, mean particle size, producer, etc.), type of reaction, testing conditions and performance (charging, discharging conditions, etc.), cyclability (number of cycles, storage efficiency at n cycles, etc.), and additional information like price, safety, corrosion, and references.

Subtask 3P: PCM Measuring Procedures and Testing Under Application Conditions

Following on from the work on a standardized procedure to measure PCM via dynamic DSC, additional standardizing activities have started. To establish measuring procedures for thermal conductivity, viscosity and density, round robin tests are going to be carried out among the experts of the PCM group. As in the DSC round robin test, octadecane is chosen as the first material to be measured. Having in mind the successful work on the DSC procedure, the experts are highly motivated to come up with measuring standards for the other thermophysical properties during the current phase of the Task.

The main objective of Subtask 3P is to work on an inventory and description of properties of PCM that change comparing lab-scale experiments with tests under application conditions. Based on the inventory, simple test procedures to assess/quantify the changes of properties shall be identified or proposed. The intended outcome of this work is to come up with recommendations how to assess the behavior of a material under application conditions using rather simple tests without the need to perform experiments at application scale.

The status quo of the inventory is a table containing several examples where such changes have been observed. The conditions/parameters the changes of properties depend on are indicated as well as a possible relation to one of the other Subtasks (2P, 4P). In addition, the table contains information for which PCM and under which testing conditions the changes of properties have been observed (incl. corresponding publications).

Subtask 3T: TCM Measuring Procedures And Testing Under Application Conditions

Work in this Subtask focused on:

- Setting up and distributing online collaboration tools provided by AIT (Salesforce and FTP server)
- D3T1: All participants can share their documents or links for the description of available and needed TCM characterization procedures for the defined quantities in a prepared excel list (FTP)
- D3T2: Definition of the first round-robin test for a zeolite (NaMSX Zeolite provided by ZAE) and a salt hydrate (SrBr2·6H2O provided by INSA Lyon). Material was shipped in June 2017 to the participating partners.
- D3T3: All participating partners put their installed methods in a prepared excel list. On material scale definition of the measurement procedures will start with the results from the first round-robin tests. On lab scale participants starting to describe their available lab reactor systems.

Two round robin tests on two different thermochemical materials were conducted:

- NaMSX Zeolite provided by ZAE
- Salt hydrate SrBr2·6H2O provided by INSA Lyon

The goal for the zeolite measurement was to analyze the water uptake and heat of adsorption at two defined temperature and water vapor pressure scenarios. Large deviations could be seen in the data due to different definitions of the dry mass and misinterpretation of the specifications. For the salt hydrate, several participants measured dehydration enthalpy and temperature as well as mass change without recommendations. Results have shown large deviations for dehydration temperature and enthalpy.

For the next round robin test, these materials are measured again with a measurement procedure and defined temperature and gas conditions to get results that are more comparable than in the first round.

What has been completed:

- D3T1: Spread sheet with literature references to available TCM measurement procedures and available methods on material scale was generated and filled with data
- D3T2: First round robin test was conducted
- D3T3: Participants sent their information about the available reactors.

Subtask 4P: Component Design for Phase Change Materials

During the Experts Meeting in Lyon participants developing new storage concepts were identified. From the presentations given in Lyon, the improvement of storage parameters, such as thermal power, was pointed out as one of the main focus of current research on PCM storage systems. As the first step in Subtask progress, there was a need to agree on the classification of concepts and the parameters to be evaluated and compared. A classification of concepts was selected and a template is prepared to compile the information on the concepts being developed and tested by the subtask participants.

A list of component concepts was completed and agreed. It will be distributed to all the participants in Subtask 4P. Information on the activities developed by each participant was collected and included in the information to be distributed for all to update/complete the information.

A first draft of different characteristics of performance was discussed. It will be also distributed and comments will be added.

Subtask 4T: Component Design for Thermochemical Materials

Work is ongoing with respect to Deliverable 1, “Basic Description of investigated thermochemical storage processes and their impact on the component design”. Input to the initial template sent to the contributing partners has pointed to the diversity of systems, emphasizing the challenge to categories basic system approaches in order to allocate general design barriers. Eight institutes have contributed and a further six contributions are expected. A basic categorization in respect to open or closed systems referring to access of sorbate from the air or by system internal evaporation process and fixed or transported referring to a combined design of sorbent storage and heat exchanger or separate storage and heat exchanger with sorbent transport has been established. Figure 1shows the basic schematics of the systems.

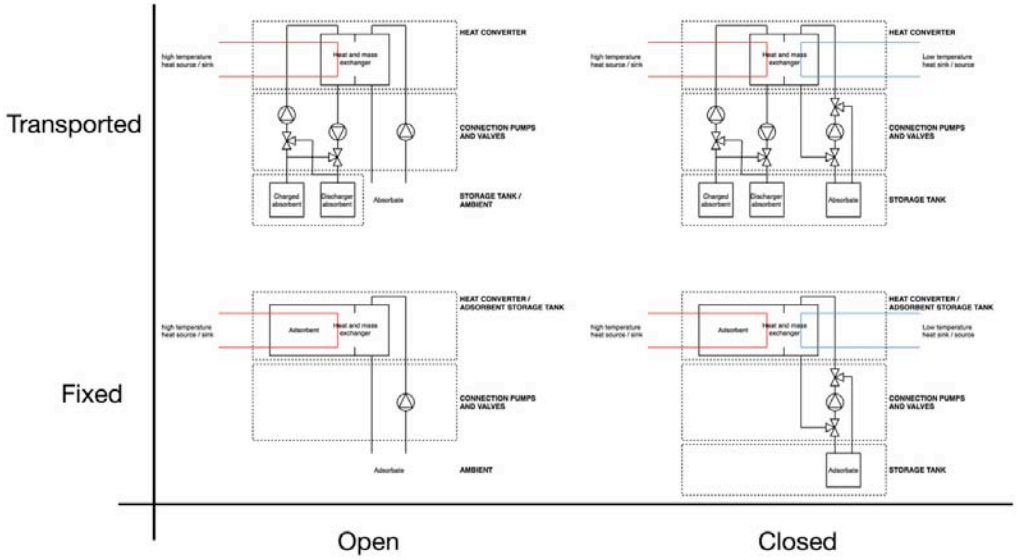


Figure 1. Illustration of the basic systems categorized as open or closed and fixed or transported.

Contributed systems are classified according to the above schematics whereby additional components are included. A basic finding in this approach is that while the open and fixed system appears to be the simplest in the basic schematics, in final designs for space heating and domestic hot water, several additional components especially heat exchangers are required as shown in the Figure 2 illustration of the open fixed system SolSpaces from ITW. Schematics of all contributed systems according to the above illustrations are made in order to identify additional and possibly performance effecting components.

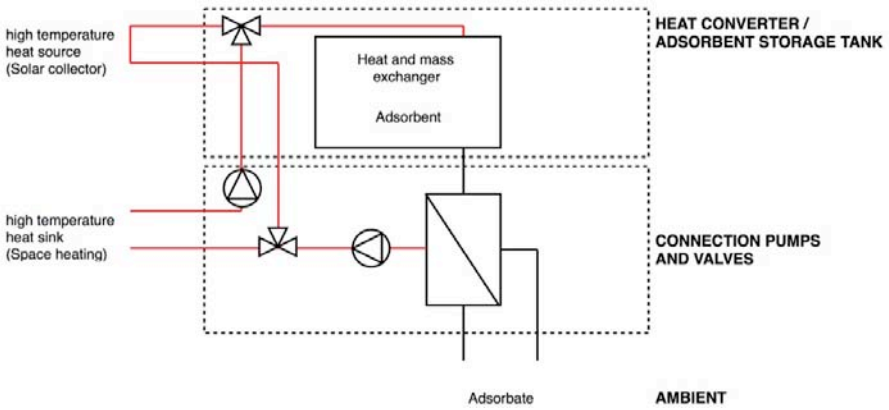


Figure 2: Illustration of the SolSpaces system from ITW according to the basic schematics from Figure 1.

On a system level performance of heat exchangers and heat and mass exchangers is a very important factor and can lead to the success or failure of a system. In general all systems based on thermo chemical materials must reach good heat and mass transport for both the sorbent as well as the sorbate. It is recognized that due to the diversity of sorbent materials and thus the variety of heat and mass exchanger design approaches, general evaluation and comparison of their performance is challenging. In addition common performance parameters such as power density and energy density are highly dependent on operation parameters, mainly working temperatures. In order to resolve this challenge, a comparison to the material specific concentration versus sorbate partial pressure in an open system or temperature difference between sorbent and sorbate condensing temperature in a closed system is sought. The specific performance can be evaluated in respect to how close the system performance fits to the material specific equilibrium curve. This is illustrated for the closed absorption process of the absorbate water on the absorbent aqueous sodium hydroxide in Figure 3. Close fit to the equilibrium line shows good performance of the heat and mass exchanger.

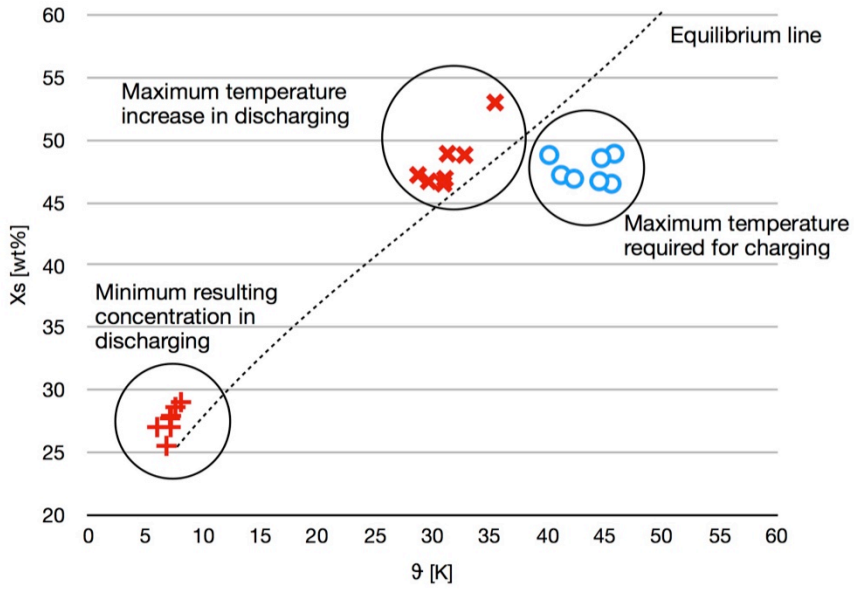


Figure 3: Equilibrium curve of aqueous sodium hydroxide in respect to concentration and temperature difference between absorber / desorber heat and mass exchanger and evaporator / condenser heat and mass exchanger.

The report for Deliverable 1 is now being formulated and will be finalized for publication at the upcoming 3rd task meeting. In addition, preparations for Deliverable 2 “Inventory of actual component designs currently under investigation” will be started.

Work Planned For 2018

Subtask 1: Energy Relevant Applications for an Application-oriented Development of improved Storage Materials

The groups for the different applications will work out the drafts of parameters for the application as a basis for the discussion at the third experts meeting.

Subtask 2P: Development & Characterization of improved Phase Change Materials

The group will work on a Wiki on PCM. The different terms that will be described are, amongst others: the DSC method, supercooling, nucleation, and hysteresis, T-history.

Subtask 2T: Development & Characterization of improved Thermochemical Materials

Database for liquids will be developed and presented for discussion in the next Task/Annex experts meeting next year.

Subtask 3P: PCM Measuring Procedures and Testing Under Application Conditions

In the next step, experts are asked to add examples to the inventory table they have been experienced during their research or encountered in literature. After the input from the experts, the table will probably merge together very different effects. Therefore, a restructuring of the table is planned prior to the next meeting in April 2018. Content of the table that is more an objective of one of the other Subtasks (2P or 4P) will be discussed within the corresponding Subtask.

Subtask 3T: TCM Measuring Procedures And Testing Under Application Conditions

Activities will include:

- D3T1: List with literature references will further grow
- D3T2: 2nd round of the round robin tests on the already measured two material candidates
- D3T3: First measurement procedure on material scale for zeolite and salt hydrate under defined application conditions sent out and reviewed by the participants.
- Measurement procedure on for lab scale tests is developed.

Subtask 4P: Component Design for Phase Change Materials

A first draft of different characteristics of performance was discussed. It will be also distributed and comments will be added. The final list will be agreed in next meeting.

The report for Deliverable 1 is now being formulated and will be finalized for publication at the upcoming 3rd task meeting. In addition, preparations for Deliverable 2 “Inventory of actual component designs currently under investigation” will be started.

Dissemination Activities In 2017

Reports, Published Books

Author(s)/ Editor	Title	Report No. Publication Date
Gaeini, M.	Thermochemical seasonal heat storage for the built environment: a multi-scale investigation	PhD thesis, Eindhoven University of Technology, The Netherlands July 2017
Diarce, G.	Development of new eutectic PCMs and plate-based LHTES systems for domestic cogeneration applications	PhD thesis, University of the Basque country (UPV/EHU) 2017

Journal Articles, Conference Papers, etc.

Author(s) / Editor	Title	Publication / Conference	Bibliographic Reference
Benjamin Fumey et al.	Task58 Material and Component Development for Thermal Energy Storage: Objectives and Outlook	IEA SHC Solar Update	May 2017

Emanuela Mastronardo, Yukitaka Kato, Lucio Bonaccorsi, Elpida Piperopoulos, Candida Milone	“Thermochemical Storage of Middle Temperature Wasted Heat by Functionalized C/Mg(OH)2 Hybrid Materials	Energies	Volume 10, 2017, 70-86
Emanuela Mastronardo, Lucio Bonaccorsi, Yukitaka Kato, Elpida Piperopoulos, Maurizio Lanza, Candida Milone	Strategies for the enhancement of heat storage materials performances for MgO/H2O/Mg(OH)2 thermochemical storage system	Applied Thermal Engineering	Volume 120, 2017, 626-634
Elpida Piperopoulos, Emanuela Mastronardo, Marianna Fazio, Maurizio Lanza, Signorino Galvagno, Candida Milone	Enhancing the volumetric heat storage capacity of Mg(OH)2 induced by the addition of a cationic surfactant during its synthesis	Applied Energy	Paper submitted
V. Brancato, A. Frazzica,	Characterization of zeotype adsorbent materials for TES applications,	14th International Conference on Energy Storage April 2018, Turkey	Paper paper
S. Höhlein, A. König-Haagen, D. Brüggemann	Latentwärmespeicher hoher Energie- und Leistungsdichte durch Makroverkapselung	Fachformum Thermische Energiespeicher July 2017, Germany	Presentation
Phillip Bendix, Gerrit Füldner, Marc Möllers, Harry Kummer, Lena Schnabel, Stefan Henninger, Hans-Martin Henning	Optimization of power density and metal-to-adsorbent weight ratio in coated adsorbers for adsorptive heat transformation applications.	Applied Thermal Engineering	124, S. 83–90 DOI:10.1016/j.applthermaleng.2017.05.165
Phillip Bendix, Stefan Henninger, Hans-Martin Henning	Temperature and Mechanical Stabilities and Changes in Porosity of Silicone Binder Based Zeolite Coatings	Industrial & Engineering Chemistry Research	55 (17), S. 4942–4947 DOI:10.1021/acs.iecr.6b00558
Simon Furbo	Langtidsvarmelagring baseret på salthydrater (Long term heat storage based on salt hydrates)	Heat storage meeting at the Danish Academy of Technical Sciences (ATV) March 2017	Presentation

Mark Dannemand	Udvikling af langtidsvarmelager til solvarmeanlæg i enfamiliehuse (Development of long term heat storage for solar heating systems in single family houses)	DANVAK DAGEN 2017 April 2017, Denmark	Presentation/Paper
Christoph Moser, Gerald Englmair, Hermann Schranzhofer, Andreas Heinz	Simulation Study of a Novel Solar Thermal Seasonal Heat Storage System based on Stable Supercooled PCM for Space Heating and Domestic Hot Water Supply of Single Family Houses	12th International conference on Buildings and Environment "enviBuild 2017" September 2017, Austria	Presentation/Paper
Gerald Englmair	Performance Evaluation of a Demonstration System with PCM for Seasonal Heat Storage: Charge with Evacuated Tubular Collectors	SHC 2017/SWC 0217 Oct – Nov 2017, UAE	Presentation/Paper
Gerald Englmair	Sustainable energy system: Long term PCM heat storage for a solar space heating and domestic hot water combisystem	Sino-Danish Center for Research and Education workshop at University of Chinese Academy of Sciences September 2017, China	Presentation/Paper
Scapino L, Zondag HA, Van Bael J, Diriken J, Rindt CCM	Sorption heat storage for long term low-temperature applications: A review on the advancements at material and prototype scale	Applied Energy	2017; 190:920–48 DOI:10.1016/j.apenergy.2016.12.148
Scapino L, Zondag HA, Van Bael J, Diriken J, Rindt CCM	Energy density and storage capacity cost comparison of conceptual solid and liquid sorption seasonal heat storage systems for low-temperature space heating	Renewable and Sustainable Energy Reviews	Rev 2017; 76:1314–31 DOI:10.1016/j.rser.2017.03.101
Donkers PAJ, Sogutoglu LC, Huinink HP, Fischer HR	A review of salt hydrates for seasonal heat storage in domestic applications	Applied Energy	2017; 199:45–68 DOI:https://doi.org/10.1016/j.apenergy.2017.04.080

van Alebeek R, Beving MAJM, Gaeini M, Rindt CCM, Zondag HA..	Design and experimental investigation of a high power segmented zeolite 13X/water sorption energy storage system	4th Sustainable Thermal Energy Management International Conference (SusTEM 2017) Netherlands	Presentation/Paper
Gaeini, M., Wind, R., Donkers, P. A. J., Zondag, H. A. & Rindt, C. C. M.	Development of a validated 2D model for flow, moisture and heat transport in a packed bed reactor using MRI experiment and a lab-scale reactor setup	International Journal of Heat and Mass Transfer	2017: 113: 1116-1129
Gaeini, M., Javed, M. R., Ouwerkerk, H., Zondag, H. A. & Rindt, C. C. M.	Realization of a 4kW thermochemical segmented reactor in household scale for seasonal heat storage	Energy Procedia	2017: 135: 105–114
Lan, S., Gaeini, M., Zondag, H. A., van Steenhoven, A. A. & Rindt, C. C. M.	Direct numerical simulation of the thermal dehydration reaction in a TGA experiment	Applied Thermal Engineering	2018: 128: 1175-1185
Stamatiou A. et al	High power thermal energy storage using phase change material slurries	12th IIR Conference on Phase Change Materials and Slurries for Refrigeration and Air Conditioning Canada	2018, Orford (QC), Canada.
Diarce, G., Campos-Celador, Á., Sala, J.M., García-Romero, A.	A novel correlation for the direct determination of the discharging time of plate-based latent heat thermal energy storage systems	Applied Thermal Engineering	129, 521–534
M. Deutsch, F. Birkelbach, C. Knoll, M. Harasek, A. Werner, F. Winter	An extension of the NPK method to include the pressure dependency of solid state reactions	Thermochimica Acta	654 (2017), 168 - 178
C. Knoll, D. Müller, W. Artner, Jan Welch, A. Werner, M. Harasek, P. Weinberger	Oxalate-hydrates in thermochemical energy storage - a so far neglected class of salt hydrates	The International Symposium on Energy 7 August 2017, UK	Presentation/Paper
D. Müller, C. Knoll, W. Artner, J. M. Welch, A.	Enhancing the hydration reactivity of MgO about	The International	Presentation/Paper

Werner, M. Harasek, P. Weinberger	particle morphology and chemical dopants	Symposium on Energy 7 August 2017, UK

Task Meetings in 2017 and 2018

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting #1	5-7 April 2017	Lyon, France	60 (13)
Experts Meeting #2	4-6 October 2017	Dübendorf, Switzerland	46 (12)
Experts Meeting #3	9-11 April 2018	Ljubljana, Slovenia	
Experts Meeting #4	1-3 October 2018	Graz, Austria	

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