2018 Annual report

Feature article on solar cooling

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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Annual report

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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: Wine cellar in Banyuls sur Mer, France relies on a 130 m2 solar thermal plant for air conditioning the 4,500 m2 cellar – the system has been operating for 28 years.

Credit: Daniel Mugnier, Tecsol

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1. Message from the Chairman

Daniel Mugnier (left) and Ken Guthrie (right)

In 2018, the IEA SHC Technology Collaboration Programme (TCP) members used the year to plan for the future, to reflect on past accomplishments, and to transition to a new Executive Committee Chair. All of which supported our underlying pursuit to be the leading and influencing international collaborative research program that produces high quality data and research on solar heating and cooling.

After four years of dedicated leadership, Ken Guthrie has passed the baton to me. As the new Chairman, I look forward to building upon Ken's work as the TCP enters its new 5-year term in 2019. I've worn many hats in the SHC TCP from Task Expert to Task Operating Agent to Alternate Executive Committee member for France and plan to use these experiences to continue to raise the visibility of solar heating and cooling at the local, national and international levels.

Sharing our work and results in the most comprehensive way is a top priority, and we do it in a variety of formats. Our Solar Academy activities included four webinars hosted by ISES, two onsite training programs held in South Africa (topic: solar cooling) and China (topic: Solar district heating and cooling), and two national days in conjunction with our Stockholm, Sweden and Lisbon, Portugal Executive Committee meetings. We published our 2018 edition of Solar Heat Worldwide, Solar Update newsletter, Task 2018 Highlights, and many Task reports and online tools. Our partnership with Solarthermalworld.org is another avenue for disseminating our work as it is the leading news service in this field in addition to numerous presentations at a variety of conferences.

As we continue to address the big issues for solar thermal deployment through our seven current Tasks, collaboration with the IEA, other IEA TCPs, international organizations, and industry is essential. In 2018 we: -organized two side meetings during the Renewable Energy Working Party meeting, Ken Guthrie and I met with IEA staff and other TCPs to discuss collaboration and our LCoH calculation method, Artur Bobovnický (Slovakia ExCo member) participated in the IEA National Day in the Czech Republic, Ricardo Enriquez (Spain ExCo member) participated in the IEA Building Coordination Group meeting, Werner Weiss (Austria ExCo member), Alessandra Scognamiglio (Italy ExCo member) and Maria Wall (Task 51 Operating Agent) participated in the IEA Working Group on Cities and Communities meetings, and I met with IEA staff to discuss solar thermal trends and costs and improved communication. We held a joint meeting with the IEA Energy in Buildings and Communities Technology Collaboration Programme (EBC TCP) at our Executive Committee meeting in Stockholm, Sweden. And, have four Tasks that are collaborating with other TCPs that cover Renewable Energy and End Use Technologies. Our relationship with industry, whether through our Tasks or TCP activities, is critical if we are to better understand their perspective and issues and are to reach a key target audience for disseminating our research results.

I want to thank Ken Guthrie for his leadership as the past Chairman and welcome the new TCP Vice Chairs, He Tao (China), Elimar Frank (Switzerland), and Richard Hall (UK). I would also like to acknowledge the contributions of the Executive Committee members, the Task Operating Agents, and all the Task experts. Lastly, thank you to the Secretariat, Pamela Murphy, and the Webmaster, Randy Martin, for their support to the Programme.

2019 is on course to be another year of significant achievements and increased visibility as we implement our new Strategic Plan and once again hold our International Conference on Solar Heating and Cooling for Buildings and Industry in Chile (SHC 2019) from our Task work and valuable collaborative work with Industry and other TCPs.

Daniel Mugnier, 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 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 2019-2023 term:

Our **Vision**…

Solar energy technologies will provide more than ***50% of low temperature heating and cooling demand for buildings in 2050*** *and contribute* ***a significant share to the heat supply for the agricultural and industrial sectors****. Thus, solar heating and cooling will contribute significantly to lowering CO2 emissions worldwide and reaching the Paris Agreement goal.*

Our **Mission**…

Through multi-disciplinary international collaborative research and knowledge exchange, as well as market and policy recommendations, the SHC TCP will ***work to increase the deployment rate of solar heating and cooling systems by breaking down the technical and non-technical barriers to increase deployment****.*

Our 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 SHC TCP 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.

Our target audiences are 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 TCP 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 2018 were:

- 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)
- Application of PVT Collectors and New Solutions with PVT Systems (Task 60)
- Integrated Solutions for Daylight and Electric Lighting (Task 61)
- Solar Energy in Industrial Water and Waste Management (Task 62)

To support the work in our Tasks, the *SHC Solar Academy* was established in 2016 to facilitate the dissemination of Task results and to support R&D and implementation of solar heating and cooling projects worldwide. The main activities are 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 2019 will be held together with ISES Solar World Congress 2019 on November 5-7 in Santiago, Chile), 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 SHC TCP 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 European Copper Institute
2 ECOWAS Centre for Renewable Energy and Energy Efficiency
3 Gulf Organization for Research & Development, withdrew in June 2018
4 International Solar Energy Society
5 Regional Centre for Renewable Energy and Energy Efficiency

Benefits of Membership

The SHC TCP 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.

83rd Executive Committee Meeting – June 2018, Stockholm, Sweden

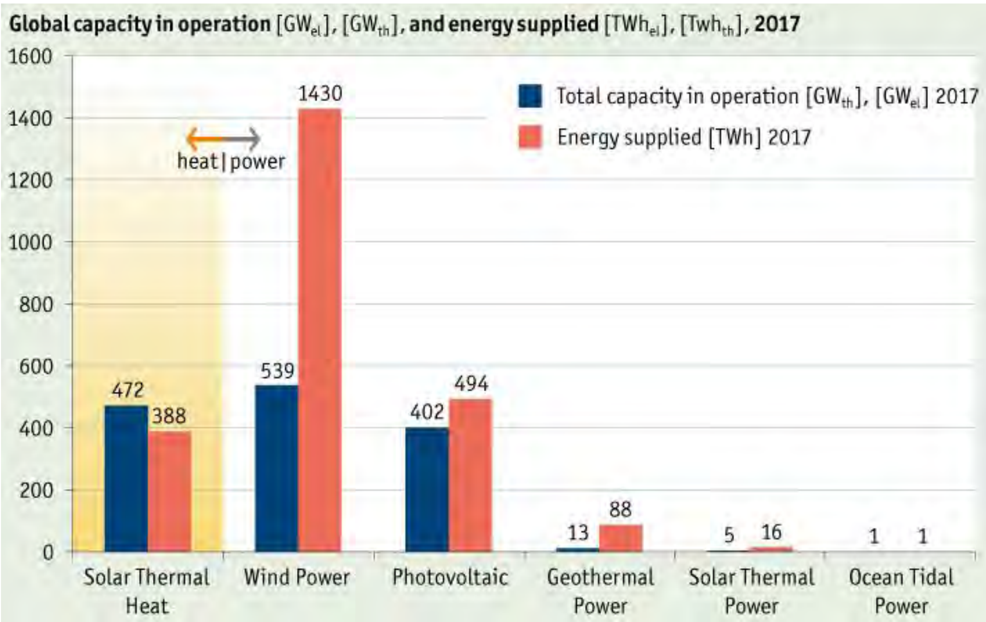
84th Executive Committee Meeting – November 2018, Lisbon, Portugal

3. 2017 Recap

Solar Thermal Outlook

Every year we publish *Solar Heat Worldwide: Markets and Contribution to the Energy Supply*, the only annual global solar thermal statistics report. The 2018 edition reports that in 2017, solar thermal technologies produced 388 TWh – which corresponds to an energy savings equivalent of 41.7 million tons of oil and 134.7 million tons of CO_2.

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. Below are is a graph showing the global capacity for different renewable energy sources in 2017 and a table with the top five markets in 2017 by total MWth and per 1,000 inhabitants.



Global capacity in operation and energy supplied in 2017

TOP FIVE MARKETS IN 2016			
Newly installed water collectors (MWth)	**Newly installed water collectors (kWth/1,000 inhabitant)**	**Total water collectors in operation (MWth)**	**Total water collectors in operation (kWth/1,000 inhabitant)**
China (27,664)	Denmark (60)	China (324,506)	Barbados (515)
Turkey (1,296)	Cyprus (36.1)	USA (17,565)	Austria (418)
Brazil (913)	Barbados (27)	Turkey (14,933)	Cyprus (399)
India (841)	China (20)	Germany (13,535)	Israel (397)
USA (682)	Greece (18)	Brazil (9,555)	Greece (292)

Top five solar thermal collector markets in 2016

SHC Tasks

New Tasks

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 2018, the following Tasks began:

- Task 60 Application of PVT Collectors and New Solutions with PVT Systems *(Lead Country: Switzerland)*
- Task 61 Integrated Solutions for Daylight and Electric Lighting *(Lead Country: Germany)*
- Task 62 Solar Energy in Industrial Water and Waste Management *(Lead Country: Austria)*

Completed Tasks

In 2018, the following Tasks ended:

- Task 52 Solar Heat and Energy in Urban Environments *(Lead Country: Germany)*
- Task 53 New Generation Solar Heating and Cooling *(Lead Country: France)*
- Task 54 Price Reduction of Solar Thermal Systems *(Lead Country: Germany)*
- Task 57 Solar Standards & Certification *(Lead Country: Denmark)*

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. The SHC 2019 conference will be held together with the International Energy Agency's Solar World Congress on November 5-7 in Santiago, Chile.

SHC Solar Award

Our prestigious award recognizes individuals, companies and institutions that have made significant contributions to the growth of solar thermal. The 12th SHC Solar Award will be presented at SHC 2019 in Santiago, Chile and recognize a financing mechanism to support deployment of solar heating or cooling project(s).

SHC Book Series

This growing collection of books on Task results is published by Wiley-VCH and can be purchased online. Books in the series are: *The Solar Cooling Design Guide: Case Studies of Successful Solar Air Conditioning Design*, *Solution Sets for Net-Zero Energy Buildings: Feedback from 30 Net ZEBs Worldwide 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 and Task 61: Integrated Solutions for Daylight and Electric Lighting.

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. Task 60: Application of PVT Collectors and New Solutions with PVT Systems, and Task 61: Integrated Solutions for Daylight and Electric Lighting.

IEA Renewable Energy Working Party meetings in 2018 were attended by the SHC Chairs, Ken Guthrie and Daniel Mugnier. Also presented our Request for Extension and Strategic Plan to the Working Group for final approval in 2019.

IEA Buildings Coordination Group meetings in 2018 were attended by the SHC Vice Chair, Ricardo Enriquez (Spain ExCo member).

IEA Working Group on Cities and Communities meetings in 2018 were attended by Werner Weiss (Austria ExCo member), Alessandra Scognamiglio (Italy ExCo member) and Maria Wall (Task 51 Operating Agent).

IEA National Day in Czech Republic provided an opportunity for Artur Bobovnický (Slovakia ExCo member) to present the TCP.

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.

Solar Heat Europe (formally ESTIF), the SHC Programme has a close working relationship with this organization and will look for opportunities for joint events during SHC 2019 conference.

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

Executive Committee Meetings

2018 MEETINGS	2019 MEETINGS
83rd ExCo Meeting Stockholm, Sweden. June 19 – 21 *(included National Day, Joint Meeting with EBC TCP, and Technical Tour)*	**85th ExCo Meeting** Vienna, Austria June 5 – 7 *(will include National Day and SHC ExCo reunion)*
84th ExCo Meeting Lisbon, Portugal November 13 – 15 *included National Day*	**86th ExCo Meeting** Santiago, Chile November 8 – 9 *following SHC 2019 conference*

4. Feature Article

Solar Cooling – Innovation and Necessity Lead the Way

Space cooling is and will continue to be one of the most critical issues in energy systems[1]. Increasing demand for refrigeration and air conditioning has led to a dramatic increase in peak electricity demand in many countries. In addition to rising electricity costs, brownouts in summer months have been attributed to a large number of conventional air conditioning systems powered by electrical energy. The increasing usage of vapor compression cooling machines (more than 100 million units of room air-conditioners were sold in 2016 worldwide) also leads to increased greenhouse gas emissions from indirect emissions related to fossil fuel derived electricity consumption.

An opportunity to reverse this trend is to use the solar source that is creating the cooling demand in buildings. The distinct advantage of the cold production based on solar energy is the high contemporaneity of solar irradiation and cooling demand (that is, the use of air conditioning is highest when sunlight is abundantly available), which reduces the need for energy storage.

Solar cooling consists of two main solutions 1) photovoltaic systems in combination with vapor compression cooling machines, and 2) solar thermal systems in combination with thermally driven sorption chillers. Both solutions are market-ready technologies.

Why Solar Cooling?

A major argument for solar-driven systems is that they consume less fossil-fuel energy and often use natural refrigerants. In Europe, their utilization is also encouraged by the European F-gas regulation No. 517/2014. Another driver for solar cooling technology is its potential to reduce peak electricity demand, particularly in countries with significant cooling needs and grid constraints. Solar energy can be converted into useful cooling by two main principles:

1. Electricity generated with photovoltaic modules (PV) can be turned into cooling using well-known refrigeration and air-conditioning technologies that are mainly based on vapor compression cycles.

2. Heat generated with solar thermal collectors (ST) can be converted into cooling using thermally driven refrigeration or air-conditioning technologies. Most of these systems employ the physical phenomena of sorption in either an open or closed thermodynamic cycle.

With the significant technical developments in solar thermal driven cooling components recently, research has shifted to the system level. R&D is focusing on the proper design and operational control of fully integrated systems. The same is true for PV driven solutions, which often use market available components and low-priced PV modules.

IEA SHC Task 53 considered both solar PV and solar thermally driven solutions. These new generation solar cooling systems were analyzed and assessed and their technical and economic potential presented.

Solar PV driven air-conditioning is beginning to emerge through the small size segment (split air-conditioners) in Asia. However, if such a system allows PV generated electricity to be significantly exported to the grid, this would not be considered as a "solar cooling system". Such a system is not different to most photovoltaic plants which are connected to the electric grid and operated independently from the heating, ventilation, air-conditioning, and refrigeration (HVAC&R) installation.

1 OECD/IEA (2018): The Future of Cooling. Opportunities for energy efficient air conditioning. Edited by IEA Publications, International Energy Agency.

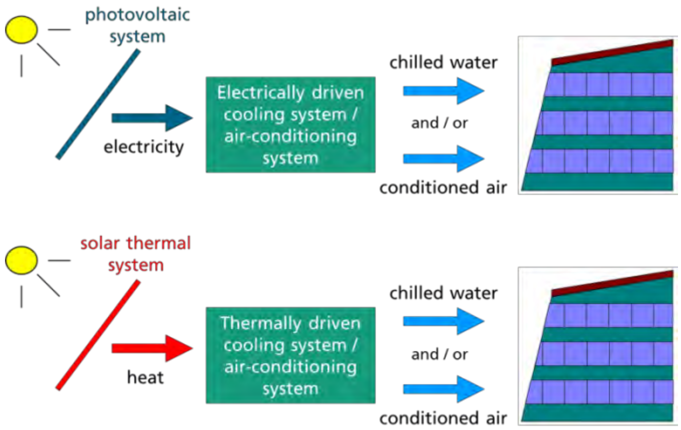


Figure 1. Principles for solar driven cooling. (source: Fraunhofer ISE)

Self-consumption-only solar PV driven air-conditioning offer potential benefits to the electricity grid and should be investigated further.

This is particularly favorable in countries where photovoltaic system energy costs are lower than that paid for electricity from the grid.

In 2018, heat driven air-conditioning and refrigeration systems using solar thermal energy as the main driving energy were the dominant technology for solar cooling.

Solar thermal systems, which simultaneously meet the demand for low-temperature heat (for domestic hot water) and high-temperature heat (for air conditioning), are more competitive.

Those combinations are very favorable, especially in moderate climates because they provide a very good year-round balance of solar energy use. Storing solar thermal energy is relatively easy as heat is shifted for cooling supply in the evenings and nights, and moreover storing surplus energy for morning cooling.

Status of the Technology and the Industry

In general, solar thermal cooling continued to face challenges during 2016 in key European and Chinese markets. This can be attributed to falling solar PV prices, which allowed cost-effective operation of vapor compression chillers powered by grid-connected solar inverters during daylight and at low fossil fuel prices[2].

In the solar cooling industry, a key focus area has been on reducing costs. Standardization of systems can reduce the investment costs of technologies that continue to be used at too small market volumes. Individually engineered solutions that consist of several components generally result in high costs. Manufacturers from around the globe have responded to the challenge by developing pre-engineered solar cooling kits with cooling capacities between 2.5 kW and 40 kW that are suitable for single-family, multi-family, and commercial properties.

In the segment of small and medium-size applications, a new generation of solar cooling systems, either PV or thermally driven, has appeared among existing solar thermal cooling solutions. Unfortunately, a real and significant market has not yet emerged from these innovations. Nevertheless, several SME's are working on solutions to reduce the relatively high system costs, space requirements and the complexity of solar cooling solutions, especially for small-capacity systems.

Several Chinese manufacturers now include a PV option on their units as a support to the main grid supply, even if this add-on renders the overall system to be an expensive air conditioner. The technological status of PV-driven heat pumps is still in its infancy. Although the technology will not be difficult to develop, the industry presently has not significantly focused on coupling photovoltaic energy and heat pumps. In some cases, it leads to autonomous systems that rely on batteries, which is a major barrier in terms of cost and reliability.

2 Weiss, Werner; Spoerk-Duer, Monika (2018): Solar Heat Worldwide. Global Market Development and Trends in 2017, detailed Market Figures 2016; 2018 Edition. Edited by SHC Solar Heating & Cooling Programme. Available online at http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2018.pdf, checked on 6/9/2018.

Systems connected to the grid but capable of running on a demand-response approach and exploiting inexpensive thermal storage units may be the best solution.

PV driven systems can either be connected with the grid or operate directly with the chiller/heat pump, whereas the compressor needs to be adapted for that variable operation. The systems need to be designed with a control strategy focused on maximizing PV self-consumption. Surplus PV electricity not used for the HVAC system needs to be considered for household electricity, or other purposes.

To reduce stress on the grid at times without radiation and to maximize self-consumption, the systems require thermal or electrical storage capacity. The design and configuration strongly depend on the entire load profile. Best technical and economic results can only be achieved by an integrated system and, if possible, building load optimization.

Solar cooling with thermal absorption chillers with a cooling capacity larger than 350 kW (100 RT) has recently improved significantly in terms of performance, and cost. The economy of scale plays an important role; solar cooling for larger office buildings, hotels, hospitals or commercial and industrial applications have become almost or entirely cost competitive under certain climate and energy price conditions.

Solar thermal systems that simultaneously combine demand for low-temperature heat (e.g., for domestic hot water) and high-temperature heat (necessary to drive solar air conditioning) are even more competitive. These combinations are very favorable, especially in moderate climates, because they deliver an optimum balance of year-round solar energy use, thus ensuring no solar heat is wasted.

Technical maturity and basic successful rules for design

According to the feedback of realized plants, the systematic preparation of a design guide[3] facilitates the introduction of ten high level qualitative key principles. These principles have been critically challenged among SHC experts through a survey conducted at new generation solar heating and cooling plants[4]. If these principles are obeyed and high-quality components are used to assemble SHC systems reliable, robust and economic results can be achieved.

An adapted version of these 10 key principles, modified for PV and solar thermal driven systems arranged in decreasing importance is given here:

- **Principle 0**: Reduce energy demand before using renewables
- **Principle 1**: Choose applications where high annual solar utilization can be achieved
- **Principle 2**: Keep the process flowsheet simple and compact
- **Principle 3**: Use efficient heat rejection units/systems
- **Principle 4**: Minimize parasitic power
- **Principle 5**: Avoid using fossil fuels as a backup for thermal driven systems (especially for single effect ab-/adsorption chillers)
- **Principle 6**: Apply appropriate resources for designing, monitoring, and commissioning
- **Principle 7**: Provide thermal storage capacity and hydraulics in a form that matches the thermal requirements of each energy demand
- **Principle 8**: Minimize heat loss
- **Principle 9**: Avoid over dimensioning of the collectors (ST and PV)
- **Principle 10:** Design the ab-/adsorption chiller for relatively constant operation at near full load

3 Mugnier, Daniel; Neyer, Daniel; White, Stephen D. (Eds.) (2017b): The Solar Cooling Design Guide - Case Studies of Successful Solar Air Conditioning Design. Berlin, Germany: Wilhelm Ernst & Sohn.
4 Neyer, Daniel; Ostheimer, Manuel; Mugnier, Daniel; White, Stephen (2018): 10 key principles for successful solar air conditioning design – A compendium of IEA SHC Task 48 experiences. In Solar Energy. DOI: 10.1016/j.solener.2018.03.086.

Energy performance for PV and solar thermally driven systems

IEA SHC Task 53 participants analyzed 28 systems that covered a variety of applications in certain locations[5]. The majority were small-scale systems with a capacity (total heating and cooling) below 10 kW. The PV supported systems were dedicated more to small-scale systems, whereas most of the solar thermal supported systems were large-scale, delivering more than 100,000 kWh/a of cooling energy. Medium-sized systems were dominated by heat pump systems in combination with both solar thermal collectors and/or PV systems. It should be noted that, due to the small number of sales, the majority of the analyzed systems were demonstration systems, which can significantly distort economic evaluation (in particular their upfront costs).

The technical and economic assessment focused on the relative savings of non-renewable primary energy ($f_{sav.NRE}$) as well as the relative levelized costs of energy (CR) against a standardized reference system (air-cooled vapor compression chiller, natural gas backup). The CR/$f_{sav.NRE}$ plot for all results is presented in Figure 2. A trendline summarizes all results, showing increasing costs with increased primary energy savings. However, this trend indicates that both technologies, solar thermal and PV supported systems, can be cost competitive at lower primary energy savings (i.e., cases with CR < 1). It is also evident that the distribution of the single results is large, thus clustering according to different characteristics can lead to a more in-depth analysis and conclusions.

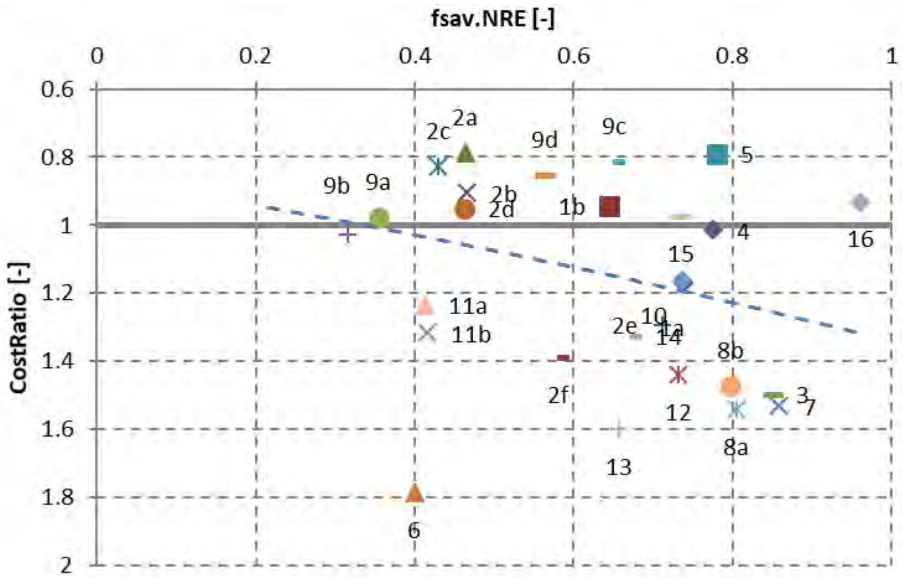


Figure 2. Comparison of the SHC systems in relation to the reference system by levelized costs of energy indicated as cost ratio and non-renewable primary energy savings. Nomenclature: 28 SHC examples (with numbers 1-16 and derivatives a, b, etc.) and its resulting trend line (dashed line) (Köll and Neyer 2018).

Economic viability and environmental benefits

In general, the economics of the solar supported systems are investment dominated. Thus, the focus, especially as it relates to small-scale systems, needs to be on reduction of the initial investment utilizing simple installation and compact, air-cooled units. PV supported systems are predestined to a capacity range, as they can be set up with chillers/heat pumps at low costs. However, the convenience and the choice of PV or ST depends on the loads (heating and cooling) to be covered, and the boundaries (quality of electrical grid, etc.).

The investment costs are changed in increments of 15%, from increased costs (115%) to decreasing investments (85, 70%) accordingly. Figure 3 shows the results of changing investment costs on the overall trend of all 28 analyzed SHC plants. The impact of the change is more relevant at higher savings levels.

If initial investment could be reduced by 15% (green) energy savings of 65% could be achieved with a CR below 1 (levelized cost of energy of SAC lower than the reference system). **If the investment could be reduced by 30% (orange) the levelized cost of energy of the solar driven system would always be lower than the reference one.**

5 Köll, R.; Neyer, D. (2018): Monitoring Data Analysis on Technical issues & performances. Deliverable C3, IEA SHC Task 53.

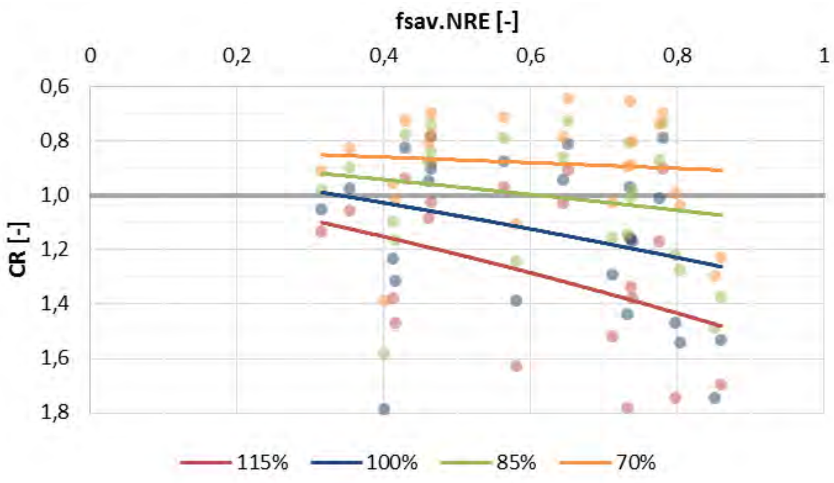


Figure 3. Sensitivity analysis of investment cost for the overall trend.

Market Status

Due to the low number of installed Solar Air Conditioning (SAC) systems worldwide, it is difficult to quantify the market status. Relatively few, but highly innovative companies are active in the solar cooling field. This can be split between component manufacturers, system supplier and specialized consulting offices. A few Energy Service Companies (ESCO) are active proposing contracting models for solar cooling for large systems (more than 500 $kW_{cooling}$). The products and status of the companies involved are mainly at the R&D stage. Commercially active companies/products are rare. The main markets for these players are often in the field of other renewable technologies. For instance, the majority of sorption chiller manufacturers are essentially selling their products in CHP or waste heat-based configurations.

The solar thermal supported components suppliers are mainly targeting: 1) small size compact plug and play units (e.g. Purix, SolabCool, etc.), 2) hybrid systems combining thermal driven with electrical driven medium-scale components for heating and cooling (R&D) or 3) the large-scale size (>500 kW) often including different applications and year around solar utilization.

For photovoltaic driven systems, all manufacturers currently know the possibility of coupling photovoltaic solar energy directly with their heat pumps and have incorporated this possibility into future developments. Large Asian manufacturers such as MIDEA (China), GREE (China), Panasonic (Japan) and LG (South Korea) already have equipment with the possibility of partially integrating photovoltaic energy into heat pumps. In any case, the real integration needs a change of the unit control system in order to maximize ambitious goals by overcoming barriers in developing solar energy in urban planning through an open communication forum.

The research illustrates 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 Potential

The potential for broader market penetration of SAC technology will require:

1. Further developing the technology in terms of improved component and system performance,
2. Reducing costs, and
3. Identifying preferred applications and business models for the market

Technical potential

The ongoing R&D on the material level is aimed at improving materials for adsorption and absorption (tailor-made absorbents, e.g., ionic liquids) or absorption cycles and composites mainly using adsorption materials. These materials and compounds have the potential to allow more compact systems with advanced heat and mass transfer and thus lead to lower costs. Work on components includes both advanced cooling cycles and advanced solar collectors, which are tailored to the needs of thermally driven cooling.

The current range of heat rejection units mainly caters for large capacity. The development of heat rejection systems specially designed for use in SAC will lead to reduced component cost, in particular for small capacity units (e.g., below 100 kW of cooling power). These heat rejection units also present limitations in hot and sunny regions of the world where water is expensive and where air-cooled systems are almost inefficient. Further progress and innovation are required in this area.

At the system level, further investigation is required to improve reliability and improve quality in the project delivery chain, ranging from design, planning, construction, and assembly to operation. This work includes measures such as training and education to increase knowledge and experience among professionals active in design and installation of solar supported HVAC systems.

The main potential that can be applied by solar cooling is its high efficiency and low non-renewable primary energy demand. In addition, the use of natural refrigerants decreases the impact on global warming. Systems that are established can be designed for reliable and robust long-life applications. Removal of systems and disposal issues need to be addressed.

The electricity demanded by a solar cooling system, e.g., running pumps and the cooling tower, is quite low. Depending on the climate, electrical SPFs (kWh_{th}/KWh_{el}) of 20 to 40 can be achieved in systems with optimized variable speed drive performances. Thus, the electric demand for air conditioning in a building is cut down by more than 80% compared to conventional HVAC equipment.

Highlights of potentials on the system level are summarized as follows:

- Adaptation of components to be compatible with future HVAC systems, that can either be variable speed driven heat pumps/chiller (that provide directly useable cooling/heating) or include storage capacity (if a shift of demand/production is needed).
- Hybrid components/systems offer significant potential to allow solar support from ST and/or PV and provide heating/cooling at the same time. This is especially of interest in the tertiary sector where energy demand differs, and the capacity often increases from medium to large scale.
- Continuous monitoring to achieve life-long reliable operation. This not only affects solar HVAC positively, but this is also true for conventional systems which often underperform.
- System simplification that leads to less complex hydraulics, easier control strategies and to lower heat loss. Overall, a fair reduction in investment cost can be expected, as well as a lower barrier to implement solar supported systems.
- In the small and medium scale range plug and play, solutions contribute to the simplification of installation and integration. While plug and play is entering the small-scale market, significant expansion potential exists in the untapped medium-scale market.

Costs and economics

On the component level, the main cost reductions are particularly expected for small capacity cooling machines. Both technology improvements and mass production on an industrial scale will certainly lead to lower costs for these key components. In principle, a noticeable potential also exists for cost reduction of solar thermal collectors, or at least for solar collector installations. However, prices of solar thermal systems have remained relatively steady over the last decade, which can be attributed to unstable market development and market policies.

In general, systems economics are mainly dominated by investment. Thus, the main aim is to reduce these initial costs, but at the same time keeping a high-quality standard for efficient and reliable components. A reduction of overall investment cost by 30% could change the overall economics dramatically. According to the sensitivity analysis presented above, the majority of the system could then provide lower levelized cost of energy than a conventional reference system. If the investment costs decrease, the natural gas and electricity cost becomes more and more a key aspect in the economic equation of a SAC project.

However, levelized cost of energy or total costs of ownership are seldom used to arrive at a decision. The amortization time is more often used to determine the outcome. Currently, 8 to 15 years are realistic if investment costs can be decreased, and in favorable cases, 5 years amortization is possible.

If the key economic performance indicators used in IEA SHC Task 53 ($f_{sav.NRE}$, CR) are considered and used for decision making, it is evident that cost ratios far below one can be reached. Cost savings of 40% during an entire lifetime can be realized. New sales models (e.g., Energy service companies, etc.) need to be developed.

Market opportunities

Generally speaking, the most favorable conditions for successful market implementation of SAC systems are:

- Applications with a high need for heating and cooling (and domestic hot water) or with high and constant cooling need over the year in very sunny regions.
- Locations with high solar energy resources.
- Conditions characterized by a high coincidence of loads and solar gain, since this reduces the need for energy storage.
- Locations with high cost of conventional energy.

A major obstacle is that in many of the locations that fulfill the above requirements, there is no or very little experience of solar energy use, and often HVAC and refrigeration installations are of a comparatively low standard. Nevertheless, under such conditions best economic performance can be expected.

Companies that offer overall solutions and have the capability to provide maintenance services (e.g., using remote control approaches) will be able to exploit this market opportunity.

Overall, renewable energies will play an increasingly important role in future energy systems due to the need to limit CO_2 emissions originating from conventional, fossil energy sources. The need to secure local energy supply to counteract instability in international markets is also a major factor. The demand for SAC technology is significant. This provides a market opportunity for stakeholders including property owners, planners, manufacturers and installation companies.

Current Barriers

Currently, the main technical challenges of SAC lie in system level integration. Many systems fail to achieve planned energy savings because of mistakes in proper design and energy management of systems that result in a high overall electricity consumption of auxiliary components. A particular area where errors occur is the heat rejection subsystem - an area that has often has not received sufficient attention in the past. Other oversights led the development of many systems that were far too complex, and as a result, created non-optimal control resulting in significant maintenance effort.

The main problem areas, observed from practical experience of realized installations, are:

- Heat rejection: cooling towers often need too much electricity and are not properly controlled at part load conditions. Small capacity wet cooling towers are relatively expensive and need an inappropriate high effort for maintenance. Dry cooling towers require significantly less maintenance effort but demand more electricity, and often the heat rejection temperatures are high, which affects system efficiency or disable the use of certain technologies.
- Highly efficient auxiliary components and careful hydraulic design are essential. This is particularly important as solar cooling systems need more hydraulic loops than standard solutions.
- The overall system design requires various professional skills for the different subsystems: solar energy at medium temperature (higher than that used for standard domestic hot water application), hydraulics with pressurized and medium temperature water, and air-conditioning or industrial cooling.

The second main shortcoming of SAC already identified in this paper is the economics. The initial investment costs of realized SAC installations remains at 1.5 to 2.5 times higher than conventional state-of-the-art systems. The two major possibilities to overcome that barrier are 1) to focus on medium to large system sizes which lead to economies of scale and 2) to standardize as much as possible the systems to reduce on-site effort and risks. An important focus should also be on policy strategies that enable a cost reflective means of internalizing electricity system costs into the upfront purchase price of solar cooling systems.

Currently, the achieved non-renewable primary energy savings or reduction in greenhouse gas emission are not reflected in the economics. Regulations and policies that include the environmental quality could improve economic viability.

Actions Needed

Solar assisted systems are necessary to reach future energy efficiency objectives in the European Union, which set out to reduce 40% of CO_2 emissions by 2030, with at least a 32% share of renewable energy. PV and solar thermal assisted heat pumps are an excellent system to support these targets.

SAC technology is at a crucial stage. Mature components are available and many installations have been realized. The technology has shown that significant energy savings are possible, and it has reached a level of early market deployment. However, the financial risk for parties involved in SAC businesses is still too high.

The following actions should lower this risk:

- **Development of systematic quality assurance requirements and standards for SAC systems**: Currently, there are no international ISO/EN standards or norms specifically relating to solar cooling. Such standards would give users the confidence to invest in such systems. They could also provide a basis for allocating funding or tax credit schemes to stimulate market development. These costs for standard developments could be supported by public funding because they create favorable conditions that assist in addressing issues related to CO_2 emissions and climate change.
- **Deployment of specific training for actors involved in SAC projects**: most planners and installers have little experience with SAC technology and thus the effort – and related cost – to install those systems is higher than for standard systems.
- **Implement industry development support schemes that provide like for like incentives for SAC technology and additionally reflect the unique benefits of SAC to the electricity system**: These support schemes support the decision-making process in energy-related investment. And it would help build the market to achieve economies of scale and a competitive supply chain. Collaboration with utility companies to provide them with turn-key solutions to address issues of peak energy demand could be beneficial also.
- **Develop specific tax credit, tax-free or even funding schemes opportunities for SAC projects** (in countries where electricity is highly subsidized, e.g., in some countries of the MENA region). At a national public budget level, electricity savings from related to solar cooling can lead to a reduction in taxation revenue. Measures to support a sustainable market development are most important. This includes establishment of large-scale demonstration programs with both incentives and quality assurance requirements that combine to encourage adoption and lower the risk.

These actions should be organized at regional and national levels. They should first be promoted in regions of the world where cooling is an important issue (e.g., the Middle East, South East of Asia, Sun Belt in the USA, Australia) and where environmental issues are a major concern (such as the impact of pollution due to greenhouse gas emissions).

Authors: Daniel Mugnier, TECSOL, France and Daniel Neyer, brainworks, Austria

5. Completed Tasks

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

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

Task Overview

Task 53 objective was to create a logical follow up of the IEA SHC work already carried out by trying to find solutions to make the solar driven heating and cooling systems at the same time cost competitive. This major target was reached through five levels of activities:

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

The scope of the Task was the technologies for production of cold/hot water or conditioned air by means of solar heat or solar electricity, that is., the subject covered by the Task started with the solar radiation reaching the collector or the PV modules and ends 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 were not the main topics of the Task this interaction was considered where necessary.

The main objective of this Task was to assist with development of a strong and sustainable market for solar PV and new innovative thermal cooling systems. It focused on solar driven systems for both cooling (ambient and food conservation) and heating (ambient and domestic hot water).

To achieve these objectives, the work focused in four main topics:

1. Components, Systems & Quality
2. Control, Simulation & Design
3. Testing and demonstration projects
4. Dissemination and market deployment

Participating Countries/Sponsors

	Research Institutes	Universities	Companies
Australia	1	0	-
Austria	3		
China		1	1
France			1
Germany	2	1	-
Italy	2	1	1
Spain	1	1	
Netherlands	-	-	1
Sweden		1	

Switzerland	1	1	2
TOTAL	**10**	**6**	**6**

Task Duration

This Task started in **March 2014** and ended in **June 2018**. Final deliverables will be published in first half of 2019.

Collaboration with Other SHC Tasks and IEA TCPs

Exchanges with SHC Task 48: Quality Assurance & Support Measures for Solar Cooling Systems experts and several results from Task 48 were used to build the state-of-the-art of new solar cooling technologies. Partnership between SHC Task 53 and PVPS Tasks 1 and 14 with recurrent joint workshops.

Collaboration with Industry

As noted above, there was significant involvement from industry and companies. Some key experts in Task 53 were from TECSOL, RTB and Coolgaïa as well as solar cooling actors were constantly supporting or acting inside Task 53 (SOLARINVENT, ATISYS, etc.). Observers that were consistently present during the Task included:

- ATISYS (France): consulting and solar cooling company
- SOLARINVENT (Italy): solar cooling manufacturer
- CLIMATEWELL (Sweden): sorption chiller manufacturer
- Sunoyster (Germany): solar cooling manufacturer
- TECNALIA (Spain): consulting & research company
- YAZAKI Solar (China): sorption chiller manufacturer
- Coolgaia (Australia): consulting company
- Polysun (Switzerland): software developer
- RTB De Beijer (Netherlands): sorption chiller developer
- Waldschütz gmbH (Germany): energy consulting company
- Easy TNT (Germany): energy consulting company

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 53 webpage and in the activities of the specific Subtasks:

- Subtask A: Components, Systems & Quality
  (Lead Country: Austria; Subtask Leader: Tim Selke: AIT Austrian Institute of Technology GmbH)

- Subtask B: Control, Simulation & Design
  (Lead Country: Italy; Subtask Leader: Roberto Fedrizzi: EURAC research)

- Subtask C: Testing and demonstration projects
  (Lead Country: Sweden; Subtask Leader: Björn Karlsson: University of Malardalen)

- Subtask D: Dissemination and market deployment
  (Lead Country: France; Subtask Leader: Daniel Mugnier: TECSOL SA)

The main objective of Task 53 was to assist a strong and sustainable market development of solar cooling systems.

The results of past IEA SHC Tasks and work on solar cooling (for example, Task: 38 Solar Air-Conditioning and Refrigeration) showed the great potential of this technology for building air-conditioning, particularly in sunny regions as well as showing the difficulty for solar thermal cooling to emerge as an economically competitive solution. Understanding the need to stimulate the solar cooling sector for small and medium power size by initiating, Task 53 has developed several tools to deal with these challenges. The following is a brief report on the Task's accomplishments.

New System Configurations for Cooling (AC, food conservation) and Heating (DHW, ambient)

This activity focused on state-of-the-art system configurations for cooling and heating examined existing market solutions and close-to-market solutions.

Storage (electrical and thermal) Concepts and Management

This activity focused on the analysis of storage solutions adequate for solar cooling and heating solutions on the market. Beyond the material itself, a particular focus was given to different possibilities for managing the storing/de-storing sequences. Not only thermal sensible and latent storage tanks were studied, but also electrical storage, building mass storage, and potentially chilled water loop/ district network storage.

LCA and Techno-eco Comparison between Reference and New Systems

This activity focused on the comparison between all the studied systems covered in Subtask A and the reference systems when accurate (same location and same boundary conditions). The comparison considered both on Life Cycle Analysis and on techno-economical. So as to properly compare solutions, adequate key performance indicators were investigated and selected from literature and practical experiences from Task experts and industry players.

Reference Conditions (economical, climatic, reference building with thermal and electrical load, etc.)

This activity aimed to better understand the reference boundary conditions for simulating a new generation solar cooling and heating system. The conditions were related to the climate and the building load especially, thermal and electrical. From the most promising identified markets a set of duo climate/application were selected and developed to produce data files. Selected buildings included single family and multifamily residences and office and commercial buildings. Air conditioning, heating, DHW and electrical appliances loads were considered and potentially food conservation cooling loads for commercial buildings

Models of Components (identification/validation) and System Simulation

This activity identified, tested and validated component models of the systems covered by the Task. Beyond components, several modeling tools were investigated to see which of them are able to go for full system modeling. The output is a set of tools to model configurations and present their level of accuracy and user friendliness.

Monitoring Procedure and Monitoring System Selection Criteria

This activity was dedicated to preparing a testing and the monitoring methodology to measure the performances of the selected demo projects. A valorization of past and ongoing results from IEA SHC Tasks 38, 44 and 48 was done on how to properly monitor these new generation solar cooling and heating systems. An uncertainty analysis was added to the method.

Monitoring Data Analysis on Technical Issues and Performance

This activity analyzed the monitored data from the projects selected in Subtask C. The analysis methodology was based on the work done in SHC Task 48, but of course was adapted with features imposed by the new generation solar cooling and heating systems. The activity included in addition to performance measurement and analysis, the important work of analyzing technical issues and events occurring during the monitoring period.

Best Practices / Feedback (planning + commissioning + operation/measurements, user and grid utility)

This activity synthesized the practical work and produced a Best Practice document. This document presents the selected field test projects from the planning phase until the monitoring period, describing the different steps (planning, commissioning, etc.). This technical descriptive document served as the basis for the part of the Position Paper for new generation solar cooling and heating systems valorizing to best practices. An important contribution of planners was valorized (flow chart for set in operation) as well as a best practice for users.

Workshops and Conferences

The Task participants organized workshops for the industry players involved in the sector (solar thermal manufacturers and installers, thermally driven cooling industry, planners). These happened about once a year and before/after Task Experts meetings in order to test and receive feedback on the last Task developments. Thanks to this yearly event interested industries could be involved in the Task without requiring a large time commitment. Short reports were written for each event and posted on the Task 53 website, including all the presentations.

Publications

Reports & Online Tools

The following table is a list of all the reports and tools produced by the Task participants.

Author(s)/ Editor	Title	Report No. Publication Date
Tim Selke	Definition of the existing cooling reference systems	Task 53/Report A1 *2019 publication*
Daniel Mugnier, Tim Selke	State of the art of new generation commercially available and close to market products including costs, efficiency criteria ranking and performance characterization	Task 53/Report A2 *2019 publication*
Dr. Elena-Lavinia Niederhäuser, Matthias Rouge	Technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's)	Task 53/Report A3 *2019 publication*
Tim Selke	Report on a new and universal classification method "new generation solar cooling square view" for generic systems	Task 53/Report A4 *2019 publication*
Marco Beccali, Maurizio Cellura, Sonia Longo	Techno-economic analysis report on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility	Task 53/Report A5 *2019 publication*
Chiara Dipasquale, Roberto Fedrizzi, Valeria Palomba, Alex Thür, DagmarJähnig	Technical report presenting the reference conditions for modelling (reference load profile and comfort conditions in case of living / office room AC/cooling)	Task 53/Report B1 *2019 publication*
Tim Selke	Overview on peak demand & demand side management possibilities including a state of the art on the management of the interface solar cooling (eg. AC unit / PV modules) and distribution system /grid	Task 53/Report B2 *2019 publication*
Chiara Dipasquale, Roberto Fedrizzi, Valeria Palomba, Alex Thür, Dagmar Jähnig	Technical report on components & system model validation	Task 53/Report B3 *2019 publication*
Chiara Dipasquale, Roberto Fedrizzi, Valeria Palomba, Alex Thür, Dagmar Jähnig	Technical report on optimised control strategies for solar cooling & heating systems	Task 53/Report B4 *2019 publication*
Chiara Dipasquale, Roberto Fedrizzi, Valeria Palomba, Alex Thür, Dagmar Jähnig	Guidebook/guideline on results of simulations including a country- and climate-sensitive economical analysis	Task 53/Report B5 *2019 publication*
Franscisco Aguilar Valero, Daniel Neyer	Monitoring procedure for field test & demo systems (depending on size and application)	Task 53/Report C1 *2019 publication*

and Pedro Vicente Quiles		
Daniel Neyer, Rebekka Köll and Pedro G. Vicente Quiles	Catalogue of selected systems	Task 53/Report C2 *2019 publication*
Daniel Neyer, Rebekka Köll	Technical report on monitoring data analysis (technical issues + performances)	Task 53/Report C3 *2019 publication*
Daniel Neyer, Daniel Mugnier	Technical content (best practices) for a part of the Task 53 Position Paper on efficient new generation cooling and heating systems	Task 53/Report C4 *2019 publication*
Daniel Mugnier	Website dedicated to the Task	Task 53/Report D1 *2019 publication*
Daniel Neyer, Daniel Mugnier	Position Paper for new generation solar cooling and heating systems	Task 53/Report D2 *2019 publication*

Journal Articles, Conference Papers, etc.

Author(s)/Editor	Title	Publication / Conference
Daniel Neyer, Daniel Mugnier, Stephen D. White	The Solar Cooling Design Guide: Case Studies of Successful Solar Air Conditioning Design	Ernst & Sohn - Wiley ISBN: 978-3-433-60686-5
Daniel Mugnier	Task 53: The Future of Solar Cooling	SHC Solar Update
Daniel Mugnier	Solar Air Conditioning	REN21 Global Status Report 2015
Daniel Mugnier	Solar Air Conditioning	REN21 Global Status Report 2016
Daniel Mugnier	Solar Air Conditioning	REN21 Global Status Report 2017
Daniel Mugnier	Solar Air Conditioning	REN21 Global Status Report 2018
Bärbel Epp, Daniel Mugnier	IEA SHC Task 53 innovative solar cooling systems	http://www.solarthermalworld.org/content/iea-shc-task-53-innovative-solar-cooling-systems
Dr. Elena-Lavinia Niederhäuser, Daniel Mugnier	IEA SHC: Most Effective Solar Cooling Storage Technologies	http://www.solarthermalworld.org/content/iea-shc-most-effective-solar-cooling-storage-technologies

Bärbel Epp, Subbu Sethuvenkatraman, Daniel Mugnier	IEA SHC: SHC industry roadmap for Australia	http://www.solarthermalworld.org/content/shc-industry-roadmap-australia
Bärbel Epp, Daniel Mugnier	IEA SHC: Solar cooling increases annual solar fraction	http://www.solarthermalworld.org/content/solar-cooling-increases-annual-solar-fraction

Conferences and Workshops

Task participants presented Task work and results at 25 conferences and workshops over the course of the Task.

Task Meetings

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

1. Paris, France March 2012
2. Paris, France October 2013

Over the entire term of the Task a total of 9 Experts Meetings were held *and all included an additional workshop, symposium or other event.*

Meeting	Date	Location
Expert Meeting 1 (Kick-off meeting)	18-19 March 2014	Vienna, Austria
Expert Meeting 2	27-28 September 2014	Mälardalen, Sweden
Expert Meeting 3	25-26 March 2015	Shanghai, China
Expert Meeting 4 (including Task 53 Workshop at 6th SAC conference OTTI, Rome, Italy)	20-22 September 2015	Bolzano, Italy
Expert Meeting 5 (including SHC Task 53 / PVPS Task 1 Joint Workshop and SHC Task 53 Industry Workshop)	11-13 April 2016	Madrid, Spain
Expert Meeting 6	10-11 October 2016	Palma de Majorca, Spain
Expert Meeting 7	19-20 April 2017	Messina, Sicilia, Italy
Expert Meeting 8	29-30 October 2017	Abu Dhabi, UAE
Expert Meeting 9 (including a final workshop)	10-12 April 2018	Dresden, Germany

SHC Task 53 Participants

Country	Name	Institution / Company	Role
FRANCE	**Daniel Mugnier**	**TECSOL SA**	**Operating Agent** & Subtask D Leader
AUSTRALIA	Stephen White	CSIRO	National Expert
AUSTRALIA	Subbu Sethuvenkatraman	CSIRO	National Expert
AUSTRIA	Daniel Neyer	UIBK	National Expert
AUSTRIA	Tim Selke	AIT	Subtask A Leader
AUSTRIA	Bettina Nocke	AEE Intec	National Expert
AUSTRIA	Alexander Thür	UIBK	National Expert
CHINA	Wei Zheng	Yazaki	National Expert
CHINA	Yajun Dai	SJTU	National Expert
FRANCE	Philippe Esparcieux	ATISYS	National Expert
GERMANY	Felix Loistl	Univ. of Appl. Sciences Munich	National Expert
GERMANY	Timo Korth	Univ. of Appl. Sciences Munich	National Expert
GERMANY	Carsten Corino	SunOyster	National Expert
GERMANY	Richard Schex	ZAE Bayern	National Expert
GERMANY	Mathias Safarik	ILK Dresden	National Expert
GERMANY	Carsten Heinrich	ILK Dresden	National Expert
ITALY	Pietro Finocchiaro	SOLARINVENT	National Expert
ITALY	Roberto Fedrizzi	EURAC research	Subtask B Leader
ITALY	Marco Beccali	DREAM	National Expert
ITALY	Salvatore Vasts	CNR ITAE	National Expert
ITALY	Alessio Sapienza	CNR ITAE	National Expert
ITALY	Sonia Longo	DEIM	National Expert
ITALY	Maurizio Cellura	DEIM	National Expert
KOREA	Dong Kyu Lee	Hyundai	National Expert
NETHERLANDS	Henk de Beijer	RTB bv	National Expert
SPAIN	Pedro Vicente Quiles	UMH	National Expert
SPAIN	Asier Sanz	TECNALIA	National Expert

SWEDEN	Chris Bales	Hogskola Darmana	National Expert
SWEDEN	Corey Blackman	Climatewell	National Expert
SWEDEN	Björn Karlsson	University of Mälardalen	Subtask C Leader
SWITZERLAND	Andreas Witzig	VELASOLARIS	National Expert
SWITZERLAND	Antonio Paone	HEF	National Expert
SWITZERLAND	Elena Lavinia Niederhäuser	HEF	National Expert
SWITZERLAND	Lukas Omlin	SPF	National Expert

Task 54 – Price Reduction of Solar Thermal Systems

Michael Köhl
Fraunhofer ISE
Operating Agent for Projektträger Jülich

TASK 54

Task Overview

Task 54 objective was to reduce the purchase price 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 was placed on the identification and reduction of post-production cost drivers, for example 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 provided 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 were explored.

To achieve these objectives, the work focused on four main topics:

1. **Subtask A: Market success factors and cost analysis**
(Lead Country: Norway; Subtask Leader: Michaela Meir, Aventa)

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

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

2. **Subtask B: System design, installation, operation and maintenance**
(Lead Country: Germany; Subtask Leader: Sandrin Saile, Fraunhofer ISE)

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

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

3. **Subtask C: Cost-efficient materials, production processes and components**
(Lead Country: Germany; Subtask Leader: Gernot Wallner, JKU Linz)

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

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

4. **Subtask D: Information, dissemination and stakeholder involvement**
(Lead Country: Germany; Subtask Leader: Stephan Fischer, IGTE University of Stuttgart)

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

Activities

- Industry liaison and Information and dissemination

Participating Countries/Sponsors

	Research Institutes	Universities	Companies
Australia			1
Austria		2	4
Denmark		1	
France			1
Germany	4	3	1
Italy		1	
Netherlands			1
Norway			1
Switzerland	1		
Total	**5**	**7**	**9**

Task Duration

This Task started in October 2015 and ended in September 2018. Final deliverables will be published in early 2019.

Collaboration with Outside Organizations/Institutions

- Solar Heat Europe
- RHC / ESTTP
- DSTTP
- ZVSHK

Collaboration with Industry

A number of companies were directly involved in Task 54. Questionnaires served as a way for getting installers/installation companies involved. Indirectly, companies were connected via associations.

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 54 webpage and in the activities of the specific Subtasks:

Subtask A: Market Success Factors and Cost Analysis

Project A.1: Definition of solar thermal and conventional reference systems
13 reference systems were elaborated on.

Following Info Sheets are online:

- A02: Reference System, Austria Conventional heating system for single-family house
- A03: Reference System, Austria Conventional heating system for multi-family house
- A04: Reference System, Austria Solar domestic hot water system for single-family house
- A05: Reference System, Austria Solar Combisystem for single-family house
- A06: Reference System, Austria Solar domestic hot water system for multi-family house
- A07: Reference System, Germany Conventional heating system for single-family house
- A08: Reference System, Germany Solar domestic hot water system for single family house
- A09: Reference System, Germany Solar Combisystem for single-family house
- A11: Reference System, Switzerland Solar domestic hot water system for multi-family house
- A12: Reference System, Denmark Solar domestic hot water system for single-family house

- A15: Reference System, France-MF-SDHW
- A16: Reference System, France-MF-SDHW-drain-back
- A17: Reference System, France-sF-SDHW

Project A2: Info Sheet with "Guideline for levelized cost of heat (LCOH) calculations for solar thermal applications"

The definitions of the LCoH in Task 54 and in the IEA SHC report, Solar Heat Worldwide are slightly different and could lead to misunderstandings. For this reason, a harmonized definition of the properties by introducing two indices was achieved based on the agreement of experts at EuroSun 2018 in Rapperswil, Switzerland.

For example, $LCoH_{sol, fin}$

LCoH depends on *system boundaries* (index 1):

Sol = solar,

conv = conventional,

ov = overall

Several *reference energies* are possible (index 2):

coll = solar collector yield

use = useful solar heat

fin = final energy (Task 54)

heat = heat demand

A Task group (including 6 institutions) developed LCoH-calculation tool that can be downloaded from the Task 54 webpage.

Related A2 Info-Sheets:

- A01: Guideline for levelized cost of heat (LCOH) calculations for solar thermal applications
- A13: LCoH calculation method: Comparison between Task 54 and Solar Heat Worldwide

Project A.3: Political, legal and social boundary conditions

The experts of all eight represented countries in Task 54 were asked for their input. This project deals with aspects that have the power to either support or hinder the market penetration of solar thermal systems. The report (Info Sheet, A.5) on the impact of legal and social boundary conditions will be completed in early 2019.

Project A.4: Market success factors

The collection of input, new ideas and examples are collected for the respective Deliverable, which will be completed in early 2019.

- European Solar Day campaign
- "Solar - na klar!": German campaign for solar thermal energy
- SOLCOL: Accompanying all the Way to Secure Solar Thermal Plants (France)
- PAYOUSE: New business model on solar heat
- Heat Changers: Breathe new life into solar thermal marketing
- Price reduction by collaboration with building industry
- "Heat as service to be sold": Large Solar DH (Denmark)
- Local Contractor Modell (Germany, Austria, Switzerland)
- "Collector installation" model
- Low-cost monitoring using digital breakthrough (France)
- EKLOR - Solar Energy Company (France)
- Results from "Subtask A Workshop on Marketing Best Practices" in collaboration with Subtask D (DD.4), held at 6th Experts meeting at Sophia Antipolis, France 25.04.2018.
- 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 flat plate collector was elaborated with standardized mounting interface and standardized hydraulic connectors.

- A standardized 300l-domestic hot water with micro circulation inhibitor fulfilling Energy efficiency label “B“ according to Regulation (EU) Nr. 812/2013, Annex II was developed.
- A standard combi store with a volume of 800 l and Energy efficiency label “B“ according to Regulation (EU) Nr. 812/2013, Annex II was defined.

The following Info sheets will be completed in early 2019:

- B.04: Cost reduction by product standardization and reduction of product variety in China
- B.06: Standardized piping for polymeric solar loop
- B.07: Standardized hot water store for domestic hot water application
- B.08: Standardized combi store for solar combi systems
- B.09: Standard flat plate collector

Project B.2: manufacturing costs

The production costs for a 2.5. m² flat plate collectors were determined with the help of leading collector manufacturers in Europe allowing the definition of a benchmark for the production costs of a 2.5 m² flat plate collector.

The production costs for hot water stores were assessed by interviewing German manufacturers.

Retail costs for solar collectors and stores were evaluated on the basis of the invoices from the German subsidy funding body BAFA.

The following Info sheets will be completed in early 2019:

- B.11: Production costs of a typical flat plate collector
- B.12: Production costs of a typical hot water store for domestic hot water application
- B.13: Production costs of combi stores for solar combi systems

Project B.3: Technical aftersales costs

Installation costs have been assessed throughout Europe by different means, e.g. installer questionnaire, evaluation of invoice from subsidy organizations, etc.

Maintenance cost have been assessed in detail, especially for Germany.

Operation costs (gas and electricity) for the reference systems (Subtask A) have been analyzed.

It could be shown that installation and maintenance costs can be significantly reduced by using methods which avoid stagnation loads with in the solar thermal systems.

The following Info sheets will be completed in early 2019:

- B.14: Maintenance costs of solar systems without stagnation load
- B.15: Telemonitoring developments at Tecsol
- B.16: Review of installation costs
- B.17: Review of operation costs

Installation costs have been assessed throughout Europe by different means, for example, installer questionnaire, evaluation of invoice from subsidy organizations, etc.

Maintenance costs have been assessed in detail, especially for Germany. Operation cost (gas and electricity) for the reference systems (Subtask A) have been analyzed. It could be shown that installation and maintenance costs can be significantly reduced by using methods which avoid stagnation loads with in the solar thermal systems.

B.4: Cost optimization of reference systems

Cost optimization of the reference systems could be found using different measures:

1. Standardization throughout the value chain
2. Using devices that allow for a better thermal stratification within the hot water store
3. Improving the thermal performance by increasing the initial investment (e.g. micro circulation inhibitors, better collectors and hot water stores) can lead to a significant reduction (up to 25%) in the LCoHsol,fin.

The following Info sheets will be completed in early 2019:

- B.18: Cost reduction by standardization
- B.19: Cost reduction using stratifies (Danish example)
- B.20: Cost reduction by performance improvement for solar domestic hot water systems
- B.20: Cost reduction by performance improvement for solar combi systems

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

Two new proposals for a 40% reduction of LCoHsol,fin were elaborated on based on different approaches:

1. Conico Valves showed that a water-based vacuum-tube solar systems with automatic thermosiphonic (back-up) frost protection, using Thermo-Differential Valve technology can result in a significant reduction of the investment and operation costs because no controller and solar heat exchanger is required.
2. The combination of different measures (Standardization, improvement of thermal performance and avoiding stagnation loads) can lead to a reduction of LCoHsol,fin up to 40 %.

The following Info sheets will be completed in early 2019:

- B.21: Installation costs of systems with Heat Pipe Collectors
- B.22: Solar thermal system using "Thermostatic valve
- B.23: Combination of different measures to reach 40 % goal. Two new proposals for a 40% reduction of LCoHsol,fin were elaborated based on different approaches.

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

In Subtask C the following main findings were deduced in 2018.

- Polymeric materials allow for significant cost reductions of products and services in various industrial sectors such as buildings, automotive, electronics or food supply due to their unique tailorable property profiles, the ease of processing and mass production capability, the high freedom of design and esthetics, their integration of multi-functions in parts or components and the ease of assembling and installation. However, significant investments for machinery and tools have to be considered which will pay back preferentially in case of mass production (Deliverable C.1).

- As major cost drivers for domestic hot water and space heating systems the high variety of different collector and system types, the problems associated with overheating of high-efficiency collectors, the low degree of standardization, the limited scalability of collector systems, the high efforts for installation and maintenance of DHW and SH systems were identified (Deliverable C.2).

- Regarding cost-efficient, all-polymeric solar-thermal systems, the following concepts were defined and evaluated (Deliverable C.3):
  - Drainback system for DHW and SH based on black absorbers and high-performance or commodity plastics (concepts Aventa (NOR) and Roth Werke (GER))
  - Pumped DHW systems for warm climate zones based on black absorbers and modular collectors made from commodity plastics (concept Sunlumo (AUT))
  - Non-pumped integrated storage collectors for warm climate zones made from fiber-reinforced engineering plastics (concept GreenOneTec (AUT))

- For screening and qualification of polymeric materials for solar-thermal systems two approaches were implemented considering low (< 5 MPa) or high mechanical stresses. The cumulative damage approach for environmental and low mechanical stresses consists of simulation and deduction of temperature loading profiles, the extrapolation of experimental endurance times at elevated temperatures to service temperature and the weighting of both, the temperature distribution and the endurance times. For environmental and high mechanical loads a fracture mechanics approach was established for screening of reinforced plastics. Special attention was given to hot water and chlorinated water environments (Deliverable C.4).

- In Task 54 for the first time, special polymer grades for absorbers of solar-thermal collector systems were developed. By the Austrian company partner Borealis, a carbon-black pigmented polypropylene block-copolymer grade was introduced into the market. This grade is optimized for absorbers of swimming pool collectors and overheating protected glazed collectors. A further field of application is outdoor irrigation piping systems. For pressurized integrated storage collectors various glass-fiber reinforced polyamide grades with drinking water approval were qualified within the Austrian SolPol research initiative. Finally, an extrudable high-performance PPS grade with impact modification and carbon-black modification was commercialized by

Solvay. The development of this specific grade for absorbers of drainback collector systems was carried-out in close collaboration with Aventa (NOR) (Deliverable C.5).

- For the qualification of specific components test procedures for extruded hollow-sheet absorbers, overheating control valves and all-polymeric collectors were developed and implemented. It was shown, that PPS absorbers fulfill the requirements for non-overheating protected collector systems. Based on the results of lab-scale tests, the absorber and collector technology of Aventa was successfully applied in various demonstration projects. By evaluation of overheating controlled collectors using the back-cooling principle, the feasibility of this approach was proven in lab-scale and field-tests (Deliverable C.6).

- Regarding the evaluation of less expensive systems, it was shown that it is possible to cut the levelized costs of solar-thermal heat by -30 to -70% for all-polymeric drainback-systems in moderate climate zones. Adjustable absorbers and glazings of fixed width but variable length (concept Aventa) are outperforming modular collector designs with fixed geometry (concept Roth Werke). Significant cost advantages can be realized during the installation. For pumped all-polyolefinic collector systems for warm climate zones levelized costs of solar-thermal heat ranging from 1 to 3 €ct/kWh were deduced. These values are comparable to LCOH data of thermosiphon systems. The main advantage of the pumped system is the high design flexibility (e.g., positioning of storage tank). An ultra-low-cost pumped DHW system made from polyolefins at a purchase price of $180 was presented by Sunlumo. For the investigated integrated storage collectors (ISC) no LCOH data were calculated. Compared to current, metal-based ISC collectors the production costs can be reduced by a factor of 2 if polymeric materials are used also for the absorber & tank-component. A main problem regarding full commercialization of the findings are relatively high annual production and sales volumes of about 100.000 systems / year which are needed to exploit the full cost advantages (Deliverable C.7).

Subtask D: Information, Dissemination and Stakeholder Involvement

Project D. 1: Industry Liaison

- *A Marketing workshop* was held during the 6th Task 54 experts meeting in Sophia Antipolis, France on April 24, 2018. The aim was to generate input for the catalogue of best practices in Subtask A regarding possibilities for making solar thermal systems more attractive. About 17 Task 54 experts worked on the question as to how different stakeholder groups, namely energy consultants and planners of solar thermal systems (1), producers and wholesalers of ST systems (2), installers of ST systems (3) and political decision makers (4) could positively influence the marketing for ST and raise the interest of their specific target groups.

- A Workshop for exploitation and dissemination was held in connection to Task 54's spring meeting on 26 April 2018 in Sophia Antipolis, France, as part of the national R&D day on solar thermal technologies organized by ADEME. The workshop was visited by about 80 mainly French participants from industry and research. It was opened by Task 54 with a 2.5 h time slot for the presentation of results. The workshop was accompanied by live tweets.

- *Data collection energy consultants*. Being those with the closest contact to energy consumers and potential customers for solar thermal, Task 54 approached the German association for energy consultants for insights into the current attitude(s) towards solar thermal – both from a customer's and their own point of view – and current trends in energy consulting. About 500 energy consultants were provided with a questionnaire, 138 replied. The data collection clearly shows that solar thermal is still among the top technologies that are favored by the consultants themselves and recommended often in combination to conventional heating. Despite this, the take up by today's costumers is actually very low. Energy consultants see a clear optimization potential in technical terms but also in aspects regarding non-technical mechanisms such as funding / taxing, promotion and an image push of solar thermal in general. The results of the survey have been summarized in the final presentations.

- *Heat Changers*. During summer 2018, active exchange and collaboration was established with the heat changers campaign as input and best practice example for Subtask A on the promotion of solar thermal. Task 54 strongly supports the Heat Changers approach to frame solar thermal anew, with a positive, easy-to-understand and easy-to-relate style of communication.

Project D.2: Dissemination and information

- LCoH calculation tool (excel), ready for download at http://task54.iea-shc.org/lcoh.

- New info sheets published on Task 54 homepage, for a comprehensive list, please see http://task54.iea-shc.org/info-sheets or table below.

- Journal publications LCoH for reference systems and cost-optimization (in preparation) will be published on Task 54 homepage.
- Task 54 webinar in the framework of the SHC Solar Academy, organized in cooperation with ISES on 14 March 2018 with more than 500 registered participants around the world http://www.iea-shc.org/solar-academy/webinar/price-reduction-of-solar-thermal-systems (ISES feedback report and evaluation available via SHC Secretariat).
- Task 54 Results published in ISEC 2018 proceedings.
- Final Task 54 Presentations EuroSun 2018 and ISEC 2018, available for download on Task 54 homepage.
- e-newsletter (month 36) published in September 2018.
- Task 54 on Twitter, followers increased steadily (150 on 16 September 2018), good interaction with Solarthermalworld.org.
- Article on Solarthermalworld.org on price reduction webinar, published on 5 April 2018.
- Task 54 Highlights.
- Info Sheets on all reference systems and LCoH comparison.

A list of current publications in conference proceedings and journals can be found on the Task webpage.

Further Actions

- IEA SHC Webinar: Cost reduction potential above 30%, published by Solarthermalworld.org in April 2018, Riccardo Battisti
- Direct solar thermal systems with thermosiphon frost protection and innovative control strategies using a Thermo-Differential Bypass Valve by Nico van Ruth in June 2018, published by EuroSun2018
- Presentation: Impact of the Improvements Developed during IEA SHC Task 54 on the Levelized Cost of Heat (LCoHsol,fin) by Dr. Karl-Anders Weiß, Fraunhofer ISE and Dr. Stephan Fischer University of Stuttgart, IGTE, published by ISEC Graz 2018
- Presentation: Calculating the Levelized Cost of Heat (LCoH) for Reference Solar Thermal Systems by François Veynandt, Yoann Louvet, published by ISEC Graz 2018
- Presentation: Introduction to IEA SHC Task 54 by Dr. Michael Köhl - Fraunhofer Institute for Solar Energy Systems ISE and Dr. Daniel Mugnier – TECSOL, published by ISEC Graz 2018
- Presentation: Improvements Developed during the IEA SHC Task 54 by Dr. Alexander Thür, Dr. Federico Giovannetti, Dr. Stephan Fischer, published by ISEC Graz 2018
- Presentation: Novel polymeric materials for cost-efficient solar thermal systems by Gernot M. Wallner, R. Buchinger, published by ISEC Graz
- LCoH Tool Announcement via website and Twitter: Levelized Cost of Heat (LCoH) Tool. The Task 54 LCoH-Tool provides an easy-to-use method for calculating the Levelized Cost of Heat (LCoH) of solar thermal systems and also other heating systems. The LCoH-Tool can be used to assess different strategies for cost reduction regarding their effects on the heat cost for the end-consumers, published by Task54
- Paper: Effect of carbon nanotubes on the global aging behavior of β-nucleated polypropylene random copolymers for absorbers of solar-thermal collectors by Gernot M. Wallner, Michael K. Grabmann, Clemens Klocker, Wolfgang Buchberger, David Nitsche, published by Solar Energy
- Paper: Fatigue characterization of potable water certified PA and PPA grades for solar-thermal applications by Patrick R. Bradler, Joerg Fischer, Gernot M. Wallner and Reinhold W. Lang, published by ISES Solar World Congress 2017
- Paper: Effect of Aging in hot chlorinated water on the mechanical behaviour of polypropylene for solar-thermal applications by Joerg Fischer, Susan C. Mantell, Patrick R. Bradler, Gernot M. Wallner and Reinhold W. Lang, published by ISES Solar World Congress 2017

- Paper: Characterization of polymeric materials for solar-thermal collector mounting systems by Joerg Fischer, Patrick R. Bradler, Sandra Leitner, Gernot M. Wallner and Reinhold W. Lang, published by ISES Solar World Congress 2017
- Paper: Sustainability assessment of solar thermal collector systems for hot water preparation by Harald Kicker, Gernot M. Wallner and Reinhold W. Lang, published by ISES Solar World Congress 2017
- Article on Solarthermalworld.org on Linz Workshop “Solar thermal cost reductions” published November 26, 2017 by Bärbel Epp / Eva Augsten
- The first info sheets on LCoH calculation and reference systems were published on the official Task 54 homepage and subsequently announced via twitter.
- Dissertation: Bradler, P. (2018). Failure behaviour of short glass fiber reinforced polyamide under superimposed mechanical-environmental fatigue, Institute of Polymeric Materials and Testing, JKU Linz, Austria.
- Dissertation: Grabmann, M. (2018). Global aging behaviour and lifetime assessment of polymeric materials for solar-thermal systems, Institute of Polymeric Materials and Testing, JKU Linz, Austria

Info sheets online at the end of 2018:

- A01: LCOH for Solar Thermal Applications - Guideline for levelized cost of heat (LCOH) calculations for solar thermal applications
- A02: Reference System, Austria Conventional heating system for single-family house
- A03: Reference System, Austria Conventional heating system for multi-family house
- A04: Reference System, Austria Solar domestic hot water system for single-family house
- A05: Reference System, Austria Solar Combisystem for single-family house
- A06: Reference System, Austria Solar domestic hot water system for multi-family house
- A07: Reference System, Germany Conventional heating system for single-family house
- A08: Reference System, Germany Solar domestic hot water system for single family house
- A09: Reference System, Germany Solar Combisystem for single-family house
- A10: Reference System, Germany Solar Combisystem for Multi-Family House - NEW
- A11: Reference System, Switzerland Solar domestic hot water system for multi-family house
- A12: Reference System, Denmark Solar domestic hot water system for single-family house
- A13: LCoH calculation method: comparison between Task 54 and Solar Heat Worldwide
- A14: Heat Changers
- A15: Reference multi-family solar domestic hot water system. France - NEW
- A16: Reference System, France Drain-back multi-family solar domestic hot water system - NEW
- A17: Reference single family solar domestic hot water system for France - NEW
- B01: Optimized Systems, Denmark - SDHW System with Heat Storage and Polymer Inlet Stratifier
- B02: Effects of Technological Measures on Costs
- B03: Reduction of Maintenance Costs by Preventing Overheating
- B04: Manufacturing Costs - NEW - Cost reduction during production by product standardization and reduction of product variety in China
- B05: Levelized Cost of Heat for Solar Thermal Systems with Overheating Prevention
- C01: Cost Drivers and Saving Potentials (1): Material substitution
- C02: Cost Drivers and Saving Potentials (2): Production, installation, design
- C03: One-World-Solar-System
- D01: Review of Installation Costs
- D02: Obstacles in Installation and Recommendations
- D04: End-Users Decision Making Factors for H&C Systems

Dissemination Activities in 2018

- Distribution of Task 54 flyer for acquisition of partners
- Task 54 promotion at EuroSun and ISEC 2018
- Further distribution of Task 54 installer questionnaire

- Publications in solarthermalworld and other consumer oriented online magazines.
- Publications on conferences and in scientific journals (http://task54.iea-shc.org/publications)
- Publication of Info Sheets (http://task54.iea-shc.org/info-sheets)
- Distribution of public newsletter no. 3
- Live feeds from Task 54 events via twitter
- SHC Academy Webinar & final publication / presentations 2018
- Publication of LCoH calculation tool for download via Task 54 homepage

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

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

Task Meetings

Meeting	Date	Location
Experts Meeting 1	21-22 October 2015	Freiburg Germany
Experts Meeting 2	3-4 May 2016	Brussels, Belgium
Experts Meeting 3	6-7 October 2016	Stuttgart, Germany
Experts Meeting 4	3-4 May 2017	Rapperswil, Switzerland
Experts Meeting 5	4-6 October 2017	Linz, Austria
Experts Meeting 6	24-26 April 2018	Sophia Antipolis, France
Experts Meeting 7	19-20 September 2018	Gardermoen, Norway

SHC Task 54 Participants

Country	Name	Institution / Company	Role
GERMANY	**Michael Koehl**	**Fraunhofer ISE**	**OA**
AUSTRALIA	Harry Suehrcke	Sunspin Pty Ltd	National Expert
AUSTRIA	Patrick Bradler	JKU Linz	National Expert
AUSTRIA	Robert Buchinger	Sunlumo	National Expert
AUSTRIA	Michael Grabmann	JKU Linz	National Expert
AUSTRIA	Harald Poscharnig	GREENoneTEC Solarindustrie GmbH	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	National Expert
	Jiao Qingtai	Sunrain	National Expert
DENMARK	Simon Furbo	Department of Civil Engineering, Technical University of Denmark (DTU)	National Expert
FRANCE	Daniel Mugnier	TECSOL	National Expert
GERMANY	Sebastian Barg	WZL RWTH Aachen	National Expert
GERMANY	Mathias Ehrenwirth	Technische Hochschule Ingolstadt, Institut für neue Energie-Systeme (InES)	National Expert
GERMANY	Stephan Fischer	ITW University of Stuttgart	Subtask B Leader
GERMANY	Sebastian Föste	Institut für Solarenergieforschung ISFH	National Expert
GERMANY	Federico Giovannetti	Institut für Solarenergieforschung (ISFH)	National Expert
GERMANY	Bernd Hafner	The European Technology Platform on Renewable	National Expert

		Heating and Cooling (RHC-Platform)	
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
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GERMANY	Christian Tönnes	WZL RWTH Aachen	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 bv	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 57 – Solar Standards and Certification

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

Task Overview

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

To achieve these objectives, the work focused on three main topics:

1. Kick-off of Global Solar Certification Network (GSCN)
2. Improvement of test procedures – support and input to ISO
3. Promotion and capacity building with respect to ISO standards and state-of-the-art certification schemes

Participating Countries/Sponsors

	Research Institutes	Universities	Companies	Other
Australia			2	
Austria			1	
China	2	1	1	3
Denmark			1	
France			1	
Germany	1	1		
RCREEE				
Portugal	1			2
Spain		2		
Switzerland	1			
Total	**5**	**4**	**6**	**5**

Task Duration

This Task started in **January 2016** and ended in **December 2018**. Final deliverables will be published in early 2019.

Collaboration with Other SHC Tasks and IEA TCPs

Collaboration with SHC Task 55: Towards the Integration of Large SHC Systems into District Heating and Cooling (DHC) Network on development of standard for check of large collector field performance.

Collaboration with Outside Organizations/Institutions

Support to and close collaboration with the Global Solar Certification Network, www.gscn.solar. Support to and collaboration with ISO/TC180, www.iso.org/committee/54018.html.

Collaboration with Industry

Collaboration with industry through the Global Solar Certification Network (GSCN). Large global acting manufacturers (so far) from Europe and China are members of GSCN.

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 57 webpage and in the activities of the specific Subtasks:

- Subtask A: Kick-off Operation of the Global Solar Certification Network (GSCN)
  (Lead Country: Germany; Subtask Leader: Harald Drück, Institut für Gebäudeenergetik, Thermotechnik und Energiespeicherung, IGTE)

- Subtask B: Improvement of Test Procedures – Support and Input to ISO
  (Lead Country: China; Subtask Leader: He Zinian, Beijing Solar Energy Research Institute, BSERI)

- Subtask C: Promotion and Capacity Building with Respect to ISO Standards and State-of-the-art Certification Scheme
  (Lead Sponsor: RCREEE; Subtask Leader: Ashraf Kraidy, Regional Center for Renewable Energy and Energy Efficiency)

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

The concept of the Global Solar Certification Network (GSCN) is now in operation. After some hesitation, several certification bodies from different certification schemes – and several of their test labs and inspection bodies are now member of the Network. This means that the industry members now can present test and inspection reports from one certification scheme to a certification body from another certification scheme – and obtain certification here – without new testing and inspection.

The first manufacturer has now (November 2018) gone through the process of using test and inspection reports from Solar Keymark (in Europe) to obtain SRCC certification (in USA).

So - after some delay - now the GSCN concept is taking off!

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

Four draft proposals for new ISO standards on solar thermal systems/components have been elaborated:

- Test methods for mechanical load on support of close-coupled solar water heating systems (to be proposed to ISO/TC 180)
- Test methods and requirements for building integrated collectors and systems (to be proposed to ISO/TC 180)
- Test methods for close-coupled solar water heating systems - Reliability and safety (to be proposed to ISO/TC 180)
- Check of solar collector field performance (has been delivered as proposal for new Work Item to ISO/TC 180)

Some basic work was done for potential future standardization:

- Brief "Survey Report" on what is going on in IEC/TC and IEA/ PVPS groups on "Extreme conditions"
- Report on "Accelerated ageing test of evacuated tube collectors
- Subtask C: Promotion and capacity building with respect to ISO standards and state-of-the-art certification schemes
- (Subtask Leader: Regional Center for Renewable Energy and Energy Efficiency, RCREEE (Sponsor))

Subtask C: Promotion and Capacity Building with Respect to ISO Standards and State-of-the-art Certification Schemes

Global Solar Certification Network is in operation

The concept of the Global Solar Certification Network (GSCN) is now in operation. After some hesitation, several certification bodies from different certification schemes – and several of their test labs and inspection bodies are now member of the Network. This means that the industry members now can present test and inspection reports from one certification scheme to a certification body from another certification scheme – and obtain certification here – without new testing and inspection.

The first manufacturer has now (November 2018) gone through the process of using test and inspection reports from Solar Keymark (in Europe) to obtain SRCC certification (in USA).

So - after some delay - now the GSCN concept is taking off!

Promotion of ISO standards and capacity building in certification

Guidelines on ISO 9806

A comprehensive guideline for use of the new solar collector testing standard ISO 9806:2017 was written. The purpose of this guide is to provide guidance about the application and use of the ISO 9806:2017 standard, concerning the testing of solar thermal collectors. It is intended to support the interpretation and application of the standard. The guide was developed with three different target groups and objectives in mind:

1. A guide directed to established and new test laboratories for collector testing. The main purpose here is to give a quick introduction to the standard for new laboratories, and in general, to contribute to a uniform interpretation of the standard and presentation of results.
2. A guide directed to manufacturers and importers of collectors. Here, the purpose is to give a very light introduction to the standard and to explain how it is used for type testing as well as for innovation and development support.
3. A guide directed to certification bodies. The intention here is to provide access to easy evaluation of the presented results.

Utilization of ISO 9806:2017 In Global Solar Certification

A new questionnaire with indication of interest in use of international standards was distributed and the results analyzed.

Guideline for Implementing Certification Schemes for Solar Heating and Cooling Products

To support implementation of certification schemes in countries regions with tradition/experience in certification scheme, an introduction to product certification schemes at a general level was elaborated. Here guidelines for how to initiate and implement a certification scheme for solar heating and cooling products are given.

Comparison of SHAMCI and Solar Keymark

In the Arab countries a certification scheme (SHAMCI) for solar thermal product is being introduced. SHAMCI is very much inspired by the European certification scheme Solar Keymark, and in the task a comparison between SHAMCI and Solar Keymark has been elaborated.

Publications

Reports & Online Tools

Author(s)/ Editor	Title	Report Number Publication Date	Target Audience
Jan Erik Nielsen, et al.	GSCN Working Rules, improved continuously during the task – latest version available from: http://gscn.solar/documents.html		GSCN members and applicants
Shen Bin	Test methods for mechanical load on support of close-coupled solar water heating systems This is a final draft which may be proposed to ISO/TC 180	Task 57/Report B2 September 2018	Test labs and manufacturers, ISO/TC 180
Zhang Lei, Gu Xiuzhi	Test methods and requirements for building integrated collectors and systems. This is a final draft which may be proposed to ISO/TC 180	Task 57/Report B3 September 2018	Test labs and manufacturers, ISO/TC 180
He Zinian	Test methods for close-coupled solar water heating systems - Reliability and safety. This is a final draft which may be proposed to ISO/TC 180	Task 57/Report B4 September 2018	Test labs and manufacturers, ISO/TC 180

He Zinian	Brief survey report on what is going on in IEC/TC and IEA/ PVPS groups on “Extreme conditions”	Task 57/Report B5 September 2018	Test labs and manufacturers, ISO/TC 180
Jan Erik Nielsen	Check of solar collector field performance (has been delivered as proposal for new Work Item to ISO/TC 180)	Task 57/Report B6 September 2018	Test labs and manufacturers, ISO/TC 180
Korbinian Kramer	Guidelines on ISO 9806	Task 57/Report C1	Test labs and manufacturers, ISO/TC 180
Jan Erik Nielsen	Guideline for Implementing Certification Schemes for Solar Heating and Cooling Products	Task 57/Report C4a November 2018	Certification bodies, national authorities, subsidy scheme operators, and manufacturers
Ashraf Kraidy, Lotus Shaheen	Comparison of SHAMCI and Solar Keymark	Task 57/Report C4b August 2017	Test labs and manufacturers
E. Nault, P. Moonen, E. Rey, M. Andersen	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

Journal Articles, Conference Papers, etc.

Author(s)/Editor	Title	Publication / Conference	Bibliographic Reference
Jan Erik Nielsen / Bärbel Epp	Three Global Solar Certification and Standardisation Meetings in Berlin IEA SHC: Mutual Recognition of Test and Inspection Reports Saves Industry Costs	www.solarthermal world.org	www.solarthermalworld.org/keyword/global-solar-certification-network
Jan Erik Nielsen / Bärbel Epp	Global Solar Certification Network: Facilitating International High-Quality Collector Trade	www.solarthermal world.org	www.solarthermalworld.org/content/global-solar-certification-network-facilitating-international-high-quality-collector-trade
Jan Erik Nielsen / Bärbel Epp	YouTube interview: Jan Erik Nielsen: Global Solar Certification Network	SHC Conference, Abu Dhabi 2017	www.youtube.com/watch?v=zEe8NkeNt0U

Jan Erik Nielsen	"IEA SHC Task 57 Solar Standards and Certification", poster	SOLARTR-2016, Istanbul, Turkey, December, 2016	solartr.org.tr
Jan Erik Nielsen	"Global Solar Certification Network"	PTB Workshop on certification of solar thermal products in Maghreb region (North Africa) Morocco 7-9 May 2017	
Jan Erik Nielsen	"Solar Standards and Certification", Keynote	SHC 2017 Conference, Abu Dhabi, November 2017	www.shc2017.org/
Jan Erik Nielsen	Global Solar Certification Network,	Asia-Pacific Solar Research Conference, Melbourne. December 2017	apvi.org.au/solar-research-conference/
Harald Drück	Global Solar Certification Network (GSCN) and Global Certification of Collectors	EuroSun 2018, Rapperswil, September 2018	www.eurosun2018.org/home.html
J.G. Parker, L.T. Guthrie, K.I. Guthrie	Utilisation of ISO9806:2017 in Global Solar Certification, 2018	Asia Pacific Solar Research Conference Sydney December 4-6 2018	apvi.org.au/solar-research-conference/wp-content/uploads/2018/12/179_SHC_Parker_J_2018_PAPER_reviewed.pdf
Jan Erik Nielsen et al.		IEA SHC Webinar on Solar Standards & Certification, December 2018	www.youtube.com/watch?v=iVcTL59_82E&index=1&list=PLHMZ2tGVXsM-ZzrQB5UKHPopviqbdv1Jq

Conferences, Workshops and Webinars

Task participants presented Task work and results at 10 conferences and workshops over the course of the Task.

Task Meetings

Meeting	Date	Location
Experts Meeting 1	11 March 2016	Berlin, Germany
Experts Meeting 2	24 November 2016	Cairo, Egypt
Experts Meeting 3	8 March 2017	Freiburg, Germany
Experts Meeting 4	29 October 2017	Abu Dhabi, UAE
Experts Meeting 5	8 March 2018	Madrid, Spain
Experts Meeting 6	10 September 2018	Rapperswil, Switzerland

SHC Task 57 Participants

Country	Name	Institution / Company	Role
DENMARK	**Jan Erik Nielsen**	**SolarKey International**	**Operating Agent**
ALGERIA	Abdelkrim Chenak	CDER	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 (BSERI)	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 Nat. Engineering Research Center for Human Settlements	National Expert
CHINA	Shen Bin	Zhejiang Solar - Energy Products Quality Testing & Inspection Center	National Expert
CHINA	Gu Xiuzhi	Beijing Building Materials Testing Academy Co. Ltd.	National Expert
DENMARK	Jan Erik Nielsen	SolarKey International	National Expert
FRANCE	Pierre Delmas	NEWHEAT	National Expert
FRANCE	Alexis Gonnelle	NEWHEAT	National Expert
GERMANY	Harald Drück	ITW, University Stuttgart	Subtask A Leader
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
RCREEE	Ashraf Kraidy	RCREEE	Subtask C Leader
PORTUGAL	Maria Joao Carvalho	LNEG	National Expert
SPAIN	Ramon Pujol Nadal	University of Balearic Islands / Solar Optics	National Expert
SPAIN	Julian David Hertel	University of Balearic Islands / Solar Optics	National Expert
SWITZERLAND	Andreas Bohren	SPF, Rapperswil	National Expert
GERMANY	Arnulf Knorr	GIZ/RCREEE	Observer

6. Ongoing Tasks

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

Sabine Putz
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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
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
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
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 dissemination of SDH/SDC and hybrid technologies in new markets
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 end 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 2018

SHC TCP and DHC TCP collaboration: joint workshop of SHC Task 55 and DHC Annex TS2:

- A SWOT Analysis for the integration of Solar Energy into District Heating Networks was finalized and published on the Task 55 Homepage.
- Joined Workshop Summary was published on the SHC Task 55 and on the DHC Annex TS2 Homepage.
- A presentation of the joint workshop is available.

Subtask A: Network Analyses and Integration

As of yet, 17 partners and about 27 projects are contributing to Subtask A. Following general achievements can be noted:

- A SWOT analyses has been continued and extended as well as discussed internally.
- Transformation strategies for Graz (SOLID), a general methodology for developing transformation strategies (AIT), the installation in Brühl (TU Chemnitz, ongoing), and multi-criteria optimization of tri-generation from hybrid technologies (University of Zaragoza) were elaborated.
- A literature review on hydraulic integration concepts was done, including SDH EU Project, DEZENTRAL from Solites and further Input from task partners (AIT, PlanEnergi).
- A study for storage designing and sizing as well as decentral integration (AIT), including a configuration study for hybrid technologies (University of Zaragoza, network excluded) was elaborated.
- Results in A-D3 show that heat pumps can be integrated in SDH systems with the aim of achieving higher share of REs and thus reducing/replacing use of fossil fuels.
- Feasibility analyses for long term storage integration and control strategies were developed and simulated (AIT).
- Feasibility study of high-share integration of solar thermal systems into typical Austrian rural district heating systems is available.

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

Achievements included:

- The project” MeQuSo” presented results on the quality assurance of large-scale solar thermal plants.

- Together with Task 57 a draft proposal for “Performance check of large collector fields” has been elaborated. A draft was delivered to the ISO TC180 in October 2018.
- Draft proposal for ISO standard on “Performance check of large collector fields.”
- International stakeholders with large scale solar heating systems are invited to connect their system to the website SolarHeatData.EU.

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

Achievements included:

- The thermal performance of a system with large seasonal storage has been investigated and reported.
- ITW presented status on Convection in insulation materials: CFD based evaluation of heat transfer processes in bulk insulation materials (Dominik Bestenlehner).
- A literature review on all publications available on modelling of large-scale storages had been undertaken and presented at the last Task 55 Experts Meeting.
- First draft report on CSP system in Tårs, Denmark
- Paper from Chemnitz: Thermal and hydraulic investigation of large-scale solar collector field; Nirendra Lal Shrestha, Ophelia Frotscher, Thorsten Urbaneck, Thomas Oppelt, Thomas Göschel, Ulf Uhlig, Holger Frey.

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

Achievements included:

- Presentation on dynamic financial appraisal method of SOLID. First descriptions of business models almost finalized and will be published in spring 2019.
- A SDH plant in Dresden in a protected area was investigated.
- The draft of the template was developed further and finalized.
- Description of drivers for global market developments.
- Number of new Country reports: Austria, China, Denmark, Germany, France and Sweden.
- CEA Ines is developing a calculation tool for renewable heat production installations. A first version is almost finished and a final version in English is expected in 2019.

Work Planned For 2019

Subtask A: Network Analyses and Integration

- Collection of other case studies to finalize A-D1.2, optimize synergy with Subtask D, work on A-D1.3.
- Collect and analyze more transformation strategies - From Partners and from literature.
- Leader to be defined for A-D3.

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

- Fact sheet on In-situ collector array testing will be written.
- Fact sheet in connection with A-D4 will be designed.
- Fact sheet based on the new ISO Standard in preparation.

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

- Presentation of Findings on “Modular conception and construction” at the next Expert Meeting.
- Report on CSP testing (DTU).
- Report on CFD modelling of CSP collector (DTU).
- Update on Storage Fact Sheet (PlanEnergi).
- Draft report on Survey of storage models (ITW).

Subtask D: Promotion and dissemination of SDH/SDC and hybrid technologies in new markets

- First descriptions of business models will be finalized in summer 2019.
- The final template for best practice examples will be finished and send to the partners to ask for input data.

- A first example of a country report will be asked from one partner. And then the example will be sent to other partners who presented country reports to provide their information.
- Training material translated into English will be presented at the Experts Meeting in April 2019.

Dissemination Activities In 2018

Reports, Published Books

No reports or books were published in 2018.

Journal Articles, Conference Papers, etc.

Author(s)/Editors	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 SHC Task 55, Subtask A	SDH Conference 2018 April 2018, Graz, Austria	
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	

Dissemination Activities Planned For 2019

First Fact Sheets for selected deliverables will be published.

Task Meetings 2018 and 2019

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting 4	9 – 10 April 2018	Graz, Austria	41 (11)
Experts Meeting 5	29 – 31 October 2018	Lianyungang, China In conjunction with the Solar Academy Training	32 (7)
Experts Meeting 6	8 – 10 April 2019	Universidad de Zaragoza Department of Mechanical Engineering, Zaragoza, Spain	
Experts Meeting 7	Autumn 2019	Sweden Härnösand (Host ABSOLICON)	

SHC Task 55 Participants

Country	Name	Institution / Company	Role
AUSTRIA	**Sabine Putz**	**SOLID**	**Operating Agent**
AUSTRIA	Christian Engel	Thermaflex Int Holding	National Expert
AUSTRIA	Christian Fink	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Christian Holter	SOLID	National Expert
AUSTRIA	Carles Ribas Tugores	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Daniel Tschopp	AEE – Institute for Sustainable Technologies	National Expert
AUSTRIA	Daniel Muschick	BIOENERGY 2020+ GmbH	National Expert
AUSTRIA	Fabian Ochs	University of Innsbruck	National Expert
AUSTRIA	Georg Engel	AEE INTEC	National Expert
AUSTRIA	Georg Sima	MGR GEORG SIMA E.U.	National Expert
AUSTRIA	Ingo Leusbrock	AEE INTEC	National Expert
AUSTRIA	Moritz Schubert	SOLID	National Expert
AUSTRIA	Markus Gölles	Bioenergy 2020+ GmbH	National Expert
AUSTRIA	Peter Luidolt	SOLID	National Expert
AUSTRIA	Philip Ohnewein	AEE INTEC	National Expert
AUSTRIA	Patrick Reiter	SOLID	National Expert
AUSTRIA	Paolo Leoni	AIT	National Expert
AUSTRIA	Ralf-Roman Schmidt	AIT/Austrian Institute of Technology	Subtask A Leader
AUSTRIA	Viktor Unterberger	Bioenergy 2020+ GmbH	National Expert
AUSTRIA	Werner Doll	SOLID	National Expert
AUSTRIA	Christian Holter	SOLID	National Expert
CANADA	James Bererton	Naked Energy	National Expert
CANADA	Ken Guthrie	SHC Chair	National Expert
CANADA	Lucio Mesquita	CanmetENERGY	National Expert
CHINA	Jianhua Fan	Technical University of Denmark	National Expert
CHINA	Youjin Xu	Tongji university	National Expert

CHINA	Aaron Feng Gao	Arcon-Sunmark Large-scale Solar Systems Integration Co., Ltd,	National Expert
CHINA	Liu MU	Vicot Solar Technology Co., Ltd	National Expert
CHINA	Qingtai Jiao	Jiangsu Sunrain Solar Energy Co., Ltd	Subtask B Leader
CHINA	Kaichun Li	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Shai Li	Jiangsu Sunrain Solar Energy Co., Ltd	National Expert
CHINA	Zheng Wei	Yazaki Energy System Corporation	National Expert
DENMARK	Lars Munkoe	Purix	National Expert
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	Jes Donneborg	Aalborg CSP	National Expert
DENMARK	Jan Erik Nilsen	PlanEnergi	Subtask C Leader
DENMARK	Jianhua Fan	Technical University of Denmark	National Expert
DENMARK	Junpeng Huang	Technical University of Denmark	National Expert
DENMARK	Povl Frich	Danish Energy Agency	National Expert
DENMARK	Simon Furbo	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
FINLAND	Morten Hofmeister	Savo-Solar Oy	National Expert
FRANCE	Alexis Gonnelle	New Heat Directeur technique / CTO	National Expert
FRANCE	Cedric Paulus	CEA/INES	National Expert
FRANCE	Nicolas Lamaison	CEA/INES	National Expert
FRANCE	Paul Kaaijk	Ademe	National Expert
FRANCE	Pierre Delmas	New Heat Directeur technique / CTO	National Expert
GERMANY	Axel Gottschalk	Bremerhaven University of Applied Sciences	National Expert
GERMANY	Magdalena Berberich	Solites - Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems	Subtask D Leader

GERMANY	Dominik Bestenlehner	ITW/TZS University of Stuttgart	National Expert
GERMANY	Detlev Seidler	SOLID	National Expert
GERMANY	Dan Bauer	DLR	National Expert
GERMANY	Dominik Bestenlehner	IGTE University of Stuttgart	National Expert
GERMANY	Bärbel Epp	Solrico	National Expert
GERMANY	Andrej Jentsch	Operating Agent IEA IA on District Heating and Cooling including the integration of CHP	National Expert
GERMANY	Karin Rühling	TU Dresden	National Expert
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
GERMANY	Roman Marx	ITW University of Stuttgart	National Expert
GERMANY	Nirendra Lal Shrestha	Technische Universität Chemnitz	National Expert
GERMANY	Norbert Rohde	KBB Kollektorbau Gmbh	National Expert
GERMANY	Stefan Mehnert	ISE	National Expert
GERMANY	Sven Fahr	Fraunhofer ISE	National Expert
GERMANY	Thorsten Urbanek	TU Chemnitz	National Expert
ITALY	Luca Degiorgis	Politecnico di Torino	National Expert
ITALY	Marco Calderoni	Polimi	National Expert
ITALY	Roberto Fedrizzi	Eurac Research	National Expert
ITALY	Marco Scarpellino	TVP Solar	National Expert
NETHERLANDS	Luuk Beurskens, L.W.M.	ECN-TNO	National Expert
NETHERLANDS	Ruud Vandenbosch	Ecovat	National Expert
POLAND	Armen Jaworski	Cim-Mes	National Expert
SPAIN	Ana Lazaro	University of Zaragozza	National Expert
SPAIN	Andoni Diazdemendibil	Tecnalia	National Expert
SPAIN	Carol Pascual	Tecnalia	National Expert
SPAIN	Javier Mazo	University of Zaragoza	National Expert
SPAIN	Miguel Lozano	University of Zaragozza	National Expert

SPAIN	Patricio Aguirre Múgica	Tecnalia	National Expert
SPAIN	Luis M. Serra	University of Zaragoza	National Expert
SWEDEN	Joakim Byström	Absolicon Solar Collector AB	National Expert
SWEDEN	Josefine Nilsson	Absolicon Solar Collector AB	National Expert
SWEDEN	Peter Kjellgren	Absolicon Solar Collector AB	National Expert
SWITZERLAND	Vittorio Palmieri	TVP Solar	National Expert
UNITED KINGDOM	Eamon Clarke	Kingspan Environmental Ltd.	National Expert
UNITED KINGDOM	Finbarr McCarthy	Kingspan Environmental Ltd.	National Expert
UNITED KINGDOM	Martin Crane	Carbon Alternatives Ltd	National Expert
UNITED KINGDOM	Gunnar Lennermo	Energianalys AB	National Expert
UNITED KINGDOM	Joshua King	AES Solar	National Expert

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

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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

The Task's work is divided into three subtasks:

- Subtask A: Solar Envelope Systems Classification and Communication (Norway)
- Subtask B: Performance Characterization of Solar Envelope Elements (Germany)
- Subtask C: Assessment of Solar Envelope Systems at Building Level (Austria)

Scope

Subtask A: Solar Envelope Systems Classification and Communication
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

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 into 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

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 through 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

Following each Task meeting industry workshops are organized to get in contact with industry stakeholders and to get feedback on the status and perspectives on the local solar envelopes market.

28 experts from 24 different institutions participated in the kick-off meeting at EURAC in Bolzano. The majority has been Universities and Research centers. However, we have had good participation by Industry (7 companies), which expressed their intention to actively participate in the project elaboration.

During the second meeting held in Darmstadt, 25 experts where present out of which 5 from industry. 2 observers from BASF and MERCK glasses presented their developments in the sector of advanced solutions for the active solar gains control. The China International Investment Promotion Agency also participated in disseminating their activates and seeking for possible collaboration in China.

During the third meeting held in Dublin, 24 experts were present out of which 5 from industry. Three additional industry representatives participated in the first industry workshop.

Sixteen experts from the well-established group of participating entities have actively contributed to the meeting in Eindhoven. Overall, eight external manufacturers joined with different levels of contribution to the meeting.

During the Task meeting in Montreal in September 2018, an industry workshop was organized bringing together BIPV-BIST manufacturers, large utility companies and Canadian associations. During a first session of presentations and round table, manufacturers (Livio Nichilo (Internat Energy Solutions), Samuel Doyon-Bissonnette (Unicel Architectural), Ronald Drews (Canadian Solar), John Hollick (Conserval), Ady Vyas (S2E)) presented their latest developments with respect to building integrated solar technologies, while barriers and market opportunities were discussed in a round table.

In the second session, the focus of the presentations and related discussion was posed on how BIPV can contribute to the flexibility of the single buildings and the electric distribution grids, allowing utilities to offer new services to customers while improving the grid management, reducing load peaks.

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

Work During 2018

Subtask A: Solar Envelope Systems Classification and Communication

During the last year, the analysis of the solar active envelopes state-of-the-art has been finalized. To provide a reasoned analysis, it was decided to directly couple this with the SWOT study of the same solutions. This assessment is carried out by evaluating product-related intrinsic features such as unique selling points or possible improvements of a specific product/technology and by looking at the market for identifying existing competitors and stimulate strategies for future developments.

The objective is three-fold, to achieve a more comprehensive view of the market evolution, to disseminate initial Task results and to increase industry involvement.

The report includes an analysis of 15 very different products. To build a more representative study, it was decided to distribute the document to relevant experts and manufacturers in the sector (not active in the Task), for them to further contribute to the elaboration of the analysis.

Before the official revision, the document will be completed with the lessons learned: based on the inputs gathered, the ultimate aim of this document is to draw common conclusions on solar envelope systems. As this document finalization requires discussion and agreement among the experts participating in its elaboration, it is proposed to use the last 12 months to improve and finalize the document.

Task A work has also focused on maintaining and updating the website with relevant information on publications, participation at conferences and submission of journal papers by the Task participants. A new website page with BISES images and short explanations on the system integration is under elaboration.

The project partners have been significantly involved in presenting BISES solutions at conferences and workshops, mainly during September (more information in the related tables).

Subtask B: Performance Characterization of Solar Envelope Elements

Deliverable B.1 was published. This, together with the industry workshops organized as part of Subtask A, the confidential feedback workshops organized within Subtask B and D A.1/A.2, will be the basis to elaborate on the strategies for market penetration (DB.2).

The work on the strategy's development started at month 30 during the Task meeting in Montreal. The discussion showed the lack of a clear approach to the problem due to the size of the sectors considered. More discussion is needed to structure the work and the related report.

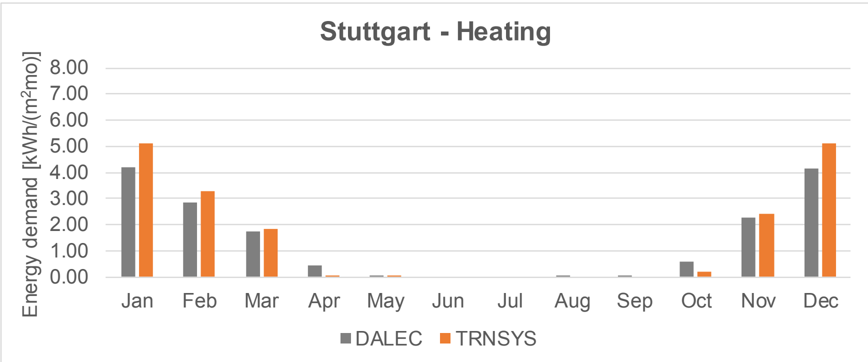
A journal review paper on simulation models' availability and purposes was delivered to a peer-reviewed journal. The paper is for all target groups of SHC Task 56 to find the best, and therefore, most cost-effective simulation models to be used for their innovative technologies.

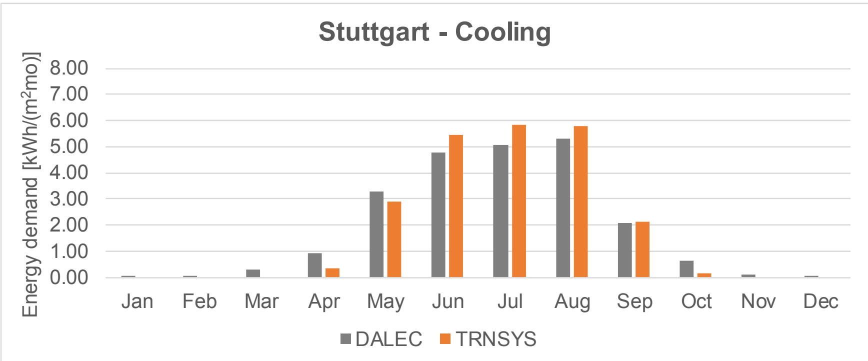
In activity B3, standards have been collected useful to rate and evaluate solar active envelope components. The understanding is that a very large number of standards are available that can be used when dealing with solar envelopes. The deliverable reporting on such norms analysis and recommendations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

Subtask C: Assessment of Solar Envelope Systems at Building Level

The subtask elaborated the report D.C.1, where a detailed description of suitable reference residential and tertiary buildings is provided. The reliability of each model has been validated with respect to a number of simulation tools (i.e., TRNSYS, Energy+, DALEC, Matlab), and the procedures for their use, allowing a fair comparison of simulation results, have been reported in detail.

Although the report has been reviewed, it is undergoing a continuous update in order to add results from more simulation tools (e.g., Modelica), to improve the coherence of the different tools and to provide better explanations of the procedures.





The performance of solar envelope systems is being analyzed in different locations, ranging from heating- to cooling-dominated climates. Additionally, for geometrical and user-behavior boundary conditions, a set of Key Performance Indicators (KPIs) were defined for the energy, environmental and comfort assessment of solar envelope systems.

The work aims to be platform-independent, meaning that no specific simulation tool is prescribed within the Task. The unique requirement is to demonstrate that the simulation results in terms of H&C demands and comfort are in agreement with the values reported in deliverable D.C.1.

The Task partners started simulating the performance of their respective BISES when implemented in the reference buildings developed and in different locations around the world.

So far, three residential and four tertiary applications have been identified, ranging from BIST to natural lighting control, moving through BIPV, and simulation results are being produced and gathered.

At the same time, the data analysis framework is under discussion: common KPIs and calculation methods are under discussion. In particular, the calculation of Primary Energy and CO_2 emission savings are in focus since different calculation methods can bring extremely different results.

Dissemination Activities In 2018

Reports, Published Books

Author(s)/Editor	Title	Report No. Publication Date
Hubschneider, C., Maurer, C., Taveres-Cachat, E., Hollick, J., Lemarchand,P., Garay,R., Loonen, R., Aagesen, V.	Barriers for New Solar Envelope Systems	Deliverable B.1 November 2018

Journal Articles, Conference Papers, Press Releases, etc.

Author(s)/Editor	Title	Publication / Conference	Bibliographic Reference
Attia, S., Bilir, S., Safy, T., Struck, C., Loonen, R.C.G.M., & Goia, F.	Current Trends and Future Challenges in the Performance Assessment of Adaptive Façade Systems	Energy and Buildings, 179, 165-182	https://doi.org/10.1016/j.enbuild.2018.09.017
Capperucci, R., Loonen, R.C.G.M., Hensen, J.L.M., Rosemann, A.L.P.	Angle-dependent optical properties of advanced fenestration systems- Finding right balance between model complexity & prediction error	Building Simulation (2018), Online ISSN 1996-8744	https://doi.org/10.1007/s12273-018-0466-4
Koenders, S.J.M., Loonen, R.C.G.M. & Hensen, J.L.M.	Investigating the potential of a closed-loop dynamic insulation system for opaque building elements	Energy and Buildings 173, 2018, Pages 409-427, ISSN 0378-7788	https://doi.org/10.1016/j.enbuild.2018.05.051
Mugaguren, M.L., Garay, R,; Martin, K.	Unglazed Solar Thermal Systems for Building Integration, Coupled with District Heating Systems. Conceptual Definition,	Journal of Facade Design and Engineering 6(2) 119-131, June 2018, ISSN: 2213-3038	https://doi.org/10.7480/jfde.2018.2.2085

	Cost and Performance Assessment		
D'Antoni M., Bonato P., Fedrizzi, R.	On the development of a façade-integrated solar water storage	Journal of Facade Design and Engineering 6(2) 9-20, June 2018, ISSN: 2213-3038	https://doi.org/10.7480/jfde.2018.2.2048
Paul-Rouven Denz, Puttakhun Vongsignha, Simon Frederik Haeringer, Tilmann E. Kuhn, Christoph Maurer, Michael Hermann, Hannes Seifarth, Katharina Morawietz	Solar thermal façade systems – An interdisciplinary approach	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
Jakob Klint, Vickie Aagesen	Living in Light – a transformation concept of existing buildings	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
David Geisler-Moroder, Christian Knoflach, Silvia Öttl, Wilfried Pohl	Advanced daylighting systems and combined lighting and thermal simulation	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
Jan de Boer, Carolin Hubschneider	Lab measurements and field testing of integrated systems	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
David Geisler-Moroder, Christian Knoflach, Silvia Öttl, Wilfried Pohl	Characterization of advanced daylighting systems and combined lighting and thermal simulation	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
Georgios Dermentzis, Fabian Ochs, Aleksandra Ksiezyk, Elisa Venturi, Mara Magni, Hannes Gstrein	Heating with PV Façade in a Passive House	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
Fabian Ochs	Heating with facade-integrated heat pumps – results of the Austrian project „SaLüH!“	13th Conference on Advanced Building Skins Bern, Switzerland, Oct. 1-2, 2018	www.abs.green
Dagmar Jaehnig, Thomas Ramschak, David Venus, Karl Hoefler, Christian Fink	Building retrofit using facade-integrated energy supply systems	ISEC - International Sustainable Energy Conference, Congress Graz, Austria, October 3-5, 2018	
Fabian Ochs, Dietmar Siegele, Toni Calabrese, Georgios Dermentzis	Deep renovation of a MFH with decentral compact heat pumps	ISEC - International Sustainable Energy Conference, Congress	

		Graz, Austria, October 2018	
D´Antoni, M., Geisler-Moroder, D., Bonato, P., Ochs, F., Magni, M., De Vries, S.B., Loonen, R.C.G.M., Fedrizzi, F.	Definition of a reference office building for simulation-based evaluation of solar envelope systems	EuroSun 2018 Rapperswil, Switzerland, September 2018	
Toni Calabrese, Fabian Ochs, Dietmar Siegele and Georgios Dermentzis	Potential of covering electricity needs of a flat of a MFH with decentral compact heat pumps with PV – Simulation study for different DHW profiles and PV field sizes	EuroSun 2018 Rapperswil, Switzerland, September 2018	
Saini, H., Loonen, R.C.G.M., Hensen, J.L.M.	Simulation-based performance prediction of an energy-harvesting façade system with selective daylight transmission	VIII Int. Congress on Architectural Envelopes Donostia-San Sebastián, Spain, June 20-22, 2018	
Nikolaus Nestle, Thibault Pflug, Christoph Maurer, Frank Prissok, Andreas Hafner, Frank Schneider	Concept for adaptive wall elements with switchable U- and g-value	VIII Int. Congress on Architectural Envelopes Donostia-San Sebastián, Spain, June 20-22, 2018	
Diego González, Beñat Arregi, Roberto Garay, Izaskun Álvarez, Gorka Sagarduy	Innovative curtain wall with solar preheating of ventilation air and integrated control system	VIII Int. Congress on Architectural Envelopes Donostia-San Sebastián, Spain, June 20-22, 2018	
Marina Palacios, Roberto Garay, Ignacio Gomis, Paul Bonnamy, Saed Raji, Koldobika Martin	Low Temperature Solar Thermal System for Building Envelope Integration	VIII Int. Congress on Architectural Envelopes Donostia-San Sebastián, Spain, June 20-22, 2018	
Bärbel Epp	IEA SHC Task 56: Building-integrated solar envelopes: barriers to deployment	Solarthermalworld.org	www.solarthermalworld.org/content/building-integrated-solar-envelopes-barriers-deployment

Task Meetings 2018 and 2019

Meeting	Date	Location	# of Participants
Experts Meeting 5	6-7 March 2018	Innsbruck, Austria	17
Experts Meeting 6	20-21 September 2018	Montreal, Canada	24
Experts Meeting 7	5-6 March 2019	Copenhagen, Denmark	

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	Carolin Hubschneider	Fraunhofer IBP	National Expert
ITALY	Matteo D'Antoni	EURAC	National Expert
ITALY	Paolo Bonato	EURAC	National Expert
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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

Task 58 – Material and Component Development for Thermal Energy Storage

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AEE INTEC
Operating Agent for Austrian Ministry for Transport, Innovation and Technology

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

The Task's work is divided into four subtasks:

- Subtask 1: Energy Relevant Applications for an Application-oriented Development of Improved Storage Materials (SHC Austria and ECES Germany)
- Subtask 2: Development & Characterization of Improved Materials (SHC Slovakia and ECES Germany)
- Subtask 3: Measuring Procedures and Testing Under Application Conditions (SHC Austria and ECES Germany)
- Subtask 4: Component Design for Innovative TES Materials (SHC Switzerland and ECES Spain)

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 economic 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 the SHC TCP and Andreas Hauer for the ECES TCP.

Task Duration

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

Participating Countries

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

Work During 2018

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

Main outcome of this Subtask is a collection of reference conditions for a number of applications. 3 Groups of applications have been defined, of which the TES for family households (short term and seasonal), inclusive ice storage for HVAC systems, is the application for which the reference conditions are developed first. A draft document for these conditions was made and discussed. For the industrial batch processes TES, a table of reference conditions was produced and discussed.

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

The objectives of this subtask are:

- To develop guidelines for the preparation of PCMs to determine properties
- Collection of PCM development approaches /material which is under development
- Preparing Wiki for PCM nomenclature on www.thermalmaterials.org
- Continuing the development of a measurement standard

A variety of work was done in this Subtask: there is a round-robin test ongoing on Viscosity, Density, Thermal diffusivity and specific heat.

Regarding the heat capacity round robin measurements: the first round using Octadecane with only different heating rates specified lead to well comparable results.

The round robin on density measurements revealed large differences in the solid phase while the results for the liquid phase were fine.

A questionnaire on materials under development was circulated, and seven institutes reacted; it showed that 16 PCMs are under development. We are still awaiting more reactions on the questionnaire.

There are now 15 PCMs shown in the public area of the database, which is a good start, but more are needed. The extension of the database for TCM and sorption is ongoing, and this part will be released soon.

Subtask 2T: Development & characterization of improved Thermochemical Materials

Ongoing investigations, which are part of different EU and national projects, dealing with development and characterization of chemical reactants, composites and sorption materials, have been continued: MOFs, composites of metallic (Al) foams with Ca, Mg and Li exchanged 13X, dealuminated binder-free zeolite Y and zeolite Y with binder, zeolite 4A, composites of different matrices and CaCl2, SrCl2-NH3 reaction, K2CO3-H2O reaction, LiCl-H2O reaction, Ba(OH)2-H2O reaction, MgCl2-H2O reaction, MgCl2*2H2O-H2O reaction, MgCl2*4H2O-H2O reaction, ammoniates, Mg(OH)2 with carbon nanotubes, clinoptilolite-salt, polymeric foam and MgSO4.

New green syntheses of microporous aluminophosphates have been developed. The database on chemical reactants is under construction on the website by programmers at FhG-ISE. The database for sorption materials is developed, while the one for liquids will be designed until the end of the year. Some properties were highlighted in the database for sorption materials, which must be present in order to make the database useful.

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

In subtask 3P, experts work on 2 deliverables: First, an inventory and description of (thermophysical) properties of PCM that change comparing lab-scale experiments with tests under application conditions; second, recommendations how to assess the behaviour of a material under application conditions using simple tests without the need to perform experiments at application scale. The inventory table of deliverable 1 will be uploaded to the task member area, reviewed by three PCM experts, and completed within the remaining period of the task. For deliverable 2, it was decided to focus on the stability of PCM. Therefore, a template was distributed to collect information about existing experimental techniques to investigate the stability of PCM. So far, several completed templates have been received. In this context, stability refers to the stability of the PCM itself subjected to different static and dynamic conditions (temperature, contact to atmosphere, and contact to container/heat exchanger material). Phase change slurries and microencapsulated PCM are also taken into account in this survey. The key message of this subtask is: "Testing the stability under application conditions is important to choose a PCM for a specific application."

Collecting input for the inventory table on other properties than stability will be continued within the entire duration of the Annex, and the inventory table as one of the deliverables of this subtask will be included in the final report. The more detailed work on stability is intended to be published in a peer-reviewed journal.

What has been done:

- D3P1: inventory and description of (thermophysical) properties of PCM that change comparing material characterization with tests under application conditions Draft
- D3P2: questionnaire to gather information on the various techniques and methodologies to investigate the stability of PCM

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

In July 2018, a separate meeting was held between experts at ISE in Freiburg to discuss the 2nd round of testing on salt hydrates. A draft was proposed for the test method for salt hydrate thermochemical materials by NRCAN and discussed at the meeting.

Subtask 4P: Component Design for Phase Change Materials

During the October Experts Meeting in Graz, the draft of deliverable D4P1 was presented. The deliverable mentioned above consists of the descriptions of the concepts developed in the participating institutions. The final version will be submitted for approval for the next meeting after the final revision aiming at harmonization of the structure and details given for each concept.

The second objective of the Subtask is to identify the characteristic of performance of PCM systems to assess the improvement and comparison for a given application. After the literature and the previous works found in the international scientific community (IEA-Annex30 and SFERA project) review and the consulting of experts own experience, the first proposal of technical parameters for the performance comparison was presented and discussed in the last meeting in Graz. Agreement was achieved for parameters assessing capacity and density. Power parameters are specifically complex and required further discussions. A first comparison is already launched, and the first results are expected before the next meeting.

Deliverable D4P2 and D4P3 are closely connected, and they will be started with the first results on the comparison to be discussed in the next meeting. For the performance improvement assessment, a first consultation was accomplished, and two improvement approaches were identified: incorporation of fins and the use of a mechanical stirrer.

Subtask 4T: Component Design for Thermochemical Materials

As a consequence of ongoing discussions of component and system categorization and description, a slight restructuring of the deliverables in order to fit to the present learning's was undertaken in the 3rd period.

Through analysis of the various basic system approaches it has become clear that in respect to storage capacity and temperature gain there are considerable system dependent limitations. For this reason, it is decided that deliverable 1 will consist of a critical discussion of these system limitations accompanied by a literature review of reported systems, in light thereof. This deliverable in the form of a review paper is close to completion and will be submitted before the end of 2018

Deliverable 2 now consist of a collection of inputs to the former template on member systems. Contributions from 11 institutes comprising 13 systems have been compiled making up a 48-page document. The deliverable is undergoing final proofreading, to be finalized by the end of 2018. It was decided that the document will remain open until the end of 2019 for further contributions to be added.

Discussion on performance evaluation of component and system has been initiated at the 3rd task meeting in Ljubljana and continued at the 4th task meeting in Graz. This work has proven to be specifically complex due not only to the varying sorbent materials and components but also the varying applications and thereof resulting performance criteria. For example, in a long term heat storage system, high capacity is very important. In a short-term storage, power is generally more critical. Intensive discussion on possible performance parameters for comparison, such as gross temperature lift with comparison to specific mass fraction to temperature lift equilibrium, volumetric power density, volumetric energy density and efficiency has been undertaken. It has been decided that rather than following the course of a lengthy process of parameter definition, a list of possible performance degradations from material level performance to system level performance will be composed as deliverable. A group of 6 experts will develop this deliverable until the end of 2019.

Work Planned For 2018

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

The final deliverable with the boundary condition for the chosen application will be made.

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

The round-robin results will be compared, test procedures will be discussed and reported.

Subtask 2T: Development & Characterization of improved Thermochemical Materials

The database will be filled with a small number of sorption materials and salt hydrates. The novel developed materials will be described and reported.

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

The inventory table will be completed and reviewed. Information on stability testing techniques will be further collected and reported. A publication will be made that includes an overview of experimental techniques and recommendations to test the stability of PCM under application conditions.

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

The proposed and tested methods will be reported.

Subtask 4P: Component Design for Phase Change Materials

The deliverables will be finalized.

Subtask 4T: Component design for Thermochemical Materials

Deliverable on component performance degradation will be finalized.

Dissemination Activities In 2018

Reports, Published Books

Author(s)/ Editor	Title	Report No. Publication Date
Michael Brütting	Internal: Michael Brütting, Intercomparison of measurement results by means of flash technique,	Report ZAE 2 0318 - 09(2018)
Benjamin Fumey, Robert Weber	“Fertig ist die Lauge, Solarkraft aus dem Sommer im Winter zum Heizen verwenden”	3sat TV, Nano, Monday, 29. January 2018, www.3sat.de/mediathek/?mode=play&obj=71365

Journal Articles, Conference Papers, etc.

Author(s) / Editor	Title	Publication / Conference	Bibliographic Reference
De Jong, A.-J., Fischer, H.	Trouton's Rule for Vapor Sorption in Solids	Appl. Sci., 8(4), 638;	2018
Sögütoglu, L. C., Donkers, P.A.J., Fischer, H.R., Huinink, H.P. & Adan, O.C.G.	In-depth investigation of thermochemical performance in a heat battery: Cyclic analysis of K2CO3, MgCl2 and Na2S	Applied Energy, 215, 159-173	2018
Sögütoglu, L. C., Donkers, P.A.J., Fischer, H.R., Huinink, H.P. & Adan, O.C.G.	In-depth investigation of thermochemical performance in a heat battery: Cyclic analysis of K2CO3, MgCl2 and Na2S	Applied Energy, 215, 159-173	2018
Dannemand, M., Delgado, M., Lazaro, A., Penalosa, C., Gundlach, C., Trinderup, C., Berg Johansen, J., Moser, C., Schranzhofer, H., Furbo, S.	Porosity and density measurements of sodium acetate trihydrate for thermal energy storage	Applied Thermal Engineering, 131, pp. 707-714	2018
Englmair, G., Moser, C., Furbo, S., Dannemand, M., Fan, J.	Design and functionality of a segmented heat-storage prototype utilizing stable super-cooling of sodium acetate trihydrate in a solar heating system	Applied Energy 221, pp. 522-534	2018
Deng, J., Furbo, S., Kong, W., Fan, J.	Thermal performance assessment and improvement of a solar domestic hot water tank with PCM in the mantle	Energy and Buildings	https://doi.org/10.1016/j.enbuild.2018.04.058
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 215 (2018) 512-522	
Elpida Piperopoulos, Emanuela Mastronardo, Marianna Fazio, Maurizio Lanza, Signorino Galvagno, Candida Milone	Synthetic strategies for the enhancement of Mg(OH)2 thermochemical performances as heat storage material	Energy Procedia (submitted)	

V. Brancato, L. Gordeeva, A. Sapienza, V. Palomba, S. Vasta, A. Grekova, A. Frazzica, Y. Aristov	Experimental characterization of the LiCl/vermiculite composite for sorption heat storage applications	International Journal of Refrigeration. Accepted paper	
Alenka Ristić, Fabian Fischer, Andreas Hauer, Nataša Zabukovec Logar	Improved performance of binder-free zeolite Y for low-temperature sorption heat storage	Journal of Materials Chemistry A, 2018	https://doi.org/10.1039/C8TA00827B
Johnson, M., Vogel, J., Hempel, M., Hachmann, B. & Dengel, A.	Design of High Temperature Thermal Energy Storage for High Power Levels	Sustainable Cities and Society, 35 (November):758-763.	https://doi.org/10.1016/j.scs.2017.09.007 (IF 1.777)
Campos-Celador, M. Delgado, E. Franquet, S. Gibout, J. Mazo, J.Pascual, P. Sanchis, A. Lázaro	Estimation of the technical and economic feasibility of two hybrid – thermal and electrical– energy storage solutions in the residential sector	ENERSTOCK 2018 April 2018, Adana, Turkey	
M.Delgado, A. Lázaro, J. Mazo, C. Peñalosa, J. M. Marín, B. Zalba	Experimental analysis of a coiled stirred tank containing a low cost PCM emulsion as thermal energy storage system. Comparison to other TES systems	ENERSTOCK 2018 April 2018, Adana, Turkey	

Task Meetings 2018 and 2019

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting 3	9-11 April 2018	Ljubljana, Slovenia	46 (11)
Experts Meeting 4	1-3 October 2018	Graz, Austria	42 (11)
Experts Meeting 5	1-3 May 2019	Ottawa, Canada	
Experts Meeting 6	9-11 October 2019	Messina, Italy	

SHC Task 58 Participants

Country	Name	Institution / Company	Role
AUSTRIA	**Wim van Helden**	**AEE INTEC**	**SHC Operating Agent**
GERMANY	**Andreas Hauer**	**ZAE Bayern**	**ECES Operating Agent**
AUSTRIA	Bernhard Zettl	ASiC-Austria Solar Innovation Center	National Expert
AUSTRIA	Christian Knoll	TU Vienna	National Expert
AUSTRIA	Markus Fink	AIT Austrian Institute of Technology GmbH	Subtask 3T Leader
AUSTRIA	Hermann Schranzhofer	Graz University of Technology	National Expert
CANADA	Reda Djebbar	CanmetENERGY	National Expert
CANADA	Dominic Groulx	Dalhousie University	National Expert
DENMARK	Simon Furbo	DTU	National Expert
FRANCE	Sylvie Rougé	CEA	National Expert
FRANCE	Erwin Franquet	LaREP-ENSGTI	National Expert
FRANCE	Frederic Kuznik	INSA-Lyon	National Expert
FRANCE	Laurent Zalewski	University of Artois	National Expert
FRANCE	Lingai Luo	University of Nantes	National Expert
GERMANY	Andreas König-Haagen	University Bayreuth	National Expert
GERMANY	Christoph Rathgeber	ZAE Bayern	Subtask 3P Leader
GERMANY	Daniel Fleig	University of Kassel	National Expert
GERMANY	Harald Mehling	PCM- Technologie und Thermische Analyse Consultant	National Expert
GERMANY	Konstantina Damianos	Rubitherm Technologies GmbH	National Expert
GERMANY	Marc Linder	German Aerospace Center	National Expert
GERMANY	Rafael Horn	University of Stuttgart	National Expert
GERMANY	Stefan Gschwander	Fraunhofer ISE	Subtask 2P Leader

GERMANY	Thomas Badenhop	Vaillant GmbH	National Expert
GERMANY	Thomas Herzog	TH Wildau	National Expert
GERMANY	Annelies Vandersickel	Technical Univ. of Munich	National Expert
ITALY	Andrea Frazzica	CNR	National Expert
ITALY	Candida Milone	University of Messina	National Expert
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NETHERLANDS	Ruud Cuypers	TNO	National Expert
SLOVAKIA	Alenka Ristic	NIC	Subtask 2T Leader
SPAIN	Ana Lazaro	University Zaragoza	Subtask 4P Leader
SPAIN	Ana Garcia Romero	Ingeneniería Minera y Metalúrgica y Ciencia de los Materiales	National Expert
SPAIN	Camila Barreneche	University of Lleida	National Expert
SPAIN	Elena Palomo del Barrio	CIC EnergiGUNE	National Expert
SPAIN	Luisa Cabeza	University of Lleida	National Expert
SPAIN	Gonzalo Diarce	University of the Basque Country	National Expert
SPAIN	Rocio Bayón	CIEMAT	National Expert
SWEDEN	Viktoria Martin	KTH Royal Institute of Technology	National Expert
SWITZERLAND	Anastasia Stamatiou	Hochschule Luzern	National Expert
SWITZERLAND	Benjamin Fumey	EMPA	Subtask 4T Leader
SWITZERLAND	Paul Gantenbein	SPF	National Expert
TURKEY	Cemil Alkan	Gaziosmanpsa University	National Expert
TURKEY	Halime Paksoy	Çukurova University	National Expert
TURKEY	Yeliz Konuklu	Ömer Halisdemir Univ.	National Expert
UNITED KINGDOM	Philip Griffiths	Ulster University	National Expert

Task 59 – Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emission

Alexandra Troi
EURAC Research
Operating Agent for ENEA

Task Overview

Historic buildings make up a considerable part of our building stock (one fourth for Europe). They are the trademark of numerous cities, and they will only survive if maintained as a living space. This means, that in order to save this heritage for future generations, we need to find conservation compatible energy retrofit approaches and solutions, which allow to preserve the historic and aesthetic values while increasing comfort, lowering energy bills and minimizing environmental impact.

In the last 10 years a shift in paradigm could be observed: While in times of the first EPBD, a strong opposition from conservators and architects could be observed – "don't touch these buildings" – there is growing a new openness, a much more constructive approach – "let's find the right solutions together". Examples for this development are last but not least the installation of the International Scientific Committee on Energy and Sustainability within ICOMOS and the development of "Guidelines for improving the energy performance of historic buildings" (EN16883, now under final vote) by the CEN TC 346 on Conservation of Cultural Heritage.

Now is an important moment to identify and promote good approaches and solutions.

Standard energy saving measures are often not compatible with preserving the historic buildings' character, nevertheless the energy performance can be improved considerably if the right package of solutions for the specific building is identified. Also, the possibilities to use solar energy in historic buildings are more than one might expect at first, solar panels/collectors:

- are compatible in color and design to established (roof) material,
- are integrated in an architecturally attractive way,
- can be positioned in parts of the building where they are not as visible,
- panels and mounting systems are reversible, and
- stand-alone solar systems are not interfering aesthetically with the building itself are possible.

Complete projects show that a reduction of "Factor 4" (i.e., reduce the energy demand by 75%) and beyond is possible in historic buildings while preserving their heritage value. While defining a minimum performance as for "standard" buildings does not make sense. When looking at the specific building, the design team should not "stop thinking" too early! A considerable reduction in demand – also thanks to optimization of passive solar use – opens up the possibility to go with active solar contribution towards nZEB.

The Objectives of the Task are to:

- Develop a solid knowledge base on how to save energy in renovation of historic and protected buildings in a cost efficient way.
- Identify the energy saving potential for protected and historic buildings according to typologies of building studied (residential, administrative, cultural, etc.).
- Identify and assess replicable procedures on how experts can work together with integrated design to maintain both the heritage value of the building and at the same time make it energy efficient.
- Identify and further develop tools which support this procedure and its single steps.
- Identify and assess conservation compatible retrofit solutions in a "whole building perspective."

- Identify specifically the potential for the use of solar energy (passive and active, heating, cooling and electricity) and promote best practice solutions.
- Transfer knowledge.

In the SHC TCP's Strategic Plan it is stated that to realize this huge potential of solar heating and cooling in the building sector, it is essential to integrate solar technologies into the built environment in an appropriate way. Solar based renovation of existing building stock is listed as one of the most important activities to achieve this.

The Task's work is divided into four subtasks:

- Subtask A: Knowledge Base (Austria)
- Subtask B: Multidisciplinary Planning Process (Sweden)
- Subtask C: Conservation compatible Retrofit Solutions and Strategies (Austria)
- Subtask D: Knowledge transfer and dissemination (United Kingdom)

Subtasks

Subtask A: Knowledge base

Objective: Collection of Best Practice cases, following the approach of IEA SHC Task 37 and 47. Assessment of existing experience and identify energy saving potential.

Subtask B: Multidisciplinary planning process

Objective: Identification of replicable procedures on how experts can work together to maintain both the expression of the building, and at the same time make it more energy efficient. Identification and further development of tools to support the process and its single steps.

Subtask C: Conservation compatible retrofit solutions and strategies

Objective: Identification of replicable solutions from case studies. Connection to and integration of ongoing R&D on conservation compatible retrofit solutions. Assessment of technical solutions from both energy and conservation point of view.

Subtask D: Knowledge transfer and dissemination

Objective: To transfer the knowledge created in the task to relevant stakeholders

Collaboration with Other IEA TCPs

The Energy in Buildings and Communities Programme (IEA EBC) is officially collaborating with SHC Task 59 as EBC Annex 76 on a ***moderate*** level as defined by the IEA SHC.

Industry and Stakeholders

Task meetings were combined with dedicated stakeholder events in order to connect and receive feedback on the status and perspectives of local market.

In connection with the Task's Kick-off Meeting, a seminar with British stakeholders involved in the energy retrofit of historic buildings was organized in Edinburgh. The seminar was received positively and included participants from The Royal Incorporation of Architects in Scotland, Scottish Ecological Design Association, Chartered Institution of Building Services Engineers, Royal Institution of Chartered Surveyors, the universities of Newcastle, Cardiff, Strathclyde and Loughborough, and British Building Standards as well as Scottish policy makers.

In connection with the Experts Meeting in Dublin in Spring 2018, two separate events were held to share the Task's goals and engage with academic and industry representatives. First, a joint meeting with members of the Irish NSCES+CC and visiting members of the ISCES+CC was held. The objective meeting was to inform members of the scientific committees' activities, to receive feedback on a recent study, and to report to the SHC study members on the work being carried out by the "Sustainable Energy Authority of Ireland (SEAI). Alexandra Troi gave a presentation on SHC Task 59 /EBC Annex 76, pointing out the possibility to contribute with Best Practice cases and be involved in the further developments via Peter Cox, president of the ICOMIS International Committee and Task member. A second event with 125 registered local stakeholders was planned, but due to severe weather and the Irish government shutting all government offices the event was cancelled.

The 3rd Experts Meeting took place in conjunction with the EEHB 2018, the 3rd international conference on energy efficiency in historic buildings, which is THE conference in the field and attracted around 150 participants from 25 countries. Participants came from academia and research (60%), public authorities and foundations (30%) as well as architects and enterprises (10%). Task experts contributed to a total of 19 presentations at this conference – not necessarily strictly resulting from the Task's workplan (as to be expected at this early stage), but all of them related to work with which the experts are contributing to the Task. In the closing plenary, Alexandra Troi presented Task 59 – the expected results and how to become involved.

Task Duration

The Task started in September 2017 and will end in February 2021.

Participating Countries

Italy, Austria, Sweden, United Kingdom, Belgium, Spain, Ireland, Denmark, United States of America, Turkey, France, Germany

Countries interested (pending confirmation): Switzerland, New Zealand, Norway and the Netherlands

Work During 2018

Subtask A: Knowledge Base

The work on the development of a "Knowledge base" started with the definition of "best practice" and the minimum criteria needed for the description of relevant examples. Coordinated by Walter Hüttler, leader of Subtask A, a template was distributed among partners to gather good examples of historic building retrofits. These examples helped illustrate the concept and facilitated the discussion around the basic criteria that should be considered for the knowledge base.

In parallel, Alexandra Troi and researchers at EURAC ran a workshop in collaboration with TeamBlau on the development of a framework for the future best practice database. The results of this workshop helped identify pitfalls of previous experiences and showed new pathways for the development of the tool towards more participative and self-sustained structures.

By the end of the Task's Kick-off Meeting, an interim list of potential examples of best practice to include in the future database was elaborated on. This list gathers around 30 examples from all the countries participating in the Task.

The work to establish a "Knowledge base" started at the kick-off meeting and continued with the development of an improved template. Joint work between e7 (Subtask A leader) and EURAC Research resulted in a template to gather all the relevant information of exemplary case studies. This template was developed based on previous experiences (e.g., hBATec) and to be compatible with other databases (e.g., Construction21). Prior to the second Experts Meeting, both partners compiled an example of best practices using the template. These "pilot" case studies were presented along with the template. The results of the discussion were translated into a refined template that will serve as the basis for the best practice database.

Participants in a June workshop in Vienna successfully developed a framework for the best practice cases – the frontend (promoting on the Task website) for presenting the best practice cases and the backend (collecting cases in the database). Through an iterative process, the experts agreed on which information should be presented in which way – to get the "fun to read" effect agreed upon early in the Task.

At the 3rd Experts Meeting the Mock-Up of the frontend was presented and the review process defined. In the following months both the frontend and backend were technically implemented. A time plan has been agreed upon, which will result in the promised 25 Best Practices to be added within the next reporting period.

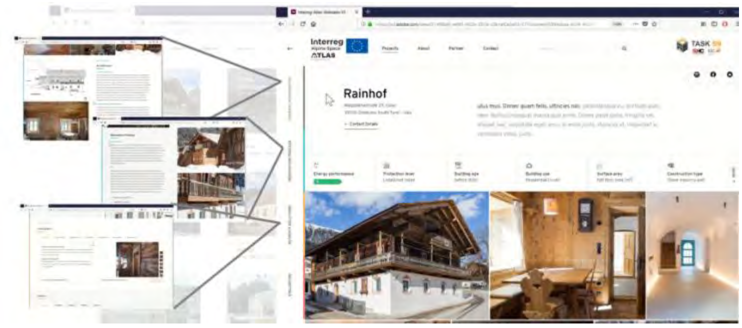

Figure 1. Mock Up of the scrollable website, with information on two levels of detail (+ buttons). The website will be programmed as "responsive" to whether it is called from a PC a tablet or a smart phone – adapting the presentation of fotos and text and keeping it visually appealing.

Subtask B: Multidisciplinary Planning Process

Subtask B has focused on evaluating the resources available and organizing the necessary steps for the completion of the first activity (B.1 Compilation and assessment of existing tools). Tor Broström, leader of this Subatsk, analyzed the results of a questionnaire distributed among partners and presented the results during the kick-off meeting.

After the structure of the work plan was detailed and agreed on with the partners, the next steps were defined. A new template to gather relevant information on existing tools and methodologies is being developed by Tor Broström and his colleagues at Uppsala University. The final template is expected to be completed in November and distributed to the partners to start receiving the data before the end of the year. In addition to that, the work plan related to simulation and characterization of historic building performance was further developed with contributions from the partners at the Politecnico di Milano (Italy). Based on the conclusions from the kick-off meeting, Nicoló Aste and his group have proposed a detailed program for the development of this activity.

Work in Subtask B has continued focus on the collection and analysis of tools to support the decision-making process. During the second expert meeting, it was agreed to extend the period for this activity in order to have a comprehensive compilation. In addition to that, it was agreed that the gathering of tools related to simulation would be coordinated by Fabrizio Leonforte as part of the new Activity B.5. This will allow the compilation of additional technical information to be used in the development of the activity. A smaller working group was formed of the partners with relevant expertise in the subject. This group is in the process of finalizing all the planned activities and timeline. On top of that, all Task 59 partners continue to look for suitable case studies for the implementation and assessment of the standard EN16883. Suitability of case studies is ultimately evaluated by team at Uppsala University (Subtask B leaders). In parallel, EURAC Research ran a workshop with local stakeholders from the construction sector specialized in heritage conservation and low-energy design. The goal of the workshop was to present the project's aim and to present the recently developed standard EN16883, as well as identifying suitable case studies for the assessment of that standard.

During the 3rd Experts Meeting, the group of experts agreed that relevant tools in national languages should be documented – the platform to be developed will take this into account. Also, Fabrizio Leonforte presented the refined workplan for the Activity B.5 which focusses on modelling and calibration and collected interested partners contributions.

To find suitable case studies for the implementation and assessment of the standard EN16883 has proven to be more difficult than expected. The experts agreed to contact consulting or larger entities who work on a portfolio of historic buildings. Moreover, the comparative analysis done by Alessia Buda in her ongoing PhD, applying both the standard and other guidelines to different case studies is already a valuable input.

Subtask C: Conservation Compatible Retrofit Solutions and Strategies

The first activity of Subtask C (C.1 Review of conservation compatible retrofit solutions) has progressed considerably thanks to the information gathered prior to the kick-off meeting and the subsequent discussions in Edinburgh.

A questionnaire developed by Rainer Pfluger, leader of Subtask C, was circulated among partners to gather relevant information on compatible solutions for the retrofit of historic buildings. Based on previous experiences of partners involved in the project, a first list of technologies and strategies was identified. This list includes at the moment eight examples of window improvement, 16 cases of internal wall insulation, 12 solutions of building services or HVAC, 12 examples of integration of solar systems, and 12 strategies implemented in retrofitted historic buildings.

Work on Subtask C has been developed along Subtask A. The format of the template was designed to serve two functions. On the one hand, it allowed gathering all the information for the best practice database, on the other hand, it allowed including specific information for the assessment of single retrofit measures. This template was circulated to all partners to continue with the compilation of conservation compatible retrofit solutions. Focusing specifically on internal wall insulation, Rainer Pfluger presented his proposal for the assessment insulation materials during the second expert meeting. This approach will consist on the development of a novel laboratory test to quantify the drying potential of materials and with that ensure the durability of retrofitted walls. The next steps of the subtask will focus on the development of analogous assessment procedures for the other retrofit solutions studied (windows, ventilation and solar integration).Although the report has been reviewed, it is undergoing a continuous update in order to add results from more simulation tools (e.g., Modelica), to improve the coherence of the different tools and to provide better explanations of the procedures.

At the 3rd Experts Meeting in Visby, Rainer Pfluger presented a decision support tool – for step-wise refurbishment, developed in the Interreg Project Alpines Bauen – and how it could be adapted to make the technical solutions resulting from Subtask C available to a broad audience. The next step in Subtask C was to hold a workshop in December to establish working groups that would further develop the different topics of Subtask C: windows, internal wall insulation, building services and HVAC, roof integrated solar systems, and retrofit strategies.

Subtask D: Knowledge Transfer and Dissemination

Carsten Hermann, leader of the Subtask, is coordinating the organization of working groups for the development of the different Subtask D activities. The Task webpage is up and running and a Task logo was created.

Following the suggestions of the Subtask leader, Task 59 partners agreed on the definition of a short title for the project. This title, "Renovating historic buildings towards zero energy", is exclusively intended for communication purposes only and the full Task title will remain as the formal title to be used in the official and scientific activities.

The Task logo was developed by EURAC Research while Historic Environment Scotland coordinated the development of a project information leaflet. Also, a survey was conducted among all partners to decide upon a number of open questions: the abbreviation of the projects name for social media pages (Twitter, Facebook, etc.), identification of small working groups around the dissemination activities, and identification of topics for potential communication papers. Besides the presentation of the project's goals in the upcoming EEHB conference and public events, Task 59 has been invited to submit a paper to a special issue of the *International Journal of Building Pathology and Adaptation*. EURAC Research will coordinate this activity with the collaboration of all the Subtask leaders.

EURAC successfully applied for the "Year of Cultural Heritage Label" for the Task, which is included in the Task's flyer and webpage. The Task is being promoted on the Year of Cultural Heritage website and their other forms of communication.

Other ongoing activities include:

- Two articles produced by solarthermalworld.org ("New standard to improve energy performance of historic buildings" and "Producing hot water underneath natural slates")
- A sign-up card with QR code to subscribe to the Task newsletter
- A poster and a banner (all based on the information and layout of the flyer)
- Social media: @HistoricNZEB – including Facebook, LinkedIn and twitter (www.facebook.com/HistoricNZEB, www.linkedin.com/company/HistoricNZEB and www.twitter.com/HistoricNZEB)
- Task blog with the first five contributions posted
- Touring Exhibition: without additional funding (the proposal has not yet been funded) it will not be possible to implement this idea as planned. Plan B would be to create posters to share among participants.

Dissemination Activities In 2018

Reports & Published Books

None.

Journal Articles, Conference Papers, Press Releases, etc.

Author(s)/Editor	Title	Publication / Conference	Bibliographic Reference
EURAC	Project launch	Press release	
Bärbel Epp	New standard to improve energy performance of historic buildings	Solarthermalwold.org 5 September 2018	www.solarthermalworld.org/content/new-standard-improve-energy-performance-historic-buildings
Bärbel Epp	Producing hot water underneath natural slates	Solarthermalwold.org 6 September 2018	www.solarthermalworld.org/content/producing-hot-water-underneath-natural-slates
Bärbel Epp	IEA SHC supports historic buildings expert network	Solarthermalwold.org 20 December 2018	www.solarthermalworld.org/content/iea-shc-supports-historic-buildings-expert-network

Conferences, Workshops, Seminars

Conference/ Workshop/ Seminar	Activity & Presenter	Date & Location
Task Workshop	Title: “Il risanamento di edifici storici verso nZEB. Il progetto IEA-SHC Task 59 e la nuova norma EN-16883:2017” Project presentation to local practitioners. Presentations from A. Troi and E. Lucchi	22 February 2018 Bolzano, Italy
STBA-SPAB 2018 conference	P. Cox (ICOMOS IE) presenting the standard EN 16883 and Task 59	7 June 2018 London, UK
EBC Annual Conference: Energy efficiency in historical buildings: Which role for SMEs and craftsmen?	Presentation: Best practices for energy efficient historical buildings in Europe (M. De Bouw, BBRI, E. Lucchi, EURAC)	29 June 2018 Paris, France
Eurosun 2018	Keynote: *Solar Renovation of Historic Buildings: Towards a Zero Energy Built Heritage* (D. Herrera, EURAC)	12 September 2018 Rapperswil, Switzerland

EEHB 2018	Keynote: IEA SHC Task 59/EBC Annex 76 (A.Troi, EURAC) Other 18 presentations from Task experts on work related to their contributions in the Task.	27 September 2018 Visby, Sweden
"European Wise Event" organised by Interreg project VIOLET	Presentations: *"Rehabilitación integral en los edificios históricos. Acortando distancias entre la investigación y la práctica"* (Task 59 Best Practice database) (D. Herrera, EURAC) *"Toma de decisiones para la mejora energética de los entornos históricos"* (A. Egusquiza, Tecnalia)	24 October 2018 Sevilla, Spain
International Urban Energy Systems Conference	Presentaion: Integration of Solar Energy Applications on Historic Buildings (D. Herrera, EURAC)	9 November 2018 Delft, The Netherlands

Task Meetings 2018

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting 2	1-2 March 2018	Dublin, Ireland	24 (10)
Workshop 2	28 April 2018	Dublin, Ireland	15
Workshop 3	12 June 2018	Vienna, Austria	9
Experts Meeting 3	27-28 September 2018	Visby, Sweden	28 (+1 remotely)
Workshop 4	25 September 2018	Visby, Sweden	

SHC Task 59 Participants

Country	Name	Institution	Role
ITALY	**Alexandra Troi**	**EURAC**	**Operating Agent**
AUSTRIA	Walter Hüttler	E-7	Subtask A Leader
AUSTRIA	Rainer Pfluger	UIBK	Subtask C Leader
BELGIUM	Michael de Bouw	BBRI	National Expert
BELGIUM	Samuel Dubois	BBRI	National Expert
BELGIUM	Yves Vanhellemont	BBRI	National Expert
BELGIUM	Sophie Trachte	UCL	National Expert
BELGIUM	Dorothée Stiernon	UCL	National Expert
BELGIUM	Nathalie Vernimme	FHA	National Expert
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DENMARK	Ernst Jan de Place	SBI	National Expert
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FRANCE	Julien Burgholzer	CEREMA	National Expert
FRANCE	Elodie Héberié	CEREMA	National Expert
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GERMANY	Sebastian Herkel	Fraunhofer	National Expert
GERMANY	Johannes Eisenlohr	Fraunhofer	National Expert
IRELAND	Peter Cox	ICOMOS	National Expert
IRELAND	Leila Budd	ICOMOS	National Expert
ITALY	Elena Lucchi	EURAC	National Expert
ITALY	Lingjun Hao	EURAC	National Expert
ITALY	Daniel Herrera	EURAC	National Expert
ITALY	Franziska Haas	EURAC	National Expert
ITALY	Dagmar Exner	EURAC	National Expert
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ITALY	Claudi Delpero	POLIMI	National Expert
ITALY	Fabrizio Leonforte	POLIMI	National Expert
ITALY	Enrico Deangelis	POLIMI	National Expert
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ITALY	Alessia Buda	POLIMI	National Expert
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ITALY	Marta Calzolari	UNIFE	National Expert
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ITALY	Luigi Marletta	UNICT	National Expert
ITALY	Giuseppe Margani	UNICT	National Expert
ITALY	Giampiero Evola	UNICT	National Expert
ITALY	Alessandro Lo Faro	UNICT	National Expert
ITALY	Francesco Nocera	UNICT	National Expert
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SPAIN	Jesus Samaniego	CARTIF	National Expert
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SPAIN	Sonia Alvarez	CARTIF	National Expert
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SPAIN	Aitziber Egusquiza	TECNALIA	National Expert
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UNITED KINGDOM	Carsten Hermann	HES	Subtask D Leader

UNITED KINGDOM	Roger Curtis	HES	National Expert
UNITED KINGDOM	Valentina Marincioni	UCL	National Expert
United Kingdom	Virginia Gori	UCL	National Expert
United Kingdom	Hector Altamirano	UCL	National Expert
United States	Amanda Webb	CINCINNATI	National Expert
United States	Daniel Chung	DREXEL	National Expert

Task 60 – PVT Systems

Jean-Christophe Hadorn
Solar Energies and Strategies
Operating Agent for the Swiss Federal Office of Energy

Task Overview

Task 60 focuses on the application of PVT collectors. The aim is to assess existing solutions and to develop new system solutions principles in which the PVT technology really offers advantages over classical "side by side installations" of solar thermal collectors and PV modules.

Energy yield, exergetic efficiency, KPIs, simulation tools, sensitivity analysis, benefits, competitive cost, safety and reliability of systems are in the scope of the Task.

Increasing awareness of the PVT solutions to all stakeholders is a key objective.

The Task's work is divided into four subtasks:

- Subtask A: Systems in Operation (Austria)
- Subtask B: PVT Performance Characterization (Germany)
- PVT Systems Modelling (Spain)
- PVT Systems Design Examples and Dissemination and Market Support (Switzerland)

Scope

The scope is on applications with PVT collecting devices in systems of any size and any type of consumers.

The objectives of the Task are to:

1. Provide a state-of-the-art of the PVT technology worldwide.
2. Gather operating experience with existing PVT systems.
3. Improve the testing, modelling and adequate technical characterization of PVT collectors.
4. Find typical PVT solutions
5. Explore potential cost reductions in the balance of PVT systems.

Subtask A: PVT Systems in Operation
The objective is to gather data and report information on heating and cooling systems with PVT collectors in operation.

Subtask B: PVT Performance Characterization
The objective is to provide testing methods for PVT collectors of all types that can become an international standard.

Subtask C: PVT Systems Modelling
The objective is to provide models of systems with PVT collectors.

Subtask D: PVT Systems Design Examples and Dissemination and Market Support
The objective is to evaluate the overall performance of PVT systems and designs and to disseminate the Task produced information and knowledge to all identified stakeholders.

Collaboration with Other IEA TCPs

Contacts with the PVPS, HPT, ECES Technology Collaboration Programmes (TCPs) have been initiated to reinforce possible collaboration. PVT systems should appear in the news of these three TCPs during 2019.

The US participant might come in Task 60 through PVPS since USA is not a member of SHC.

Collaboration with Industry

Task 60 has several companies involved in the collaborative work and interest from industry is high.

Collaborating companies: DualSun from France, PA-ID from Germany, Solarus from the Netherlands, Abora from Spain, Endef also from Spain, 3F solar from Austria, Trigo energies from Canada, Solink from Italy, Consolar from Germany, SunOyster also from Germany, Solar Speedflex from UK, Systovi and GSE from France, and Sunovate from Australia.

As far as Switzerland is concerned, contacts have been established with Energie Solaire SA and 3S, but participation is not yet settled mainly due to funding issues. DualSun has a Swiss subsidiary that is also participating.

Task Duration

This Task started in January 2018 and will be completed in December 2020.

Participating Countries

Australia, Austria, Canada, Denmark, France, Germany, Italy, Mexico, Netherlands, South Africa, Spain, Sweden, Switzerland, UK

Work During 2018

Two meetings were held in 2018 with more than 45 participants in each.

Subtask A: PVT Systems in Operation

1. List of PVT projects was set up and currently included 11 projects. Subtask A has set a format of a Task 60 “infosheet”, a total of 31 projects could be included in 2019.
2. The square view system developed in Task 44 to describe a concept was selected as the tool of Task 60 and was enhanced to accommodate for PV elements.
3. Classifications of PVT systems were completed and will be issued with the report 1.
4. A manufacturer questionnaire was developed and distributed to more than 60 companies. The results will be finalized in 2019.

Subtask B: PVT Performance Characterization

1. Current equations for collectors yield used by each research group and industry participant have been included in the draft of report 1.
2. Gaps or simplification are still being identified between model and reality (e.g., condensation, snow, rain, temperature effect on PV module).
3. Standard test procedures have been described and gaps with market needs will be identified in 2019.
4. Labels for PVT were discussed and gaps identified. The Solar Keymark committee will be approached during 2019.

Subtask C: PVT Systems Modelling

1. Modeling needs for system simulation of all types of collectors have been discussed.
2. A list of current modeling tools was compiled by Task participants.
3. Reference system discussion was initiated: Are one or many references needed? An air heat pump system might be the most interesting “competitor.”
4. Criteria to evaluate systems against a reference system to deliver the same service were discussed and transmitted to Subtask D.

Subtask D: PVT Systems Design Examples and Dissemination and Market Support

1. A LinkedIn account on PVT systems will be run by Task 60.
2. The existing Wikipedia page on PVT systems will be enhanced.
3. A logo was created and has been in use since EuroSun 2018.

4. A Task leaflet was prepared and distributed at EuroSun 2018.
5. Two PVT sessions were held at EuroSun 2018 and chaired by Task 60 leaders.
6. A Solar Keymark discussion and/or labeling discussion about PVT requirements with industry will be organized in March 2019 and during the Task's Industry Workshop during Experts Meeting #3 in Eindhoven, The Nethelands.678
7. KPIs were set up with contributions from several participants.

Work Planned For 2019

Subtask A: PVT Systems in Operation

1. Produce and disseminate the infosheet.
2. Produce and disseminate the manufacturers survey.
3. Produce report 1.

Subtask B: PVT Performance Characterization

1. Produce and disseminate a standard Task 60 equation for PVT collectors.
2. Describe Standard test procedures needed.
3. Discuss a PVT label with the Solar Keymark committee.

Subtask C: PVT Systems Modelling

1. Produce and disseminate a modelling framework solution for PVT systems.
2. Produce and disseminate a reference system definition.
3. Produce and disseminate a set of criteria that models can handle to evaluate systems.

PVT Systems Design Examples and Dissemination and Market Support

1. Create a LinkedIn site on PVT systems.
2. Enhance the Wikipedia page on PVT systems
3. Distribute our Task leaflet at all occasions.
4. Share news with the PVPS, HPT, ECES TCPs.
5. Chair PVT sessions at the SHC 2019 conference in Chile.
6. Set KPIs both quantitative and qualitative to evaluate systems.

Dissemination Activities In 2018

Reports, Published Books

Author(s)/ Editor	Title	Report No. Publication Date
	Draft Report 1: Activity B1: Methods for Testing PVT Collectors (water, air, concentrator, etc.) Current and Gaps	RB1 October 2018

Conferences, Workshops, Seminars

Workshop/Conference/Seminar	Activity & Presenters	Date & Location
PVT Industry Workshop	Korbinian Kramer, JC Hadorn	16 May 2018 Freiburg, Germany
EuroSun 2018	14 papers + 14 posters + 2 sessions as chairman (all papers posted in Task 60 member area)	September 2018 Rapperswil, Switzerland
Webinar: Solar Heating and Cooling Market and Industry Trends 2017 www.youtube.com/watch?v=n1JA-xccIN8&t=3049s	SHC Solar Academy	June 2018

Dissemination Activities Planned For 2019

Publish the following reports:

- Report 1 for Activity A1: Collection of Datasheet on Existing PVT Systems and Solutions (April 2019)
- Report 1 for activities C1+C2: Numerical Simulation Tools for the Simulation of PVT Collectors and Systems (October 2019)

Task Meetings 2018 and 2019

Meeting	Date	Location
Experts Meeting 1	17-18 May 2018	Freiburg, Germany
Experts Meeting 2	18-19 October 2018	Zaragoza, Spain
Experts Meeting 3	8-10 May 2019	Eindhoven, Netherlands

SHC Task 60 Participants

Country	Name	Institution / Company	Role
SWITZERLAND	**Jean-Christophe Hadorn**	**Solar Energies & Strategies**	**Operating Agent**
AUSTRIA	Thomas Aigenbauer	FH Weiss	National Expert
AUSTRIA	Alexander Friedrich	3F Solar Technologies Gmbh	National Expert
AUSTRIA	Thomas Ramschak	AEE - Institute For Sustainable Technologies	National Expert
CANADA	Christian Vachon	Trigo Energies Inc.	National Expert
CANADA	Christian Vachon	Trigo Energies Inc.	National Expert
COUNTRY	Name	Organization	National Expert
DENMARK	Mark Dannemand	DTU BYG	National Expert
DENMARK	Adam Jensen	DTU BYG	National Expert
FRANCE	Jean-Baptiste Beyssac	CESP Univ. Perpignan	National Expert
FRANCE	Gabriel Blaise	Dualsun	National Expert
FRANCE	Laetitia Brottier	Dualsun	National Expert
GERMANY	Joseph Bergner	HTW Berlin	National Expert
GERMANY	Sonja Helbig	Institutue Solarenergieforschung Gmbh	National Expert
GERMANY	Danny Jonas	Univ. Saarbrücken	National Expert
GERMANY	Andreas Jurack	HTW Berlin	National Expert
GERMANY	Johannes Kneer	Sunoyster	National Expert
GERMANY	Korbinian Kramer	Fraunhofer-Institut Für Solare Energiesysteme ISE	National Expert
GERMANY	Manuel Lämmle	Fraunhofer ISE	National Expert
GERMANY	Thomas Noll	Easy-Int	National Expert
GERMANY	Markus Proll	ZAE Bayern E.V.	Subtask D Leader
GERMANY	Danjana Theis	HTW Saar	National Expert
ITALY	Antonio Gagliano	Univ. Catania	National Expert
ITALY	Marco Pellegrini	Univ. Bologna	National Expert
ITALY	Giuseppe Tina	Univ. Catania	National Expert

NETHERLANDS	Corry De Keizer	SEAC-TNO	National Expert
NETHERLANDS	Oscar Mogro	BDR Thermea BV	National Expert
NETHERLANDS	Len Rijvers	Eindhoven Univ. Of Tech.	National Expert
NETHERLANDS	Manuel Vargas Evans	Solarus Sunpower	National Expert
SPAIN	Marta Cañada	ABORA	Subtask B Leader
SPAIN	Marta Cañada	ABORA	National Expert
SPAIN	Daniel Chemisana	UDL Cat	National Expert
SPAIN	Alejandro Del Amo Sancho	Abora	National Expert
SPAIN	Norberto Fueyo	University of Zaragoza	National Expert
SPAIN	Isabel Guedea	Endef Engineering	National Expert
SPAIN	Maria Herrando	University of Zaragoza	National Expert
SPAIN	Asier Sanz Martinez	TECNALIA	Subtask A Leader
SPAIN	Raquel Simon	Endef Engineering	National Expert
SWEDEN	Diogo Oliveira Cabral	Univ. Gävle	National Expert
SWEDEN	João Gomes	Solarus Sunpower	Subtask C Leader
SWITZERLAND	Andreas Häberle	University Of Applied Sciences HSR	National Expert
SWITZERLAND			National Expert
SWITZERLAND	Jürg Rohrer	ZHAW	National Expert
SWITZERLAND	Maike Schubert	ZHAW	National Expert
SWITZERLAND	Andreas Witzig	ZHAW	National Expert
SWITZERLAND	Daniel Zehnhäusern	SPF	National Expert
UNITED KINGDOM	James Bererton	Consultant	National Expert
UNITED KINGDOM	Eric Hawkins	Solar Speedflex Co Ltd	National Expert
UNITED KINGDOM	Adrian Murrell	Naked Energy	National Expert

Task 61 – Integrated Solutions for Daylighting and Electric Lighting: From Component to User Centered System Efficiency

Jan de Boer
Fraunhofer Institute for Building Physics
Operating Agent for the German Government (PtJ for BMWi)

Task Overview

The overall objective of this joint activity with the IEA EBC TCP is to foster the integration of daylight and electric lighting solutions to the benefits of higher user satisfaction and at the same time energy savings. This can be subdivided into the following specific objectives.

- Review relation between user perspective (needs/acceptance) and energy in the emerging age of “smart and connected lighting” for a relevant repertory of buildings.
- Consolidate findings in use cases and “personas” reflecting the behavior of typical users.
- Based on a review of specifications concerning lighting quality, non-visual effects as well as ease of design, installation and use, provision of recommendations for energy regulations and building performance certificates.
- Assess and increase robustness of integrated daylight and electric lighting approaches technically, ecologically and economically.
- Demonstrate and verify or reject concepts in lab studies and real use cases based on performance validation protocols.
- Develop integral photometric, user comfort and energy rating models (spectral, hourly) as pre-normative work linked to relevant bodies: CIE, CEN, ISO. Initialize standardization.
- Provide decision and design guidelines incorporating virtual reality sessions. Integrate approaches into widespread lighting design software.
- Combine competencies: Bring companies from electric lighting and façade together in workshops and specific projects. Thereby support allocation of added value of integrated solutions in the market.

The Task’s work is divided into four subtasks and a working group:

- Subtask A: User Perspective and Requirements (Norway)
- Subtask B: Integration and Optimization of Daylight and Electric Lighting (Denmark)
- Subtask C: Design Support for Practioners (Austria)
- Subtask D: Lab and Field Study Performance Tracking (Denmark)
- Joint Working Group: Evaluation Method for Integrated Lighting Solutions & Virtual Reality (VR) Based Decision Guide

Scope

The scope of the Task is on general lighting systems for indoor environments. The focus is laid on lighting appliances in non-domestic buildings. Technically the Task deals with integrating:

- daylight utilization by enhanced facade technologies and other architectural solutions,
- electric lighting schemes addressing technology and design strategies, and
- lighting control systems and strategies with special emphasis on visual and non-visual user needs with special emphasis on the interface of day- and electric lighting.

The Task targets building designers and consultants, industry (façade, electric lighting, software companies), owners (investors) and authorities by providing strategic, technical and economic information and with network activities helping these stakeholders overcome barriers in integrating lighting installations and implementing holistic lighting solutions.

Collaboration with Other IEA TCPs

The Task is collaborating at the maximum collaboration level with the IEA EBC TCP, which is referred to by the

EBC TCP as EBC Annex 77.

Task Duration

This Task started on 1 January 2018 and will end on 31 June 2021.

Participating Countries

Australia, Austria, Belgium, Brazil, China, Denmark, Germany, France, Japan, Netherlands, Norway, Poland, Singapore, Slovakia, Sweden, Switzerland, United Kingdom, United States

Work During 2018

Subtask A: User Perspective and Requirements

Before the user requirements can be precisely defined, a thorough literature review of user needs regarding daylight and electric light was initiated in project A.1 "User Requirements." The literature review is divided into the four following topics: a) Visual perception, b) Visual comfort, c) Psychological aspects d) Non-visual aspects of lighting (see Figure 1). Over 100 articles were reviewed so far; their content and relevance were analyzed and presented.

Use cases ("profiles") – i.e. typical daily occupancy schedules with specific multi-criteria lighting needs as a function of activities in the space – will be developed for main building types like a) education buildings, b) offices, c) healthcare premises, d) industrial buildings in project A.2 "Use Cases". The task in this project will be to combine (ref. Figure 1) the new lighting requirements (A.1) with newly developed occupancy calculations (like the OccupancySimulator.lbl.gov program developed in the frame of EBC Annex 66 which enables precise and representative simulation of occupancy in office buildings as well as in other building types) to create a reference model for different building types. The reference model, together with the climate/daylight data and the lighting control specifications will then be used for calculation of the energy consumption of lighting. This will enable more precise calculations of the energy consumption for lighting.

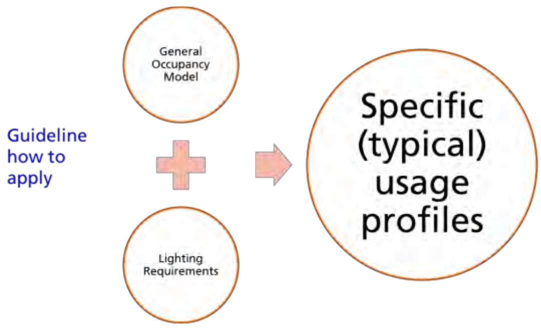


Figure 1. Process of defining usage profiles in project A2.

Subtask B: Integration and Optimization of Daylight and Electric Lighting

In project B.1 "Interview of professionals: opportunities and barriers" a questionnaire was prepared to identify opportunities and barriers in the market covering the following aspects:

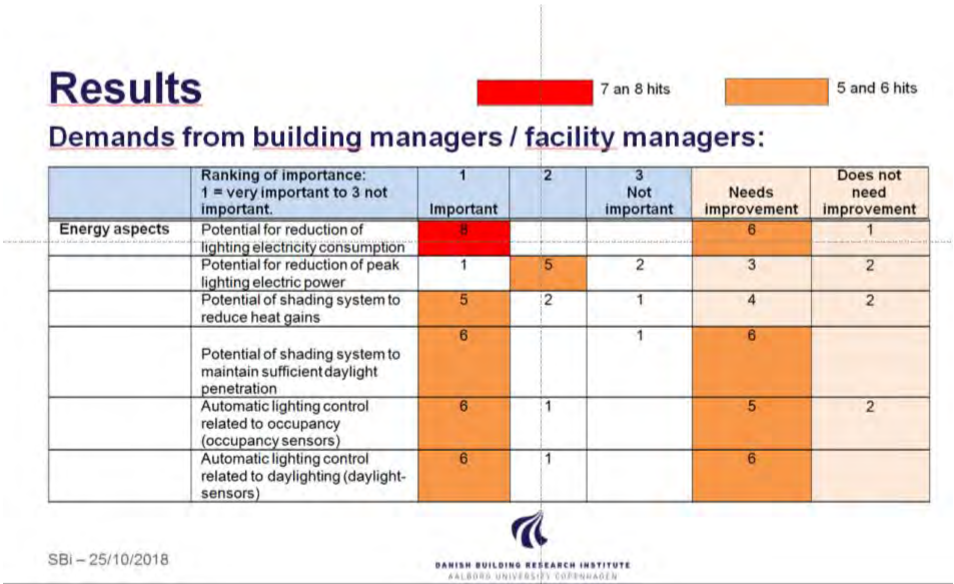
- Demands from building managers/facility managers
- Aspects related to occupants/demand from occupants
- Aspects related to building owners/lease holders
- New technology opportunities available

The questionnaire was handed out in a first test run to 10 practitioners in Denmark. A first evaluation was performed (see Figure 2). The questionnaire will now be distributed in other participating countries in order to get a broader and regionally more distinguished market feedback.

In project B.3 "Critical review of new approaches under development" information on systems, views and opinions on possible trends are being collected. Suggestions for the testing campaign in ST D were communicated to and discussed with ST D:

- Priority 1: Simple interface solutions for occupants and facility managers, intuitive controls, acceptability of control system
- Priority 2: Easy commissioning (change of equipment, functionality, future proof)
- Priority 3: select open source solutions
- Priority 4: Identify cost models and benefits for the market

In project B.6 "Link with standardization activities" the collection of relevant documents from relevant bodies, such as CIE, ISO, CEN, CN Standards, BREAM, LEED, DGNB is ongoing.



	Ranking of importance: 1 = very important to 3 not important.	1 Important	2	3 Not important	Needs improvement	Does not need improvement
Energy aspects	Potential for reduction of lighting electricity consumption	8			6	1
	Potential for reduction of peak lighting electric power	1	5	2	3	2
	Potential of shading system to reduce heat gains	5	2	1	4	2
	Potential of shading system to maintain sufficient daylight penetration	6		1	6	
	Automatic lighting control related to occupancy (occupancy sensors)	6	1		5	2
	Automatic lighting control related to daylighting (daylight-sensors)	6	1		6	

Figure 2. Excerpt from the first questionnaire handed out to different stakeholders. Here evaluation of the responses from building managers/facility managers on energy aspects.

Subtask C: Design Support for Practitioners (Tools, Standards, Guidelines)

In project C1 "Review of state of the art design workflows" in addition to the Bartenbach R&D building also the DIAL headquarters is included in the report as an example design project (see Figure 3). A first draft of this report should be available in the fall of 2019.

In project C2 "Standardization of BSDF daylight system characterization" the first task is to document the currently used procedures to generate (measure and/or simulate) BSDF data for daylight systems. A draft report was developed and sent out to the experts. For the scope of this SHC Task, it is important to select the best available procedures to be able to provide guidance for the main 80% of daylight systems and applications on the market. Additionally, it should be noted, where these procedures fail and what to do in these cases. Further research on highly detailed procedures, which are, however, likewise important, should be clearly separated from this work. At the Radiance workshop the beginning of September 2018, two presentations were given by the Task experts on this topic.

Figure 3. The DIAL headquarters office building as an example design project for an integrated lighting solution.

In project C3 “Spectral sky models for advanced daylight simulations” it is aimed at supplementing the current sky models describing the spatial luminance distribution with spatial color temperature information. Jan Remund from Meteotest, Switzerland, Operating Agent of IEA PVPS Task 16: Solar Resource for High Penetration and Large Scale Applications, joined the Subtask to work with other experts on the topic of spectral and angular sky distributions. The Task 61 experts and Jan Remund both agree that further information exchange with the experts from PVPS is desirable to benefit from each other’s research.

In project C4 “Hourly rating method for integrated solutions” the status of a first relevant generic model was presented. Other work in this field was discussed by the experts (LBNL: Modellica based, Bartenbach: DALEC model, work at the University of Singapore). If possible, this will be integrated in the further development of the generic model.

Subtask D: Lab and Field Study Performance Tracking

In project D1 “Literature review” keywords for search and a template for the literature review were defined. The risks of overlaps with other reviews (in ST A and B) was addressed and shall be avoided by tight collaboration and coordination.

In project D.2 “Monitoring protocol” the planned monitoring protocol was discussed in detail with the focus on the four main items: energy, photometry, circadian, and user aspects. In a joint meeting, ST B identified criteria that may possibly be addressed in the case study assessments: Ease of installation; calibration of sensors; zoning (functionalities, daylight penetration, etc.); individual locations; interface (design/user-friendliness/tablets/etc.); and closed-loop local controls.

In project D3 “Case Studies” the collection of possible case studies and living labs was consolidated and 21 case studies have been selected by the experts.

Joint Working Group: Evaluation Tool & VR Decision Guide

The integrative concept of the Joint Working Group with its two development activities “Hourly Evaluation tool” and “VR Decision Guide” (conceptual sketch in Figure 5) was presented to the new members of the group by Marc Fontoynont and Jan de Boer. It was stressed that both activities rely to a high degree on contributions from the separate Subtasks and have to be integrated following concise formats to be jointly defined.

Since the last meeting, the work on the generic model for the hourly rating method has been started. A general closed or open-loop control model has been developed (see Figure 4) bringing together user requirements, electric lighting and daylighting aspects. Thus, addressing the development of sub models for instance in the field of user modeling, combining new occupancy models (as from IEA EBC Annex 66) with lighting requirements and in the field of façade models. The early method has been tested and demonstrated in an example of a group office.

Meanwhile, it was decided in the standardization bodies ISO TC 163, “Thermal performance and energy use in the built environment”, currently home of the relevant daylight and energy standard “ISO 10916, Calculation of the impact of daylight utilization on the net and final energy demand for lighting,” and ISO TC 274 “Light and Lighting”, currently home of the relevant standard “ISO/CIE 20086, Light and lighting – Energy performance of lighting in buildings” to migrate responsibility of ISO 10916 to ISO TC 274. Now both energy relevant lighting standards are in one ISO TC. The process of revising ISO 10916 with scope of changing/extending the annual into an hourly approach to rate lighting energy demands will probably be started by the end of 2019.

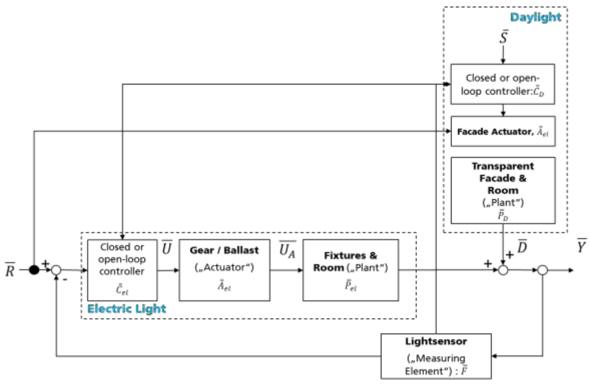


Figure 4. General closed or open-loop control model.

For the “Virtual Decision Guide” the group was asked to get involved with first ideas of relevant cases studies, that is scenes (even stories) to later be implemented into the VR environment.

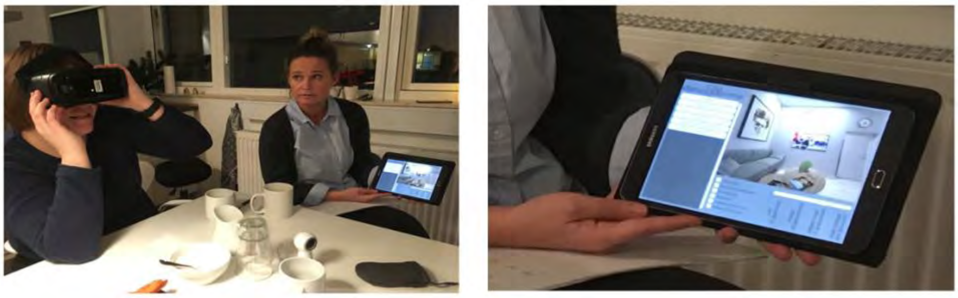


Figure 5. VR Decision Guide: linking interfaces and images.

Highlights of Industry Involvement and Market Activities

Industry Workshops

Two industry workshops (in Lund and Lausanne) were organized and hosted with 20 presentations in total on different daylighting and electric lighting topics. With the industry workshops, the objective is to mirror the work of the Task with respect to the needs of the industry.

Brochure and Task Website and Internal Communication

A Task brochure was printed and sent to the experts for local distribution (see Figure 6). The SHC Task 61/EBC Annex 77 websites as well as a live link platform for internal communication is being maintained. In addition, a standard set of PowerPoint slides, to be used by experts in public presentations has been compiled.

Figure 6. Task 61 /EBC-Annex 77 brochure.

Work Planned For 2019

Subtask A: User perspective and requirements

- Internal, Draft, Document on User Requirement for User Centred Integrated Lighting Solutions
- Internal, Draft, Document on Use Cases for Specified Applications

Subtask B: Integration and optimization of daylight and electric lighting

- Review of New Integrated Approaches

Subtask C: Design support for practitioners (Tools, Standards, Guidelines)

- Guidelines for Use of Simulations in the Design Process

- Identification of Appropriate Standardization Body
- System Architecture of Rating Model

Subtask D: Lab and field study performance tracking

- Initial Draft Document for Internal Use on Experience with State-of-the-art, Integrated Daylighting and Electric Lighting Systems, Their Energy Performance and the Operation of Their Control Systems
- Internal Draft Document for Use in Case Studies Conducted by the Task

Joint working group: Evaluation tool & VR Decision Guide

- Software Architecture
- Data Model Including Input from the Different Subtasks

Dissemination Activities In 2018

Reports, Published Books

Author(s)/ Editor	Title	Report No. Publication Date	Target Audience
IEA Task 61 / EBC Annex 77	IEA SHC Task 61 / EBC Annex 77 Information Brochure	June 2018	Industry

Journal Articles, Conference Papers, etc.

Author(s)/Editor	Title	Publication/Conference	Bibliographic Reference
E.S. Lee, D. Geisler-Moroder, G. Ward.	Modeling the direct sun component in buildings using matrix algebraic approaches: Methods and validation	Solar Energy 160 (2018) 380–395 January 2018	https://doi.org/10.1016/j.solener.2017.12.029

Conferences/Workshops/Seminars

Conference / Workshop / Seminar Name	Activity & Presenter (keynote, presentation, poster, etc.)	Date & Location	# of Attendees
IEA SHC 61/ EBC 77 1st Industry Workshop	10 presentations from the industry and Task experts	18 March 2018; Lund, Sweden	41
Smart Energy Systems Week Austria 2018	Presentation: Innovative Lösungen für Tages- und Kunstlicht, David Geisler-Moroder	14-18 May 2018; Vienna, Austria	

17th International Radiance Workshop 2018	Presentation: Generating High-Resolution BSDFs for the Direct Beam Component, Eleanor Lee	3-5 September 2018; Loughborough, UK	
17th International Radiance Workshop 2018	Presentation: Towards a standardization of BSDF daylight system characterization, David Geisler-Moroder	3-5 September 2018; Loughborough, UK	
17th International Radiance Workshop 2018	Presentation: Measuring and Modelling Spectral Composition of Equatorial Light, Priji Balakrishnan and J. Alstan Jakubiec	3-5 September 2018; Loughborough, UK	
17th International Radiance Workshop 2018	Presentation: Making Simulations More Colorful: Extension of gendaylit to Create a Colored Sky, Jan Wienold and Aicha Diakite	3-5 September 2018; Loughborough, UK	
Advanced Building Skins 2018	Presentation: Characterization of advanced daylighting systems and combined lighting and thermal simulation, David Geisler-Moroder	1-2 October 2018, Bern, Switzerland	
Advanced Building Skin 2018	Session: Façade Integrated Day- and LED-Lighting Based on Micro-Optical Components with 5 presentations, Session chair Jan de Boer	1-2 Oct 2018, Bern, Switzerland	30
Advanced Building Skin 2018	Presentation: Lab measurements and field testing of integrated systems, Jan de Boer	1-2 Oct 2018, Bern, Switzerland	30
IEA SHC 61/ EBC 77 2nd Industry Workshop	10 presentations from the industry and task experts	5 September 2018; Lausanne, Switzerland	35

Dissemination Activities Planned For 2019

Two industry workshops in Beijing and Gdansk and a IEA SHC Position Paper on Daylighting.

Task Meetings 2018 and 2019

Meeting	Date	Location
Task Meeting 1	28 February - 2 March 2018	Lund, Sweden
Industry Workshop 1	28 February 2018	Lund, Sweden
Task Meeting 2	5 - 7 September 2018	Lausanne, Switzerland
Industry Workshop 2	5 September 2018	Lausanne, Switzerland
Task Meeting 3	27 - 29 March 2019	Beijing, China
Industry Workshop 3	27 - 29 March 2019	Beijing, China

SHC Task 61 Participants

Country	Name	Institution / Company	Role
GERMANY	**Jan de Boer**	**Fraunhofer IBP**	**Operating Agent**
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BELGIUM	Ruben Delvaeye	Belgian Building Research Institute (BBRI)	National Expert
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NETHERLANDS	Peter Fuhrmann	Lighting Control Systems Group, Philips Research	National Expert
NETHERLANDS	Rajendra Dangol	Eindhoven University of Technology	National Expert
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NORWAY	Biljana Obradovic	Norconsult AS	National Expert
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POLAND	Natalia Sokol	Gdansk University of Technology	National Expert
SINGAPORE	John Alstan Jakubiec	Singapore University of Technology and Design	National Expert
SLOVAKIA	Stanislav Darula	Institute of Construction and Architecture, Slovak Academy of Sciences	National Expert
SWEDEN	Harris Poirazis	Inform Design AB	National Expert

SWEDEN	Marios Larios	Inform Design AB	National Expert
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Task 62 – Solar Energy in Industrial Water and Wastewater Management

OA Christoph Brunner
AEE – Institute for Sustainable Technologies
Operating Agent for The Republic of Austria

Task Overview

The change to a sustainable, resource- and energy-efficient industry represents a major challenge in the coming years. The efficient supply of energy, the best possible integration of renewable energy sources and the recovery of resources in the sense of circular economy must go hand in hand. The use of solar process heat represents a large, but so far largely unused, potential in industry. Innovative and concrete solutions are needed for the long-term and successful introduction of solar thermal energy. The integration of solar process heat to supply technologies for wastewater treatment represents a new field of application with great technical and economic potential for solar thermal energy. The efficient interaction, the nexus, between solar energy and water opens up new and innovative approaches.

The main objective of IEA SHC Task 62 is to increase the use of solar thermal energy in industry, to develop new collector technologies and to open up industrial and municipal water treatment as a new area of application with high market potential for solar thermal energy. The nexus between solar thermal energy and water treatment enables the development of new and innovative technology combinations and the change to a sustainable, resource- and energy-efficient industry.

The Task's work is divided into three subtasks:

- Subtask A: Thermally Driven Water Separation Technologies and Recovery of Valuable Resources (Germany)
- Subtask B: Solar Water Decontamination and Disinfection Systems (Spain)
- Subtask C: System Integrations and Decision Support for End-User Needs (Australia)

Scope

The scope of work covers all low temperature solar radiation technologies supplying either thermal or photon primary energy for fluid separation and water treatment in regard to industrial applications and sewage plants either in the context of municipal water treatment/purification or development cooperation.

Subtask A: Thermally Driven Water Separation Technologies and Recovery of Valuable Resources
The main objective of subtask A is to foster the development and promotion of new energy efficient solar driven separation technologies for industrial wastewater and process fluid treatment via:

- Identification of separation technologies that show high potential for solar thermal heat supply (e.g., membrane distillation, pervaporation, vacuum evaporation, rectification, etc.)
- Identification of suitable fields of application (e.g., industrial sectors, production processes, geographical sites; synergistic use of solar and industrial excess heat, etc.).
- Assessment of advantages and disadvantages of these technologies for different industrial applications and the interaction with solar thermal technologies and other renewable energy technologies
- Comparison (technical and economic) of these emerging technologies with state-of-the-art separation technologies (e.g., ultrafiltration, reverse osmosis, etc.).

Subtask B: Solar Water Decontamination and Disinfection Systems
The main objective of this subtask is the elaboration of emerging process technologies with increased efficiency which can render process technologies much more efficient due to the integration of solar radiation, as it also may affect the quality of the conversion process under study. The most prominent example is wastewater treatment. But also, many chemical processes could benefit from the direct use of solar radiation.

The definition of new solar collectors' concepts for reducing manufacture costs though maintaining high efficiency in the collection of UV photons for better performance of chemical oxidation reactions according to the specific operational requirements should be tackled in close collaboration with technology providers companies.

Specific objectives:

- To provide an in-depth analysis of the energy reduction potential associated with the application of solar based processes to the industrial water management system. (Electrical consumption associated with UV lamps will also be considered).
- To address research questions, such as fluid dynamics and reactor design, to optimize the purification results, as well energy consumption.
- To promote collaborative initiatives for assessment of technical and economic feasibility of specific water decontamination and disinfection problems.
- To identify treatment processes of other water-based streams (e.g., in the bio-based and agro-food industries) that could potentially benefit from direct solar/UV radiation.
- To initiate the development of new collector technologies.
- To promote tools and services in this area to accelerate market penetration.

Subtask C: System Integrations and Decision Support for End-User Needs

The main objective of subtask C is to develop a guideline for decision support, designed purposefully for end users/technology adopters, who wish to achieve a certain practical outcome. The work within this Subtask and the development of the guideline will build on the results of IEA SHC Task 49/IV where among others an integration guideline for solar heat into industrial processes was developed. The guideline of this Task will refer to water process solutions, with examples, that principally harness solar thermal energy. The end user may be an industry such as a manufacturer or foods producer or water utility operating a wastewater treatment plant. Solar thermal energy will be a key focus, but will also consider excess industrial heat where possible, due to its abundance and ability to minimize the use of more expensive solar collectors to improve technology cost viability. The practical outcomes of interest will be assessed in the project in consultation with industry experts, which could include needing to deal with matters such as removing contaminants from wastewater before environmental/sewer disposal or reuse. The proposed technologies may achieve this by contaminant destruction (e.g., organic mineralization), isolation/purification for potential sale as a valuable product or by reducing its volume to enable more convenient disposal. In keeping a narrow focus on solar driven technologies, acknowledgment of other technologies will be included respecting their benefits such as maturity and/or efficiency. Technologies investigated in more detail will be an important feature in the proposed guidelines produced in this subtask.

Where possible, the SHIP Database, which was also developed within Task 49/IV, will be utilized or potentially built on present working examples of processes that are using a solar driven process to meet a treatment need or produce a valuable product. A key feature of the work will be to connect the process need to a technology solution; for example, removal of carbon (biological oxygen demand) from wastewater using solar thermal reactor. Selection criteria can include options better suited to where the industry is located, such as in an urban region serviced by a sewer system that is charged for use by a utility which will have different treatment process requirements compared to one in a remote/isolated region where the environmental discharge occurs.

Aspects to be weighed up include technology maturity/readiness, range (e.g., types of solar thermal collectors), reliability or operation continuity (e.g., 24/7 for municipal water treatment or 5-day operation with peaking/variable flows/compositions). Companies providing technology solutions will be contacted to provide information on their products and working examples.

The output will be a publication (print and/or online database) containing a decision-making framework for selecting solar thermal technologies to achieve a desired outcome. The target audience includes industry (plant operators), consultants, governments/councils, and potentially farm operators or house owners. The aim is to show viable and innovative solutions to particular needs in treating wastewater or capturing valuable products.

Collaboration with Other IEA TCPs

Discussions are ongoing to collaborate with the IEA SolarPACES Task VI: Solar Energy and Water Processes and Application[1], which is led by Diego Alarcón from CIEMAT in Spain.

Collaboration with Industry

Discussions are underway with Mr. Alexander van der Kleij from the company SolarDew[2] are ongoing.

Task Duration

This Task started in October 2018 and will end in September 2022.

Participating Countries

Australia, Austria, Germany, Italy, Netherlands, Spain

Countries interested: Brazil, China, Cyprus, Denmark, Greece, South Africa, Sweden, Switzerland, UAE

Work During 2018

Subtask A: Thermally driven water separation technologies and recovery of valuable resources

- Definition of action items
- Definition of experts to be addressed (solar thermal AND water technology (e.g., MD experts)
- Definition of synergies between Subtask A and C (A.1. and C.1.)
- Definition of technologies to be focused on
- Survey will be built up for existing simulation models (focus on thermal technologies)

Subtask B: Solar Water Decontamination and Disinfection Systems

- Definition of action items
- Preparation of questions and multiple answers for a survey to identify potential applications in industry for water decontamination and disinfection
- Start of identification of the state-of-the-art and potential applications of solar water decontamination and disinfection systems in industrial water management.

Subtask C: System integrations and decision support for end-user needs

- Definition of action items
- Definition of guideline structure, content, aim and readership (manufacturers, end-users, planners)
- Start of a technology analysis to figure out which technologies will be included in the guideline. Parameters were defined to characterize technologies. Excel template is prepared and will be sent out to national experts.
- First "marketing" activities in the form of a logo and presentation to be distributed

Work Planned For 2019

Subtask A: Thermally driven water separation technologies and recovery of valuable resources

- Specification of System design and key performance indicators as a basis for comparative simulation studies
- Development of a matrix of different industrial separation demands to be subjected to cutting edge thermal technologies versus availability of different low exergy heat sources

Subtask B: Solar Water Decontamination and Disinfection Systems

- Identification of existing solar-based technologies applied to industrial water decontamination and disinfection (real and research cases).
- Identification of potential applications on industrial new sectors
- Evaluation of technological, economic and political barriers for up-scaling new decontamination and disinfection systems for industrial water and wastewater management and reuse

Subtask C: System integrations and decision support for end-user needs

- Development of a report on the guidelines to be considered for the Task 62 guideline
- Report on how the water-energy nexus concept is actually being applied in the industry

Dissemination Activities In 2018

Task 62 started in October 2018 so no publications were published or conferences/workshops held.

Dissemination Activities Planned For 2019

Task Meetings 2018

Meeting	Date	Location
Task Meeting 1	1 - 2 November 2018	Graz, Austria

SHC Task 62 Participants

Country	Name	Institution / Company	Role
AUSTRIA	**Christoph Brunner**	**AEE INTEC**	**Operating Agent**
AUSTRALIA	Mikel Duke	Victoria University	Subtask C Leader
AUSTRALIA	Cagil Ozansoy	Victoria University	National Expert
AUSTRALIA	Xiwang Zhang	Monash University	National Expert
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