SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2020
Annual report

Feature article on PVT systems and collectors

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May 2021

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

Cover: PVT installation on the Iberostar Royal Andalus hotel in Cadiz, Spain. *Photo: abora solar, La Muela (Zaragoza), Spain.*

Table of Contents

1. Message from the Chair

In 2020, the IEA SHC Technology Collaboration Programme (SHC TCP) members followed up on its commitment to start new Tasks and collaboration with emerging economies. In 2020, the TCP welcomed two more of UNIDO's Global Network of Regional Sustainable Energy Centres, EACREEE (5 East African countries) and CCREEE (15 Caribbean countries), for a total of five centres and two more in the process of joining. And in March of 2021, SICREEE (8 Central American countries) joined.

Of course, 2020 has been difficult due to the COVID-19 pandemic, but our TCP had the chance to rely on its experts' huge dynamism to keep up the momentum for all of our ongoing activities.

Sharing our work and results in the most comprehensive way is a top priority, and we do it in a variety of formats. Through events, all virtually in 2020 – our strong support in the organization of ISES's EuroSun 2020 international conference, our four Solar Academy webinars on the topics of integrated solutions for daylighting and electric lighting, PVT systems, renovating historic buildings towards zero energy, and the status of the solar heating and cooling market and industry, and our Solar Academy online solar cooling training with SHC TCP experts for CCREEE. And through our well-known publications – *Solar Heat Worldwide* published every year, Solar Update newsletter published twice a year, Task Highlights published every year, Technology Position Papers (two published in 2020), and of course many Task reports and online tools. All these modes of communication are supported through our partnership with Solarthermalworld.org, the leading news service in the solar heating and cooling field. And, last but not least, our TCP launched in 2020 a new version of our website.

As we continue to address the big issues for solar thermal deployment through our seven current Tasks, our collaboration with the IEA, other IEA TCPs, international organizations, and industry is essential.

In 2020, our outreach activities beyond our Task work included contributions from me as the Executive Committee Chair and other members – our annual briefing to the IEA Renewable Energy Working Party, review of several IEA publications (ETP 2020, TCEP 2020 database, Renewable Energy Market Report 2020), and presenting the SHC TCP at the Joint Programming Conference Smart Energy Systems 2020, Asia Pacific Solar Research Conference, and EuroSun 2020.

I want to thank the very active 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 TCP.

Even as we face significant challenges in the SHC sector, as nearly all economic sectors due to the global pandemic, 2021 is on course to be another year of significant achievements and increased visibility as we continue to implement our Strategic Plan (2019-2024).

Solar heat's potential is immense. As the IEA reports in *Renewables 2020*, heat is the largest energy end-use, accounting for half of global final energy consumption, significantly more than electricity (20%) and transport (30%). And in 2020, about 50% of total heat consumed was used for industrial processes and another 47% consumed in buildings for space and water heating, which means solar heat is key to combatting climate change and creating sustainable economies worldwide.

In 2021, I look forward to enhancing our relationship with industry, whether through our Tasks or TCP activities. This is critical if we are to understand their perspectives and issues better and strengthen solar heating and cooling markets across the globe.

Daniel Mugnier, *SHC Executive Committee Chair*

2. Solar Heating and Cooling Technology Collaboration Programme

IEA

The International Energy Agency (IEA) is an international organization that is at the heart of global dialogue on energy, providing authoritative analysis, data, policy recommendations, and real-world solutions to help countries provide secure and sustainable energy for all. Taking an all-fuels, all-technology approach, the IEA advocates policies that enhance the reliability, affordability and sustainability of energy. It examines the full spectrum of issues including renewables, oil, gas and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more. For more information on the IEA, visit http://www.iea.org.

SHC TCP

The IEA's Technology Collaboration Programme was created with a belief that the future of energy security and sustainability starts with global collaboration. The TCP is made up of thousands of experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The Technology Collaboration Programme on Solar Heating and Cooling (SHC TCP) was founded in 1977 as one of the first multilateral technology initiatives of the IEA. All our work is supporting 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.

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 and the solar industry to expand the solar market. Our activities are supporting market expansion by providing 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 2020 were:

- Towards the Integration of Large SHC Systems into DHC Networks (Task 55)
- Building Integrated Solar Envelope Systems for HVAC and Lighting (Task 56)
- Deep Renovation of Historic Buildings Towards Zero Energy (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)
- Solar Neighborhood Planning (Task 63)
- Solar Heat Processes (Task 64)
- Solar Cooling for the Sunbelt Regions (Task 65)

To support our Task work, the *SHC Solar Academy*, established in 2016, facilitates the dissemination of Task results and supports 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.

Our other activities are the SHC International Conference on Solar Heating and Cooling for Buildings and Industry (SHC 2019 was held together with ISES Solar World Congress 2019 on November 5-7 in Santiago, Chile), 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	**Netherlands**	Contracting Party
Austria	Contracting Party	**Norway**	Contracting Party
Belgium	Contracting Party	**Portugal**	Contracting Party
Canada	Contracting Party	**RCREEE**[6]	Sponsor
CCREEE[1]	Sponsor	**SACREEE**[7]	Sponsor
China	Contracting Party	**SICREEE**[8]	Sponsor
Denmark	Contracting Party	**Slovakia**	Contracting Party
EACREEE[2]	Sponsor	**South Africa**	Contracting Party
ECI[3]	Sponsor	**Spain**	Contracting Party
ECREEE[4]	Sponsor	**Sweden**	Contracting Party
European Commission	Contracting Party	**Switzerland**	Contracting Party
France	Contracting Party	**Turkey**	Contracting Party
Germany	Contracting Party	**United Kingdom**	Contracting Party
ISES[5]	Sponsor		
Italy	Contracting Party		

1 Caribbean Centre for Renewable Energy & Energy Efficiency (Joined in June 2020)
2 East African Centre for Renewable Energy and Energy Efficiency (Joined in February 2020)
3 European Copper Institute
4 ECOWAS Centre for Renewable Energy and Energy Efficiency
5 International Solar Energy Society
6 Regional Centre for Renewable Energy and Energy Efficiency
7 SADC Centre for Renewable Energy and Energy Efficiency
8 SICA Centre for Renewable Energy and Energy Efficiency

Benefits of Membership

The SHC TCP is unique in that it provides an international platform focused on solar thermal R&D. The benefits of membership are numerous.

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

How to Join

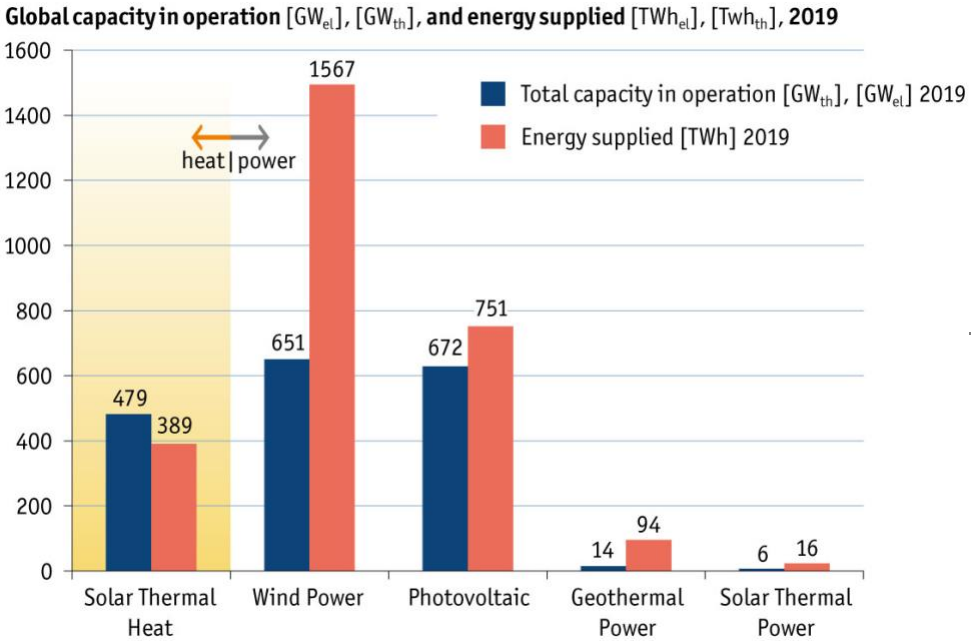
To learn how your government agency or your international industry association, international non-profit organization or international non-governmental organization can join please contact the SHC Secretariat, secretariat@iea-shc.org.

3. 2020 Recap

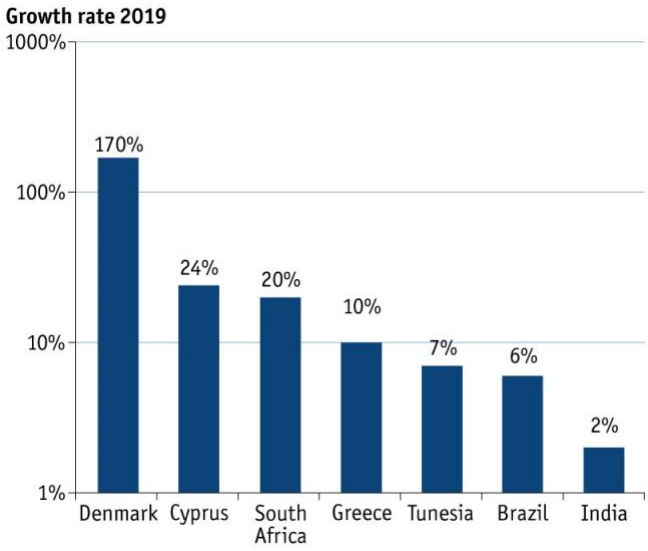
Solar Thermal Outlook

Every year we publish *Solar Heat Worldwide: Markets and Contribution to the Energy Supply*, the only annual global solar thermal statistics report. The 2020 edition reports that in 2019, solar thermal technologies produced 479 TWh – which corresponds to an energy savings equivalent of 43 million tons of oil and 139 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 is a graph showing the **Global Capacity for different renewable energy sources for 2019** and the markets with the strongest **Growth Rates in 2019**.



Strong growth rates in some of the largest solar thermal markets prove that the different types of solar thermal applications are cost competitive.



SHC Tasks

New Tasks

The TCP 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 2020, the following Tasks began:

- Task 64 Solar Process Heat *(Lead Country: Switzerland)*
- Task 65 Solar Cooling for the Sunbelt Regions (*Lead Country: Germany*)
- Task 66 Solar Energy Buildings (*Lead Country: Germany, start date is July 2021*)

Completed Tasks

In 2020, the following Tasks ended:

- Task 55 Integration of Large SHC Systems into DHC Networks *(Lead Country: Austria)*
- Task 56 Building Integrated Solar Envelope Systems for HVAC and Lighting *(Lead Country: Italy)*
- Task 60 PVT Systems and Collectors *(Lead Country: Switzerland)*

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 TCP.

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 68 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 of solar heating and cooling. In 2022, the SHC TCP will partner with ISES to co-organize EuroSun SHC 2022.

SHC Solar Award

Our prestigious award recognizes individuals, companies and institutions that have made significant contributions to the growth of solar thermal. The SHC TCP has presented this award twelve times since 2003 and looks forward to once again honoring those working to advance solar heating and cooling at EuroSun SHC 2022.

SHC Book Series

This collection of books on Task results is published by Wiley-VCH and can be purchased online. There are five books currently in the series: 1) *The Solar Cooling Design Guide: Case Studies of Successful Solar Air Conditioning Design*, 2) *Solution Sets for Net-Zero Energy Buildings: Feedback from 30 Net ZEBs Worldwide Modeling*, 3) *Design and Optimization of Net-Zero Energy Buildings*, 4) *Solar and Heat Pump Systems for Residential Buildings*, and 5) *Polymeric Materials for Solar Applications*.

SHC Collaboration

To support our work, the SHC TCP is collaborating with other IEA Technology Collaboration TCPs (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 Photovoltaic Power Systems TCP is collaborating in Task 59: Renovating Historic Buildings Towards Zero Energy and Task 60: Application of PVT Collectors and New Solutions with PVT Systems.

IEA SolarPACES is collaborating in Task 62: Solar Energy in Industrial Water and Wastewater Management and managing jointly Task 64: Solar Process Heat.

IEA Renewable Energy Working Party meetings in 2020 were attended by the SHC Chair, Daniel Mugnier and Pam Murphy, SHC Secretariat.

IEA Buildings Coordination Group meetings in 2020 was attended by the SHC German Executive Committee member, Kerstin Krüger.

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC TCP to increase awareness of solar thermal's potential and to encourage industry to use solar thermal R&D results in new products and services.

Solar Heat Europe, the SHC TCP has a close working relationship with this organization and will look for opportunities for collaboration in 2021.

Mission Innovation Challenge 7: affordable Heating and Cooling of Buildings, is supporting the work of Task 65: Solar Cooling for the Sunbelt Regions

ISO TC 180, the SHC TCP, specifically through Tasks, is supporting the work of ISO TC 180. For example, Task 60 on PV-Thermal Systems.

Executive Committee Meetings

2020 MEETINGS	2021 MEETINGS
87th ExCo Meeting Virtual June 2 – 4 *(was to be in South Africa)*	**89th ExCo Meeting** Virtual June 15 – 18 *(was to be in the Netherlands)*
88th ExCo Meeting Virtual November 3 – 5 *(was to be in Slovakia)*	**89th ExCo Meeting** TBD November

4. Feature Article

PVT Today & Tomorrow

Introduction

The quest to decarbonize society's electrical and thermal systems has never been more urgent. While this decarbonization of the electrical system is on track, the decarbonization of thermal systems is not, and its added complexity has contributed to this. There is also the need for better sector coupling to ensure a resilient energy system to meet these needs. Thermal systems typically make up about 50% of the final energy demand and a large portion of the demand could be serviced by renewable PVT (PV/Thermal) solutions. PVT solutions address another important and increasingly emerging issue – spatial and network constraints. PVT systems deliver high yielding solutions per unit of area and maximize the existing electrical infrastructure through their distributed application.

A PVT field of collectors on a flat roof is not different from a T field or a PV array. Integrated solutions will look totally similar to PV-only solutions. *Credit: Endef - Spain*

PVT technology is a hybrid technology combining a PV (photovoltaic) module and a solar thermal collector (ST); therefore, it produces electricity and heat simultaneously from solar without requiring more space than a PV-only collector would. Cooling (radiative and convective) can also be provided directly during the night using the PVT collector's thermal absorber or indirectly through a machine driven by the PV electricity.

The technology is somewhat more complex than just a PV or a ST collector but provides significant advantages are:

1. PVT uses the same area as a PV or ST module to provide electricity and heat, and in some cases cooling.
2. The solar electricity production of an uncovered PVT module is not less than that of a PV-only module. It can be even slightly higher if the collector is operated at temperatures below those of a PV-only module thanks to the thermal energy extracted and used.
3. PVT collectors can be uncovered, glazed or concentrating (with low concentration factors). Depending on their type, PVT collectors can therefore produce heat at temperatures from about -20° to +150°C and serve a wide range of applications throughout the world.
4. The solar thermal production can be used to preheat or heat domestic hot water. In well-designed hybrid collectors, the production can be almost as high as that of just a ST collector, only 10 to 20% less, a reduction mainly due to the part of the irradiation that is converted to electricity.
5. The thermal energy of the PVT collectors, converted from either solar radiation or ambient heat, can be used as a heat source for a heat pump.
6. The PV part can directly supply the electricity needed for circulation pumps and partially for heat pumps. In some cases, for example a DHW heat pump in summer periods, PV can completely power the heat pump thus leading to a 100% solar solution.
7. Solar generated thermal energy can be stored in many ways, including onsite tanks, precinct level tanks, aquifers, ground strata and pit storage systems. The current storage options are much more cost effective than electricity storage. This is especially true when PVT is used in combination with a heat pump to make good use of the stored energy. The heat pump enables higher output temperatures enabling more compact storage solutions to be implemented. This is important when space is a premium. The larger

thermal energy solutions can be accessed via district heating networks and enable the excess heat produced in summer to be stored seasonally for the winter.

8. As the demand for cooling increases, PVT has the potential to address this demand in a number of ways. The first is through direct solutions using the heat in absorption machines. The second is at nighttime when the unglazed PVT collector under clear skies is exposed to the night radiation phenomena. This effect sub cools the working fluid below ambient temperatures and can be used directly and stored. A compact storage example is ice storage. When coupled as a heat pump source, it can be recharged by an unglazed PVT collector with very high efficiencies even during the cold heating season.
9. PVT collectors have a low social impact; they produce no noticeable noise and have no detrimental visual impact when incorporated into a roof or façade.
10. The lifetime of a well-designed PVT collector is expected to be between 20 and 40 years. Case studies of recently developed PVT collectors, however, are still lacking.

The trade-off between the higher cost of a PVT collector and that of separate PV or T collectors must be balanced by the value of the heat or electricity produced on the same occupied area for the system owner. The heat produced can be delivered to a heating network, used onsite or stored in heat storage devices. The electricity produced can be delivered to a grid, used onsite or stored as either electricity or converted to heat. If the electricity is self-consumed, the savings can deeply enhance the Return on Investment (ROI) depending on the local electricity price. This is especially true when substituting alternative heat sources for the combination of heat pump technology; the trade-off costs vs. savings have to be taken into account since boreholes or air heat exchangers are replaced.

PVT systems are used in many applications: single-family and multi-family houses, hotels, campuses, public services, hospitals, agricultural and industrial processes, and even district heating. Payback times as low as 4 years have been observed in hotel case studies in Spanish conditions.

Optimizing a PVT system design and operating philosophy varies significantly depending on the application, size of the system, the spatial constraints and the customer's utility prices. In some cases, this can be quite a complex modeling process to ensure the design meets the customer's operational and financial goals

Current Status

Existing PVT products (collectors) in 2020

- Uncovered PVT (or WISC) collectors
  - Products: About 80% of the market are liquid- and air-cooled collectors.
  - Market: DHW and space heating in renovated buildings (in combination with a heat pump) and in new buildings (with or without heat pumps, for heating and cooling), space heating for low energy houses using air in the ventilation system or using water in a floor heating solution.
  - Labs: Collectors tested and certified according to PV and/or T standard testing, but still missing a simple global PVT standard at a reasonable price and a simple solution when only the PV module is changed.

- Covered PVT collectors
  - Products: Several are on the market and more are coming.
  - Market: DHW in large buildings – commercial, residential and administrative. Hotels and resorts are an important target.
  - Labs: a global PVT standard is still missing.

- Concentrating PVT collectors
  - Products: A few on the market with a trend to disrupt since the cost of heat tends to be high.
  - Market: DHW and industrial thermal processes.
  - Labs: no global PVT standard is available.

Product market situation

- Estimated 2 million m^2 installed over the past 5 years (this represents, according to conventional conversion factors, about 270 MW PV and 1,400 MW Thermal).
- Market is slowly growing with very strong competition from PV. In many cases where a heat demand in sunny months is present, PVT is more attractive than PV because it does the same plus heat!
- Increasing number of PVT manufacturers producing high quality products.
- Niche markets: Air PVT in France is a niche market that has boomed over the last years. DHW for hotels with unglazed or glazed collectors is an attractive market segment. The combination of heat pumps with unglazed collectors is a very efficient PVT application that early adopters have caught on to.
- Need to increase installers' awareness of PVT. Trend to franchise installers can be observed.

Research questions answered by the PVT community

- TRL 8 (technology readiness level according to the NASA scale from level 1: a concept to level 9: deployed in a market) is reached for most PVT commercial solutions (new collectors, however, can still be developed).
- How to build durable PVT collectors is known (Task 60 has issued report B2 on the topic).
- PVT collectors with concentration factors of 2 to 5 are developed (but there is less field experience than for non-concentrating PVT collectors).
- PVT built on evacuated tubes have a high TRL by one manufacturer.
- How a PVT collector operates is well known by the manufacturers and reported.
- Which test procedure to apply is known for the PV part and the T part, but a PVT standard per se to reduce the cost of a test and to tackle risks generated by combining the two technologies is still missing.

Research questions still to be answered

- TRL 9 levels are still needed for some PVT collectors with more demonstration plants monitored.
- Make the cost fall by a factor of 1.5 to 2 through volumes and/or technology improvements.
- Subsidy fair schemes for PVT collectors in all markets (Task 60 issued report D6 on this topic).
- Integrated standards that combine PV and T in one testing cycle at a reasonable cost for the manufacturer and when "minor" changes to the design are made.
- Labels for PVT solutions.
- Durability testing and feedback, especially for concentrating PVT.
- Optimization and best combinations deserve more work based on best practices.
- The advantages of the cooling effect on PV production and reduced lifetime performance degradation in a PVT collector, especially with heat pumps, deserve more work.
- Use of PVT in solar thermal cooling applications is still not developed, although attractive.
- Use of the PVT hardware at night to capture night sky radiation effects and the associated cooling applications is still not well developed, although attractive.
- System optimization like local use vs. grid injection, cold or hot storages combinations for large projects needs study cases.
- Reducing system costs through innovation and teaching is a topic, especially for PV-only or PV + heat pump solution.

- Simplifying installation is always a topic.
- LCA and recycling of PVT collectors deserve some attention, although not different from PV and T existing solutions.

Challenges faced by PVT industries

- Deciding on the right choice of materials to use in a PVT collector can be a challenge due to the thermal constraints the PV module must bear.
- Thermal system modeling and yield prediction are more complicated than for electricity alone.
- The limited number of validated system modeling cases makes it difficult for the supplier to quantify the advantages of PVT.
- The limited power of the PVT industry makes it difficult to influence standards and policies to favor PVT.
- The general awareness of PVT is still very limited among all types of stakeholders – homeowners, planners, policymakers, utilities and investors.
- Selling a complete system, which PVT somehow needs to make the most out of the combination of technologies, requires more effort than selling a PVT collector and more skills from the salespersons.
- There are some exciting emerging opportunities in the development of new low-temperature district heating systems, where temperatures less than 60 - 80°C are being trialed and promoted as the future choice for expanding the decarbonization of heating and cooling. This significantly enables PVT coupled with heat pumps to play a role in distributed and centralized solutions.
- Always being compared to PV is a situation that industries and distributors must be prepared to face with arguments and facts.

Opportunities for PVT industries

- Exciting policy setting opportunities will present with the New Green Deal in the EU. The PVT sector needs to be prepared to ensure that the case for PVT is heard and facilitated and not inadvertently excluded (as it was unfortunately in 2020 in Australia when renewable heat was not supported by policy).
- The European Commission on 14 October 2020 published its Renovation Wave Strategy to improve the energy performance of buildings. Deep renovations can improve energy performance by 60%. Again, an emerging opportunity to place PVT front and center of this initiative by being engaged as a body in this process (https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en).
- There are some exciting emerging opportunities in the development of the 4GDH (4th Generation District Heating) program where temperatures less than 100°C are being trialed and promoted as the future choice for expanding the decarbonization of heating and cooling. This significantly enables PVT coupled with heat pumps to play a role in distributed and centralized solutions (https://www.4dh.eu/).
- Seasonal storage opportunities will provide PVT systems the ability to monetize more of the heat generated that may otherwise be lost due to curtailed production. For example, when the customer's summer PVT production exceeds thermal demand.
- Solar cooling is emerging as another area of great interest. PVT can contribute to these low carbon solutions with its diurnal heating features during the day and cooling during the night.

Potential

Energy that could be replaced by PVT systems will be important for meeting societies' needs for decarbonized thermal and electrical systems.

The range of production varies from 700 to 2500 kWh/kW for electricity and 100 to 700 kWh/m^2 for heat, depending

on collector type, climate and application.

Assuming that a PVT installation produces in a mid-European climate, 1,000 kWh/kWp of electricity and 500 kWh/m^2 of heat, the 2019 savings from a PVT installation are about 270,000 MWh of electricity and 1,000,000 MWh of heat, which corresponds to about 100,000 toe (tons of oil equivalent).

If the PVT market grows by 10% each year, starting from a base of 2 million m^2 in 2018, it can be assumed that 40 million m^2 will be sold in 2050. This would be 20 times the current market volume and represent a significant part of the solar thermal market (around 180 million m^2 in 2020).

We can even take this a step further. There is no PV roof without PVT collectors if the owner runs a heat pump in the building! Especially in dense areas where air heat pumps are considered to be too noisy and borehole drilling can be limited.

Cooling needs will continue to increase in the coming years. This represents an opportunity for PVT collectors because they can 1) produce electricity for the operation of a compression chiller and 2) be used to reject heat to the environment via convection and heat radiation. This additional function as a heat sink will also increase the competitiveness of PVT.

Other applications in the agriculture and process heat segment will develop.[1]

Actions Needed

Challenge	Action needed
Increase governments' awareness of PVT solutions: PVT is an attractive alternative to PV and T solutions and to air or ground-sourced heat pumps.	Targeted dissemination of SHC Task 60 results and reports.
Propose clever and fair subsidy schemes for PVT collectors and systems to governments and support their adoption.	• SHC Task 60 issues recommendations, namely to improve the situation in France, and Task participants continue to work with national solar energy associations to promote improved schemes in their countries.
Increase architects' awareness of PVT solutions – PVT is more efficient than just PV.	Researchers and industries should attend more conferences to present successful solutions and publish articles in relevant magazines.
Increase planners' awareness of PVT solutions that PVT can be more cost effective than any other solar solutions, especially for some applications like hotels.	Articles in technical magazines, teaching seminars, and testimonials of leading planners in the field should be undertaken by the PVT industry.
Increase installers' awareness of PVT solutions – PVT is as easy to install as PV and T solutions.	Articles in journals – demonstration projects – video channels.
Increase engineering students' awareness of PVT solutions by giving classes and tools for simulation, such as the ones found on PVT collector providers' websites.	Develop teaching materials and dedicated classes on the topic.
Develop an appropriate standard on combined PVT testing so that all in one testing batch can be achieved and subsequent design changes can also be-covered at a lower cost.	Continue SHC Task 60 work based on Task report, Status Quo of PVT Characterization, with ISO and Solar Keymark.

1 Task 60 wiki page: https://en.wikipedia.org/wiki/Photovoltaic_thermal_hybrid_solar_collector

Develop Solar Keymark certification for PVT.	Annex P5.1 of Solar Keymark is in place and should be more widely disseminated with the help of SHC.
Reduce PVT collector costs and ensure that they are as durable and easy-to-install as PV-only collectors	PVT industry + research needs financial support for innovation.
Make PVT systems cheaper and simpler to install.	PVT industry + researchers need financial support for pilot and demonstration projects with monitoring and results communicated.
Increase the number of available PVT best practice examples.	Survey campaigns in several countries or at the IEA level, see also the Task 60 website and Task report, Existing PVT Systems and Solutions.
Increase automation in PVT industry so that the cost of producing collectors can be reduced without giving up quality and durability.	Expand public support and market development.
Inform PV and heat pump industries about PVT's possibilities as a heat source and train their installers.	More articles and communication. Meet them in fairs and conferences and disseminate best practices and cost-effective cases.
Use KPIs based on testing and not just simulations when promoting PVT solutions to ensure the evaluation is reliable and relevant and to increase customer and planner confidence.	Some test labs must be made aware of PVT global testing and the industry should rely more on them.
Use common notations and KPI's for communicating research and field results so that comparisons are possible between different manufacturers and planner offers.	Disseminate the relevant SHC Task 60 reports.

*This article is one of a series of Technology Position Papers published by the IEA SHC for policy- and decisionmakers, https://www.iea-shc.org/publications.

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5. Completed Tasks

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

Roberto Fedrizzi
EURAC Research
Operating Agent for ENEA, Italy

Task Overview

This Task focused on the analysis, simulation, test and onsite monitoring of multifunctional envelope systems entailing elements that use and/or control incident solar energy

- To deliver renewable thermal or/and electric energy to the HVAC system of the building
- To reduce heating and cooling demands of buildings, while controlling daylight

The integration of the above solar envelope solutions into the building systems through a systemic approach is central in this task: energy performance, indoor comfort and architectural integration were addressed all along the Task elaboration.

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

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

To achieve these objectives, the work focused on 3 main topics:

- Solar envelope systems classification, so to provide an overview of the solar envelope systems both on the market and under development and identify the main strengths, weaknesses, opportunities and threats of such solutions (Subtask A).
- Performance characterization of solar envelope elements, focusing on the tools and strategies needed to foster the market penetration of industrialized solar envelope systems, intended as the sub-systems strictly incorporated in the building envelope (Subtask B).
- Assessment of solar envelope systems at building level, tackling the issue of the integration of solar envelope components into the HVAC system of buildings (Subtask C).

Participating Countries

	Research Institutes	Universities	Companies
Austria	1	1	1
Canada		1	1
Denmark		1	1
Germany	2		1
Italy	1		
Netherlands		1	
Norway		1	1
Spain	1		
TOTAL	**5**	**5**	**5**

Task Duration

This Task started in **February 2016** and ended in **January 2020**.

Collaboration with Other SHC Tasks and IEA TCPs

There was no formal collaboration with other TCPs.

Collaboration with Outside Organizations/Institutions

Many activities of Task 56 were carried out in collaboration with the Dublin Institute of Technology (Ireland), whose experts intensively contributed to the Task work, participated in Task meetings and hosted the 3rd Task meeting in March 2017.

Collaboration with Industry

The involvement with industry was fundamental to get in contact with industry stakeholders and receive feedback on the status and perspectives of the solar envelopes market. To this end, several manufacturers and companies were called to contribute to the analysis of solar envelope solutions carried out in Activities A1 and A2 (state-of-the-art analysis). The vast majority showed their interest in collaborating in the proposed activities and more in general for the outcomes of the Task.

In addition, the participation of solar envelope manufacturers to Task 56 meetings and the organization of dedicated industry workshops throughout the duration of the Task was key to create valuable opportunities for sharing views and ideas and discussing the topic from the perspective of actors active “in the field”.

The kick-off meeting at EURAC in Bolzano was attended by 28 experts from 24 different institutions. The majority of experts came from universities and research centers, but there was good participation by the industry sector (7 companies), which expressed their intention to actively participate in the project elaboration.

The second meeting held in Darmstadt in September 2016 was attended by 25 experts, 5 of whom came from industry. Two observers from BASF and MERCK glasses presented their developments in the sector of advanced solutions for the active solar gains control. The “China International Investment Promotion Agency” also participated in disseminating their activates and seeking possible collaboration in China.

During the third Task meeting held in Dublin in March 2017, 24 experts were present, with 5 from industry. Three additional industry representatives participated in a dedicated industry workshop, where barriers, opportunities and strategies for the development of solar envelopes were discussed.

Sixteen experts from the well-established group of participating entities actively contributed to the Task meeting in Eindhoven in September 2017. Overall, 8 external manufacturers joined the meeting. In addition, a confidential industry workshop (protected by a non-disclosure agreement) was organized as part of the activities of Subtask B.

During the Task meeting held 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 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.

During the Task meeting held in Copenhagen in March 2019, an industry workshop was organized in collaboration with “Smart Energy Green Cities”, bringing together a total of 22 experts including architects, urban planners, manufacturers, and a representative of a utility company.

Key Results

The main accomplishments of this Task are highlighted below. More details and specific deliverables can be found on the SHC Task 56 webpage, https://task56.iea-shc.org/.

Subtask A: Solar Envelope Systems Classification and Communication

(Subtask Leader: Michaela Meir, Inaventa Solar, Norway)

An overview of products and solar envelope systems solutions available on the market and under development in laboratories was completed. A market analysis assessing existing solutions through a literature review with input from the Task experts and with manufacturers in the participating countries. Different products and solutions were evaluated through a SWOT analysis, accounting for technical and non-technical issues that in the past determined the success or the failure of solar envelope systems or, on the contrary, that could result in opportunities for the future market growth.

In addition, a major activity of Subtask A was the communication of the overall Task results to attract and involve central actors, decisionmakers, planners, builders, architects, and experts from research and industry. This was achieved through the exchange of information generated in all the Subtasks at local workshops, in newsletters, during webinars, conferences and other events, in scientific papers, and through the Task’s online solar envelopes gallery. Finally, a *Technology Position Paper* was published to explain the relevance, potential and present status of development and market of building solar envelope systems contributing to HVAC and lighting of buildings, leading to actions needed to best exploit their integration into building design practices.

Subtask B: Performance Characterization of Solar Envelope Elements

(Subtask Leader: Christoph Maurer, Fraunhofer ISE, Germany)

Solar envelope elements need to be integrated in the construction process during the early planning stage. To this purpose, planners need to be provided with the necessary information – integration parameters, performance measurements and modelling, etc. – when starting their work. Subtask B developed tools and strategies fostering the market penetration for industrialized solar envelope systems. In particular, the experts analyzed the conditions for the effective deployment of solar envelope systems and identified market barriers and market strategies. The experts also categorized norms, test methods and numerical tools to create a starting basis for the development of new solutions and design process of buildings integrating solar envelope elements.

Subtask C: Assessment of Solar Envelope Systems at Building Level

(Subtask Leader: Fabian Ochs, University of Innsbruck, Austria)

Subtask C focused on the integration of solar envelope systems into buildings and their HVAC systems. To begin an analysis of virtual reference buildings different solar envelope elements incorporated. Numerical models were elaborated and validated, allowing a reliable comparison among simulations run with different software. The numerical models are posted on the Task webpage. The numerical results were analyzed to extrapolate design guidelines and reliable information in terms of energy and cost performance for different solutions. These results were used to validate simplified pre-design to use in the early stages of a building planning process to account for the integration of solar envelope systems. In parallel to the numerical simulation work, a few selected demonstration buildings were evaluated by monitoring installed solar envelope systems.

Dissemination Activities

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
Gaeini, M.	Thermochemical seasonal heat storage for the built environment: a multi-scale investigation	PhD thesis, Eindhoven University of Technology, The Netherlands, July 2017
Diarce, G.	Development of new eutectic PCMs and plate-based LHTES systems for domestic cogeneration applications	PhD thesis. University of the Basque country (UPV/EHU), 2017
Michael Brütting	Internal: Michael Brütting, Intercomparison of measurement results by means of flash technique,	Report ZAE 20318 - 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, http://www.3sat.de/mediathek/?mode=play&obj=71365
	http://forschung-energiespeicher.info/projektschau/industrielle-prozesse/projekt-einzelansicht/109/Effizienz_von_Heizkraft_und_Stahlwerken_steigern/	www.iea-shc.org
	http://www.forschungsjahrbuch-energie.de/projekt/2597	
	An internal / non-public progress report for Line A/Fraunhofer ISE was generated in February 2018 and filed to the German project agency PTJ.	
	StoreItUp Final Report (issued by AIT-Vienna)	
Z. Jiang, A. Palacios, M. E. Navarro, Y. Ding	The research of formulation and detecting methods of high temperature molten salts	2018
Z. Jiang, A. Palacios, M. E. Navarro, Y. Ding	The study of corrosion behavior of high temperature molten salts	2018
B. Fumey	Yearly report to the Swiss Federal Office of Energy	2019
	http://forschung-energiespeicher.info/projektschau/industrielle-prozesse/projekt-einzelansicht/109/Effizienz_von_Heizkraft_und_Stahlwerken_steigern/	
	http://www.forschungsjahrbuch-energie.de/projekt/2597	
	Intermediate progress report of project HYBRITES (ENE2017-87711-R) for the Spanish funding agency.	
Angerer, M.; Becker, M.; Härzschel, S.;	Abschlussbericht TcET 2018 – Thermochemischer Energiespeicher für thermische Kraftwerke und industrielle	2018

Ostermeier, P.; Würth, M.; Gleis, S.; Vandersickel, A.; Spliethoff, H.	Wärme. Bundesministerium für Wirtschaft und Energie, 2018	

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Bärbel Epp	IEA SHC: Task 56 Kick-Off Meeting on Building Integrated Solar	Solarthermalworld.org	http://www.solarthermalworld.org/content/iea-shc-task-56-kick-meeting-building-integrated-solar
D. Venus, B. Nocke, C. Fink, K. Höfler	Facade integrated HVAC systems for the renovation of residential buildings – results from Austrian research projects	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications//aee_intec_abstract_dv_v2.pdf
Peter Veisig	Nordic Built Active Roofs and Facades and Living in Light urban renewal in Valby, Copenhagen	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/20161003_abstract_bern_10_oct_peder_vejsig.pdf
P. Bonato, M. D'Antoni, R. Fedrizzi	Integration of a sorption collector coupled with a decentralized mechanical ventilation unit in curtain wall modules	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/eurac_abstract_dm.pdf
Wilfried Pohl, David Geisler-Moroder	Daylight-driven and user-centered lighting and energy management	Task 56 session at 12th Conference on Advanced Building Skins, 2.-3.10.2016, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/56/media/publications/20160701_bartenbach_abstract.pdf
Roberto Garay Martineza, Julen Astudillo Larraza	Performance assessment of façade integrated glazed air solar thermal collectors	International Conference – Alternative and Renewable Energy Quest, AREQ 2017, 1-3 February 2017, Spain	http://task56.iea-shc.org/publications
Roberto Garay Martinez, Beñat Arregi Goikolea, Ignacio Gomis Paya, Paul Bonnamy, Saed Raji, Jerôme Lopez	Performance assessment of an unglazed solar thermal collector for envelope retrofitting	International Conference – Alternative and Renewable Energy Quest, AREQ 2017, 1-3 February 2017, Spain	http://task56.iea-shc.org/publications
Roel Loonen, Fabio Favoino, Jan Hensen, Mauro Overend	Review of current status, requirements and opportunities for building performance simulation of adaptive facades	Journal of Building Performance Simulation, 10(2), 205-223	http://www.tandfonline.com/doi/full/10.1080/19401493.2016.1152303
Mohammad Ghasempourabadi,	Towards simulation-assisted performance monitoring of	IEEE 43rd Photovoltaic Specialists Conference	http://ieeexplore.ieee.org/document/7750241

Kostas Sinapis, Roel Loonen, Roland Valckenborg, Jan Hensen, Wiep Folkerts	BIPV systems considering shading effects	(PVSC), Portland Oregon, USA	
Bärbel Epp	IEA SHC Task 56: Cooperation on Energy Balance and Building Design Tools	Solarthermalworld.org	http://www.solarthermalworld.org/content/iea-shc-task-56-cooperation-energy-balance-and-building-design-tools
E. McLean, B. Norton, D. Kearney, P. Lemarchand	A Review of Control Methodologies for Dynamic Glazing	12th Conference on Advanced Building Skins (ABS). Bern, Switzerland, October 2-3, 2017	https://abs.green/program-2017/
P. Lemarchand, E. McLean, B. Norton	Switchable Windows - Spectral Transmission and Switching Times	ISES Solar World Conference and Solar Heating Conference. Abu Dhabi, United Arab Emirates (UAE), 29.10.-02.11.2017	http://proceedings.ises.org/
D. Jähnig, C. Fink, T. Ramschak, D. Venus, K. Höfler	Fassadengekoppelte Energieversorgungskonzepte für die Sanierung	ACR - Austrian Cooperative Research, Online database	http://www.acr.ac.at/fileadmin/documents/ACR-Wissen/AEE_INTEC_Fassadengekoppelte_Energieversorgungskonzepte_02_2018.pdf
R. Battisti, R. Fedrizzi, Bärbel Epp	Building-Integrated Solar Envelopes:Barriers to Deployment	Solarthermalworld.org	http://www.solarthermalworld.org/content/building-integrated-solar-envelopes-barriers-deployment
S. Attia, S. Bilir, T. Safy, C. Struck, R.C.G.M. Loonen, F. Goia	Current Trends and Future Challenges in the Performance Assessment of Adaptive Façade Systems	Energy and Buildings, 179, 165-182	http://doi.org/10.1016/j.enbuild.2018.09.017
R. Capperucci, R.C.G.M. Loonen, J.L.M. Hensen, A.L.P. Rosemann	Angle-dependent optical properties of advanced fenestration systems-Finding right balance between model complexity & prediction error	Building Simulation (2018), Online ISSN 1996-8744	http://doi.org/10.1007/s12273-018-0466-4
S.J.M. Koenders, R.C.G.M. Loonen, J.L.M. Hensen	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 Mikel Lumbreras, Roberto Garay, Koldobika Martin	Unglazed Solar Thermal Systems for Building Integration, coupled with District Heating Systems. Conceptual Definition, Cost and Performance Assessment	Journal of Facade Design and Engineering 6(2) 119-131, June 2018, ISSN: 2213-3038	https://doi.org/10.7480/jfde.2018.2.2085
P. Elguezabal, R. Garay, K. Martin	Experimentation under real performing conditions of a highly integrable unglazed	Energy Procedia, Volume 122, 2017, Pages 775-780, ISSN 1876-6102	https://doi.org/10.1016/j.egypro.2017.07.395

	solar collector into a building façade		
Roberto Garay Martinez, Beñat Arregi Goikolea, Paul Bonnamy, Jérôme Lopez	Concept, development and thermal characterisation of an unglazed solar thermal collector for facade integration	Dyna, National University of Colombia, Medellín	http://task56.iea-shc.org/publications
Matthias Werner, David Geisler-Moroder, Bert Junghans, Oliver Ebert, Wolfgang Feist	DALEC – a novel web tool for integrated day- and artificial light and energy calculation	Journal of Building Performance Simulation, 10:3, 344-363	http://task56.iea-shc.org/publications
Matteo D´Antoni, Paolo Bonato, Roberto Fedrizzi	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://journals.library.tudelft.nl/index.php/jfde/article/view/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	http://task56.iea-shc.org/Data/Sites/1/publications/DenzMaurer18_3bistTechnologiesForSolarArchitecture_ABS18.pdf
Jakob Klint, Vickie Aagesen	Living in Light – a transformation concept of existing buildings	13th Conference on Advanced Building Skins, Oct. 1-2, 2018, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/1/publications/2018-Living-in-Light--Advanced-Building-Skins-201806221.pdf
David Geisler-Moroder, Christian Knoflach, Silvia Öttl, Wilfried Pohl	Advanced daylighting systems and combined lighting and thermal simulation	13th Conference on Advanced Building Skins, Oct. 1-2, 2018, Bern, Switzerland	http://task56.iea-shc.org/Data/Sites/1/publications/2018-ABS-Geisler-Moroder-Paper.pdf
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	http://task56.iea-shc.org/Data/Sites/1/publications/2018-Advanced-Building-Skins-TaLed-jdb-2_10_2018_final_u1.pdf
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	http://task56.iea-shc.org/Data/Sites/1/publications/ABS2018_v10.pdf
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	http://task56.iea-shc.org/Data/Sites/1/publications/ABS_Conference_2018_Ochs.pdf
Hubschneider, C.; de Boer, J	Performance Tracking: Lab measurements and field testing of integrated systems -	13th Conference on Advanced Building Skins,	http://task56.iea-shc.org/publications

	Integration into practical design application	1-2 October 2018, Bern, Switzerland	
Dagmar Jaehnig, Thomas Ramschak, David Venus, Karl Hoefler, Christian Fink	Building retrofit using facade-integrated energy supply systems	ISEC - International Solar Energy Conference, Congress Graz, Austria, Oct. 3-5, 2018	http://task56.iea-shc.org/Data/Sites/1/publications/Jaehnig_Facade_Integration_ISEC_2018_Full3.pdf
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, Sept. 10-13, 2018	http://task56.iea-shc.org/publications
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, Sept. 10-13, 2018	http://task56.iea-shc.org/publications
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	http://task56.iea-shc.org/Data/Sites/1/publications/18_icae_saini.pdf
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, June 20-22, 2018, Donostia-San Sebastián, Spain	http://task56.iea-shc.org/Data/Sites/1/publications/2018-NESTLE_Nikolaus_F_icae-S_switchable_u-value_korr.pdf
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	http://task56.iea-shc.org/Data/Sites/1/publications/ICAE2018_Innovative_curtain_wall_with_solar_preheating.pdf
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	http://task56.iea-shc.org/Data/Sites/1/publications/ICAE%202018%20Marina_20180212.pdf
Beñat Arregi, Roberto Garay, Peru Elguezabal	Hybridization of solar thermal systems into architectural envelopes	PowerSkin Conference, Munich, Germany, Jan. 19, 2017	http://www.researchgate.net/publication/313114409_Hybridization_of_solar_thermal_systems_into_architectural_envelopes
Sebastian Hernandez, Gumpp & Maier, Germany; Fabian Ochs	Prefabricated timber-frame envelopes for building retrofit with integrated ventilation, heating system and building services	11th Conference on Advanced Building Skins, Bern, Switzerland, Oct. 10-11, 2016	http://task56.iea-shc.org/Data/Sites/1/publications/2016-ochs_etal_inspire_abs_2016-08-22.pdf
Roberto Garay Martinez, Peru Elguezabal	Integrated Solar Thermal Systems for renovation of external walls	11th Conference on Advanced Building Skins,	http://www.researchgate.net/publication/308969098_Integrated_Solar_Therm

Esnarrizaga, Julen Astudillo Larraz		Bern, Switzerland, Oct. 10-11, 2016	al_Systems_for_renovation_of_external_walls
Paul Bonnamy, Saed Raji, Jérôme Lopez, Roberto Garay	Expérimentation et modélisation d'un capteur solaire opaque pour préchauffage de l'eau	Congrès annuel de la Société Française de Thermique, Toulouse, France, 21 May - 3 June, 2016	http://www.researchgate.net/publication/303940385_Experimentation_et_modelisation_d

Conferences, Workshops, Seminars, etc.

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	If Task Hosted: Organized with, # participants
IEEE 43rd Photovoltaic Specialists Conference (PVSC),	Presentations, abstracts, papers 1 Task 56 partner	June 5-10, 2016, Portland Oregon, USA	
11th Conference on Advanced Building Skins	Presentations, abstracts, papers 5 Task 56 partners	Oct. 10-11, 2016, Bern, Switzerland	(1 session hosted by Task 56)
International Conference – Alternative and Renewable Energy Quest, AREQ 2017	Presentations, abstracts, papers 1 Task 56 partner	February 1-3, 2017, Barcelona, Spain	
VIII Int. Congress on Architectural Envelopes (ICAE)	Presentations, abstracts, papers 3 Task 56 partners	June 20-22, 2018, Donostia-San Sebastián, Spain	
EuroSun 2018 – 12th International Conference on Solar Energy for Buildings and Industry	Presentations, abstracts, papers 2 Task 56 partners	Sept. 10-13, 2018, HSR University of Applied Science, Rapperswil, Switzerland	
Canada Research, Development, Demonstration and Industry Workshop	Presentations 10 invited speakers and Task 56 participants	Concordia University, Montreal, QC, Canada	hosted during IEA SHC Task 56 6th Experts meeting
13th Conference on Advanced Building Skins	Presentations, abstracts, papers 6 Task 56 partners	Oct. 1-2, 2018, Bern, Switzerland	1 session hosted by Task 56
ISEC - International Sustainable Energy Conference 2018	Presentations, abstracts, papers 1 Task 56 partner	Oct. 3-5, 2018, Graz, Austria	

Austrian Industry Meeting	Workshop 3 Task 56 partners	December 13, 2018, Vienna, Austria
Austrian Industry Meeting	Workshop 1 Task 56 partner	June 6, 2019, Vienna, Austria
BISES webinar – Solar Academy	Webinar 3 Task 56 partners	September 18, 2019

Task Meetings

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

1. Freiburg, Germany September 2014
2. Munich, Germany October 2015

Over the entire term of the Task a total of 9 Experts Meetings were held and 5 included an industrial workshop.

Meeting	Date	Location	# of Participants
Experts Meeting 1	March 21-22, 2016	Eurac Research Bolzano, Italy	28
Experts Meeting 2 +industry workshop	September 13-14, 2016	Darmstadt University, Darmstadt, Germany	25
Experts Meeting 3 +industry workshop	March 2-3,2017	Dublin Institute of Technology, Dublin, Ireland	23
Experts Meeting 4 + industry workshop	September 21-22, 2017	Eindhoven Institute of Technology Eindhoven, The Netherlands	22
Experts Meeting 5	March 6-7, 2018	University of Innsbruck Innsbruck, Austria	17
Experts Meeting 6 + industry workshop	September 20-21, 2018	Concordia University Montreal, Canada	20
Experts Meeting 7 + industry workshop	March 5-6,2019	Kuben Management – Aalborg University Copenhagen, Denmark	11
Experts Meeting 8	October 24-25, 2019	Fraunhofer ISE Freiburg, Germany	17
Experts Meeting 9	February 3-4, 2020	Eurac Research Bolzano, Italy	16

SHC Task 56 Participants

Country	Name	Institution / Company	Role
ITALY	**Roberto Fedrizzi**	**EURAC**	**Operating Agent**
AUSTRIA	Fabian Ochs	University Innsbruck	Subtask C Leader
AUSTRIA	Mara Magni	University Innsbruck	National Expert
AUSTRIA	David Venus	AEE-INTEC	National Expert
AUSTRIA	David Geisler-Moroder	Bartenbach GmbH	National Expert
AUSTRIA	Martin Hauer	Bartenbach GmbH	National Expert
CANADA	John Hollick	Solar Wall	National Expert
CANADA	Zissis Ioannidis	Concordia University	National Expert
CANADA	Efstratios Rounis	Concordia University	National Expert
DENMARK	Vickie Aagesen	Cenergia (Kuben Management)	National Expert
DENMARK	Alireza Afshari	Aalborg University	National Expert
GERMANY	Christoph Maurer	Fraunhofer ISE	Subtask B Leader
GERMANY	Bruno Bueno	Fraunhofer ISE	National Expert
GERMANY	Paul-Rouven Denz	Facade-Lab GmbH	National Expert
GERMANY	Jan de Boer	Fraunhofer IBP	National Expert
GERMANY	Carolin Hubschneider	Fraunhofer IBP	National Expert
ITALY	Matteo D'Antoni	EURAC	National Expert
ITALY	Paolo Bonato	EURAC	National Expert
NETHERLANDS	Roel Loonen	Eindhoven University of Technology	National Expert
NETHERLANDS	Samuel de Vries	Eindhoven University of Technology	National Expert
NORWAY	Michaela Meir	Inaventa Solar	Subtask A Leader
NORWAY	Francesco Goia	NTNU, Felles fakturamottak	National Expert
NORWAY	Ellika Taveres-Cachat	NTNU, Felles fakturamottak	National Expert
SPAIN	Roberto Garay	Tecnalia	National Expert

Task 60 – PVT Systems

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

Task Overview

The main objectives of SHC Task 60's work on PVT collectors and systems were to:

- Improve knowledge of current PVT collectors and evaluate their risks.
- Improve collector designs and cost.
- Improve PVT collectors modelling.
- Provide a basis for the comparison of collectors with respect to technical and economic conditions.
- Give useful recommendations for standardized testing procedures and pave ways to new standards if needed.
- Identify current PVT project examples.
- Identify most interesting PVT applications in all type of climates.
- Develop system models.
- Validate models against monitored systems.
- Improve the PVT knowledge through design guidelines.
- Provide a large overview of results and experiences from PVT solutions in order to lower the barriers for market deployment and to disseminate the knowledge to all target groups.
- Support current industry and future project stakeholders by providing design guidelines and definition of performance assessment of the hybrid PVT technology (using also methods developed in other Tasks like Task 54).

To achieve these objectives, the work focused on 4 main topics:

- To gather data and report information on heating and cooling systems with PVT collectors in operation (Subtask A). This work was led by Austria
- To provide testing methods of PVT collectors of all kind that can become an international standard (Subtask B). This work was led by Germany.
- To provide models of systems with PVT collectors (Subtask C). This work was led by Spain.
- To evaluate the overall performance of PVT systems and to disseminate the Task produced information and knowledge to all identified stakeholders (Subtask D). This work was led by Switzerland.

Participating Countries

	Research Institutes	Universities	Companies
Australia			1
Austria	1	1	1
Canada			1
China		1	
Denmark		1	
France	1		2

Germany	3	4	2
Italy		2	1
Netherlands	2		1
South Africa			1
Spain	1		2
Sweden		1	
Switzerland	2		2
United Kingdom			1
TOTAL	**10**	**10**	**15**

Task Duration

This Task started in **January 2018** and ended in **December 2020**.

Collaboration with Other SHC Tasks and IEA TCPs

There was no formal collaboration with other TCPs.

Collaboration with Outside Organizations/Institutions

Outreach with Solar Heat Europe.

Collaboration with Industry

Fifteen companies participated in Task 60 at different time and levels: DualSun, Systovi, and GSE of France, PA-ID of Germany, Solarus of the Netherlands, Abora and Endef of Spain, 3F solar of Austria, Trigo energies of Canada, Solink of Italy, Consolar and SunOyster of Germany, Naked energy and Photonomi of the United Kingdom, and Sunovate of Australia. Two new PVT companies made contact the beginning of 2020: Sunthalpy of Spain and Birdseyeview of India.

There was a strong level of collaboration with five of the companies above, which is worth highlighting: Dual-Sun, Abora, Endef, Sunovate, and Naked Energy.

Key Results

The main deliverables of this Task are highlighted below. More details can be found on the SHC Task 60 webpage, https://task60.iea-shc.org/.

Subtask A: PVT Systems in Operation *(Subtask Leader: Thomas Ramschak, AEE Intec, Austria)*

No.	Deliverable	Month
A1	Collection of data sheet on existing PVT systems and solutions	April 2020

Subtask B: PVT Performance Characterization *(Subtask Leader: Korbinian Kramer, Fraunhofer ISE, Germany)*

No.	Deliverable	Month
B1	Methods for testing PVT collectors + equations + PVT performances	November 2020
B2	Design Guidelines for PVT collectors and systems	October 2020 and on Research Gate

Subtask C: PVT System Modelling *(Subtask Leader: Asier Sanz, Tecnalia, Spain)*

No.	Deliverable	Month
C1	Numerical simulation tools for the simulation of PVT collectors and systems	November 2020
C2	PVT systems simulation and validation	December 2020

Subtask D: PVT System Design Examples and Dissemination and Market Support *(Subtask Leaders: Andreas Häberle and Daniel Zenhäusern, SPF, Switzerland)*

No.	Deliverable	Month
D1	Key performance indicators for PVT Systems	November 2020
D2/A2	Performance assessment of example systems	December 2020
D3	Control strategies for PVT systems *(combined with A2)*	
D4	Visualization of energy flows in PVT systems	June 2019
D5	Basic concepts in PVT technologies (also a Wikipage)	December 2020
D6	PVT subsidies survey in selected countries	October 2020
D7	Collection of documents prepared along the Task for industry and market	December 2020

Dissemination Activities

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
Thomas Ramschak et al.	Existing PVT systems and solutions *DOI 10.18777/ieashc-task60-2020-0001*	A1 May 2020
Korbinian Kramer et al.	Status Quo of PVT Characterization *DOI 10.18777/ieashc-task60-2020-0004*	B1 Oct 2020
Manuel Lämmle et al.	https://en.wikipedia.org/wiki/Photovoltaic_thermal_hybrid_solar_collector	Wikipedia
Jean-Christophe Hadorn et al.	Design Guidelines for PVT Collectors	B2 July 2020
Asier Sanz et al.	Numerical Simulation Tools for the simulation of PVT collectors and systems	C1 WIP
Daniel Zenhäusern et al.	Key Performance Indicators for PVT Systems *DOI: 10.18777/ieashc-task60-2020-0007*	D1 Oct. 2020
Maike Schubert et al.	Performance assessment of example PVT systems	D2 December 2020

Danny Jonas	Vizualisation of energy flows in PVT systems	D4 May 2019
Manuel Lämmle et al.	Basic concepts of PVT collector technologies, applications and markets *DOI: 10.18777/ieashc-task60-2020-0002*	D5 May 2020
Alois Resch et al.	2020 Subsidies for PVT collectors in selected countries *DOI: 10.18777/ieashc-task60-2020-0005*	D6 July 2020
Daniel Zenhäusern, Jean-Christophe Hadorn	Collection of documents prepared along the Task for industry and market	D7 December 2020
Jean-Christophe Hadorn et al.	Technology position paper	December 2020

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
	13 papers	EuroSun 2018	http://proceedings.ises.org/?conference=eurosun2018
	14 papers	SHC 2019/SWC 2018	http://proceedings.ises.org/?conference=swc2019
	6 papers	EuroSun 2020	http://proceedings.ises.org/

Conferences, Workshops, Seminars, etc.

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	If Task Hosted: Organized with, # participants
EuroSun 2018	14 papers + 14 posters and 2 sessions as chairman 350 attendees	September 2018, Rapperswil, Switzerland	

SHC Solar Academy webinar https://www.youtube.com/watch?v=n1JA-xcclN8&t=3049s	PVT Systems JC Hadorn, Werner Weiss, Bärbel Epp	June 2018	200+ online 735 views
SHC 2019/SWC 2019	5 papers + Keynote Interview with Subtask B leader	November 2019 Santiago, Chile	400+
EuroSun 2020	6 papers + posters	September 2020	200 online
SHC Solar Academy webinar https://www.youtube.com/watch?v=N8YlqODkbpA	PVT Certification Andreas Häberle, et al	April 2019	47 online 282 views
SHC Solar Academy webinar https://www.youtube.com/watch?v=CdVFqzbSNP8	PVT Systems JC Hadorn, et al	March 2020	450 online 968 views
Webinar held by EnerPlan of France	JC Hadorn et al	April 2020	104 online In French

Task Meetings

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

1. Zurich, Switzerland March 2017
2. Abu Dhabi, UAE October 2016
   (in conjunction with SHC 2017)

Over the entire term of the Task a total of 6 Experts Meetings were held and 2included an industrial workshop. One more industrial workshop was planned, but due to the pandemic it was cancelled.

Meeting	Date	Location	# of Participants
Experts Meeting 1 + Industry workshop	May 16-18, 2018	Freiburg, Germany	44
Experts Meeting 2	October 18-19,2 018	Zaragoza, Spain	46
Experts Meeting 3 + Industry workshop	May 8-10, 2019	Eindhoven, Netherlands	46
Experts Meeting 4	October 9-11, 2019	DTU, Lyngby, Denmark	28
Experts Meeting 5	April 23-24, 020	Virtual	25
Experts Meeting 6	September 4, 2020	Virtual	25

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	Industry
AUSTRIA	Thomas Ramschak	AEE INTEC	Subtask A Leader
AUSTRIA	Alois Resch	FH Weiss	National Expert
CANADA	Christian Vachon	Trigo Energies Inc.	Industry
CHINA	Ruobing Liang	Dalian UT	National Expert
CHINA	Liangdong Ma	Dalian UT	National Expert
CHINA	Jili Zhang	Dalian UT	National Expert
CHINA	Peng Wang	Dalian UT	National Expert
CHINA	Shen Dandan	Low carbon E tech	National Expert
DENMARK	Mark Dannemand	DTU BYG	National Expert
DENMARK	Simon Furbo	DTU BYG	Expert
DENMARK	Adam Jensen	DTU BYG	National Expert
DENMARK	Ioannis Sifnaios	DTU BYG	National Expert
FRANCE	Jean-Baptiste Beyssac	CESP Univ. Perpignan	National Expert
FRANCE	David Chèze	CEA	National Expert
FRANCE	Gabriel Blaise	Dualsun	Industry
FRANCE	Laetitia Brottier	Dualsun	Industry
FRANCE	Mohammed Benandelkarim	Systovi	Industry
GERMANY	Joseph Bergner	HTW Berlin	National Expert
GERMANY	Sonja Helbig	Institute Solarenergieforschung Gmbh	National Expert
GERMANY	Danny Jonas	University Saarbrücken	National Expert
GERMANY	Andreas Jurack	HTW Berlin	National Expert
GERMANY	Johannes Kneer	SunOyster	Industry
GERMANY	Korbinian Kramer	Fraunhofer ISE	Subtask B Leader

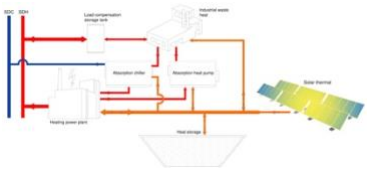
GERMANY	Manuel Lämmle	Fraunhofer ISE	National Expert
GERMANY	Thomas Noll	Easy-tnt	Industry
GERMANY	Markus Proell	ZAE Bayern e.V.	National Expert
GERMANY	Danjana Theis	HTW Saar	National Expert
ITALY	Antonio Gagliano	University Catania	National Expert
ITALY	Marco Pellegrini	University Bologna	National Expert
ITALY	Giuseppe Tina	University Catania	National Expert
NETHERLANDS	Corry De Keizer	SEAC-TNO	National Expert
NETHERLANDS	Oscar Mogro	BDR Thermea BV	Industry
NETHERLANDS	Len Rijvers	Eindhoven University of Technology	National Expert
NETHERLANDS	Manuel Vargas Evans	Solarus Sunpower	Industry
RSA	Sibusiso Dlamini	Johannesburg Univ	National Expert
SPAIN	Marta Cañada	ABORA	Industry
SPAIN	Daniel Chemisana	UDL Cat	National Expert
SPAIN	Alejandro Del Amo Sancho	ABORA	Industry
SPAIN	Norberto Fueyo	University of Zaragoza	National Expert
SPAIN	Isabel Guedea	EndeF Engineering	Industry
SPAIN	Maria Herrando	University of Zaragoza	National Expert
SPAIN	Asier Sanz Martinez	TECNALIA	Subtask C Leader
SPAIN	Raquel Simon	EndeF Engineering	Industry
SPAIN	Omar Suarez	Sunthalpy	Industry
SWEDEN	Diogo Oliveira Cabral	University Gävle	National Expert
SWEDEN	João Gomes	Solarus Sunpower	Industry
SWEDEN	Puneet Saini	Högskolan Dalarna	National Expert
SWITZERLAND	Daniel Zehnhäusern	SPF	Subtask D Leader
SWITZERLAND	Andreas Häberle	SPF	Alternate Subtask D Leader
SWITZERLAND	Jürg Rohrer	ZHAW	National Expert
SWITZERLAND	Maike Schubert	SPF	National Expert
SWITZERLAND	Andreas Witzig	ZHAW	Industry

UNITED KINGDOM	James Bererton	Consultant	National Expert
UNITED KINGDOM	John Quinn	Photonomi	Industry
UNITED KINGDOM	Eric Hawkins	Consultant	Industry
UNITED KINGDOM	Adrian Murrell	Naked Energy	Industry
UNITED KINGDOM	Alexander Mellor	Naked Energy	Industry

6. Ongoing Tasks

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

Sabine Putz
SOLID Solar Energy Systems GmbH
Operating Agent for the Republic of Austria



Task Overview

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 (Germany)

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.

The expected outcomes are collection of best practice examples and case studies; energetic, ecologic and economic assessments of the overall solar DHC system; possible transformation strategies of DHC networks towards high shares of ST; lessons learnt on challenges and benefits of ST integration; and optimized control strategies and hydraulic options for the integration of SHC systems into DHC networks.

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

The main research objective of Subtask B is 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 economic aspects and the promotion of results from SHC Task 55. Large scale solar thermal systems require sophisticated financing models due to high initial investment costs. Different business models are already in place and facilitate the realization of large systems. The subtask will assist planers, architects, system designers and district heating providers in their efforts for the integration of DHC applications. Stakeholders face several economic challenges and risks and can benefit from the deliverables of this subtask.

Best practice examples will collect information on different system types already in operation. Moreover, the subtask will assist the other subtasks in the promotion and dissemination of their results.

Collaboration with other IEA TCPs

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

Collaboration with Industry

Around 20 industry companies have actively provided expertise to SHC Task 55. As most of them are not funded for the Task work their contribution is explicitly to highlight.

Several SDH installations were built as a result of cooperation that started during the first Task meetings. For example, the installation of a solar district heating plant in Langkazi, Tibet, link. As the SDH market is still a niche market, the strategic business cooperation established amongst the Task Experts over the Task's duration is a very important outcome.

Task Duration

The Task started September 2016 and ended December 2020.

Participating Countries

Austria, Canada, China, Denmark, Finland*, France, Germany, Italy, Spain, Sweden, United Kingdom
Observer: The Netherlands
**Through IEA DHC*

Work During 2020

Subtask A: Network Analyses and Integration

- In synergy with D-D3 in Subtask D, the best-practice collection (with 17 installations) was uploaded on Task webpage.
- Economic analysis of overall DHC network supply strategies, transition strategies, heat demand, and energy price scenarios, posted on Task webpage as Fact Sheets.
- Techno-economic comparison of the collected best-practice examples, Fact Sheet posted on Task webpage.
- The Fact Sheet, "The future of SDH in different European countries," was finalized the end of 2020 and will be available on the Task webpage by June 2021.
- SWOT analysis of solar thermal integration in district heating and cooling, Fact Sheet posted on Task webpage.
- Feasibility analysis of hybrid technologies for DHC including ST, Fact Sheet posted on Task webpage.
- Integration concepts of central ST systems in DHC, Fact Sheet posted on Task webpage.
- Integration concepts of decentral solar thermal systems in DHC, Fact Sheet posted on Task webpage.
- Large-scale thermal energy storage systems to increase the ST share in DHC, Fact Sheet posted on Task webpage.
- Supervisory control of large-scale solar thermal systems. Fact Sheet under review and will be posted in 2021.

- Control of DHC networks and reduction of the operating temperatures in DH systems. Fact Sheet under review and will be posted in 2021.

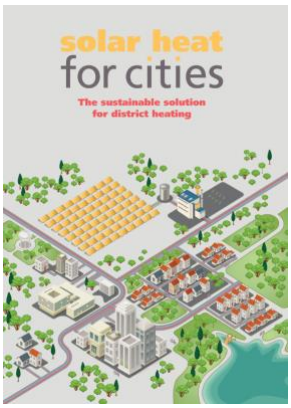
Subtask B: Components Testing, System Monitoring, and Quality Assurance

- Improved in situ performance testing of line-concentrating solar collectors: Comprehensive uncertainty analysis for the selection of measurement instrumentation, summarized in an ELSEVIER paper and posted on Task webpage.
- Solar energy - Collector fields - Check of performance: Fact Sheet according to ISO 24194 posted on Task webpage.
- Control of large-scale solar thermal plants, Fact Sheet under review and will be posted in 2021.
- Automated monitoring solar thermal, Fact Sheet posted on Task webpage.

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

- Long-term thermal performances of solar collector fields: Measured and calculated, Fact Sheet posted on Task webpage.
- Solar radiation modelling on tilted surfaces based on global radiation, Fact Sheet posted on Task webpage.
- Collector types for large collector fields - thermal performance, Fact Sheet posted on Task webpage.
- CFD models of different collector types, Fact Sheet posted on Task webpage.
- Seasonal pit heat storages – Guidelines for materials & construction, Fact Sheet posted on Task webpage.
- Thermal and hydraulic investigation of large-scale solar collector field, Publication posted on the Task webpage as an ELSEVIER paper.

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



- Business Models of Solar Thermal and Hybrid Technologies published on Task webpage.
- Published an investor brochure, *Solar Heat for Cities: The Sustainable Solution for District Heating* (http://task55.iea-shc.org/publications). Info charts from the publication are also on the Task webpage (http://task55.iea-shc.org/). Translated into Chinese and Turkish.
- Identification and preparation of Best Practice Examples: In synergy with Subtask A, the best-practice collection (with 17 installations) was uploaded on Task webpage.
- Evaluation of diverse global market developments for large scale SDH/SDC and country reports: Country reports on 7 of the largest SDH installations.

  EnRSIM calculation tool for renewable district heating (technical and economic), Fact Sheet posted on Task webpage.

Task 55 Follow-On Task

The Task Definition Phase has started for a follow-on Task. Mr. Viktor Unterberger of Austria is the Task Organizer.

Investor Brochure

Within Subtask D the investor brochure “Solar Heat for Cities” was published in November 2019 to raise awareness and interest about this technology and facilitate the entry of investors into SDH by answering their key questions. Successful case studies and testimonials that prove the key advantages of using SDH are a core part of the brochure. The brochure contains very useful info charts and general information about large scale SDH as well as several case studies of SDH installations in Denmark, China, Serbia, Austria, France, Latvia and Germany.

SDH markets are growing in Denmark, Germany, China and new markets are starting like in France, Italy, Poland, Spain etc. To increase the market share of SDH in new and existing markets, communication efforts are necessary. Therefore, one important activity in Subtask D is the publishing of the brochure in English and Turkish and soon in Chinese.

UK Training Workshop on Renewable Heat for Heat Networks

In December 2019, Triple Point Heat Networks Investment Management, in collaboration with the SHC TCP, hosted a workshop in the UK on Renewable Heat for Heat Networks. The workshop built upon the success of the March 2019 UK Solar Academy on Solar Heat Networks: Policy, Planning, Design and Performance. This second workshop was aimed at people either participating or seeking to participate in the HM Government Heat Network investment Project (HNIP) and provided attendees with a good grasp of what solar heat networks are, as well as supplying them with the resources they need to include solar in their heat network projects. IEA Solar Heating and Cooling TCP Task 55 (Towards the Integration of Large SHC Systems into District Heating and Cooling Networks) experts discussed the role which solar could play in decarbonising UK heat networks, providing examples from other projects across the world, discussing how these had been achieved, and providing evidence of the level of decarbonisation these had attained.

Four national experts of Task 55 spoke about the role of solar in heat networks. These experts were:

- Magdalena Kowalska from the renewable energy planning company, PlanEnergi, in Denmark
- Christian Holter from the solar engineering company, SOLID, in Austria
- Grant Feasey from the solar collector manufacturing company, AES Solar, in England
- Renaldi Renaldi from Oxford Martin School at the University of Oxford, in England

The SHC speakers were supported by experts from the IEA Heat Pumping Technologies TCP (Roger Hitchin), the IEA District Heating TCP (Dr Anton Ianakiev and Robin Wiltshire) and the Danish Embassy in the UK (Jacob Byskov Kristensen).

The workshop was fully booked, with the capacity of 120 attendees being reached within the first couple of weeks of registration. This clearly demonstrates the level of interest in solar as a component in heat networks and the demand for expert knowledge of their implementation.

Chair Election RHC Horizontal Working Group Renewable Districts

Heating & cooling and hot water preparation account for over half of the energy demand in buildings. Paired with an increasing urbanization rate, this demand defines one of the key challenges of the energy transition in Europe (and beyond): How to decarbonize heating & cooling in urban districts? The HWG will be tasked in 2021 with the development of a roadmap supporting the decarbonization of urban districts across Europe. On top a vision for 2050 is prepared and all results communicated towards policy-makers (e.g., European Commission) in the form of a briefing. Sabine Putz as SOLID´s Head of R&D and Operating Agent of IEA SHC TASK 55 “Towards the Integration of Large SHC Systems into District Heating and Cooling (DHC) Networks” will lead this group as chair. https://www.rhc-platform.org/meet-the-new-hwg-districts-chair-and-co-chair/

Work Planned For 2021

Task 55 officially ended in December 2020. In 2021 the remaining 5 Fact Sheets will be finalized and posted on the Task webpage.

Dissemination Activities In 2020

Reports, Published Books

Author(s)/Editor	Title	Report No. Publication Date
	19 Fact Sheets	https://task55.iea-shc.org/fact-sheets

Journal Articles, Conference Papers, etc.

Author(s)/Editors	Title	Publication/Conference	Bibliographic Reference
Unterberger, V., Muschick, D., Loidl, A., Poms, U. R., Gölles, M., & Horn, M. (2020).	Model-based control of hydraulic heat distribution systems — Theory and application	Control Engineering Practice, 101, [104464].	https://doi.org/10.1016/j.conengprac.2020.104464
Kaisermayer, V., Muschick, D., Gölles, M., & Horn, M. (2020).	Progressive Hedging for Stochastic Energy Management Systems: The Mixed-Integer Linear Case. Energy Systems	Control Engineering Practice, Elsevier	https://doi.org/10.1016/j.conengprac.2020.104464
Moser, A. G. C., Muschick, D., Gölles, M., Nageler, P. J., Schranzhofer, H., Mach, T., Hofer, A. (2020).	A MILP-based modular energy management system for urban multi-energy systems: Performance and sensitivity analysis	Applied Energy, 261, [114342].	https://doi.org/10.1016/j.apenergy.2019.114342
Ochs, Fabian; Dahash, Abdulrahman; Tosatto, Alice and Bianchi Janetti, Michele (2020).	Techno-economic planning and construction of cost-effective large-scale hot water thermal energy storage for renewable district heating systems	Renewable Energy Elsevier	Renewable Energy, 150, 1165-1177. DOI: 10.1016/j.renene.2019.11.017.
Dahash, Abdulrahman; Ochs, Fabian; Tosatto, Alice and Streicher, Wolfgang. (2020).	Toward efficient numerical modeling and analysis of large-scale thermal energy storage for renewable district heating	Applied Energy	Applied Energy, 279, 115840. DOI: 10.1016/j.apenergy.2020.115840.
Paolo Leoni, Roman Geyer, Ralf-Roman Schmidt	Developing innovative business models for reducing return temperatures in district heating systems: Approach and first results	Energy	Vol. 195, 2020, 116963 https://doi.org/10.1016/j.energy.2020.116963
Tschopp, D., Tian, Z., Berberich, M., Fan, J., Perers, B., Furbo, S., 2020:	A review and comparative study of Denmark, China, Germany and Austria.	Applied Energy, 270, 114997,	doi.org/10.1016/j.apenergy.2020.114997
Tschopp, D., Jensen, A. R., Dragsted, J., Ohnewein, P., Furbo, S.,	Measurement and modeling of diffuse irradiance masking on tilted planes for solar engineering applications	under review at Applied Energies	
Zlabinger, S., Unterberger, V., Gölles, M., Horn, M., Wernhart, M., & Rieberer, R. (2020).	Development and experimental validation of a linear state-space model absorption heat pumping systems for model-based control strategies	In T. Meyer (Ed.), ISHPC 2021 proceedings – online pre-conference 2020 (pp. 191 -195). Technische Universität Berlin	https://doi.org/10.14279/depositonce-10430.2
Tschopp, Daniel	Review of In situ Test Methods for Solar Thermal Installations		

SOLITES	SDH newsletter; News about SDH market, promotion of the brochure “Solar Heat for Cities”	www.solar-district-heating.eu; April 2020	https://www.solar-district-heating.eu/solar-heat-for-cities-iea-brochure-and-infographics/
Putz, S.	SHC Solar Update newsletter contributions	June and October 2020	
Epp, B.	1 GW - Danish SDH market reaches new milestone	Solarthermalworld.org	https://www.solarthermalworld.org/news/danish-sdh-market-reaches-new-milestone
Newsletter Fernwärme/Kälte	Newsletter Fernwärme/Kälte		
Epp, B.	Success Factors in top SDH countries	June 2020	
Epp, B.	Improved design for giga-size pit heat storage GBP 320 million for low-carbon heat networks	October 2020	

Conferences, Workshops, Seminars, etc.

Conference/ Workshop/ Seminar	Activity & Presenter	Date & Location
6th International Conference on Smart Energy Systems	Paolo Leoni, Aurelien Bres, Ilaria Marini, Alessandro Capretti; Lowering the operating temperatures in old-generation district heating systems: first results from the TEMPO demonstration project in Brescia (Italy)	6 - 7 October 2020 Virtual
In T. Meyer (Ed.), ISHPC 2021 proceedings – online pre-conference 2020 (pp. 191 -195). Technische Universität Berlin	Zlabinger, S., Unterberger, V., Gölles, M., Horn, M., Wernhart, M., & Rieberer, R. (2020).; Development and experimental validation of a linear state-space model absorption heat pumping systems for model-based control strategies https://doi.org/10.14279/depositonce-10430.2	August 2020 Virtual
13th International Conference on Solar Energy for Buildings and Industry (EuroSun 2020)	Putz, S. ; Results of IEA SHC TASK 55 “Towards the Integration of Large SHC Systems into DHC Networks	September 1 – 3, 2020 Virtual
13th International Conference on Solar Energy for Buildings and Industry (EuroSun 2020)	Dahash, Abdulrahman; Ochs, Fabian and Tosatto, Alice: Advances in modeling and evaluation of large-scale hot water	September 1 – 3, 2020 Virtual

	tanks and pits in renewable-based district heating	

Dissemination Activities Planned For 2021

Abstract submitted by Putz, S. for 17th International Symposium on DHC in Nottingham, September 2021

Abstract submitted by Putz, S. for Euroheat & Power Congress, May 2021

Plan to submit an abstract for the ISEC, 2nd International Sustainable Energy Conference, Graz, October 2022

SHC Technology Position Paper. June 2021

Task Meetings 2020

Meeting	Date	Location	# of Participants (# of Countries)
Final Experts Meeting	October 13 - 14, 2020	Virtual	51 (11)
Technology Transfer Workshop	October 15, 2020	Virtual	72 (11)

SHC Task 55 Participants

Country	Name	Institution / Company	Role
AUSTRIA	**Sabine Putz**	**SOLID**	**Operating Agent**
AUSTRALIA	Ken Guthrie	Sustainable Energy Transformation Pty Ltd	National Expert
AUSTRIA	Christian Engel	Thermaflex Int Holding	National Expert
AUSTRIA	Christian Fink	AEE INTEC	National Expert
AUSTRIA	Christian Holter	SOLID	National Expert
AUSTRIA	Daniel Tschopp	AEE INTEC	National Expert
AUSTRIA	Daniel Muschick	BIOENERGY 2020+ GmbH	National Expert
AUSTRIA	Fabian Ochs	University of Innsbruck	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	Subtask A Leader
AUSTRIA	Viktor Unterberger	Bioenergy 2020+ GmbH	National Expert
AUSTRIA	Werner Doll	SOLID	National Expert
CANADA	James Bererton	Naked Energy	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

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ITALY	Marco Calderoni	Polimi	National Expert
ITALY	Roberto Fedrizzi	Eurac Research	National Expert
ITALY	Marco Scarpellino	TVP Solar	National Expert
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Task 59 – Renovating Historic Buildings Towards Zero Energy

Alexandra Troi
EURAC Research
Operating Agent for ENEA

Task Overview

Historic buildings represent a large share of the existing building stock. They are the trademark of numerous cities, and they will only survive if maintained as a living space. In order to preserve this heritage, we need to find conservation compatible energy retrofit approaches and solutions, which allow to maintain the historic and aesthetic values while increasing comfort, lowering energy bills and minimizing environmental impact.

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.

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
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
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
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
Transfer of knowledge created in the Task to relevant stakeholders.

Collaboration with Other IEA TCPs

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

Collaboration with Industry

Stakeholders of Task 59 are besides the building owners, clearly architects and planners as well as craftsmen and constructors but also public authorities and policy makers. They all are addressed in different ways in order to gather their input and needs and bring results to their realities.

Task Duration

The Task started in September 2017 and was scheduled to end in February 2021, but due to COVID19 related delays and the final Task conference scheduled for April 14-16, 2021, the end date was moved to April 2021.

Participating Countries

Austria, Belgium, Denmark, France, Germany, Ireland*, Italy, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States* *(thru IEA EBC/EBC PVPS)*

Work During 2019

Subtask A: Knowledge Base

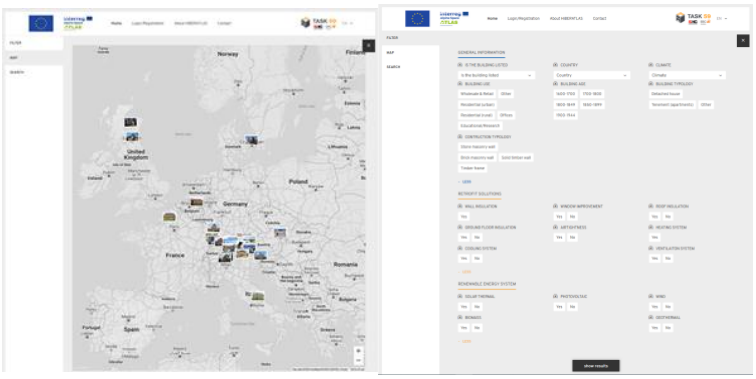
The website on best practices, the Historic Building Energy Retrofit Atlas (HiBERATLAS), www.hiberatlas.com, has been an online beta version since October 2019. It has been publicized through different channels, including at the Renovate Europe Day in the European Parliament and by Architects Council of Europe contacts. HiBERATLAS is being used as a trigger for social media communications (see Subtask D). Google analytics show there is steady use of HiBERATLAS, despite it being a beta version with a limited number of published cases. The share of new users is high and as the map below shows viewers are from all over the world.

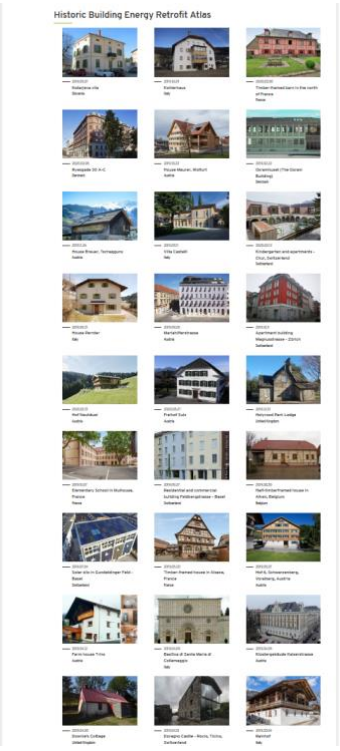
Google analytics screenshot for 2020.

With the last modifications and changes, the final version of HiBERATLAS will be released the beginning of 2021. The final changes include:

- final privacy IP forms
- map
- filter (screenshot of foreseen filters below)
- search function

HiBERATLAS is being developed to continue after SHC Task 59 ends so a major effort has been placed on developing a user-friendly backend for adding cases, user management, and the integrated process of gathering IP and privacy forms.

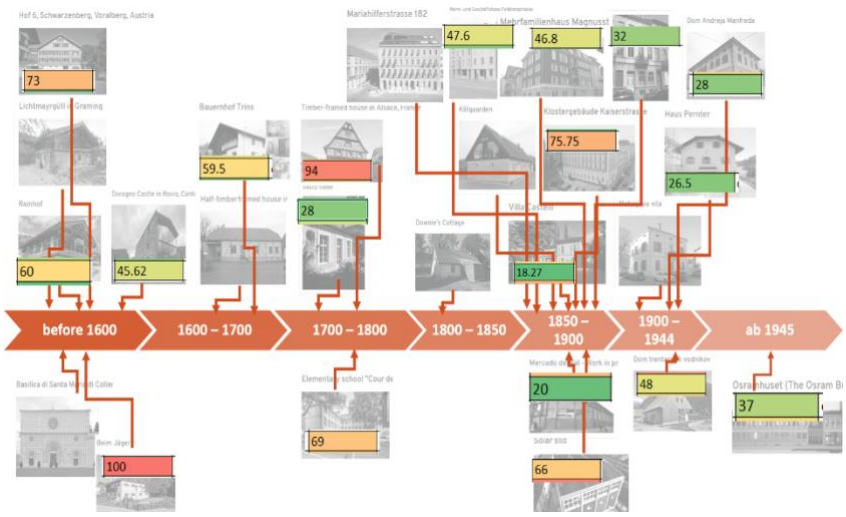




Maps and filters in the HiBERATLAS.

In 2020, a **version one of the assessment report**, based on the finished or nearly finished best practice cases (a total of ~25), was prepared. This process included 1) the decision on the report structure and 2) the actual analysis of the first tranche of cases in the database. Besides a quantitative assessment, it also has a qualitative part focused on the "Replicability of Case Studies" and "Transferability of favorable framework conditions."

During the expert meeting in Autumn, a number of hypotheses based on this draft report were discussed and some preliminary conclusions were drawn:



The variety of presented best practice is considerable – ranging from buildings from before 1600 to those built after 1945.

Renovation process/Integrated planning/evaluation:

- An early and iterative dialogue between the planning team and the heritage authorities is in many ways a key to a successful end result and an efficient planning process
- Engaged clients can contribute to the project in many ways, from identifying what is worthy of preserving to customizing solutions
- Limited project budgets can hamper innovative solutions which might be more efficient over the whole life cycle

Retrofit solutions/Building envelope/Renewable energy:

- Are solutions replicable? Is this important?
  - Also from an economic point of view
  - Importance of situation of the building pre-intervention
- Are solutions usable to others in their present form?
  - Inspiration vs. Implementation
- Is it a problem that 75% of case studies are residential? Are the solutions still representative?
  - residential buildings are very representative in Europe, so HiBERATLAS representation covers what is most important in Europe

Favorable conditions / Policy recommendations:

- In many of the examples, interaction and overlapping of several favorable framework conditions (research project - financial support for innovative measures - committed and experienced planning team)
- "Classic financial incentive" models (tax reductions, subsidies, soft loans) plus alternative approaches such as sponsoring by private companies and private investors (Solar Silo, Basilica Santa Maria di Collemaggio)
- The public sector can play a very important role as owner when it comes to exemplary redevelopment and the development of innovative projects that are also open to the public (Osramhuset, Holyrood Lodge)
- Similarly, in the case of **Alpine farmhouses**, the **owners play a central role**. Here, the generational change in ownership seems to play an important role in the life cycle, where important decisions are made on how to deal with historic buildings.
- Some of the favorable framework conditions have considerable **potential for transferability**

- **Research programs** that focus on the high-quality renovation of historic buildings and thus enable the implementation, but also the documentation and detailed monitoring of demonstration projects
- National or regional authorities should also provide **targeted financial incentives** to make better use of the possibilities for energy-efficient renovation of historic buildings.

The results of these discussions will feed into the final report, which will be based on the complete set of 50 best practice cases.

Draft conclusions include:

- Case studies provide a **good overview of the broad range of examples** – different buildings, different starting points, different strategies, and different technical solutions – to improve EE and include RES
- Case studies provide **direct access to more detailed information on technical solutions** (including detailed values, drawings, etc.)

→ Basically, there is no reason to exclude the energy efficiency and renewables issue when it comes to retrofit.

HiBERATLAS has proven to be a valuable **source and working tool for a university course** at Coburg University, where 15 students from architecture, interior architecture, and heritage design learned about renovating historic buildings by analyzing and documenting six best practice buildings for HiBERATLAS. Their final presentation was combined with bringing the Travelling Exhibition to Coburg University. This experience was repeated in the winter term 2020/21.

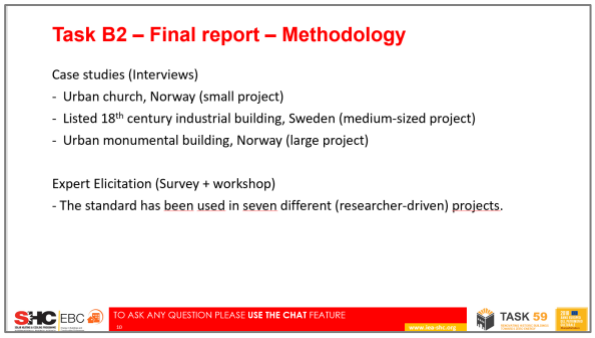
The Best Practices collected as of Autumn 2020 total 31 cases (IT 8, AT 8, CH 5, FR 3, DK 2, UK 2, SL 2, BE 1), some are from the ATLAS project. Additional case studies are expected, including 3 from Belgium, 2 from Germany, 2 from Turkey, 1 more from Italy, 1 from the US, 2 from Spain, 2 from Sweden, 2 more from the UK, and 2 from Switzerland.

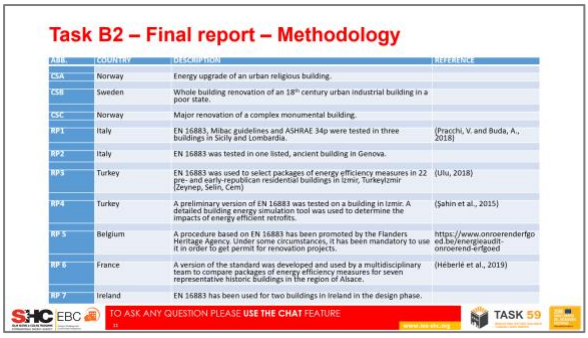
Subtask B: Multidisciplinary Planning Process

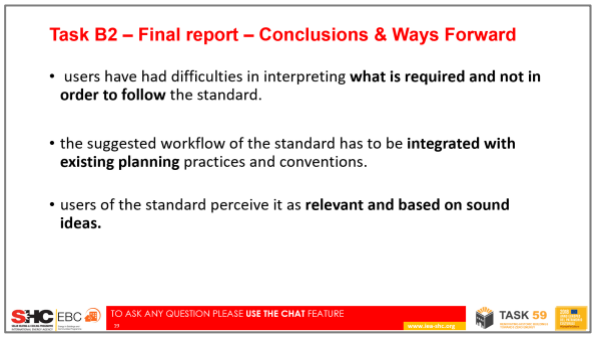
As for Subtask B, the fact sheets' editing has concluded, and they are available for the ExCo. List of fact sheets and coordinating author: 1) Literature, Alessia Buda, 2) Assessment Heritage Value, Petra Eriksson, 3) LCA/LCC, Tor Broström, 4) Guidelines, Alessia Buda, and 5) Certifications, Elena Lucchi.

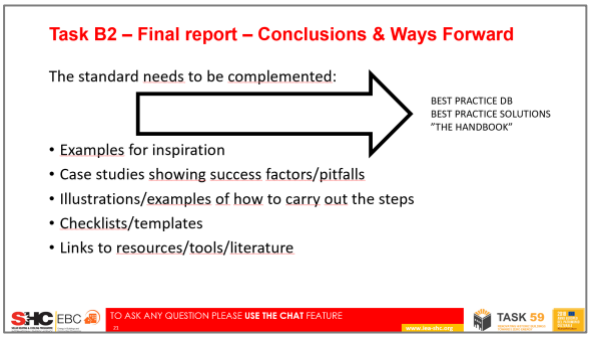
As announced in the last annual report, the Subtask B5 content presented by Fabrizio Leonforte to the Task experts and included in the paper on "Dynamic thermal and hygrometric simulation of historical buildings: critical factors and possible solutions" was elaborated on by Task 59 experts and was accepted in February 2020 by the *International Journal on Renewable & Sustainable Energy Reviews*. A second paper on the calibration of models and connected to the development of an excel sheet for the easy determination of statistical indexes was also accepted by this journal in August 2020 (see dissemination).

Significant work was done in 2020 in Subtask Activity B2, the Assessment of the European standard EN 16883 *Conservation of cultural heritage — Guidelines for improving the energy performance of historic buildings.* This work along with deliverable D.B2 will feed into a proposal for improving the standard. The analysis was based on 3 case studies and information from experts from different countries.



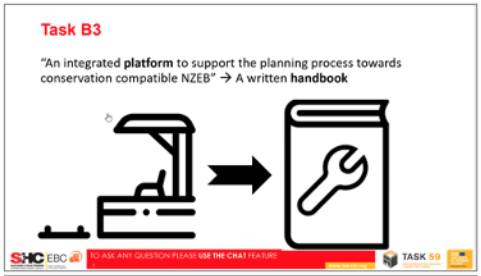


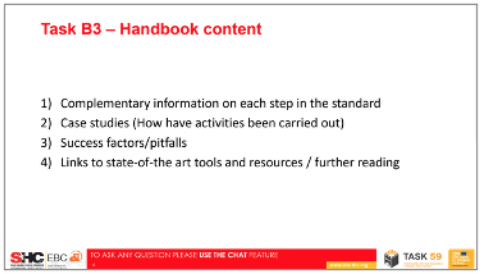


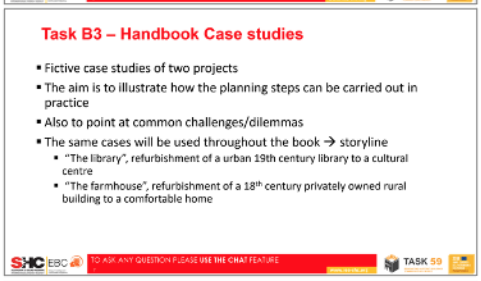


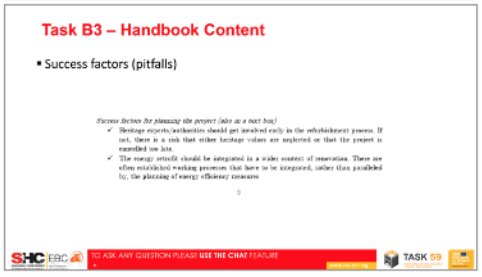
Assessment of the implementation of EN 16883 as presented at the expert meeting.

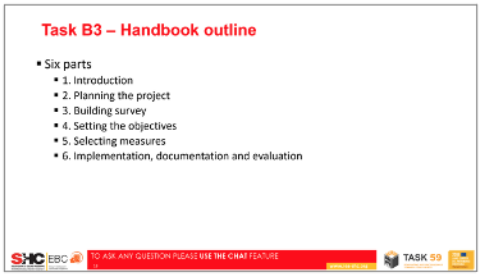
The **Integrated Platform** and its interaction with the standard EN 16883, including issues related to respective copyrights, led to a final proposal to keep the developed structure but publish it as a handbook via the Swedish standard. This option will give the experts the freedom to provide guidance on the application of the standard outside the formalized procedure but still within the "system borders." Relevant content was collected in a dedicated workshop during the 7th expert meeting in 5 groups, meeting in breakout groups, and working on padlets.

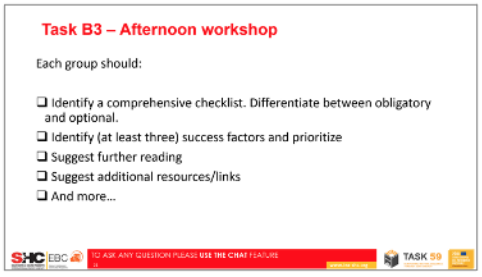












Handbook content and outline.

Subtask C: Conservation Compatible Retrofit Solutions and Strategies

The experts of Task 59 have formed working groups to work on the topics of SOLAR, HVAC, WALLS, WINDOWS, and STRATEGIES. The collection, assessment, and documentation of the solutions within these working groups has progressed well: 38 solutions were collected for the walls, 17 for windows, 43 for HVAC, and 36 for solar systems, totaling more than 130 solutions.

The draft version of Report D.C1: "Conservation compatible energy retrofit technologies," delivered in Spring 2020, summarizes and presents the results to date of the working groups. To document the solutions, experts used simple, open questions to enable a continuous structure of the solutions. In this report, the first part of the solutions are documented. Many more solutions on the different topics are in progress and will be included in the final report. In addition to the documentation of the solutions, general information and access to the technical solutions for historical buildings are described in the different working groups in the draft version of D.C1.

The Decision Guidance Tool will be developed within the Interreg project ATLAS as part of Task 59 work. The above-collected information will thus be made available to users in a very user-friendly and interactive way beyond the mere report. Thanks to the contribution of the Interreg Alpine Space ATLAS project (which is one of the contributing projects for 3 experts, namely Eurac, SUPSI, and University of Innsbruck), the so-called HiBERtool was further developed in 2020, mock-ups were discussed in the subgroups and presented at expert meetings. The tool will be presented at the final conference in April 2021.

Website HiBERtool: (1) Choosing the element, (2) Answer the questions, (3) final result: Download of the PDF Documentation of the Solution and the Link to the best practice example of the Hiberatlas [Rieser et. Al. SBE21 heritage].

The approach to combine the assessment and documentation of solutions with writing common papers has proven to be very motivating and successful. At this stage, 5 scientific papers are underway:

- Two papers from the walls working groups 1) Conservation-compatible retrofit solutions in historic buildings: an integrated approach and 2) How can scientific literature support decision-making in the renovation of historic buildings? An evidence-based guideline for improving the performance of walls
- One paper from the ventilation working group 1) Integration of energy efficient ventilation systems in historic buildings)
- One paper from the solar working group 1) Solar systems solutions for historic buildings: assessment of case studies and review of EN-16883:2017 standard
- One paper from the strategy working group 1) Review of energy retrofit decision-support tools in historical contexts, towards the definition of a system for combining conservation-compatible solutions

Each working group has adapted the assessment criteria to their specific category. For the detailed assessment: each working group has promised three detailed assessments.

Subtask D: Knowledge Transfer and Dissemination

In January 2020, a **Solar Academy webinar** was held using a new format with the goal to give a voice to the building owner and the design team through short videos and the Task experts answering their questions and concerns instead of having separated presentations.

The **Travelling Exhibition** successfully started its journey with "stopovers" in Santiago (Chile), Coburg (Germany), Stirling (United Kingdom), and Salzburg (Austria), and then COVID19 brought the tour to an end. The hope is that it will once again go to events after the pandemic.

The virtual **Adapt Northern Heritage Conference** on May 5-6 was organized by Subtask D leader Historic Scotland, and Task 59 expert Lingjun Hao (Eurac) presented part of her Ph.D. work.

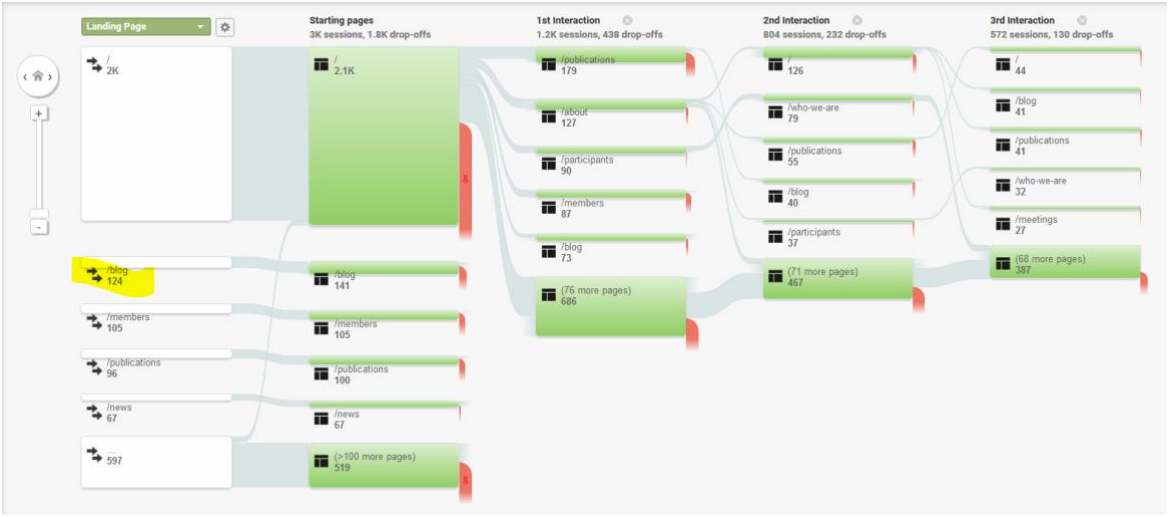
Task 59 participated in the Euro-American Congress on construction, rehabilitation, technology, and heritage management **REHABEND 2020** with three presentations (see list under dissemination activities) and was a collaborating entity.

The International Conference on Energy Efficiency in Historic Buildings **EEHB 2020** to be held in Benediktbeuern in early October 2020, which would have featured numerous Task59 contributions, was postponed by one year to Autumn 2021. However, Fraunhofer organized a virtual preview event on October 7 2020, to which also Task 59 experts Tor Broström (UU, Sweden) and Samuel Dubois (BBRI, Belgium) contributed.

- The **blog** section of the website has started well with monthly articles presented in short and easy-to-digest ways.
- Thermal performance of historical masonry structures: experimental data and numerical modeling
  December 2020 -- A. Lo Faro, V. Constanzo, G. Evola, F. Nocera - Universita di Catania
- Embedding thermal comfort into retrofitting design
  November 2020 -- A. Petsou - University College London
- SBE21 Heritage Conference, the final event of Task59
  October 2020 -- D. Herrera, A. Troi - Eurac Research
- Old buildings can't be energy efficient, right?
  August 2020 -- L. Angelaka - Historic Environment Scotland
- Sweden launches a new stage of the national research program on energy efficiency in historic buildings
  July 2020 -- T. Broström - Uppsala University, Sweden
- A spatial-based approach for enhancing the energy renovation of historic settlements
  June 2020 -- E. Lucchi, A. Troi - Eurac Research
- RIBuild guidelines for internal insulation of historic buildings
  April 2020 -- E. Jan de Place Hansen - Aalborg University, Copenhagen

- The ROP ERDF Sicily 2014/2020 for planning the energy retrofit of 106 public historic buildings
  March 2020 -- A. Buda, V. Pracchi, R. Sannasardo - Politecnico di Milano, Regione Sicilia - Dipartimento Energia
- Decision support tool for the innovative and sustainable renovation of historic buildings (HISTool) summary
  February 2020 -- W. Hüttler, D. Bachner, G. Hofer, M. Krempl, G. Trimmel, I. Wall - EEHB2018
- Dynamic thermal and hygrometric simulation of historical buildings: Critical factors and possible solutions
  January 2020 -- F. Leonforte, Ph.D - Politecnico di Milano

Google analytics show that in 2020 there were 124 direct entries to the website via the blog, plus a high number of people who explored several blog articles continued browsing on the Task website:



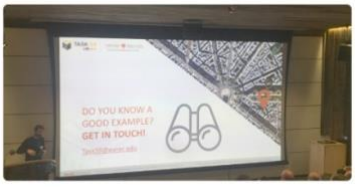
As of December 2020, Task 59 has posted **173 tweets**, which had 78.8K so-called impressions in total. This number represents a total of the times the tweets have been seen in followers' timelines. At this point, the **Twitter** account has 182 followers. This has been the **most impactful social media site**. The tweets ranged from notices about events, publications, the Task newsletter, new Task partners, and HiBERATLAS case studies.

One of the most interactive Twitter content was the tweet on Daniel Herrera's presentation of the HiBERATLAS at the engine shed, which earned 1,220 impressions.

The possibility of tagging partner organizations as well as connecting via hashtags has enabled more interaction between affiliated projects as well. For example, the hashtag #SolarHeat was often picked up and retweeted by the IEA SHC account, increasing the posts' publicity.

Top media Tweet earned 1,220 impressions

Daniel Herrera asks the audience at @HESEngineShed - do you have an example of a historic building energy efficiency retrofit? Contact us! @EURACrenewables @EURAC #energyefficiency #BestPracticeBuildings pic.twitter.com/cokqImRLwU



7 5

Three Task newsletters were published in 2020:

- Winter 2019/20 newsletter, overview of the Task's latest case studies added to the HiBERATLAS platform, new blog posts, introductions to partners University of Innsbruck and Cerema, and updates on Task meetings and workshops
- Spring 2020 newsletter, overview of Task's final conference SBE21 Heritage, latest case studies added to the HiBERATLAS platform, new blog posts, introductions to partners CARTIF, CIEMAT, and TECNALIA, and updates on Task meetings and events
- Summer 2020 newsletter, overview of Task's latest case studies added to the HiBERATLAS

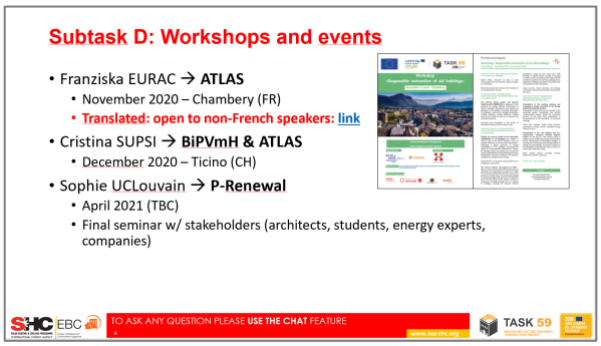
The **trade magazine campaign** led by Bärbel Epp combined offering articles on Best Practice and the HiBERATLAS translated and adapted to the specific country combined with following up with contacts resulted in a broad uptake of the information in the national languages.

Article	Country	Date	Journal/Paper
Når Energiforbruget I Historiske Bygninger Skal Reduceres	Denmark	Feb 20	Energi Forum Danmark
Hvordan Kan Energiforbruget Reduceres I Historiske Bygninger?	Denmark	Feb 20	Bygge-&Anlægsavisen
Efficienza Energetica Negli Edifici Storici: Le Strategie Per Ridurre I Consumi	Italy	February 20	Info Buildenergia
La Plataforma Hiberatlas Muestra La Rehabilitación De Edificios Históricos	Spain	Feb 20	Ecoconstrucción
¿Como Reducer El Comsumo Enérgetico En Los Edificios Históricos?	Spain	Feb 20	SolarNews
Hvordan Kan Energiforbruget Reduceres I Historiske Bygninger?	Denmark	April 20	HVAC Magazinet
Ejemplos De Buenas Prácticas En La Rehabilitación De Edificios Históricos Mediante La Plataforma Hiberatlas	Spain	April 20	Construbile
Online Plattform Für Gelungene Sanierungsobjekte	Austria	May 20	Handwerk+Bau
Come Ridurre I Consumi Energetici Negli Edifici Storici?	Italy	May 20	Rinnovabili.it
Altbau-Sanierungs-Altas	Austria	May 20	Building Times
Wie Lässt Sich Der Energieverbrauch In Historischen Gebäuden Senken?	Austria	Aug 20	Online Magazin Umwelttechn-ik, Energie und Abfallwirtschaft
Hygrothermal Performance of Traditional Buildings	UK	Winter 20	SPAB Magazine
How to Maintain Your Traditional Tenement Flat and Communal Areas	UK	July 20	Scottish Construction Now

The **final Task conference** will be held from April 14-16, 2021 in Bozen/Bolzano as part of the Sustainable Built Environment series (SBE) series and as a joint conference of Task 59, ATLAS, and Hylab.

The SBE series was launched in 2000 and has a 3 year cycle with regional conferences over two years, leading to a final global event in the third year. With Task 59, we decided to hold a regional conference within the series mainly to benefit from the popularity of the conference series and attract a larger audience, which would otherwise have been much more difficult with a project-specific final conference.

Nearly 90 abstracts were submitted and evaluated by the scientific committee. Thanks to Interreg Alpine Space project ATLAS the middle day will be organized under the topic "science meets practice" in a multilingual way (all alpine space languages, covering also numerous Task 59 languages (EN, DE, IT, FR, SL) to attract practitioners. More information can be found on sbe21heritage.eurac.edu.



Unfortunately, the stakeholder event planned in conjunction with the Spring 2020 Task meeting in Louvain-la-Neuve and then postponed to Autumn 2020, in the end could not be held due to the COVID19 restrictions. There were two stakeholder events of Task 59 held in collaboration with national and international supporting projects and one planned for 2021.

Work Planned For 2021

Subtask A: Knowledge Base

The documentation of the 50 Best Practice cases will continue into early 2021. Based on these cases, a final assessment report will be prepared. At the SBE conference, Subtask A's results will be presented in the paper, *Making deep renovation of historic buildings happen – learnings from the Historic Buildings Energy Retrofit Atlas*. Furthermore, also the teaching experience with the HiBERATLAS will be disseminated at this event.

In parallel, the continued use of the HiBERATLAS, even after Task 59 has ended, will be promoted and disseminated to research projects and programs, stakeholder associations, and last but not least as a resource and tool for education.

Subtask B: Multidisciplinary Planning Process

The assessment of the implementation of EN 16883 will be presented as a paper at SBE21 Sustainable Built Heritage, the final conference of Task 59. The Handbook will include guidance on applying the standard using two fictitious case studies – a library and a farmhouse.

Subtask C: Conservation compatible retrofit solutions and strategies

The documentation of solutions will be finalized and fed into an update deliverable at the end of the project. In parallel, the link to the decision support tool is being implemented, the decision trees are developed, and the solutions' assessment according to EN 16883. The HiBERtool will also be presented in a paper at the final conference (*A new decision guidance tool for the adoption of energy retrofit solutions in historic buildings*)
The results of the working groups will also feed into a number of scientific papers – at this stage, five papers are envisaged. Several of them will be submitted to the *MDPI* special issue "Advances in Historic Buildings Conservation and Energy Efficiency."

Subtask D: Knowledge Transfer and Dissemination

Besides some stakeholder events organized e.g., by HES (RIAS Aberdeen CPD: Hagrothermal Matters) and UC Louvain/BBRI (P-Renewal final workshop), the main event will be SBE21, which includes the final Task conference*.
* Together with Interreg project ATLAS and EFRE project Hylab, projects, which feed into Task 59.

Dissemination Activities In 2020

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Akkurt, G.G., Aste, N., Borderon, J., Buda, A., Calzolari, M., Chung, D., Costanzo, V., Del Pero, C., Evola, G., Huerto-Cardenas, H. E., Leonforte, F., Lo Faro, A., Lucchi, E., Marletta, L., Nocera, F., Pracchi, V., Turhan, C.	Dynamic thermal and hygrometric simulation of historical buildings: critical factors and possible solutions	Renewable & Sustainable Energy Reviews	Volume 118, February 2020 https://doi.org/10.1016/j.rser.2019.109509
H.E.Huerto-Cardenas, F.Leonforte, N.Aste, C.Del Pero, G.Evola, V.Costanzo, E.Lucchi	Validation of dynamic hygrothermal simulation models for historical buildings: State of the art, research challenges and recommendations	Building and Environment	Volume 180, August 2020, https://doi.org/10.1016/j.buildenv.2020.107081

Conferences, Workshops, Seminars

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	# of Attendees
Solar Academy webinar	Alexandra Troi and Daniel Herrera (Eurac), Walter Hüttler (e7), Tor Broström (UU), Pavel Sevela (UIBK)	28.1.2020	185
Energy Efficiency Seminar 2020	Julien Borderon, CEREMA: Engaging Owners in Energy Renovations: a case study of farmhouse refurbishment in Alsace, France	6.-7.2.2020	~100
Energy Efficiency Seminar 2020	Daniel Herrera, EURAC: Inspiring Good Practices	6.-7.2.2020	~100
Monumento Fair, Salzburg/Austria, 5-7 March 2020	Franziska Haas (Eurac), presentation of the Touring Exhibition		
REHABEND 2020	Aitziber Egusquiza, Josè Luis Izkara, Inaski Prieto: quiskisa3D-GIS Models to support the co.-creation of energy efficient strategies for historic urban environments	24th-27th March postponed to 28.9.-1.10.2020	
REHABEND 2020	Daniel Herrera-Avellanosa, Dagmar Exner, Franziska Haas, Alexandra Troi: Dissemination of Best-Practice in energy retrofit of historic buildings. Rainhof, a case study in the Italian Alps	24th-27th March postponed to 28.9.-1.10.2020	
REHABEND 2020	Cristina Polo Lopez, Elena Lucchi, Givanna Franco: Acceptance of building-integrated photovoltaics (PiPV) in heritage buildings and landscapes: potential, barriers and assessment criteria	24th-27th March postponed to 28.9.-1.10.2020	
EEHB 2020 postponed			
WTA international day postponed again			

Task Meetings 2020

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting 6	April 23-24, 2020	online	40
Experts Meeting 7	October 19-21, 2020	online	34
Workshop together with P-Renewal	Planned for October 2020	Louvaine-la-Neuve, Belgium	Cancelled due to COVID19

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
DENMARK	Jørgen Rose	SBI	National Expert
DENMARK	Kirsten Thomsen	SBI	Subtask D Leader
DENMARK	Ernst Jan de Place	SBI	National Expert
FRANCE	Julien Borderon	CEREMA	National Expert
FRANCE	Julien Burgholzer	CEREMA	National Expert
FRANCE	Elodie Héberié	CEREMA	National Expert
GERMANY	Arnulf Dinkel	Fraunhofer	National Expert
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
ITALY	Niccolo Aste	POLIMI	National Expert
ITALY	Claudi Delpero	POLIMI	National Expert
ITALY	Fabrizio Leonforte	POLIMI	National Expert

ITALY	Enrico Deangelis	POLIMI	National Expert
ITALY	Valeria Pracchi	POLIMI	National Expert
ITALY	Alessia Buda	POLIMI	National Expert
ITALY	Harold Enrigue Huerto Cardenas	POLIMI	National Expert
ITALY	Pietromaria Davoli	UNIFE	National Expert
ITALY	Marta Calzolari	UNIFE	National Expert
ITALY	Giovanna Franco	UNIGE	National Expert
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
ITALY	Antonio Gagliano	UNICT	National Expert
SPAIN	Cesar Valmaseda	CARTIF	National Expert
SPAIN	Jesus Samaniego	CARTIF	National Expert
SPAIN	Miguel Angel Garcia	CARTIF	National Expert
SPAIN	Sonia Alvarez	CARTIF	National Expert
SPAIN	Emanuela Giancola	CIEMAT	National Expert
SPAIN	Eduardo Garcia	CUPA	National Expert
SPAIN	Aitziber Egusquiza	TECNALIA	National Expert
SPAIN	Ander Romero	TECNALIA	National Expert
SWEDEN	Tor Broström	UU	Subtask B Leader
SWEDEN	G. Leijonhufvud	UU	National Expert
SWEDEN	Petra Eriksson	UU	National Expert
TURKEY	Gülden Gökçen Akkurt	IYTE	National Expert
TURKEY	Zeyenep Durmuş Arsan	IYTE	National Expert
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 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 the 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 the allocation of the 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 Practitioners (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 network activities

to help 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, referred by the EBC TCP as EBC Annex 77.

Task Duration

This Task started in January 2018 and will end in June 2021.

Participating Countries

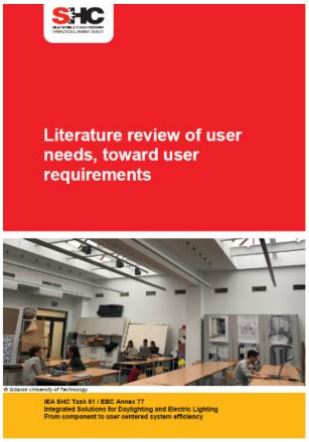
Australia, Austria, Belgium, Brazil*, Canada, China, Denmark, Germany, Italy, Japan*, Netherlands, Norway, Poland*, Slovakia, Sweden, Switzerland, United States*. **Through EBC TCP*

Work During 2020

Subtask A: User Perspective and Requirements

In between the spring and fall virtual Task Meetings, the subtask held Webex meetings.

A.1 - User Requirements. Activity closed. The report, *Literature review of user needs, toward user requirements'* is posted on the Task webpage. In parallel, a scientific paper based on the content of the A.1 report was submitted for publication.



A.2 - Use-Cases. Use cases ("profiles") – typical daily occupancy schedules with specific multi-criteria lighting needs as a function of activities in the space – are under development for main building types like a) education buildings, b) offices, c) healthcare premises, and d) industrial buildings. For this, standards and requirements (CIE, CEN, ISO, DIN) have been reviewed. Occupancy behavior in non-residential buildings has been analyzed in a literature review. Occupancy simulation and registration has been addressed. The structure of the report is set, covering the chapters, which are currently written by different authors: 1) Introduction, 2) Building Codes and Requirements, 3) Use of buildings 4.1) Occupancy simulation, and 4.2) Occupancy registration. To study the use of lighting in buildings, both electric lighting and daylight, the approach of lighting diaries, which require user responses, will be used.

The Internal draft document of report A.2 was expected September 2020 but is delayed mainly due to the COVID restrictions that have resulted in limited access to buildings and employees. Experts are still working with the registration, which is possible at the moment in Poland and Norway, but not in Brazil, Italy or Japan. The new deadline is March 2021.

A.3 - Representation of user behavior – *personas.* Relevant results from A1 are available, nevertheless, they depend on development in project A.2. Personas will be developed as follows: large offices, small offices, hospitals/health care, university buildings, schools, library, commercial/retail, and industry. An internal draft document is expected March 2021 and the final version June 2021.

Subtask B: Integration and Optimization of Daylight and Electric Lighting

B.1 - Interview of professionals. The report on opportunities and barriers to be published in 2021 is the final report on the questionnaire 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

B.2 - Critical review of existing control systems and their functionalities. The final report will be published in 2021.

B.3, B.4. It was decided to merge B.3 - Critical review of new approaches under development and B.4 - Review of other important aspects affecting the performance of controls into one project and one report, *"Trends and new systems,"* that will be published in 2021. The information on systems, views and opinions on possible trends have been collected.

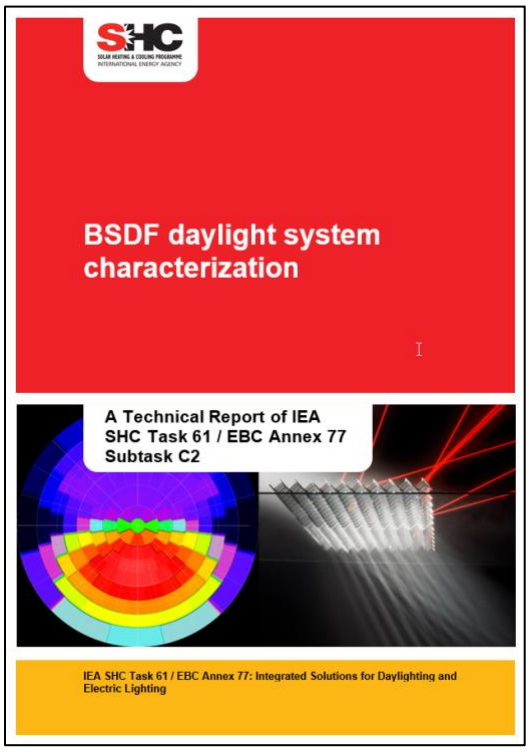
B.5 - Critical analysis of interfaces. The following topics have been addressed and the corresponding sections of the report written: analog, digital, hybrid components, and trends. Sections to be completed are: link to energy savings, combined control of lighting and daylighting, and consequence of possible occupant satisfaction.

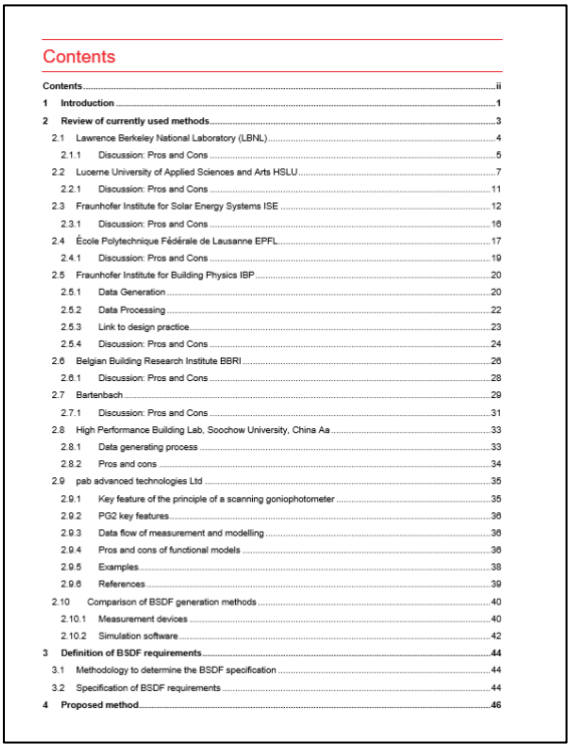
B.6 - Link with standardization activities. The collection of relevant documents from relevant bodies like CIE, ISO, CEN, CN Standards, BREAM, LEED, DGNB is ongoing and will be compiled in a report.

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

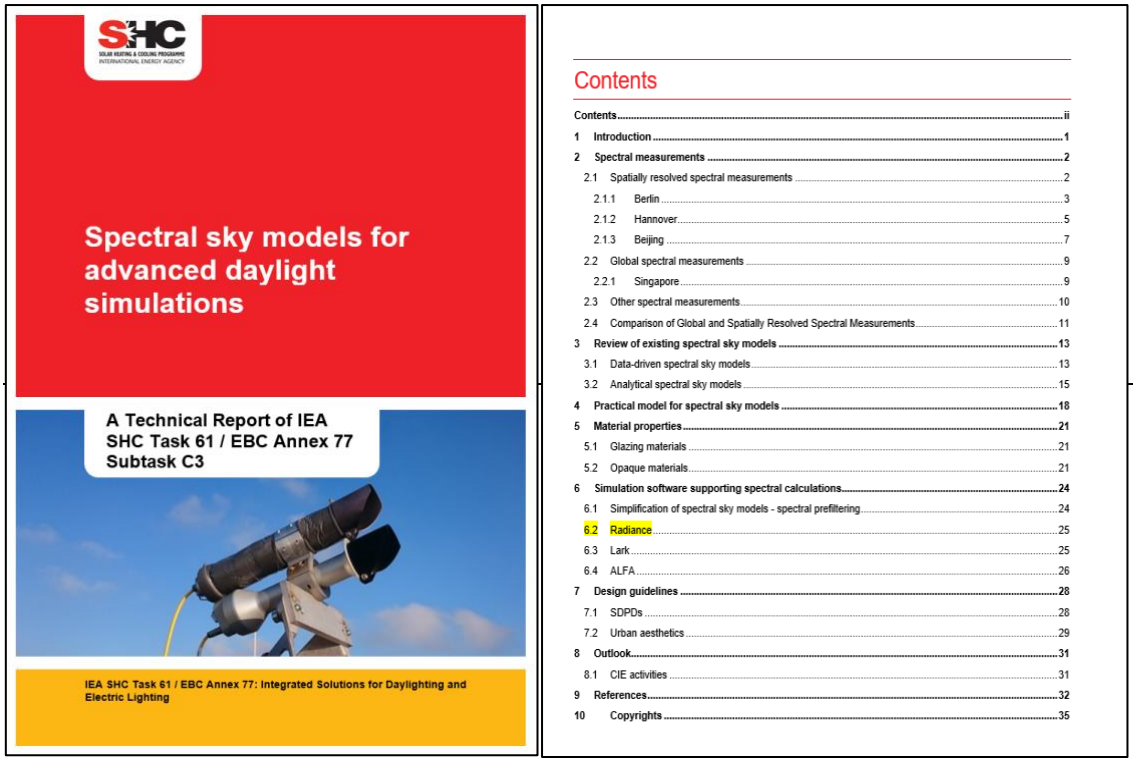
C1: Review of state-of-the-art design workflows. The report is published and project C1 is closed.

C2: Standardization of BSDF daylight system characterization. As preparatory work on standardization, a white paper on BSDF data generation for daylighting systems is in draft form. This white paper, or parts thereof, can serve as input to or as a reference for international standardization efforts. For the planned BSDF round robin test in different goniophotometers worldwide, one venetian blind system and one fabric screen were selected as test samples. The measurements have started in the participating labs. Measurements shall be finished by the end of 2020. The different results shall then serve as input to different software processing the data, for example, annual lighting/ energy calculations. The impact of the possible differences in the measurement data was analyzed and documented in the report, *BSDF daylight system characterization*.




Contents

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. The report, *Spectral sky models for advanced daylight simulations,* will be published in June 2021. The collaboration with IEA PVPS Task 16 and CIE experts continued. CIE is planning to establish an expert group to continue working on the issue for the next four years.

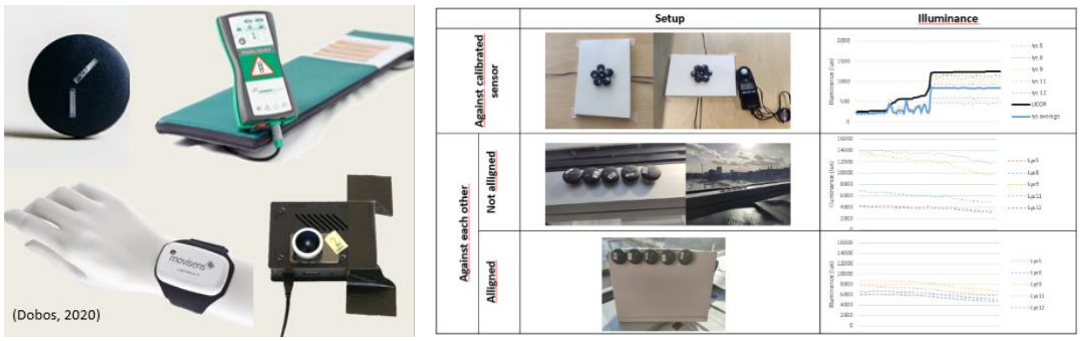


C4: Hourly rating method for integrated solutions. The Subtask C4 meeting was held as a joint meeting with the ISO TC274 Task Force for the revision of ISO10916. Please also refer below to the status of the joint working group.

Subtask D: Lab and Field Study Performance Tracking

D1: Literature review. The draft report currently covers the review of about 200 papers. It will be published in 2020.

D2 Monitoring protocol. The monitoring protocol has been established in a draft format for internal use in Task 61 and is continuously being updated in connection with the ongoing case studies. The monitoring protocol is, therefore, basically available. Where possible, researchers conducting case studies test additional innovative approaches to assess specific metrics and describe these approaches for possible inclusion in the monitoring protocol. Not all monitoring methods will be applied in all case studies. Recently assessments on wearable measurement and assessment devices have been added.

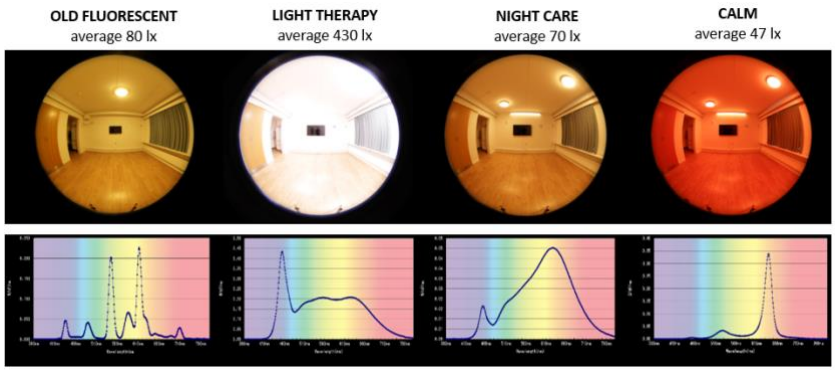


Wearable devices tested at Aarhus University in Denmark.

List of case studies and planned activity schedule as of September 2020

Country	Name	Type	Type (additional)	Location	Monitoring Period Start
AUS	AECOM	Office (open plan)		Brisbane	ongoing
AUS	AURECON	Office (open plan)	Sustainable Building	Brisbane	ongoing
AUT	Bartenbach R&D Office	Living Lab	Office	Aldrans, Tyrol	nearly completed
BEL	Stephenson Garden	Retirement Home	Circadian Assessment	Brussels	nearly completed
BRA	Ministry of Energy	Office		Brasilia	completed
BRA	Forum Sobral Pinto	Office		Boa Vista	ongoing
BRA	Building			Brasilia	completed
CHN	CABR	Meeting Room		Beijing	no update
CHN	CABR	Office		Beijing	no update
DEN	Klarahus, De Gamles By	Retirement Home	Circadian Light	Copenhagen	on hold
DEN	DTU Library	Educational	Library Reading Room	Lyngby	on hold
DEN	Navitas Building	Educational	Classrooms, Offices, Shading use, Lighting control	Aarhus	ongoing
DEN	Vikaergaarden	Health Care	Rehabilitation Center, Circadian Light	Aarhus	finalizing report
DEN	Psychiatric Hospital	Health Care	Circadian Lighting	Slagelse	finalizing report
GER	IBP Fraunhofer Lab	Living Lab	Office	Stuttgart	ongoing
GER	DIAL Building	Office	Lighting Control	Luedenscheid	ongoing
ITA	Abazia di San Lorenzo Ad Septimum	Educational (listed)	Private Office	Aversa	ongoing
ITA	Abazia di San Lorenzo Ad Septimum	Educational (listed)	Office mockup	Aversa	ongoing
NOR	Headquarters Norconsult	Office	Light Pipe	Sandvika	ongoing
SWE	Kindergarten Vipeholm	Educational	Daycare	Dalby	ongoing
SWE	The Spark	Office	Circadian Lighting	Lund	ongoing
SWE/GER	IKEA Kaarst	Other	Furniture Store	Kaarst	completed
SWE/ESP	IDOM	Office	High-performance Lighting	Madrid	completed
SWI	Smart Living Lab	Living Lab		Fribourg	on hold
USA	Office Building	Office (private)	Electrochromic Windows	Portland, OR	completed
USA	Office Building	Office (open plan)	Dual Zone Shading System	Oakland, CA	completed
USA	Office Building	Office (open plan)	High-Resolution Lighting Control	New York, NY	completed

D3:Case Studies. The collection of possible case studies and living labs was updated. Twenty-seven case studies are identified of which 7 are already completed. Due to COVID, many case studies in the participating countries have been affected by lock-downs, severe restrictions on entering buildings, and general regulations. Because of these reasons, many case studies are delayed and one case study in China has been cancelled. Currently, a six-month is anticipated. The experts will nevertheless try to stay with this activity in the overall time frame of the Task's end date of June 2021.



Patient room case study at Vikaergaarden, Denmark with various lighting scenarios.

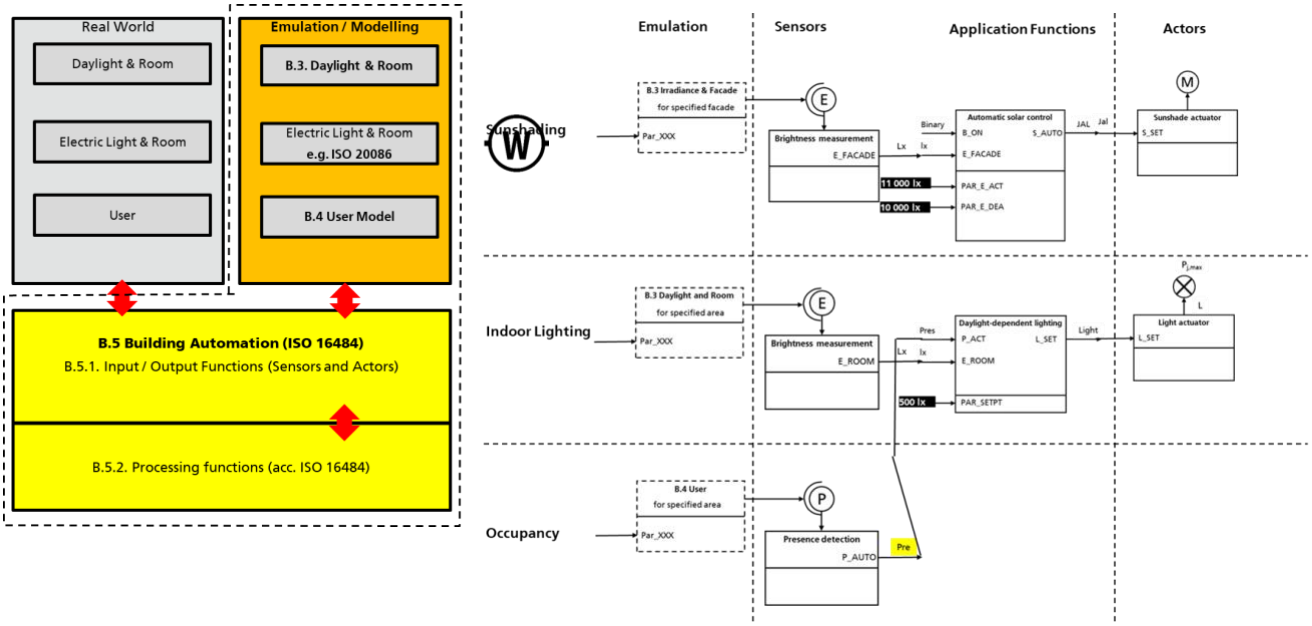
D4: Lessons learned. Activities in this project have continued as work in project D3 progressed. For reporting of the case studies a format was opted which consists of a 4- page Fact Sheet. Seven completed case studies are now available in this format. The final report for D.4 will be a collection of these Fact Sheets plus overall lessons learned.

Joint Working Group: Evaluation Tool & VR Decision Guide

The integrative concept of the Joint Working Group with its two development activities “Evaluation Method for integrated lighting solutions” and “VR Decision Guide” are coordinated by Jan de Boer and Marc Fontoynont.

Evaluation model. The Subtask C4 meeting was held as a joint meeting with the ISO/TC 274/JWG 1 Task Force for the revision of ISO10916. The generic model has been further development. This is based on a logical, clear segregation introduced to emulate reality, i.e., daylight & room, electric lighting & room, and occupancy behavior on the one side and description of sensors, actors, and (network) functionality on the other side. The latter is kept in accordance with standard BACS description semantics as in VDI 3813 / ISO 16484, i.e., allowing it to be directly used / implemented into the automation hardware of a building. The common double modelling in lighting design and design of the BACS can be avoided in the future, boosting efficiency. To bring it onto standardization level, the revision of ISO 10916 is ongoing in a task force of ISO TC 274 WG 1. Here a new work item has now officially been approved. In addition, an option of an integration into the ISO EN 52000 series on building energy performance is currently being discussed. A draft of the standard is being written and will be send out to the task force the end of 2020.

In parallel, the development of a calculation tool (web-based and desktop) continues.



Emulation concept and structure of the comprehensive hourly method and an example of the model structure for a fully automated single office.

Highlights of Industry Involvement and Market Activities

Industry Workshop

The 5th industry workshop was cancelled and rescheduled for the first Task Meeting in 2021.

IEA SHC Solar Academy Webinar on Task 61

On September 24th a webinar on Task 61 with a Q&A session was given by the five Subtask Leaders and the Operating Agent. The webinar was replayed on September 25th for the Asian / Pacific region. More than 225 participants followed both sessions.

Work Planned For 2021

Subtask A: User Perspective and Requirements

- Finalization of the Subtask's work plan under constraints of pandemic situation partly impeding user studies in building or labs.

Subtask B: Integration and Optimization of Daylight and Electric Lighting

- Finalization of the Subtask's work plan.

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

- Finalization of the Subtask's work plan.
- Continued collaboration with ISO TC 274 on hourly rating method.

Subtask D: Lab and Field Study Performance Tracking

- Finalization of the Subtask's work plan under constraints of pandemic situation partly impeding user studies in building or labs.

Joint Working Group: Evaluation Tool & VR Decision Guide

- Finalization of VR decision guide.
- Finalization of hourly rating method and associated tool.

Dissemination Activities In 2020

Reports, Published Books

Author(s)/ Editor	Title	Report No. Publication Date	Target Audience
Baumann, T. F.	Determination of daylight provision and spectral composition of lighting in indoor environments from practical measurements of the luminance distribution	MSc Thesis, January 2020	Academia, architects, engineers, lighting measuring professional
Medeiros, A.; Amorim, C. (supervisor)	A arquitetura de Severiano Mario Porto na cidade de Boa Vista: um olhar com enfoque bioclimático (The architecture of Severiano Mario Porto in the city of Boa Vista: a bioclimatic approach)	MSc Thesis, January 2020	Academia, architects
Dobos, F.	Development of a light measurement method: assessing lighting and human light exposure using a RaspberryPi camera and dosimeters in a short-term care facility	MSc Thesis, February 2020	Academia, architects, engineers, lighting measuring professionals
Geisler Moroder, D. et.al.	Workflows and software for the design of integrated lighting solutions	Report IEA SHC Task 61 T61.C.1, February 2020	Practitioners, lighting designers, industry
de Boer, J. et.al	IEA SHC Task 61 / EBC Annex 77 1st Newsletter	May 2020	Academia, practitioners

			Industry, authorities
Yilmaz, E.C.; Abdulhaq, R.	Assessment of the circadian stimulus potential of an integrative lighting system in an office area	MSc Thesis, June 2020	Academia, architects, lighting and façade designers
Nielsen, K. G.	Investigating Non-Visual Effects of Lighting in Health and Elderly Care Facilities: Comparing Simulations and Measurements	MSc Thesis, June 2020	Academia, architects, engineers, lighting measuring professionals
Matusik, B. et.al	Literature Review of user needs, toward user requirements	Report IEA SHC Task 61 T61.A.1, September 2020	

Journal Articles, Conference Papers, etc.

Author(s)/Editor	Title	Publication/Conference	Bibliographic Reference
Scorpio, M.; Laffi,R.; Masullo, M.; Ciampi, G.; Rosato, A.; Maffei, L.; Sibilio. S.	Virtual reality for smart urban lighting design: applications and opportunities	Energies 13(15) July 2020	Article
Ciampi, G.; Scorpio, M.; Spanodimitrou, Y.; Rosato, A.; Sibilio, S.	Thermal Model Validation of an Electric-Driven Smart Window through Experimental Data and Evaluation of the Impact on a Case Study	Building and Environment Vol. 181 August 2020	Article
Scorpio, M.; Ciampi, G.; Rosato, A.; Maffei, L.; Masullo, M.; Almeida, M.; Sibilio, S.	Electric-driven windows for historical buildings retrofit: Energy and visual sensitivity analysis for different control logics	Journal of Building Engineering, Volume 31, 2020,101398, ISSN 2352-7102 September 2020	Article

Conferences, Workshops, Seminars, etc.

Conference / Workshop / Seminar Name	Activity & Presenter (keynote, presentation, poster, etc.)	Date & Location	# of Attendees
ISES SWC 2019 (SHC Conference)	Oral presentation: Gremmelspacher, J.M. (on behalf of Niko Gentile and Werner Osterhaus)	November 4 – 7, 2019 Santiago de Chile, Chile	> 400
ISES SWC 2019 (SHC Conference)	Campama Pizarro, R.; Gentile, N.	November 4 – 7, 2019 Santiago de Chile, Chile	> 400

CIE Australia Lighting Research Conference 2020	Garcia-Hansen, V.	February 11, 2020 Brisbane, Australia	
PLEA 2020	Gkaintatzi-Masouti, M.	September 1 – 3, 2020 A Coruna, Spain	
IEA SHC Solar Academy Webinar on Task 61	de Boer, J.	September 24 – 25, 2020 Webinar	> 225
IEA SHC Solar Academy Webinar on Task 61	Matusiak, B. S.	September 24 – 25, 2020 Webinar	> 225
IEA SHC Solar Academy Webinar on Task 61	Fontoynont, M.	September 24 – 25, 2020 Webinar	> 225
IEA SHC Solar Academy Webinar on Task 61	Geisler Moroder, D.	September 24 – 25, 2020 Webinar	> 225
IEA SHC Solar Academy Webinar on Task 61	Gentile, N.	September 24 – 25, 2020 Webinar	> 225

Dissemination Activities Planned For 2021

5th Industry Workshop in Aversa, Italy.

Energy and Building: IEA Task 61 related special issue on integrated lighting solutions.

Task Meetings 2020 – 2021

Meeting	Date	Location
Task Meeting 5	March 16-18, 2020	Virtual
Task Meeting 6	September 23-25, 2020	Virtual
Task Meeting 7	November 23-24, 2020	Virtual
Task Meeting 8	March 2021	Virtual
Task Meeting 9	May 10-12, 2021	Aversa, Italy
Industry Workshop 4	May 5, 2021	Aversa, Italy

SHC Task 61 Participants

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CHINA	Zhen Tian	Soochow University	National Expert
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SWITZERLAND	Lars Oliver Grobe	Lucerne University of Applied Sciences and Arts	National Expert
SWITZERLAND	Jérôme Kaempf	Idiap Research Institute	National Expert
UNITED STATES	Eleanor Lee	Lawrence Berkeley National Laboratory	National Expert
UNITED STATES	Gregory J. Ward	Anyhere Software	National Expert

Task 62 – Solar Energy in Industrial Water and Wastewater Management

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 Organizations

- SPIRE Association
- WSSTP – European Technology Platform for Water

Collaboration with Industry

Meetings

In 2020, the interest in Task 62 increased and online meetings raised interest in the work. Particularly, the area of Membrane Distillation has drawn great interest in the scientific work as shown by industry participation in the 4th and 5th Expert Meetings. Also, having industrial players for MD development and scientific partners coming together shows the drive to bring results to the market.

Nexus Energy, Water & (Bio) Industry

On January 30, 2020, AEE INTEC (Operating agent Christoph Brunner) hosted a conference at the Austrian Federal Economic Chamber on the topic "Nexus Energy, Water and (Bio)Industry". Participants from industry, research and administration were highly interested in the presentations. Task 62 members from Ciemat P.S.A, SolarDew and AEE INTEC (see publication list/conferences) presented issues from Task 62. The output of this one-day conference was quite clear – water and energy in industrial applications have become central issues that require holistic approaches. The main objective 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 field of application for solar thermal energy as there is a high market potential.

Industry Workshop

The 5th Expert Meeting of Task 62 was opened on November 25, 2020 with an Industry Workshop organized jointly with Victoria University (Prof. Mikel Duke – Subtask C Leader). Talks from Operating Agent Christoph Brunner, Subtask A Leader Joachim Koschikowski and Subtask B Leader Isabel Oller included topics from Task 62 and the drivers for renewables in industry as well as research on advanced solar and water technologies and research.

Discussions in the breakout sessions showed that the main drivers for industry to integrate renewables for reducing emissions in water treatment are regulations. And that there is a specific need for business cases and the definition of selections criteria for technologies (e.g., costs, reliability, resource recovery, emission reduction, etc.) as well as financing and risk strategies. Specific research needs for solar technologies in water treatment were identified in energy storages and technology flexibility, long-term and pilot testing of technologies to get answers about reliability. Further communication and dissemination strategies for results are important.

Collaboration with EACREEE (East African Centre of Excellence for Renewable Energy and Efficiency)

After the initial intent of ExCo members from EACREEE (East African Centre of Excellence for Renewable Energy and Efficiency) to participate in Task 62 and the first contacts in 2019, finally the first exchange meetings with OA Christoph Brunner took place in summer 2020. Collaboration in the field of Solar Energy in Water and Wastewater Management is an area of interest of the EACREE and the region as a whole should build upon. Specifically, joined submissions within the European Green Deal in order to foster opportunities for international collaboration in addressing the needs for Africa within the context of the Paris Agreement as well as the Sustainable Development Goals (SDGs).

Solar Dew – collaboration with CIEMAT P.S.A and AEE INTEC

Within the work of Task 62 collaborations between SolarDew and the institutes CIEMAT PSA (Spain) and AEE INTEC (Austria) have been set up on membrane and prototype testing.

Focus area: ammonia separation via membrane distillation

Task 62's 4th Experts meeting had a high level of interest from different institutes/universities in various countries on ammonia separation. The following examples of ammonia separation work underway are:

- Within the Austrian flagship project Thermaflex AEE INTEC tests ammonia recovery with membrane distillation via building up a pilot at a wastewater treatment plant. The system started its operation in November 2020 at a wastewater treatment plant in Austria. The basis for up-scaling membrane distillation is based on various pre-projects from AEE INTEC (e.g., see publication section "Vacuum membrane distillation multi-component numerical model for ammonia recovery from liquid streams").

- CIEMA P.S.A. has designed a new membrane distillation system for ammonia recovery. It is now under construction by APRIA Systems. The system is composed by a MD system coupled to a crystallizer for not only ammonia but also other salts recovery. This design has been carried out in collaboration with the University of Aalborg, specifically with Cejna Anna Quist-Jensen. The new MD system is much more robust to face high pH and ammonia conditions.
- SolarSpring and Fraunhofer ISE have developed a demonstration system for ammonia extraction from municipal wastewater. The system is currently under construction and will be implemented at wastewater treatment plant near Freiburg.

Task Duration

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

Participating Countries

Australia, Austria, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom

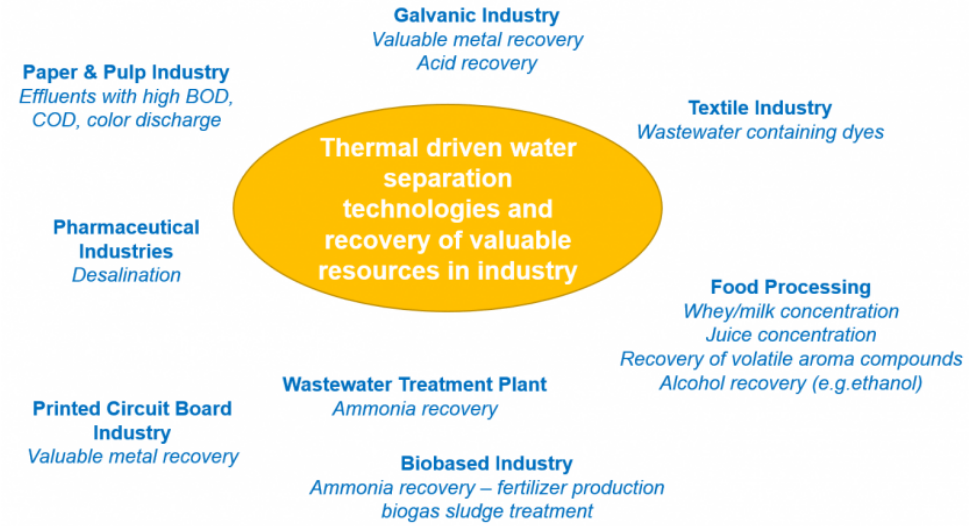
Work During 2020

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

Deliverable A1: Matrix of different industrial separation demands to be subjected to cutting edge thermal technologies versus availability of different low exergy heat sources

In 2020 a matrix that was designed to define the different criteria for the selection of technologies in context with availability of low exergy heat sources was further developed. In the frame of the BMWI project, “Green Manufacturing”, information was collected for wastewater and process fluids in PV industry. Significant changes can be expected for the edging processes of Silica wafers. While in the past highly toxically HF-HNO3 was used, there will be less toxic basis used in the future. The steel plating and galvanizing industry is also still under investigation to collect more information on the very different processes. The collection of information is ongoing, but considerable limited by the COVID-19 lockdown and canceled conferences and meeting opportunities. The matrix will be completed in March 2021.

Following is an overview of the potential industries.



Overview on potential industry sectors for integration solar-water-treatment

Deliverable A2: Definition of future R&D demand

The R&D demand for MD is evaluated and defined in accordance with the different demonstration cases investigated in the last years by different groups. R&D demand is addressing performance increase (flux, specific energy demand, selectivity) in competition with other technologies, durability for long term operation under harsh

conditions, application to new industrial separation demands and measures for cost reduction. New material as ceramic is investigated for MD membrane design. For polymeric membranes PTFE is still one of the favorable materials for MD membranes with respect to hydrophobicity and resiliency against strong acids and bases. Problems of PTFE are associated with costs and environmental concerns. Low cost and recyclable materials for MD membranes are key factors for economical sound and sustainable implementation of MD.

MD simulation also supports the definition of MD membrane and module design parameters and gives a clear indication that different membrane architectures are needed for different applications of MD in order to optimize the output and energy efficiency. This implies that MD development needs to be conducted specifically for individual applications and cannot be done on a holistic basis. Therefore, future R&D activities close cooperation with industry is required in order to identify the future application of MD.

Deliverable A3: Specification of System design and key performance indicators as basis for comparative studies

After elaborating on and analyzing the survey on existing simulation models, the system designs and technical configurations for the comparative simulation study was fixed and the categories for the parameter variation were identified. Based on this, a matrix was created to be send out for comparative simulation. The simulation will focus on Direct Contact and the Air Gap configuration, as according to the surveys these are the most common used. After trying to increase the feedback on the simulation to get a critical mass for simulation afterwards, a definitive version of Deliverable A.3 was finished and reviewed.

Deliverable A8: Conduction of workshops with industry (producing industry, separation technology supplier, solar thermal technology)

On January 30, 2020 AEE INTEC (Operating agent Christoph Brunner) hosted an IEA initiated workshop at the Austrian Federal Economic Chamber on the topic “Nexus Energy, Water and (Bio) Industry”. Participants from industry, research and administration were highly interested in the presentations. Task 62 members from Ciemat P.S.A, SolarDew and AEE INTEC (see publication list/conferences) presented issues from Task 62.

Subtask B: Solar Water Decontamination and Disinfection Systems

Subtask B participants are actively participating in projects in collaboration with industries related to the topic of the Task and mainly focused on the application of new technologies based on solar energy for wastewater treatment and reuse and nutrients recovery.

Here some examples in which energy-water nexus are deeply considered:

- University of Rey Juan Carlos in Spain (Prof. Javier Marugan, activities leader):
    - *HYSOLCHEM project*: A hybrid reactor for solar CO_2 and N_2 conversion coupled to wastewater treatment. H2020-FETPROACT-2020-2, Grant Agreement pending of signature. Partners: IMDEA Energy Institute (IMDEA, Spain), Universidad Rey Juan Carlos (URJC, Spain), Katholieke Universiteir Leuven (Belgium), Innova SRL (Italy), Amer-Sil SA (Luxemburg), Diamond Light Source Limited (United Kingdom), Apria Systems SL (Spain)
    - REWATERGY project: Sustainable Reactor Engineering for Applications on the Water-Energy Nexus. H2020-MSCA-ITN-2018, Grant Agreement N. 812574. Partners: Universidad Rey Juan Carlos (coord., Spain), University of Cambridge (United Kingdom), University of Ulster (United Kingdom), Delf IMP (The Netherlands), Prophotonics (Ireland), FCC Aqualia (Spain).
    - DEEPPURPLE project: Conversion of diluted mixed urban bio-wastes into sustainable materials and products in flexible purple photobiorefineries. Convocatoria: H2020-BBI-JTI-2018, Grant Agreement N. 837998. Partners: FCC Aqualia (Spain), Activatec Ltd (UK), Apivita Kallyntika Diaititika Farmaka Anonymi Emporiki Kai Viotechniki Etaireia (Greece), Natureplast Sas (France), FCC Ceska Republika, S.R.O. (Check Republik), Instituto tecnologico del embalaje, transporte y logistica (Spain), Salsnes filter AS (Norway), Brunel university london (UK), Novamont spa (Italy), Universidad Rey Juan Carlos (Spain), Bioversum - naturinspirierte systeme (Austria), Asociacion Espanola de Normalizacion (Spain), Investornet-gate2growth aps (Denmark), Universidad de Valladolid (Spain), Agro Innovation International (France).

- PureBlue Water b.v. (Angelo de Mur, activities leader): A wastewater treatment system for agriculture for the removal of nitrate out of drainage water of acres have been built in collaboration with the University of Leuven. The treatment is placed in a rural area. The unit is 100% powered by solar.

- University of Barcelona (Dr. Ignasi Sirés, leader of the activities):
    - Study of natural iron oxide minerals for the development of water treatment technologies to remove arsenic and/or persistent organic pollutants (POPs) by solar photo-Fenton-like process. Project funded by Fondecyt (Peru). Partners: Universidad Nacional de Ingeniería, Lima, Peru) and University of Barcelona (Spain).

- University of Almería (Prof. Jose Antonio Sánchez Pérez, leader of the activities):
    - LIFE PureAgroH2O project: Pollutant photo-NF remediation of agro-water. LIFE17 ENV/GR/000387. Partners: Benaki Phytopathological Institute (Greece), National Centre for Scientific Research "Demokritos" (Greece), Universidad de Almeria (Spain), Agricultural Cooperative of Zagora Pilion (Greece).

- CIEMAT-Plataforma Solar de Almería (Dr. Isabel Oller, leader of the activities):
    - ALICE Project: AcceLerate Innovation in urban wastewater management for Climate change. H2020-MSCA-RISE-2016/H2020-MSCA-RISE-2016. Grant Agreement Nº 734560. Partners: University of Ulster (United Kingdom), Northern Ireland Water Limited (United Kingdom), The Queen´s University of Belfast (United Kingdom), Dublin City University (Ireland), Dioenergy Limited (Ireland), ASOCIACION BC3 BASQUE CENTRE FOR CLIMATE CHANGE - KLIMA ALDAKETA IKERGAI (Spain), CIEMAT-Plataforma Solar de Almería (Spain), Región de Murcia (ESAMUR, Spain), Universitat Digli Studi Di Macerata (Italy).

    - RATOCAT Project: Rational design of highly effective photocatalysts with atomic-level control. M-ERA.NET Call 2016. Partners: University College Cork (Ireland), Delft University of Technology (The Netherlands), Instituto de Ciencia de Materiales de Sevilla, CSIC (Spain) and CIEMAT-Plataforma Solar De Almería (Spain).

Deliverable B1: Report on existing solar based technologies applied to industrial water decontamination and disinfection (real and research cases). Potential applications on industrial new sectors
A deliverable was submitted on existing initiatives on solar based technologies for industrial wastewater recovery, mainly in food and beverages industries. It is important to take into account that details on technology development and performance have been almost impossible to obtain directly from the industries. Therefore, the core of the information has been obtained from the companies´ websites. Nevertheless, it is important to note the near future objectives and challenges adopted by a great number of industries for reducing their water footprint.

Deliverable B4: Technological, economic and political barriers for up-scaling new decontamination and disinfection systems for industrial water and wastewater management and reuse
From deliverable C1, technological solutions most studied and applied at DEMO scale for industrial wastewater treatment, management and reuse have been clearly identified. Direct contact with potential providers (not only private companies but also public entities) as well as key stakeholders is being carried out to make an assessment on which technological, economic and political barriers could be identified for each technology and how we could tackle them. Vision of Circular Economy must be applied.

The team of Subtask B developed an internal survey to access, according to their experience, the barriers they consider or have confronted regarding the technologies going to the market. The possibility of such technologies to be applied for attaining required water quality for specific reusing purposes within their own industrial process is being strongly focused and considered for this study.

Deliverable B6: Marketplace/Fair
This deliverable was organized jointly with Subtask C as the integration between technology and necessities (end users, stakeholders, etc.) are a key objective. A first attempt and contact with industry was done in a workshop organized within Subtask C and held jointly with the Task Meeting in November 2020.

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

The 5th Expert Meeting of Task 62 on November 25, 2020 included an Industry Workshop organized jointly with Victoria University (Prof. Mikel Duke – Subtask C Leader). Talks from Operating Agent Christoph Brunner, Subtask

A-Leader Joachim Koschikowski and Subtask B-Leader Isabel Oller included topics from IEA SHC Task 62 and the drivers for renewables in industry as well as research on advanced solar and water technologies and research.

Deliverable C1: Report on technologies to be considered for guidelines

The main activity of C1 was a literature and market review report based on established and emerging technologies, gathered knowledge from other Subtask leaders, and external contacts. Final draft is completed and has been reviewed.

Deliverable C2: Report on how water-energy nexus concept is actually being applied in the industry

The C.2.2 report, ‘’Draft solar thermal energy guidelines/decision making tool’’ is getting close to completion. The process on industry criteria to decide on the technology based on the water treatment needs has begun. The purpose of this is to identify selection criteria for the subsequent deliverable, a decision-making tool. The report includes examples where industry is actually using solar thermal technologies for a water treatment function. These were originally intended for the C1 deliverable report but were transferred into the C2 deliverable report. The C2 deliverable was defined as “Report on how water-energy nexus concept is actually being applied in the industry” where it was found that this transferred material found only two examples of where solar thermal was actually being used in water. So, the material of the C2 deliverable now adopts activities defined in C.2.2 of the work plan that includes the criteria for end user selection of technologies and defining the boundaries of the decision-making tool.

Table of contents for draft report for the C2 deliverable:

1. Introduction
2. Summary of surveyed technologies.
3. Criteria for choosing solar technology for water treatment
3.1 Water treatment needs
3.2 Energy needs
3.3 Costs
3.4 Capacity/scale
3.5 Compatibility and integration with other technologies
4. Application examples
4.1 Sundrop farms, Australia - thermal collectors and desalination
4.2 Aquas de Portugal, SGPS
5. Gaps and opportunities
6. Conclusion

Work Planned For 2021

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

- Deliverable A1: Matrix of different industrial separation demands to be subjected to cutting edge thermal technologies versus availability of different low exergy heat sources
- Deliverable A2: Definition of future R&D demand
- Deliverable A4: Summary of results from comparative simulation calculations
- Deliverable A8: Conduction/Participation of/in 3 workshops initiated by the IEA activities

Subtask B: Solar Water Decontamination and Disinfection Systems

- Deliverable B2: Report on existing solar based technologies applied to industrial water decontamination and disinfection (real and research cases). Potential applications on industrial new sectors
- Deliverable B3: Roadmap for technology implementation for defined applications and industries
- Deliverable B4: Technological, economic and political barriers for up-scaling new decontamination and disinfection systems for industrial water and wastewater management and reuse
- Deliverable B5: Report on legal thresholds for accomplishing water quality required depending on the final application
- Deliverable B6: Marketplace/Fair

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

- Deliverable C2: Report on how water-energy nexus concept is actually being applied in the industry
- Deliverable C3: Report on draft version of guidelines/decision making tool

Dissemination Activities In 2020

Reports, Published Books

Author / Editor	Title	Bibliographic Reference
Book editors: Y. M. Lee and E. Drioli. Chapter authors: M. Duke and X. Yang	Book title: Membrane Distillation: Materials and Processes. Chapter title: Economic Analysis of Membrane Distillation	Technology providers, researcher and appliers; 2020; Publisher: Nova Scientific Publishers

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
A.Ruiz-Delgado, P. Plaza-Bolaños, I. Oller, S. Malato , A. Agüera.	Advanced evaluation of landfill leachate treatments by low and high-resolution mass spectrometry focusing on microcontaminant removal	Publication in Journal of Hazardous Materials	Journal of Hazardous Materials 384 (2020) 121372
S.Nahim-Granados, G. Rivas-Ibáñez, J.A. Sánchez Pérez, I. Oller, S. Malato, M.I. Polo-López.	Synthetic fresh-cut wastewater disinfection and decontamination by ozonation at pilot scale	Publication in Water Research	Water Research 170 (2020) 115304
A Cabrera Reina, S. Miralles-Cuevas, L. Cornejo, L. Pomares, J. Polo, I. Oller, S. Malato	The influence of location on solar photo-Fenton: Process performance, photoreactor scaling-up and treatment cost	Publication in Journal Renewable Energy	Renewable Energy 145 (2020) 1890-1900
A.Ruiz-Aguirre, J. A. Andrés-Mañas, G. Zaragoza	Evaluation of permeate quality in pilot scale membrane distillation systems	Publication	MDPI *Membranes* 9 (2019) 69
J.A.Andrés-Mañas, L. Roca, A. Ruiz-Aguirre, G. Acién, J. D. Gil, G. Zaragoza	Application of solar energy to seawater desalination in a pilot system based on vacuum multi-effect membrane distillation	Publication	Applied Energy 258 (2020) 114068
C. Brunner, S. Meitz, B. Muster-Slawitsch, J. Buchmaier	Nexus Energy, Water & (Bio) Industry	Press Release	Öko+
D.M. Scheepers, A.J. Tahir, C. Brunner, E. Guillen-Burrieza.	Vacuum membrane distillation multi-component numerical model for ammonia	Journal of Membrane Science	Journal of Membrane Science, Volume 614, 2020, 118399. ISSN 0376-7388.

	recovery from liquid streams		https://doi.org/10.1016/j.memsci.2020.118399.

Conferences, Workshops, Seminars

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	# of Attendees
Conference Nexus Energy, Water & (Bio)Industry	Organized by AEE INTEC (Operating Agent)	January 30, 2020 (Vienna, Austria)	36
Conference Nexus Energy, Water & (Bio)Industry: Renewable energy driven technologies for water treatment - ex.: Solar Disinfection	Presentation Subtask B Isabel Oller	January 30, 2020 (Vienna, Austria)	36
Conference Nexus Energy, Water & (Bio)Industry: Resource and energy efficiency in municipal wastewater treatment plants	Presentation Wolfgang Gruber-Glatzl (AEE INTEC)	January 30, 2020 (Vienna, Austria)	36
Conference Nexus Energy, Water & (Bio)Industry: Applicability of Solar Energy & Water in a new collector for applications in the bio-industry	Presentation Alexander van der Kleji (SolarDew)	January 30, 2020 (Vienna, Austria)	36
Conference: Holistic approaches for water and resource efficiency in process industry	Presentation: Resource recovery from industrial wastewater by cutting edge membrane technologies – Outcomes of the ReWaCEM project	March 25-26, 2020	~70
Conference: Holistic approaches for water and resource efficiency in process industry	Energy Footprint of Water Treatment	March 25-26, 2020	~70

Dissemination Activities Planned For 2021

- IEA SHC Solar Academy webinar, March 2021

Task Meetings 2020 – 2021

Meeting	Date	Location	# of Participants (# of Countries)
Task Meeting 4	April 21-22, 2020	Online	44 (14)
Task Meeting 5	November 26-27, 2020	Online	
Task Meeting 6	2nd quarter 2021 Online or Florence, Italy		

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
AUSTRALIA	Yunchul Woo	University of Technology Sidney	National Expert
AUSTRALIA	Gabriele Sartori	APEC Project EWG 13 2017A; Future Carbon Australia; EUAA	National Expert
AUSTRALIA	Anthony Fane	UNSW	National Expert
AUSTRIA	Bettina Muster-Slawitsch	AEE INTEC	National Expert
AUSTRIA	Elena Guillen	AEE INTEC	National Expert
AUSTRIA	Sarah Meitz	AEE INTEC	National Expert
AUSTRIA	Hendrik Müller-Holst	Evonik	National Expert
GERMANY	Joachim Koschikowski	Fraunhofer Institute for Solar Energy Systems ISE	Subtask A Leader
GERMANY	Christian Sattler	DLR	National Expert
GERMANY	Dirk Krüger	DLR	National Expert
GERMANY	Matthias Kozariszczuk	VDEh-Betriebsforschungsinstitut GmbH	National Expert
GERMANY	Ewa Borowska	KIT	National Expert
GERMANY	Florencia Saravia	KIT	National Expert
GERMANY	Heike Glade	Universität Bremen	National Expert
GERMANY	Rebecca Schwantes	Solar Spring	National Expert
GERMANY	Wolfgang Heinzl	Wolf07	National Expert
ITALY	Mariachiara Benedetto	Industrie De Nora S.p.A.	National Expert
ITALY	Daniela Fontani	CNR-INO	National Expert
ITALY	Paola Sansoni	CNR-INO	National Expert
ITALY	Fabrizio Vicari	University of Palermo	National Expert
ITALY	Luigi Rizzo	University of Salerno	National Expert

ITALY	Giacomo Pierucci	University of Florence	National Expert
NETHERLANDS	Alexander van der Kleij	SolarDew	National Expert
NETHERLANDS	Bart Nelemans	Aquastil	National Expert
PORTUGAL	Maria João Carvalho	LNEG	National Expert
PORTUGAL	Marta Carvalho	Aguas de Portugal	National Expert
PORTUGAL	Ana Magalhães	INEGI	National Expert
PORTUGAL	Ricardo Barbosa	INEGI	National Expert
PORTUGAL	António Manuel Pedro Martins	Águas do Algarve, S.A	National Expert
PORTUGAL	Luís Paulo Mestre Henriques	Águas do Algarve, S.A	National Expert
PORTUGAL	Tiago Osório	University of Évora	National Expert
SPAIN	Isabel Oller Alberola	CIEMAT PSA	Subtask B Leader
SPAIN	Junkal Landaburu	IMDEA Water	National Expert
SPAIN	Fernando Fresno	IMDEA Energy Institute	National Expert
SPAIN	Javier Marugán Aguado	Rey Juan University	National Expert
SPAIN	Antonio Arqués	Polytechnic University of Valencia, Alcoy campus	National Expert
SPAIN	Jose Ignacio Ajona	Seenso Renoval, S.L.	National Expert
SPAIN	Diego Alarcón-Padilla	CIEMAT PSA	National Expert
SPAIN	Lourdes Gonzalez	CIEMAT PSA	National Expert
SPAIN	Guillermo Zaragoza	CIEMAT PSA	National Expert
SPAIN	Sara Dominguez	APRIA Systems	National Expert
SPAIN	Javier Pinedo	APRIA Systems	National Expert
SPAIN	Manuel Pérez García	University of Almería	National Expert
SPAIN	Sandra Contreras Iglesias	Rovira i Virgili University	National Expert
SWEDEN	Joakim Byström	Absolicon Solar Collector AB	National Expert
SWEDEN	Stavros Papadokonstantakis	Chalmers University of Technology	National Expert
UNITED KINGDOM	Harjit Singh	Brunel University London	National Expert

Task 63 – Solar Neighborhood Planning

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

Task Overview

The main objective of Task 63 is to support key players to achieve solar neighborhoods that support long-term solar access for energy production and for daylighting buildings and outdoor environments – resulting in sustainable and healthy environments. Key players include e.g. developers, property owners/associations, architects, urban planners, municipalities and institutions.

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

1. New neighborhood development
2. Existing neighborhood renovation and development

Solar energy aspects include active solar systems (solar thermal and photovoltaics) and passive strategies. Passive solar strategies include passive solar heating and cooling, daylighting, and thermal/visual comfort in indoor and outdoor environments.

The types of support being developed in this Task include strategies for the design of new and existing communities with focus on solar energy, comprising methods to secure sunlight access (right to light). Furthermore, the Task aims to focus on economic strategies and business models for better use of passive and active solar energy. Apart from economic values, added values or co-benefits of solar energy are considered. Another objective is to study the workflow of tools needed to support decisions in all planning stages (tool chain). Finally, case studies in each participating country will be a central part to bind close ties to practice and implementation.

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

- Solar planning strategies and concepts for achieving net zero energy/emission neighborhoods.
- Economic strategies, including added values and stakeholder engagement.
- Solar planning tools for new and existing neighborhoods.
- Case studies and stories, to test Task developments in dialogue with key players, implement and disseminate.

Task 63 will require a dialogue and cooperation with key players in neighborhood planning in each participating country. These include developers, real estate owners, architects, consultants, urban planners, municipalities, and other institutions. This cooperation gives the possibility to identify barriers, and test strategies, methods and tools to get feedback on development needs. In addition, case studies and lessons learnt will be documented to show inspiring examples of solar neighborhoods. Local collaborations within municipalities are an important part that complements the international cooperation within the Task and links Task experts with the practice and implementation in each country.

The Task is organized in four main activities/Subtasks, derived from the above described key areas:

- Subtask A: Solar planning strategies and concepts
- Subtask B: Economic strategies and stakeholder engagement
- Subtask C: Solar planning tools
- Subtask D: Case studies

Subtask A is looking at concepts for solar neighborhood planning in view of achieving high environmental goals (e.g. NZE, NZC), and the role of various strategies to reach them (including planning, design and technology implementation). Subtask B is focusing on strategies - business models and stakeholder engagement - to increase the solar energy utilization towards zero emission neighborhoods. Subtask C works on supportive tools, related to active solar energy systems and daylighting, within a chain of tools needed for neighborhood planning and design.

Subtask D focuses on implementation issues and dissemination of case studies with solar planning of existing and new neighborhoods. Subtask D also gives input and serves as a testing platform for Subtask A, B and C, thus the case studies are a core activity for the Task work.

Scope

Subtask A: Solar planning strategies and concepts *(Lead Country: Canada)*

The main objectives of Subtask A are:

- Review existing concepts and targets that underlie neighborhood design, both new and existing.
- Develop (criteria for) the design of representative archetypes/prototypes in existing and new neighborhoods (e.g., spatial design and building design - types of buildings, mixes of buildings, density, open space -, passive solar design potential, various active solar strategies and technologies, synergies and conflicts with other potential usages - in connection with Subtask B).
- Develop and test planning strategies and concepts for increased solar energy capture and utilization in neighborhoods, in view of achieving net zero energy (NZE), low carbon status or other goals in the era of low-carbon energy transition.
- Recommend strategies and concepts for the conceptual design of new and existing neighborhoods.
- Give a common definition/concept of urban surface usages relating to functions (e.g. energy production, microclimate regulation, permeability of surface, etc.) and materials (e.g. solar thermal panels, PV panels, green areas/facades/roofs, water, cool/reflective materials, etc.).

Subtask B: Economic strategies and stakeholder engagement *(Lead Country: Italy)*

The main objectives of Subtask B are:

- Analyse the potential integration of the Task outputs for the New Urban Agenda implementation.
- Identify and describe conflicts and synergies of the different and potential usages of urban surfaces, with specific relevance to solar energy harvest.
- Develop a method to propose and assess alternative scenarios for urban surface usages.
- Identify the potential co-benefits related to the hybrid or/and integrated usage of urban surface, apart from the solar energy production.
- Recommend suitable activities for stakeholder engagement/nudging strategies, and integrate the lessons learnt in the urban planning practice.
- Identify financial mechanisms and suggest ways to finance the transition, moving from energy market to added value services.

Subtask C: Solar planning tools *(Lead Country: Sweden and France)*

The main objectives of Subtask C are:

- Identify the current solar planning tool workflows and related tools used by key actors for planning solar neighborhoods. This could include tools from all platforms (GIS, CAD, or BIM). Analyse the strengths, weaknesses, and development needs.
- Identify relevant common indicators synthetizing solar energy and daylight performance of neighborhoods to be used in a summary dashboard for easy comparison.
- Develop a roadmap for improved workflows and solar planning tools needed in all planning stages (tool chain).

Subtask D: Case studies *(Lead Country: joint by subtask A-C leaders and OA)*

The main objectives of Subtask D are:

- Coordinate and collect case studies across subtask (A, B and C) topics.
- Serve as a platform for exchange of experiences from practice, including testing strategies and tools and interview stakeholders.
- Describe and disseminate case studies and stories of new and existing solar neighborhoods.

Collaboration with Industry

Local collaboration with municipalities and key actors in participating countries is in planning.

Task Duration

This Task started in September 2019 and will end in October 2023.

Participating Countries

Canada, China, Denmark, France, Italy, Sweden, and Switzerland.

And, planned participation from Australia, Germany, Norway, and from the organizations ECREEE, EACREEE and RCREEE.

Work During 2020

Subtask A: Solar Planning Strategies and Concepts

The first activity has the goal to define design options and analyse solar neighborhoods in participating countries, to identify key influencing factors in reaching NZE or low carbon neighborhoods. A matrix was developed in order to characterize different archetypes of neighborhoods. The matrix was used to collect information about typical neighborhoods from different countries. So far, 24 examples from 7 countries have been documented. The main criteria was extracted and will be used to develop neighborhood archetypes for simulations and analysis of solar planning strategies and concepts for neighborhoods.

Subtask B: Economic Strategies and Stakeholder Engagement

The New Urban Agenda was discussed; how the work in Task 63 is connected and how to implement these principles in planning solar neighborhoods. The NUA principles are the backbone and motivation for the Task's work. This will be especially useful as a way to communicate the concrete outputs of the Task and link them to the global visions.

A literature review on surface uses of neighborhoods was carried out to identify and describe conflicts and synergies of the different and potential uses of urban surfaces, with specific relevance to solar energy harvest. A classification of urban surfaces and surface uses and a matrix of conflicts and synergies among surface uses was established. A method was developed to define urban surface uses to be used in future work. In parallel, the report on surface uses of neighborhoods is drafted.

Work also has started on identifying potential co-benefits related to the hybrid or/and integrated use of urban surface, apart from the solar energy production. An analysis of literature and selected case studies of innovative financial models and trends is ongoing. A workshop was held in May 2020 to discuss these issues.

Another objective is to recommend suitable activities for stakeholder engagement and "nudging" strategies and to integrate the lessons learned in the urban planning practice. The work started with a literature review of stakeholder engagement and citizen involvement in solar neighborhoods and will continue next year.

Subtask C: Solar Planning Tools

A review of current tools and workflows is ongoing. Also, key performance indicators used in different countries are documented. Task experts also completed a survey on the tools they use and the problems they have encountered when using the tools.

Workflow stories is a way to obtain data from external actors like companies, regarding the use of tools for solar neighborhood planning. A "template" how to document such stories was decided on and examples of workflow stories are currently being gathered.

The three most common indicators for solar neighborhood planning in the participating countries were gathered. So far, the provided common indicators demonstrate a wide range of different metrics used for active and passive solar energy. Most of the legislation in the countries is specific to daylight access, but not much on outdoor solar access.

A benchmark study has been proposed (not in the original Task work), which would aim to compare the difference of solar irradiation modeling of a neighborhood by using different software. The study particularly focuses on the modeling of irradiation on façades.

These activities will lead to a report on existing tools and workflows that focuses on the different types of tools and how they can be linked, the types of output (Key Performance Indicators), visualization of results, users (needed competences), and target audiences. This report will be a basis for the next phase/report.

Subtask D: Case Studies

A matrix was developed to fill in potential case studies, including some key information (category, stage of project, goals for planning of the neighborhood, solar strategies used, energy targets, tools used, economic issues, other benefits, stakeholder engagement, etc.). This matrix is presently used to collect potential solar neighborhood cases from different (participating) countries to study within Task 63. Case studies could be new area developments or existing areas to be further developed (refurbishments, infills, etc.).

The main work in Subtask D during 2020 has been on developing a template for describing the Task 63 case studies, in relation to the topics of each Subtask A/B/C, to ensure that we will work on and get all the information needed. Drafts have been discussed and improved during the year, and presently final comments and inputs are considered to create a final version. The template was also tested on a case study from Canada.

In parallel, Task experts are locally involved in the planning of different neighborhoods, and in cooperation with local stakeholders. The cooperation with different local solar neighborhood planning projects will give feedback on our work and the Task participants the opportunity to present the results. Selected case studies will be presented according to the developed template and published on the SHC website.

Work Planned For 2021

Subtask A: Solar planning strategies and concepts

A survey will be prepared and carried out on existing strategies in the design of existing and new neighborhoods. The result will be included in an internal report. The next step will be to refine the selection criteria for archetypes and presentation methods of these criteria. Links to the other subtasks will be further discussed, including how to use the archetypes for separate or joint studies. Planned main activities in 2021:

- Prepare and carry out a survey on existing strategies in the design of neighborhoods.
- Extract and refine main criteria that can be used in the development of neighborhood archetypes.
- Design neighborhood archetypes that encompass combinations of design parameters.
- Finalize the review of existing neighborhoods and detailing criteria of selection of archetypes (internal report D.A1).
- Start simulation and analysis of the defined archetypes.
- Prepare and carry out a “summer school” for advanced PhD students and master students in Calgary, Canada. In conjunction to the Task 63 meeting in September/October 2021, if possible due to the pandemic.

Subtask B: Economic strategies and stakeholder engagement

The main activities planned for Subtask B in 2021 are:

- Start testing the method for urban surface uses.
- Apply and test the method on archetypes (Subtask A link).
- Work on the report on surface uses of neighborhoods, focused on how to define most suitable uses, prevent conflicts and create synergies. Finalize the report (end of 2021).
- Continue and finalize the analysis based on literature and selected case studies of innovative financial models and trends.
- Start the development of a framework to assess multiple benefits created by the adoption of hybrid and integrated strategies for urban surface usage.
- Continue and finalize the review on stakeholder engagement and citizen involvement in solar neighborhoods.

Subtask C: Solar planning tools

The main activities planned for Subtask C in 2021 are:

- Finalize the work on identifying and describing current tools and workflows.
- Continue to investigate performance indicators related to solar aspects, connected to legislation and recommendations.
- Finalize the identification and descriptions of common workflows.
- Draft report on the identification of existing tools and workflows.
- Start to identify how to improve workflows and identify missing parts in workflows.
- Start to work on a roadmap for improved workflows and development needs of solar planning tools.

Subtask D: Case studies

The main activities planned for Subtask D in 2021 are:

- Test new draft of the template on additional case studies and revise.
- Finalize template for describing case studies, based on identified key aspects and indicators.
- Identify additional/potential case studies per country and add in the overview matrix.
- Identify (if any) missing case studies needed for the work in Subtask A, B and C.
- First drafts of case studies described using the case study template.

Dissemination Activities In 2020

Reports, Published Books

No reports or books were published in 2020.

Journal Articles, Conference Papers, etc.

Author(s) / Editor	*Title*	*Publication / Conference*	*Bibliographic Reference*
Manni, M., Lobaccaro, G., Goia, F., Nicolini, A., Rossi, F.	Exploiting selective angular properties of retro-reflective coatings to mitigate solar irradiation within the urban canyon	Solar Energy	189, pp. 74-85. (2019)
Taveres-Cachat, E., Lobaccaro, G., Goia, F., Chaudhary, G.	A methodology to improve the performance of PV integrated shading devices using multi-objective optimization	Applied Energy	247, pp. 731-744. (2019)
Lobaccaro, G., Lisowska, M.M., Saretta, E., Bonomo, P., Frontini, F.	A methodological analysis approach to assess solar energy potential at the neighborhood scale	Energies	12 (18), art. no. 3554. (2019)
Lobaccaro, G., Croce, S., Lindkvist, C., Munari Probst, M.C., Scognamiglio, A., Dahlberg, J., Lundgren, M., Wall, M.	A cross-country perspective on solar energy in urban planning: Lessons learned from international case studies	Renewable and Sustainable Energy Reviews	108, pp. 209-237 (2019)
Paparella, R.; Caini, M.	Analysis of the solar potential of urban public areas for the installation of integrated photovoltaic systems.	IOP Conference Series. Hearth and Environmental Science	ISSN:1755-1315 vol. 296 (2019)
Croce, Silvia; Vettorato, Daniele; Paparella, Rossana	A Systemic Approach for the Optimization of Urban Surfaces Usage.	IOP Conference Series. Hearth and Environmental Science	ISSN:1755-1315 vol. 290 (2019)

D'Alpaos, Chiara; Moretto, Michele	Do Smart grid innovations affect real estate market values?	AIMS Energy 7(2), pp. 141-150	7(2), 2019, pp. 141-150
D'Alpaos, Chiara; Bragolusi, Paolo	Prioritization of energy retrofit strategies in public housing: An AHP model	In: Calabrò F., Della Spina L., Bevilacqua C. (eds) New Metropolitan Perspectives. ISHT 2018. Smart, Innovation, Systems and Technologies	vol 101, 2019, Springer, Cham, pp. 534-541 https://doi.org/10.1007/978-3-319-92102-0_56
Bottero, Marta; D'Alpaos, Chiara; Dell'Anna, Federico	Boosting investments in buildings energy retrofit: The role of incentives	In: Calabrò F., Della Spina L., Bevilacqua C. (eds) New Metropolitan Perspectives. ISHT 2018. Smart Innovation, Systems and Technologies	vol 101, 2019, Springer, Cham, pp. 593-600 https://doi.org/10.1007/978-3-319-92102-0_63
M. Thebault, L.A. Berrah, G. Desthieux, C. Ménézo	Towards a Solar Cadastre For The Monitoring of Solar Energy Urban Deployment: The Case of Geneva.	Solar World Congress 2019	04-07 November 2019, Santiago, Chile
M.Thebault, V. Clivillé, L.A. Berrah, L. Gaillard, G. Desthieux, C. Ménézo	Multi-criteria decision aiding for the integration of photovoltaic systems in urban environment: the case of the Greater Geneva agglomeration.	Territorio Italia - Land Administration, Cadastre, Real Estate	2020
Andreolli F., D'Alpaos C., Moretto M.	Investing in a Solar Home Systems by a grid-connected household: investment timing, technological choice and the value of flexibility	EFI5 - Energy Finance Italia Edn. 5	Roma Tre University - Department of Economics February 10 - 11, 2020
Stendardo, N.; Desthieux, G.; Abdennadher, N.; Gallinelli	GPU-Enabled Shadow Casting for Solar Potential Estimation in Large Urban Areas. Application to the Solar Cadaster of Greater Geneva.	***Appl. Sci.*** 2020, ***10***, 5361. https://doi.org/10.3390/app10155361	2020
M. Thebault, V. Clivillé, L.A. Berrah, G. Desthieux	Multicriteria roof sorting for the integration of photovoltaic systems in urban environments	*Sustainable Cities and Society (2020): 102259.*	2020
Hasan, J., Horvat, M. and K. Saunders	The Application of Solar Envelope Zoning for the Enhancement of Solar Access in a Densely Populated Neighborhood	EuroSun 2020, Sept 1st-3rd, 2020, Athens, Greece	Proceedings not yet available
Manni, M., Lobaccaro, G., Lolli, N., Bohne, R.A.	Parametric Design to Maximize Solar Irradiation and Minimize the Embodied GHG Emissions for a ZEB in Nordic and Mediterranean Climate Zones.	Energies	2020, vol. 13, n. 4981. DOI: 10.3390/en1318498
Devetaković, M., Djordjević, D., Radojević, M., Krstić-Furundžić, A., Burduhos, B. G.,	Photovoltaics on Landmark Buildings with Distinctive Geometries	Applied Sciences	2020, vol. 10, n. 6696. DOI: 10.3390/app10196696

Martinopoulos, G., Neagoe, M., Lobaccaro, G.			
Manni, M., Bonamente, E., Lobaccaro, G., Goia, F., Nicolini, A., Bozonnet, E., Rossi, F.	Development and validation of a Monte Carlo-based numerical model for solar analyses in urban canyon configurations	Building and Environment	2020, vol. 170, DOI: 10.1016/j.buildenv.2019.106638
Manni, M., Cardinali, M., Lobaccaro, G., Goia, F., Nicolini, A., Rossi, F.	Effects of retro-reflective and angular-selective retro-reflective materials on solar energy in urban canyon	Solar Energy	(2020), vol. 209, pp. 662-673. DOI: 10.1016/j.solener.2020.08.085
D'Alpaos C., Bragolusi P.	The Market Price Premium for Residential PV Plants	New Metropolitan Perspectives. NMP 2020. Smart Innovation, Systems and Technologies	2021, vol. 178, pp. 1208-1216. Bevilacqua C., Calabrò F., Della Spina L. (eds). Springer, Cham
D'Alpaos C., Andreolli F.	The economics of solar home systems: State of art and future challenges in local energy markets	Valori e Valutazioni	24, 2020, pp. 77-96. ISSN:2036-2404
D'Alpaos C., Andreolli F.	Renewable Energy Communities: The Challenge for New Policy and Regulatory Frameworks Design	New Metropolitan Perspectives. NMP 2020. Smart Innovation, Systems and Technologies	2021, vol. 178, pp. 500-509. Bevilacqua C., Calabrò F., Della Spina L. (eds). Springer, Cham
D'Alpaos C.	Do policy incentives to buildings energy retrofit encourage homeowners' free rider behavior?	Appraisal and Valuation - Green Energy and Technology	2021, pp. 105-116 Morano P., Oppio A., Rosato P., Sdino L., Tajani F. (eds). Springer, Cham.

Conferences, Workshops, Seminars

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	# of Attendees
COST Action PEARL PV – Cross fertilization S3 Simulation of complex shading for BIPV	Gabriele Lobaccaro, NTNU. Oral presentation on Solar energy in Nordic climate: overshadowing effect on BIPV façade in Nordic urban environment: a case study of Trondheim.	February 26, .2020 Utrecht (The Netherlands)	20
Seminar: Energy communities in housing associations and apartment buildings. + Exhibition: coloured solar panels, solar roof, street furniture with solar energy as stand-alone	Organizing the event. Introducing Task 63 in Denmark. Karin Kappel, Solar City Denmark	February 27, .2020 Copenhagen	70 persons mainly from housing associations but also PV suppliers and energy companies

EFI5 - Energy Finance Italia Edn. 5	Andreolli F. Paper Presentation: Investing in a Solar Home System by a grid-connected household: investment timing, technological choice and the value of flexibility by Andreolli F., D'Alpaos C., Moretto M.	Roma Tre University - Department of Economics February 10-11, 2020	About 40
Conference: Holistic approaches for water and resource efficiency in process industry	Presentation: Resource recovery from industrial wastewater by cutting edge membrane technologies – Outcomes of the ReWaCEM project	March 25-26, 2020	~70
Conference: Holistic approaches for water and resource efficiency in process industry	Energy Footprint of Water Treatment	March 25-26, 2020	~70

Dissemination Activities Planned For 2021

Due to the pandemic, seminars and workshops in conjunction to Task meetings are postponed. All Task meetings are presently virtual. A "summer school" is planned in conjunction to the Task meeting in September/October 2021, for advanced PhD and Master Students to contribute to the study of neighbourhood archetypes (coordinated by Subtask A).

Task Meetings 2020 – 2021

Meeting	Date	Location	# of Participants (# of Countries)
Task Meeting 2	March 10-12, 2020	Virtual	42 registrations (9 countries + 1 sponsor)
Task Meeting 3	September 22-25, 2020	Virtual	38 registrations (8 countries + 1 sponsor)
Task Meeting 4	September/October 2021	Calgary, Canada TBC	
Summer school	September/October 2021	Calgary, Canada TBC	

SHC Task 63 Participants

Country	Name	Institution / Company	Role
SWEDEN	**Maria Wall**	**Energy and Building Design, Lund University**	**Operating Agent**
CANADA	Caroline Hachem-Vermette	University of Calgary	Subtask A Leader + co-leader Subtask D
CANADA	Ajit Jassal	University of Calgary	National Expert
CANADA	Ricardo D'Almeida	University of Calgary	National Expert
CANADA	Kuljeet Sing Grewal	University of Calgary	National Expert
CANADA	Olivia Alarcon Herrera	University of Calgary	National Expert
CANADA	Miljana Horvat	Ryerson University, Department of Architectural Science	National Expert
CANADA	Javeriya Hasan	Ryerson University, Department of Architectural Science	National Expert
CANADA	Ursula Eicker	Concordia University	National Expert
CANADA	Andreas Athienitis	Concordia University	National Expert
CANADA	James Bambara	Concordia University	National Expert
CHINA	Jianqing He	Chinese Society for Sustainable Development (CSSD)	National Expert
CHINA	Xiuxiu Gao	China National Engineering Research Center for Human Settlements, CAG	National Expert
CHINA	Ying Cao	China National Engineering Research Center for Human Settlements, CAG	National Expert
CHINA	Xi Zhao	China National Engineering Research Center for Human Settlements, CAG	National Expert
CHINA	Xiaotong Zhang	China National Engineering Research Center for Human Settlements, CAG	National Expert
CHINA	Xin Cui	Xi'an Jiaotong University (XJU)	National Expert
CHINA	Wei Chen	Xi'an Jiaotong University (XJU)	National Expert

CHINA	Xiangzhao Meng	Xi'an Jiaotong University (XJU)	National Expert
CHINA	Xiangfeng Liu	Tianjin University	Observer/ expert
CHINA	Yang Wang	China Agricultural University in Beijing	National Expert
CHINA	Taofang Yu	Tsinghua University	Observer/ expert
DENMARK	Olaf Bruun Jørgensen	Danish Energy Management (DEM)	National Expert
DENMARK	Karin Kappel	Solar City Denmark	National Expert
FRANCE	Christophe Ménézo	University Savoie Mont-Blanc - INES	National Expert
FRANCE	Leon Gaillard	University Savoie Mont-Blanc - INES	National Expert
FRANCE	Martin Thebault	University Savoie Mont-Blanc - INES	Subtask C Leader + co-leader Subtask D
FRANCE	Karine Bouty	University Savoie Mont-Blanc - INES	National Expert
FRANCE	Stéphanie Giroux	Centre for Energy and Thermal Sciences of Lyon (CETHIL)	National Expert
FRANCE	Benjamin Govehovitch	Centre for Energy and Thermal Sciences of Lyon (CETHIL)	National Expert
FRANCE	Bruno Georges	OTEIS ITF	Observer/ expert
FRANCE	Romain Nouvel	OTEIS ITF	Observer/ expert
GERMANY	Harald Drück	University of Stuttgart (IGTE)	Observer
ITALY	Daniele Vettorato	EURAC Research	Subtask B Leader
ITALY	Silvia Croce	EURAC Research	Subtask B Leader
ITALY	Rossana Paparella	Civil, Environmental and Architectural Engineering, Padua University	National Expert
ITALY	Mauro Caini	Civil, Environmental and Architectural Engineering, Padua University	National Expert
ITALY	Chiara D'Alpaos	Civil, Environmental and Architectural Engineering, Padua University	National Expert

ITALY	Francesca Andreolli	Civil, Environmental and Architectural Engineering, Padua University	National Expert
ITALY	Fabio Bignucolo	Industrial Engineering, Padua University	National Expert
ITALY	Simone Giostra	DASTU, Politecnico Milano	Observer
ITALY	Andrea Giovanni Mainini	Politecnico Milano	Observer
NORWAY	Inger Andresen	NTNU – Norwegian University of Science and Technology	Observer
NORWAY	Gabriele Lobaccaro	NTNU – Norwegian University of Science and Technology	Observer/ expert
NORWAY	Anne Grete Hestnes	NTNU – Norwegian University of Science and Technology	Observer
NORWAY	Johannes Brozovsky	NTNU – Norwegian University of Science and Technology	National Expert
NORWAY	Tommy Kleiven	NTNU – Norwegian University of Science and Technology	National Expert
NORWAY	Matteo Formolli	NTNU – Norwegian University of Science and Technology	National Expert
NORWAY	Ida Bryn	Erichsen & Horgen	National Expert
NORWAY	Arnkell J. Petersen	Erichsen & Horgen	National Expert
NORWAY	Ragnhild Haugland Løge	Erichsen & Horgen	National Expert
NORWAY	Lisa Henden	Erichsen & Horgen	National Expert
SWEDEN	Jouri Kanters	Energy and Building Design, Lund University	Subtask C Leader + co-leader Subtask D
SWEDEN	Rafael Campamà	Energy and Building Design, Lund University	National Expert
SWEDEN	Agnieszka Czachura	Energy and Building Design, Lund University	National Expert
SWEDEN	Marja Lundgren	White Arkitekter AB	National Expert
SWEDEN	Viktor Sjöberg	White Arkitekter AB	National Expert
SWEDEN	Nicholas Baker	White Arkitekter AB	National Expert
SWEDEN	Caroline Cederström	White Arkitekter AB	National Expert

SWITZERLAND	Raphael Compagnon	Haute école of Fribourg (HEIA-FR)	Observer/ expert
SWITZERLAND	Jérôme Kämpf	Idiap Research Institute	Observer/ expert
UNITED KINGDOM	Donna Munro		Observer/ expert
UNITED KINGDOM	John Mardaljevic	Loughborough University	Observer
EACREEE / Tanzania	Lugano Wilson	Tanzania Industrial Research and Development Organization (TIRDO)	Observer/ expert
EACREEE / Uganda	Fred Ishugah	East African Center for Renewable Energy and Energy Efficiency (EACREEE)	Observer/ expert
EACREEE / Uganda	Michael Kiza	East African Center for Renewable Energy and Energy Efficiency (EACREEE)	Observer/ expert
ECREEE / Nigeria	Okala Nwoke	National Centre for Energy Research and Development, University of Nigeria/ ECREEE	Observer
RCREEE / Egypt	Khalid Salmi	Regional Center for Renewable Energy and Energy Efficiency (RCREEE)	Observer

Task 64 – Solar Process Heat

Andreas Häberle
SPF Institute for Solar Technology | Eastern Switzerland University of Applied Sciences (OST)
Operating Agent for the Swiss Office Fédéral de l'Economie Energétique

Task Overview

The goal of Task 64 is to help solar technologies be (and also be recognized as) a reliable part of process heat supply systems. Instead of focusing on component development, we will look at the overall (solar) system at process temperatures from just above ambient temperature up to approx. 400°C-500°C. Open research questions are the standardization of integration schemes on process level and on supply level and the combination with other efficient heat supply technologies such as combined heat and power plants, heat pumps, or power-to-heat. As a very important aspect, the experiences of numerous solar process heat markets throughout the world will be brought together to enable a market-oriented dissemination of existing and new knowledge.
The key objective of this Task is to identify, verify, and promote the role of solar heating plants in combination with other heat supply technologies for process heat supply, such as fossil and non-fossil (biomass and biogas) fuel boilers, combined heat and power plants, high temperature heat pumps, or power-to-heat.

The integration of solar energy in a hybrid energy supply system has to be completed by an optimized energy storage management under consideration of different thermal energy storage technologies. Based on this, solar energy can become a reliable part of the future industrial heat supply in industrial systems.

Scope

Subtask A: Integrated energy systems *(Lead Country: Germany)*
Subtask Leader: Prof. Dr. Ulrike Jordan and Dr. Felix Pag, University of Kassel

The main objective of Subtask A is to develop innovative hydraulic schemes for future process heat supply. These schemes will deploy different regenerative or highly efficient heating technologies to maximize the final energy and greenhouse gas emission savings compared to monovalent regenerative heating systems.

Specific objectives of Subtask A are to:

- define reference applications for further research in the whole task.
- adapt hydraulic schemes, operational modes and dimensioning rules of renewable heating technologies when combined to integrated energy systems.
- asses the benefits of integrated energy concepts regarding overall synergies and economical achievable greenhouse gas emission savings.

Subtask B: Modularization *(Lead Country: Spain)*
Subtask Leader: Dr. Eduardo Zarza Moya, Plataforma Solar de Almería

Since the advantages of using modularized components/packages are evident and widely admitted by the entities involved in the design and implementation of SHIP applications, the specific objective of Subtask B is the definition of modularized and "normalized" components/packages for these applications (e.g., components/packages for the balance of plant, solar field, interfaces and hydraulic circuit). The legal requirements currently imposed to some industrial equipment (boilers, heat exchangers...) will be taken into consideration when proposing normalized components/systems.

Subtask C: Simulation and Design Tools *(Lead Country: Chile)*
Subtask Leader: Prof. Dr. José Miguel Cardemil, University of Chile

The main objective of Subtask C is to develop simulations and monitoring tools for assessing the potential benefits of integrating Solar Heat into industrial processes, with known uncertainties sources, taking into consideration economic, social and environmental issues. In addition, the subtask C will devote significant efforts for assessing monitoring strategies that allow improving the performance of actual systems.

Subtask D: Standardization / Certification *(Lead Country: Greece)*
Subtask Leader: Vassiliki Drosou, CRES

The main objective of Subtask D is to investigate the standardization and certification area regarding the technology of solar process heat, to support the existing ongoing relevant standardization and certification activities and to suggest and develop new innovative standardization procedures and certification aspects considering the relevant technological developments and legislative requirements

Subtask E: Guideline to Market *(Lead Country: Germany and Austria (co-chairs))*
Subtask Leader: Dr. Peter Nitz, Fraunhofer ISE, Jürgen Fluch, AEE INTEC

Subtask E aims at drafting the guidelines of a market approach more prone to be successful among industrial end-users. Closing the circle of strategies tackling technical and non-technical barriers to market penetration, in this subtask Solar Process Heat is to be delivered to industrial end-users as a simple, reliable, innovative, affordable and profitable technological solution for the decarbonization of heating (and cooling) supply to industry.

Collaboration with Other IEA TCPs

This is a fully joint Task with the SolarPACES Task IV.

Collaboration with Industry

Twenty-one companies from 12 countries participated in the Task meetings in 2020.

Task Duration

This Task started on January 2020 and will end December 2023.

Participating Countries

Australia, Austria, Belgium, Brazil, Canada, Chile, China, Denmark, France, Germany, Greece, Italy, Korea, Mexico, Namibia, Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA

Work During 2020

Subtask A: Integrated energy systems

The definition of daily heat load profiles for reference applications was nearly completed. Four clusters with different ambient temperature dependencies were built with approx. 800 German heat load profiles as a basis. Other available profiles were used for validation purposes. The distribution of daily heat demand on hours of the day is difficult but seems not to be too important because heat storages can easily shift the supply for several hours.

Subtask B: Modularization

The current promotion of commercial applications with very different integration schemes between the solar field and the industrial process led to a focus of Subtask B on the Balance of Plant (BoP) instead of on the integration schemes.

Subtask C: Simulation and Design Tools

The present activities in Subtask C are associated with the comparative study between simulation tools. The differences between simulation results show to be significant and more case studies will be included in the comparison.

Subtask D: Standardization / Certification

The main points that were discussed within Subtask D concern deliverable D2 “Proposal for new standardization work” and the organization of work for deliverable D1 "Standardization Plan".

Subtask E: Guideline to Market

Within Subtask E good progress was made, mainly in the collection of information about available funding and financing schemes and the collection of relevant parameters to evaluate SHIP projects within all involved stakeholder groups.

Work Planned For 2021

Subtask A: Integrated energy systems

Continue work on A.2 Integration concepts for solar process heat with a special link to Subtask B and start working on A.3 System concepts for integrated renewable energy systems with a link to Subtask C.

Early in the year: finalize Deliverable A1.

Subtask B: Modularization

All three activities will be worked on: B1 Modular system concepts for solar process heat applications, B2 Standard packages for collectors and hydraulics (easy installation; easy dismantling), B3 Development of a modular and scalable interfaces unit for solar process heat applications.

Mid-year: complete Deliverable B1

Subtask C: Simulation and Design Tools

Continue and Complete the work on C1 Identification and evaluation of available simulation tools for SHIP. Start with C2 Simulation Tools for Solar Process Heat Systems.

End of the year: complete deliverable C1.

Subtask D: Standardization / Certification

Continue and Complete the work on D1 Standardization Plan. Start with D2 New standardization Work.

End of the year: complete deliverable D1.

Subtask E: Guideline to Market

Activity E1 Stimulating Innovation will be completed with the finalization of Deliverable E1, early in the year. Continue working on E2 Competitiveness indicators and E3 Financing Models.

Dissemination Activities In 2020

Reports, Published Books

As the Task began in 2020, it is still too early for the publication of reports and books.

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Dirk Krüger, Bärbel Epp, Tobias Hirsch, Martina Neises-von Puttkamer	Developments in Solar Heat from Concentrating Solar Systems	SolarPACES Conference	2020
Bärbel Epp	Project sponsors need to offer banks sufficient securities and guarantees	solarthermalworld.org	2020

Conferences, Workshops, Seminars

None at this time.

Dissemination Activities Planned For 2021

Participation at a side event for the EU Industry Days together with Solar Heat Europe (SHE), IRENA, AEE Intec and companies specializing in the topic, such as Absolicon, newHeat and Solrico on March 9, 2021.

Contributions atI SES SWC 2021, SolarPACES and national conferences.

If possible, we will plan for an industry workshop towards the end of the year.

Task Meetings 2020 – 2021

Meeting	Date	Location	# of Participants (# of Countries)
Task Meeting 1	March 26, 2020	online	51 participants (18 countries
Task Meeting 2	June 25, 2020	online	52 participants (24 countries)
Task Meeting 3	September 9, 2020	online	57 participants (23 countries)
Task Meeting 4	December 16, 2020	online	52 participants (23 countries)
Task Meeting 5	March 24, 2021	online	…
Task Meeting 6	June 2021	online	…
Task Meeting 7	September 2021	tbd	…
Task Meeting 8	December 2021	tbd	…

SHC Task 64 Participants

Country	Name	Institution / Company	Role
SWITZERLAND	**Andreas Häberle**	**SPF**	**SHC Operating Agent**
AUSTRALIA	Ken Guthrie	sustainable energy transformation	National Expert
AUSTRIA	Winfried Braumann	REENAG	National Expert
AUSTRIA	Christoph Brunner	AEE INTEC	National Expert/SHC Task 62 Operating Agent
AUSTRIA	Jürgen Fluch	AEE INTEC	ST Leader
AUSTRIA	Wolfgang Gruber-Glatzl	AEE INTEC	National Expert
AUSTRIA	Markus Haider	TU Wien	National Expert
AUSTRIA	Valerie Rodin	JKU	National Expert
BELGIUM	Felix Ainz	Rioglass	National Expert
BELGIUM	Pablo del Prado	Rioglass	National Expert
BELGIUM	Irene di Padua	Solar Heat Europe	National Expert
BELGIUM	Jean-Yves Peugnieu	Sunoptimo	National Expert
BELGIUM	Costas Travasaros	Solar Heat Europe	National Expert
BRASIL	Leonardo Lemos	UFSC	National Expert
BRASIL	Allan Ricardo Starke	UFSC	National Expert
CANADA	Lucio Mesquita	CanmetENERGY Ottawa	National Expert
CHILE	José-Miguel Cardemil	PUC	ST Leader
CHILE	Maria Cerda	Fraunhofer Chile	National Expert
CHILE	Mauro Henriquez	Uni Antofagasta	National Expert
CHINA	Yanjun Dai	Shanghai Jiao Tong University	National Expert
CHINA	Dongqiang Lei	Chinese Academy of Science	National Expert
CHINA	Guofeng Yuan	Chinese Academy of Science	National Expert
DENMARK	Jakob Jensen	Heliac	National Expert
DENMARK	Weiqiang Kong	DTU	National Expert
FRANCE	Raphael Albert	CEA	National Expert
FRANCE	Pierre Delmas	newHeat	National Expert

FRANCE	Christine Delord	INES	National Expert
FRANCE	Alexis Gonelle	newHeat	National Expert
FRANCE	Valéry Vuillerme	CEA	National Expert
GERMANY	Stefan Abrecht	Solar-Experience GmbH	National Expert
GERMANY	Andreas Burger	Industrial Solar GmbH	National Expert
GERMANY	Bärbel Epp	SOLRICO	National Expert
GERMANY	Klaus Hennecke	DLR	National Expert
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GERMANY	Mateo Jesper	Uni Kassel	National Expert
GERMANY	Ulrike Jordan	Uni Kassel	ST Leader
GERMANY	Korbinian Kramer	Fraunhofer ISE	National Expert
GERMANY	Dirk Krüger	DLR	National Expert
GERMANY	Peter Nitz	Fraunhofer ISE	ST Leader
GERMANY	Felix Pag	Uni Kassel	ST Leader
GERMANY	Werner Platzer	Fraunhofer ISE	National Expert
GERMANY	Martin Scheuerer	protarget AG	National Expert
GERMANY	Kai Schickedanz	Wacker	National Expert
GERMANY	Nicolas Ürlings	protarget AG	National Expert
GERMANY	Christian Zahler	Industrial Solar GmbH	National Expert
GREECE	Vassiliki Drosou	CRES	ST Leader
ITALY	Marco D'Aurea	ENEA	National Expert
ITALY	Alessandro Guzzini	DIN-UNIBO	National Expert
ITALY	Marco Pellegrini	University of Bologna	National Expert
ITALY	Luca Turchetti	ENEA	National Expert
KOREA	Jinyoung Kim	KIER	National Expert
MEXICO	Sergio Lugo Ucan	CIMAV	National Expert
MEXICO	Angel Mejía Santiago	Inventive Power	National Expert
MEXICO	Mario Nájera Trejo	CIMAV	National Expert
MEXICO	Naghelli Ortega Avila	CIMAV	National Expert
NAMIBIA	Readlay Makaliki	SACREEE	National Expert

NAMIBIA	Asteria Markus	SACREEE	National Expert
NAMIBIA	Kuda Ndhlukula	SACREEE	National Expert
NETHERLANDS	Adriano Desideri	SOLHO	National Expert
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PORTUGAL	Diego Canavarro	University of Evora	National Expert
PORTUGAL	José Maria Cunha	INEGI	National Expert
PORTUGAL	Tiago Osório	University Evora	National Expert
SOUTH AFRICA	Henning Holm	Holms & Friends	National Expert
SPAIN	Diego Alarcón	CIEMAT	National Expert
SPAIN	Antonio Cazorla-Marín	UPV	National Expert
SPAIN	Marco David	UPV	National Expert
SPAIN	Jesús Fernández-Reche	CIEMAT-PSA	National Expert
SPAIN	Miguel Frasquet	Solatom	National Expert
SPAIN	Ana Lozano Garcia	Circe	National Expert
SPAIN	José Gonzálvez-Maciá	UPV	National Expert
SPAIN	Susana Lopez	Tekniker	National Expert
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SPAIN	Alan Pino	University of Seville	National Expert
SPAIN	Raquel Simón	Endef	National Expert
SPAIN	Josep Ubach	Rioglass	National Expert
SPAIN	Loreto Valenzuela	Ciemat	National Expert
SPAIN	Jeroen van Schijndel	Rioglass	National Expert
SPAIN	Cristóbal Villasante	Tekniker	National Expert
SPAIN	Eduardo Zarza	Ciemat	ST Leader
SWEDEN	Avip Bastakoti	MG Sustainable Engineering AB	National Expert
SWEDEN	João Gomes	Absolicon AB	National Expert
SWEDEN	Rafael Guédez	KTH Royal Institute of Technology	National Expert
SWEDEN	George Pius	MG Sustainable Engineering AB	National Expert
SWEDEN	Puneet Saini	Uppsala University	National Expert

SWITZERLAND	Andreas Bohren	SPF	National Expert
SWITZERLAND	Guglielmo Cioni	TVP	National Expert
SWITZERLAND	Elimar Frank	Frank Energy	National Expert
SWITZERLAND	Mercedes Rittmann	SPF	National Expert
TURKEY	İbrahim Halil Yılmaz	Adana University	National Expert
UNITED KINGDOM	Alex Mellor	Naked Energy	National Expert
USA	Lun Jiang	University of California, Merced	National Expert
USA	Parthiv Kurup	NREL	National Expert
USA	Collin McMillan	NREL	National Expert

Task 65 – Solar Cooling for the Sunbelt Regions

Uli Jakob
Dr. Jakob energy research GmbH & Co. KG
Operating Agent for the German Government (PtJ for BMWi)

Task Overview

The key objective of Task 65 is to adapt, verify and promote Solar Cooling as an affordable and reliable solution in the rising Cooling demand across Sunbelt countries. The (existing) technologies need to be adapted to the specific boundaries and analysed and optimized in terms of investment and operating cost and their environmental impact (e.g., solar fraction) as well as compared and benchmarked on a unified level against reference technologies on a life cycle cost basis.

Solar Cooling should become a reliable part of the future cooling supply in Sunbelt regions. After completion of the Task, we should have achieved:

- Increase the audience and attention on Solar Cooling solutions through the combination of MI IC7 and IEA SHC activities and the entire stakeholders.
- Provide a platform for the transfer and exchange of know-how and experiences from OECD countries, already having long experiences in Solar Cooling, towards Sunbelt countries (e.g. Africa, MENA, Asia, …) and vice versa.
- Support the development of Solar Cooling technologies on component and system level adapted for the boundary conditions of Sunbelt (tropical, arid, etc.) that are affordable, safe and reliable in the medium to large scale (2 kW-5,000 kW) capacities
- Adapt existing technology, economic and financial analyses tools to assess and compare economic and financial viability of different cooling options with a life-cycle cost-benefit analyses (LCCBA) model.
- Apply the LCCBA framework to assess case studies and use cases from Subtasks A and B to draw conclusions and recommendations for solar cooling technology and market development and policy design.
- Pre-assess ‘bankability’ of solar cooling investments with financial KPIs.
- Find boundary conditions (technical/economic) under which Solar Cooling is competitive against fossil driven systems and different renewable solutions.
- Establishing of a technical and economic data base to provide a standardized assessment of demo (or simulated) use-cases.
- Accelerate the market creation and development through communication and dissemination activities.

The Task’s work is divided into four subtasks:

- Subtask A: Adaptation
- Subtask B: Demonstration
- Subtask C: Assessment and Tools
- Subtask D: Dissemination

Scope

Subtask A: Adaptation *(Lead Country: Italy)*
The main objectives of Subtask A are:

- Collection of technical / climatic boundary conditions for sunbelt regions to better understand the operating conditions for all components of solar cooling systems
- Adaptation and documentation of specific key components for solar cooling as well as complete systems according to the specific boundaries of sunbelt climates.
    - Sources (PV, ST, PVT)
    - Heat rejection (direct air-cooled, Cooling towers: electricity/water demand, …)

    - Heat pumps/chillers (improved heat/mass transfer, multistage concepts, hybrid systems, sorption storage for combined cooling and storage)
    - Storage concepts (cold, hot side, sorption storage)
- Complete systems incl. hydraulic concepts, control strategies, etc.
- Identify the technical and economic potential of building and process the optimization for solar cooling technology and system adaptation needs.
- Identify ongoing and future related standards and testing methods and initiate the update/extension of testing methods / standardization (norm)

Subtask B: Demonstration (Lead Country: USA)
The main objectives of Subtask B are:

- Show cases on system and component level through existing projects & new MI IC7 activities but also theoretical investigations through simulations
- Maximize solar fraction of solar cooling under certain local technical & economic boundaries, also including load optimization (building & passive measures)
- Force the work of standardisation and solar cooling kits in all capacity ranges and different technologies
- Documentation of the lessons learned (technical & non-technical) and prepare for dissemination activities (Subtask D)

Subtask C: Assessment and Tools (Lead Country: Austria)
The main objectives of Subtask C are:

- Overview, possibly update/merging of useful tools for design & assessment.
- Establishing/adapting of assessment method and benchmarking (incl. reference system in different locations).
- Create common data base for technical, environmental and economic assessment for the participating countries.
- Analyses of Subtask B results and benchmarking against reference systems and different renewable and solar solutions.
- Sensitivity analyses of high influencing parameters on the technical/economic/ environmental assessment.

Subtask D: Dissemination (Lead Country: Germany)
The main objectives of Subtask D are:

- Communication of best practice demo cases, successful installations and business models (based on summary of lessons learned; subtask B5)
- Accelerate know how transfer from Scientists to Industry & knowhow carrier to Sunbelt regions
- Establish of network of scientists / consultants / companies to accelerate the establishing of projects in Sunbelt regions
- Synchronize national / international research & funding programs
- Financing & business models for Solar Cooling
- Mapping of necessary R&D as base for a road map of Solar Cooling in Sunbelt regions

Collaboration with Other IEA TCPs

The Task is collaborating at no formal level with the IEA HPT TCP, which is referred to by the HPT TCP as HPT Annex 53 on Advanced Cooling/Refrigeration Technologies Development.

Collaboration with Industry

The strong industry and business interest and involvement is reflected in the number of Task 65 participants from solar thermal collector manufactures, sorption chiller manufactures, system suppliers, consultancies, business developers and ESCOs – overall 40% of the Task experts are from industry and SMEs.

Task Duration

This Task started in July 2020 and will end in June 2024.

Participating Countries

Australia, Austria, China, Denmark, France, Germany, Italy, Mozambique*, Netherlands, Spain, Sweden, Switzerland, Uganda**, United Kingdom, United States***, Zimbabwe*.
**through SACREEE, **through EACREEE, ***Limited Sponsor*

Work During 2020

Subtask A: Adaptation

Activities planned to achieve the specific objectives, and their timeframe were discussed.

- Work started in Activity A1 to collect climatic conditions and typical applications to understand the reference boundary conditions for adaptation of the components and solar cooling systems.
- Activity A2 has also started to document existing components for an up-to-date overview for all necessary apparatuses for the solar cooling systems from the transformation to useful energy (collectors: PV, ST, PVT, …), storages (cold, hot side, etc.), chillers (vapor compression, ab/adsorption, DEC, etc.), heat rejection units (dry, hybrid, wet, others) and others.

Subtask B: Demonstration

Activities planned to achieve the specific objectives, and their timeframe were discussed.

- In Activity B1 the goal is to collect show cases on system and component level by identifying applications and utilizing existing projects and products. Therefore, the collection of system designs and evaluated monitoring data of existing and new demonstration plants is the first step to build up a base for the calculation of technical and economic KPIs (Subtask C). Furthermore, the comparison of the designed and effective performance data is used to evaluate and improve the performance of the solar cooling plants. Lessons learned are derived out of the deviation of design and field performances as well as general design rules.
- One more activity was initiated: Activitiy B2 “Design Guidelines” has started to collect design and system integration guidelines, which will be updated for the specific boundary conditions for the sunbelt countries. The solar cooling system concepts are combined with other renewables/backups to be assessed as a complete system in order to avoid misleading KPIs when comparing e.g. systems with different solar fractions. The definition of minimum required standards for data quality will be further analyzed in activity Subtask C.

Subtask C: Assessment and Tools

Activities planned to achieve the specific objectives, and their timeframe were discussed.

- The review of tools and models for technical and financial assessment and design for solar cooling and the different project’s phases from pre-feasibility to simulation to monitoring has started in Activity C1. During the discussions it turned out that different solutions are of interest among the interested participants from mobile apps to dynamic simulation models for consultants, manufacturer, researcher, etc. This discussion will continue in the next months.
- Work started in Activity C2 to elaborate the required database and the collection of technical (e.g. standard reference systems, etc.) and economic data (energy prices for electricity, natural gas, etc.) for different components (investment, maintenance, lifetime, etc.) and for the different sunbelt countries (based on subtask B demo cases). The database elaboration has first reviewed the existing information from previous IEA SHC Task 53.

Subtask D: Dissemination

Activities planned to achieve the specific objectives, and their timeframe were discussed.

- The Activity D1 has already fulfilled the first Milestone M.D1 in Month 3 as the Task 65 website was launched in June 2020 with the support from the SHC web consultant. In September 2020 the Task 65 website was also transformed into the SHC layout design and was therefore set up again. During

the first 6 months of Task 65 several presentations and publications by task participants have already been conducted.
- In Activity D5 the first SHC Academy Online Training for the SHC member CCREEE was organized and hold in November 2020. Furthermore, the first National Workshop was held in early December 2020 in China and the upcoming next National Workshop will be in Austria (March 2021).
- The stakeholder engagement in Activity D6 focus on the identification of key stakeholders around the sunbelt countries. This activity was highly supported by several EU Horizon 2020 call proposal development among the task participants in the second half of the year 2020 to build relationships with stakeholders e.g., in India and the African continent.

Work Planned For 2021

Subtask A: Adaptation

The main activities planned for Subtask A in 2021 are:

- Deliver a base for market studies for certain components and solar cooling systems
- Document the commercially available equipment compatible with PV electricity supply as well as solar thermal cooling equipment
- Get to know R&D entities / manufacturer working on solar cooling components and systems and their expected technology development, especially according to the key point of climatic adaptation efforts
- Document and show different possibilities of storages on hot / cold side or any other state
- Evaluate the economic potential of adaption to certain climates and application, especially when they can be simplified on component and system level

Subtask B: Demonstration

The main activities planned for Subtask B in 2021 are:

- Update and transfer procedures for measuring the performance of the solar cooling systems and to communicate existing monitoring procedure for field tests or demo projects
- Define and select technical and economic key performance factors for the different stakeholders in the entire project phases.
- Documentation of the demonstration plant and their achieved technical and economic key performance indicators
- Analyse potential technical issues on monitored systems and create lessons learned for the specific climactic conditions.
- Report selected pest practise examples of solar cooling in sunbelt countries

Subtask C: Assessment and Tools

The main activities planned for Subtask C in 2021 are:

- Collection of supporting decision tools for technical, economic and financial analyses with different levels of detail from simple pre-study tools to sophisticated dynamic simulation models.
- Adapt existing technology, economic and financial analyses tools to assess and compare economic and financial viability of different cooling options with a life-cycle cost-benefit analyses (LCCBA) model.
- Apply the LCCBA framework to assess case studies and use cases from subtasks A and B to draw conclusions and recommendations for solar cooling technology and market development and policy design.

Subtask D: Dissemination

The main activities planned for Subtask D in 2021 are:

- Establish communication structure with stakeholders
- Disseminate the task results on national and international level

- Provide efficient communication tools such as brochures/guidelines/Roadmaps
- Collect and structure evidence for policymakers of the sunbelt countries
- Stimulate innovation through the communication of shortcomings

Dissemination Activities In 2020

Reports, Published Books

As the Task began in 2020, it is still too early for the publication of reports and books.

Journal Articles, Conference Papers, etc.

Author(s)	Title	Publication / Conference	Bibliographic Reference
Bärbel Epp	Global support for solar cooling in sunbelt regions	solarthermalworld.org	09/2019
Bob Critoph	Solar/Renewable Cooling	WREN Seminar: Renewable Energy & Climate Change, Energy Efficiency, Conservation, Cooling and Green Buildings Design. Bahrain	02/2020
Bärbel Epp	Solar cooling concepts for hot climates	solarthermalworld.org	07/2020
Daniel Neyer, Uli Jakob	Solar cooling for the Sunbelt Regions – a new IEA SHC task	EuroSun 2020	09/2020

Conferences, Workshops, Seminars

Conference / Workshop / Seminar Name	Activity & Presenter	Date & Location	# of Attendees
IEA HPT Annex 53 3rd Expert working meeting	Solar Cooling for the Sunbelt Regions. Uli Jakob, JER	June 24-25, College Park, USA / Virtual	12
EuroSun 2020 – 13th International Conference on Solar Energy for Buildings and Industry	Solar Cooling for the Sunbelt Regions – a new IEA SHC Task. Uli Jakob, JER	September 1-3, Virtual	200
SunHorizon Solar Stakeholders Workshop	Solar PV and Thermal Cooling. Daniel Mugnier, TECSOL	September 10, Virtual	
ISES SWC 50 Online Conference – Session 4: Transforming the Heating and Cooling Sector	Solar Cooling for buildings and processes. Uli Jakob, JER	December 4, Virtual	800
The 6th Yangzi River Delta	Solar Cooling for the	December 5,	100

International Conference on new energy – Workshop on Renewable and Clean Energy	Sunbelt Regions - IEA SHC Task 65: Introduction and cooperation possibilities. Daniel Neyer, NB	Nanjing, China / Virtual	
IEA HPT Annex 53 4th Expert working meeting	Solar Cooling for the Sunbelt Regions – Update. Uli Jakob, JER	December 16-17, Beijing, China / Virtual	12

Dissemination Activities Planned For 2021

Author / Editor	*Title*	*Bibliographic Reference*
Amín Altamirano	PhD Thesis: Development of a new concept of compact and low-cost absorption chillers: application in solar cooling for hot climates	(2021), Université Savoie Mont Blanc, France

A second public workshop (Austrian National Workshop) is planned in conjunction with the Task meeting in March 2020. Moreover, the first industry workshop is also planned as part of the Task Meeting in March 2020 which is held in collaboration with the HPT Annex 53 experts.

Task Meetings 2020 – 2021

Meeting	Date	Location	# of Participants (# of Countries)
Experts Meeting **1**	September 28-29, 2020	Virtual	50 (16)
Experts Meeting **2**	March 24-25, 2021	Innsbruck, Austria/Virtual	
Experts Meeting **3**	Autumn 2021 (date TBD)	Messina, Italy	
Public Workshop	December 5, 2020	Nanjing, China/Virtual	
Public Workshop	March 24, 2021	Innsbruck, Austria/Virtual	
Industry Workshop	March 25, 2021	Innsbruck, Austria/Virtual	

SHC Task 65 Participants

Country	Name	Institution / Company	Role
GERMANY	**Uli Jakob**	**JER / Green Chiller**	**Operating Agent**
AUSTRALIA	Lu Aye	University of Melbourne	National Expert
AUSTRIA	Alexander Friedrich	3F Solar	National Expert
AUSTRIA	Roland Schneemeyer	Ecotherm	National Expert
AUSTRIA	Antoni Castells	Ecotherm	National Expert
AUSTRIA	Jan Bleyl	Energetic Solutions	National Expert
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