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Newsletter of the International Energy Agency Solar Heating and Cooling Programme

INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

#SolarHeat
#SolarThermal
#SolarProcessHeat
#SolarCooling
#SolarDistrictHeating

In This Issue

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IEA 2024 SHC Solar Award

▲ **SHC 2024 Solar Award recipients – Alexis Gonnelle, François-Xavier Sarda and Thomas Colin De Verdière of Newheat.**

Newheat project wins IEA SHC 2024 Solar Award

Newheat's LACTOSOL project in Verdun, France demonstrates how solar heat in an industrial process can competitively reduce gas consumption. François-Xavier Sarda, Industry Key Account Manager, Thomas Colin De Verdière, Control Engineer, and Alexis Gonnelle, Principal Scientist, received the award on behalf of Newheat during EuroSun 2024, the International Conference on Sustainable and Solar Energy for Buildings and Industry, of the IEA SHC and ISES held this year in Limassol, Cyprus.

> *"The 2024 SHC Solar Award celebrates projects of substantial achievement and measurable impact on an industrial process to reduce costs and emissions by incorporating solar thermal technologies. Newheat's LACTOSOL project is certainly substantial, the largest solar thermal plant in France and second largest in Europe, and is not only reducing production costs but reducing CO_2 emissions by using a combination of new technology and financing mechanism."*
>
> LUCIO MESQUITA, IEA SHC Executive Committee Chair

The SHC Solar Award recognizes an individual, company, or private/public institution that has shown outstanding leadership or achievements in solar heating and cooling. The category for this year's award was a **project that reduces costs and emissions by incorporating solar thermal technologies in an industrial process.**

> For Newheat, *"We are honored to receive this award, which acknowledges our team's work and the confidence shown by LACTALIS Ingredients, a world leader renowned for its industrial excellence and capacity for innovation. This project demonstrates NEWHEAT's ability to provide its customers with reliable and competitive solutions, even in a sector known for its very high-quality standards."*
>
> HUGUES DEFRÉVILLE, CEO Newheat

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Project Impact

Newheat, a supplier of renewable heat and the leading French supplier of solar heat, commissioned the solar thermal plant at LACTOSOL in Verdun, France, in 2023.

This plant provides heat for one of the Ingredients division sites of the Lactalis Group. This massive solar heat project is **cutting the CO_2 emissions of the site's drying tower by 2,000 tons per year**, in other words, **7 % of the site's total emissions.**

LACTOSOL is France's largest solar thermal plant and the **second largest in Europe**, serving an industrial site. The process-level integration of this project is a unique showcase of the potential to decarbonize heat in industrial processes competitively and effectively. **The project was developed under the "Heat as a Service Scheme," with Newheat as a majority shareholder and EPC contractor,** thus taking on the technical and financial risk for the project. This model is particularly promising for developing industrial solar heat – it allows the industrial heat consumer to focus on their core business.

newheat
renewable heat supplier

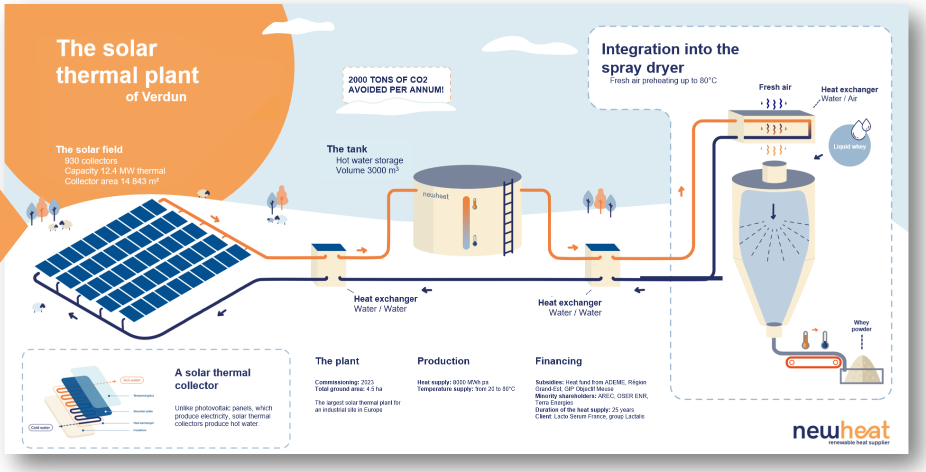
Newheat, a renewable heat supplier preserves and develops local energy resources, using a tailor-made approach to help towns and industries transition to sustainable and renewable heat. Its unique expertise lies in prioritizing these different available resources with short-term competitiveness and medium- to long-term environmental sustainability in mind. www.newheat.com

The plant delivers approximately **8,000 MWheat annually** using a **15,000 m² solar collector area** and a **3,000 m³ storage tank** capable of storing several days' worth of heat production to ensure continuity of supply at night and on cloudy days during the summer.

Lactalis Ingredients chose solar thermal technology for the LACTOSOL plant to meet its carbon footprint reduction commitment. The partnership with Newheat was initially established through a trust-based relationship with Lactalis Ingredients, who believed in solar thermal solutions. This relationship led to direct negotiations, which formed the foundation of the partnership throughout the project development, the new spray dryer tower, and the solar thermal field.

Newheat designed, built, and financed the solar thermal plant. An onsite proprietary hot water loop generates solar heat to convert liquid whey, a by-product of cheesemaking, into whey powder for the food industry. By replacing the gas boiler that powered the drying tower to dry the liquid whey, LACTOSOL has **reduced the site's gas consumption by 6%** (11% for the drying tower and 30% for preheating needs).

This facility marks a milestone in the large-scale deployment of solar heat, of renewable heat, of Newheat.



▲ **Project: NEWHEAT / photo credit: IMAGESinAIR Productions.**

In the Pipeline

New Work

Two new Tasks are now underway! If you're interested in joining and are from an, IEA SHC member country, it's as simple as two steps: contact your national SHC Executive Committee member and reach out to the Task Manager.

Solar Photoreactors for the Production of Fuels and Chemicals

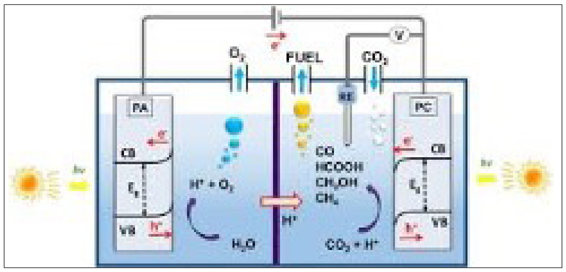
Fact – Decarbonization requires a change in our energy supply and hybridization. Green fuels will and can meet industrial energy demand (e.g., hydrogen) in combination with CO_2 energy carriers (e.g., methane, methanol, ethanol). But today, 99% of H^2 for industrial use is from non-renewable energy sources!

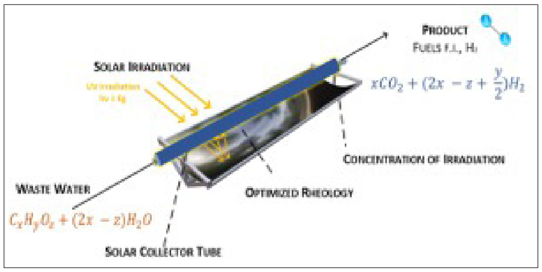
That is what one would call an untapped potential for solar reactors. The demand for "green" energy sources is increasing, and using the sun to produce them is a win-win.

Participants in this Task will collaborate to offer detailed insights and strategies for optimally using photoreactors under actual sunlight to produce green fuels and chemicals. The aim is to present technological solutions that improve the efficiency of solar energy utilization by integrating the latest advancements in materials, reactor design, and system integration.

Are you an expert on photo-active materials, photo-reactor and collector design, or system integration? Do you want to collaborate with an international team on designing materials, reactors, and systems and developing standardized testing and evaluation protocols to pave the way for future solar photo reactors as new market segments for the solar thermal industry?

To learn more, visit the SHC Task 72: Solar Photoreactors for the Production of Fuels and Chemicals webpage. To explore opportunities for joining the Task, contact the Task Manager, Dr. Bettina Muster-Slawitsch, at b.muster@aee.at.

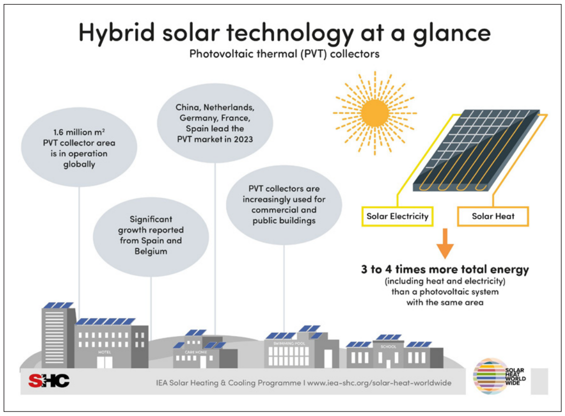




(Source: Kalamaras, 2018)

PVT Heating Systems – Markets, Trends and Future Potential

PVT Technology is rather new to the market, making strategic market preparation crucial for its successful adoption. Without this information, the technology can easily be underestimated, and its potential may be overlooked. Since PVT must compete with established solutions, its positioning in relation to other heating technologies is key to unlocking its full potential. To address this, the Task participants will work to: 1) create factful awareness about PVT Heating Systems (air and liquid heating), 2) Identify and tackle hurdles in the innovation systems around PVT heating systems, 3) Foster and activate the industry and research community on PVT heating systems, and 4) Initiate and multiply PVT heating installations and projects.



(Source: Solar Heat Worldwide 2024)

Are you working in the solar thermal, PV or heat pump sectors or for a PV manufacturing or system design/planning company? Would you like to collaborate with an international team to help advance PVT heating systems?

To learn more, visit the SHC Task 73: PVT Heating Systems webpage. To explore opportunities for joining the Task, contact the Task Manager, Dr. Korbinian Kramer, korbinian.kramer@ise.fraunhofer.de.

OPINION

Reflections from the Chair

As we draw near the end of 2024, it is a good opportunity to take stock of a very busy year. Throughout the year, we had significant outputs from our Programme, including a new edition of Solar Heat Worldwide, four webinars, and numerous Task publications and industry workshops. We saw the conclusion of three Tasks: 65, 66, and 67, all with impressive results and significant contributions to our mission of *bringing the latest solar heating and cooling research and information to the forefront of the global energy transition.* Task 65, *Solar Cooling for the Sunbelt Regions*, was led by Dr. Uli Jakob. It looked into the very important issue of solar-driven cooling with a focus on warmer areas of the globe. On a warming planet, air-conditioning is rapidly evolving from an end-use associated with comfort to a life-saving intervention, and market penetration expands with income and ambient temperatures, albeit with strong disparities between countries (see *Air conditioning and global inequality*). Task 66, Solar Energy Buildings, was led by Dr. Harald Drück and focused on developing economic concepts for buildings with high solar fraction, or in other words, buildings for which solar has a significant contribution for heating, cooling, and electricity. Task 67, Compact Thermal Energy Storage Materials within Components within Systems, was led by Dr. Wim Van Helden and had a strong focus on the characterization of compact thermal storage materials.

A big thank you to all the Task leaders and the experts involved in them.

In August, we had one more successful conference in partnership with the International Solar Energy Society, EuroSun 2024. It was a great atmosphere and a fantastic opportunity to engage with about 200 researchers from over 40 countries. At this event, we presented our Solar Award to Newheat for their LACTOSOL plant in Verdun, France, recognizing it as an outstanding solar heat for industrial processes (SHIP) project. In November, we had our 96th Executive Committee meeting in Berlin, expertly organized by our colleagues Kerstin Krüger and Dr. Daniela Rolf. The meeting included a highly successful and well-attended National Day. This following another very well-organized meeting in June, hosted by our colleagues in Norway.

On the membership side, we welcomed Poland and Solar Heat Europe to our Programme and renewed our collaboration with UNIDO and its Global Network of Regional Sustainable Energy Centres.

Despite all the activities and positive news, we also have some sad news to share. Pam Murphy, who has been the SHC Secretariat for almost 30 years, will retire from our Programme at the end of the year. We have been incredibly lucky to have Pam's wisdom, wit, and great sense of humor for so many years. Pam, you will be greatly missed, and we wish you all the best in your new endeavors!

Lucio Mesquita
SHC Executive Committee Chair

National Day Shines Light on Future Potential and Market Realities

At the German National Day at the beginning of November entitled "Solar Technology for the Future," the heat experts clearly pointed out the huge gap that currently exists between long-term potential studies and the actual market development of solar heat technologies. They made clear and precise demands to policymakers for better framework conditions. The two German representatives of the IEA Solar Heating and Cooling Programme (IEA SHC), Kerstin Krüger and Dr. Daniela Rolf, organized the National Day, which also offered a deep dive into important fields of application: solar district heating and solar process heat.

▲ **Prof. Dr. Hans-Martin Henning, Director of the Fraunhofer ISE, during the Q&A session after presenting the latest results from the study "Paths to a climate-neutral energy system."** (Photo: project sponsor Jülich)

"The packed hall demonstrated the great interest in the question of how solar heat can support the decarbonization of the German heat sector," said Krüger. "The composition of the speakers on the agenda, with internationally active IEA SHC experts and German industry and association representatives, offered a good mix with something new for all participants."

Several speakers highlighted the huge potential that solar heat has for the energy transition.

Hans-Martin Henning, for example, illustrated the latest results for solar heat from simulations with REMod, a national energy model that analyses cost-effective paths toward carbon neutrality in 2045. In four different scenarios, solar heat contributes between 27 and 40 TWh to overall heat production by 2045. At the end of 2023, German solar thermal systems supplied 9.3 TWh, according to BSW Solar statistics. This means three to four times more collector area will need to be installed over the next 20 years.

However, market figures from BSW Solar show the opposite trend. The new collector area installed each year needs to increase to compensate for the collectors decommissioned due to age. This means that the total collector area in operation in Germany is decreasing instead of increasing.

"The discussions about the national subsidy scheme for efficient Buildings (BEG) have unsettled homeowners and paradoxically have given gas boilers a boost," complained Juliane Hinsch from the German association BSW Solar. "Research, industry, and politics must work together to develop growth opportunities for solar heat solutions."

Solar District Heating: Accelerating The Authorization Process

Germany is the European leader in solar district heating. In terms of newly installed capacity in 2023, Germany was number two worldwide after China, according to the report Solar Heat Worldwide. At the National Day, the SDH solar project developer Ritter XL Solar reported on the construction of what will become the largest solar district heating system in Germany: a 41 MWth vacuum tube field for the city of Leipzig. The system is scheduled to go into operation in 2026 and is expected to achieve a solar fraction of 1.6 %.

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The German SDH market is developing dynamically, reported Magdalena Berberich from Solites. While 58 SDH plants with a capacity of 114 MWth have been commissioned in the last 20 years, 12 plants totaling 100 MWth are currently being realized. "We should work to accelerate the authorization process," demanded Berberich, as project development times are still far too long.

She quoted targets from the Climate Neutral Germany 2045 report from the consulting company Prognos. According to this, collector fields are expected to feed 13 TWh into heat networks by 2045. This corresponds to 30 million m2 of collector area (21 GWth), assuming a specific yield of 433 kWh/m^2. This is an extremely ambitious increase compared to the 114 MWth currently in operation.

▲ **Christian Maaß, Department Head at the German Federal Economy Ministry.** (Photo: Bärbel Epp)

Heat Transition Plans Are A Mindset Shift

The biggest challenge for the German district heating sector is the requirement to create a heat transition plan. "It is more cost effective to decarbonize heat grids than individual heating systems, which is why we need heat transition plans", explained Christian Maass, Head of the Department for Heat, Hydrogen and Efficiency at the Federal Economy Ministry (see photo above). The national Heat Planning Law has been in force since January 2024. It requires municipalities with a population of over 100,000 to develop a heat transition plan by June 2026 that describes the path to climate neutrality. Municipalities with fewer than 100,000 inhabitants have until June 2028.

"This is a shift in the mindset because until now, it was left to building owners to decide on the most favorable CO_2-reducing heating solution. Now municipalities must support building owners in this decision", said Maass. Another important starting point for successful heat transition is the "awareness that we will have to change infrastructure." It is indeed a problem, according to Maass, that "a lot of people are convinced that we can just make the gas green and leave all the infrastructure the same."

▲ **The Green Chiller Association offered a tour around a mobile sorption classroom. The completely open absorption cooling system makes it possible to explain the technology clearly and illustrate various operating states. Christian Kemmerzehl, Managing Director of EAW Energieanlagenbau, demonstrates the unique system.** (Photo: Bärbel Epp)

Solar Process Heat: Rapid Depreciation Reduces Payback Period

The biggest gap between potential and actual market development in Germany is in the solar process heat segment. So far, 48,172 m^2 of solar industrial heat systems have been installed countrywide, a large proportion of them for solar drying. Felix Pag from the University of Kassel highlighted the results of a potential study forecasting 20 TWh of solar heat contribution to industry. Potentially, 50 million m^2 of collector area would be necessary to cover that demand.

Pag underlined the fact that solar process heat solutions are flexible in terms of integration and typically contribute to optimizing energy efficiency. To speed up deployment rates, the researcher suggested two important measures: subsidizing feasibility studies and implementing faster depreciation.

"You can't give enough subsidies to ensure that the payback period for a solar process heat plant is perhaps only three years, which is what industry is demanding," stressed Prof Klaus Vajen from the University of Kassel. He calls for very rapid depreciation because that has an extraordinarily positive effect on the payback period.

This article was contributed by Bärbel Epp of solrico, Germany, for IEA SHC.

What Role Will Solar Cooling Play For Sustainable Cooling In The Global South?

IEA SHC Task 65 on Solar Cooling for the Sunbelt Regions concluded after four years of investigating how to adapt, verify, and promote solar cooling (solar thermal and PV) as an affordable and reliable solution to the growing cooling demand in the world's Sunbelt regions - the Global South. Eighty-three experts from 17 countries, including four UNIDO GN-SEC (Global Network – Sustainable Energy Centres) countries (Egypt, Mozambique, Uganda, and Zimbabwe) analyzed the adaptation of existing technologies to the specific boundary conditions and optimization in terms of investment and operating cost and their environmental impact. Generally, they focused on the combination of cost reduction, simplifications of the systems, and stimulation of market conditions through policies. This article highlights the key results for implementation/ adaptation of components and systems for the different boundary conditions to develop a market uptake of solar cooling in the Sunbelt regions.

Why This Task?

Air-conditioning (AC) accounts for nearly 20% of the total electricity demand in buildings worldwide and is growing faster than any other consumption in buildings, according to the IEA's The Future of Solar Cooling. The undisputed rationales for the increase are global economic and population growth and, thus, rising standards of living. Growth in cooling demand is especially driven by countries with high temperatures. Three emerging countries (India, China, Indonesia) contribute to more than half of the annual growth rates. If no measures are taken to counteract this increase, space cooling demand could triple to 6,000 TWh/a by 2050. In some countries, peak load caused by air conditioning does reach a share of >70% of the total electricity consumption on hot days.

With an increase in cooling demand comes an increase in the cost of electricity and summer blackouts, which have been attributed to the large number of conventional air conditioning systems running on electricity. As the number of vapor compression chillers for AC purposes increases globally, so do AC-related greenhouse gas emissions, both from direct leakage of high Global Warming Potential (GWP) refrigerants, such as Hydrofluorocarbons (HFCs) and from indirect emissions related to fossil fuel derived electricity consumption. Solar cooling is intuitively a well-suited alternative because the demand for air-conditioning correlates quite well with the availability of solar energy. Interest in solar cooling has grown steadily over the last years. As of 2023, nearly 2,000 systems have been installed worldwide, as reported by IEA SHC's Solar Heat Worldwide. Solar cooling can be achieved by 1) operating a vapor compression air-conditioner with electricity generated by solar photovoltaic cells or by 2) using solar thermal heat to run a thermally driven sorption chiller. Both these technologies can be used with or without a storage option, such as batteries or thermal storage units.

Task Highlights – Main Results & Importance

From July 2020 to June 2024, a multi-disciplinary, international team of solar cooling researchers and industry representatives joined SHC Task 65:Solar Cooling for the Sunbelt Regions to investigate ways to make solar cooling applications

> "The future of solar cooling lies in the Global South, where the demand for cooling will increase dramatically due to increasing heat waves and the climate crisis."
>
> DR. ULI JAKOB
> *SHC Task 65 Manager*

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more competitive and affordable in the Sunbelt regions. Based on the results, technical and economic suggestions for innovations for affordable, safe, and reliable Solar Cooling systems for the Sunbelt regions were developed. Below are a few key results from this work.

Climatic Conditions & Applications

Generally, the suitability of (solar) cooling systems and the specific applications are highly contingent on geographic location. To establish region-specific prerequisites for solar cooling systems, leveraging geographical data is a logical approach. This necessitates using a Geographic Information System (GIS) that can acquire, store, validate, and visualize data associated with Earth's surface coordinates. Most pertinent geographical data essential for this purpose can readily be sourced from various outlets, including solar radiation statistics, climate records, population demographics, and more.

GIS software was used to combine geographical data in a way that local reference boundary conditions for solar cooling systems in the Sunbelt regions can be determined and evaluated. The data sources used in this study consist of multiple layers, with each layer containing data on specific topics or numerical values. These data layers are extensive, comprising 145 million grid cells and having a size of approximately 1.5 gigabytes each. The analysis took into account various conditions and sources, including geographic areas requiring cooling (spanning latitudes between 48°N and 44°S), different solar irradiances (DNI, GHI, DIF) and photovoltaic power potential (PVOUT), population density and settlement levels, climate zones based on the Köppen–Geiger climate classification system, water availability, assessment of market risk through Environmental Social Governance (ESG) factors, and considerations of Purchasing Power Parity (PPP) and Gross Domestic Product (GDP). These data sources and conditions played a crucial role in conducting the comprehensive analysis (Figure 1). As a result, potential sites and economic factors can be considered to identify (future) markets.

Further reading: SHC Task 65 report, *Climatic Conditions & Applications*.

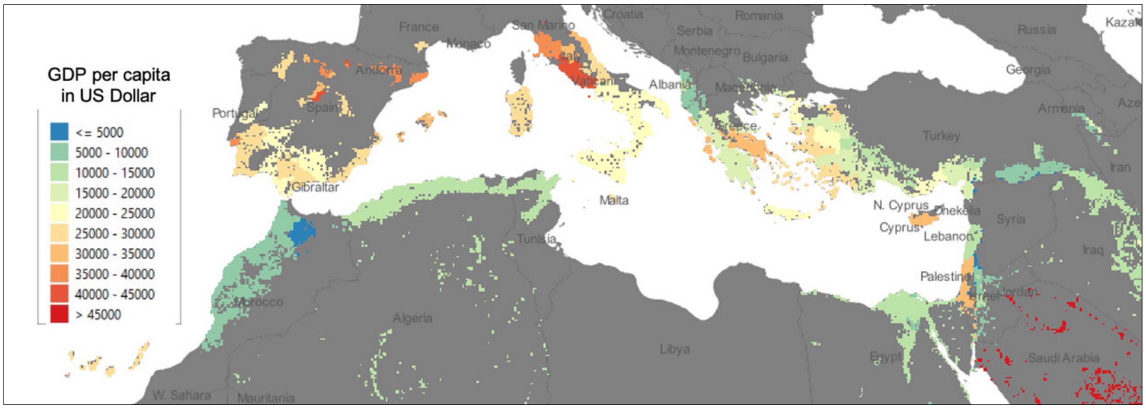

Figure 1. The Mediterranean region was used to identify the potential for a specific Solar Cooling System in building cooling applications. The analysis was conducted on a 10km raster grid, taking into account the Gross Domestic Product (GDP) levels.

Show Cases on System and Component Level & Adapted Components

A number of installed projects were examined to find the constituent elements employed in different solar cooling technologies and their relationships with various variables, including the type of solar collector, climate zone, application, and the components integrated into the systems. Solar cooling is a promising and efficient means of contributing to decarbonization efforts in nations within the Sunbelt region. Considering the expected increase in cooling needs within these nations, there is a substantial opportunity to identify the best components and conduct comprehensive evaluations of existing/ongoing projects. This approach is expected to help expand the scope of solar cooling and amplify its overall influence significantly. The research undertaken in this work package encompasses 31 studies conducted in 18 countries located in the Sunbelt region. Figure 2 illustrates the demographic distribution of these projects.

The studies conducted included a diverse range of project types. Among these, 50% of the projects are

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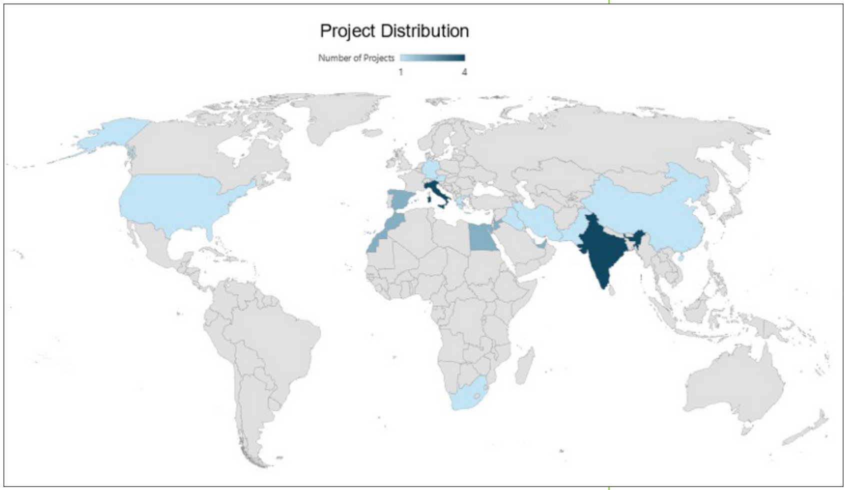
currently in the implementation phase, 25% of the projects are in the conceptual phase, 19% are in operation with established outcomes, 3% are validated concepts, and the remaining 3% have been modeled using simulation tools like TRNSYS, Python, Matlab, or other mathematical modeling techniques. Additionally, the study includes published works featuring laboratory experiments and simulations validated by real-time building energy usage. This mixed approach ensures a comprehensive and varied analysis.



▲ **Figure 2. Case studies located in the Sunbelt region.**

The analysis shows that evacuated tube collectors are utilized in 30% of the analyzed projects, while flat plate collectors and Fresnel collectors are equally prominent at 17% each. The research also indicates that Fresnel and flat plate collectors are the most commonly chosen options in executed projects, whereas evacuated tubes are predominant in simulation projects. Examining the distribution of different solar collectors across various temperature profiles provides valuable insights into their suitability for different scenarios. Evacuated tube collectors find extensive application across three distinct climate regions: BSk (Cold semi-arid), BWh (Hot desert climates), and Csa (Hot-summer Mediterranean climate). Similarly, flat plate collectors are suitable for a range of five different profiles, spanning from Hot Desert (BWh) to Warm-summer Mediterranean climates (Csb).

In terms of buildings, the analysis shows that in the majority of the examined cases, solar cooling systems are installed in public buildings (34%), including offices, schools, and university buildings, enabling direct utilization of solar energy during daytime hours. Domestic buildings (25%) appear to be the next most studied due to prevalent requirements for improved indoor comfort in the Sunbelt region. The third most studied application (19%) includes indoor test facilities and the process industry. The remaining applications include district cooling, food processing and preservation, and high-rise buildings. This comprehensive analysis underscores the effectiveness and versatility of solar thermal cooling technologies across diverse climatic conditions, paving the way for their broader adoption in various sectors and contributing to sustainable energy solutions in Sunbelt regions worldwide.

For further reading: SHC Task 65 report, *Show Cases on Systems and Component Level & Adapted Components*

Standardized Solar Cooling Kits

For the market uptake of solar cooling, it is essential to have pre-designed and adapted solar cooling kits to meet the market needs of the Global South. Therefore, the Task work presents experiences from 11 component and/or system suppliers of solar cooling kits, which adapted/investigated their products/concepts for Sunbelt region conditions. Moreover, several findings on system adaptations for Sunbelt regions are collected and analyzed from manufacturers, equipment providers, solar system providers, and researchers.

The essential findings/results are:

- Eight products/concepts were adapted to the constraints of the Sunbelt regions, including information on Sunbelt-specific adaptations or experiences.
- Medium-temperature solar systems used to operate two-stage absorption chillers increases competitiveness.
- Dust accumulation on collector systems can decrease performance by up to 20% per month. To minimize this impact, cleaning the system every 14 days is recommended, reducing the average performance loss to just 5%.

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- Lack of knowledge of design guidelines, including the effects of part load conditions and techno-economic boundary conditions, is a critical issue.
- Heat rejection systems in dry climates present significant challenges

For further reading: SHC Task 65 report, *Standardized Solar Cooling Kits*.

Design Guidelines

A set of design and system integration guidelines for solar cooling projects was developed. To support this effort, a comprehensive questionnaire was created detailing various solar cooling components, design aspects, sizing considerations, and sub-systems such as heat rejection units and cold distribution systems. Data from 10 case studies highlight the performance of solar cooling systems under varying boundary conditions. Additionally, three distinct case studies, each with its own scope and unique characteristics, are discussed in detail in the Task report, *Design Guidelines*.

In summary:

- Industrial cooling offers significant opportunities for solar thermal cooling applications. Such systems can achieve a high solar fraction and thus significantly reduce CO2 emissions compared to conventional electricity-powered chillers.
- Integrating solar PV with vapor compression chillers is an emerging solution for decarbonizing cooling systems. A comparative analysis considering different load and weather profiles suggests that solar PV cooling can result in a lower levelized cost of cooling compared to solar thermal.
- Hybrid chillers emphasize the potential of combining electrical and thermal chillers. Both simulation and practical results indicate a significant reduction in electricity consumption when using the topping cycle of an adsorption chiller.

In summary, these case studies highlight the transformative potential of cooling solutions. As technology advances and policies evolve, adopting such systems will be critical in shaping a greener, more energy-efficient cooling future.

For further reading: *SHC Solar Update – July 2024*

Standardization Activities

It's important to have a comprehensive understanding of the significance of standardized actions and key performance indicators (KPIs) in driving advancements in the field of solar heating and cooling systems. Therefore, the importance of standardization in promoting interoperability, ensuring quality, and fostering confidence among stakeholders was examined. In addition, the critical role of KPIs in assessing system performance, economic profitability, and environmental impact were investigated. As a final result, the SHC Task 65 report, *Standardization Activities*, provides a comprehensive roadmap outlining actionable strategies, recommendations, and initiatives to catalyze the widespread adoption of solar heating and cooling solutions. The Australian Standard AS 5389 emerged as a cornerstone for implementing these measures, providing a solid foundation for addressing the specific challenges and opportunities inherent to Sunbelt climates. The proposed list of actions aims to enhance the applicability of AS 5389 to Sunbelt climates by addressing specific challenges and opportunities.

These actions encompass various initiatives aimed at streamlining the integration of solar thermal heating and cooling systems, enhancing industry expertise, and promoting financial mechanisms to support sustainable energy solutions. The six proposed standardized actions to facilitate solar heating and cooling in the Sunbelt region market are:

1. Standardization / Best Practice Design: Develop standardized designs for solar thermal heating/cooling systems to accommodate various collector and chiller technologies and integrate them into existing systems. Standardization can lower initial system costs, increase stakeholder confidence, and promote local component development. Regulatory support, such as an extension of AS5389, is vital to estimate energy savings from these standardized designs.
2. Environment Upgrade Agreements (EUA): Encourage agreements that support environmental upgrades in buildings, potentially including solar thermal systems.
3. Training/Knowledge Dissemination: Promote training and knowledge sharing in the heating and cooling industry to enhance expertise and understanding of solar thermal technology.
4. On-Bill Finance: Explore financial mechanisms allowing customers to finance solar thermal systems through utility bills.
5. Energy Performance Contracts (EPCs) / Pilot Projects: Initiate pilot projects and EPCs to demonstrate the viability and benefits of solar thermal systems.
6. Energy Services Companies (ESCOs): Encourage the involvement of ESCOs in implementing and managing solar thermal projects.

Database for Technical and Economic Assessment

For the successful design of solar cooling systems, it is necessary to have a comprehensive database of technical and economic data for solar cooling components and Sunbelt

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No.	Country/ Institution	Cooling demand				Cooling in sectors								Technology								Env.		Scale			
		Demand analysis	Demand analysis by sector	Demand projection	Demand projection by sector	Domestic refrigeration	Commercial refrigeration	Industrial refrigeration	Transport refrigeration	Domestic A/C	Commercial A/C	Mobile A/C	Other	Solar Thermal	Solar PV	Absorption chiller	Adsorption chiller	Compression chiller	Split units/ heat pumps	Thermal energy storage	Increase of efficiency	GHG emission	potential GHG emission savings	National	Continental/ Regional	Global	Implementation Plan
1	Bangladesh	x	x	x	x	x	x	x	x	(x)	(x)	x	x	o	o	x	o	x	x	x	x	x	x	x	o	o	x
2	Cambodia	x	x	x	x	x	(x)	x	x	x	x	x	x	o	(x)	x	x	x	x	x	x	x	x	x	o	o	x
3	Kenya	x	x	x	x	x	x	x	x	x	x	x	x	o	x	o	o	x	x	x	x	x	x	x	o	o	x
4	Rwanda	o	o	o	o	o	o	o	o	x	o	o	o	o	(x)	o	o	x	x	x	x	(x)	o	x	o	o	x
5	Panama	x	(x)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	x	o	x	(x)	o	x	o	o	o
6	India	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	x	x	x	x	(x)	o	x	o	o	x
7	Barbados	(x)	(x)	o	o	x	x	o	o	x	x	(x)	o	x	x	x	x	x	x	x	x	x	x	x	o	o	x
8	Lebanon	x	x	x	x	x	x	x	x	x	(x)	x	o	o	x	o	o	x	x	x	x	x	x	x	o	o	x
9	Usbekistan	o	o	o	o	o	o	o	o	o	o	o	o	x	x	x	x	o	o	o	(x)	x	x	x	o	o	x
10	UNEP	o	o	o	o	o	(x)	(x)	o	x	x	o	o	x	x	x	x	x	x	x	x	(x)	(x)	x	x	o	x
11	SEIA	o	o	o	o	o	o	x	o	x	x	o	o	x	x	x	o	x	(x)	x	(x)	x	(x)	x	o	o	o
12	EU	o	o	o	o	o	o	o	o	o	o	o	o	x	x	x	x	o	o	x	x	o	o	o	x	o	x
13	IEA	o	o	o	o	o	o	x	o	x	x	o	o	x	(x)	x	x	x	(x)	x	x	o	(x)	o	o	x	x
14	Austria	(x)	o	(x)	o	o	o	o	o	(x)	(x)	o	o	x	(x)	(x)	o	o	o	x	o	o	(x)	x	o	o	o
15	France	o	o	o	o	o	o	x	o	(x)	(x)	o	o	x	o	o	o	o	o	x	x	o	o	x	o	o	(x)

x	The indicator field is mentioned in the roadmap and is assessed/ given a role
(x)	The indicator field is mentioned once or twice, but not further treated
o	The indicator field is not mentioned

countries, supporting extensive assessments and providing insights into future scenarios. The database established allows a solid framework for sensitivity analyses and future scenario planning for solar cooling concepts. An internal Task 65 expert survey shows the average investment costs per kW cold for different system sizes:

- 2,100 €/kW for small ST-based or 1,500 €/kW for small PV-based systems (<10 kW),
- 1,600 €/kW for medium ST-based systems or 1,200 €/kW for medium PV-based systems (10-50 kW),
- 1,200 €/kW for large ST-based systems (50-100 kW) and
- 1,000 €/kW for ST-based systems over 500 kW.

These costs are critical for techno-economic analysis and future scenario planning. Economic parameters influencing key performance indicators (KPIs) include economic base data, consumption-based costs, operational costs, and capital costs. The Climate Profiling Tool helped to assess local weather conditions for solar cooling potential. Life-Cycle Cost-Benefit Analyses (LCCBA) were used to develop business models and financing solutions, emphasizing dynamic cash flow models. Learning curve models showed cost reductions through experience, though their application is limited by data availability for complex solar cooling systems. A detailed economic and financial LCCBA model focused on dynamic cash flow and KPIs such as internal rate of return (IRR), net present value (NPV), and levelized cost of energy (LCoE). Sensitivity and

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risk analyses helped to optimize project outcomes and support financial due diligence. The concept of 'Multiple Benefits of Energy Efficiency' was applied to solar cooling projects to capture additional benefits and drivers.

For further reading: SHC Task 65 reports, *Design Tools and Models* and *Technical and Economic Database for Assessment of Solar Cooling* and news article, *"Overview of Design Tools and Models for Solar Cooling Systems."*

Financing Models

As solar cooling solutions typically require high upfront capital expenditures, several new financing schemes suitable for solar cooling were investigated to provide relevant information. Potential clients may also perceive them as risky due to their complexity or unfamiliarity with solar cooling technologies. These and other non-technical barriers underscore the importance of developing client- and service-oriented solar cooling solutions for greater market penetration – particularly in the Sunbelt regions. However, a common language in this interdisciplinary developmental area is missing, which limits effective communication and collaboration among stakeholders. The aim was to establish a common understanding of technical terms and core concepts in economics and financing necessary for developing successful business and financing models for solar cooling. The following topics are covered:

- Business Models vs. (Third Party) Financing.
- Basic Financing Options for Solar Cooling Investments.
- Business Models including Third Party Financing for solar cooling investments and services.
- Life-Cycle Cost-Benefit Analyses (LCCBA) to support Business Model development and financing solutions.

This work serves as a basis for better informed discussions among technical and non-technical stakeholders from various disciplines. These are crucial for advancing client-oriented financing and business models to achieve greater market penetration of solar cooling solutions.

For further reading: SHC Task 65 report, *Business Models and Financing Options for Solar Cooling*.

Guideline / Roadmaps & Policy Advice for Sunbelt Countries

To promote solar cooling in the Global South, guidelines and recommendations were developed to create roadmaps and policy recommendations for accelerating and scaling up the adoption of solar cooling technologies. Task experts conducted a literature and roadmap review to gather information and compare exemplary roadmaps and documents addressing cooling demand and solar technologies. The review identified promising methods and opportunities for formulating roadmaps and implementation plans (see Figure 3). The indicated linkage between solar cooling technologies and their potential field of application on a national scale, directly targeting the most fruitful operation, is promising.

Finally, this Task work updated and adapted step-by-step process recommendations for roadmap development and provides a list of policy recommendations to guide policymakers in promoting solar cooling technologies at the national level.

For further reading: SHC Task 65, *Roadmaps for Solar Cooling in Sunbelt Countries*.

Conclusion

Key Messages

The key messages and takeaways from the work of SHC Task 65: Solar Cooling for the Sunbelt Regioins are:

- Designing effective solar cooling systems in Sunbelt regions requires a comprehensive understanding of the climatic conditions to use solar resources for efficient and eco-friendly cooling solutions.
- Further demonstration projects are necessary to gain experience and create confidence in the technology in Sunbelt regions.
- The wide penetration of solar cooling in Sunbelt countries depends not only on the accomplishment of technical barriers.
- Non-technical barriers often play a critical role. Financing, policy advice, and dissemination/communication of success stories are among the important activities for overcoming these barriers.

According to the Cool Coalition report, *Global Cooling Watch 2023*, led by the IFC and UNEP, the cooling market in developing economies is projected to grow from approximately 300 billion to 600 billion USD, or more, by 2050. With billions of people worldwide affected by extreme heatwaves intensified by the climate crisis, improving access to sustainable cooling has become essential.

This highlights the timeliness and importance of this SHC Task. Solar cooling technology's key driver is its potential to reduce greenhouse gas emissions and peak electricity demand, especially in countries with high cooling needs and grid limitations. To tackle this challenge, SHC Task 65 adopted an innovative approach – adapting existing concepts and technologies to the Sunbelt regions, utilizing solar energy (either thermal or photovoltaic).

This article was contributed by Dr. Uli Jakob of Dr. Jakob energy research GmbH & Co. KG and SHC Task 65 Manager. To find more Task results and download free reports, visit the Task webpage.

TASK 65 INTERVIEW

Solar Cooling for the Sunbelt Regions

Uli Jakob

The SHC Programme finalized its work on Solar Cooling for the Sunbelt Regions (SHC Task 65) this year. [link to Task title - https://task65.iea-shc.org/] To learn first-hand about the Task's impact, we asked the Task 65 Manager, Uli Jakob of Dr. Jakob energy research GmbH & Co. KG in Germany, to share his thoughts on this 4-year project.

Why was a project like this needed?

Maria Wall (Maria): This project was important since an increased use of solar energy is central for sustainable development, where the urban fabric needs to utilize passive solar gains and daylight to reduce energy consumption in buildings and improve indoor and outdoor comfort for inhabitants. In addition, active solar energy systems integrated in the urban context contribute to the production of renewable energy in the form of heat and electricity. We need to push for solar planning since all these solar strategies support cities and citizens in achieving sustainable and healthy developments.

Uli Jakob (Uli): As the energy demand for air-conditioning is growing faster than any other energy consumption in buildings, this project was very important to tackle this issue using solar technology that provides innovations for affordable, safe, and reliable Solar Cooling systems for the Sunbelt regions worldwide – the Global South. Therefore, the know-how capitalized in OECD countries (Europe, the US, Australia, etc.) on Solar Cooling technology (both thermal and PV) was already very relevant, but very few efforts had been made to adapt and transfer this know-how to Sunbelt countries such as Africa, MENA, Asian countries, which are all dynamic emerging economies.

Solar Cooling was already the subject of four SHC Tasks: Task 25, Task 38, Task 48, and Task 53. The previous Tasks achieved substantial progress for Solar Cooling systems. However, the implementation/adaptation of components and systems for the different boundary conditions was forced in Task 65 by cooperation with industry and with the support of target countries like UAE and India through Mission Innovation (MI) Innovation Community "Affordable Heating and Cooling of Buildings" (IC7).

What is the current status of the applications used for solar cooling?

Uli: The main applications that we identified in Sunbelt countries are in public buildings (34%), with an average working span of 8 hours/day, while some others were utilized in the domestic building (25%), process industry (9%), and food processing sector, among others. It is also interesting that manufacturers and system providers of solar cooling kits or large-scale systems have adapted their products for the Sunbelt region conditions. The focus here is on the heat rejection systems for dry and hot or humid and hot climates and, thus, the operational safety of these systems and kits. In addition, using medium-temperature solar systems to operate two-stage absorption chillers is becoming increasingly popular to increase competitiveness against traditional compression chiller systems.

The future markets for solar thermal cooling systems are in the Global South, where the demand for cooling is increasing rapidly due to the constantly growing population and extreme heat waves. Moreover, an important driver for solar cooling technology is its potential to reduce GHG and peak electricity demand, particularly in those countries with significant cooling needs and grid constraints. Today, for example, 30% of India's total energy consumption in buildings is used for space cooling, reaching up to 60% of the summer peak load. This is already stretching the capacity of the Indian national electricity supply dramatically. In other countries, like the USA, the peak load through conventional air conditioning reaches >70% on hot days.

Is there one result/outcome that surprised you?

Uli: Yes, the GIS tool developed by the Task participants from ZAE Bayern in Germany. They integrated geographic data to establish local reference boundary conditions for evaluating solar cooling systems in Sunbelt regions. By incorporating data such as population density and purchasing power, the tool provides a foundation for future market potential studies on specific products or technologies. As a result, potential sites can be identified and economic factors can be considered to identify (future) markets.

What is a Task success story from an end-user or industry?

Uli: The success stories I would highlight are our comprehensive roadmap and proposed actions that address specific challenges and opportunities

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to enhance the applicability of the existing Australian Standard AS 5389 on solar cooling to Sunbelt climates. This is crucial for making the technology comparable, calculable, and promotable in Sunbelt regions. And to support this effort, an existing life cycle cost-benefit analysis (LCCBA) tool was further developed to meet the specific requirements for modeling solar cooling systems in Sunbelt countries. Both results are extremely important for the industry to develop markets. The strong interest from industry and business was evident in the number of Task 65 participants from solar thermal collector manufacturers, sorption chiller manufacturers, system suppliers, consultancies, business developers, and ESCOs. Overall, 50% of the 83 Task experts came from industry and SMEs.

How has the Task's work supported capacity and skill building?

Uli: The widespread adoption of solar cooling in Sunbelt countries does not depend solely on removing technical barriers but also non-technical barriers. Financing, policy advice, and dissemination/communication of success stories are important activities to overcome non-technical barriers. Therefore, we organized 11 workshops, two onsite trainings in South Africa and Cape Verde, and two online trainings for the Caribbean and Türkiye, reaching over 565 participants (manufacturers and installers, consultants, policymakers).

What is the future of solar cooling – new developments, markets, policies, etc.?

Uli: Whether or not there will be a take-off of solar cooling, a key driver could be the UNEP's Global Cooling Pledge, which offers the opportunity to take concrete actions to promote "Sustainable Cooling." In total, 71 countries have signed the Pledge so far. The aim is to reduce cooling-related emissions by 68% by 2050 compared to today, significantly improve access to sustainable cooling by 2030, and increase the global average efficiency of new air conditioning systems by 50%. The emissions targets are based on models from the UNEP Cool Coalition 2023 report.

To drive this effort forward, current and future product development is focused on compact, small-scale solar air conditioning units with air-cooled absorption and adsorption chillers, as well as small and large multi-stage desiccant systems featuring solar thermal collectors or desiccant coated components. In addition, the development and launch of x.N stage chillers (half, single, 1.N, double, triple) paired with new medium temperature collectors, as well as thermally driven heat pump systems for heating and cooling, also in hybrid operation with vapor compression chillers. Not forgetting the future market penetration of small PV-driven components with new heat pumps/chillers that use natural refrigerants, such as propane.

What were the benefits of running this as an IEA SHC Task?

Uli: The Task was able to build a strong international network of experts from academia and industry with an interest in solar cooling and motivation to support and leverage existing know-how for the Sunbelt regions. The involvement of the GN-SEC experts (especially from Africa) was also very important and fruitful for the Task work to consider regional needs and requirements. This was highlighted by two GN-SEC experts who acted as activity leaders. In addition, the lively exchange of ideas and sharing of research and commercial project results between the experts was very fruitful, leading, for example, to several funded research activities.

Will we see more work in this area in the IEA SHC Programme?

Uli: The Task experts discussed several topics of interest for future work, including new focus areas (e.g., agri-food, commercial, tourism, industry), technical (e.g., storage, hybrid chillers, etc.), and socio-economic research areas (e.g., adaptation to climate change, etc.) and market needs (e.g., advanced GIS tool to identify markets and geographical areas, development of business cases, etc.).

A follow-up Task on "Solar Cooling for the Global South" to demonstrate the potential for sustainable and efficient heating and cooling solutions using a systems approach for industrial and commercial applications, including thermal energy storage and industrial waste heat recovery, is fully prepared and ready for kick-off in the future.

Solar Energy Buildings – THE new building standard

IEA SHC Task 66 on Solar Energy Buildings was initiated to develop and promote integrated solar energy solutions for climate-neutral buildings and communities, shaping the vision of the "City of the Future" and highlighting their transformative potential. To do this, existing challenges and actions needed to enhance the use of solar energy to cover energy requirements in the building sector were identified by an international team of experts from around 50 countries, working intensively together. The Task ended in September 2024 after more than three years. This article summarizes the highlights of SHC Task 66 and provides recommendations for future activities.

Why This Task

On a global level, building operation accounts for around 40% of primary energy consumption and approximately 25% of greenhouse gas emissions. In China, buildings are responsible for 21% of the energy consumption and 22% of CO_2 emissions. Even more impressive are the figures for Europe. There, buildings account for 40% of the energy consumption and 36% of the CO_2 emissions. Therefore, a significant reduction of the non-renewable energy consumption of buildings is an important goal for many countries and regions around the world.

One excellent way to contribute significantly to reducing greenhouse gas emissions is by using solar energy in the building sector. Therefore, the participants in SHC Task 66 on *Solar Energy Buildings (SEB)* worked to develop and promote economic and ecologic feasible energy supply concepts with high solar fractions. Within this framework, the Task focused on new and existing single-family buildings, multi-story residential buildings, building blocks and communities. Within the Task, Solar Energy Buildings" are defined as buildings in which the thermal energy demand for heating and cooling, as well as the electrical energy demand for household electricity and possibly electric mobility, is largely covered by solar energy, resulting in high solar fractions. The solar fraction is the part of solar energy used in relation to the total energy consumption of the building, which is required for heating, cooling, and electricity. To contribute significantly to reducing greenhouse gas emissions, new buildings should be designed, and existing buildings should be energetically renovated so that high solar thermal and solar electrical fractions in the range of 60 up to 100% can be achieved. For further information on the solar fraction, please look at the explanation in the separate box entitled "Solar Fraction."

Task Overview

SHC Task 66's main objective was to develop economically and ecologically feasible solar energy supply concepts for heat and electricity with high solar fractions for new and existing buildings and communities. This included, for example, giving an overview of various technology options and the available technology portfolio and considering existing and emerging technologies with the potential to be successfully applied within the Task. Furthermore, strategies were elaborated on how to overcome challenges in an economic context.

> "Several projects have shown that realizing economically and ecologically Solar Energy Buildings with high solar fractions is the solution for today and the future!"
>
> DR. HARALD DRÜCK
> IEA SHC Task 66 Manager

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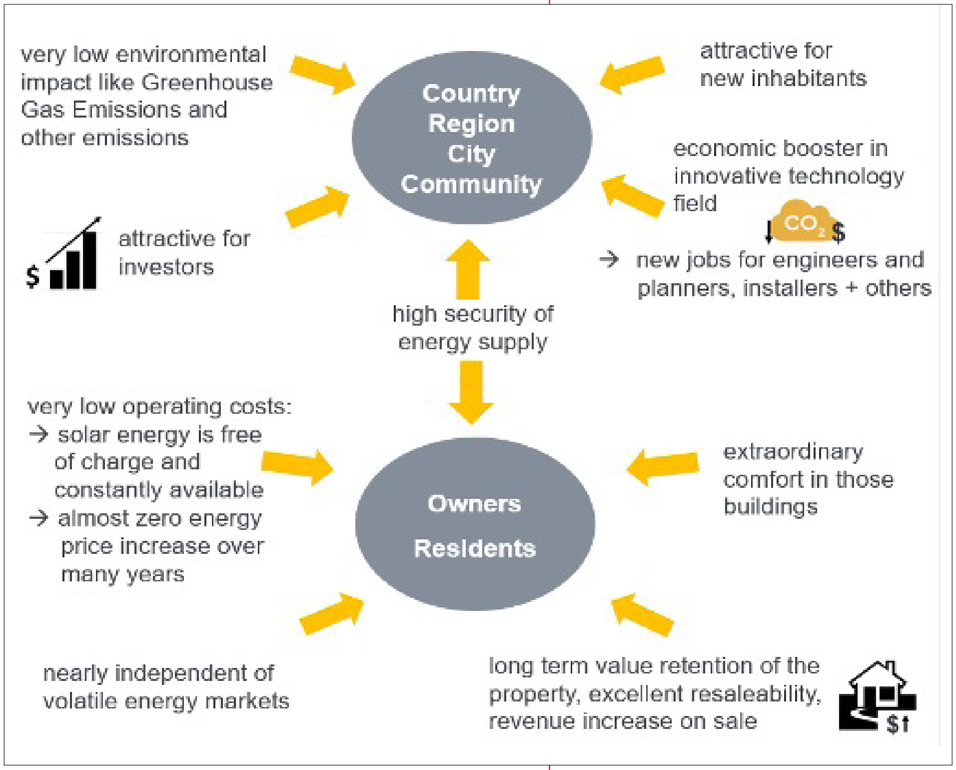
To tackle the work, the Task was divided into three subtasks.

Subtask A, focusing on Boundary Conditions, KPIs, Definitions, and Dissemination, was led by Frank Späte from OTH-AW (Ostbayerische Technische Hochschule Amberg-Weiden) in Germany. This subtask concentrated on defining Key Performance Indicators (KPIs) and coordinating dissemination efforts. Public outreach included five industry workshops and a final presentation of the Task's results at EuroSun 2024, attracting around 320 participants in total. In a first for an SHC Task, two videos were produced: an introductory video at the start of the project and a closing video showcasing the key results.

One key objective was to provide recommendations to policymakers and investors on accelerating the adoption of cost-effective solutions for planning and implementing Solar Energy Buildings. Two brochures, "Information for Investors" insert link to title, and "Information for Policymakers" were developed to support this. These brochures highlight the benefits of Solar Energy Buildings, and Figure 1 shows an excerpt from the policymakers' brochure.

Subtask B/C on New and Existing Buildings and Building Blocks/ Communities was led by Elsabet Nielsen, a Senior Researcher at the Department of Civil and Mechanical Engineering at the Technical University of Denmark and co-led by Xinyu Zhang and Wenbo Cai from the China Academy of Building Research (CABR) in Beijing. This group primarily focused on developing energy supply concepts and conducting modeling and simulation activities.



▲ **Figure 1. Excerpt from the policymakers brochure on the benefits of solar energy for the region and the owners and residents.**

The last Subtask D, Current and Future Technologies and Components was led by Michael Gumhalter and Thomas Ramschak, both from AEE INTEC Austria. It focused on the definition of current and future technologies and the techno-economic assessment of newly developed solutions for Solar Energy Buildings.

Task Highlights – Main Results & Their Importance

"Several projects have shown that realizing economically and ecologically feasible solar energy supply concepts with high solar fractions for new and existing buildings and communities is possible!" concludes Task 66 Manager Harald Drück with a smile on his face after more than three years of analyzing integrated solar energy supply concepts for climate-neutral buildings and communities for the "City of the Future," together with his international team. Within Task 66, twenty-one demonstration cases of Solar Energy Buildings were collected, analyzed, and summarized in the soon to be published report, "Demonstration Cases of Solar Energy Buildings".

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Demonstration Cases

The term Solar Energy Buildings includes single- and multi-family as well as commercial buildings in different climate zones. These demonstration cases (see Figure 2) show buildings in district heating areas and individual buildings outside district heating areas. All demonstration cases, except one building in India, are connected to the electric grid. Solar Energy Buildings are characterized by high solar fractions for heating, cooling, and electricity. The Solar Energy Building demonstration cases in Europe are located in Austria, Germany, Poland, Portugal, and Denmark, and further ones are in China, India, and Australia.

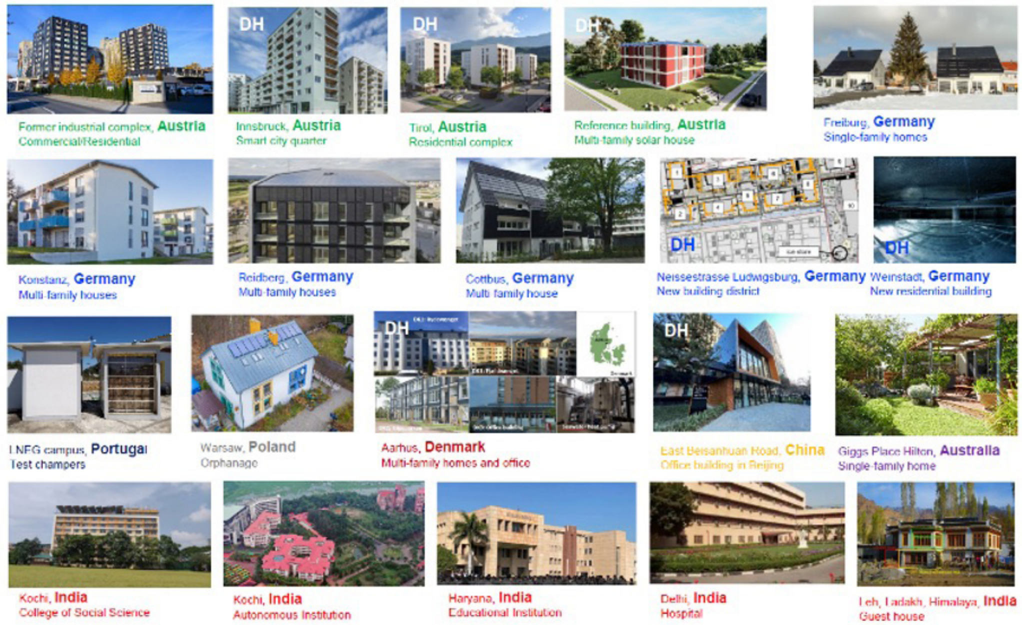

Figure 2. Demonstration cases of Solar Energy Buildings analyzed within SHC Task 66.

A relatively extensive technology portfolio is available within Solar Energy Buildings. The investigation within SHC Task 66 shows that the variability of different technologies is more significant in European demonstration cases than in Asian ones (see Figure 3).

On average, the 13 European cases use five different technologies, and the Australian case uses six to achieve relatively high solar fractions. In contrast, the Asian average is three. This is partly because Asian Solar Energy Buildings generally do not require space heating. The assessment found that the use of different technologies strongly depends on the region.

In Europe, the following technologies are widely used.

- Solar thermal systems for hot water preparation and space heating.
- Photovoltaic systems are often combined with batteries as electrical energy storage.
- Photovoltaic-thermal (PVT) collectors and solar thermal air-brine collectors are used primarily to melt ice stores but also as a heat source for heat pumps.
- Various types of heat pumps, in combination with solar thermal and photovoltaic systems, are widely used in more than 60% of Solar Energy Building projects.

In Asia, common technologies are:

- Solar thermal systems for hot water preparation.
- Photovoltaic systems are predominately used to provide electricity for cooling technologies.
- In one particular case, in the high mountain region of the Himalayas, a solar air heating system is used for space heating and domestic hot water production.

Technology Radar

The scientists of SHC Task 66 analyzed 150 Solar Energy Buildings, identifying and listing new and innovative technological elements as the foundation for developing a Technology Radar. This Technology Radar for Solar Energy Buildings includes over 50 measures evaluated based on their

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market availability and potential. Michael Gumhalter from the Austrian institute AEE INTEC led this initiative.

The most promising technologies are further detailed in factsheets compiled in the report New Technologies and Components for Solar Energy Buildings, which is set to be published in early 2025. These factsheets provide a description of the technology, guidance on effective integration into building services or envelopes, examples of applications, and an evaluation of their contributions to Solar Energy Buildings.

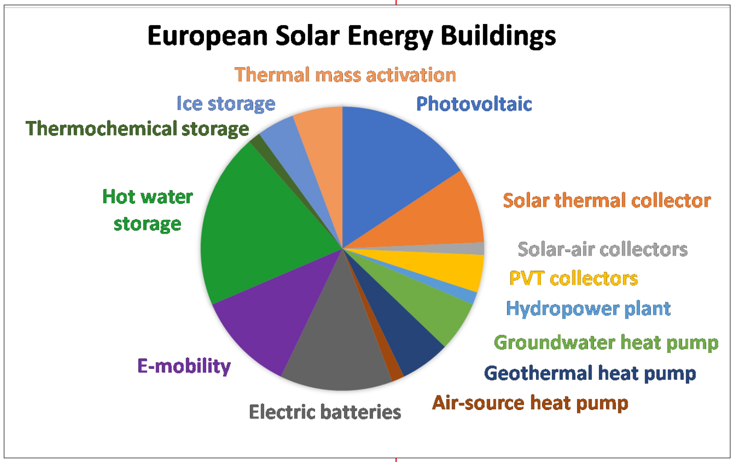
Michael Gumhalter and his team performed a profound technical and application-related assessment of new and innovative technologies and components that are key elements for Solar Energy Buildings. The Technology Radar groups all measures into four areas: generation, storage, thermal grids, and building & community. "We have rated more than 50 technologies and solutions in terms of their relevance in solar energy buildings until 2026", explained Gumhalter. "We checked facts such as technology readiness level but also made a qualitative assessment based on the high level of expertise and experience available in the multi-institutional SHC Task 66 team."

The researchers discussed and rated the following questions for all solutions:

- Are there any barriers that hinder current and future market entry?
- Are there national and international regulations that support or hinder a specific solution?
- Is a technology strong enough to compete in the market with its advantages and cost?
- How strong is the total value of the solution for building projects and, hence its potential growth rate?

As a result of this intensive assessment, the Technology Radar highlights 24 measures with high market relevance in green (see Figure 5).

In addition to the most common technologies such as PV, solar thermal, biomass boilers, and various types of heat pumps, innovative solutions like covered and uncovered PVT collectors, thermal building mass activation, ice storages, and low-temperature district heating grids are also included.



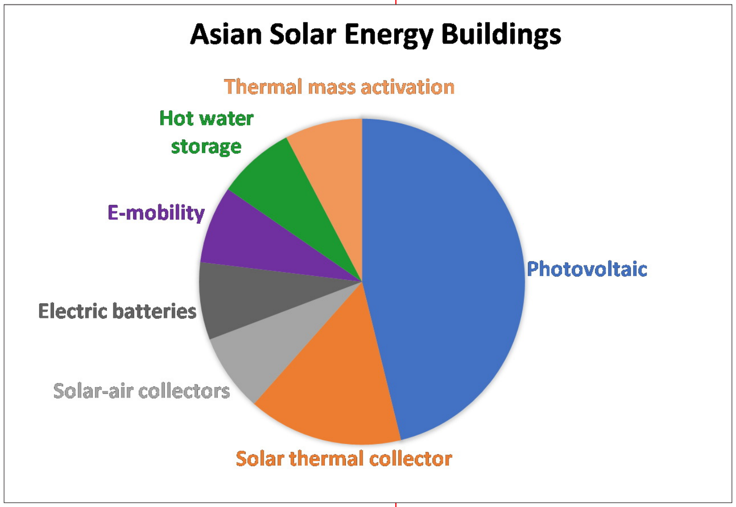


Figure 3. Technologies used in Solar Energy Buildings in Asia, Australia, and Europe.

Outlook

In summary, there is enormous potential for cost-effective Solar Energy Buildings with minimum CO_2 emissions. Many of the needed technologies for these buildings are already available, so now the main challenge is integrating Solar Energy Buildings into the real estate market.

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To achieve this, appropriate political, technical, and social boundary conditions must be implemented. A key aspect of this effort is increasing public awareness of Solar Energy Buildings' advantages. Additionally, it is crucial to establish standards and regulations that benefit Solar Energy Buildings. That means changing national building codes toward zero-emission buildings.

To unlock the full potential of Solar Energy Buildings, we must work together to establish Solar Energy Buildings as THE new building standard.

This article was contributed by Task 66 Manager Dr. Harald Drück and Claudia Scholl-Haaf, both from IGTE at the University of Stuttgart, Germany. To find more Task results and download free reports, visit the Task webpage. Note: More publications will be posted in early 2025.

Solar Fraction

To contribute significantly to reducing greenhouse gas emissions, new buildings should be designed, and existing buildings should be energetically renovated so that high solar thermal and solar electrical fractions in the range of 60 up to 100% can be achieved.

For the calculation of the solar fraction, short time intervals, e.g., 15 minutes, have to be used.

The aspect of calculating the solar fraction on relatively short time intervals is especially relevant if the ratio of the storage capacity divided by the demand is smaller than the time interval used for the calculation of the solar fraction, as in this case, the result strongly depends on the length of the time interval used for the calculation. This is typically the case for grid-connected PV systems without electrical energy storage. In this case, the short time intervals take into account the fact that the electricity grid itself cannot store energy. Hence, electricity fed into the grid is used immediately and excess photovoltaic energy in the summer cannot be taken out of the grid again in the winter. To cover electricity requirements in the winter, the electricity must be supplied by the grid, which, in many countries, still contains a lot of electricity generated from fossil fuels. Calculating net values of the electricity consumption based on annual values would, therefore, result in significantly lower equivalent carbon emission values than in reality.

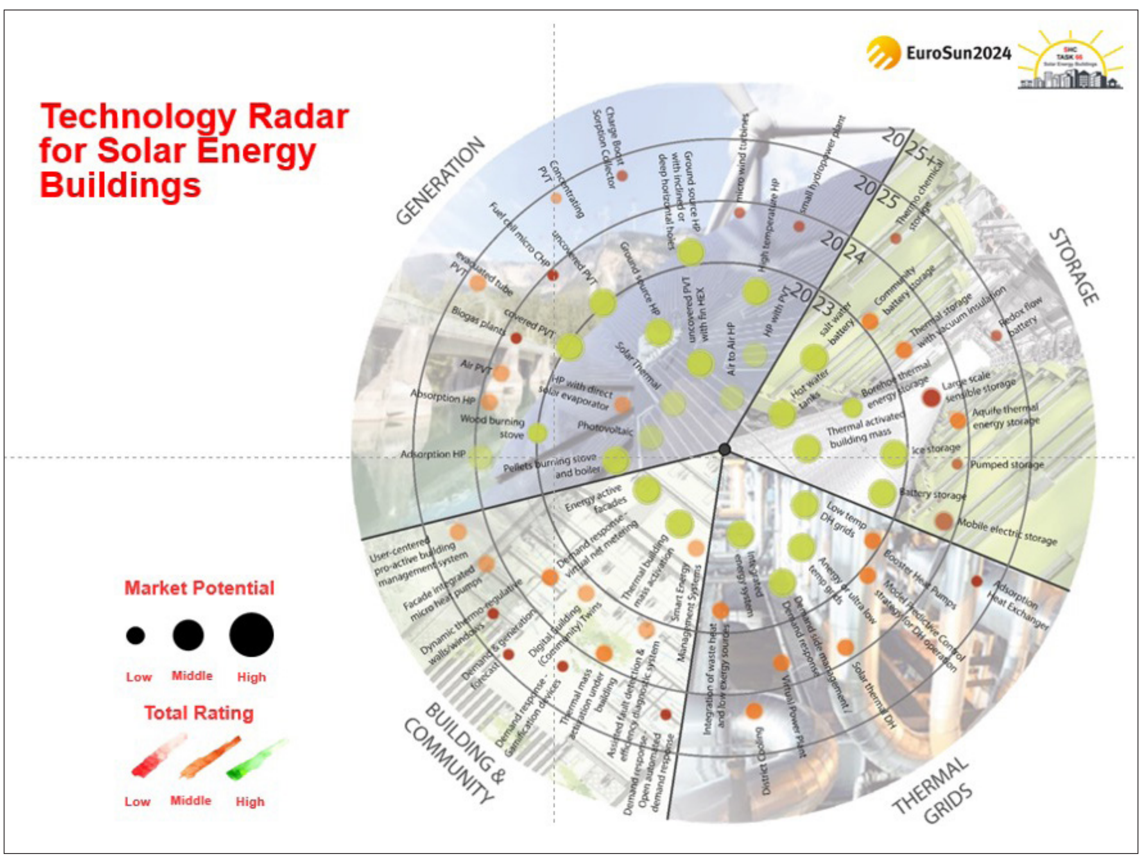


Figure 5. Technology Radar for Solar Energy Buildings

TASK 66 INTERVIEW

Solar Energy Buildings

Harald Drück

The SHC Programme finalized its work on Solar Energy Buildings (SHC Task 66) this past year. To learn first-hand about the Task's impact, we asked the Task 66 Manager, Harald Drück of the University of Stuttgart, to share his thoughts on this 3-year project.

Why was a project like this needed?

Harald Drück (Harald): This Task on Solar Energy Buildings was mainly needed due to two reasons.

The first reason is that the operation of buildings requires a lot of energy that is still predominately generated by burning fossil fuels. If a significant share of this energy is generated by using solar energy, a huge amount of CO_2-emissions can be avoided.

The second reason is that nearly all buildings require both – electric energy for the operation of household appliances such as lights, fridges, and communication devices as well as thermal energy for heating and cooling. Both forms of energy can be provided in an environmentally friendly and cost-effective way by using solar thermal collectors and PV modules. Hence, Solar Energy Buildings are a nice example for the combined applications of the different technologies being part of the Solar Heating and Cooling (SHC) Programme within the framework of the International Energy Agency (IEA).

What is the current status of the applications used for solar planning?

Harald: The knowledge required for planning and also constructing Solar Energy Buildings is still quite rare. Buildings with high solar thermal and solar electric fractions are still a niche market. In this Task, we performed a survey related to process and tools for planning Solar Energy Buildings. The survey showed that in Germany, POLYSUN is the most popular program, followed by TRNSYS, nPro and Hottgenroth Energiberater. In China, TRNSYS is the most popular program, followed by EnergyPlus and Dymola Modelica. In Austria, Trimble Nova is the most used program followed by Plancal. In Denmark, POLYSUN, EnergyPro and Revit are most used.

The survey also showed that many stakeholders use self-made programs, mainly because of the complexity and costs of the programs but also due to limitations in the commercially available software. A high number of tools and programs are used in the design and planning phase for Solar Energy Buildings. A smaller number of the tools and programs are used in the construction and verification phases and the operation and maintenance phases. No tools and programs, up to now, are used in the renovation and end-of-life phases.

Is there one result/outcome that really surprised you?

Harald: In fact, more results surprised me. One is that many countries and regions require new buildings to be built as "nearly zero energy buildings" (NZEB), "zero emission buildings," or "low-carbon buildings," but that Solar Energy Buildings are not mentioned in this context – this means we have to do much more promotion and lobbying work.

One other result I find remarkable is that the results of a survey showed that besides subsidies, aesthetic aspects and the availably of a potential solar energy label for Solar Energy Buildings are of high relevance for many stakeholders.

What is a Task success story from an end-user or industry?

Harald: Concerning end-users, I consider our collection of 27 demo cases of Solar Energy Buildings a success story because this document can serve as a basis for inspiration if someone intends to realize a Solar Energy Building. The collection provides a large variety of different Solar Energy Buildings. Both with regard to specific applications such as residential or office buildings as well as with regard to countries and climate zones.

For industry, our technology radar is of high interest, as it provides information about current and future technologies for Solar Energy Buildings and also assesses the market potential of these technologies.

How has the Task's work supported capacity and skill building?

Harald: Task 66 lasted for a bit more than three years. In this period, we performed 5 industry workshops and one event where we presented the final Task results. In total, around 320 people from approximately 50 counties participated in these events. The industry workshops were dedicated to different subjects such as "Demonstration project of Solar Energy Buildings around the globe", "Solar thermal and/or PVT combined with heat pumps as an innovative energy supply solution," and "Solar Energy Buildings – Design, Planning and Operation in Practice." Plus, we held an IEA SHC Solar Academy webinar on Solar Energy Buildings.

What is the future of Solar Energy Buildings – new developments, markets, policies, etc.?

Harald: Most relevant to establish Solar Energy Buildings as THE new building standard is awareness raising for the concept itself as well as for the advantages. This is also the reason why we produced two target-group specific information brochures: one dedicated to investors and one for policymakers.

Furthermore, it is important to generate awareness by looking on the overall lifecycle cost and not only at the investment cost. Even if it is more expensive to build Solar Energy Buildings compared to conventional buildings, Solar Energy Buildings are much more cost-effective as they save a lot of money during the operation period.

What were the benefits of running this as an IEA SHC Task?

Harald: The main benefit of dealing with Solar Energy Buildings within an IEA SHC Task was the possibility of working with an international team. Due to this, we were able to learn a lot from China, where both the building sector as well as the use of renewable energy is much more dynamic than in Europe.

Also, the collection of the demo cases and the elaboration of the technology radar benefited a lot from the international framework provided by IEA SHC. Thanks to the fact that we had experts from many different countries in the Task we were able to investigate a large of technologies and Solar Energy Building solutions for a huge spectrum of different climate zones and specific local boundary conditions.

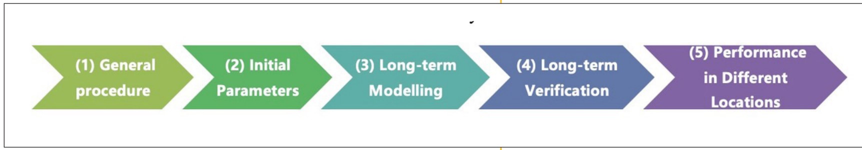
Will we see more work in this area in the IEA SHC Programme?

Harald: This is what I really hope! With Task 66, we did a first step towards the total energy supply, which means heat, cold and electricity, of new and existing buildings with a large share of solar energy. During the work, we noted that a lot of technologies are already available and some Solar Energy Buildings exist. However, to make the Solar Energy Building concept even more cost-effective additional R&D is needed. In parallel, awareness raising for Solare Energy Buildings is required, as they are the perfect solution for the realization of "nearly zero energy buildings" (NZEB), "zero emission buildings" and "low-carbon buildings" required in many countries today and in the near future. And finally, they offer many interesting and promising future options for our solar energy sector.

Solar Hot Water Systems and Greenhouse Gas Reduction in China

Solar thermal technologies play an important role in reducing carbon emissions. However, the assumptions that work in Europe may not work in China. To provide reference values of annual GHG emission reduction for China's SHW systems, the China Academy of Building Research (CABR) and Sunrain developed and validated a country-specific emissions reduction analysis within the SHC Task 69: Solar Hot Water for 2030 framework.

As global climate change worsens, achieving a carbon emissions peak and mapping pathways to carbon neutrality has become increasingly urgent. Under such conditions, solar thermal represents a readily available solution to dramatically reduce carbon emissions in the building sector. According to the International Energy Agency (IEA), China accounts for 73.1% of the world's total installed solar collectors, making it the world's largest market, producer, and exporter of solar thermal products. It is safe to say that China's solar thermal industry has made significant contributions to global energy saving and carbon reduction. At the same time, several differences exist between Greenhouse Gas (GHG) reductions in China and Europe (and other parts of the world).



▲ **Figure 1. Research activities flow chart.**

Other countries' experiences may not be entirely suitable for GHG reduction evaluation in China. To develop an assessment method for GHG emission reduction of Solar Hot Water (SHW) systems under China's climate resources and usage conditions, CABR and Sunrain partnered to conduct a series of research activities, including (1) Development of General Procedure. This step required a procedure to evaluate the long-term GHG reduction performance of solar hot water systems. Next, the (2) Initial Parameters were defined, according to ISO 9459-2 and GB/T 18708-2002, followed by (3) Long-term Modelling. This step involved the creation of a model to calculate annual energy saving and carbon reductions. Next, (4) Long-term verification was used to improve the methods by comparing with the long-term operation data. Finally, the verified model was used to determine the 5) Performance in Different Locations. This step involves simulation of the GHG reduction of solar hot water systems in different cities in China.

In the Initial parameters testing process, four characteristic solar hot water systems were tested to get initial performance parameters. Examples are shown in Figure 2.

▲ **Figure 2. Photos left to right: Compact system with ETC. Closed system with FPC. Testing platform at the Clean Thermal Energy Carbon Emission Test Center.**

The developed simulation method was similar to ISO 9459-2, but new software was developed (in Chinese) to make it easier for local experts to use. For verification, a carbon reduction testing field was established in Jiangsu province. The test was conducted in the Clean Thermal Energy Carbon Emission Test Center of the Solareast Group. Overall, a total of 15 types of solar thermal system configurations were installed for long-term testing. For a compact (open) system, the

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average daily GHG reduction is about 0.33~0.75 kg/m^2. For a pressured (closed) system, the average daily GHG reduction is about 0.14~0.50 kg/m^2. Table 1 shows the validation results from the simulations as compared to the testing results. By comparing the simulated and tested average daily heat gain, the deviation is within 12%, verifying the accuracy of software calculations.

Table 1. Comparison of simulated and tested average daily heat gain.

Type	Sample	Testing Results		Calculated Result		
		Avg. Daily Heat Gain MJ/(m^2·d)	Avg. Daily GHG Reduction kg/(m^2·d)	Daily Heat Gain MJ/(m^2·d)	Avg. Daily GHG Reduction kg/(m^2·d)	Deviation
Compact (open) system	1	3.62	0.58	3.19	0.52	**11.9%**
	2	3.18	0.51	2.97	0.48	**6.6%**
Pressured (closed) system	14	0.86	0.14	0.84	0.14	**1.2%**
	15	1.76	0.28	1.71	0.28	**2.8%**

Due to the differences in solar resources, the GHG reduction is very different in different cities. Based on the developed carbon reduction calculation software, 14 cities with different solar energy resources have been used to analyze its application effect. To obtain the national average operating effect, the average GHG reduction is weighted according to the population of each region. The average heat gain is 489.72 kWh/m^2, and the average GHG Reduction is 284.53 kg/m^2.

According to the Solar Heat Worldwide 2024, China's total installed solar thermal collector capacity is 545 million m^2. If these are all solar hot water systems, then this new analysis indicates that the annual GHG reduction will be 155 million tons. Considering that average emissions per person in China is estimated to be ~8 tons, this means that solar thermal hot water technologies alone are offsetting the entire carbon emissions of more than 19 million people in China.

Article analysis and reporting from Li Bojia, Bian Mengmeng, and Sang Wenhu of the China Academy of Building Research as part of SHC Task 69, Subtask B: Thermosyphons. Edited and contributed by Prof. Robert Taylor, SHC Task Manager of Task 69: Solar Hot Water for 2030. To learn more about this Task, visit https://task69.iea-shc.org/.

Task 71 Workshop

Explores Life Cycle and Cost Assessment of Solar Heating and Cooling Technologies

A workshop on *Life Cycle and Cost Assessment (LCA and LCoH) of Solar Heating and Cooling Technologies* held this past October at the Technical University of Denmark drew a diverse audience of 80 in-person and online participants. Researchers, policymakers, students, and industry professionals gathered to discuss the ongoing debate surrounding the role of LCA and LCoH in shaping both political and industrial strategies.

The primary objective of the workshop was to evaluate the relationship between LCA and LCoH, two key methodologies used to assess the environmental and economic impact of heating and cooling technologies. Participants discussed how these tools can be balanced to provide a more comprehensive understanding of energy solutions. In particular, there was a focus on ensuring that future planners and decision-makers are equipped with the necessary tools and knowledge to apply these methods effectively, aligning both economic and sustainability goals.

A major theme of the discussions centered around integrating LCA and LCoH into the planning and renovation of buildings. Experts emphasized how these assessments can support the deployment of environmentally friendly energy solutions while also leveraging political frameworks to accelerate the transition to a sustainable society.

The workshop kicked off with a welcome address from Karl-Anders Weiss of Fraunhofer ISE in Germany and project leader for the IEA SHC Task on Life Cycle and Cost Assessment for Heating and Cooling Technologies (SHC Task 71). The day's agenda featured a series of thought-provoking presentations on topics ranging from EU policy to life cycle analysis in renewable energy. Presentations included:

- EU policy aspects, energy labeling, and eco-design for sustainable products (Philippe Riviere, European Commission)
- Transforming heating systems as part of the energy transition (Mihai Tomescu, European Environment Agency)
- Life cycle analysis and renewables: A growing agenda and opportunity for Solar Heat? (Valérie Séjourné, Solar Heat Europe)
- National requirements on LCA for buildings and energy systems: A view on LCoH(E) (Lau Raffnsøe, Danish Green Building Council)
- IEA SHC Task 71: Life Cycle and Cost Assessment for Heating and Cooling Technologies: Investigated energy systems and database for energy systems (Karl-Anders Weiss, ISE Fraunhofer)
- Quantifying the environmental implications of solar thermal technologies: A comprehensive examination of life cycle impacts and payback periods (Maria Zagorulko, Naked Energy Ltd., United Kingdom)

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Following the presentations, participants split into seven groups led by SHC Task 71 experts. Their task was to discuss and answer the following questions:

- How can we ensure a balanced consideration between Life Cycle Assessment (LCA) and Levelized Cost of Heat (LCoH) when evaluating energy solutions, and should these factors be given equal weight in decision-making?
- How do decisions about the vulnerability of energy infrastructure (like power and gas lines) to threats like terrorism and war impact Life Cycle Assessment (LCA) results and the Levelized Cost of Heat (LCoH)?
- How can we ensure that future planners and decision-makers are equipped to use Life Cycle Assessment (LCA) and Levelized Cost of Heat (LCoH) while understanding the challenging balance between economic considerations and sustainability goals?
- How can Life Cycle Assessment (LCA) and Levelized Cost of Heat (LCoH) be effectively integrated into the planning and renovation of buildings and building communities to promote sustainable energy solutions?
- What are the potential advantages and disadvantages of company-driven LCA (Life Cycle Assessment) databases that require paid access? What benefits might arise from an EU-financed, free-of-charge LCA database, and are there any drawbacks associated with such a publicly funded model?
- How can we effectively manage the inevitable changes in future energy systems' energy mix, and what impact will these changes have on Life Cycle Assessment (LCA) results?
- How can regulations and politics governing energy solutions in the building sector support and accelerate the transition to a sustainable society?

After lively discussions, everyone came back together to share their key recommendations, which included:

- Putting more focus on LCA and less on LCOH when designing heating and cooling systems and planning building renovations.
- Simplifying LCA results to make them easier to understand, for example, by focusing only on CO_2 emissions.
- Introducing LCA labeling of products to help consumers make informed choices.
- Developing planning and design tools for heating and cooling systems focused on both LCA and LCOH.
- Including LCA in educational curricula at schools and universities.
- Introducing CO_2 tax on all products to encourage sustainable practices across industries.
- Incorporating LCA and LCOH into the design and protection of energy grids to ensure the long-term sustainability of energy systems.

The results of the workshop will feed into the ongoing work of SHC Task 71.

The day concluded with a panel discussion featuring policymakers and industry leaders, moderated by Simon Furbo of the Technical University of Denmark (DTU).

As the transition to a more sustainable and energy-efficient society continues, workshops like this serve as critical platforms for collaboration between academia, industry, and government, ensuring that all stakeholders are aligned in the pursuit of sustainable energy solutions.

This article was contributed by SHC Task 71: Life Cycle and Cost Assessment for Heating and Cooling Technologies experts Simon Furbo of DTU, Denmark, Karl-Anders Weiss of Fraunhofer ISE, Germany SHC Task 71 Manager, and Kyra Sophie Rimrodt of Fraunhofer ISE. For more information, visit the Task 71 webpage.

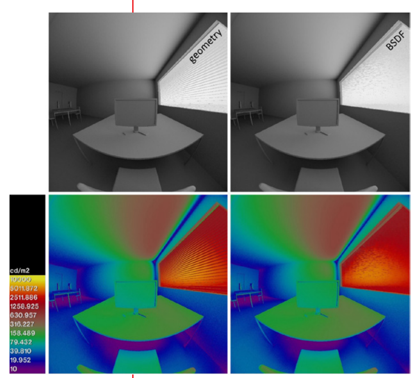
Marketplace

The Solar Heating and Cooling Programme is not only making strides in R&D but also supporting the growth of the solar thermal sector. This section of the newsletter highlights the link between our R&D work and its practical impact on the world.

New Shading Standard Turns To BSDF Data Generation For Complex Fenestration Systems

Shading or daylighting devices are mentioned in several standards and must be considered in standardized methods and regulations. Their importance is growing in the context of increasing risks of building overheating while maintaining high visual comfort for occupants. However, it is often not specified how these devices can or should be represented.

Bidirectional Scattering Distribution Functions (BSDFs) offer an efficient possibility for this. The revised version of ISO/CIE 10916 introduces a three-phase calculation method in its new Annex B and explicitly requires BSDF data for the calculation. This adaptation of ISO/CIE 10916 was developed and coordinated in the context of former IEA SHC Task 61 on integrated lighting solutions.

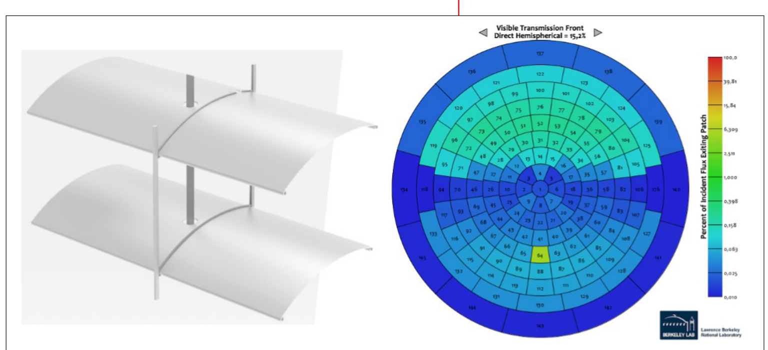


▲ **Figure 1. Daylight simulation of an office space with a CFS (venetian blinds) modeled as geometry (left) and modeled with its BSDF (right).**

For transparent glazing in windows, standardized methods are well established to characterize the angle-dependent, solar-optical properties (transmittance, absorptance, reflectance). However, no standardized methods currently exist for "optically complex" or light scattering, shading, and daylighting systems. This, in turn, makes objective evaluation of energy performance, solar distribution, daylighting, comfort, and other building performance qualities almost impossible.

Simplified methods for characterizing complex fenestration systems (CFS) have been developed using normal-normal, normal-hemispherical, and diffuse-hemispherical transmittance and reflectance measurements. These methods have found their way into European and international standards (EN 14500/14501, ISO 52022) but can contribute to significant errors when assessing daylighting, indoor environmental quality (visual comfort), and solar gains-related building energy performance.

Standards and guidelines exist in various application areas that relate to daylighting and solar heat gains. In some cases, BSDFs are already incorporated, or methods and metrics are used that can be supported by BSDFs. The explicit introduction of BSDFS in ISO 10916 is certainly a milestone here.



▲ **Figure 2. Left: Example CFS, exterior venetian blinds © HELLA Sonnen- und Wetterschutztechnik GmbH). Right: false color representation of BSDF in Klems discretization (right).**

The newly launched ISO/CIE AWI 25176 project in ISO/TC 274/JWG 1 aims to specify procedures for the BSDF characterization of CFS and the generation of tabular BSDF data sets as input to ISO 10916 and in simulation tools. The content is based on the results of the completed IEA SHC Task 61: Integrated Solutions for Daylighting and Electric Lighting and is being developed as part of the ongoing IEA SHC Task 70: Low Carbon, High Comfort Integrated Lighting.

Article contributed by David Geisler-Moroder, leader of SHC Task 70, Subtask C: Subtask C: Digitalized Lighting Solutions (Technology & Design Tools / Process) and Dr. Jan de Boer, Task Manager of SHC Task 70. To learn more about this ongoing Task, visit the Task webpage.

IEA SHC programme

The International Energy Agency was formed in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement a program of international energy cooperation among its member countries, including collaborative research, development and demonstration projects in new energy technologies. The members of the IEA Solar Heating and Cooling Agreement have initiated over 70 R&D projects (known as Tasks) to advance solar technologies for buildings and industry. The overall Programme is managed by an Executive Committee while the individual Tasks are led by Task Managers.

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