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!"

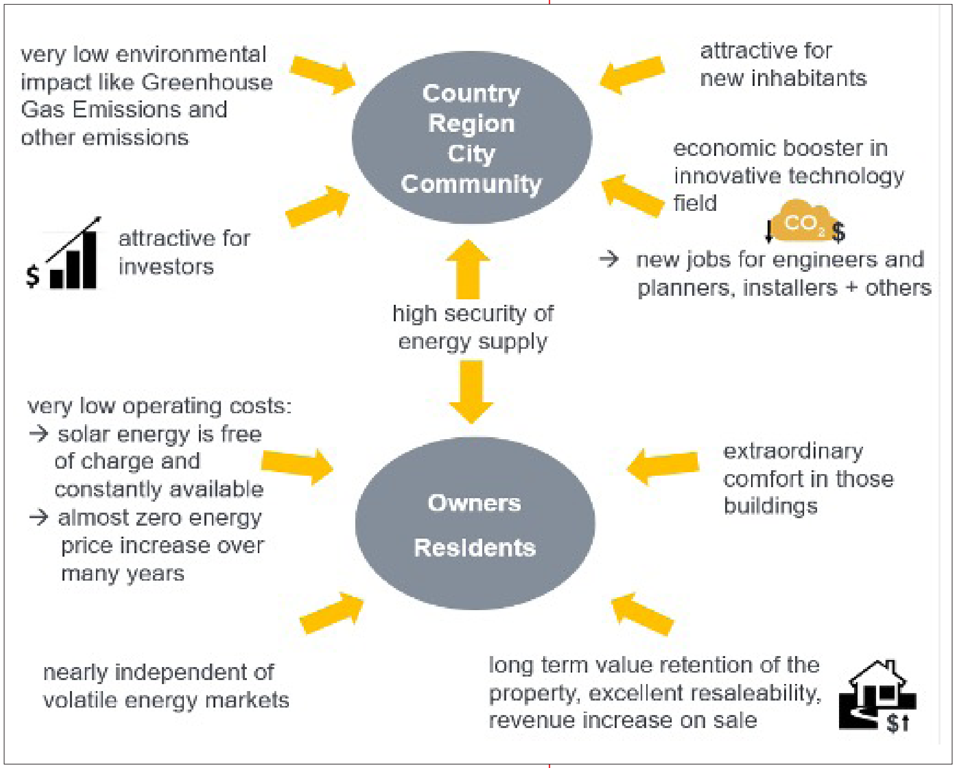
DR. HARALD DRÜCK
IEA SHC Task 66 Manager

continued on page 16

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.



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

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.

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.

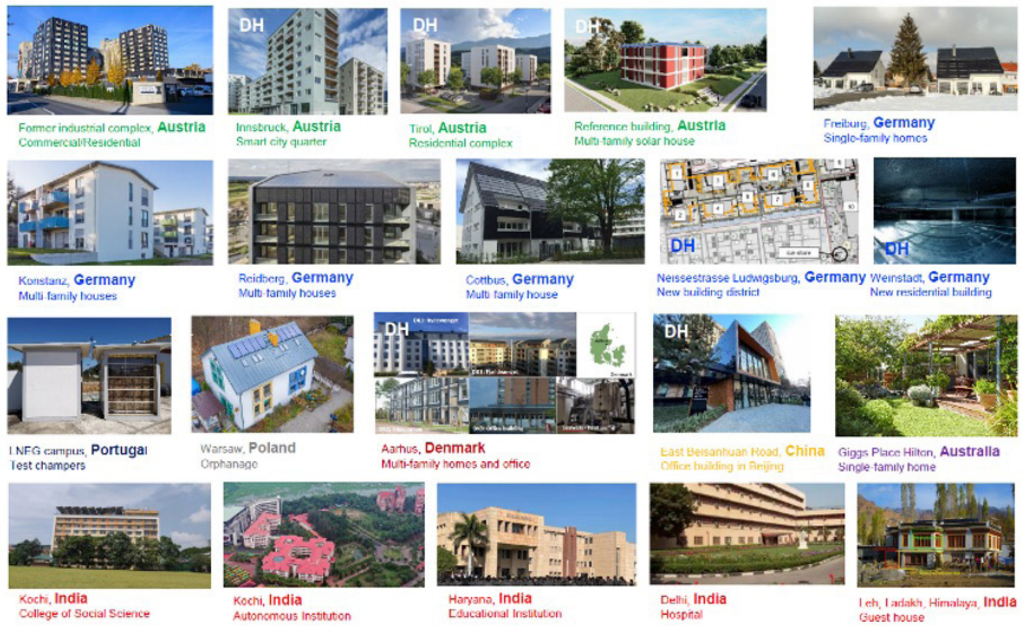
Task Highlights – Main Results & Their Importance

"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".

continued on page 17

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

continued on page 18

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:

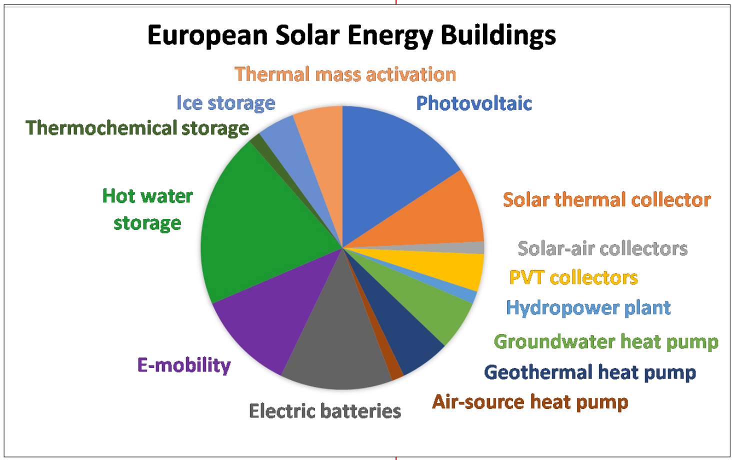
- Are there any barriers that hinder current and future market entry?
- Are there national and international regulations that support or hinder a specific solution?
- Is a technology strong enough to compete in the market with its advantages and cost?
- How strong is the total value of the solution for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

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.



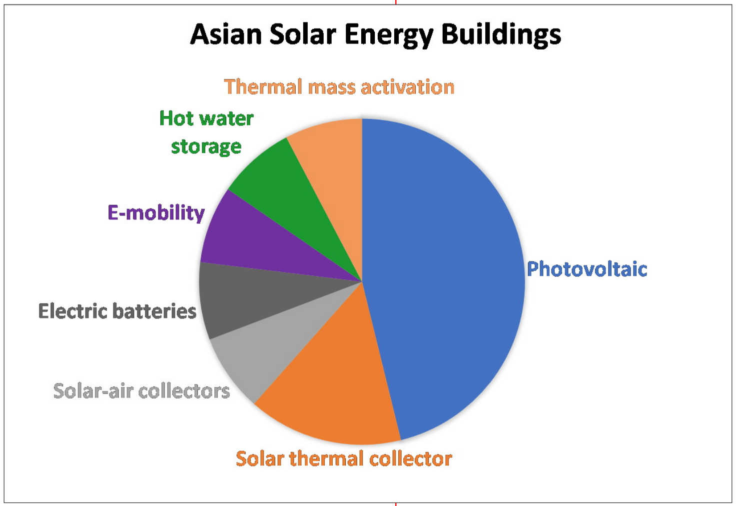


Figure 3. Technologies used in Solar Energy Buildings in Asia, Australia, and Europe.

continued on page 19

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.

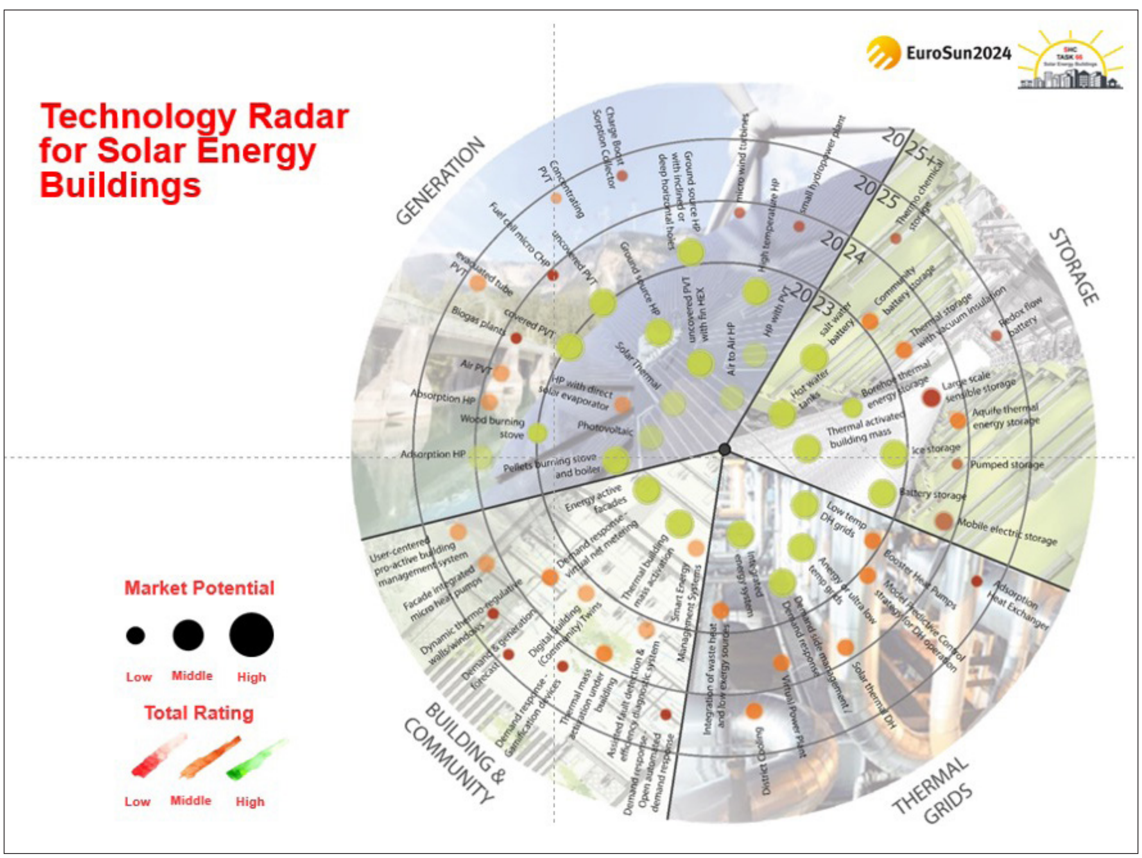


Figure 5. Technology Radar for Solar Energy Buildings