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INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

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Solar Energy Buildings Around the World

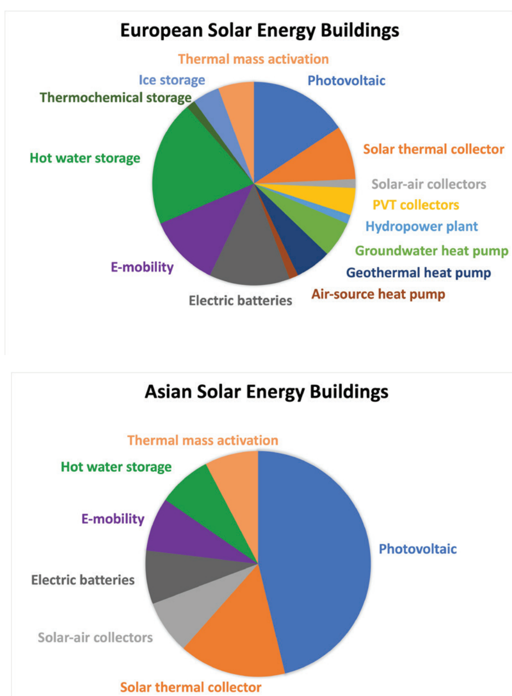
▲ **Single-family houses in Freiberg, Germany, in continental climate.** Photo: Lukas Oppelt, TU Bergakademie Freiberg.

The analysis of 20 Solar Energy Buildings demonstration cases is wrapping up in IEA SHC Task 66 on Solar Energy Buildings. In this article, you will preview some of the high-solar fraction buildings in this collection.

The case studies include single- and multi-family homes and commercial buildings in different climate zones and inside and outside district heating areas. All the buildings, except one in India, are connected to the electric grid. The selected buildings aim for high self-sufficiency in heating, cooling, and electricity. The degree of self-sufficiency is defined as renewable energy consumption divided by total energy consumption. The Solar Energy Building demonstration cases are distributed across Europe (13), Asia (6), and Australia (1). The European demonstration cases are in Austria (4), Germany (6), Poland (1), Portugal (1), and Denmark (1), and the Asian are in China (1) and India (5).

The technologies used in the IEA SHC Task 66 Solar Energy Building cases in Europe and Asia are shown in Figure 1.

It is noticeable that the variability of technologies is more significant in Europe than in Asia. On average, the 13 European cases use five different technologies to reach a high degree of self-sufficiency, while the Australian case uses six different technologies. In contrast, the Asian average is



◄ **Figure 1. Technologies used in the IEA SHC Task 66 demonstration cases in Europe and Asia.**

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only three, influenced partly by the fact that most Asian solar energy buildings do not require space heating.

Photovoltaic (PV) panels play an essential role in solar energy buildings. In Europe, they are more often combined with batteries than in Asia. Solar thermal systems also play an important role. In Europe, alongside traditional flat plate and evacuated tube solar thermal collectors, photovoltaic-thermal (PVT) collectors are used, while solar air collectors are used primarily for melting ice-storages. In Asia, traditional solar thermal collectors are used. In one notable case, in the high mountain region of the Himalayas, a solar air collector is used for space heating and domestic hot water production.

Heat pumps are very popular in Europe, and different types of heat pumps are used in more than 60% of the European Solar Energy Building cases. In contrast, no heat pumps are used in the demonstration cases in Asia.

Demonstration Buildings

The following buildings are a few examples of the demonstration cases showcasing different energy supply systems. These buildings illustrate the high degree of flexibility and possibilities for combining different technologies within the energy system for heating, cooling, electricity, and even e-mobility. The complete report describing all 20 demonstration cases will be published in 2024 on the IEA SHC Task 66 homepage: https://task66.iea-shc.org/.

▲ **Multi-family building in Reidberg, Germany, in continental climate.** Photo: Constantin Meyer, SIZ energieplus.

Multi-family building in Reidberg, Germany

Based on measurements, this five-story multi-family building in Reidberg, Germany, built in 2015, reaches 26% self-sufficiency for heating, 100% for cooling, and 42% for electricity. The building has seventeen apartments and a heated area of 1,600 m^2. A brine-water heat pump (50 kWth) uses a solar ambient air absorber on the roof (85 m^2, located under the PV modules) and an ice-storage (100 m^3) as the source for floor heating and domestic hot water. Central mechanical ventilation with heat recovery reduces heat loss in winter and increases indoor comfort. After the heating period, the ice storage regeneration is carried out through the solar ambient air absorbers. Photovoltaic modules are installed on the roof (84 kWp) and the building's façade (15 kWp). To improve the system's flexibility, a battery storage of 59.4 kWh is integrated. The surplus energy is used on-site and charges electric cars and e-bikes in the building's underground car park, which the tenants share.

Single-family houses in Freiburg, Germany

(see photo on page 1)

These two single-family houses in Freiberg, Germany, built in 2013, reach 70% self-sufficiency on the thermal side and 94% on the electricity side – based on measured data. One of the buildings serves as a residential building (206 m^2), the other as an office building (162 m^2). The energy system consists of solar thermal collectors (46 m^2) and photovoltaic panels (8.4 kWp) on the roof, heat storage (9.1 m^3), a backup heating stove (25 kW), battery storage (58 kWh), and a geothermal collector system for cooling. An electric vehicle is used to increase the self-consumption share of the residential building.

▼ **Office building in Beijing, China, in continental climate.** Photo: Xinyu Zhang, China Academy of Building Research.

Office building in Beijing, China

The office building in the China Academy of Building Research office park was refurbished in

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2021. The building reaches 31% self-sufficiency on the electricity side – based on measurements. The two-story office building has an area of 3,000 m^2. The building is cooled by a split air conditioner in summer and heated by district heating in winter. Domestic hot water is prepared in an electric-heated hot water tank. Three types of photovoltaic panels are used on the roof and façade and in the window glass: Monocrystalline silicon 569 m^2 (115 kWp), Thin film 849 m^2 (118 kWp), and transparent thin film 51.6 m^2 (2.2 kWp).

▲ **Guest house in Ladakh, India, in subarctic climate.** Photo: Christoph Müller, Simply Solar GbR.

Guest house in Ladakh, India

This guest house in Ladakh, Himalaya, India, reaches 94% self-sufficiency for heating – based on measurements. A solar air collector system on the roof completely heats the guesthouse, including the domestic hot water tank. The solar heated air flows through a pebble-bed storage below the ground floor of the building and a heat exchanger connected to the hot water tank. Building mass activation ensures room heating even for one to two days without sun. Photovoltaic panels (2 x 60 Wp) drive the ventilators. The high share of self-sufficiency is achieved due to the cold but sunny winters, which you find in many other locations worldwide. Gas is used for cooking (2 gas bottles of 12 kg per year), which is why the self-sufficiency is 94 % and not 100 %.

Single-family house in Hilton, Australia

A solar electric single-family home in Hilton, Australia, built in 2013, reaches 89% self-sufficiency - based on measurements. The building energy system comprises an electrical-driven heat pump, photovoltaic panels (6.4 kWp), battery storage (10 kWh), a solar hot water system, and a charging station for an electric vehicle. The building collects and recycles most of its water, and landscaping includes food production, wildlife habitat, and play spaces.

This article was contributed by Elsabet Nielsen, Senior Researcher at the Department of Civil and Mechanical Engineering, Technical University of Denmark, and leader of the SHC Task 66 Subtask C on New and Existing Building Block/Communities.

▲ **Single-family house in Hilton, Australia, in Mediterranean climate.** Photo: Rebecca Yang, RMIT University, Australia.