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Solar Thermal Yearbook 2021

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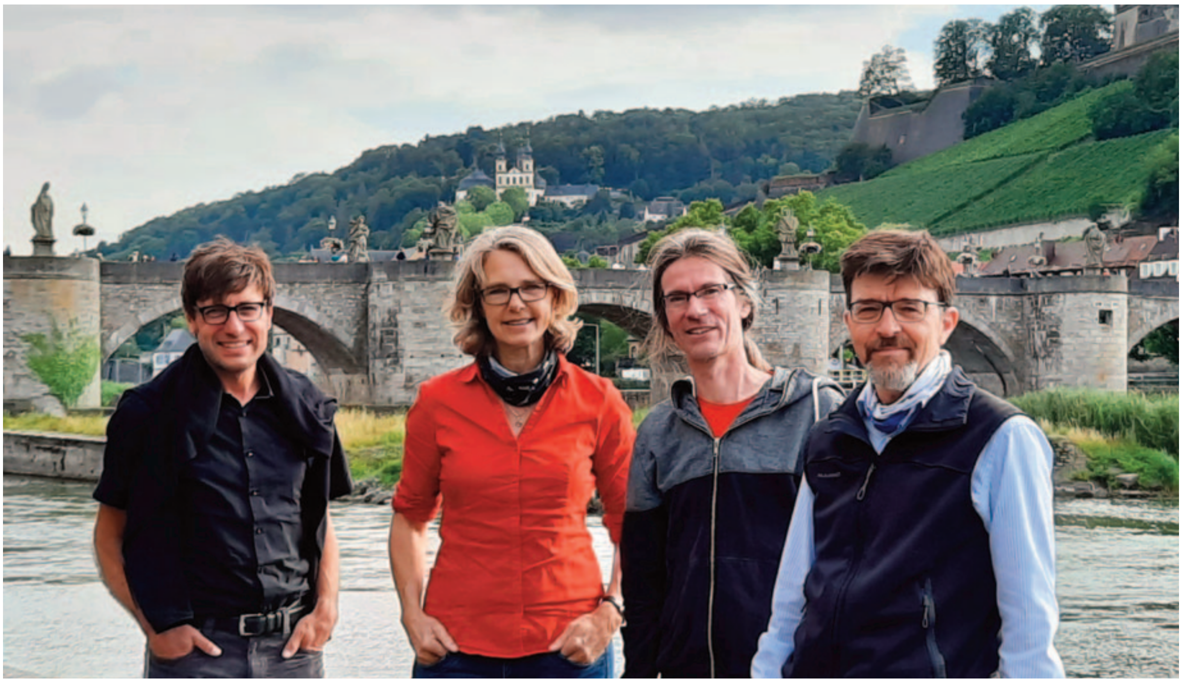

Indispensable for the energy transition

Humans need energy in many forms to live. But above all, they need heat. The sun provides an abundance of energy for this purpose. Solar thermal energy is the most effective technology for converting it into heat.

For several decades, solar thermal energy has been used to heat homes and supply them with hot water. The decentralized supply of individual houses was later supplemented by the centralized supply of settlements. These local solar heating systems, supplemented by in combination with large storage tanks, can supply heat well into the winter.

Solar thermal energy is indispensable for the energy transition, which will be our major task in the coming decades. But just as indispensable is informing the interested public about the state of the art and the wide range of possible applications.

That is why we decided three years ago to publish this yearbook. It was previously only published in German, but because the energy transition is ultimately a global issue, there is now also an abridged English version.

A more comprehensive edition is scheduled to appear next year. To make this publication a success, we will take up your suggestions and proposals. After all, an international edition relies on information from as many countries as possible. Please write to us so that we can report as comprehensively as possible.

November 2021

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Solar thermal energy: And yet it pays off

The prejudice that solar heating systems are not profitable is persistent. But in truth solar thermal installations make themselves paid and all the more valid, as at present the subsidy conditions in Germany are excellent. Jens Peter Meyer, author of the knowledge portal www.solarthermie-jahrbuch.de, puts the most frequent errors regarding solar thermal heating right.

Among all possibilities to win warmth for showering and heating, solar heat systems offer the best climatic and environmental friendliness. They emit no greenhouse gas because they use free solar radiation. They are made of environmentally friendly, extremely durable materials that can be easily recycled. Their efficiency is enormous. This can be seen by comparing them with heat pumps. A heat pump has a coefficient of performance of 3 to 5, which means it produces 3 to 5 parts of heat from one part of electricity put into it. Solar thermal energy, on the other hand, has a coefficient of performance of up to 100. Solar thermal energy is also ahead of photovoltaics. Thanks to their 3 to 4 times greater efficiency, solar collectors require much less space on the roof than photovoltaic modules that generate solar electricity. This small footprint is also one reason why solar thermal and solar electric systems combine well. This is because solar thermal takes up so little space that there is still enough room left over for solar electricity.

But these undisputed advantages are far too little known to the general public. Instead, misconceptions often dominate the discussion about solar heat generation.

Misconception 1: Solar thermal energy is not worthwhile

It is often claimed that solar thermal energy is not worthwhile. The truth is that solar thermal systems are doubly worthwhile. They are worthwhile for the climate, because they save a lot of carbon dioxide, and they are worthwhile for the wallet. In the long term, the investment in a solar heating system pays for itself. Regardless

Solar house heated with with 70 percent solar thermal in Bavaria (left) and solar thermal on a residential and commercial building in Munich PHOTOS (2): INA RÖPCKE

of whether the solar thermal system saves oil for oil heating, gas for gas heating, pellets for pellet heating, or electricity for heat pump heating, the savings in fuel costs ensure that the solar thermal system pays for itself in 11 to 16 years, depending on the size of the system. This corresponds to a return on investment of 2.8 to 6.9 percent.

In this calculation of the German Solar Association no subsidies are considered. In view of the currently particularly attractive subsidy conditions, the amortization periods are currently significantly lower. In addition, the CO_2 pricing, which will make fossil fuels expensive from 2021, will further improve the amortization of solar thermal energy. In the payback calculation, the experts assume a service life of 20 years for the solar thermal system. However, solar collectors and heat storage systems last 30 years or longer, according to all that is known. That pushes the return even higher.

Again, the comparison to photovoltaics: Electricity storage systems are much more expensive than heat storage systems and do not last nearly as long. While with solar heat the storage is always included, the electricity storage makes the photovoltaic system significantly more expensive. So much so that photovoltaic systems with electricity storage are just on the threshold of economic viability, and in many cases do not even reach it.

Misconception 2: Solar thermal energy is only for the south of Germany

The view that solar thermal energy is only worthwhile in the south of Germany is also a misconception. It is true that solar radiation is greater in many places in the South than in the North. But there are also very sunny areas in the North, for example near the coast. And solar thermal energy also pays for itself in the less sunny regions, although not as quickly as in the south. You have to reckon with one to two years longer payback time. The figures mentioned above refer to the Würzburg location, which is in Northern Bavaria.

By the way, the choice of installer is much more important for the return on investment of the solar system than the location. Not every heating engineer today has sufficient competence to be able to install a solar heating system without errors. But a faulty installation will never be profitable. In addition: In the past there were, according to estimations of industry experts, not rarely overpriced offers of heating engineers, who wanted to avoid thereby the unloved solar installations. Therefore: A solar heat plant can be worthwhile itself only if a competent plumber settles this at a fair price. Without price comparison and reference plant check it does not go thus.

Misconception 3: Solar hot water systems are more worthwhile than solar heating systems

The third misconception about solar heating concerns the type of system. Experts distinguish between solar systems that only provide hot water for showers, bathrooms and kitchens, and solar heating systems that also provide heating. It is true that in many - but not all - model calculations, the return on investment of hot water solar systems is better than that of solar heating systems. This is because solar heaters require more heat output. As a result, they produce more solar heat in the summer than the household can take. This unused potential can have a negative impact. This is why it is important for any solar heating system to make the best use of the heat in the summer. Household appliances, such as the dishwasher or washing machine, should definitely be connected to the hot water supply. Because only in this way they can use free solar heat instead of expensive electricity. However, the argument in favor of the larger solar heating systems is that the proportion of storage costs and installation costs decreases with the size of the system. And even if the return on investment of the larger system is somewhat lower than that of the smaller one: The large system saves 20 to 30 percent on fuel costs. The small one saves less than 10 percent.

In the example calculation of the German Solar Association, the small system saves around 10,000 Euros in 20 years. With the large one, on the other hand, more than 14,000 Euros. In total, the large system is therefore more worthwhile than the small one, even if its return is somewhat higher. Incidentally, it is now possible to cover 70 percent or more of domestic heating with solar thermal energy without any problems. This is possible both in new buildings and in comprehensive building renovations. Thanks to government subsidies, this is worthwhile and ensures extremely low heating costs in the long term. And it means extensive independence from price fluctuations of fossil fuels and from political regulations in the course of combating the climate crisis.

Misconception 4: Solar thermal only saves a lot in well-insulated houses

The fourth misconception is that solar thermal is only worthwhile in well-insulated homes. It is true that only well-insulated houses can also cover a large proportion of their energy with solar heat. In poorly insulated houses, the amount of heat required is simply so large that the solar system can contribute little in proportion. If the solar coverage percentage for a well-insulated house is 30 percent, the equally powerful solar system for a poorly insulated house only manages 10 percent. But this does not mean that it is not worthwhile. On the contrary, it actually saves more fuel costs. This is because modern buildings need practically no heating in months like April and May, but also in September and October. However, April and May in particular are months with very high solar radiation. Therefore, solar thermal energy can optimally heat the house during these times.

New German funding conditions improve cost-effectiveness enormously

Solar thermal energy was already economical in previous years. But since the German government increased the subsidies for renewable energies in heating technology in the climate package, it pays off particularly quickly. The subsidy rate is currently 30 percent of the cost. Anyone who invests in a renewable energy hybrid heating system and replaces an old oil heating system receives an additional 45 percent from the government. This means that solar thermal energy pays for itself in less than ten years.

Jens-Peter Meyer

"Balance your solar mandate between what the market is ready for and what you want to achieve"

Barcelona pioneered renewables obligations for solar energy in Europe. Solar Thermal Yearbook spoke with Fermín Jiménez Castellanos, head of the city's renewable energy projects unit, about the impact of the local solar building regulations.

PHOTO: PRIVATE

In August 2000, the city in the Spanish Catalonia region adopted solar building regulations that required a predefined share of solar-heated water for newly constructed buildings and those to be fully renovated or repurposed.In the last two decades, the obligation has been the main driver behind the municipality becoming a mature solar thermal market, helping to install about 96,000 squaremeters of collector area (estimate based on registered installations).

Barcelona's solar mandate was the first of its kind for a large European city 20 years ago. What was the city council's motivation behind adopting these building regulations at the time?

Jiménez: When the city council adopted a solar thermal ordinance in 2000, the aim was to help make solar thermal a mainstay in buildings and start a long-term trend that would see Barcelona turn into an energy-independent and low-carbon city.

You have been following the implementation of the mandate since 2007. Are you satisfied with its impact on the market?

Jiménez: Yes, I am pleased with the effects the policy has had on the local solar thermal market. A lot of small Barcelona-based companies now specialise in solar water heater installation. But the policy has also had an impact far beyond city borders. In the first several years after its implementation, about 50 towns and cities in Spain followed Barcelona's example, a remarkable movement that culminated in the implementation of the national technical building regulations (CTE) in 2007.

Do you know how many solar water heaters have been installed in the city thanks to the mandate?

Jiménez: We at the city council have kept records of the number of permits granted for newbuilds or buildings undergoing major renovation, the two instances in which the mandate requires the use of a solar water heater. And once a building or renovation work is finished, we check again whether the owner or investor has fulfilled the measures mentioned in the permit, which allows us to estimate the collector area newly installed each year due to the mandate (see the chart next page).

Have you improved the solar mandate in Barcelona over the years?

Jiménez: It has always been difficult to revise the mandate, but we mana-

Solar mandate in Barcelona

As early as August 2020, Barcelona had enacted a solar obligation for all new buildings and also for buildings that are being extensively renovated. Originally, this mandate only applied to solar thermal energy. This is because it required a certain solar fraction that owners must provide for their building's water heating.

In 2011, the city also expanded the solar mandate to include a photovoltaic requirement for non-residential buildings.Buildings with a hot water demand of less than 10,000 liters per day must generate 60 percent of that with solar heat. For 10,000 to 12,500 liters, it is 65 percent. 70 percent solar coverage is required if the hot water demand exceeds 12,500 liters per day. The CTE national building regulations in Spain, which have had a solar mandatev since 2007, are also based on Barcelona's example. They stipulate a minimum solar coverage of 70 percent from 5,000 liters of hot water per day.

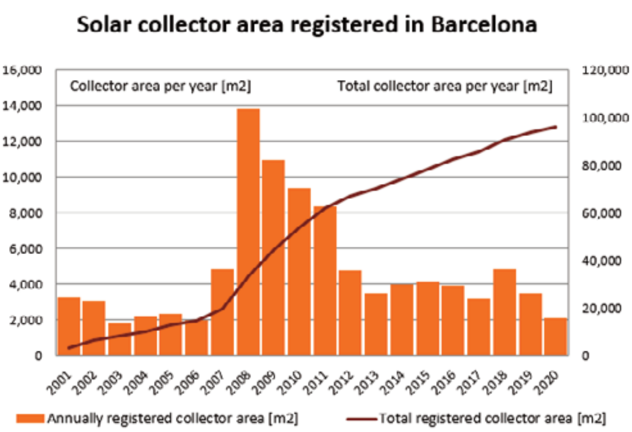
ged to do so twice in 2006 and 2011. The main changes in 2006 consisted of expanding solar requirements to more buildings and increasing the solar fraction. In 2011, we introduced mandatory PV installation for all buildings, except residential.

What exactly did you change in 2006?

Jiménez: Since 2006, solar water heaters have been mandatory for not only residential buildings but also public swimming pools (30 % share) and industrial process heat installations (20 %). We changed other requirements too, setting rules on how to transfer solar systems to end users. Since then, it has been necessary to perform an audit after commissioning a solar system and to create end-of-work documentation. Another stipulation introduced in 2006 was a 60 % share of solar heated water at a reference temperature of 60 °C. The share increases to 65 % if demand for hot water exceeds 10,000 litres a day, and to 70 % if consumption is more than 12,500 litres of warm water per building.

"50 towns and cities in Spain followed Barcelona's example"

In addition, if an investor wants to use an electric boiler as a backup system, the solar share increases to 70 % to make this a less appealing option, in line with Catalonian regulation Decret d'Ecoeficiència, which entered into force in January 2007.



Evolution of the solar thermal collector area in Barcelona registered in building permits thanks to the solar mandate
Source: Barcelona Energy Agency

In which year did heat pumps become eligible for the solar mandate in Barcelona?

Jiménez: After the EU Renewable Directive classified heat pumps as a renewable heat technology in 2009, the CTE followed suit in 2013. In Barcelona, we had a hard time incorporating heat pumps into the mandate. We had to develop a transparent and comprehensive procedure at the municipal level to compare the amount of renewable energy produced by heat pumps with that generated by solar thermal in order to accept it as a feasible alternative according to our municipal regulations. This was especially difficult because the information that heat pump manufactures supplied to planners did not match and was not always in line with ecolabelling directive 2020/30/EU. Even today, not every manufacturer can easily produce the required certification. Therefore, a regulatory process is needed to make sure heat pumps installed in Spain fulfil EU requirements.

Photo: basiczto - stock.adobe.com

A revised version of Spain's national building regulations CTE took effect in September 2020. What impact will they have on Barcelona and beyond?

Jiménez: The objective of the new CTE is to progress further toward net zero energy buildings. In the CTE's chapter on hot water production, the term "solar contribution" was replaced with "renewable contribution". This shows that legislators aim to let all eligible renewable technologies compete for a more restrictive renewable share, increased from an earlier minimum of 30 % to a minimum of 60 % in the new regulations.

In Barcelona, nothing much will change in terms of hot water production, as the planners here had to already apply the strictest of all mandates, which used to be that for Barcelona or Catalonia. The new CTE may now be stricter on consumers that exceed 5,000 litres of hot water demand per day.

But outside Barcelona, the local regulators' attitudes will probably not change either, as heat pumps are the most often used alternative to solar and have already been eligible since 2013. In Barcelona's case, more than 60 % of new hot water systems are solar water heaters, while around 40 % use other renewable options to fulfil the mandate, with heat pumps being at the top of that list, followed by district heating and cooling networks.

How can you prevent a situation where market players refuse to comply with a solar mandate as soon as this comes into force?

"You can avoid negative responses if you have a good public consultation process in place"

Jiménez: In our experience, you can avoid negative responses if you have a good public consultation process in place. The regulations' economic impact on building developers, the know-how needed by planners as well as installers, and fulfilment criteria are all topics that should be properly discussed during the drafting process. Regarding fulfilment criteria, a key objective is to set realistic goals for the solar or renewable share and stipulate exceptions, such as for shading and other external factors that prevent the achievement of the minimum

What other lessons learned do you believe could help municipal administrators across Europe in implementing solar building regulations?

Jiménez: Regarding a mandate, you have to find a middle ground between what the market is ready for and what you want to achieve. In Barcelona, the first thing we had to cope with when we tried to bring solar energy to each building is that the supply chain was not prepared for it. Too few installers had enough expertise to help fulfil the mandate.

Another critical point is system maintenance during the systems lifetime. The 2006 changes to the mandate brought with them a requirement for an external audit when commissioning solar thermal systems. But some failures that we observed during later audits were not foreseeable when the systems were put into operation. What we need is proper quality assurance during execution, something that is not always done by the building developer.

Interview conducted by Bärbel Epp. It was published first on www.solarthermalworld.org

Solar thermal energy for the world's tallest building

SOLE Managing Director Vangelis Lamaris on the collector field of the Hamdan Sports Center, which can be seen in the background.
PHOTOS (2): SOLE

This solar plant was installed right next to the Burj Khalifa.

The Greek manufacturer of thermal collectors SOLE has been installing solar thermal systems since 1974. The reference list is accordingly long. It started with hot water supply for hotels in Greece, extending this business model to North Africa and the Arab region over the years.

"We produce high-quality solar collectors with top performance in all regions," explains Managing Director Vangelis Lamaris. The absorbers have an Alanod coating, and as Vangelis explains "we prefer the coating of the world market leader, which has proven itself as a reliable supplier of high quality absorbers."

After having installed many large systems in Greece during 70's, 80's & 90's, the company first installed a large plant in Tunisia in 1999, followed by a smaller plant in Morocco a year later (see table). Soon after, the oil-rich countries in the Persian Gulf also turned to solar energy. This is because it is a resource that is just as abundant as black gold, but unlike oil and natural gas sources, it is inexhaustible.

By the end of the 20th century, solar energy did not play a special role in the Arab region. Due to the fact that oil could be obtained extremely cheap, it was exploited in enormous quantities to meet the growing demand for energy. For many years, crude oil and natural gas could be sold abroad with a high economic profit. The fluctuating world market price caused a change of mindset. When the oil price reached a low point in 1999, it was important to export as much as possible in order to secure the increased standard of living.

When the price per barrel rose again, the effect was the same. As much as possible was exported in order to use the profit for local investments that would secure the standard of living. The best-known example is the building boom in Dubai, which transformed the capital of the United Arab Emirates (UAE) into a global trading centre with a huge container port and the third largest airport in the world.

Nowadays, not only the UAE, but actually all oil-exporting countries are predominantly striving, being only partially successful, to curb the waste of resources locally and to increase the use of solar energy.

Climate protection also plays an important role. Since the climate protection agreement in Paris in 2015, reducing the exorbitant carbon dioxide emissions has been an important goal of the government. With aproximately 22 tonnes per inhabitant, the UAE is one of the biggest climate sinners. Only recently, the government reaffirmed its intention to reduce emissions by 25 percent until 2030.

Conservation of resources and protection of the climate are the two main arguments in favour of solar energy in this region. The SOLE company could benefit from this from the very first stage. In 2002, the US Embassy in Abu Dhabi was the first building in the UAE which was equipped with SOLE collectors. A few years later, SOLE succeeded in realising a prestigious project in Dubai. The Burj Khalifa, the tallest building in the world, has been covering part of its heating needs with solar energy. The system with 714 kilowatts of power (1,020 square metres of surface area, see photo) is connected to an 80 cubic metre storage tank.

A year later, a plant of about the same size followed including 16 cubic metres of storage volume. It supplies heat to the huge Hamdan Sports Centre, which was built for the 2010 World Swimming Championships. The solar system not only heats the water in the two swimming pools and the showers, but also the floor is heated.

Relatively large storage tanks are typical for the solar thermal systems of the Greek manufacturer.

With 60 to 70 litres of storage volume per kilowatt of collector output, not only the Burj Khalifa but also residential buildings are supplied, for example the Al Zahia Residential in Sharjah and the Danat Al Baraka in Jannusan.

These storage volumes, which are about twice as large as those of European residential buildings, for example in Germany, correspond with the solar radiation, which is about twice as large. Not only because of the optimal weather conditions, the Arab region is increasingly becoming one of the most important emerging markets for solar thermal systems.

Detlef Koenemann

Year	Project	Location	Country	Area m²	Capacity kW	Storage Liter
1975	Calypso Bungalows Hotel	Arkitsa	Greece	100	70	5000
1976	Skiathos Palace Hotel	Skiathos	Greece	250	175	12500
1979	NSCR Demokritos	Athen	Greece	800	560	40000
1989	Daidalos Hotel	Kos	Greece	400	280	20000
1999	Sarantis Air Conditioning	Oinofita	Greece	2664	1865	9000
1999	Mediteranee Hotel	Hammamet	Tunesia	626	438	31300
2000	Le Berbere Palace	Ouarzazate	Morocco	550	385	27500
2001	Club Med Hotel	Midoun	Tunesia	1000	700	55000
2002	American Ambassy	Abu Dhabi	VAR	320	224	16000
2004	Public Baths	Gonabad	Iran	150	105	12000
2005	Simien Park Lodges Hotel	Debark	Ethiopia	43	30	3200
2007	European Business Center	Dubai	VAR	216	151	16200
2007	Hydramis Palace Hotel	Kreta	Greece	1215	851	70000
2009	Burj Khalifa Tower	Dubai	VAR	1020	714	80000
2010	Hamdan Sports Complex	Dubai	VAR	1026	718	16000
2012	Al Raha Gardens Villas	Abu Dhabi	VAR	730	511	54400
2014	Sultan Gardens Resort	Sharm El Sheikh	Egypt	104	73	15600
2017	Salam Crown Plaza Hotel	Jeddah	Saudi-Arabia	208	146	16000
2019	Kiriri Garden Hotel	Bujumbura	Burundi	84	59	6000
2019	Al Zahia Residential	Sharjah	VAR	1296	907	100800
2020	Danat Al Baraka Development	Jannusan	Bahrain	492	344	42500
2020	Ngong Road Apartments	Nairobi	Kenya	468	328	15000

SOLE solar projects (in selection): The solar company SOLE installed numerous large-scale solar thermal plants, first in Greece, among others for the Solar Energy Laboratory of the National Centre of Scientific Research (NCSR Demokritos), and later in Africa as well as in the Arab region. The catchment area extends as far as Iran.

Mountain air in the solar collector

Mountain air does good. Solar air collectors can use it to keep mountain huts dry. This also works on Austria's highest alpine emergency shelter, the Glockner bivouac.

Helicopters flew all the prefabricated hut components to the construction site - including the module with the integrated solar air collector, which can be seen at the front in the picture above.

Exposed, thin air and little space to work: At over 3,000 meters, the assembly of the new Glockner bivouac proved challenging in many ways.
PHOTOS (2): FABIO KECK

As Austria's highest mountain, the Grossglockner attracts hundreds of thousands of tourists to the Hohe Tauern mountains in Carinthia. Most admire its distinctive peak along the High Alpine Road with its 36 hairpin bends and from the Kaiser-Franz-Josefs-Höhe. Ambitious mountaineers can choose from routes of varying difficulty to climb to the summit cross. The route from the north side is considered particularly strenuous. It is steep and long. For emergencies, a bivouac box was therefore built 600 meters below the mountain peak more than six decades ago.

But the old shelter was getting on in years. Problems were caused mainly by damage caused by moisture. "In addition, the beds were infested with mold," says Peter Kapelari of the Austrian Alpine Association, explaining why the mountain association built a new emergency shelter last year and equipped it with a 1.5-square-meter solar air collector. With a thermal output of 900 watts, it generates pleasantly warm and dry indoor air even from the coldest high-altitude air. "The comfort for alpinists is now significantly higher and mold growth is a thing of the past," explains Kapelari.

Solar air collectors keep mountain huts dry

The airy sun catcher was supplied by the Bavarian manufacturer Grammer Solar. A fan lets filtered outside air flow through the insulated aluminum collector - up to 90 cubic meters per hour. In the process, the air heats up. Inside the bivouac box, the solar air warms the interior and absorbs moisture before returning to the outside. Because integrated solar cells generate the electricity for the fan, the system operates independently.

What ventilates well at an altitude of 3,205 meters also works at lower mountain elevations. At the Klostertal Environmental Hut, for example, it has for over 20 years. The self-catering cottage of the German Alpine Association (DAV) is located an hour's walk above the Silvretta reservoir in Vorarlberg at 2,362 meters. Since 1999, a ten-square-meter air collector, also from Grammer Solar, has been mounted on the south façade. "Since then, there have been virtually no moisture problems in the premises," says Ernst Pfeifer, who is responsible for the hut. Previously, things were different, with the result that moisture had damaged the interior furnishings.

For DAV resort manager Robert Kolbitsch, solar air technology has proven to be a simple and practical means of ventilating mountain huts in winter, when they are sometimes empty for long periods, and thus preventing mold from forming. And it can be done without much effort. There are hardly any maintenance and operating costs. "In the 20 years, it was necessary to change the fan once, and with the clean mountain air, it was sufficient to change the filter every six to eight years," Pfeifer reports.

Grammer Solar has now equipped more than 60 Alpine Club huts in Germany, Austria and Switzerland with its air collectors. Also the Zwinglipasshütte, located at 1,999 meters near the pass of the same name at the foot of the Altmann south face in eastern Switzerland. Since 2017, a 4.5-square-meter solar air system has ventilated and tempered its guest room as well as the winter room. "The air collectors keep the hut at a pleasant temperature even on sunny winter days," explains Peter Büchel. Even at minus 5 degrees Celsius outside, the winter room can be warmed to a cozy 20 degrees Celsius. Büchel was involved in the hut construction committee of the Swiss Alpine Club SAC for twelve years. The architect was convinced by the air collectors. In recent years, he has planned and implemented numerous air collector systems on huts in the Swiss Alps.

Air collectors adapted to bivouac element

Back to altitude at 3,205 meters. Below Austria's highest mountain, a twelve-man volunteer team of alpinists, mountain guides and technicians built the new Glockner bivouac in two and a half days last October, although rain and snow made construction work difficult. But the team made it. The new bivouac hut has been erected. Its thermal-bridge-free wall structure consists of aluminum cladding, sheep's wool insulation, a vapor barrier and birch plywood interior cladding. Their octagonal shape is designed so that the wind always blows them free of ice and snow.

The solar air system is integrated into one wall element. Grammer Solar developed the special solution together with the company Polybiwak. The aim of the development is to equip future bivouac projects with the adapted air collector technology. In the new bivouac box below the Großglockner, 15 mountaineers can find a place to sleep in an emergency. Thanks to the integrated air collector, it not only provides an important shelter, but also a dry one all year round.

Joachim Berner

Germany's biggest solar-heated house nears completion

his summer, the first families will be able to move into Solardomizil III, Germany's soon-to-be-largest showcase of residential solar thermal design. The multi-family property is being put up by FASA, a solar thermal-only construction firm founded in 1990 after the fall of the Berlin Wall.

Garden view of solar domicile III (top): 340 square meters of solar collectors installed in February 2021 (bottom) generate heat for 24 condominiums.
PHOTO: FASA AG, ILLUSTRATION: HIRSACK & CO.

Our main focus over the past 20 years has been solar architecture and solar thermal," said FASA Chief Executive Ullrich Hintzen. His overarching aim is to use as much solar thermal energy in the construction sector as economically feasible.

What this could look like in practice can be seen on the premises of Chemnitz's former castle brewery, where FASA is building Germany's probably unique solar thermal settlement. Since it acquired the land in 2005, the company has put up 14 single-family homes, each equipped with solar collectors to meet at least half, if not all, of residents' heat demand. Once the homes were completed, FASA started working on Solardomizil, a group of three primarily solar-heated multi-family buildings with 53 flats to own. From the outset, FASA made clear that it would deploy solar thermal collectors and a big storage tank, not a PV-heat pump combination, to heat the buildings.

"Solar thermal can generate up to three times as much energy as a PV system, so there was little doubt about what technology would go on the roof and facade," said Hintzen. And, he said, the solar thermal storage units that you can buy on the market today are cheap and easy to install and will only receive more improvements over time.

100 EUR/m² for solar heating

During the first two phases of construction in 2017 and 2019, FASA completed 29 Solardomizil flats with about 3,000 m2 of floor area. Half their heat demand is met by a 317 m2 solar thermal system, equipped with 200 m3 of long-term storage made by Swiss-based Jenni Energietechnik. The use of solar heat increased construction costs by round about 100 EUR/m2 of floor area compared to the installation of conventional heating. But the solar system will also provide low, stable energy prices for a long time to come.

In November 2019, FASA then started construction on Solardomizil III, a multi-family building with 24 flats to own. On average, 50 % of its heating needs are to be met by solar energy. The 340 m^2 of solar collector system covering the south-facing facade and part of the balconies was delivered by FASA partner Retec Solar. The energy it collects is transferred to a 72 m^3 tank – another Jenni Energietechnik product but smaller than the one used in first two phases, as Solardomizil III's south-facing collectors harvest more energy throughout the day.

The solar heat will later be distributed evenly throughout the house, to both the floor heating system and the fresh water tank. On winter days with less sunshine, an 80-kilowatt condensing boiler will serve as the backup system.

FASA puts the building's annual heat demand at 109,000 kWh. A 50 % solar contribution would therefore reduce carbon emissions by about 13 tonnes a year.

Like last time, the company will shoulder the additional financial burden brought on by its flagship project. FASA spent an additional EUR 300,000 on the house compared to a conventional multi-family building, which makes it 10 % more expensive than the average gas-fired newbuild. "We did not pass these costs along to customers," said Hintzen. To him, the entire area including Solardomizil III, is a reference that the company can put on its website, in the hopes that the showcases will lead to some intriguing projects down the road.

Flats sell like hot cakes

Each of the 24 Solardomizil III flats were sold even before the building shell was finished. At 2,700 to 3,100 EUR/m2, the soon-to-be residents paid no more than the average price for a flat in Chemnitz. Each flat, from the 80 m2 to the 120 m^2 one, went that quickly, Hintzen said, because of the building's location near the centre of Chemnitz and because of its eco-friendly solar thermal system, which provides stable, low-cost heat long term. Flats selling like hot cakes, he added, is not something you see happening very often in Chemnitz.

Thanks to an increase in the demand for solar-heated multi-family property, Hintzen and his team have already begun working on other large solar thermal projects. "We are currently designing a solar-heated house with a floor area of 2,000 m^2, to fill in the gap between two existing buildings in a late-19th-century neighbourhood." That house will then be called Solardomizil IV. "And we have investors who would like us to replicate our biggest project to date in other locations around the world."

Ina Röpcke

The core component of the building's heating system is a 72 m^3 steel tank, incorporated into the base build in October 2020. With a diameter of 2.3 m and a height of 17.8 m, it extends to all floors of the house. Photo: Volkmer Zichner

Solar settlements bring about the heat turnaround faster

The installation of central solar heat supply systems can achieve the heat turnaround more quickly than installations on each individual house. For this reason, the Ritter company began planning and installing solar systems for district heating networks at an early stage.

The community of Büsingen am Hochrhein is considered Germany's first solar village. The heating center building is also equipped with evacuated tube collectors. FOTOS (3): RITTER XL SOLAR

Up to now, solar thermal energy has mainly been used on a decentralized basis. That is, solar systems were installed on stand-alone buildings. For the climate, however, centralized heat supply is just as important as decentralized supply. For only if as many settlements as possible are supplied centrally with solar district heating in the future will solar thermal energy exploit its enormous potential. Only then can it make an appropriate contribution to climate protection.

The importance of large-scale solar thermal systems has grown steadily in recent years, and it will continue to grow. About ten years ago, the Ritter company with its Ritter XL Solar brand therefore set itself the ambitious goal of making a significant contribution to the heat transition with large-scale solar thermal district heating systems.

Great potential can be tapped

There are around 8,800 communities in Germany with a population of between 200 and 10,000. If just a quarter of these communities were to cover around 20 percent of their annual heating requirements with solar heating networks, several million square meters of collector area could be created to reliably supply sustainable heat.

The solar thermal potential of the energy transition is being scientifi-

	Village district heating								Urban district heating			
	Büsingen	Neuer-kirch-Külz	Hallern-dorf	Breklum	Randegg	Ellern	Gimb-weiler	Bergheim	Hamburg	Senften-berg	Potsdam	
Installation area	2500	3700	3000	1500	5700	3000	2850	3300	3250	20000	10000	m^2
Collektor area	1090	1422	1304	652	2400	1245	1186	1334	1350	8300	5157	m^2
Collektor output	763	995	913	456	1680	872	830	934	945	5810	3610	kW
max. continuos output	650	853	783	391	1440	747	693	795	810	5000	3100	kW
Storage volume	100	120	85	88	300	105	100	88	2000	0	0	m^3
Solar yield per year	565	626	600	290	1067	575	535	600	590	4000	2300	MWh
Solar yield per m^2	518	440	460	445	444	462	451	450	437	482	446	kWh/m^2
Solar Coverage Ratio	14%	20%	22%	8%	19%	16%	29%	17%	5%	4%	< 5%	
Start-up	2013	2016	2017	2018	2018	2018	2019	2020	2013	2016	2019	

Technical data of the large-scale solar thermal systems installed by Ritter. All systems were equipped with vacuum tube collectors of the type Ritter XL Solar 19/49 or 19/49 P.

cally determined with increasing accuracy. A year ago, the solar research institute Fraunhofer ISE published a study entitled "Paths to a Climate-Neutral Energy System", which outlines the energy system of the year 2050. In it, four different scenarios are distinguished. In each of these, the individual energy technologies are used in different proportions. In the scenario with the largest possible share of solar thermal energy, heat generation from solar energy reaches almost 80 terawatt hours in 2050. If two-thirds of this is accounted for by systems on buildings and one-third by large-scale systems feeding into heating networks, these would supply around 25 terawatt hours. If we calculate with 500 kilowatt hours per square meter of collector area, we arrive at an area of 50 square kilometers to cover this demand. Last year, about one-eighth of this was installed in Germany. The potential that can still be tapped by solar thermal systems is therefore enormous.

Bioenergy and solar thermal energy complement each other

Before there were the first large-scale solar thermal plants that fed into local heating networks, there were bioenergy villages. The starting point was the realization that a village that builds its own heating network can manage the heat transition in one fell swoop. If the heating network is supplied with renewable fuels from the village's own region, this also benefits regional value creation.

In Germany, there are already around 200 villages that cover their heating requirements primarily by using renewable fuels. The central component of the heat supply is always a heating network to which as many buildings as possible are connected and which in this way replaces the old individual heating systems in which fuel oil is usually burned.

Initially, biogas cogeneration plants were mostly used. However, biogas production is relatively costly and prone to failure. For this reason, wood boilers fired with wood chips or pellets from the region are increasingly bearing the brunt of heat generation during the heating season. Large solar thermal systems take over this task in the summer months, so that the uneconomical partial load operation of the wood-fired boiler is largely eliminated.

This combination makes sense because modern high-performance collectors supply the heat very cheaply. If a full cost calculation is carried out, the price of solar thermal heat is usually not higher than the price of heat generation from wood chips, but lower. In addition, wood is actually relatively expensive from an environmental economics perspective. To generate the same amount of heat with a wood boiler as a solar thermal system requires about 60 times the land area. If you grow corn to produce biogas for a biogas CHP, the required area is even larger.

It all began with Büsingen

The community of Büsingen am Hochrhein is considered Germany's first solar village. The district heating network, which went into operation in 2013, is not only heated by wood chips from the region, but also by a large solar system installed by Ritter XL Solar, which covers 14 percent of the annual heat demand. Biomass and solar thermal together supply not only the majority of residential buildings in the village, but also commercial properties and nearly all public buildings. The wood boilers remain out of service for several weeks in the summer. The maintenance costs of the boilers saved by the solar system outweigh the operating costs of the solar thermal system several times over.

The example set a precedent. From 2016 to 2020, Ritter installed large-scale solar thermal systems in Neuerkirch-Külz, Hallerndorf, Breklum, Randegg, Ellern and other locations (see table).

A milestone for the Ritter company was the construction of what was then Germany's largest solar thermal plant for the district heating network of the Senftenberg municipal utility in 2016. Ritter XL Solar contributed the solar plant design, collector array and control technology to this project.

It is the first system of this size in Germany to feed into a municipal district heating network. In 2018, a particularly sunny year, the Senftenberg solar plant supplied a quarter more district heating than was expected on average, and a third more than was guaranteed to the utility by the builders. Relative to solar irradiation, the yield grew disproportionately.

The two buffer storage tanks in Breklum have a volume of 44 cubic meters each.

An interesting project has also been realized in Hamburg. The former air-raid shelter and flak bunker in the Wilhelmsburg district was converted into an "energy bunker" whose south facade is covered by a photovoltaic system. A solar thermal system from Ritter XL Solar, consisting of 315 vacuum tube collectors, extends over the entire roof. The rows of collectors are inclined at only 15° in order to gain as much heat as possible throughout the year with little shading and to keep the wind load as low as possible at a height of 50 meters. In this exposed location, only collectors that generate heat for 20 years with virtually no maintenance are considered because they are difficult to access after construction is complete.

The part of the solar heat that cannot be used directly is stored in a very large tank inside the bunker. The other heat generators, a biogas cogeneration plant and a natural gas peaking boiler, are also located there. The storage tank also takes in industrial waste heat from nearby businesses. Therefore, the storage is much larger than would be necessary to store the solar heat. The examples of Senftenberg and Hamburg-Wilhelmsburg show that not only rural but also urban settlements can be effectively supplied with solar district heating.

Detlef Koenemann

The collector field in Randegg occupies an installation area of 5,700 square meters.

A dual benefit that experts and the public still know little about: PVT collectors generate electricity and heat.
PHOTOS (2): FRAUNHOFER ISE

Hermaphrodite in the solar world

Neither solar thermal nor photovoltaic, PVT is difficult to categorize. In the meantime, the IEA SHC Task 60 has drafted a system, created performance indicators, and developed design guidelines. The most difficult task still lies ahead of it: getting hybrid technology into the standards and funding programs.

The idea is simple: combine photovoltaics and solar thermal and generate electricity and heat simultaneously with one solar module. This provides a double benefit and saves space on the roof. But it is not that simple. Which key performance indicators can be used to adequately assess PVT systems? How should they be designed? And which standards apply at all? In recent years, it has become apparent that the photovoltaic and solar thermal worlds are quite far apart when it comes to such questions.

This can be seen from the fact that most of the activities regarding technological classification and public information comes from the solar thermal world. For example, the IEA SHC Task 60 is the main working group on PVT technology within the International Energy Agency's solar thermal program. And while the international collector standard includes hybrid technology, as does the Solar Keymark certification program, there are no projects addressing it in the PV standards work. If PVT has not even fully arrived in the professional community, one should not be surprised that it is largely disregarded by European funding agencies.

Complex subsidy situation hinders PVT market

Germany does subsidize the thermal component of a PVT system if it is used as the heat source of a subsidized heat pump. However, full subsidies are only available if operators use the solar power generated by their system primarily for their own supply and do not claim compensation under the Renewable Energy

Sources Act. However, this only applies to systems with covered hybrid collectors. The federal government does not consider non-covered PVT to be eligible for subsidies.

The situation is no better in neighboring European countries. Austria only provides funding in the context of innovative projects. France suspended its special innovation program last year. In Switzerland, some cantons subsidize, but the subsidies are generally low because they depend on the thermal output calculated for traditional hot water systems. They require high temperatures, but PVT collectors cannot produce them efficiently. Such guidelines put hybrid technology at a disadvantage.

In an overview, SHC Task 60 has compiled the subsidy situation for individual European countries and listed further problems. According to this, it is not clear from many subsidy guidelines whether PVT systems are eligible for subsidies at all. In some cases, the different collectors – covered, non-covered, air-driven, water-driven – are considered differently, which makes it quite difficult to find out whether they can receive funding. Separate funding for the thermal and electrical portions does not make the request any easier. Conclusion of the working group: "A simplification of the PVT funding situation is necessary!"

Lack of standards, lack of trust

PVT is a relatively new technology. Investors need to have confidence that the products will function and meet certain quality standards. Test procedures do exist for photovoltaic modules and solar thermal collectors, which can be used to measure the electrical and thermal performance of PVT elements. However, there is no specific PVT standard.

The SHC Task 60 considers it necessary "to reduce the cost of a test and to tackle risks generated by combining the two technologies," as it writes in a position paper. The idea, it says, is to have integrated standards that combine the phthotovoltaic and solar thermal portions in a single test cycle at a reasonable cost to the manufacturer and with minor design changes.

Andreas Bohren, head of the testing laboratory at the Swiss Institute for Solar Technology SPF, explained the current situation regarding certification at his institute's virtual symposium Solar Energy and Heat Pumps on October 28, 2020. He distinguished four cases:

Case 1: A manufacturer changes a certified photovoltaic module to a PVT element by attaching a heat exchanger to its back. Guidelines for retesting exist. The testing laboratory must decide what retesting is required. According to Bohren, the testing costs range between 9,000 and 18,000 euros, and between 27,000 and 37,000 euros for photovoltaic modules that are not already certified. Such products can be found on the market and are certified, according to Bohren.

Case 2: A manufacturer replaces the solar thermal absorber with a photovoltaic module or packs the solar cells under a glass cover in an insulated collector box. In such designs, there is a risk that high stagnation temperatures will damage the EVA film of the photovoltaic module. Since no existing PV standard can be ap-

PVT: State of the art

According to IEA SHC Task 60, most commercial PVT solutions have proven their viability. PVT collectors with concentration factors of two to five have been developed, but sufficient field experience is still lacking. Solutions for solar cooling applications have not yet been developed.

The working group believes that a reduction in costs by a factor of 1.5 to two is necessary, either by increasing production volumes or by improvements in technology or a mix of both.


Freiburg City Hall in Stühlinger: Europe's largest net-zero energy public building is supplied, among other things, by PVT collectors (left on the roof).

Country	Water collectors		Air collectors	Concentration systems	Total
		m²	m²	m²	m²
	not covered	covered			
France	12,619	68	471,900	0	484,587
South Korea	280,814	0	0	0	280,814
China	133,721	50	0	171	133,942
Germany	110,622	1,452	87	165	112,326
Israel	57,488	0	0	0	57,488
Netherlands	30,353	0	0	1,773	32,126
Italy	13,331	2,170	0	0	15,501
Spain	1,552	11,350	0	0	12,902
Schwitzerland	7,720	36	3,530	0	11,286
Ghana	8,000	0	0	0	8,000

The top ten international PVT markets

Quelle: Solar Heat Worldwide 2020, IEA Solar Heating & Cooling Programme

Application	collector area m²
air	485,510
not classified	360,877
hot water	133,831
hot water (single family houses)	60,588
hot water and heating	57,024
hot water and heating (single family houses)	26,903
solar process heat	21,624
solar district heating	11,082
pool heating	9,449
Total	**1,166,888**

Worldwide installed PVT by application

Quelle: Solar Heat Worldwide 2020, IEA Solar Heating & Cooling Programme

plied for temperatures above 100 degrees Celsius, customized tests would first have to be developed for certification. Bohren therefore estimates testing costs of up to 90,000 euros. Such covered PVT elements are also already offered, but to his knowledge they are not certified.

Case 3: A manufacturer equips his covered PVT module from case 2 with stagnation protection. He can then have it certified as in case 1, but also at quite high testing costs. Such offered products are not certified as far as known.

Case 4: An existing photovoltaic system is equipped with heat exchangers. According to Bohren, there is no certification solution and no subsidy for this yet.

Making PVT known

Nevertheless, the PVT market is growing. In Germany, the first prominent examples can be found. For example, 43 square meters of covered PVT collectors on Freiburg's town hall in Stühlinger provide hot water for showers and the canteen. In the Durlach district of Karlsruhe, the municipal real estate company Volkswohnung and the municipal utility replaced the old heat supply in five apartment buildings built in the 1960s. In two buildings, PVT collectors supply a heat pump system with their energy. The University of Freiburg has set up a monitoring system and will evaluate the collected measurement data over the next three years. The project in Durlach could help PVT technology gain more attention because of its scale and the players involved.

The Integrate joint project has been working on further dissemination of the technology since December 2019. The Fraunhofer Institute for Solar Energy Systems ISE, the Institute for Building Energetics, Thermotechnology and Energy Storage at the University of Stuttgart and the Institute for Solar Energy Research in Hamelin have joined forces in this project. Together, they want to advance the use of PVT collectors in combination with heat pumps. "Up to now, either geothermal energy or outdoor air has almost exclusively been the chosen heat source for heat pumps in the building sector," the partners write in a project information. Especially for energy retrofits in existing buildings, these two conventional heat sources often could not be utilized. The use of PVT collectors would offer the chance to equip buildings with a heat pump heating system.

In a first step, the Integrate participants want to define the essential characteristics in order to be able to describe and evaluate the technology. As a basis for this, they will classify the concepts available on the market and measure selected systems for two years. By the end of 2022, they want to present practical design and planning tools as well as a comprehensive collection of information materials. Brochures, websites, social media campaigns and videos will be used to educate construction companies, planning offices and industry as well as consumers. They also plan to write an entry in Wikipedia about PVT building energy supply systems.

Integrate is addressing the problems that SHC Task 60 also identified as barriers. For example, modeling the systems and predicting yields is more complicated than for electricity generation alone. General awareness of PVT is still very limited among all stakeholders. In addition, selling a complete system requires a lot of effort and knowledge. Last but not least, industry and sales would have to be prepared to be compared with photovoltaics again and again. Well equipped with arguments and facts, they should be able to help a simple idea become a success.

Joachim Berner

Further Information

IEA SHC Task 60 Application of PVT Collectors: https://task60.iea-shc.org/