SOLARUPDATE

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Newsletter of the International Energy Agency Solar Heating and Cooling Programme

#SolarHeat
#SolarThermal
#SolarProcessHeat
#SolarCooling
#SolarDistrictHeating

In This Issue

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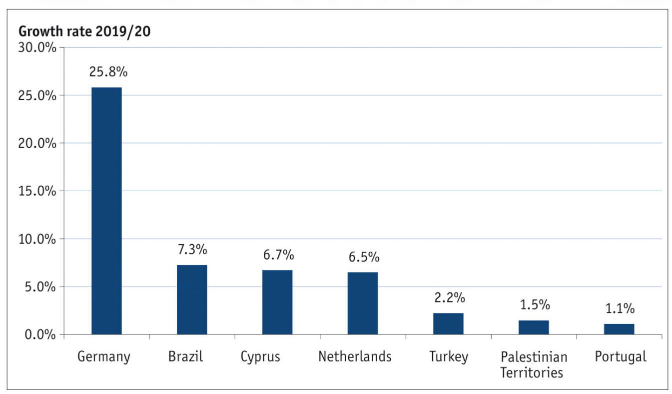
Solar Heat Worldwide 2021

Solar Heat Worldwide 2021 is the most comprehensive evaluation of solar heating and cooling markets, with data from 68 countries representing 95% of the global market. The 2021 edition is available for free on the IEA SHC website. Highlighted below are just a few of the findings from this year's report.

Growth Despite COVID-19

Despite the pandemic taking a heavy toll on most national economies in 2020, some of the larger solar thermal markets grew due to increased policy support, like in Germany and the Netherlands. And in Turkey and Brazil, demand for solar water heaters increased as homeowners spent more time at home and made improvements around the house.



Number of Large-Scale Solar Heating Systems Keeps Growing

Large-scale solar thermal plants connected to a local or district heating grid or installed on a large residential, commercial or public building have been in use since the early 1980s. And until 2016, the market was almost exclusively in Europe and dominated by Denmark. In 2020 though, there was a shift, and China led the field with 48% of the newly installed collector area with a large portion built for residential, commercial, and public buildings, followed by Germany accounting for 23%, and Denmark for 11%.

Solar district heating systems

The market for solar district heating, the largest subsector of large solar systems, has been dominated for more than a decade by Denmark due to favorable energy policy conditions and a market-dominating company. However, this changed in 2020 when energy policy conditions for solar thermal expired and favorable policy conditions for

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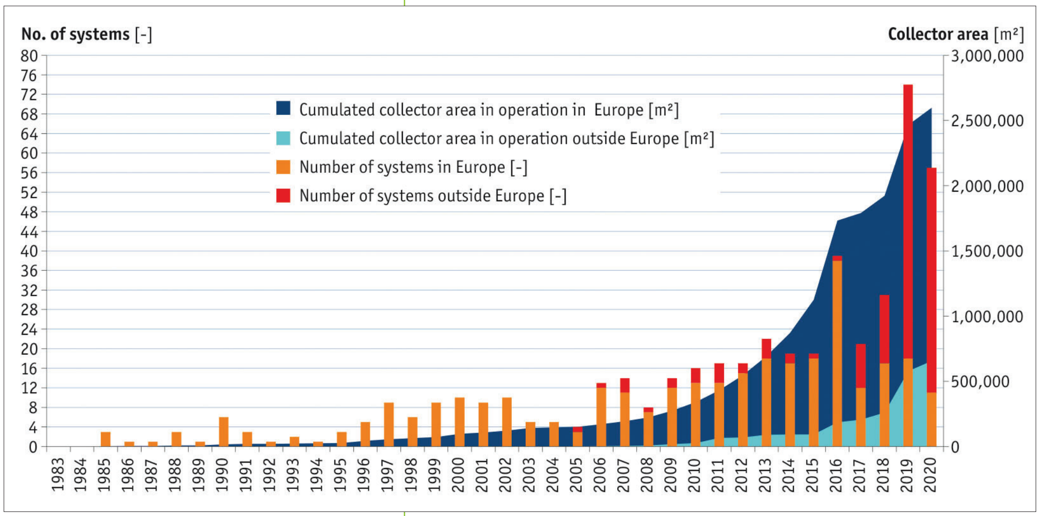
▶ **Large-scale systems worldwide – annual achievements and cumulated collector area in operation.** (Data Source: Daniel Trier (PlanEnergi, Denmark), Jan-Olof Dalenbäck (Chalmers University of Technology, Sweden), Sabine Putz (SHC Task 55, Austria), Bärbel Epp (solarthermalworld.org, Germany), AEE INTEC)



large heat pumps began. So, for the first time, Germany took over as leader. Of the 11 large-scale solar district heating systems added in Europe in 2020, 7 were in Germany (31,200 m²), 4 in Denmark (14,600 m²), 2 in Austria (6,571 m²), and 1 in Switzerland (784 m²). And, Germany installed the largest European system in the city of Ludwigsburg (14,800 m²).

Outside of Europe, two solar district heating systems were installed in China (13,000 m²) in 2020, with the largest system (11,250 m²) in the Tibetan city of Lasha.

This cost-effective way of greening the heat supply of neighborhoods, towns, and even cities is sparking new interest in markets like France, Switzerland, Russia, and South Africa.

▲ **Lasha solar district heating system in Tibet, China, with 11,250 m² collector area (9.1 MWth).** (Photo: Solareast Holding Company Ltd.)

"Solar heating and cooling systems with 501 GWth were in operation at the end of 2020 and saved 43.8 million tons of oil and 141.3 million tons of CO_2. The standout application is once again solar district heating plants and their important contribution in decarbonizing the heating sector. With Germany, Denmark, and China leading the way and generating interest in other parts of the world,"

TOMAS OLEJNICZAK

Chair of the IEA SHC Programme

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Large solar thermal systems for residential, public, and commercial buildings

In the second-largest subsector, China is the market leader with 76 systems and a capacity of 216 MWth, followed by Turkey with 11 systems and 11 MWth, and France with 14 systems and around 10 MWth.

In addition to the European countries of Austria, Greece, Spain, and Switzerland, more and more large-scale systems are being built in Latin America (Brazil and Mexico), the MENA region (Dubai, Jordan, Kuwait, United Arab Emirates), and Asia excluding China (Cambodia, India, Thailand). These systems are often installed on hospitals, hotels, and sports centers.

▲ **Solar water heating systems in combination with heat pumps for apartment buildings in Cape Town, South Africa.**
(Photo: Solarex Energy SA (Pty) Ltd., SOLTRAIN)

Market Trends to Follow

- The combination of solar **Photovoltaic (PV) and Thermal (T)** in one collector, referred to as PVT, is leading the trend towards hybrid solar heat solutions with a steady average growth of 9% from 2018 to 2020 and 8% growth in the dominant European market. France leads this market with a total installed collector area of 500,992 m^2, followed by South Korea (280,814 m^2) and China (141,966 m^2).

▲ **Uncovered PVT collectors reduce the gas consumption for hot water heating by 50% at a hotel in Sao Paulo, Brazil.**
(Photo: www.2Power.de)

- **PV2heat** (using PV to heat water) is a new take on hot water heating emerging in South Africa. These systems consist of PV modules directly connected to an electrical element that heats the water with DC power without the need for inverters. By the end of 2020, there were 11,700 PV2heat systems installed in South Africa.

◄▲ **PV2heat system at the Mariendal Experimental Farm of Stellenbosch University in South Africa consisting of 1.5 kWpeak PV and a 200-liter hot water tank.** (Photo: SOLTRAIN)

- **Solar heat for industrial processes** (SHIP) continues its steady growth, with at least 74 plants added in 2020, primarily in China, Mexico, and Germany. SHIP plants are used for many applications, with the largest at an oil production plant in Oman (300 MWth), followed by a greenhouse application in Australia (36.6 MWth) and copper mine in Chile (27.5 MWth). 2020 closed out with a count of at least 891 SHIP installations supplying 791 MWth of heat to factories worldwide.

  A new sector to keep an eye on is horticulture and solar heated greenhouses for flower and vegetable cultivation. In 2020, four systems larger than 50 m^2 were installed in the Netherlands (15,000 m^2), Ethiopia (4,170 m^2), China (5,000 m^2), and Guatemala (2,175 m^2).

▲ **Large-scale flat plate collectors for an industrial application feed into the district heating network in Vienna, Austria. The 656 m^2 collector area, located on a 70 m high roof of an existing boiler house, produces 780 kWh/m^2 annually.**
(Photo: Greenonetec Solar Industries GmbH)

- **Solar cooling** is trending toward hybrid solutions to improve efficiency and an investment advantage up to 40% to conventional solar cooling systems. As the cooling and refrigeration markets track upwards, particularly in emerging countries, with an estimated 37% share of the world's electricity demand growth in 2050, there is enormous potential for small and large solar cooling

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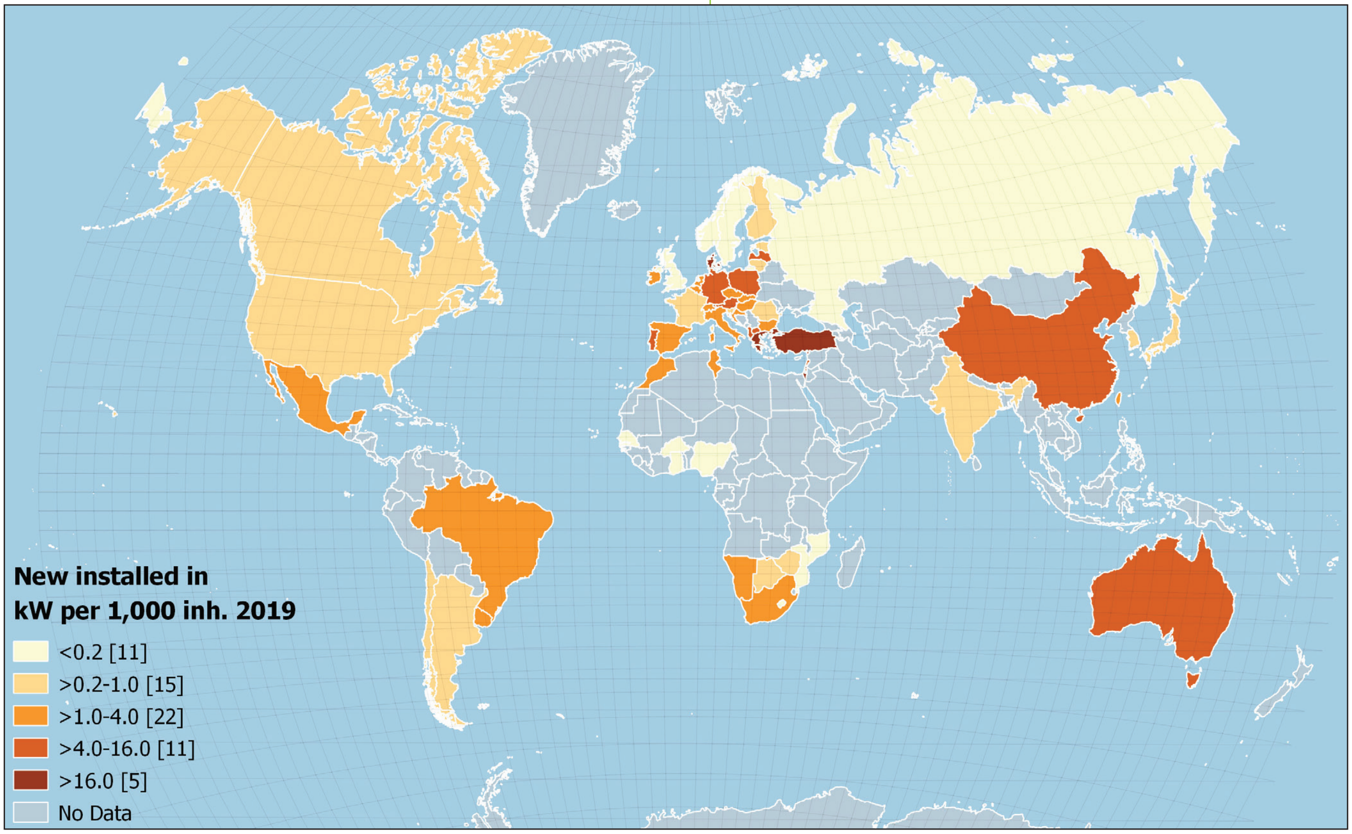
systems that use solar energy, both solar thermal and PV. In 2020, two solar cooling plants were commissioned in Graz, Austria (660 kW cooling capacity) and the UAE.

- **Solar air heating systems'** primary application is heating buildings, including ventilation air, and crop drying. In buildings, solar air heating systems can reduce conventional energy use by 20–30%. By the end of 2019, a total of 1,039 MWth (1,484,274 m²) of glazed and unglazed air collectors were installed worldwide. Canada (476,957 m²), Australia (312,800 m²), Japan (283,161 m²), and the United States (196,103 m²) representing the largest share of installations. In 2019, new installations were in the range of 20 MWth (26,700 m²). They are popular due to their low cost and ease of architectural integration into buildings.

▲ **Concentrating solar collectors supply heat and steam to power absorption chillers for the Härnösand hospital's radiology department in Sweden.** (Photo: Absolicon)

◀ **0.6 MWth façade integrated solar air system at Montana State University in Bozeman, Montana, USA.** (Photo: SolarWall)



Solar Heat Worldwide 2021 *from page 4*

QUICK STATS

Total Capacity

- **501 GWth** (715 million square meters of collectors) = cumulated solar thermal capacity in operation at the end of 2020.
- **407 TWh** = solar thermal heat supplied in 2020.

Market Growth

- Top markets in 2020 = Germany (25.8%), Brazil (7.3%), Cyprus (6.7%), Netherlands (6.5%), Turkey (2.2%) Palestinian Territories (1.5%), Portugal (1.1%), South Africa 20%, Greece 10%, Tunisia (7%), Brazil (6%), and India (2%)

New Capacity

- **26.1 GWth** = new installed capacity in 2019.

Once again, led by China (18.5 GWth) and Europe (3.0 GWth), which together accounted for 82.4% of the total new collector installations.

Environment

- 407 TWh solar thermal energy yield correlates to a savings of **43.8 million tons of oil** and **141.3 million tons of CO_2**.

Fun fact: the CO_2 savings are 3.8 times the annual CO_2 emissions of Switzerland.

Applications

- Domestic hot water systems = most common application at **58%** of total capacity and 33% of new installations in 2019.
- Large-scale domestic hot water applications = **36%** of total capacity and 57% of new installed capacity in 2019.

A shift from small scale to large-scale domestic hot water systems is happening.

Top 10

Total Installations in 2019 (in MWth)	**Total Installations per 1,000 Inhabitants in 2019** (in kWth)
China 346,443 ^	Barbados 577 ^
Turkey 18,076 ^	Cyprus 469 ^
United States 18,039 ^	Austria 400
Germany 13,922 ^	Israel 398
Brazil 12,151 ^	Greece 320 ^
India 10,433 ^	Palestinian Territories 272 ^
Australia 6,537 ^	Australia 260
Austria 3,531	China 249 ^
Greece 3,407 ^*	Denmark 224 ^
Israel 3,393 ^	Turkey 221 ^

^ denotes increase from 2018
* not on the list in 2018

Top 10

New Installations in 2019 (in MWth)	**New Installations per 1,000 Inhabitants in 2019** (in kWth)
China 18,522	Cyprus 39.1 ^
Turkey 1,320 ^	Israel 29.5
India 1,270	Barbados 28.7 ^
Brazil 925 ^	Greece 23.8 ^
United States 600	Denmark 23.2 ^
Australia 388	France (overseas) 17.4 *
Germany 358	Turkey 16.2 ^
Mexico 286 ^	Australia 15.5
Greece 253 ^	China 13.3 ^
Israel 252	Latvia 8.5 *

^ denotes increase from 2018
* not on the list in 2018

You can download the full report for free from the IEA SHC website, http://www.iea-shc.org/solar-heat-worldwide.

OPINION

Our Sleeping Giant at a Crossroad – Which Way Will It Turn?

Dr. Daniel Mugnier, the IEA Solar Heating and Cooling Technology Collaboration Programme's former Chair shares his thoughts on the future of solar thermal.

In a world where climate change is driving policies across the globe, solar thermal energy has a unique position and a lot of assets for becoming the King of energy.

Solar thermal is one of the most obvious and competitive options when it comes to producing renewable heat. And with heating accounting for nearly half of all the energy consumed globally, the IEA SHC Programme has the unique opportunity to capitalize on its more than 40 years of experience in technology development and innovation.

This scenario would be ideal, but the reality is, unfortunately, different in 2021.

Being deeply involved for more than 20 years in the IEA SHC Programme at nearly all levels—a Task expert starting in 1999, Task Operating Agent in 2008, Vice-Chair in 2015, and finally Chair from 2018 to 2021—I have had a front-row seat to the evolution of solar heating and cooling technology within the Renewable Energy world and more generally the Energy world.

Of course, there are reasons to explain why this sector has not had the massive deployment breakthrough you would expect, especially over the last 10 years. For me, this sector is hampered by—lack of massive investment in innovation, technical issues impacting reliability, operation costs for certain applications, and competition with other renewables, especially solar photovoltaics.

Nevertheless, from my point of view, a major mistake we should avoid in the coming years when orienting R&D on solar thermal is to think that this technology is a competitive option in all sectors. In other words, solar heat is nearly always performing when synonymous with simplicity or integration and when addressing regular and costly heat needs.

Simplicity is the keyword and the success story from more than 20 years of the Thermosiphon approach.

"Simplicity is the keyword and the success story from more than 20 years of the Thermosiphon approach."

Why has solar PV been gaining from a marvelous momentum? Mainly because policymakers and investors are confident in the technology. "Magic" feed-in tariffs create ideal conditions for technology development. And solar PV electricity production is predictable for 20 years with minor risks of failure.

Therefore, I strongly think the solar thermal sector should concentrate its efforts in the coming years on innovation and applications where renewable heat is needed when the sun shines and for the long-term (several decades). This would include large district heating systems, heat-intensive industries based on stable governance, and residential domestic hot water applications.

The challenge for solar thermal is real as more and more energy actors describe and forecast renewable heat production as green electricity.

Instead of being a threat and a barrier, I believe solar PV for heating can be a boost for the solar thermal sector. Innovation is never so active and creative when a climate of survival is appearing.

Let's take this opportunity and let's innovate to awake our Sleeping Giant and make our policymakers think again that solar thermal is a competitive and reliable answer when dealing with renewable heat.

IEA SHC Welcomes SICREEE & Its Central America Members

The Regional Centre for Renewable Energy and Energy Efficiency of SICA (SICREEE) member countries are Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. SICREEE opened its doors in 2021 with the support of the Austrian Development Agency (ADA), the United Nations Industrial Development Organization (UNIDO), and in coordination with the General Secretariat of the Central American Integration System (SG-SICA).

SICREEE is a member of the Global Network of Sustainable Energy Centres (GN-SEC), a powerful global south-south multi-stakeholder partnership coordinated by the Department of Energy of UNIDO in collaboration with various regional economic communities and organizations. The regional centres respond to the urgent need for enforced south-south cooperation and regional capacities to promote inclusive and sustainable energy industries and markets in developing and transformation countries in the post-2015 era. The centres count on the high-level support of national Energy Ministers and act in response to the individual needs of the respective governments.

Motivation

SICREEE's partner countries have made considerable progress in creating national environments to promote renewable energy (RE) and energy efficiency (EE). And now, working under the umbrella of this regional organization, countries can begin to tackle some underlying challenges, including political and legislative barriers, social conflicts that arise in RE projects, lack of EE standards, and financial barriers to investment. Changes in these areas would have a real impact on investments and create a more vibrant market and industrial sector.

"Contributing to the promotion of ER&EE at the regional level for the implementation of transformative projects in industrial, commercial, service and residential sectors, that support the market for innovative technologies is the SICREEE's objective," says María Eugenia Salaverría, SICREEE Programme Officer. Adding that, "to boost the growth of solar thermal in Central America, we have joined the IEA SHC Programme along with six other regional Sustainable Energy Centres. For me, this new partnership with its access to a global team of experts will help to expand the use of solar thermal in small-scale industries and beyond in this region."

SICREEE focuses on capacity building, knowledge and data management, awareness-raising, and investment and business promotion in the energy sector. SICREEE is aware that sustainable energy investments and appropriate regulations and standards go hand in hand with the need for local institutional capacity and a qualified workforce.

SICREEE Partner Countries

- Belize
- Costa Rica
- Dominican Republic
- El Salvador
- Guatemala
- Honduras
- Nicaragua
- Panama

▲ **Figure 1. SICREEE's focus areas.**

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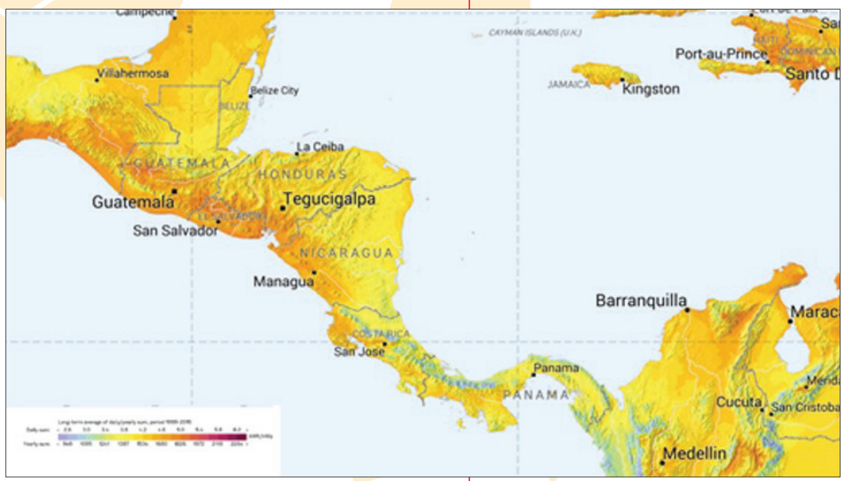
New Member SICREEE *from page 7*

The governments of the SICA countries have established innovative energy policies to promote renewable energy, a culture of energy efficiency, and the reduction of CO_2 emissions in the energy sector. As part of these policies, investment in renewable energy projects for electricity generation is being promoted, as well as distributed generation, especially with solar technologies. Other solar activities in the SICA region are solar thermal projects to improve small rural industrial processes.

SICREEE's priority activities include solar energy because of the tremendous solar potential in SICA countries and its expertise in implementing solar technologies in urban and rural areas. Among the knowledge areas of the SICREEE are business models design and evaluation, energy policy advice and advocacy, capacity building, gender and energy, as well as characterization and technical quality of photovoltaic (PV) technology, mini-grids and Solar Home Systems (SHSs) of Second and Third Generation, distributed generation, and solar thermal technical issues (see Figure 1).

A Snapshot of Solar in SICA Countries

Located in an area privileged by solar irradiation, SICA countries have great potential for using solar energy. With a global irradiation of 4.6 to 6.2 KWh/m^2 /daily, the countries can generate electricity as well as use it for thermal uses as space heating, air conditioning, hot water, industrial process heat, drying, and so on (as shown in Figure 2).



▲ **Figure 2. Long-term average of daily/yearly sun.** (Source Solar GIS/ESMAP/World Bank)

The use of solar energy in the region supports countries to reduce their carbon emissions and, at the same time, empowers vulnerable communities, mainly in remote areas, facilitating their access to electricity.

According to data provided by the Ministries of Energy, solar energy use in SICA countries is significantly increasing; in just six years, the installed capacity grew from 50 MWp in 2014 to 1,575 MWp in 2020. The detailed situation of some SICA countries is highlighted below.

Guatemala has installed 91.5 MWp of PV capacity, of which 80 MWp corresponds to large-scale systems and 11.5 MWp for distributed generation. The largest solar plants in the country are Horus I and Horus II, with 50 MWp and 30 MWp.

▲ **Figure 3. SIBO Solar Power Plant in Guatemala.** (Source: MEM, Guatemala)

The country has also increased household solar energy use, both as distributed generation for self-consumption and energy access. In addition, small and medium businesses and industries are exploring different alternatives to generate electricity with PV systems to take advantage of the Technical Standard for self-producing users approved by the government. (CNEE, 2014, Norma Técnica de Generación Distribuida Renovable y Usuarios Autoproductores con Excedentes de Energía).

In this country, solar thermal energy represents an emerging industry; however, it is possible to find two types of technologies for solar heating systems: non-pressurized and pressurized. The first is used in the residential sector because it is pressure and easy to install, and the second is commonly applied in the industrial and service sectors. In addition, solar thermal energy is also utilized to dry grains, especially coffee and cardamom.

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Belize National Sustainable Energy Strategy 2012-2033 proposes to reduce the country's dependence on imported fuels. It promotes the deployment of solar technology for electricity generation in rural and urban areas and has the goal of shifting 50% of rural households using firewood to biogas, plant oil, and solar cookers. Notwithstanding, the country currently lacks a regulatory framework for this issue. Belize has the least development of solar energy but has installed a 435 kWp PV system connected to the grid at the University of Belize.

Costa Rica has a regulatory framework for electricity self-consumption (MINAE, 2015, Reglamento generación distribuida para autoconsumo con fuentes renovables modelo de contratación medición neta sencilla) that regulates the interconnection and operation of distributed generators with renewable energy and compensates for the electricity surplus sent to the grid. However, the capacity that each customer installs meets the amount of energy consumed because the electricity surplus is not compensated. Most of these projects are PV installations. At the same time, the country also has a rural electrification program for communities not connected to the grid, where solar technology is the primary energy source.

There are installed 95 MWp of PV capacity: 12 MWp at large scale and 73 MWp for distributed generation connected to the country electric net. Juanilama Solar Park is the largest solar plant in the country, and its installed capacity is 6 MWp.

In the country, 41.3% of households use electric domestic hot water systems, so there is great potential for solar thermal energy. Moreover, there are available technical standards for solar thermal equipment, such as solar collectors and their components and solar sanitary water heating systems. Indeed, the regulatory framework is being prepared to allow the massification of solar thermal, especially in the residential and tourist sectors (MINAE, SEPSE and others, 2017, Hoja de Ruta Tecnológica Solar para Calentamiento y Enfriamiento).

Dominican Republic has great potential to generate solar energy; the average global solar irradiation varies between 5.25 and 6.00 kWh/m^2/day. The Law of Incentives to Renewable Energies and Special Regimes (Comisión Nacional de Energía, 2012, Ley número 57-07 Sobre Incentivo al Desarrollo de Fuentes Renovables de Energía y sus Regímenes Especiales y el Reglamento-Decreto 202-08) creates the framework to facilitate the expansion of solar technologies. The regulation grants up to 40% of the cost of the initial investment in equipment as a single income tax credit for family homes, commercial or industrial locations that change or expand systems for self-consumption. The country has 166 MWp of installed solar capacity connected to the grid and 7.2 MWp in off-grid systems.

El Salvador has been promoting the entry of renewable energies through long-term power purchase agreements that allow securing long-term energy prices, guaranteeing supply and economic income for independent private generators. As a result, solar energy's share in the country's generation mix is growing, with an installed power of 403 MWp, representing 18% of the country's installed capacity.

The use of solar thermal systems in El Salvador is practically limited to hotel and hospital users, and its application is minimal in the residential sector. Moreover, there are no regulations that support and promote the development of the sector.

Honduras has made significant progress in terms of electricity generation with solar systems. It is the country in the region with the highest installed capacity in solar generation, 510 MWp. Honduras has implemented an attractive tax incentive policy for the solar sector that is beginning to show excellent results.

▲ **Figure 4. Solar thermal system at a dairy plant in Honduras.** (Source: SOPELIA)

In Honduras, like many other countries, there is not a strong solar thermal energy market. At the residential level, solar thermal energy use is infrequent and primarily used in the commercial and industrial sectors.

Nicaragua, in 2013, started to boost solar energy production with the installation of two power plants: one of 1.3 MWp and the other of 3.1 MWp. In the same year, Nicaragua started to bring electricity based on solar systems in rural areas, achieving a total capacity of 63 MWp.

Furthermore, Nicaragua has installed 338 solar thermal heaters, the second-largest solar thermal system in the world, and the only one in Latin America. This emblematic project is located at the Dr. Alejandro Davila Bolaños Military School Hospital in Managua. The project was executed with the support of the United Nations Agency for Industrial Development (UNIDO) and the National Cleaner Production Centre of Nicaragua. The installation covers

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▲ **Figure 5. Solar thermal installation on a Nicaraguan hospital.** (Source: Hospital Militar Esuela Dr. Alejandro Dávila Bolaños)

30% of the air conditioning demand and 100% of the hot water demand for various operational functions of the hospital, such as patient and doctor personal hygiene, food cleaning and preparation, and laundry.

Panama, as part of their 2015 regulation to promote solar energy, the National Energy Secretariat put out a tender to contract solar energy on a large scale. As a result, Panama has the largest PV generation project in Central America, with an installed capacity of 150 MWp. The total installed capacity in the country is 194.6 MWp plus 43.4 MWp for self-consumption.

Panama will be a pioneer in the implementation of a modern solar energy system called “Maverick.” It is a revolutionary modular, prefabricated, prewired solar solution that folds up to send to a site and install. It is one of the easiest and fastest ways to add solar resources, using fewer tracts of land. Panama will be one of the first countries where this technology will be implemented in a 2 MWp fast track project as a part of AES (a Panama utility) electricity generation projects.

In the same line, the country is implementing the *Termosolar Panama Project*. It is executed through an inter-institutional alliance between the UN Environment Regional Office for Latin America and the Caribbean and the National Energy Secretariat (SNE), with financial support from the Global Environment Facility (GEF), and several partners from the public and private sectors. The objective is to install one million square meters of solar thermal technology applications for water heating throughout the country by 2050. With this, the country will reduce 6.4 million tons of CO_2 and will save more than US$ 3 million annually in fossil fuels. The project started in 2018 with the implementation of demonstration pilot projects with solar water heating systems. Energy audits were carried out in pre-selected households, businesses, and hospitals to identify savings opportunities and the market potential that exists in the country. One hundred of these pilot projects have been implemented in health and social assistance buildings, hotels, private companies, and residences.

SICREEE’s Vision for the Future

At SICREEE, we believe that clean energy development is essential to reduce the devastating effects of climate change. Renewable energies have received significant support at an international level with the Paris Agreement and the Sustainable Development Goals (SDGs) adopted in 2015 by all United Nations Member States and in the SICA region with the Sustainable Energy Strategy 2030. The transition towards energy systems based on renewable technologies will thus have very positive effects on the economy, society, and the sustainable development of the countries of the SICA region.

As the region has a great potential for solar energy, this is one of the main themes of technical support of SICREEE. “Solar energy is the only renewable energy resource that allows electricity service to be democratized, for users to become prosumers, stating out a challenge for building up new and innovative regulations and business models. The opportunity is there, and the support of the SICREEE would facilitate the outlining of new ideas and holistic projects to increase solar deployment at large and small scales, for both urban and rural areas, in the SICA countries. The great advantage is that solar technology, especially PV, is the most competitive to phase out harmful fossil fuels and guarantee affordable electricity prices. Lessons learned in solar energy from the GN-SEC network could be adopted by the region through the leadership of the SICREEE”, indicates Andrea Eras Almeida, International Consultant at UNIDO.

The Center seeks to support SICA member states to address existing barriers to sustainable energy and efficient technology markets more effectively. At the same time, SICREEE will complement and strengthen activities that are already being carried out at national and regional levels in the areas of policies, capacity development, knowledge management, as well as investments and business promotion in renewable energy and energy efficiency.

Article contributed by Alexandra Arias, SICREEE Expert on RE&EE and SHC Executive Committee Member. For more information on SICREEE, please email info@sicreee.org or visit the SICREEE website, www.sicreee.org. For details on GN-SEC visit, www.gn-sec.net.

AUSTRIAN DEVELOPMENT AGENCY

GN-SEC Global Network Regional Sustainable Energy Centres

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATIC

Centre for Renewable Energies and Energy Efficiency (SICREEE) | SICA Central American Integration System

Task 60

PVT Systems: Heat or Electricity From Solar – Why Only One When You Can Have Both?

A solar PV/Thermal (PVT) collector produces both heat and electricity thanks to a combination of a PV panel and a solar thermal collector or absorber. IEA SHC Task 60: PVT Systems investigated the possible concepts for the last three years with a group of experts from research laboratories and solar industries. The end results, good examples of different types of installations around the world, simulation models, key performance indicators, and a comparison of concepts. This article summarizes the work and findings of the Task and confirms that PVT technologies can play a vibrant role in the transition towards more solar energy for both heating and electricity production.

PVT concepts are not a new idea for the hybridization of solar energy collectors. For more than 20 years, there have been developments on possible solutions, and IEA SHC conducted preliminary work in SHC Task 35: PV/Thermal Systems from 2005–2010 followed up on by Task 60: PVT Systems from 2018–2020. A new PVT push came in 2016 when the PV industry reached relatively low costs for their technologies, and the solar thermal industrial market was mature. These developments in the solar community opened the door for more and new PVT applications building on:

- Strong and increasing interest in Building Integrated PV (BIPV) and Façade Integrated PV (FIPV) not only in office and industrial buildings but also in residential buildings where both electricity and heating and sometimes cooling are required
- Developments in heat pump technology creating more possibilities to use the low exergy heat source of uncovered PVT collectors and reduce the energy cost for the user and the need for borehole storage
- Decreasing costs of PV modules, making it more attractive to combine PV with thermal to produce more solar energy while using the same roof area

But there is still work to be done to show the HVAC industry the possibilities and benefits of PVT solutions. SHC Task 60 experts contributed to this effort by helping to make the technology more visible and working on international standards devoted to PVT collectors to create more confidence in the use of a new technology by solar energy planners and final customers.

Three clear conclusions came out of this Task work:

1. PVT maximizes the use of a rooftop or any area by delivering electricity and heat without compromising the efficiencies of either technology.
2. Reliable solutions are on the market.
3. PVT can play a valuable role in the energy transition of any country with its attractive cost of electricity and heat from the sun.

Participating Countries

Australia
Austria
Canada
China
Denmark
France
Germany
Italy
Netherlands
South Africa
Spain
Sweden
Switzerland
United Kingdom

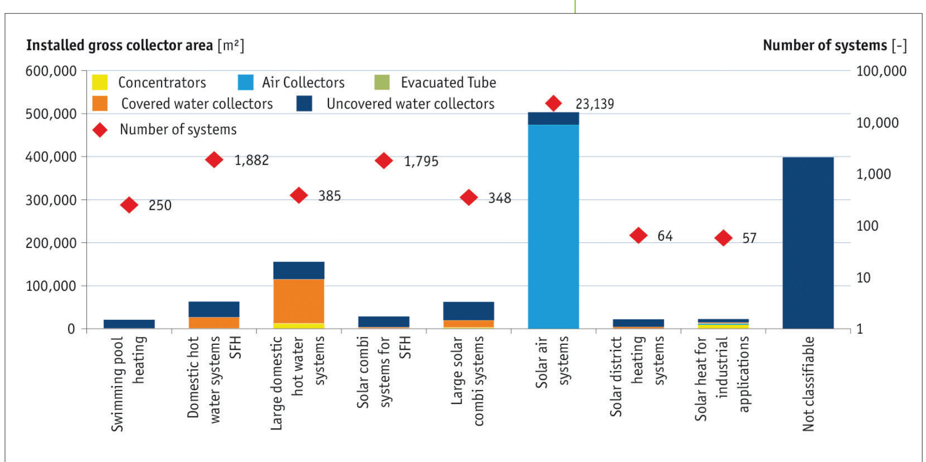

Figure 1. PVT systems in operation worldwide by the end of 2020. (Source: IEA SHC Task 60 survey, AEE INTEC. IEA SHC Solar Heat Worldwide 2020)

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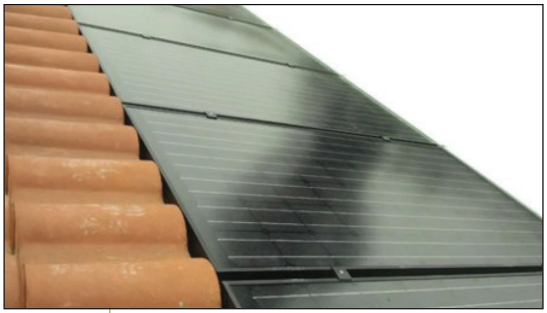
PVT Systems Around the World

By the end of 2020, a cumulated PVT collector area of 1,275,431 m^2 was installed with 27,920 systems in operation. What this latest data confirms is that the global PVT market is experiencing steady growth, 9% on average from 2018 to 2020, and the market momentum is strong.

Figure 1 shows the dominance of solar air systems in the PVT market, mainly driven by France, where PVT air systems were successfully introduced quite early by two manufacturers. The advantages of PVT solar air systems are that the low-temperature systems with air as the distribution medium exhibit high efficiencies and low stress on the PV cells. Plus, they are very well suited to low-energy houses, easily achieving a solar fraction of up to 50%. But there are numerous other PVT applications for all different heating and cooling market segments, some of which were analyzed and documented in SHC Task 60's report, Existing PVT Systems and Solutions.



▲ **Figure 2. In France, six PVT uncovered panels, 9.6 m2 and 1.5 kWp, for domestic hot water preparation, heat for a heat pump, and electricity for self-consumption and the grid.** (Credit: Dualsun)

Systems with Heat Pumps

Uncovered PVT collectors are very well suited to operate as a heat source of a heat pump. This solution provides several advantages 1) unlike an air heat pump, the noise of a water/water heat pump is much lower, and inside a cellar, the cost of a borehole is avoided, 2) the temperature of the evaporator source is on the average higher than for other sources like ambient air, 3) the PV part produces part of the electricity to drive the heat pump, and 4) the area taken up by the PVT field is not larger than what would have been installed if only PV was selected.

Several manufacturers provide turnkey solutions of hybrid PVT collectors with heat pumps mainly for single-family houses, but not exclusively. Many of these installations have high COPs (3 to 5 annually) and a reasonable payback time of 7–12 years. Moreover, in houses, this solution maximizes the use of the rooftop area for collecting solar energy.

Collectors can be made of aluminum or polymer and, because they are uncovered, show high durability due to the maximum temperature reached under stagnation stays well below 100°C. This means less stress on the PV cells than in covered or concentrating technologies.

▲ **Figure 3. In Switzerland, this PVT system uses 178 uncovered PVT panels + 699 PV modules to generate 237 kWp. The heat pre-heats the groundwater storage, which is then transferred directly to the heat pump and the overflow basins of the pools. The heat pump generates heat for pools, space heating, and domestic hot water. A gas boiler supports the heat pump for peak loads. Electricity is for self-consumption and the grid. (**Credit: Meyer Burger)

Systems without Heat Pumps

Unglazed collectors can deliver heat to low-energy houses at 30°C–40°C in sunny climates during winter, such as in the south of France, thus avoiding the need for a heat pump. Air PVT systems are an excellent example of such installations.

In more harsh climates or to deliver 60°C heat for DHW preparation, PVT collectors must be glazed or operated under vacuum, such as in evacuated tube collectors. Several PVT manufacturers produce very good collectors that can achieve 60°–80°C fluid delivery temperatures and are well suited for when DHW is needed year-round, as for hotels, sports centers, and community dwellings. The electricity produced can be self-consumed during the day for any of the building's electrical equipment.

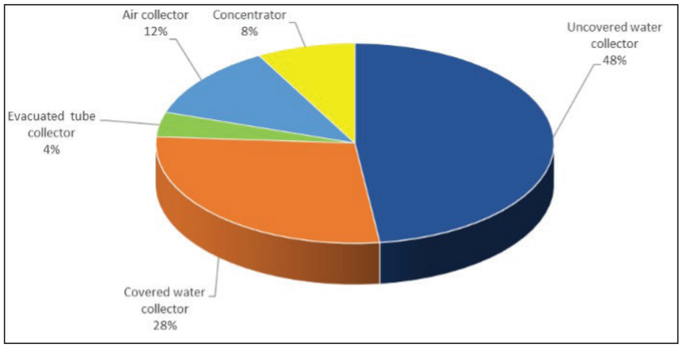
▲ **Figure 4. In Spain, 28 PVT glazed panels covering 46 m2 generates 6.7 kWp for DHW in a firehouse. Electricity is for self-consumption and the grid. (**Credit: Endef Engineering)

continued on page 13

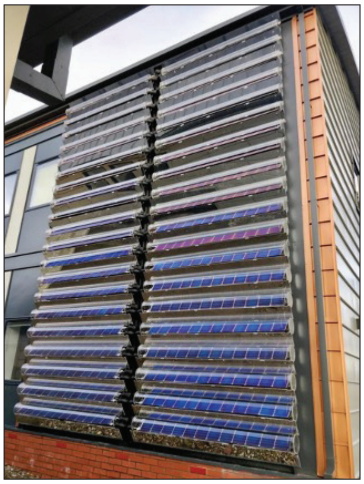
PVT Collector Technologies

Depending on their use, PVT collectors vary in design. The most common PVT collectors are uncovered collectors, also referred to as unglazed or WISC (wind and/or infrared sensitive) collectors.

Manufacturers try to reduce collector costs through three actions 1) choice of material, 2) automation of production, and 3) simplicity of concepts. The absorber plays a big role in the efficiency of a PVT collector, and several new designs have been developed over the last three years. Total current system costs range between 500 and 1500 €/m². The PVT collector cost is between 100 and 300 €/m².



► **Figure 6. Distribution of PVT collector types in 2018.** (Source: IEA SHC Task 60 report, Existing PVT Systems and Solutions)



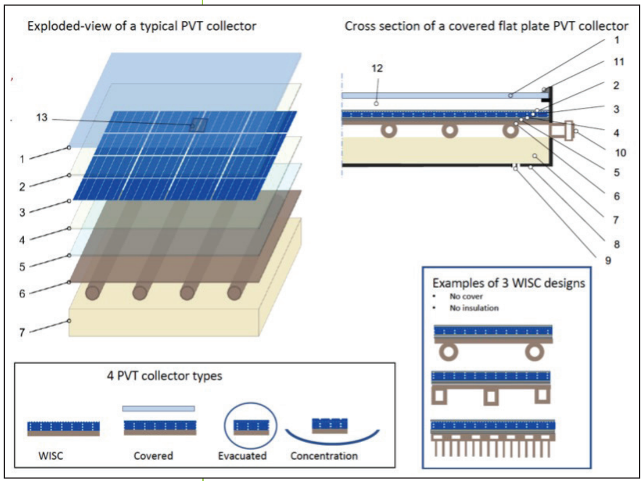
▲ **Figure 5. In the UK, an example of an evacuated tube PVT collector system on a vertical facade.** (Credit: Naked Energy)

How to Define PVT Efficiency

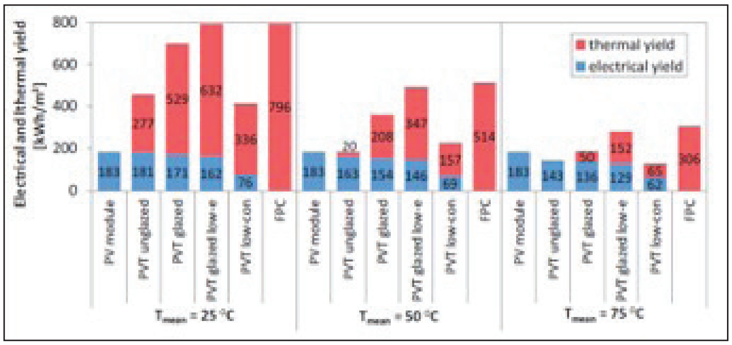
Global efficiency can be defined as the sum of the outputs (electricity + heat) defined by the incident solar radiation. This is with no exergy consideration for the electrical output to keep it simple.

PV efficiency can depend on the temperature of the collector, so this also has to be taken into account for PVT collectors operated at various variable temperatures. The average yearly and weighted operating temperature of a PVT collector is thus an important value to assess system efficiency.

Other factors to consider are ISO standards and Solar Keymark certification, which can provide the basic characteristics curve of a PVT module by testing according to PV or T protocols. A PVT protocol is a work in progress. One reason for testing is to provide input for the economic and technical key performance indicators (KPIs). For PVT, the challenge is, to some extent, that the KPIs are not yet mature and settled in the market. SHC Task 60 has issued a list of relevant KPIs for PVT that can be regarded as a standard.



▲ **Figure 7. PVT collector design concepts.** (Source: IEA SHC Task 60 report, Design Guidelines for PVT Collectors)



◄ **Figure 8. PVT collectors maximize the solar energy collected at all temperatures. The temperature influence in thermal and electrical gains per square meter of collector aperture area calculated using the software "ScenoCalc" for the city of Würzburg, Germany (Central Europe).** (Source: IEA SHC Task 60 report, Status Quo of PVT Characterization)

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PVT Systems *from page 13*

Energy	Thermal and electrical solar yields per m²
	Thermal and electrical utilization rations (yield/irradiation)
	Output-weighted operating temperature
	Solar thermal fraction
	Seasonal performance factor (for heat pump systems)
Economics	Specific investment cost per m²
	Levelized cost of heat and electricity (LCOH, LCOE)
	Saved fuel and grid electricity cost
Environment	Avoided primary energy depletion [kWh oil-eq/(a* m²)]
	Avoided global warming impact [kg CO_2-eq/(a* m²)]

▲ **KPIs for PVT systems considered by SHC Task 60**

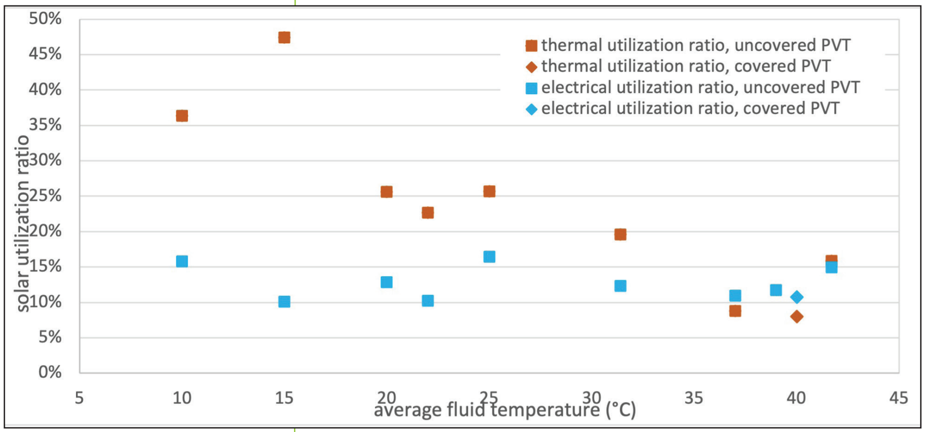
Low Payback Time in Sunny Conditions

In good conditions, such as a sunny climate, electricity demand during the day and heat demand year-round can be met using PVT with a payback time as low as 4–5 years compared to an electrical or gas solution. This is the case for hotels in the Mediterranean, particularly where fossil fuel costs are high. PVT also can deliver electricity for e-mobility, heat for DHW, and act as a cooler for cooling machines.

PVT Deserves Increased Visibility

The results of SHC Task 60's work on assessing existing PVT solutions and developing new system solution principles will no doubt help with the uptake of PVT applications.

As part of the Task's work, participants assessed the many parameters of a PVT installation, including heat production, electricity yield, global efficiency, qualitative indicators, user benefits, investment, energy and maintenance costs, and safety and reliability of operation. All these Key Performance Indicators were defined and evaluated for several typical PVT applications. Participants also collected best practices to accelerate the market acceptance of PVT technologies and highlight the advantages over the classic "side by side installations" of solar thermal collectors and PV modules.



▲ **Figure 9. Temperature dependency of the solar thermal annual utilization ratio (in red, thermal energy output divided by total incident solar) for the example systems studied in SHC Task 60 divided into covered (diamond) and uncovered PVT (square). In blue, the solar electrical utilization ratio for covered and uncovered PVT collectors.** (Source: IEA SHC Task 60 report, Performance Assessment of Example PVT Systems)

The main outcomes of the Task are:

- A state-of-the-art of PVT technology worldwide
- A collection of PVT operating experiences
- Improved testing, modeling, and adequate technical characterization of PVT collectors
- Examples of standard and best practice PVT solutions
- Exploration of potential cost reductions in PVT systems
- Increased awareness of PVT solutions by all stakeholders through webinars and journal articles

But perhaps the most important result was the confirmation that the PVT industry can actively participate in the decarbonization of the heat energy sector and that PVT solutions deserve more consideration.

Article contributed by Jean-Christophe Hadorn, Operating Agent of IEA SHC Task 60: PVT Collectors and Systems. For more information and to download reports, visit https://task60.iea-shc.org

◄ **In Spain, the conditions are suitable for a low payback time. 102 PVT glazed panels covering 200 m² generate 30 kWp to provide hot water and electricity for self-consumption and the grid at this hotel.** (Credit: Abora Solar)

INTERVIEW

PVT Systems

One on One with Jean-Christophe Hadorn

The SHC Programme completed its most recent work on PVT Systems (Task 60) in December 2020. To learn how this Task impacted this market sector, we've asked Jean-Christophe Hadorn, the Swiss Task Operating Agent, to share some of his thoughts on this 3-year project.

Why was a project like this needed?

There are a couple of reasons the SHC Programme decided to take on this topic. The first being that PVT technologies lack visibility in the building community despite the successes of several PVT industries in France and Spain making breakthroughs since 2015. Other reasons include the absence of a real PVT community, the need for scientific and independent work on simulations and performance measurements, and the lack of PVT statistics. But, as we all know, a technology gets consideration when there is data to back it up and positive progression over the years is observed.

What is the current status of the technology?

PVT collectors (unglazed or glazed) are reliable and sold as industrial products and deployed in many countries. We estimate that more than 2.5 million m^2 of PVT collectors were installed worldwide at the end of 2020. And PVT prototype collectors with concentration factors of 2 to 5 are being developed but still need to find their niche markets. As for testing procedures and simulation methods to predict PVT collector and system performance, these are now being disseminated thanks to the work of SHC Task 60. You can find reports on these topics on the SHC Task 60 webpage.

Is there one outcome that surprised you?

I was surprised by how active the PVT industries were in the Task despite there only being 4–5 of them. They act and react as startups and try to rapidly deliver the best system to their clients. In the Task, they were very willing to share their knowledge and experiences for the benefit of the PVT community and, in the end, all PVT clients.

Do you have a Task success story from an end-user or industry to share?

One of our industry participants refined the design of their new PVT collector thanks to the Task participant's expertise. This is where international collaboration has all its meaning.

What is the future of this technology?

Being versatile, PVT systems can be used for single-family and multi-family houses, hotels, campuses, public services, hospitals, agricultural and industrial processes, and even district heating.

Unglazed PVT collectors can be used efficiently with a heat pump with no noise and installed aesthetically on a house's roof. And glazed PVT collectors show a low payback time for hotels. As for concentrating PVT collectors, they are well suited for industrial applications.

New developments to enhance existing collectors will always occur but are not crucial. Current PVT technologies are pretty well adapted, efficient, and reliable. The challenge is a lack of national policies to promote PVT hybrid collectors and awareness of PVT solutions.

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

The network of international experts from industry and science that joined this work couldn't have been found elsewhere, drawn together by a common activity and objective. Plus, the SHC Programme's platform, methods, and website provided very useful tools to manage an international project.

Will we see more PVT work in the IEA SHC Programme?

I hope that PVT systems will be studied as a mature technology and that the work will include sharing the best and most appealing examples, system performance according to the SHC Task 60 KPIs, and best practice recommendations in all the relevant market segments.

An area I see for future collaboration is PVT solutions with storage capacities for heating or cooling and electricity.

An IEA Task has to be set up by pioneers with a vision, and this is not rare in the solar community, so my guess is that there will be another Task dealing with PVT soon.

Unexpected Solar Thermal Partnership Catalyzes Government Collaboration, Skills, Investment and Emissions Targets

One of the roles of the South African National Energy Development Institute (SANEDI) is to facilitate and coordinate renewable energy and energy efficiency research, development, and demonstration through local and international cooperation, technology transfer, and information exchange leading to the deployment and commercialization of sustainable, efficient, reliable, cost-competitive and environmentally sound renewable energy technologies.

The South African National Defense Force (SANDF) owns and operates multiple military bases across the country where, more often than not, entire communities of military families reside. Additionally, the service infrastructure (water and energy) of small towns is often located on these military bases and serves the entire community's needs in the area. To this end, the SANDF has established a technical structure that supports the maintenance and repair of these facilities. As can be expected, water and energy infrastructure and efficiency are paramount not only to the smooth functioning of bases but also to the energy savings, emissions reduction targets, and energy security.

A partnership between SANEDI and the SANDF began intensively in 2018, collaborating on sustainable renewable energy and energy efficiency solutions for the SANDF. This alliance led to the signing of a five-year Memorandum of Agreement (MoA) to collaborate on specifically identified projects, one of which is implementing pilot projects at a military base in Limpopo, in collaboration with the Solar Thermal Training and Demonstration Initiative (SOLTRAIN). SOLTRAIN is a regional initiative for capacity-building and demonstration of solar thermal systems in the SADC region, funded by the Austrian Development Agency and co-funded by the OPEC Fund for International Development.

SOLTRAIN demonstrates ways to tap solar's potential using solar thermal systems to significantly reduce electricity demand and CO_2 emissions. Major adoption of these systems could lead to industry and associated skills development and job creation if local assembly or manufacturing is stimulated. In South Africa, SOLTRAIN is implemented by SANEDI and the Centre for Renewable and Sustainable Energy Studies at Stellenbosch University, in partnership with AEE Institute for Sustainable Technologies (AEE INTEC) from Austria.

SANEDI & SANDF Partnership Has Far-Reaching Impact

The SANDF spends a significant amount of money on the operation, maintenance, and replacement of water heating hardware in its high-density domestic housing on military bases across South Africa. Understanding the energy and cost-saving benefits of solar thermal, this uniquely executed tri-way partnership (SANEDI, SANDF, SOLTRAIN) has managed to deliver mutually beneficial outcomes to all three parties through technology implementation focused on interdepartmental government collaboration and investment, skills development in the solar thermal sector through upskilling of military artisans, and addressing governmental emissions targets through CO_2 reduction. In addition, it has catalyzed a knock-on effect on future investments in large-scale solar thermal installations at SANDF housing and hospital facilities that serve not only military personnel but also government employees and civilians.

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Solar Academy *from page 16*

SANEDI, the SANDF, and SOLTRAIN collaborated to implement two solar water heating systems at the Air Force Base in Hoedspruit, Limpopo Province, which have improved energy efficiency and acted as a catalyst for upskilling SANDF personnel. The two systems, each with a 15 m^2 solar array collector area and 1,500-liter hot water storage, were installed at two buildings. The systems operating through a well-insulated ring main unit provide the added benefit of less water being wasted while waiting for a shower to heat up – hot water is almost instant in each of the 32 rooms once a tap is opened. A unique aspect of the pumped solar thermal systems with a 20-year life is that they consider the cohabiting bush-life, including primates, and climatic conditions at Air Force Base Hoedspruit.

To prepare the SANDF members for the projects, SANEDI held half-day awareness training seminars on renewable energy, energy efficiency, and more specifically, solar water heating at military units across Limpopo. And, to ensure the ongoing operation and maintenance of the solar thermal systems, SANEDI also provided specialized training in partnership with Stellenbosch University to 45 artisans who completed a SOLTRAIN thermosiphon course and four who were intensively trained during the systems' construction. These members were upskilled further and are transferring their skills to other SANDF artisans, thus ensuring the security of knowledge retention and a system maintenance autonomy for the SANDF.

The first project implemented through the SANEDI-SANDF collaboration went live in May 2019, and by July 2021 has realized a savings of approximately 490,300 kWh, equating to an estimated 981,000 Rand. Although the buildings are not at full capacity, it is expected that the capital costs, associated maintenance, and training will be recouped in less than 2.5 years. Furthermore, after this period, supplying hot water to these two bungalows (each supporting 16 staff members) will be "FREE," bar a minimal running cost of approximately 16,000 Rand per year in comparison with a previous cost of 150,000 Rand (per bungalow). Thus, this investment is proving to be extremely beneficial, showing a projected Internal Rate of Return (IRR) of 33% and a Return On Investment (ROI) of 570% over the 20 year lifetime of the project.

These solar water heating systems reduced electricity use and the need for the backup diesel generator, thus enabling the SANDF to provide housing with functional hot water supplies under most conditions. Before installing the two solar systems, the military facility had defunct electrical hot water systems for their medical and training personnel residing in the two buildings.

The SANDF seeing first-hand how solar thermal can reduce operating costs and improve the reliability of the hot water infrastructure on military bases, is keen to learn more about other energy savings and emissions-reducing solar technologies. And, SANEDI is confident that given the number of government and parastatal entities that own housing, this model of co-funding public sector renewable energy projects can be replicated throughout South Africa.

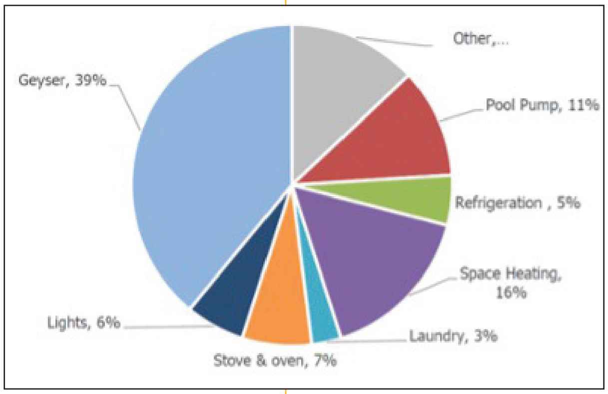
Article contributed by Karen Surridge of SANEDI and the South African representative on the IEA SHC Executive Committee.

SANEDI, the SANDF, and SOLTRAIN collaborated to implement two solar water heating systems at the Air Force Base in Hoedspruit, Limpopo Province, which have improved energy efficiency and acted as a catalyst for upskilling SANDF personnel.

PV2heat in South Africa — Almost 12,000 Systems Installed

Through the SOLTRAIN project, coordinated by AEE INTEC and funded by the Austrian Development Agency, the Center for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University in South Africa has been collecting data on PV2heat installations in South Africa since 2018.

PV2heat systems are a technology entering the market with little fanfare but great potential. One country where this technology is gaining in popularity is South Africa. Solar thermal collectors (both flat plates and evacuated tube technologies) and heat pumps historically dominated the market for sustainable hot water preparation, but now there is a trend towards heating water directly with electricity from solar photovoltaic (PV) technologies. These systems, referred to as PV2heat, consist of PV modules directly connected to an electrical element that heats the water with DC power without the need for inverters. The system also usually includes an AC element connected to the electricity grid to heat the water when the sun is not shining.



▲ **Figure 1. Residential electricity load in South Africa.** (South Africa Geyser: Cost-Efficiency Technical Study, 2014.)

The falling cost of solar technologies, increasing cost of electricity, abundant sunshine, and regulations mandating more sustainable hot water heating are steadily moving the South African hot water market away from traditional water heating methods to electrical elements using electricity from the grid.

As recent as 2014, the residential sector in South Africa accounted for 17% of the country's electricity load, increasing to 35% during peak consumption periods. Considering that 39% of the electricity use of middle- and high-income households is used to heat water, switching to non-fossil fuel alternatives for hot water could significantly reduce the country's carbon emissions.

The growth in the installation of PV2heat technologies is in some ways fueled by their simpler installation, only requiring wiring from the panels to the tank instead of insulated pipes, as is the case with traditional solar water heaters. The hot water tank also can be installed much closer to the taps, resulting in a shorter wait time for the flow of hot water. However, the greatest incentive for installing these systems is the mandated regulation that stipulates that not more than 50% of the annual hot water volume consumed in households be heated by fossil fuel-derived energy. This 50% requirement is deemed to be 100 liters of hot water tank size per bedroom per residence. There is no "deemed to be" interpretation for a PV2heat system yet, allowing for the installation of systems with a lower solar energy yield at an obviously reduced cost.

PV2heat systems do have some disadvantages compared to conventional solar thermal collectors—PV panels require approximately 3–4 times the roof area to install the same thermal capacity as conventional solar thermal collectors and present a higher risk of theft.

Although the country currently has no testing standards for PV2heat technologies, most municipalities allow for the installation of locally supplied PV2heat technologies. There is, however, some resistance towards this technology and its ability to comply with national building regulations.

At the end of 2018, there were an estimated 2,400 PV2heat systems installed in the country, and by December 2020, approximately 11,700 systems with an estimated total PV capacity of 9,869 kWp, with an average PV capacity of roughly 850 Wp of PV per system (see Figure 2).

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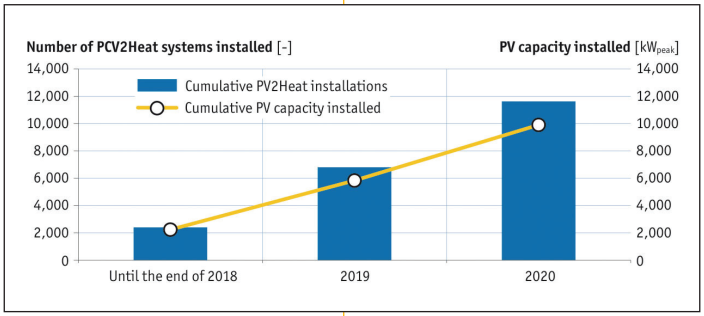
The technical capabilities of locally available PV2heat products indicate that most, if not all, are installed within the residential sector for domestic hot water. And it is assumed that most of these installations are in new buildings, but it is impossible to say this with certainty with the available data. However, through observation, it can be confirmed that PV2heat systems are being installed in multi-story housing developments (apartment complexes), semi-detached houses, terraced houses, and single-family houses, mostly for middle- to high-income households.

The degree to which PV2heat technologies are being used to retrofit existing geysers would be interesting to quantify since these technologies provide a unique degree of simplicity for integration into existing hot water tanks compared to solar water heating systems. However, it is expected that a larger percentage of PV2heat installations are in new building developments since their uptake is primarily driven by the previously mentioned regulations.



▲ **Figure 2. PV2heat installations and capacity in South Africa.** (Solar Heat Worldwide, 2021 edition)

In South Africa, there are several local suppliers and distributors of PV2heat technologies and "off-the-shelf" PV2heat solutions. All of these suppliers have contributed to the understanding of the local market and installation numbers presented in this article. Another contributing factor to the noticeable rise of PV2heat installations over recent years is that companies supplying and distributing these products have all been involved in the South African hot water market for many years, so they know the market very well.

The electrical elements for PV2heat systems in South Africa are rated anywhere between 900 W to 4 kW (DC) and are integrated with storage volumes ranging from 100–300 liters. Local distributors recommend using PV capacities ranging between 0.5–4 kWp, depending on the element size and type, geyser volume, annual solar radiation in the area, as well as the specific daily hot water demand of the respective household. In essence, sizing of PV capacities can vary depending on the installer, hot water storage volume, solar radiation in the region, element size, and the desired percentage contribution of solar energy throughout the year. On average, 900W DC/2kW AC PTC elements made up more than half of the PV2heat installations in South Africa at the end of 2020.

Although the number of PV2heat systems is showing rapid growth in South Africa, it has yet to take off in other markets. Nevertheless, this emerging technology shows significant promise for sustainable hot water preparation in the residential sector, despite not receiving the same amount of attention as solar thermal heating and heat pumps. With the appropriate standards in place, correct exposure, capacity building, and other initiatives, PV2heat technologies could provide a cost-competitive, sustainable hot water solution for South Africa and the world.

Article contributed by the SOLTRAIN partners Angelo Buckley and Karin Kritzinger of CRES, and Werner Weiss of AEE INTEC and the Austrian IEA SHC Executive Committee representative.

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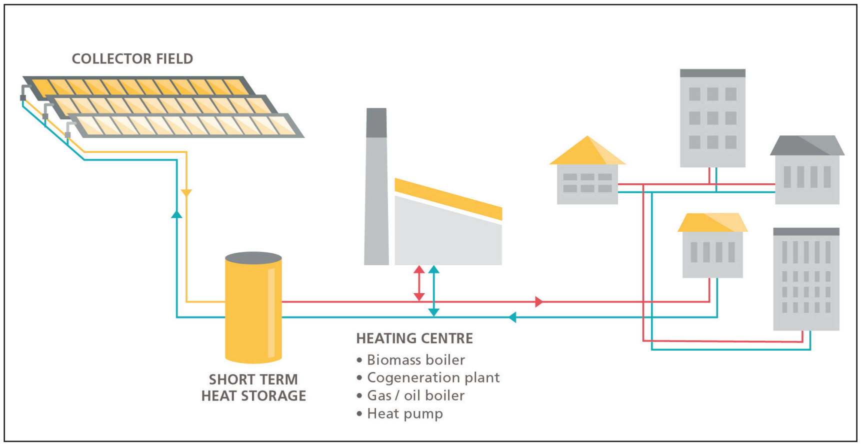
Integrating Large SHC Systems into District Heating and Cooling Networks

Integrating large-scale solar thermal plants into district heating and cooling grids is playing a crucial role in many countries' energy transformation to decarbonize their heating sector. Thermal networks offer a dual solution – increasing energy efficiency in urban areas and integrating renewable energies into the heat supply. The participants in IEA SHC Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks worked from 2016–2020 on this topic with a holistic focus on solar systems that supply heating and cooling networks with high thermal shares

Renewable sources are a central component of the sustainable energy supply in the urban environment. Nowadays, traditional supply technologies and infrastructures are experiencing big challenges, resulting in significant changes in how energy is stored and distributed. In this evolution, new, economically attractive, and technologically innovating possibilities for solar thermal energy are emerging in European towns and beyond. One such option is large solar thermal plants. To seize this growing market opportunity, solar thermal district heating and cooling will need to optimize the integration and design of complex systems and develop targeted transformation strategies and new financing models.

These topics were the subject of the IEA SHC Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks. An important innovation point of the Task was the analysis of solar systems supplying heating and cooling networks with high thermal shares. Contrarily to previous studies, in which solar thermal covered low network shares, the Task looked at a holistic approach for successful large-scale integration. This approach takes into consideration the evaluation of economically optimized transformation strategies of an entire network, a significant reduction of network operating temperatures, the development of efficient algorithms for operational optimization and control, the integration of seasonal thermal energy storage systems, and the analysis of the effect of decentral supply on the network hydraulics.



▲ **Figure 1. Solar district heating scheme.**

Participating Countries

Austria

Canada

China

Denmark

Finland

France

Germany

Spain

Sweden

United Kingdom

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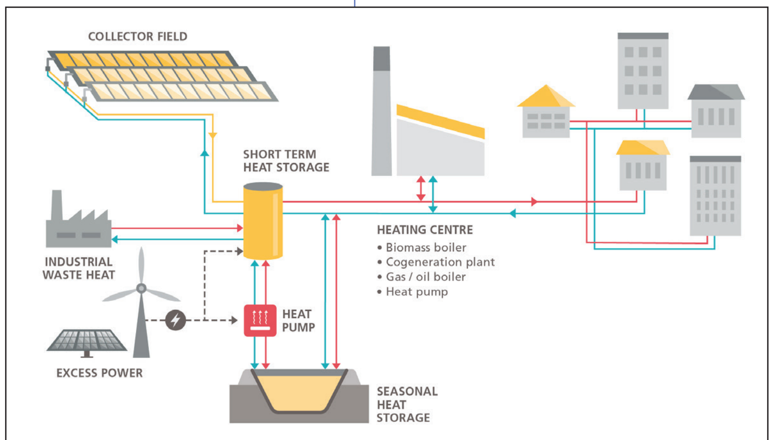
As explained by Sabine Putz, the Operating Agent of SHC Task 55, "lively know-how exchanges over more than four years of collaboration between industry and research built a shared basis for development activities of solar district heating and cooling." And, to provide full access to the Task's results, the participants summarized their findings in 27 Fact Sheets that you can download at https://task55.iea-shc.org/.

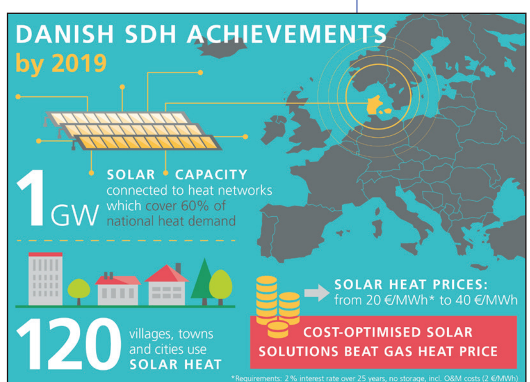


▲ **Figure 2. Example of a large-scale solar thermal system integration into district heating.**

Why Solar District Heating?

Large-scale solar thermal plants are used, mainly in Europe, to integrate a locally available, sustainable heat source into district heating networks, industrial processes, and thermally driven cooling systems. The expansion of their application is part of the energy transition occurring in countries, particularly as part of decarbonizing the heating sector. The concept of integrating large-scale solar thermal plants into district heating and cooling grids, which was investigated in SHC Task 55, plays a crucial role in this transformation as it enables synergies between thermal grids and solar thermal energy.

Solar heat networks are a proven and reliable technology based on more than 25 years of development, operation, and maintenance by operators and industry experts. In the last decade, interest in the economic deployment of solar thermal networks has grown tremendously, especially in Denmark, where 1 GW (>1.6 million m² collector area) of solar district heating was installed by 2019 (see Figure 3). However, despite the remarkable potential of large solar thermal systems, the heat contribution of solar thermal to heating and cooling in thermal grids is less than 1% worldwide. Given this fact, SHC Task 55 set the goal to support the growing market of solar district heating and cooling systems.

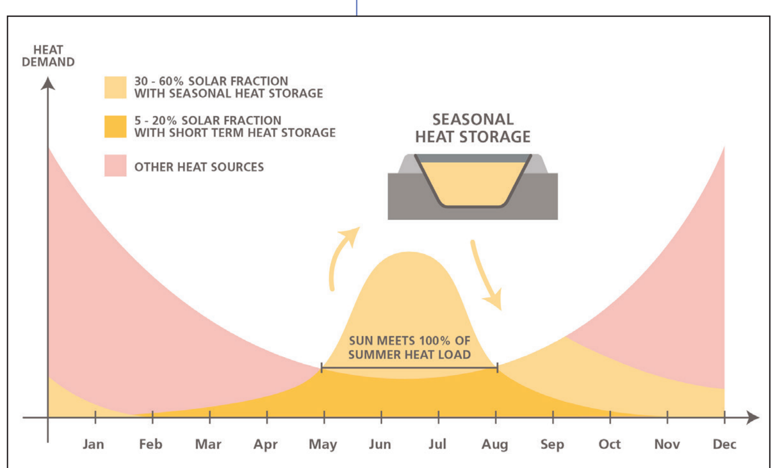


◀ **Figure 3. Key figures for solar district heating in Denmark in 2019.**

What About Storage?

Seasonal pit heat storages connected to large-scale solar plants for district heating are now in use in several countries throughout the world (e.g., Denmark, Germany, China). The concept is for seasonal storage, but has the possibility for shorter heat storage periods, as it provides quick charging and discharging.

In principle, pit heat storage is a large water reservoir for storing thermal energy. Water is an excellent medium for heat storage as it is cheap, non-toxic, and has a high heat capacity. The cost of water storage mainly consists of the parts surrounding the water, for example, the watertight tank and thermal insulation. For smaller storages (up to 5,000 m³), an insulated steel tank is typically used, but for larger storages, a pit heat storage is considerably cheaper per m³ water.



▲ **Figure 4. Seasonal storage principle.**

Based on the experiences from the implemented storages in Denmark, an extrapolated price curve is shown in Figure 5. The economy of scale is clear. Going from 60,000 m³ to 500,000

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m³, the expected specific costs are reduced by more than 20% (from approximately 50–30 €/m³).

Is the Market Growing?

Solar district heating is steadily growing along with the number of megawatt-scale systems for district heating and industrial applications. Twenty-three large-scale solar thermal systems with about 228,900 m² (160 MWth) were installed in Europe in 2019. Of these installations, 15 were in Denmark (191,300 m²), including five extensions of existing systems, six in Germany (14,700 m²), one in Latvia (21,700 m²), and one in Austria (1,200 m²). With the addition of Denmark's new systems, that market grew a remarkable 170% in 2019.

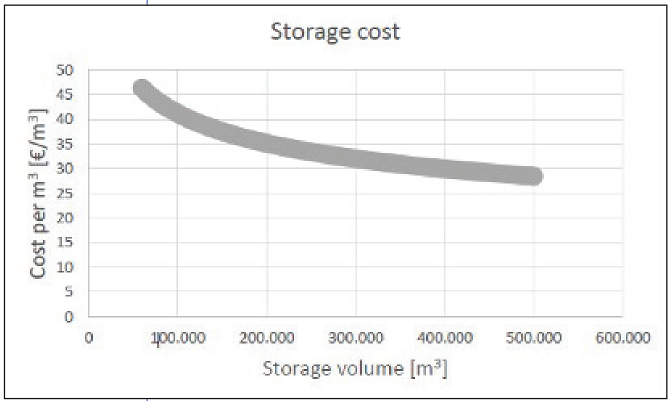

Figure 5. Estimation of the costs for pit heat storage as a function of the size of the storage. (Source: PlanEnergi)

During SHC Task 55, the installed collector area for solar district heating (SDH) has increased significantly. In 2016, the world's largest SDH collector area was built in Denmark, coming in at 157,000 m², followed by major projects in Tibet with 22,000 m² of collectors reaching solar fractions up to 100% of the space heating demand, and Germany's largest plant with 14,800 m² of collectors. It is expected that this trend of large-scale SDH systems will continue in the coming years and that these systems will become increasingly important for the decarbonization of the heat supply.

The chart below classifies several countries according to their attractiveness for SDH. The appeal of a national market is based on the technological readiness of its district heating sector.

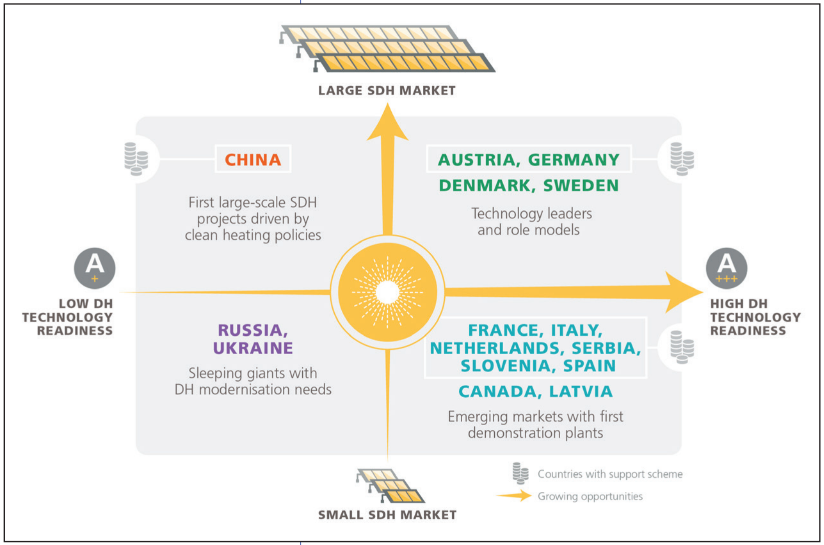

Figure 6. Attractiveness of solar district heating in different countries.

Conclusion and Outlook

Solar-assisted district heating and cooling networks form an essential part of a future-oriented renewable-based energy system, with high CO_2 savings and low operational costs. The integration of large-scale solar thermal plants into district heating or district cooling networks exploits the interactions between thermal networks and solar thermal, contributing to significant decarbonization of the heating sector.

Thermal grids offer the possibility of increasing energy efficiency in urban areas and integrating renewable energies into the heat supply. Solar thermal energy is essentially emission-free, fully renewable, always available, and cost-stable over the long term. Moreover, solar heat networks are a proven and reliable technology based on more than 25 years of experience of operators and industry experts regarding development, operation, and maintenance.

Financing solar district heating projects, however, can be complex. Especially if the construction of seasonal storages or heating networks is planned in addition to the large-scale solar thermal system as these are very capital-intensive investments. Since there is still a lack of broad practical experience, many stakeholders are still unclear and uncertain about the financing of solar thermal energy. A professional assessment of the risks is therefore indispensable for a viable financing concept. Transparent risk management is relevant for a large and diverse target group ranging from

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investors, lenders, bankers, and insurers to project developers, operators, and if applicable, end customers and political decision-makers. Although considered to play an essential role in the decarbonization of the heating sector, solar thermal energy needs very attractive funding instruments, particularly when using solar thermal energy in heating grids to accelerate its expansion.

Unfortunately, there is no patent remedy. Rather a differentiated approach is necessary to take into account the unique risks of each project due to their specific parameters, such as geographical location, model selection, participation structure, etc. Nevertheless, with each built plant, the wealth of experience gained and the contribution to a renewable energy transition is unquestionable.

If the goal of an almost climate-neutral supply of heat to buildings is to be achieved, there is no way around a massive expansion of the renewable district heating supply.

For the decarbonization of district heating, it will be important to use all the available renewable generation options and to combine them optimally according to the respective local conditions. In addition to the many individual measures, large-scale projects are indispensable, particularly in the area of district heating supported by solar thermal energy and solar thermal systems for housing blocks and neighborhoods.

Article contributed by Sabine Putz of SOLID, Austria, and the Operating Agent of Task 55: Integrating Large Solar Heating and Cooling Systems into District Heating and Cooling Networks, https://task55.iea-shc.org.

**A follow-on IEA SHC project on Efficient Solar District Heating Systems is scheduled to begin in January 2022. For more information on this new project, contact Viktor Unterberger, viktor.unterberger@best-research.eu.*

INTERVIEW

Large-Scale Solar Thermal District Heating and Cooling

One on One with Sabine Putz

The SHC Programme wrapped up its third project on large solar systems (Task 55) in December 2020. To learn how the Task impacted this market sector, we've asked Sabine Putz, the Austrian Task Operating Agent, to share some of her thoughts on this 4-year project.

Why was a project like this needed?

Solar thermal district heating has developed rapidly in recent years, and today, it's a technology ripe for delivering heat on a large-scale to district heating networks. In combination with large-scale heat storage, solar heat can become an important part of the energy mix for heating cities or districts. Several studies have proven that solar heat could hold a significant share of existing and new district heating networks all over the world.

What is the current status of the technology?

The first large-scale solar heat networks started to be deployed in the USA and Europe around the 1970s.

In Europe, the first solar heat networks were installed in Sweden around 1979; they were connected to newly built residential areas at Ingelstad, outside the city of Växjö, and at Lambohov, outside the city of Linköping. By 2007, there were around 119 solar heat networks installed across Europe.

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The first solar heat network in Denmark, the current worldwide leading solar district heating country, was put into operation in the spring/summer of 1985 at Vester Nebel. It consisted of 296 m2 of flat plate collectors installed on the field in front of the district heating substation (straw and oil) and heated approximately 100 houses.

Today, Denmark is the leading country in solar thermal district heating and a good example of a mature and commercial solar district heating market, but other markets are catching up, especially China. In several other countries, smaller niche markets exist, such as in Austria, where 29 systems >500 m^2 are installed to feed into district heating networks, smaller microgrids in urban quarters, or local biomass heating networks supply heat to large residential, commercial, and public buildings. Other countries to note are Germany with 46 large-scale systems (some of these with seasonal storage), Sweden 25 systems, France 18 systems, Poland 15 systems, Greece 13 systems, and Switzerland 17 systems. Although Germany is currently considered a niche market, relative to Denmark, accelerated market growth is observable.

Is there one result/outcome that surprised you?

Yes, industry participation was very high. More than 60% of the Task experts came from industry, such as collector producers and solar thermal system installers. The cooperation of participants, even when from competing industries, was driven by the common goal – faster market development through awareness building of the technology and its reliability.

Do you have a Task success story from an end-user or industry to share?

At the first Task Meeting in 2016, two industry experts (a Danish and Chinese system installer) met for the first time. They discussed a potential solar district heating plant in China, which was finally built in 2018. This installation of 22,000 m^2 flat plate collectors, a 15,000 m^3 seasonal pit storage, and new district heating pipes was installed at an altitude of more than 4,000 meters in Tibet and was entirely financed by the Chinese Government.

Another success story is the Task's investor brochure, which explains solar district heating technologies, their advantages, and market developments. The brochure includes business models, best practice examples, infographics, and statements by investors. You can download it from the Task 55 webpage.

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

The cooperation of solar thermal industry partners and the information shared by experienced turnkey installers no doubt contributed to a faster-growing number of installations. For example, a French solar thermal installer decided to step into solar district heating while before he only wanted to install solar process heat plants.

Furthermore, four big events were held – two IEA SHC Solar Academy trainings to build awareness in the U.K. and China, an SHC Solar Academy Webinar, and a technology transfer workshop at the end of the Task. So, I would definitely say that the Task´s work supported capacity and skill building.

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

Today, the energy cost of solar thermal for district heating is just under 40–60€/MWh for district heating (depending on location/country conditions/fossil price). This price needs to come down to 30€/MWh to compete with conventional fuels. It is estimated that this is achievable with investment aid. In the long run, a price of 20–25€/MWh is realistic. The path to profitability is calculated with a relatively low-price elasticity where the energy price of solar heat is halved in the event of a 20 times increase in sales volume. This is because certain costs such as laying pipes in soil and construction work are well-established techniques with fewer volume effects.

What is needed to bring down heat costs?

- The bigger, the better – the larger a solar district heating system is, the lower the heat generation costs and heat price (in case of selling the heat instead of the installation)
- Large components, like solar thermal collectors, need to cost less
- Standards for design and construction of seasonal storages
- Support by decision-makers and funding bodies to convince utilities to switch to renewable district heating

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

Better cooperation between research and industry. The research experts got first-hand information about what the industry really needs – bring down costs and help facilitate the uptake of new technologies, such as concentrating solar thermal systems for district heating.

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

Yes, a follow-up Task is already on the way. The first Task Definition Meeting was held, and there is even more interest by stakeholders and utilities in joining this project. The focus is on taking the next steps to reduce solar district heating system costs, the use of medium and high-temperature collectors, as well as digitalization measures to increase data quality and use.

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.

Solar District Heating

Business Models for Large-Scale Solar District Heating

Large solar thermal plants feeding into district heating networks represent only about 1% of the installed capacity of solar thermal systems, even though competitive prices lower than 40€/MWh can be reached. In the long run, solar district heating could represent 4–15% of the total technical potential of solar thermal energy.

Increasing the solar fraction in district heating systems requires considerable technological development and management structures for all phases starting from the idea to the implementation and operation.

Societal and regulatory challenges:

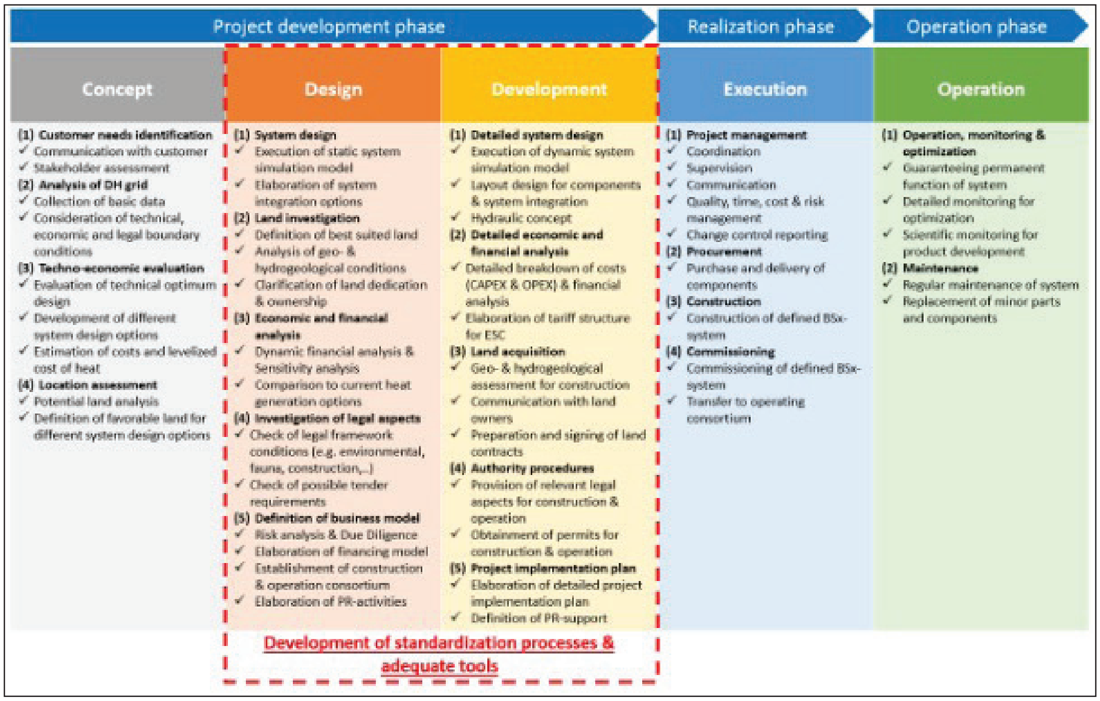
- Lack of awareness about solar heat generation among heat suppliers and stakeholders
- National approval procedures have yet to be developed because solar projects of this size are not known
- Needs of procurement procedures don't match the structure of highly innovative projects

Technological challenges:

- A great variety of different technological competencies and building trades must be joined together
- Seasonal storages are characterized by their dimensions, which need to be established individually for each location. Therefore, the system design and operation strategy are essential and complex–they must comply with the framework conditions of the existing system and be developed individually for each project.
- Land availability is usually a major issue and may cause system adaptations, e.g., long transport pipelines and additional smaller buffer tanks

Business and organizational challenges:

- Project development is still extremely complex, both time-consuming and expensive
- Investment volumes are enormous, so high-level due diligence is needed
- Many stakeholders need to be involved
- Partnerships with energy suppliers and financiers must be established



◀ **Big SolarX project life cycle.**

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- A suitable, individual business model is needed for each project, including major steps such as:
  - Financing structures with several partners
  - Construction partnerships
  - Risk-sharing model
  - Establishment of an operating company
  - Long-term energy service contracting models up to 30 years agreed on

Below is a business model based on a large-scale solar district heating installation with an energy performance contract to overcome these challenges. This model is particularly applicable for turnkey solution providers.

To learn more, download the Fact Sheet, Business Models of Solar Thermal and Hybrid Technologies and visit the Task 55 webpage, https://task55.iea-shc.org.

Solar Process Heat

Spain recently launched an investment grant scheme focused on industrial solar heat, joining an already long list of European countries—including Austria, Germany, France, Italy, and the Netherlands—that have created similar programs. Outside Europe, investments in the technology, also known as SHIP, are often supported via tax incentives (accelerated depreciation or tax exemptions), as is the case in Mexico, Morocco, South Africa, Uruguay, and the United States.

To get a better grasp of the existing national funding programs, IEA SHC Task 64: Solar Process Heat surveyed experts involved or connected to the Task. You can find the survey results in the SHC Task 64 report, Collection of available solar process heat related national and trans-national research and funding programs.

"One clear conclusion from the survey results is that the availability of SHIP incentives has a significant influence on whether the technology becomes more widespread," explained the co-author Peter Nitz of SHC Task 64. "However, incentives or funding alone are not a guarantee for success. There are many more factors involved in these rollouts." Nearly all experts of the Subtask agree that a funding or incentive scheme should be set up, preferably one that offers direct support when the initial investment is made. This would help get the SHIP market off the ground – at least as long as competing fossil fuel-fired systems are comparatively cheap and the carbon price low.

To learn more, visit the SHC Task 64 webpage, https://task64.iea-shc.org, and read the solarthermalworld.org news article, https://www.solarthermalworld.org/news/europe-holds-top-spot-ship-incentives.

"One clear conclusion from the survey results is that the availability of SHIP incentives has a significant influence on whether the technology becomes more widespread. However, incentives or funding alone are not a guarantee for success. There are many more factors involved in these rollouts."

PETER NITZ

IEA SHC Task 64 expert
Fraunhofer Institute

PVT Systems

The work of SHC Task 60: PVT Systems during 2018–2020 benefited from the participation of some of the top manufacturers of PVT collectors in the world. One of these manufacturers, DualSun in France, recently became the first PVT material manufacturer awarded the prestigious "EU Top Brand PV label" by EUPD Research.

To learn more, visit the SHC Task 60 webpage, https://task60.iea-shc.org.

SHC Publications

New Publications Online!

You won't want to miss the new reports highlighted below. You can read them online or download them for free. Our complete library of publications – online tools, databases, and more – dating back to the start of the SHC Programme can be found on the IEA SHC website under the tab "Publications" or under a specific Task.

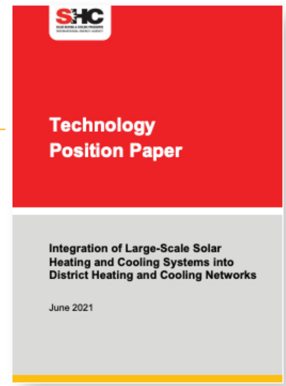
Technology Position Papers

Each Technology Position Paper explains the relevance, current status, potential, and actions needed for the uptake and further development of a specific technology or application. The target audience is policy- and decision-makers.

Integration of Large-Scale Solar Heating and Cooling Systems into District Heating and Cooling Networks

Explains how a holistic approach is necessary for successful large-scale integration of thermal heating and cooling systems, including large-scale heat pumps and seasonal storages, and how the technology can support the rapid decarbonization of district heating through specific actions.

**Based on the work of SHC Task 55*



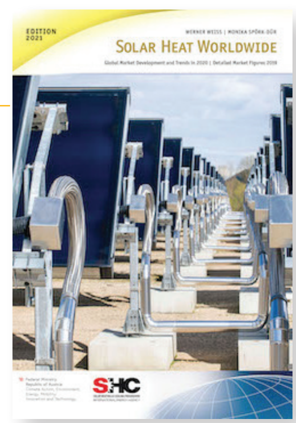
PVT Collectors and Systems

Examines how to support the development and market penetration of PVT collectors and systems. PVT technology is a hybrid technology combining a PV (photovoltaic) module and a solar thermal collector (ST); therefore, it produces electricity and heat simultaneously from solar without requiring more space than a PV-only collector would.

**Based on the work of SHC Task 60*

Solar Heat Worldwide 2021

This is the most comprehensive report on the solar thermal market and trends. Data from 68 countries, representing 95% of the solar market, provides the basis for this comprehensive annual report on solar heat. It is divided into two parts: Part 1(Chapters 3-4) covers global market developments in 2020 and highlights trends for different applications, and Part 2 (Chapters 5-7) presents detailed market figures for 2019.



SHC Annual Report 2020

Feature article on PVT.

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Publications *from page 27*

Integrated Solutions for Daylighting and Electric Lighting

BSDF Generation Procedures for Daylighting Systems

This white paper summarizes the current state of the art in the measurement and simulation characterization of daylighting systems by bidirectional scattering distribution functions (BSDFs). It provides recommendations broken down by classes of systems and use cases.

Solar District Heating

A series of 29 **Fact Sheets** summarize the main results from the work of SHC Task 55: Integration of Large-Scale Solar Heating and Cooling Systems into District Heating and Cooling Networks

Solar Process Heat

Reference Applications for Renewable Heat

An overview of the requirements for renewable heating systems by defining reference applications composed of a load profile, a temperature level, and a location. A supplementing Excel Tool can be downloaded here.

Collection of available solar process heat related national and trans-national research and funding programs

This is a collection of research and incentive programs available for SHIP projects, plus information on additional aspects and recommendations.

Material and Component Development for Thermal Energy Storage

TCM measuring procedures and testing under application conditions

This report includes a list and description of available and needed TCM characterization procedures for the identified material and reaction properties, results of a round-robin test of a TCM candidate, a description of a harmonized measurement procedure for the TCM performance under realistic application conditions.

PVT

PVT Systems: Numerical Simulation Tools for PVT Collectors and Systems

The report summarizes the currently available and most commonly used tools for solar photovoltaic-thermal (PVT) solutions performance determination.

Collection of Documents Prepared Along the Task for Industry and Market

This report gathers all documents and links to information that SHC Task 60 produced to promote its activities and PVT technologies.

Performance Assessment of Example PVT Systems

The Key Performance Indicators (KPIs) determined for the different PVT solutions give the possibility to compare the systems despite their diversity. The goal was to show the potential of PVT collectors in different fields of application.

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 a total of 67 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 Operating Agents.

Follow IEA SHC on

SOLARUPDATE

The Newsletter of the IEA Solar Heating and Cooling Programme

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