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Newsletter of the International Energy Agency Solar Heating and Cooling Programme

SHC INTERNATIONAL ENERGY AGENCY Solar Heating & Cooling Programme

iea Energy Technology Network

#SolarThermal
#SolarProcessHeat
#SolarCooling
#SolarDistrictHeating

In This Issue

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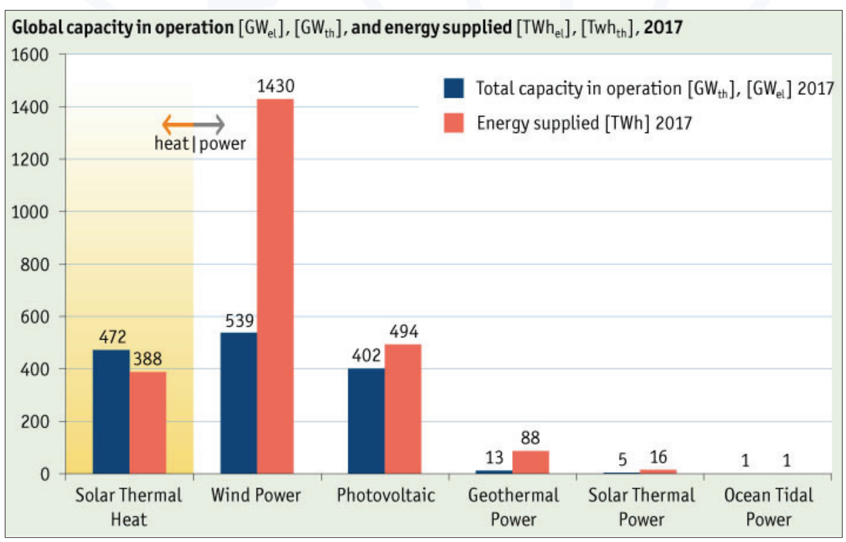
Solar Heat Worldwide 2018

Rising demand for megawatt systems and industrial applications

Based on data collected from 66 countries, representing 95% of the global solar thermal market, means that the IEA SHC Programme's Solar Heat Worldwide is the most comprehensive publication on the global solar heating and cooling market. New to this year's report is an overview of concentrating solar collectors used for district heating and industrial processes.

With 472 gigawatt thermal (GWth) installed at the end of 2017, solar heating and cooling was again the largest solar sector worldwide followed by Photovoltaics (402 GWel) and Concentrating Solar Power (5 GWel). The two key areas of growth were solar heat for industrial processes (SHIP) and solar district heating.



Global capacity in operation [GWel], [GWth] 2017 and energy supplied [TWhel], [TWhth]. Sources: AEE INTEC, Global Wind Energy Council (GWEC), SolarPower Europe, (EPIA), REN21 - Global Status Report 2018

Solar Heat in Industry

2017 was a record year for solar heat in industrial processes (SHIP), which was driven by economic competitiveness, a strong supply chain and policies to reduce air pollution. The year ended with 124 new SHIP plants installed worldwide with India and Mexico topping the list for number of new plants.

SHIP is a global business – the largest plants that came online last year were in Oman, China and Afghanistan. The Mirah solar plant in Oman is a 100 MWth

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"Heating accounts for 47% of the world's energy demand, which is higher than the combined demand for electricity (17%) and transport (27%) — a statistic that highlights the huge potential for solar heat."

DANIEL MUGNIER
IEA SHC Chairman

parabolic trough collector field installed in a greenhouse structure to protect the collectors from wind and sand. The solar steam generated is used in place of natural gas to extract heavy oil at the Amal oilfield.

Solar District Heating

Solar thermal district heating (SDH) is proving to be the most cost-effective way to decarbonize the heating sector. In 2017, France, Serbia, Australia and Kyrgyzstan brought their first SDH installations above >500 m^2 (350 kWth) online. In total, 15 large-scale solar thermal systems began operation, mostly in the established markets of Austria, China, Denmark, Germany and Sweden. The largest installation (75,000 m^2) started operation in Inner Mongolia in October 2016 and is followed by a Danish installation (26,929 m^2) in the municipality of Brønderslev. And for the first time, parabolic trough collector technologies were used for feeding energy into district heating networks.

Residential Solar Heating and Cooling

Due to increasing competition with other renewable technologies in the residential sector and continuously low fossil fuel prices in 2017, new installations in China and Europe declined. The added global solar thermal capacity of around 35 GWth was down by 4.2% in 2017.

This downward trend of the previous year flattened out somewhat in China last year due to the rising demand for solar space heating and solar water heaters for large real estate projects. New installations in China declined by only 6% relative to 2016, which saw a 9% one-year market decline, following an even larger year-to-year contraction (-17%) in 2015.

Despite declining markets in China and Europe, three countries saw their markets grow – India (26%), Mexico (7%) and Turkey (4%). All three markets have cost competitive residential solutions and no direct subsidy schemes in place. Therefore, it is no surprise that India and Turkey have the lowest solar hot water prices with 2 to 3 €-ct/kWh according to the Levelised Cost of Heat calculations documented in this report.

On the high end of solar hot water costs are France with 19 €-ct/kWh for small systems and 14 €-ct/kWh for multi-family houses, and Denmark with 16 and 12 €-ct/kWh respectively.

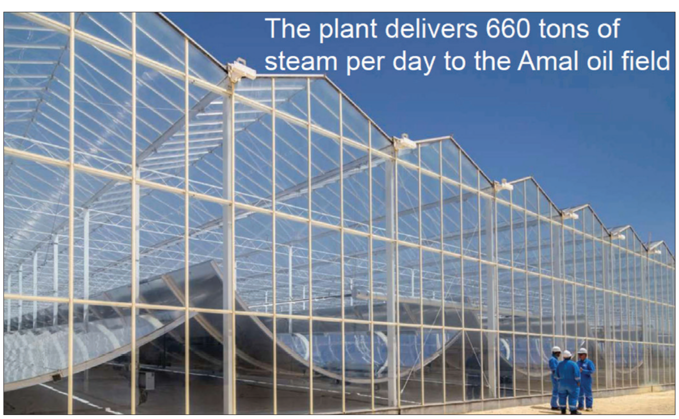
HIGHLIGHTS FROM THIS YEAR'S REPORT

New Capacity

The vast majority of the 36.5 GWth of new installed capacity in 2016 was in China (27.7 GWth) and Europe (3.2 GWth), which together accounted for 85% of all new installations.

Applications

On the technology side, evacuated tube collectors are the clear market leader, accounting for 73.8% of the newly installed capacity and driven by the dominance of the Chinese market. Followed by flat-plate collectors (22%), unglazed water (4%), and glazed and



Indoor parabolic trough collectors at the Mirah plant in Oman.
Photo credit: Barbara Soldera, GlassPoint Solar, Inc.

Solar district heating plant with load-balancing pit storage in Vojens, Denmark.

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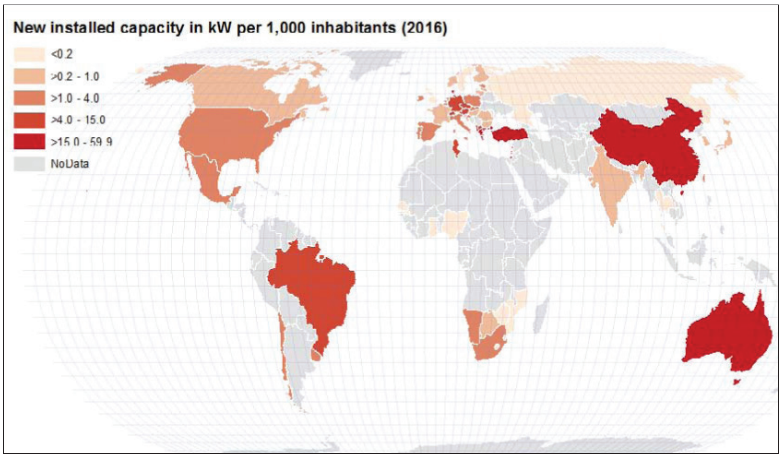
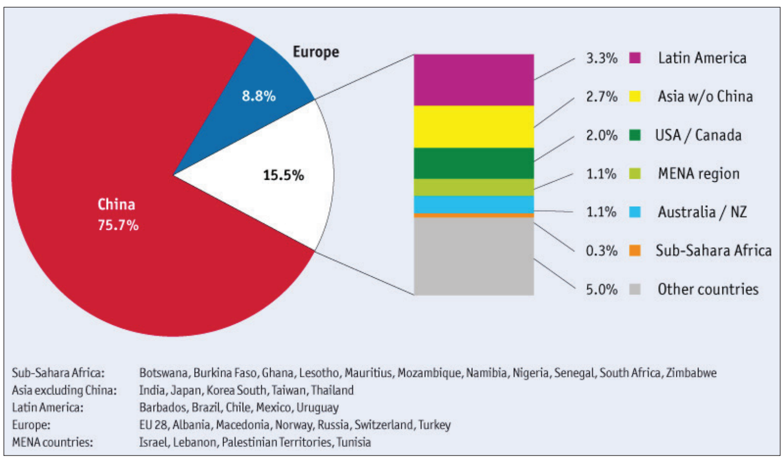
Solar Heat Worldwide *from page 2*



Share of newly installed capacity (glazed and unglazed water and air collectors) by economic region in 2016.



New installed capacity in 2016 in kWth per 1,000 inhabitants.

unglazed air collectors (0.2%). Evacuated tube collectors dominated the market, but there was a notable change with the share of evacuated tube collectors decreasing from 82% in 2011 to 73.8% in 2016 and in the same timeframe flat plate collectors increasing their share from 14.7% to 22%.

Jobs & Environment

In 2016 the estimated number of jobs (production, installation and maintenance) was 708,000.

The worldwide turnover of the solar thermal industry in 2016 is estimated at €16 billion.

Solar thermal systems in operation at the of end of 2016 produced 375 TWh, which corresponds to a final energy savings equivalent to 40.3 million tons of oil and 130 million tons of CO_2.

You can read the full report at IEA SHC website, http://www.iea-shc.org/solar-heat-worldwide.

Top 10 Markets

New Installations in 2016 (in MWth)	**New Installations per 1,000 Inhabitants in 2016** (in kWth)
China 27,664	Denmark 60
Turkey 1,296	Cyprus 36.1
Brazil 913	Israel 36
India 841	Barbados 27
United States 682	China 20
Germany 536	Greece 18
Australia 381	Australia 17
Denmark 335	Turkey 16
Israel 295	Austria 9
Mexico 256	Palestinian Territories 8

Top 10 Total Capacity

Total Collector Installations in 2016 (in MWth)	**Total Collector Installation per 1,000 Inhabitants in 2016** (in kWth)
China 324,506	Barbados 515
United States 17,565	Austria 418
Turkey 14,933	Cyprus 399
Germany 13,535	Israel 397
Brazil 9,555	Greece 292
India 6,673	Palestinian Territories 289
Australia 6,181	Australia 269
Austria 3,645	China 236
Israel 3,244	Denmark 204
Greece 3,148	Turkey 186

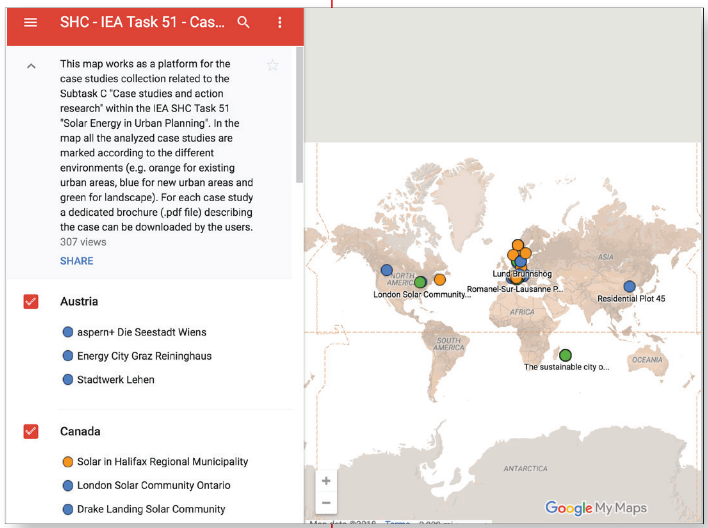
Task 51

Solar Energy – An Important Part of Urban Planning

Producing energy locally by integrating solar energy systems in the built environment is a key element of sustainable buildings and cities. And with the built environment accounting for over 40% of the world's total primary energy use and 24% of greenhouse gas emissions, a combination of making buildings more energy efficient and using a larger fraction of renewable energy is vital.

How to technically integrate solar energy systems into buildings is important, but the only way to ensure long-term solutions is if urban planning takes into account the technical and the non-technical solar issues. Because what's the purpose of integrating a solar system into a building if in a few years it becomes shaded by a new building across the street? Understanding that long-term solar strategies, including legal considerations, need to be taken into account in urban planning, the participants in SHC Task 51: Solar Energy in Urban Planning worked for four years to do just this.

The main objective of SHC Task 51 was to support urban planners, authorities and architects by providing guidance. This included developing approaches, methods and tools capable of assisting cities in developing a long-term urban solar energy strategy that also takes heritage and aesthetic issues into consideration, and preparing material and suggest teaching methodologies to strengthen education.



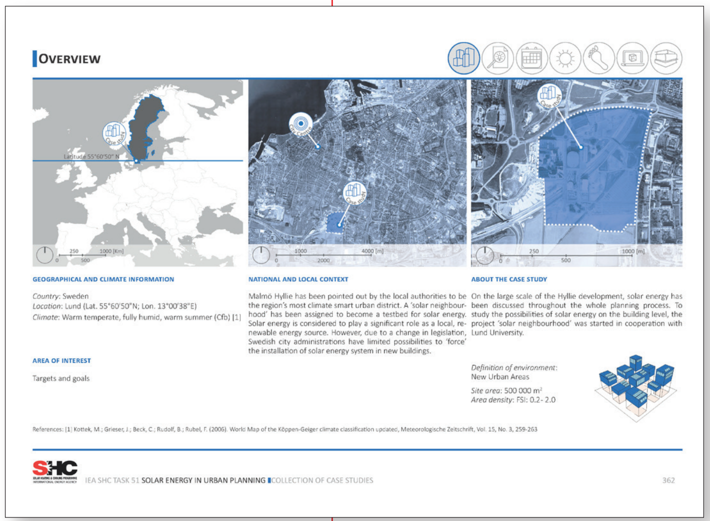
SHC Task 51 participants created this map database of the 30+case stories. It can be found on the SHC Task 51 webpage, http://task51.iea-shc.org/.

The scope of the Task included solar energy issues related to 1) new urban area development, 2) existing urban area development and 3) sensitive and protected landscapes (solar fields). Both solar thermal and photovoltaics were taken into account as well as passive solar (i.e., passive solar heating, daylight access and outdoor thermal comfort). Understanding the existing parameters and challenges under which planners operate in each of these three scenarios is critical.

Action Research Results in 30+ Case Stories

Through action research the participants actively took part in urban planning processes, creating "arenas" for mutual interaction between researchers and city managers. More than 30 case stories from 10 countries were analyzed and compared in three reports[1, 2, 3] and the lessons learned were condensed into guidelines for solar energy in urban planning.

One example of the lessons learned was the importance of raising awareness on how to implement solar energy into an urban area. One holistic approach is to involve all relevant stakeholders of urban planning. This involvement extends to citizen engagement, which is crucial in building agreements, creating understanding and achieving solutions. This approach ensures wide representation of stakeholders and increases the chances of reaching ambitious goals



Every case story in the map database shown above includes a PDF with a detailed write-up.

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by overcoming barriers in developing solar energy in urban planning through an open communication forum.

The research also illustrated the importance of introducing solar with systematic respect to the urban context to preserve heritage and avoid unnecessary aesthetic conflicts. There is a risk if these aspects are not taken seriously that the social acceptance of solar technologies may decrease and in the long run slow down the pace of solar utilization.

Generic Planning Process Highlights Methods and Tools

Urban planners are typically generalists who have to consider many different aspects so it is important that methods, tools and approaches are designed to aid them in their work rather than increase their workload. To structure and describe supportive methods and tools related to different urban planning stages, a generic planning process was developed in SHC Task 51 that involves four stages: 1) comprehensive/strategic planning, 2) urban and landscape design, 3) detailed development plans, and 4) architectural design (see illustration below).

In this Task, the approaches, methods and tools (AMTs) are described according to one of the four urban planning stages noted above. The AMTs can be divided into four types: 1) regulatory, policy and governance approaches, 2) integrated design and planning support, 3) assessment methods and tools, and 4) awareness and consultation methods.

Today, urban planners are increasingly calling for more sophisticated decision support tools to assess the active solar energy potential and measures when determining the impacts of a future development. And many software tools do exist to calculate and visualize the solar insolation of an urban area, but there is a lack of approaches and methods on how to integrate the results from these tools into traditional urban planning processes. Available software tools also vary in complexity, user friendliness and quality of end result. To address this, the participants of SHC Task 51 worked extensively on developing approaches, methods and tools to help better understand solar energy's potential in an urban planning context and to define the level of detail needed in the different phases of urban planning.

Solar Access is a Right

Legal aspects are crucial to highlight as they can ensure the long-term access to solar radiation onto buildings and other collecting areas. Historically, solar access rights focused on daylight. Now with increased local solar energy production, it is time to revisit the legal framework and identify to what extent it enhances or hinders deployment of solar energy technologies. The analysis carried out from national perspectives in SHC Task 51 shows that the laws are insufficient. Legal reform is needed in many countries as the typical subjective judgment that a lack of solar access is only a 'nuisance' creates significant investment uncertainty and barriers that could be solved through more informed decision-making processes.

Ultimately, the research found that active solar systems have a critical role to play and their deployment will conflict with future development heights if there is not a more cohesive relationship between planning approval processes and building innovation.

Urban Planning Education Needs Link to Solar Energy

Urban planning curriculums at universities rarely include solar energy. These types of courses are instead mostly offered in other

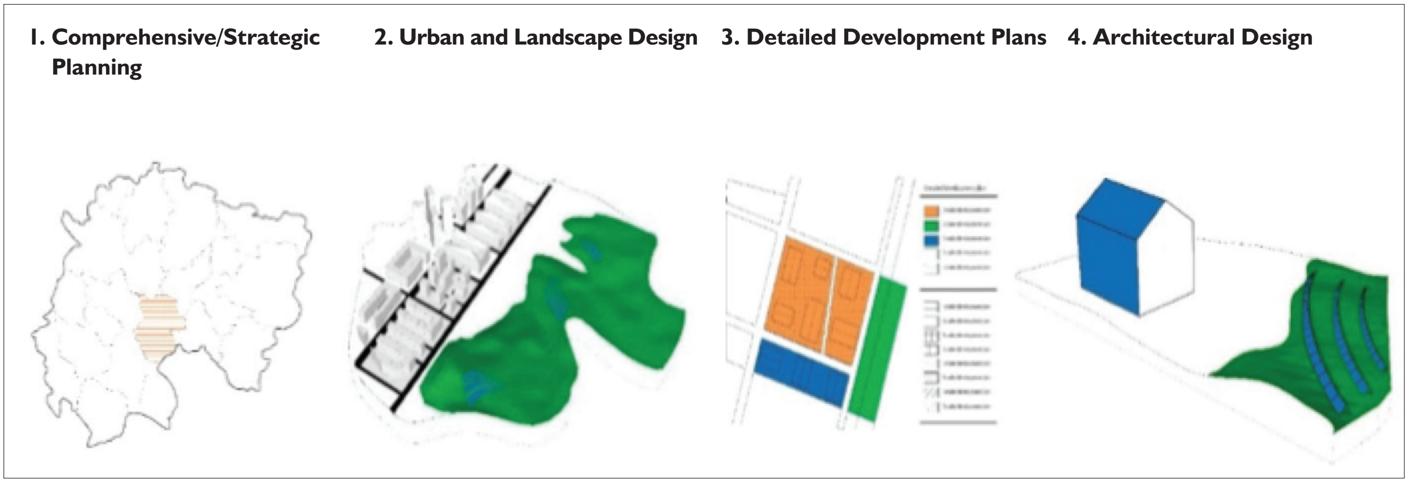

Illustration of SHC Task 51's four stages of urban planning.
Source: Marja Lundgren & Johan Dahlberg. Illustrations by Amanda Fröler, White Arkitekter

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disciplines[4]. By identifying the gaps and barriers in existing courses and pedagogy the missing links can be added to relevant seminars, lectures and tools for educating the next generation of architects, urban planners and specialist planners. SHC Task 51 has supporting materials and reports available for free on the SHC Task 51 webpage for example, the online tool, Solar Potential Analysis that was developed for both students and life-long learners can be found here.[5]

Solar Energy + Urban Planners Equals a Brighter Future

As the number of sustainable developments continues to grow it is inevitable that the demand for solar technologies in both urban environments and open landscapes also will continue to grow. And, with this growth comes the need for more work on ways to help urban planners and designers understand the complexities when dealing with daylight, active solar and energy performance in cities experiencing rapid population growth.

The role of the urban planner is to design areas that can be built to last. Urban design that addresses the need for daylight and sunlight will not only contribute to a healthier urban environment, it will also enable solar thermal technologies and photovoltaics to be implemented if not now, then in the future. Action research related to planning and designing solar neighborhoods is a much needed activity as it enables researchers, professionals and municipalities, including their inhabitants, to jointly develop and test concepts and solutions for the sustainable use of solar resources in the built environment.

Parts of this article are based on the more comprehensive conference paper: Urban Planning for Solar Energy – IEA SHC Task 51 by Wall, M., Snow, M., Dahlberg, J., Lundgren, M., Lindkvist, C., Lobaccaro, G., Siems, T., Simon, K. & Munari Probst, MC., presented at SHC 2017 / SWC 2017 Conference and to be published online in 2018.

To learn more and find all the SHC Task 51 reports visit the Task 51 webpage, http://task51.iea-shc.org/.

1 Lobaccaro, G., Lindkvist, C., Wall, M., Wyckmans, A. (eds.), 2017. Illustrative Prospective of Solar Energy in Urban Planning. Collection of International Case Studies. IEA SHC Task 51/Report C1. DOI: 10.18777/ieashc-task51-2017-0002.

2 Lobaccaro, G., Lindkvist, C., Wall, M. (eds.), 2018. National and International Comparison of Case Studies on Solar Energy in Urban Planning. IEA SHC Task 51/Report C2. DOI: 10.18777/ieashc-task51-2018-0001.

3 Lobaccaro, G., Lindkvist, C., Wall, M. (eds.), 2018. Lesson Learnt from Case Studies of Solar Energy in Urban Planning. IEA SHC Task 51/Report C3. DOI: 10.18777/ieashc-task51-2018-0003.

4 Siems, T., Simon, K., Wall, M. (eds.), 2017. State-of-the-Art of Education on Solar Energy in Urban Planning. Part I: Approaches and Methods in Education. IEA SHC Task 51/Report D1 Part 1. DOI: 10.18777/ieashc-task51-2017-0001.

5 Hendel, S. & Voss, K., 2017. Urban-based solar potential analysis – A teaching and learning tool for determining the solar energy use at the district scale. User manual, IEA SHC Task 51. The online tool is available free of charge here.

Heat and Electricity from the Same Roof

Solar heat and solar electricity can make a good team when combined on a roof. The technology, PV-Thermal (PVT) systems combine the production of both types of solar energy in one collector. In the past few years, demand for this new type of solar technology has been growing, and to support this upcoming market, IEA SHC launched Task 60: Application of PVT Collectors and New Solutions in HVAC Systems.

In several European countries the PVT market is picking up speed, particularly in France and Switzerland. "We see interest in new PVT solutions rising in several countries, as roof space is limited in urban areas," notes Jean-Christophe Hadorn, leader of SHC Task 60 on PVT systems. In 2016, France installed a total of 620 PVT installations with a solar peak power of 1.7 MWel (around 17,000 m^2) according to a market survey carried out by the French consultancy Observ'ER.

PVT system in the southern French town of Sète supplies heat and electricity to a public pool.
Photo credit: Dualsun

In Switzerland, water-driven PVT systems dominate the market. These panels have the same size and structure as PV modules, but a heat absorber is laminated, glued or clamped to the backside of the PV module. This type of system is increasingly being used in combination with ground-sourced heat pumps because the solar energy can be used to re-heat the ground over the summer – to "regenerate" the heat source, as experts say. Researchers from the Swiss SPF Institute of Solar Technology estimated that in Switzerland 300 PVT systems were operating at the end of 2016. Despite the growing demand, PVT is still a young technology so needs the full range of support from research to marketing.

PVT's Potential

Seven multi-family houses in the Swiss town of Blatten with PVT systems on the roofs.
Photo credit: Schweizer Reisekasse (Reka) Genossenschaft

PVT technology has the potential to be very efficient because of the symbiotic combination of the two technologies. A PV module uses 15 to 20% of the incoming solar energy, depending on the cell technology used, and the rest is lost in the form of heat. A PVT system uses this "lost" energy to heat air or water. At the same time, taking away the heat from the panels cools the PV cells, and this makes the PV component work more efficiently. But the output of electricity and heat depends on many variables, therefore, Hadorn sees an urgent need to create more transparency regarding the output, costs and certification of the different types of PVT systems. To support this, SHC Task 60 participants

Table 1. Simulated and monitored annual yields of two PVT systems (300 m2 area each) installed at public swimming pools in France. Source: Dualsun

PVT location	Annual solar heat yield (TRNSYS simulation) kWh/a	Annual solar heat yield (measured) kWh/a	Difference	Annual solar electricity yield (TRNSYS simulation) kWh/a	Annual solar electricity yield (measured) kWh/a	Difference
Sète	81,354	82,100	2 %	55,826	59,113	5.9 %
Perpignan	97,077	119,870	23 %	60,535	63,942	5.6 %

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PVT *from page 7*

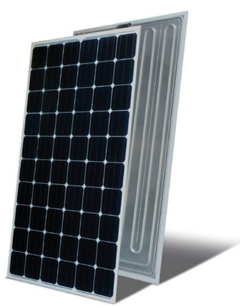
will gather monitoring data on heating and cooling systems using PVT systems. The goal is to compare the monitoring data with the simulated output so that calculation methods can be optimized.

Scientists at SPF Institute of Solar Technology have already made some evaluations:

- PVT collectors in central Switzerland usually produce an annual electric yield of about 160 kWh/m^2.
- The hot water production depends greatly on the application – the lower the required temperature, the higher the energy output. If domestic hot water (for showers, etc.) is heated directly, around 150 kWh per m^2 collector area can be gained annually. If the water is only pre-heated, 250 kWh/m^2 per year is possible. If boreholes of ground-sourced heat pumps are regenerated, annual solar yields of 300 to 400 kWh/m^2 can be gained.
- How much electricity production benefits from the cooling effect of PVT varies by the operating temperature on the heat side. Low-temperature applications lead to the highest efficiency gain – they typically show a 5% increase in annual solar electricity output compared to standard PV systems.

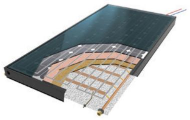
PVT TECHNOLOGIES

PVT without insulation
The structure is usually the same as a PV module. The PV cells are laminated between a glass on the front side and a polymer sheet on the backside. A heat absorber is laminated, glued or clamped to the backside of the module. The absorber can be made of metal or polymer material and it can be filled with air or liquid.



EVALUATION: Relatively simple construction, but higher heat losses and therefore lower temperatures of the heat transfer fluid

PVT with insulation
The structure is the same as above, but includes an insulation layer at the backside of the heat exchanger and an outside casing.



EVALUATION: More complex construction, but lower heat losses and therefore higher temperatures of the heat transfer fluid

The Emerging Industry

In the past three years, a growing number of specialized suppliers with approved technologies are dominating the European PVT markets. One of them is French-based Dualsun, which is participating in SHC Task 60. It has realized more than 500 PVT projects in Europe according to company information. Dualsun has published monitoring data for two 300 m^2 PVT fields for commercial swimming pools in the south of France, which match well with simulation results (see Table 1). This shows that the co-production of heat and electricity can be reliably predicted.

To learn more about SHC Task 60: Application of PVT Collectors and New Solutions in HVAC Systems visit the Task webpage, or contact the Task Operating Agent, Jean-Christophe Hadorn, jchadorn@gmail.com. This article was contributed by Bärbel Epp of Solrico.

SHC PVT Project

IEA SHC Task 60: Application of PVT Collectors and New Solutions in HVAC Systems began in January and will run through December 2020. Eleven countries (Austria, Canada, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, Switzerland and the UK) are working together to assess existing solutions and develop new system solution principles in which the PVT technology really offers advantages over the classical "side by side installations" of solar thermal collectors and PV modules. Energy production, competitive cost, safety and reliability of systems are therefore in the scope of the Task.

The international team of experts will work together to:

1. Provide an overview on the present (2018-2020) state-of-the-art PVT technology worldwide.
2. Gather the results and operating experiences from systems using PVT collectors.
3. Improve the testing, modeling and adequate technical characterization of PVT collectors to enhance (and simplify) the correct inclusion of PVT technology in simulation programs and planning tools.
4. Address all types of PVT collectors since the current markets have made no clear choices.
5. Find more typical PVT solutions beside the two applications that are now well known (i.e., regeneration of borehole storages and pre-heating of DHW for multi-family houses).
6. Explore potential cost reductions in the balance of systems, including piping technology and materials, hydraulics, controls, etc.
7. Increase awareness of PVT.
8. Support the "re-start" of the PVT industry.

For more information contact the Task Operating Agent, Jean-Christophe Hadorn, jchadorn@gmail.com, and visit the Task 60 webpage, http://task60.iea-shc.org/.

Solar Hot Water Training Course

SOLAR ACADEMY SHC

FOR HEATING & COOLING IN BUILDINGS & INDUSTRY

Increasing the number of Solar Water Heating (SWH) systems in Southern Africa could play a major role in reducing stress on the security of electricity supply, at the residential level and also for heating and cooling at the commercial level, for example in hospitals, hotels, student hostels, as well as providing heat for industrial processes. The Solar Thermal Demonstration and Training Initiative (SOLTRAIN) project aims to tackle these needs and create opportunities through addressing the SWH sector across six partner countries in the Southern African Development Community (SADC), which includes Botswana, Lesotho, Mozambique, Namibia, South Africa and Zimbabwe. The project has been running for three phases, and SANEDI and the Centre for Sustainable and Renewable Energy Studies (CRSES) are the South African implementation partners for this phase.

The partner countries in SOLTRAIN phase III are pursuing policies that enhance security of supply, energy conservation and increase energy access. CRSES is acting as a central point of entry into Stellenbosch University for the general field of renewable energy. The Centre has been hosting specialized trainings under SOLTRAIN and has been involved in the project for all three phases. In November 2017, CRSES hosted a 3-day specialized course on Solar Heat for Industrial Application supported by the IEA SHC Solar Academy. Fifty stakeholders from various sectors, such as government, private sector, universities, industry and other SOLTRAIN partners participated in the course. The course was lectured by Christoph Brunner, head of the Department of Industrial Processes and Energy Systems at AEE INTEC, Austria and the Operating Agent for the recently completed IEA SHC Task 49: Solar Heat Integration in Industrial Processes and the soon to start IEA SHC Task 62: Solar Energy in Industrial Water and Wastewater Management.

In addition to technical lectures, the course was interactive with problem solving group sessions simulating real situations and the participants were encouraged to apply lessons learned during the sessions. SANEDI/CRSES received feedback from participants that unanimously agreed that they derived great benefit from attending the course, and they expressed great interest in any future SOLTRAIN courses.

Comments from a survey sent to all participants after the course highlighted how participants returned home to immediately start implementing what they had learned regarding the diversification of the solar thermal business through including process heat functions. And, the training component on energy auditing has allowed knowledge transfer amongst workplace colleagues. Participants were eager to participate in future courses as this format of a low-cost professional training is of great benefit to the industry.

A second IEA SHC Solar Academy supported SOLTRAIN course is already planned for November 28-30 at Stellenbosch University. This course will be on solar cooling and air conditioning and will cover small scale and large scale cooling systems. The target audience is experts from universities, vocational training centers, solar companies and energy producing industries in South Africa, Namibia, Botswana, Lesotho, Mozambique and Zimbabwe.

This article was contributed by Khothatso Mpheqeke and Thembakazi Mali of SANEDI and the IEA SHC Executive Committee member representing South Africa. To learn more about the upcoming SOLTRAIN course contact Thembakazi Mali, ThembakaziM@sanedi.org.za. To find out more about all the SHC Solar Academy activities go to http://iea-shc.org/solar-academy.

Upcoming IEA SHC Academy WEBINARS

1. **Task 53: Solar Air Conditioning and Cooling**
   September 19, 2018
2. **Task 57: Solar Standards & Certification**
   December 12, 2018
3. **Task 55: Towards the Integration of Large SHC Systems into District Heating and Cooling (DHC) Networks**
   March 12, 2019

You can watch past webinars on the SHC YouTube channel – https://www.youtube.com/playlist?list=PLJnsUy6hAZRoFB7UIBSNHZHRLudQaXHgG

New Standard for On-Site Collector Testing in Development Stage

Once a large solar field is set up at its designated location, what tests can be conducted to show that it performs as expected? Soon, the IEA SHC Programme may have an answer to this question, as participants in two SHC Tasks are working on internationalizing Denmark's testing procedure. No decision has been made yet on whether the procedure will become part of a full-fledged standard or be turned into a technical specification.

Two IEA SHC Tasks, Task 55:Towards the Integration of Large SHC Systems into District Heating and Cooling Networks and Task 57: Solar Standards and Certification, have been involved in drafting a proposal for a new ISO standard to cover solar energy collector fields and performance testing. Jan Erik Nielsen, the SHC Task 57 Operating Agent, has been in charge of exploring the possibility of designing a new standard, mainly based on three sources:

- The collector test methods described in the recently published ISO 9806:2017.
- Performance guarantee – Collector field power output, a fact sheet published by IEA SHC Task 45, Large Systems: Large Solar Heating/Cooling Systems, Seasonal Storage, Heat Pumps. (http://task45.iea-shc.org/fact-sheets)
- Yield data from the long-term operation of large solar thermal fields in Denmark (see http://www.solvarmedata.dk).

A fact sheet that outlines the usual procedure that manufacturers use to test the on-site performance of large solar arrays in Denmark has been included in the solar district heating guidelines developed during SDHplus. (http://solar-district-heating.eu/Documents/SDHGuidelines.aspx)

Is a New Standard Coming?

Last October and December, basic ideas for a new standard were presented during ISO and CEN technical committee meetings. The CEN committee's subsequent vote on a rough draft showed that the proposal should not be viewed as a guarantee, but rather a performance test and that it will be turned into a technical specification and not a full-blown standard. In regard to ISO, it has yet to be made clear whether it will become a technical specification or a standard. The ISO committee is awaiting a new draft and will come to a decision at its next meeting in September.

Exporting Danish Expertise

The general idea is to benefit from the long-used Danish procedure for testing large solar district heating plants and comparing real-world yield data to a manufacturer's guarantee. This on site test is usually performed after a system has been fine tuned post-commissioning, which means a couple of months after a plant has been put into operation.

The testing procedure may now be approved and implemented at the international level via inclusion in a standard. Of course, it will also need to comply with collector standard ISO 9806.

The Details

In principle, the proposed standard would require a simple examination of a solar field's maximum performance based on certain criteria. First, solar irradiance levels need to be between 600 and 800 W/m². Second, performance has to be measured at less than 30° incidence to calculate the angle modifier, typically one of the most important unknown variables, and eliminate its impact on the total yield measured during the test.

Additionally, the collectors must not be at risk of solar shading or frost damage. The latter means that the test has to be carried out at temperatures above 5°C. Last, during the one-hour test cycle, the collector needs to show a stable temperature that is always less than 5 K from the mean.

Some typical equations should then be used to calculate expected output and compare it to the test results. The standard will not prescribe how much those two values can differ from each other. Instead, manufacturers or plant operators can specify a percentage themselves, be it 2%, 3% or 5%.

The reason for this freedom to choose is the considerable dependence of measuring instruments on factors such as quality. The new standard will therefore include some non-mandatory recommendations on how to select the best measuring set.

The article was contributed by Riccardo Battisti, a solar thermal consultant and market researcher working at Ambiente Italia (Rome, Italy).

Trending in 2018

2018 is underway, and our team of SHC Task Operating Agents wanted to share the trends they're seeing in their areas of expertise. Our hope is that by taking time to stop and think about where solar thermal is headed, we can stay one step ahead and make sure that our current work is forward thinking.

SOLAR COOLING

Large potential. The demand for cooling and refrigeration will continue its rapid growth, particularly in emerging countries (several hundred million AC units are estimated to be sold per year by 2050, https://www.iea.org/cooling/). And, this means there is a huge potential for cooling systems that use solar energy, thermal systems as well as photovoltaic (PV) systems. A major argument for this application is that it consumes less than conventional energy sources and generally uses natural refrigerants, such as water and ammonia. (In Europe, this application is also pushed by the European F-gas regulation No 517/2014).

Emerging PV cooling solutions. In the segment of small and medium size systems, a new generation of solar cooling systems, either PV or thermally driven, has appeared among existing solar thermal cooling solutions, but a real and significant market has not yet emerged from these innovations. Nevertheless, several SMEs are avidly innovating to find ways to reduce relatively high system costs, space requirements, and the complexity of solar thermal-based cooling, especially for small capacity systems.

Thermal storage for cooling. The continued declining cost for PV and the need for self-consumption mechanisms is energizing the market for green cooling systems in buildings. In these products, thermal cold storage will be key because it offers the lowest cost option to store cooling energy between its production and its consumption.

SOLAR THERMAL SYSTEM COSTS

Cost-competitiveness to PV. Advances in cost-efficient materials, production and installation-friendly designs with low maintenance needs and a restructuring of the distribution channels are still needed to make solar thermal more competitive as a renewable heat source. Cost optimization ideally happens hand in hand in each part of the value chain.

Downsizing of ST distribution channels. Multilevel distribution channels lead to high margins and purchase prices for the end-customer. For solar thermal, this means shortening the distance between producer and customer and creating easy access to reasonably priced products.

ST for multi-family houses. LCoH calculations show that prices for solar thermal are favorable to conventional energy sources when installed in larger applications, such as multi-family houses. This is particularly true when the integration in the building and the system infrastructure are planned together. A few exciting approaches include thermal activation of the building mass, combining with heat pumps and lowering the heat supply temperature, all of which benefit from affordable solar heat.

Cost-transparency and planning security. Cost-competitiveness over time and making investment and operation costs transparent, easy to understand, and easily accessible for the customers will continue to be a market driver for solar thermal systems.

Image enhancement for solar thermal. Image campaigns still need to be synchronized and supported by governments and industry – solar thermal is a green, cost-saving lifestyle product and a simple, uncomplicated way to heat water.

SOLAR DISTRICT HEATING

Storage. Tests on installed solar energy storage in district heating systems are limited, but modeling is popular. Energy storage for solar district heating systems requires a large area of land, so actual installations are limited. In urban areas, long-term storage in larger sized systems hasn't happened yet because suitable land is scarce and costly in cities. Further research and public commitment is needed to facilitate the realization of storages for solar district heating.

Modeling and Simulations. The complexity of cross-sector energy systems and district heating networks calls for the support of computers and algorithms. Several simulations are available to investigate system and network performance of solar district heating. Also modular design in computer systems is allowing for easy experimentation with different configurations and newly installed technologies. The key to success will be well-developed interfaces to process the system visualizations and simulations.

Heat pumps. Heat pumps have become a popular technology choice in district heating networks. The integration of a heat pump in a solar district heating installation can have environmental benefits, but careful planning is required and time of electricity use has to be considered otherwise the integration of the heat pump could be overrated.

1 pvcooling.atisys.fr; https://www.sunoyster.com/socool/; http://www.freescoo.com/en/

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BUILDING INTEGRATED SOLAR ENVELOPE SYSTEMS FOR HVAC AND LIGHTING

Solar envelope systems market. The solar envelope systems market is highly diversified, ranging from building integrated PV and solar thermal, to shading solutions controlling solar thermal gains and luminous comfort. While shading solutions are now established practices in new construction tertiary buildings, envelope integrated PV and solar thermal products are still niche markets.

Small enterprises. Small enterprises offering their solutions in the construction market dominate the sector, and mainly have architects as their target customers. Improved aesthetics, as compared to traditional components, are offered as an added value by envelope integrated PV and solar thermal products.

Regulations. National and regional construction regulations are hindering the wide adoption of envelope integrated PV and solar thermal systems. A standardization process to facilitate the planning and operation of such solutions is needed.

Systems. Industry and researchers are working to develop economically affordable, pre-industrialized systems that would move as much of the building plants (i.e., space heating, cooling and ventilation) as possible into the envelope, thus speeding up the construction process.

COMPACT THERMAL ENERGY STORAGE

Thermochemical materials. Improvements in the thermochemical materials using composites of porous materials and salt hydrates, and for higher temperatures metal hydroxide-oxide reactions will continue.

Development and testing. The targeted development and testing of critical components, for example heat exchangers, thermal reactors and evaporators will continue.

Integration. Increasing attention will be given to the integration of thermal energy storages in flexible grids and in electro-mobility.

PV/THERMAL SYSTEMS

Growing Market. PVT modules (PV and Thermal collectors combined) are currently on the market in Europe! The surprisingly high number of these systems shows that innovation is on the way. Plus, new companies are trying to enter the markets for residential, commercial and industrial PVT applications.

R&D. Research institutions are active in Europe designing and characterizing better PVT products and systems, but still, there are no standards to help industries convince customers and installers to use PVT. New collectors have been designed in several parts of Europe by young entrepreneurs that are making breakthroughs. They are low temperature collectors (0-50°C), medium temperature (30 to 80°C) and high temperature (up to 180°C), and most are unglazed, that is without a transparent cover, and used in combination with a heat pump while others are glazed collectors and even concentrated collectors.

Energy output. PVT solutions drastically increase the energy yield of every m^2 of collector or rooftop. Return on Investment is often shown to be between 5 to 7 years due to the high yield; in some examples a 50% to 60% annual efficiency in solar energy harnessing can be reached. When a heat pump is used with uncovered PVT collectors, the energy yield increases dramatically because both direct solar energy and ambient energy are collected.

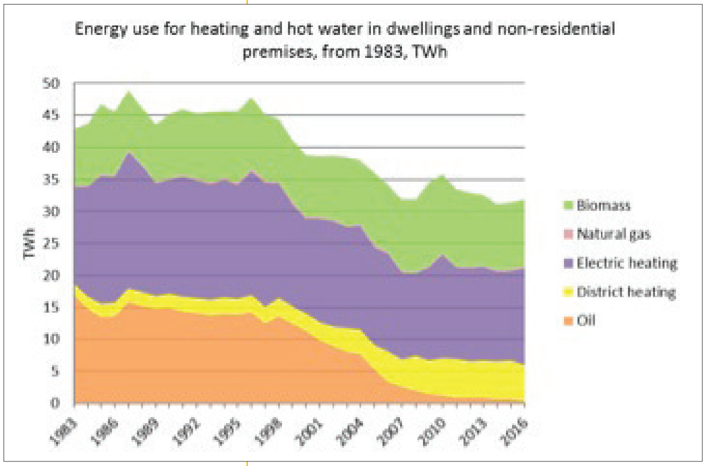
COUNTRY HIGHLIGHT

Sweden moves towards sustainability with a smorgasbord of innovative solutions!

Sweden, through a broad political agreement, introduced the target to achieve a net level of zero greenhouse gas emissions by 2045. This ambitious target requires not only introducing innovative technologies into the market, but also a higher level of engagement from citizens. Energy systems are socio-technical systems where users, technologies and infrastructures continuously interact. Achieving sustainable energy systems and phasing out fossil fuels, therefore, require harmonized efforts between several actors, including end-users and prosumers (those who both consume and produce energy). Sweden values innovation greatly and was ranked in 1st place in the EU-28 Eco-innovation scoreboard 2017, having been among the top 5 Member States since the introduction of the scoreboard in 2010.

▲ **Figure 1. The king, Carl XVI Gustaf, inspecting the first solar modules installed by the National Property Board of Sweden on the roof of the Stockholm Palace.**
Photo credit: Melker Dahlstrand

The evolution of energy systems is strongly influenced by policies, regulations and societal values that are linked together. Policies and regulations may not, however, always correctly address the needs and expectations of the citizens. In fact, sometimes even kings cannot avoid bureaucratic barriers; the Swedish King Carl XVI Gustaf wanted to install PV modules on the roof of the Stockholm Palace, but the permitting process took almost ten years as the palace is a protected cultural heritage building. Very soon, the planned 1,000 square meter PV system, which would meet 12% of the annual energy demand of the palace by generating 170 MWh annually, is expected to be operational. The National Property Board of Sweden is coordinating the project. Observing the installation of the first panels, HM the King said, "We hope that we can bring this out and show that we in Sweden are at the forefront when it comes to energy issues of the future."



▲ **Figure 2. Energy use for heating and hot water in dwellings and non-residential premises in Sweden.**
Source: the Swedish Energy Agency

The Swedish heating and cooling market

Sweden has a large heat demand due to its challenging Nordic climate. In addition to this, the large South to North distance in the country results in significant climatic differences, prompting the use of different heating and cooling solutions. The Swedish heating sector has relatively low carbon-intensity compared to several European countries. Heating in Sweden relies primarily on district heating, which often provides both heat and electricity using Combined Heat and Power plants that run on biofuel and waste. There is also widespread use of electrically driven heat pumps and wood pellet burners, especially in one- and two-dwelling buildings. The heating demand in Sweden has been decreasing in the last decades due to energy renovations and the stricter energy performance requirements imposed on new buildings. Figure 2 shows the development of energy use for heating and hot water in Swedish dwellings and non-residential buildings.

Although one may not expect that there would be demand for cooling in Sweden, the Swedish cooling sector has been growing the last decades. Sweden is a pioneer in district

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cooling technologies, which provide cooling primarily for office buildings, computer server rooms and industry. In 2014, networks throughout Sweden delivered approximately 1 TWh of district cooling. The projected demand for district cooling in 2030 is around 3 TWh.

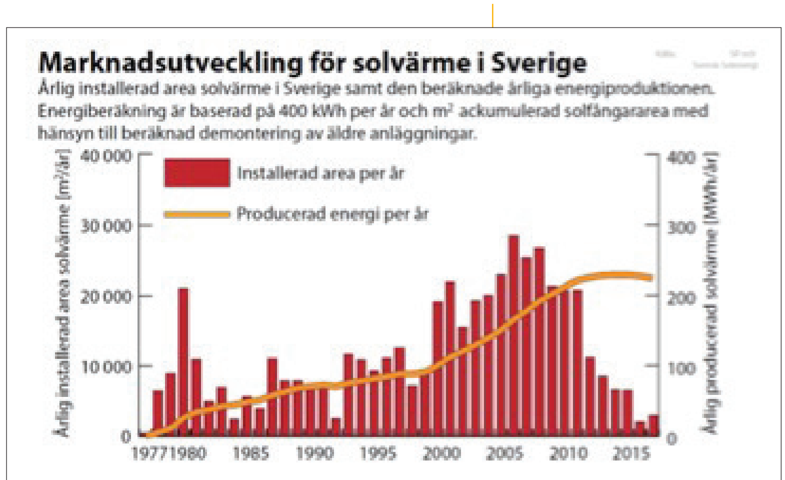

Figure 3. Market development of solar heating in Sweden, the red lines represent the annual installed area and the orange line represents the annual produced energy.
Source: SP and Solar Energy Association of Sweden

Solar Heating in Sweden

Sweden receives enough sunlight for implementing solar energy solutions, particularly in the Southern regions of the country. The solar irradiation varies geographically between the North and South of Sweden as well as seasonally. The average solar irradiation in Sweden is around 1 000 kWh/m2 year.

Despite this potential, however, the solar heating market in Sweden has shrunk in recent years. Nevertheless, solar heating is still of interest as one of the solutions in achieving renewable energy systems. The history of solar heating in Sweden dates to the 1970s when the first systems appeared on the market. There was a spike in the total installed area of solar heating systems due to the oil crisis in the beginning of the 1980s. During this period, several demonstration projects that were installed around the country were among the largest in the world. In the following years, the development was somewhat conservative until the year 2000 when the Swedish government introduced subsidies for installing solar heating systems. The subsidies provided a boost to the solar heating market, where the annual installed capacity reached as high as nearly 30,000 m2 in 2006. The high interest in solar heating continued until the end of 2011, after which the subsidies were abolished. The annual installed capacity has shrunk considerably in the recent years and the annual generated energy, which peaked in 2011, leveled out after the subsidies ended. Figure 3 shows the development of the solar heating market in Sweden.

Although the absence of subsidies plays a substantial role in the declining interest in solar heating systems, there are several other factors that also negatively impact the Swedish solar heating market. Low electricity prices combined with a strong heat pumps market make heat pumps the first choice of heating method for many one- and two-dwelling buildings. In addition, the low costs of biofuels for district heating, around €30/MWh, favors the use of biofuels over solar heating. Moreover, the governmental policies in place support the development of solar PV systems; there is an investment subsidy that covers 30% of the total investment costs and there are government funded information campaigns to encourage the uptake of solar PV technologies. In the light of this, the growth of the Swedish solar heating market can be expected to happen largely through the installation of large systems that are integrated in district heating networks. Figure 4 shows a combined solar power and heating system in Härnösand, installed by the IEA SHC Task 55: Task 55 - Towards the Integration of Large SHC Systems into District Heating and Cooling (DHC) Network participant Absolicon, that provides both electricity and district heating to the local networks.

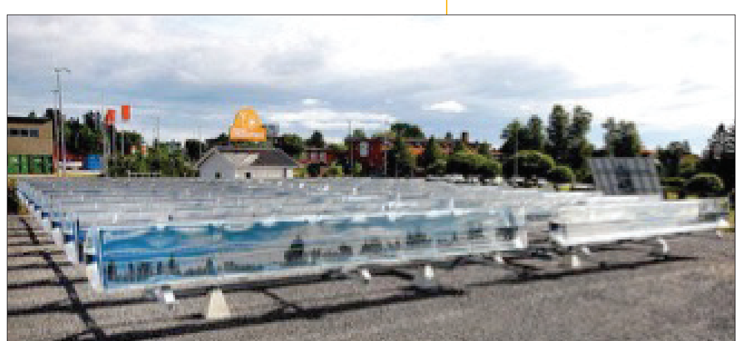

Figure 4. 200 m² solar heating collectors installed in Härnösand Energy Park, providing electricity (20 kWp,el) and district heating (80 kWp, th).
Source: Absolicon

There is an installed solar PV capacity of around 50 MW in Sweden, generating enough electricity to meet only a mere 0.1% of the total annual electricity demand. However, there is good availability of roof and façade area so it can be expected that, given favorable technical developments and interest, the annual electricity production from solar PV will reach a level of between 7 and 14 TWh, representing 5 to 10% of

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the total electricity demand. The factors that negatively impact the development are related to the project costs, regulatory barriers, issues with the accommodation of the systems in distribution grids and the current electricity market design.

▲ **Figure 5. A hybrid PVT installation on a building at the University of Gävle provides electricity (5 kWp, el) and district heating (25 kWp, th) with twenty collectors.** Source: Solarus

The integration of solar heating technologies in buildings

The Swedish building stock is in major need of energy renovations, and is expected to peak between 2015-2025, but the actual investments in energy efficiency measures are not keeping up with the renovation demand in the building sector. Smaller maintenance measures are often preferred over comprehensive energy efficiency renovations, which are required to upgrade the energy performance of the existing building stock to the targeted standards. The building regulations require buildings that undergo major renovation to meet the energy performance standards for new construction buildings. Major renovations can create opportunities for the integration of solar heating and cooling systems in buildings. Figure 5 shows a hybrid PVT system installed on a building at the University of Gävle by the IEA SHC Task 60: Application of PVT Collectors participant Solarus.

Another challenge for Sweden is to improve the energy performance and indoor climate of historic buildings without compromising their historic values. The Swedish Energy Agency manages a research funding program that focuses on improving the energy performance of historic buildings. The program has resulted in increased knowledge on methods to address the energy performance of historic buildings and produced several projects showcasing successful examples. Sweden also participates in IEA SHC Task 59: Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO2 Emission (NZEB). Figure 6 shows the integration of a solar heating system in a historic building. To support this work, the Swedish Energy Agency is sponsoring the 3rd International Conference on Energy Efficiency in Historic Buildings http://eehb2018.com/ , that will be held in Visby, Sweden on September 26-27, 2018. Join us for an interesting conference in the historical city of Visby!

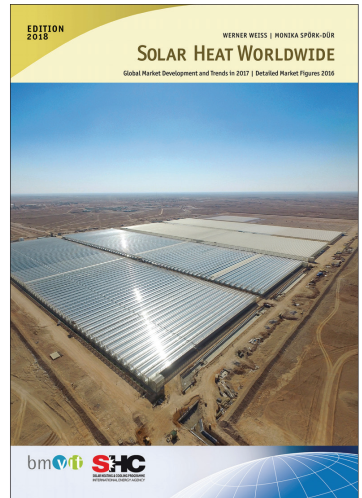
There are opportunities for the future growth of solar energy in Sweden. It is, however, important to not only focus on solar PV technologies, but also encourage the development of solar heating and cooling applications. Through the right policy support, solar energy technologies can play an important role in diversifying the energy supply and transforming the current energy system to become more sustainable in Sweden.

This article was contributed by Mehmet Bulut and Marie Claesson of the Swedish Energy Agency and the Swedish representatives on the IEA SHC Executive Committee.

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 and Databases" or under a specific Task.



SOLAR HEAT WORLDWIDE 2018

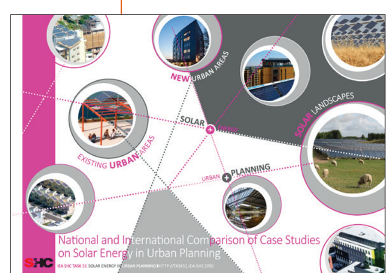
Global Market Development and Trends in 2017 / Detailed Market Figures 2016

This is the foremost report on the solar thermal market and trends. Data from 66 countries, or 95% of the solar market, is used to provide a comprehensive status report on solar heat. The report is divided into two parts: Part I (Chapters 3-4) covers the trends and detailed data for 2017 on successful applications, such as solar assisted district heating and solar heat for industrial processes and Part 2 (Chapters 5-8) presents detailed market figures for 2016, solar thermal system costs and the levelized cost of solar heat for different applications and regions worldwide.

SOLAR ENERGY IN URBAN PLANNING

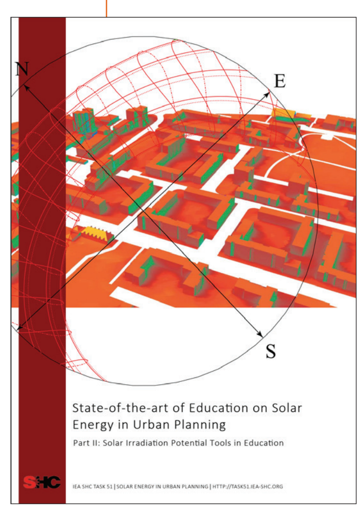
Lessons Learnt from Case Studies of Solar Energy in Urban Planning

The lessons from case studies are divided into ten categories in this report. Each category includes lessons learned from the environments 1) new urban areas, 2) existing urban areas, and 3) landscapes. These lessons are presented and examined primarily through cross-country comparisons of planning processes, research actions, legislation, simulation, education, etc. The report concludes by highlighting the most relevant lessons learned.



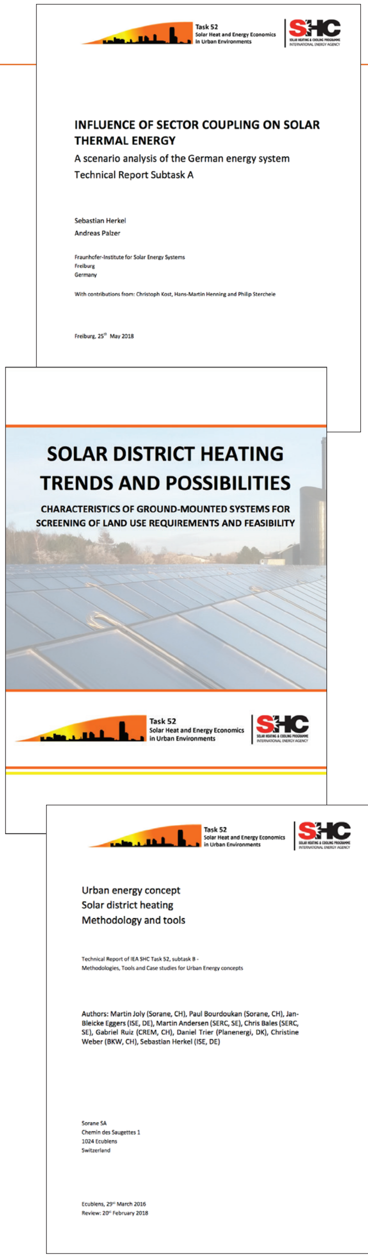
National and International Comparison of Case Studies on Solar Energy in Urban Planning

Focused on the replicability of successful practices through case studies and stories, this report presents 14 comparisons among the case studies collected in SHC Task 51. The case studies represent new urban areas, existing urban areas and landscapes and the comparisons cover 1) scale and planning process, 2) legislation and technology, and 3) targets and goals. Each comparison provides lessons learned and recommendations for different target groups, such as urban planners, architects, researchers, and urban stakeholders involved in the planning process.



State-of-the-Art of Education on Solar Energy in Urban Planning: Part 2: Solar Irradiation Potential Tools in Education

This report compares the experiences using selected software tools in seminars at universities with the experiences of the SHC Task 51 international partners and discusses the status of new research and teaching tools.



SOLAR HEAT AND ENERGY ECONOMICS IN URBAN ENVIRONMENTS

Influence of Sector Coupling on Solar Thermal Energy: A Scenario Analysis of the German Energy System

The results of a scenario study on the potential role of solar thermal in future energy systems in Germany were used to more thoroughly investigate solar thermal energy use in urban environments; this report presents the scenario results calculated based on a methodology developed in SHC Task 52: Solar Heat and Energy Economics in Urban Environments.

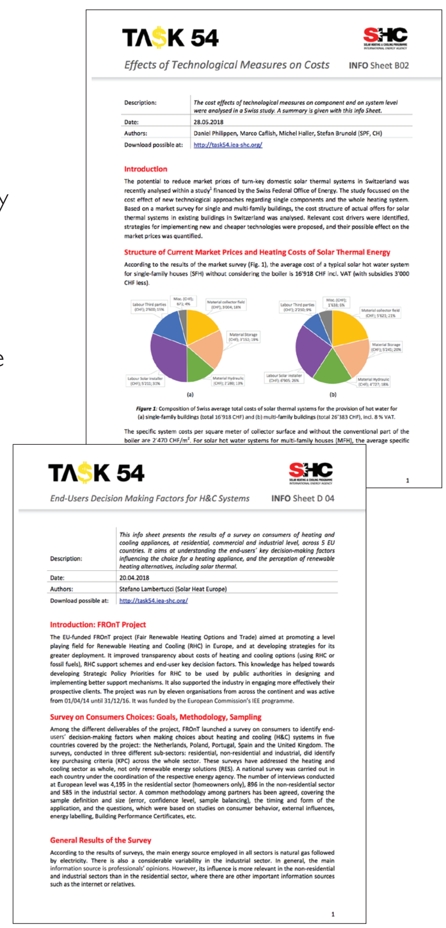
Solar District Heating Trends and Possibilities: Characteristics of Ground-mounted Systems for Screening of Land Use Requirements and Feasibility

The booming solar district heating market in Denmark serves as the basis for the investigation on the possibilities for similar solar district heating deployments in other countries; this report examines the specific characteristics of the Danish SDH systems and the prospect of seeing similar developments in other countries.

Urban Energy Concept: Solar District Heating Methodology and Tools

Existing tools and an assessment of the needs of urban actors served as the basis for the development of a new methodology; this report presents the new methodology that is designed to guide stakeholders in their different choices when considering solar district heating for an urban environment.

PRICE REDUCTION OF SOLAR THERMAL SYSTEMS



Effects of Technological Measures on Costs

INFO Sheet B02

The potential to reduce market prices for turnkey domestic solar thermal systems in Switzerland was recently analyzed in a study financed by the Swiss Federal Office of Energy. This study focused on the cost of new technological approaches regarding single components and the whole heating system and the results are summarized in this Info Sheet.

End-Users Decision Making Factors for H&C Systems

INFO Sheet D04

Consumers of heating and cooling appliances for residential, commercial and industrial uses from five EU countries were surveyed, and the results and decision-making factors influencing their choices are summarized in this Info Sheet.

Task 62

Solar Energy in Industrial Water and Wastewater Management

With industry being the second largest water consuming sector after agriculture and fresh water being a scarce resource in many regions, the SHC Programme has initiated SHC Task 62: Solar Energy in Industrial Water and Wastewater Management to tap the huge potential for solar heat in the industrial sector and to support a new market sector for the solar thermal industry.

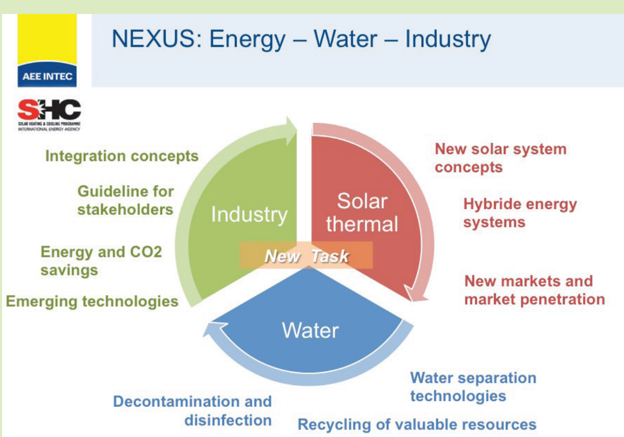
The objective of this new Task is to improve the conditions and increase the application of low-temperature solar technologies to disinfect, decontaminate and separate industrial process water and wastewater.

Building on the work of SHC Task 49: Solar Heat Integration in Industrial Processes, this Task will work with the IEA SolarPACES Programme to:

- To improve the conditions and increase the applications of solar driven separation and water purification technologies in industrial applications in order to:
  - push the solar water treatment market, and
  - solve water problems at locations with abundant solar energy resources.
- Reduce the water and energy demand (CO_2 emissions) in industry (process water) and water purification plants (communal and industrial).
- Support solar turnkey providers, water technology sector (e.g., membrane producer), engineering companies, and producing industries.

The Task's kick-off meeting will take place on October 2-3 in Graz, Austria before the International Sustainable Energy Conference 2018.

For more information contact Christoph Brunner of AEE INTEC, Austria, c.brunner@aee.at.



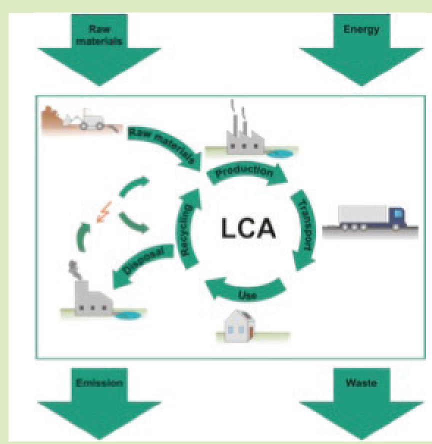
working group

Life Cycle Assessment

A Working Group on Life Cycle Assessment for Solar Heating and Cooling Technologies got the green light to start. The objectives of this group are to:

- Identify, monitor and influence existing and upcoming regulations and standards for environmental performance of solar heating and cooling technologies.
- Enhance the eco-quality of products.
- Create business opportunities for producers.
- Provide standardized and reliable analyses to sustain customer trust.
- Improve and expand the LCA methodology and database for solar heating and cooling technologies.
- Develop guidelines on methodologies, system boundaries (included components, lifetime, location of use, etc.), and impact categories (CO_2 emissions, toxicity, energy-payback-time, etc.).
- Define the parameters for location specific LCA assessment (climate, electricity mix, etc.).
- Work closely with current and future SHC Tasks.

For more information contact Michael Köhl of Fraunhofer ISE, Germany, michael.koehl@ise.fraunhofer.de.



IEA programme SHC

Current Tasks and Operating Agents

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 62 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

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SOLARUPDATE
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