SOLARUPDATE

VOL.62 | NOVEMBER 2015

Newsletter of the International Energy Agency Solar Heating and Cooling Programme

See You In Istanbul!

The 2015 IEA SHC conference is this December in Turkey – the largest solar thermal market in Europe.

The unique partnership with the host, GÜNDER, the International Solar Energy Society Turkey Section, and co-organizer, ESTIF, the European Solar Thermal Industry Federation, means that this year's conference program will address the key issues facing industry and delve into important scientific developments.

New this year is a full day track dedicated to industry. Not to miss sessions included in this *Industry Day* are:

- A sustainable and competitive energy future: the Industry Day will open with a series of talks on the achievements and future of solar heating and cooling.
- New opportunities: specialists from different countries share their latest insights on market developments with highlights from the MENA region.
- Global certification removes market barriers: how mutual recognition of test and inspection reports saves industry costs.
- Global perspective: an international CEO panel discusses the technology and market outlook.

Scientific sessions will focus on the most important commercial real-life applications of solar thermal technology – solar process heat, solar district heating, solar cooling, building integration and urban planning, thermal storage, performance measurement and solar resource management.

Don't miss THE solar thermal conference!
Register before November 25 at **www.shc2015.org.**

SHC Members

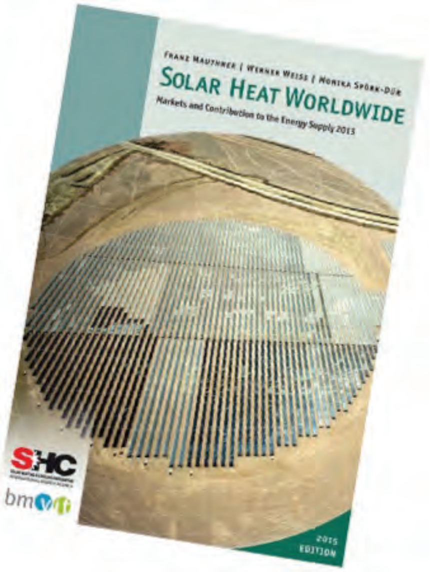
Australia
Austria
Belgium
Canada
China
Denmark
ECREEE
European Commission
European Copper Institute
France
Germany
GORD
Italy
Mexico
Netherlands
Norway
Portugal
RCREEE
Singapore
South Africa
Spain
Sweden
Switzerland
Turkey
United Kingdom

In This Issue

SHC 2015 Conference 1
Solar Heat Worldwide 2
Energy Reserves 4
Task 54: Price Reductions 7
Task 53: Solar Cooling 2.0 8
Task 46: Solar Measurements 10
Task 51: Solar Education 12
Country Highlight: Spain 15
SHC Reports 19
Members 20

Solar Thermal = Savings of Over 118 Million Tons of CO_2 Annually

The IEA SHC Programme's Solar Heat Worldwide is the most comprehensive publication on the global solar heating and cooling market. This year's report includes data from 60 countries, or 95% of the solar thermal market and can be downloaded for free.

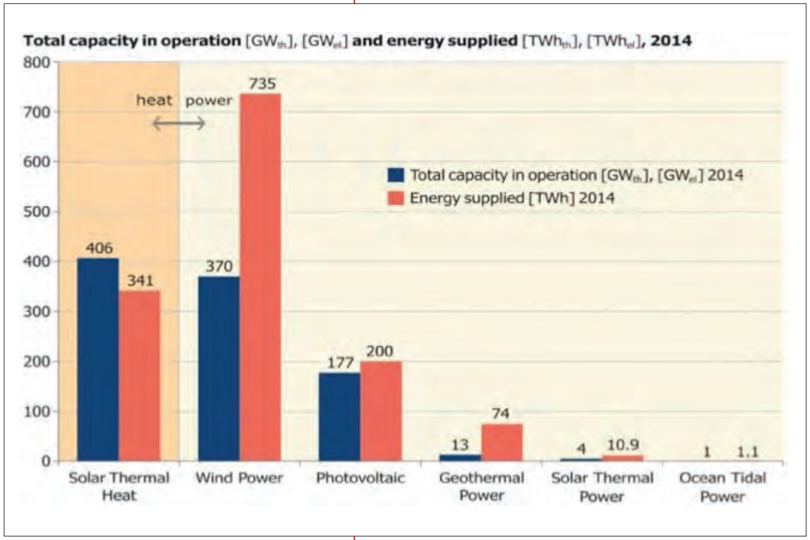


In 2013, 94% of the energy provided by solar thermal systems worldwide was used for heating domestic hot water, mainly by small-scale systems in single family houses (84%) and larger applications attached to multi-family houses, hotels, schools, etc. (10%). Swimming pool heating held a 4% share and the remaining 2% was met by solar combi-systems.

Over the past 15 years, the number of systems in operation worldwide has significantly increased. In 2000 there were 89 million square meters of collectors installed or 62 GWTH. And, in 2014 there were 580 million square meters or 406 GWth. The annual solar thermal energy yields totaled 52 TWh in 2000 and and 341 TWh in 2014.

Compared with other forms of renewable energy, solar heating's contribution to the global energy demand will remain, besides the traditional renewable energies like biomass and hydropower, second only to wind power (Figure 3). When considering installed capacity, solar thermal is the leader.

Ken Guthrie, IEA SHC Chairman notes that "Heating accounts for 47% of the world's energy demand. This is higher than the demand for electricity (17%) and transport (27%) combined. What this means for solar heating and cooling is that there is huge potential for this renewable supply of energy that is just waiting to be exploited."



▲ **Figure 2. Global capacity in operation [GWel], [GWth] 2014 and annual energy yields [TWhel], [TWhth]**

(Sources: AEE INTEC, Global Wind Energy Council (GWEC), European PV Industry Association (EPIA), REN21-Global Status Reports 2014 and 2015)

Highlights From This Year's Report

Total Capacity

The vast majority of systems in operation in 2013 were installed in China (262.3 GWth) and Europe (44.1 GWth), which together accounted for 82% of the total capacity installed.

China, as the world leader in total capacity, is focusing very much on evacuated tube collectors, whereas the United States is holding second position due to its high installation of unglazed water collectors. Only in Australia, and to some extent in Brazil, unglazed water collectors also play an important role. The rest of the "Top 10 countries" are clearly focusing on flat plate collector technology.

Market Growth

In 2013, a total capacity of 55.0 GWth, corresponding to 78.6 million square meters of solar collectors, was installed worldwide, which represents a 1.8% increase compared to 2012.

continued on page 3

Solar Heat Worldwide *from page 2*

Top 10

Top 10 Installed Capacity in 2013* (in GWth)
China 262.3
United States 16.7
Germany 12.3
Turkey 10.9
Brazil 6.7
Australia 5.6
India 4.4
Austria 3.5
Greece 2.9
Israel 2.9

Top 10 Installed Capacity per 1,000 inhabitants in 2013* (in kWth)
Austria 430
Cyprus 425
Israel 377
Barbados 319
Greece 271
Palestinian Territories 257
Australia 252
China 194
Germany 151
Turkey 136

**cumulated water collector installations*

Top 10

Top 10 Markets in 2013* (in MWth)
China 44,492
Turkey 1,344
Brazil 965
India 770
Germany 714
United States 705
Australia 585
Israel 296
Italy 208
Poland 192

Top 10 Markets per 1,000 inhabitants in 2013* (in kWth)
Israel 38
China 33
Australia 26
Palestinian Territories 19
Turkey 17
Austria 15
Greece 15
Denmark 13
Switzerland 12
Cyprus 11

**glazed and unglazed water collectors*

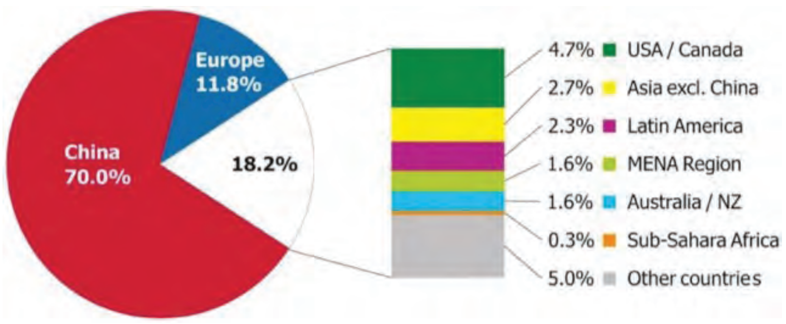
The leaders were China (44.5 GWth) and Europe (3.6 GWth), which together accounted for 87% of the overall new collector installations.

Of the top 10 markets in 2013, growth was reported from China (+2.5%), Turkey (18.2%), Brazil (+19.8%) and Israel (+35.8%). The other major solar thermal markets saw a decline, India (–22.9%), the United States (–0.2%), Germany (–11.3%), Australia (–8.8%), Italy (–10.0%) and Poland (–9.2%).

Applications

On the technology side, evacuated tube collectors are the clear market leader accounting for 79.4% of the newly installed capacity, which is driven by the dominance of the Chinese market. Followed by 17.4% glazed flat-plate collectors, 3.1% unglazed water collectors and 0.1% glazed and unglazed air collectors.

Download and read the full report at www.iea-shc.org.



Sub-Sahara Africa: Mauritius, Mozambique, Namibia, South Africa, Zimbabwe

Asia excluding China: India, Japan, Korea South, Taiwan, Thailand

Latin America: Barbados, Brazil, Chile, Mexico, Uruguay

Europe: EU 28, Albania, Macedonia, Norway, Russia, Switzerland, Turkey

MENA Region: Israel, Jordan, Lebanon, Morocco, Palestinian Territories, Tunisia

▲ **Figure 3. Share of the total installed capacity in operation (glazed and unglazed water and air collectors) by economic region at the end of 2013**

A Fundamental Look At Supply Side Energy Reserves For The Planet

This is an update of the April 2009 Solar Update article. The objective of the 2009 article was to put in perspective the potential of often-cited nuclear and renewable alternatives to Greenhouse Gas (GHG) emitting fossil energy sources. Its main conclusion was that although a mix of alternatives, including hydropower, biomass/biofuels, geothermal, ocean thermal energy conversion, waves, tides, wind and solar, appeared like a sound approach to bringing about the desired economically and environmentally sustainable energy future (akin to putting future energy eggs in different baskets), a review of their potential clearly showed that the solar resource dwarfed all other renewables (and fossil/nuclear alike) by orders of magnitude. And therefore, the desired economically and environmentally sustainable energy mix of the future should be essentially solar-based.

The three-dimensional rendering appearing in the April 2009 Solar Update and reproduced here in Figure 1 compared the annual energy consumption of the world at the time to (1) the known economically exploitable reserves of the finite fossil and nuclear resources and (2) the yearly potential of the renewable alternatives. The volume of each sphere in the figure represents the total amount of energy recoverable from the finite reserves and the energy recoverable per annum from renewable sources.

Conditions have evolved since 2009, thus the rationale for this update. The energy consumption of the world has increased nearly 12% to 18.3TW-yr per annum in 2014 [26]. We estimate it will reach 27TWyr per annum in 2050. The economically exploitable fossil fuel energy reserves have increased appreciably thanks to the development of hydraulic fracturing technologies along with exploitation of the Canadian tar sands and Venezuela's Orinoco basin – although many question the correspondingly increased CHG and other environmental impacts of these technologies.

▼ Figure 1: 2009 estimate of finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables.

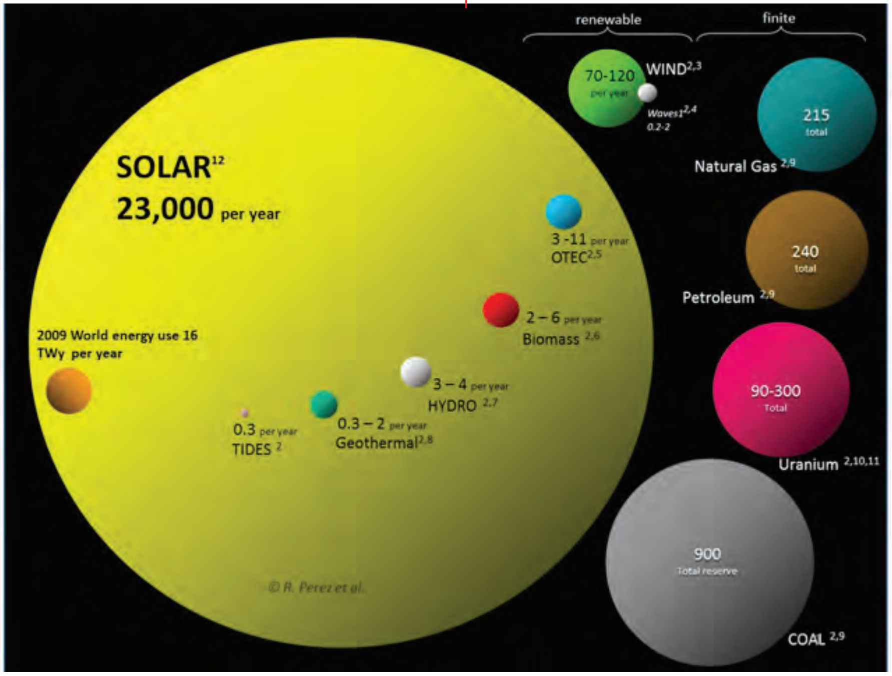


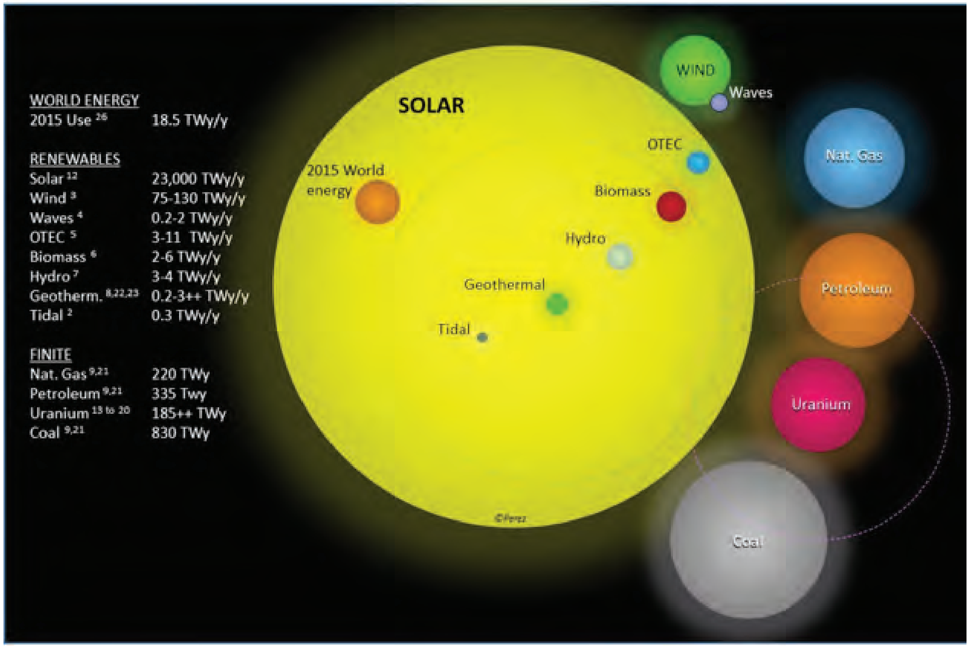
Figure 2 illustrates the current conditions. Overall, the conclusions remain the same – solar remains the largest resource by far. Even when pushing economically acceptable fossil sources to their current limit, the global picture is basically unchanged. Especially if one considers that the threshold for economic viability will be lowered by environmental pressure and, more effectively perhaps, by the fact that solar is rapidly becoming the lowest cost resource on a straight energy production basis, further lowering the economic viability threshold of other sources.

Figure 2 Notes:

1. The uranium sphere [13-20] assumes direct fission of all known exploitable sources of uranium on the planet including reasonably assured and inferred reserves, as well as prognosticated and speculated reserves, and uranium extractable from phosphates.

continued on page 5

Energy Reserves *from page 4*



▲ **Figure 2: 2015 estimated finite and renewable planetary energy reserves (Terawatt-years). Total recoverable reserves are shown for the finite resources. Yearly potential is shown for the renewables.**

However it does not include uranium that could be extracted from seawater (a technology that does not yet exists). The dotted outline represents the nuclear potential that would be achievable if 100% of all fission byproducts were ideally reprocessed.

2. The yearly geothermal potential illustrated is based on the IEA cumulative recoverable estimate of 85 GW-yr to the year 2050 using conventional technologies [22]. Future, yet highly environmentally questionable, deep hydro-fracking-based technologies known as enhanced geothermal systems (EGS [23]) could enhance geothermal recovery well over a 100-fold (dotted line). These technologies do not exist today.
3. 2015 global primary energy use is extrapolated from the 2014 reference [26] by linear forecasting.

Another point that many have questioned in the 2009 article is that the solar resource potential represented is that of the entire planet (excluding oceans), accounting for weather, but assuming perfect conversion efficiency. However, even if one only assumes optimal solar deployment in urban/suburban areas of the world [23, 24] plus transportation and other networks and small amount of central plants deployment – a total amounting to <4% of land area, and a conversion efficiency of as little as 20% (achievable today and a very conservative estimate for the years to come) solar remains the essential part of the energy mix of the future. In addition, while with such efficiency and deployable land limits, the one-year solar potential would "only" be of the order of the planetary reserves of coal, a multiple-year outlook unquestionably shows that solar is the overwhelming energy solution for the future of the planet.

This article was contributed by Richard Perez of the Atmospheric Sciences Research Center, University at Albany, Statue University of New York, perez@asrc.cestm.albany.edu and Marc Perez of MGH-Energy. Richard Perez is an expert of SHC Task 46: Solar Resource Assessment and Forecasting. This Task, led by David Renné, provides the solar energy industry, the electricity sector, governments, and renewable energy organizations and institutions with the means to understand the "bankability" of data sets provided by public and private sectors.

References

1. Perez, R. and M. Perez, (2009): A fundamental look at energy reserves for the planet. The International Energy Agency SHC Programme Solar Update, Volume 50, pp. 2-3, April 2009.
2. S. Heckeroth, Renewables.com, adapted from Christopher Swan (1986): Sun Cell, Sierra Club Press
3. C. Archer & M. Jacobson, Evaluation of Global Wind Power -- Stanford University, Stanford, CA
4. World Energy Council
5. G. Nihous, An Order-of-Magnitude Estimate of Ocean Thermal Energy Conversion (OTEC) Resources, Journal of Energy Resources Technology -- December 2005 -- Volume 127, Issue 4, pp. 328-333
6. R. Whittaker (1975): The Biosphere and Man -- in Primary Productivity of the Biosphere. Springer-Verlag, 305-328. ISBN 0-3870-7083-4.

continued on page 6

Energy Reserves *from page 5*

7. Environmental Resources Group, LLC http://www.erg.com.np/hydropower_global.php

8. MIT/INEL The Future of Geothermal Energy-- Impact of Enhanced Geothermal Systems [EGS] on the U.S. in the 21st Century http://www1.eere.energy.gov/geothermal/egs_technology.html -- based on estimated energy recoverable economically in the next 50 years. Ultimate high depth potential would be much higher.

9. BP Statistical Review of World Energy 2007

10. http://www.wise-uranium.org/stk.html?src=stkd03e

11. R. Price, J.R. Blaise (2002): Nuclear fuel resources: Enough to last? NEA updates, NEA News 2002 – No. 20.2

12. Solar energy received by emerged continents only, assuming 65% losses by atmosphere and clouds

13. Number includes existing global stockpiles of U3O8 ore, Highly Enriched Uranium (HEU), Low Enriched Uranium (LEU), Plutonium stockpiles, Identified Resources (Reasonably Assured Recoverable + Inferred), Waste Resources (Stockpiles of Reprocessed Uranium, Depleted Uranium, Mill Tailings and Spent Nuclear Fuel), Undiscovered Resources (Prognosticated resources, and speculative resources) and super speculative resources including the assessed uranium resource in global marine and organic phosphates. All stockpiles and resources are converted to their N.U. equivalents available at a price point <=$450/kgU. For waste resources and resources with a low concentration of U235, the costs of reprocessing or enriching are taken into account as are the costs of downblending for already enriched resources like HEU and LEU. More information available upon request.

14. Supply of Uranium in phosphates: International Atomic Energy Agency. 2001. Analysis of Uranium Supply to 2050.Vienna.

15. Supply of Uranium in fission waste: Nuclear Wastes: Technologies for Separations and Transmutation. Commission on Geosciences, Environment and Resources (CGER), National Academy Press (1996)

16. Supply of Uranium in global arms inventory: Carter, L. J. & Pigford, T. H. The World's Growing Inventory of Civil Spent Fuel. Arms Control Today, January/February (1999).

17. Supply of Uranium in global mill tailings:

16a. Mudd, G. M. & Diesendorf, M. Sustainability of uranium Mining and Milling: Toward Quantifying Resources and Eco-Efficiency. Environmental Science and Technology 2008, 2624-2630 (2007). 18 Abdelouas, A. Uranium Mill Tailings: Geochemistry, Mineralogy, and Environmental Impact. Geo Science World: Elements 2, 335-341 (2006).

16b. Uranium Mill Tailings Inventory. WISE-Uranium, http://www.wise-uranium.org/umaps.html (2010).

16c. Abdelouas, A. Uranium Mill Tailings: Geochemistry, Mineralogy, and Environmental Impact. Geo Science World: Elements 2, 335-341 (2006).

18. Supply of Uranium in depleted uranium stockpiles:

17a. Health and Environmental Consequences of Depleted Uranium Use in the U.S.Army: Technical Report. Army Environmental Policy Institute, Atlanta, Georgia 1995, 200+ p.

17b. Schneider, E. A., Deinert, M. R. & Cady, K. B. Cost analysis of the US spent nuclear fuel reprocessing facility. Energy Economics 31, 627-634, doi:10.1016/j.eneco.2008.12.011 (2009).

17c. IAEA, OECD/NEA, Management of Depleted Uranium, OECD, Paris, France, 2001.

19. Supply of Uranium in reprocessed uranium stockpile:

18a. Ragheb, M. in Nuclear, Plasma and Radiation Science: Inventing the Future Ch. 10, (University of Illinois, Dept. of Nuclear, Plasma, and Radiological Engineering, 2009).

18b. Villani, S. Progress in Uranium Enrichment. Natur Wissenschaften 71, 115-123 (1984).

18c. Management of Reprocessed Uranium: Current Status and Future Prospects. Report No. IAEA- TECDOC-1529, (IAEA: International Atomic Energy Agency, 2007).

20. Supply of Uranium in Identified Resources (RAR + inferred): OECD Nuclear Energy Agency, International Atomic Energy Agency (2014). Uranium 2014: Resources, Production and Demand.

21. Oil, gas, coal and global primary energy use: British Petroleum Company. 2015. BP Statistical Review of World Energy Primary Energy: Consumption, June, 2015. London

22. Eisentraut, A. & Brown, A. 2014. Heating without Global Warming. International Energy Agency. 2014. Paris

* Note that 85 GWyr is the forecast for 2050 for cumulative Geothermal capacity outlay by the IEA. The potential of EGS (Enhanced Geothermal System) is nearly infinite. 8800 TWyr conservatively (accessing 2% of the resource). However, accessing this resource is fraught with environmental issues. [see 23]

23. Tester, J., et al., (2006): The Future of Geothermal Energy. MIT Energy Initiative report, http://miti.mit.edu

24. Center for International Earth Science Information Network - CIESIN - Columbia University, International Food Policy Research Institute - IFPRI, The World Bank, and Centro Internacional de Agricultura Tropical - CIAT. 2011. Global Rural-Urban Mapping Project, Version 1 (GRUMPv1): Urban Extents Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4GH9FVG. Accessed 01 Sep 2015.

25. Balk, D.L., U. Deichmann, G. Yetman, F. Pozzi, S. I. Hay, and A. Nelson. 2006. Determining Global Population Distribution: Methods, Applications and Data. Advances in Parasitology 62:119-156. http://dx.doi.org/10.1016/S0065-308X(05)62004-0.

26. International Energy Agency, Paris, France

Task 54

Price Reduction of Solar Thermal Systems

Driving down the costs of solar thermal systems is not just about cheaper collector production. In fact, post-production processes, such as sales, installation and maintenance account for up to 50% of the price that end consumers pay. This new IEA SHC Task, Price Reduction of Solar Thermal Systems, will investigate these other factors and find ways to reduce systems costs. The Task's kick-off meeting was hosted by Fraunhofer ISE in Freiburg, Germany the end of October. Researchers and industry representatives from all over the world participated.

The significant reductions in material costs have had little effect on the consumer price for a solar system, as shown by Fraunhofer ISE's market studies carried out within the framework of *IEA SHC Task 39: Polymeric Materials for Solar Thermal Applications*, which ended in October 2014. "In SHC Task 39, we learned that polymers offer many new opportunities, but they cannot solve all of the cost problems that solar heat has. In SHC Task 54, we will also have to look at the distribution channels, installation and maintenance costs," says Sandrin Saile of Fraunhofer ISE and the leader of SHC Task 54's Subtask D on information, dissemination and stakeholder involvement. Ms. Saile emphasized that a "comprehensive approach covering all aspects of the value chain" is needed to achieve significant cost reductions.

Significant market research needs to be done to identify opportunities for cost saving potential in post-production processes. "We want to look at markets with high potential for solar thermal. Then, we plan to define typical reference systems for the different regions and applications, for example, pumped systems with flat plate collectors for Europe or thermosiphon systems for the MENA region," states Ms. Saile. The reference systems will first be used by the researchers to establish cost benchmarks and then to look for ways to reduce the purchase price by up to 40%. Increasing the use of standardized and mass-produced components (such as connection sets) and more plug-and-play in system installations are two of the ideas to achieve such an ambitious goal. Additionally, the researchers will explore ways to make solar thermal more attractive by improving marketing campaigns and consumer-oriented designs.

Task Work

SHC Task 54 is managed by Michael Köhl of Fraunhofer ISE's Service Life Analysis Group. Over the next two years, Dr. Köhl and experts from seven countries representing Australia, China and Europe will work towards reaching a 40% reduction in the purchase price of select solar thermal systems. To do this, the Task is organized into four work streams:

- Subtask A: Market Success Factors and Cost Analysis (Leader: Michaela Meir of Aventa, Norway)
- Subtask B: System Design, Installation, Operation and Maintenance (Leader: Stephan Fischer of ITW University of Stuttgart, Germany)
- Subtask C: Cost-Efficient Materials, Production Processes and Components (Leader: Gernot Wallner of JKU Linz, Austria)

SHC Task 54

Price Reduction of Solar Thermal Systems

Duration
October 2015 - October 2017

Operating Agent
Michael Köhl
Fraunhofer ISE, Germany
michael.koehl@ise.fraunhofer.de

Webpage
http://www.task54.iea-shc.org

Participating Countries
Australia
Austria
China
Germany
Italy
Norway
Switzerland

continued on page 9

Task 53

Solar Cooling 2.0
A New Generation Is Growing Up

The September workshop on New Generation Solar Cooling & Heating Systems focused on the status of solar cooling technology research and market developments. About 40 professionals gathered in Rome for this half day event, which was organized by IEA SHC Task 53: New Generation Solar Cooling & Heating Systems and the German Eastbavarian Institute for Technology Transfer, OTTI e.V. the day before OTTI's 6th International Conference on Solar Air-Conditioning. Participants learned first hand about the first outcomes of SHC Task 53 that began its collaborative work in March 2014 and includes the participation of ten countries from across the globe.

The R&D Road to Competitiveness

According to the IEA's Technology Roadmap on Solar Heating and Cooling, solar cooling should cover at least 17% of the total cooling needs by 2050. In the last ten years, however, the development has not been as fast and effective as it was expected to be. In only a few specific cases is solar cooling economically competitive and have market appeal. The vast majority of the potential applications offer solutions that still have too long a payback time, and as a result are only installed when there are very high incentives, as happens for instance in research and demo projects.

“Due to hydraulic complexity and high investment costs, the first generation of solar cooling systems have shown not to be competitive,” Daniel Mugnier, Operating Agent of SHC Task 53, made clear when opening the workshop in Rome. “Because of this situation, we cannot yet talk of a marketable technology, but rather an intense R&D activity to develop a new generation of innovative systems towards Solar Cooling 2.0.”

Another point discussed in the workshop was that the future trend of cooling and air-conditioning has a chance to move more towards large-scale systems, as is already happening for other applications of the energy sector. Such solutions, potentially including solar thermal energy for both cooling and heating, could also include small, medium and large district cooling grids. One additional possible feature of such plants is the parallel coexistence of different energy sources, both electrical and thermal, to supply energy for cooling.

Although the application of solar cooling primarily focuses on new buildings, the use of this technology in existing buildings should not be excluded although it does require some pre-requisites, such as the availability of sufficient roof space (an issue in modern cities with many high-rise buildings) and the capacity of the current cooling distribution system to be adapted to the energy supply by solar.

Solar Cooling 2.0: Compact and Easy to Install

What will this new generation of innovative systems look like? For sure, Solar Cooling 2.0 will be characterized by increased compactness and ease of installation, which means high compatibility for a direct coupling with chillers. Only with such a plug-and-play approach can solar cooling be a viable competitor with other technologies, heat pumps for instance.

continued on page 9

Task 53 *from page 8*

What else is needed? There is a need for new standards and more data monitoring. Potential customers want to know upfront how a system performs in real time. Another message coming from the workshop was the need to 'keep it simple'. A model example of such a philosophy is the relatively small (130 m^2) solar plant in Banyuls, France, where the produced heat is used for air conditioning the 4,500 m^2 wine cellar – the system has been operating for about 25 years without major failures and mainly due to its simplicity.

The good news is that something is moving in the industry. In his presentation, Wei Zheng, from the large and well-known chiller manufacturer Yazaki of Japan, announced that they are working on improving some of their chillers to make them more suitable for solar use. It is no longer only solar moving toward the cooling machine industry, but also the chiller producers working to be compatible with solar! The main technical issue Yazaki is working on is to allow their chillers to be activated at lower temperatures and with lower flow rates, thus increasing the efficiency of the solar field. An example shown by Yazaki reported an increase in the solar fraction from less than 50% to 66%, thanks to such improvements.

Photovoltaics: A Partner or a Competitor?

A peculiarity of SHC Task 53 is that it is also dealing with solar PV cooling and is working in collaboration with the IEA Photovoltaic Power Systems (PVPS) Programme. Gaetan Masson, Operating Agent of PVPS Task 1, put it clearly, "For our business plans to work with feed-in incentives no longer available in the key countries, PV has to maximize self-consumption and cooling demand. This is the main reason why compact units with PV modules directly coupled to a cooling machine are taking their position in the market at the moment."

So, is PV a collaboration partner or a merciless competitor of solar thermal in the struggle for potential customers? When explicitly asked about that, Mugnier explained his point of view, "PV will be the main technology for small to medium scale single-user cooling applications, for instance mono or multi-split systems, while solar thermal is possibly still the best option for large scale (industry, grids) systems."

This article was contributed by Riccardo Battisti, solar thermal consultant and market researcher working at Ambiente Italia in Rome, Italy and SHC Task 53 expert. For more information on SHC Task 53 contact Daniel Mugnier, Task 53 Operating Agent, daniel.mugnier@tecsol.fr or visit the websites www.task53.iea-shc.org/, www.solaircon.com/ and www.solaircon.com/workshop.html.

Task 54 *from page 7*

- **Subtask D: Information, Dissemination and Stakeholder Involvement**
  (Leader: Sandrin Saile of Fraunhofer ISE, Germany)

Industry Support

This type of work requires industry partners. "Wherever they may be located around the world, all companies and organizations with projects in this field should contribute their ideas on the price reduction of solar thermal systems and are invited to participate," says Dr. Köhl. At the kick-off meeting, industry participants gave short presentations on the background of their company or organization and their experiences and expertise they will bring to SHC Task 54. Many members of the recently finished SHC Task 39 are now part of this new Task, such as the Norwegian solar collector manufacturer, Aventa, Austrian material specialists from the University of Linz, and system experts from the University of Stuttgart.

For more information on SHC Task 54 contact Michael Köhl, Task 54 Operating Agent, michael.koehl@ise.fraunhofer.de, or visit the Task webpage, http://task54.iea-shc.org/.

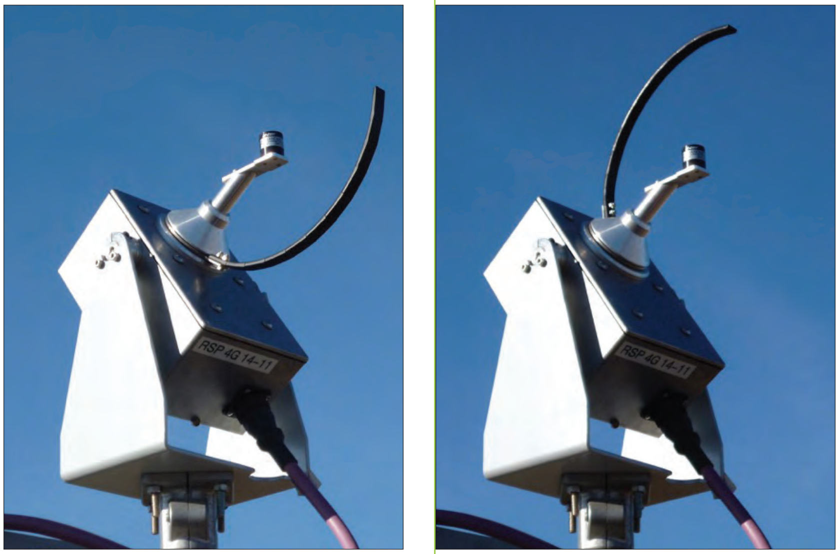
Task 46

Best Practices: Solar Irradiance Measurements with Rotating Shadowband Irradiometers

Large-scale solar thermal projects, such as those producing industrial process heat for mining areas in Chile or district heating in Denmark, require diligent solar resource assessments. Unfortunately, high accuracy irradiance data are scarcely available in many regions, which are attractive for solar energy applications. This holds especially true for solar thermal technologies using concentrating collectors to produce high temperatures. For these systems, the focus of the resource assessment lies on direct normal, or beam irradiance (DNI). Satellite data can only be used in combination with ground data to estimate inter-annual variability and long-term mean values. Hence, new ground measurements have to be collected for projects using concentrating collectors, such as high temperature process heat or district heating systems.

Ground measurement data usually show significantly higher accuracies than satellite derived irradiance data, when general guidelines regarding site selection and preparation, instrument selection and maintenance and data quality monitoring are respected. Best practices for Rotating Shadowband Irradiometers (RSIs), developed within the framework of IEA SHC Task 46: Solar Resource Assessment and Forecasting, are presented in the recently published report, *Best Practices for Solar Irradiance Measurements with Rotating Shadowband Irradiometers*

A continuously rotating RSI consists of a horizontally mounted solid-state pyranometer in combination with a shadowband. The shadowband is mounted below the sensor at an angle of (approximately) 45° and rotates around the sensor continuously at approximately once per minute (see Figure 1). This way the shadowband once casts a shadow on the sensor during the rotation, blocking out the sun for a short moment, which provides briefly a measure of the diffuse horizontal irradiance (DHI).



▲ **Figure 1. Rotating Shadowband Irradiometer (RSI) in normal position (left) and during rotation (right).**

Before this shadow is cast the pyranometer measures global horizontal irradiance (GHI). The irradiance measured over time during the rotation results in a typical measurement curve, which is analyzed to determine the diffuse horizontal irradiance (DHI). In the moment when the center of the shadow falls on the center of the sensor it basically only detects DHI. Subsequently, direct normal irradiance (DNI) is calculated by the datalogger using GHI, DHI and the actual sun height angle by known time and coordinates of the location.

Appropriate irradiance sensors for ground measurements must be selected in consideration of general surrounding conditions for equipment and maintenance to gain and maintain the necessary accuracy over the entire operation period. Thermopile instruments like pyrheliometers as specified in ISO standard 9060 [ISO9060, 1990] are severely affected by soiling [Pape, 2009] and also require expensive and maintenance-intensive support devices such as solar trackers. Thus, the uncertainty of resource assessment with pyrheliometers

continued on page 11

depends heavily on the maintenance personnel and cannot be determined accurately in many cases. The initially lower accuracy of RSIs, which can yield deviations of 5 to 10 % and more, is notably improved with proper calibration of the sensors and corrections of the systematic deviations of its response. The main causes of the systematic deviations are the limited spectral sensitivity and temperature dependence of the solid-state pyranometer commonly used in most RSIs. Several sets of correction functions exist and are documented in scientific publications and in the report.

▲ **Figure 2. Solar tracker with reference radiometers for RSI calibration at Plataforma Solar de Almeria.**

Besides the systematic deviations of the sensor response, a significant contribution to the measurement inaccuracy originates from the sensor calibration at the manufacturer, where no corrections are applied. For proper calibration however, the proposed corrections still need to be considered in the calibration procedure. While well documented standards exist for the calibration of pyrheliometers and pyranometers ([ISO9059, 1990], [ISO9846, 1993], [ISO9847, 1992]) they cannot be applied to RSIs and no corresponding standards exist for RSIs. Different RSI calibration methods exist and are compared in the report (Figure 2). Application of two or more calibration factors for the different irradiance components (GHI, DHI and DNI) respectively yields noticeable higher accuracy than the application of only one calibration factor derived from GHI measurements.

The IEA SHC Task 46 report contains RSI specific best practices for the following tasks:

- Requirements on the selection of a location for a measurement station
- Installation, operation and maintenance of a measurement station, including the case of remote sites
- Documentation and quality control of the measurements
- Correction of systematic errors & instrument calibration
- Also the performance and accuracy of RSIs are described.

RSIs have proven to be appropriate instruments for diligent solar resource assessments for large-scale solar thermal projects, especially for those using concentrating collectors. Due to their lower maintenance requirements, lower soiling susceptibility, lower power demand, and comparatively lower cost, RSIs show significant advantages over thermopile sensors when operated under the measurement conditions of remote weather stations. For properly calibrated RSIs that use correction functions for systematic effects, uncertainties of below 3% for 10 min DNI averages and below 2% for yearly DNI sums have been found in various studies. Thus, RSI's offer a low-cost solution for obtaining accurate DNI data for the proper sizing of solar systems using concentrating collectors.

This article was contributed by SHC Task 46: Solar Resource Assessment and Forecasting experts S. Wilbert, N. Geuder, M. Schwandt, B. Kraas, W. Jessen, R. Meyer, B. Nouri. For more information contact Dave Renné, Task 46 Operating Agent, drenne@mac.com or Stefan Wilbert, Stefan.Wilbert@dlr.de and visit the Task webpage http://task46.iea-shc.org/.

References

[ISO9059, 1990] ISO 9059:1990(E), Solar energy – Calibration of field pyrheliometers by comparison to a reference pyrheliometer, International Organization for Standardization, Case Postale 56, 1211 Genève, Switzerland (1990).

[ISO9060, 1990] ISO 9060:1990(E). Solar energy - Specification and classification of instrments for measuring hemispherical solar and direct solar radiation. International Organization for Standardization, Case Postale 56, 1211 Genève, Switzerland (1990).

[ISO9847, 1992] ISO 9847:1992(E), Solar energy – Calibration of field pyranometers by comparison to a reference pyranometer, International Organization for Standardization, Case Postale 56, 1211 Genève, Switzerland (1992).

[ISO9846, 1993] ISO 9846:1993, Solar energy – Calibration of a pyranometer using a, International Organization for Standardization, Case Postale 56, 1211 Genève, Switzerland (1993).

[Pape, 2009] B. Pape, J. Battles, N. Geuder, R. Zurita, F. Adan, B. Pulvermueller, Soiling Impact and Correction Formulas in Solar Measurements for CSP Projects, Proceedings of SolarPACES Conference, Berlin (2009).

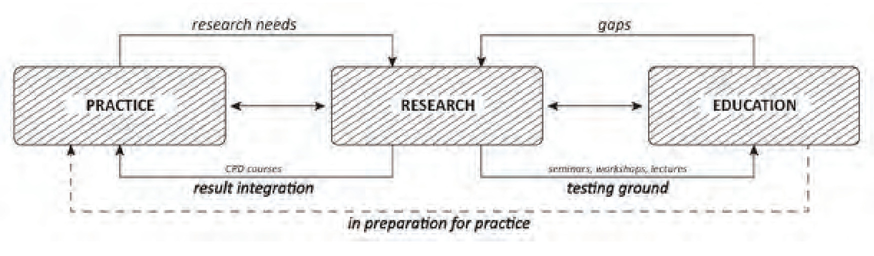
Task 51

State-of-the-Art: Solar Energy in Urban Planning Education

Education and dissemination are important issues for SHC Task 51 on Solar Energy in Urban Planning. As part of this work, Subtask D experts are focusing on educational issues to strengthen the knowledge and competence in solar energy and urban planning of relevant stakeholders, including university students, planners and other professionals. The creation of a substantial link between research and education as well as between research and practice is the core of Subtask D. This subtask is working to determine where deficits currently exist and then will evaluate the reasons for these deficits and propose solutions and strategies to overcome these shortcomings.

Task's Education Work

The goal of this work is to inform students as well as planners and professionals within the field of urban design and development on how to find relevant courses and to create a solar urban planning platform for dissemination and education. To do this, Task participants are integrating relevant methods for using digital and analogue tools and compiling experiences from case studies of completed projects and ongoing "action research/case stories."



▲ **Figure 1. Diagram of inter-dependencies of practice, research and teaching.** (Source: Simon)

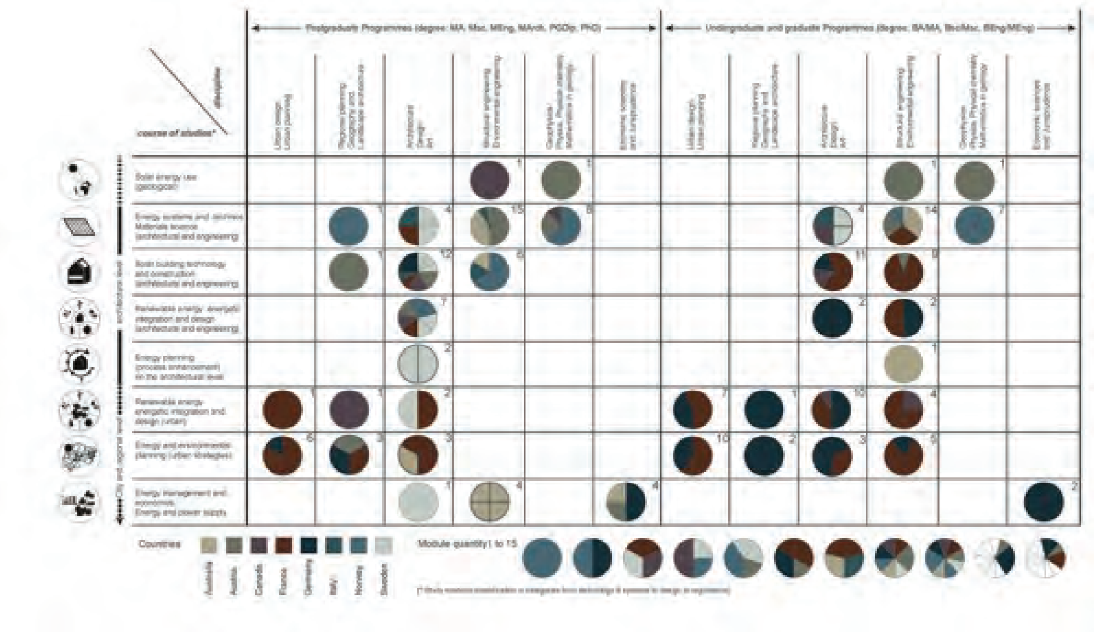
The experts in Subtask D are clearly summarizing the shortcomings and barriers in existing courses, and the related teaching methods, in order to provide relevant seminars, lectures and tools for educating the next generation of architects, urban planners and specialist planners.

The Subtask's modus operandi on how to find and evaluate existing teaching material was based at first on general online research, followed by a survey of the relevant programs and courses in regards to teaching about solar energy at universities and colleges. After identifying and analyzing these programs, expert interviews with various educators at different levels of experience took place to investigate in more detail the individual approaches of the applied methods behind teaching solar energy in the urban context. The final results of the survey and its evaluation show that solar energy and its adaption to the urban fabric are typically not included in the academic teaching programs.

The matrix in Figure 2 describes the information and data generated for solar energy adaptation in higher education. Among other approaches used, specific questionnaires were emailed to educators at universities in the SHC Task 51 participating countries of Australia, Austria, Canada, France, Germany, Italy, Norway and Sweden. And, to ensure a wide range of detailed information about the existing courses on solar energy, in addition to the survey various experts were directly interviewed.

The survey demonstrates a concrete overview on the content and methodology of the seminars and lectures in the different countries. Most of the taught courses focus on technical specifications, such as material and system studies as well as construction of solar integration systems. These topics were typically part of engineering and architectural programs at the undergraduate and postgraduate levels. The survey also shows that courses on solar energy design integration and energy planning are mostly taught in architectural and urban planning faculties at the undergraduate level. In regards to the education of students at an earlier stage of their studies, the survey shows that various courses

continued on page 11



▶ **Figure 2. Matrix on the study modules classification in categories. Each pie shows the number of identified and investigated courses in each country in relation to the educational program and course category.**
(Source: Siems, Simon).

exist at the undergraduate level for urban solar integration in design and planning in Germany and France.

The survey underlines our hypothesis that the importance of teaching solar energy as it relates to the urban context is necessary at an earlier stage of the educational training in universities to support the future practice. Currently, more specialized seminars and lectures on solar energy integration in the planning process are taught within postgraduate programs, which were chosen by the students after completing their first degree.

This comprehensive survey aimed to find modules on solar energy integration in construction and planning throughout a variety of disciplines. Within the field of urban and architectural design, in addition to urban integration in planning, the design project courses also exist that are integrating solar energy topics in the early stage of the design process. The survey reveals that various courses on solar energy also exist in the field of urban and regional planning and economic science and in jurisprudence. In the following matrix (Figure 2) the described information is displayed in a comparable overview.

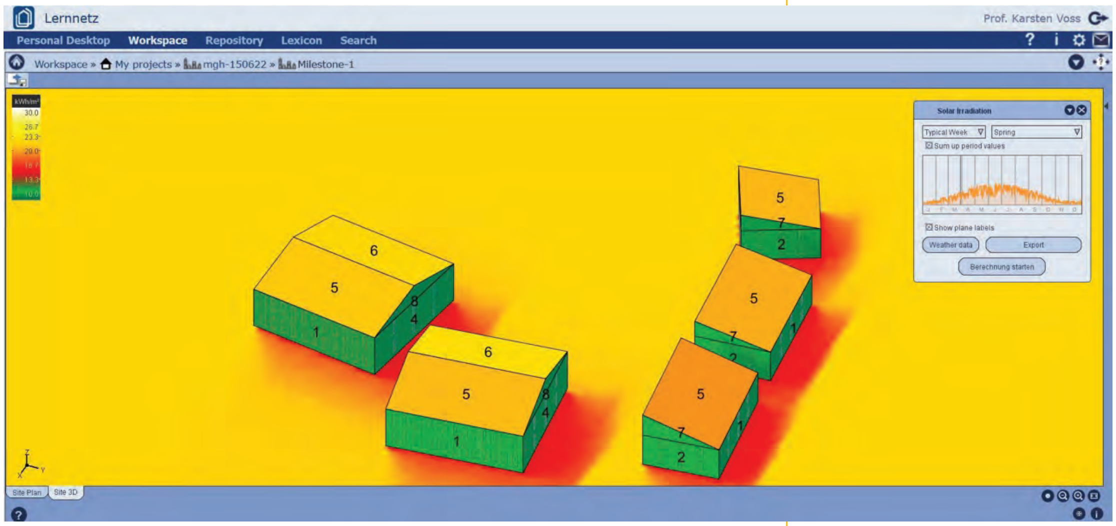
Development of Online Tools

This study identified that one of the core problems is the accessibility of relevant teaching material. We therefore will develop a web-based lifelong learning platform that will allow shared open source access to the constantly evolving research field. This platform will include a knowledge base of available digital and analogue tools and teaching methodologies as well as examples of best practices of integrating solar energy in an early phase of the planning process. During the development of this lifelong learning platform an evaluation in real-time of participating online users, students and educators will be taken into account in order to reflect existing educational material and possible deficits in its usability and accessibility.

Another activity within Subtask D is the development of the "EnOB Lernetz," which will be an exemplary tool to demonstrate how digital software tools can be integrated into the education process. The prototype web platform "EnOB Lernnetz" aims to let students acquire self-organized fundamental knowledge about energy-optimized design and building physics [Abromeit 2011]. A platform integrated basic CAAD module allows modeling of free-formed buildings within a web browser. The model data are stored on the server allowing shared work. As part of the German

continued on page 12

contribution to SHC Task 51, funded by the Federal Ministry of Economy, the basic functionality of the platform was improved and enhanced to handle shading and solar radiation analysis on the urban scale. Simulation modules for solar radiation, shadowing and sunlight hours are now fully functional. Results can be displayed as false color pictures and exported graphically as well as numerically. The degree of detail has been limited in favor of fast modeling and visual feedback in the early design phase (master plan). The calculation model only takes shadowing of direct sunlight into account. Building details, vegetation, shaded horizons as well as uneven site plans have not yet been implemented. After an initial application of the platform in a seminar at Wuppertal University in 2014, a second test phase starts in late 2015 when SHC Task 51 members will test and evaluate the functionality.



Typical Week ∇ Spring ∇
☒ Sum up period values
☒ Show plane labels

▲ **Figure 3. The user interface of the "EnOB Lernetz"** (Source: Voss).

Supporting the Task's Overall Goals

The main objective of SHC Task 51 is to provide a framework of support for urban planners, authorities and architects to achieve urban areas, and eventually entire cities, with integrated solar energy solutions thus achieving a substantial level of renewable energy in the total energy supply of cities and urban areas in the future. This includes the goal of develop processes, methods and tools capable of assisting cities in developing a long-term urban energy strategy. The scope of the Task includes solar energy issues related to new and existing urban area development and sensitive/protected landscapes (solar fields).

Institutions and universities in higher education are educating and forming the next generation of architects, urban planners and experts in this field. It is therefore of upmost importance that students gain in-depth and comprehensive knowledge in all relevant areas of the profession during their studies so that they can later apply this advanced knowledge in practice. Within this framework, the aim is to strengthen education at universities on the topic of solar energy in urban planning, by testing relevant software tools, generating an e-learning platform called "EnOB Lernnetz," and developing teaching materials in form of a web-based platform for lifelong learning. These materials will be useful also for tertiary educational courses and continuing professional development (CPD).

In addition to educational institutions, SHC Task 51 targets municipalities. This requires a direct dialogue and close collaboration with the various municipalities in each participating country. On this basis, good communication between different key actors provides a possibility to develop and test the important tools that allow logging exemplary work with different method approaches within the urban planning process. Also, it demonstrates 'best practice' examples of solar energy integration in urban planning.

This article was contributed by SHC Task 51 experts, Tanja Siems and Katharina Simon of the Institute for Urban Design and Urban Research at Wuppertal University, Germany and by Karsten Voss of the Institute for Building Physics and Building Services at Wuppertal University, Germany. For more information on SHC Task 51 contact the Operating Agent, Maria Wall, maria.wall@ebd.lth.se or visit the Task webpage, http://task51.iea-shc.org.

Reference

Abromeit, A., Wagner, A.: Web based building modeling and simulation, CISBAT, Lausanne, 2011.

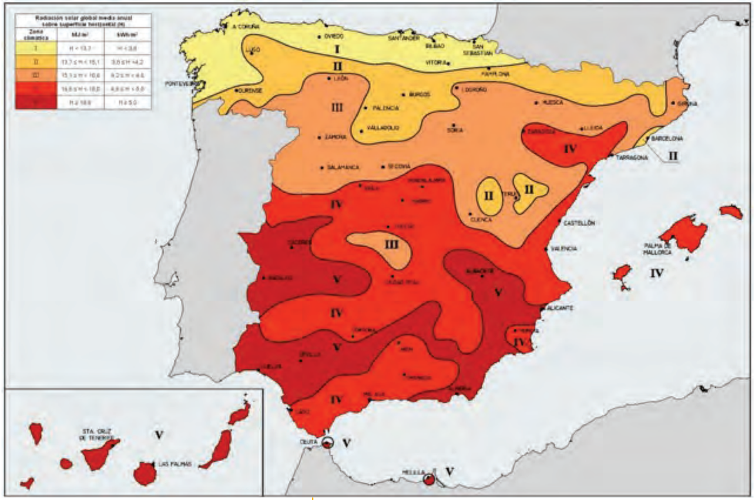
Country Highlight

Spain

A Sunny Paradise Truncated by a Financial Crisis: The Building Code Experience

In the recent past decades, Spain has pioneered two solar revolutions: mandatory inclusion of solar thermal in new and refurbished buildings and solar thermal electricity. The 2008 financial crisis deeply impact the industry and the future recovery and development will depend strongly on these and other adopted policies.

A Tale of Two Successes: Solar Thermal Building Codes and Concentrating Solar

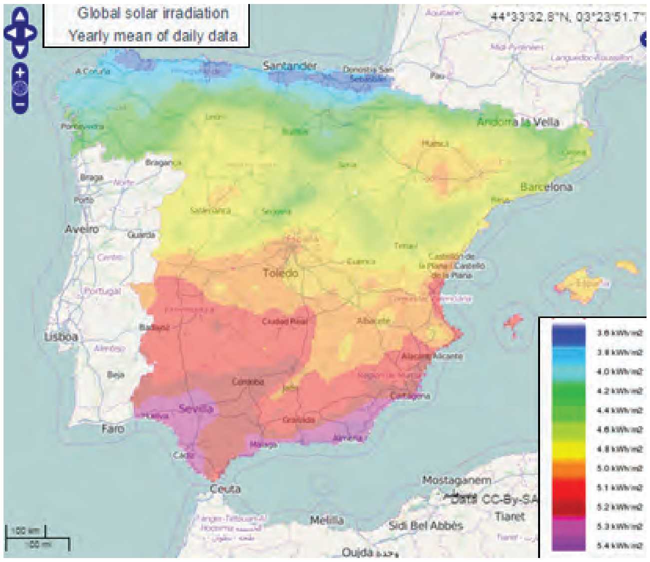


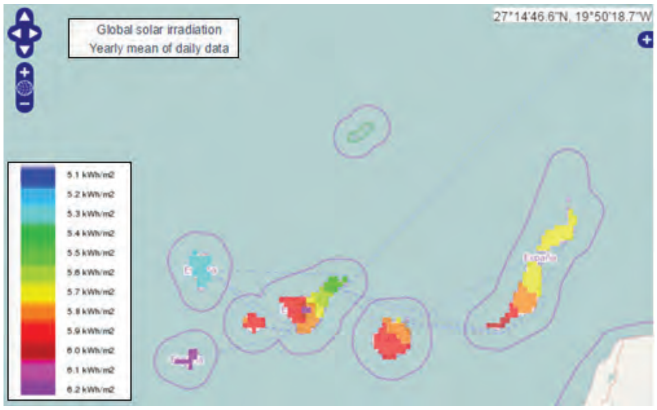
▲ **Figure 1. Climatic Zones as defined in the Spanish Building Technical Code.**

Spanish people are proud of their sun, as is confirmed by a long sunny tourism-oriented tradition. The sun is also a strategic policy-making focus. After a series of local solar regulations, in 2006 the Spanish Building Technical Code was approved, which included explicitly mandatory energy-saving measures in terms of energy demand limitation, HVAC and lighting performance and a minimal solar contribution. The minimal solar thermal contribution is for domestic hot water (DHW), and when applicable swimming pools, according to different climatic zones (see Figure1).

The Spanish government allows for both technologies (thermal and photovoltaic) the application of official climatic zones map from the building technical code. In 2012, CIEMAT (Spanish Energy, Environment and Technology Research Centre) published the Spanish Solar Global Irradiation map (http://www.adrase.es/en/) to contribute to the solar resource knowledge for the development of both technologies in the country.

The spatial distribution of solar radiation was estimated using satellite imagery and the processing of measured data in more than 50 AEMET (Spanish Meteorological Agency) stations over 10 years.

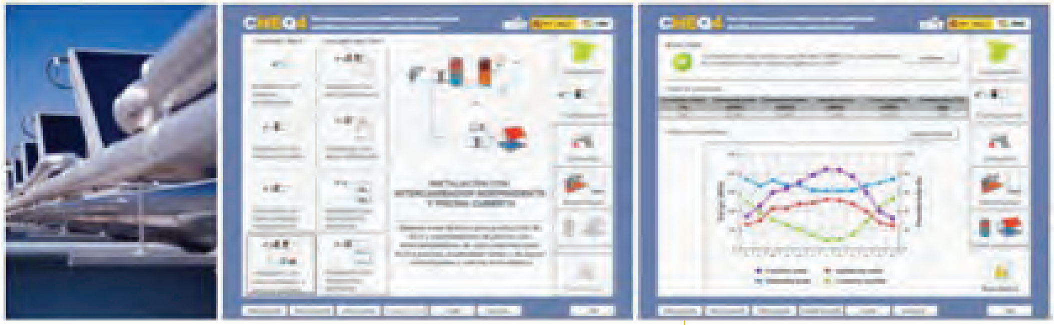




▲ **Figure 2. Spanish Solar Global Irradiation map for solar energy applications.** (Source: CIEMAT)

continued on page 15

Spain *from page 15*



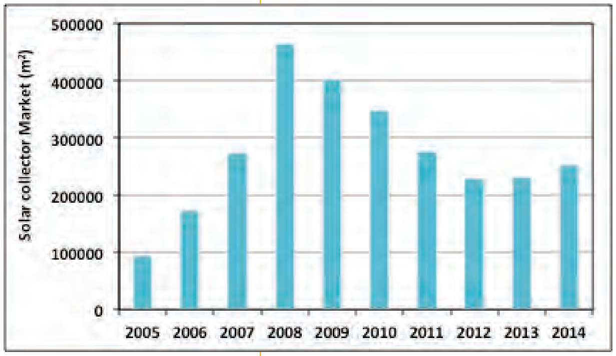
▲ **Figure 3. CHEQ4, a software package to promote solar thermal systems compliance with the Spanish Building Technical Code** (Source: http://www.codigotecnico.org/index.php/cheq4).

The energy saving measures were actualized in 2013, according to national implementation of the European Energy Performance of Buildings Directive 2010/31/UE. A new limit for the non-renewable contribution to DHW and HVAC was established, which created an opportunity for solar thermal applications beyond DHW. To promote solar thermal among the different stakeholders, IDAE (Institute for Energy Saving and Diversification, Spanish Ministry of Industry) and ASIT (Spanish Solar Thermal Industry Association) developed CHEQ4, a software package to evaluate a broad variety of solar thermal systems, assess their performance and generate all the official documentation for the project (see Figure 3). This tool allows in-situ system checking, which helps commissioning the appropriate system size.

The Key Issue: Solar Thermal Policies

Solar thermal systems in Spain consist mainly of water-based flat plate collectors. In 2012, the total capacity was 2,074 MWth (2,962,824 m^2) with a breakdown of flat plate collectors (1,862.9 MWth, 2,661,260 m^2), unglazed (93.9 MWth, 134,191 m^2) and evacuated tube (117.2 MWth, 167,373 m^2) collectors. In 2014, 178.5 MWth (255,000 m^2) was added to the overall system, representing a 9.7% increase with respect to 2013 figures. The share for the newly added capacity corresponds to flat plate collectors and prefabricated systems (92%), unglazed (2%) and evacuated tube collectors (6%).

As can be seen in Figure 4, the building code produced a relevant increment of the market size during the first years of application. But when the construction industry crashed, there was an exponential decay observed in 2008-2013. After this period, in 2014, a 9% increase of the Spanish market was reported. More than a half of this increment was due to a regional promotion program in Andalucía (PROSOL program), showing that policymaking is a key issue for solar thermal development. This regional program to promote renewable energy has produced a record 56 MWth installed in Andalucía.



▲ **Figure 4. Evolution of the solar collector market in Spain.**

National Strategy Addresses Building Energy Refurbishment

The Spanish policy at the national level is to promote the ESCO business model and to improve energy efficiency and the use of renewables in existing buildings. To achieve this goal there are specific financing programs (SOLCASA, 5 M€approximately) and cross sectorial ones, such as the renewable energy promotion in deep refurbishment of the building stock (see PAREER CRECE, 200 M€ approximately) in addition to a State plan for building refurbishment and urban renovation (RD233/2013, in total 2,300 M€approximately; with 100 M€approximately for energy efficiency measures). A hotel industry energy refurbishment program (PIMA SOL, 400 M€ approximately) is also expected to promote solar thermal in this sector.

The support of combined measures of Energy Efficiency and Renewables gives a common and homogenous framework where applicants can find the means to finance their actuations.

continued on page 17

Spain *from page 16*

Solar Thermal Electricity: The Golden Age

Since 2007 when the first commercial plant using concentrating solar thermal technology was connected to the Spanish grid, the figures for both installed capacity and generated energy saw enormous growth up to 2013 at which time the government drastically cut its support for electricity production using this renewable energy source (see Figure 5(a)).

The installed capacity is implemented in 50 solar thermal electricity (STE) plants, 40% of them with thermal storage systems. Normally, the STE plants are provided with thermal storage designed to cover 4 to 7 hours of operation after sunset or during cloudy periods, but the reference plant, Gemasolar, can produce electricity 24 hours during the summer (Figure 5 (b)). Commercial storage systems with such big capacities makes STE technology pivotal for creating an energy mix with a high percentage of renewables, including wind and PV although not being dispatchable electricity sources at this moment.

The experience gained in the design, construction, operation and maintenance of these 50 plants has placed the STE Spanish industry as 'number 1 worldwide' in the words of the European Solar Thermal Electricity Association. The experience and optimization of operation of the plants can be seen clearly by comparing the energy production in 2014 (4,958 GWh) to 2013 (4,429 GWh), resulting in an increase of around 12% in the energy production with the same power installed in both years.

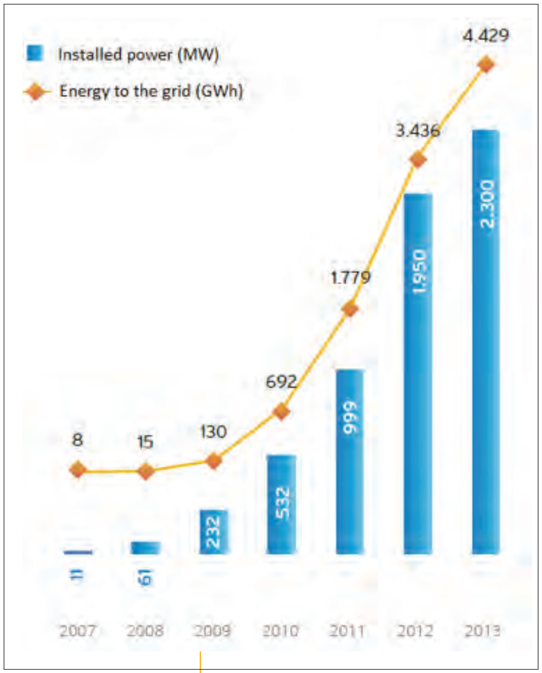


Figure 5(a) Evolution of the solar thermal electricity installation and energy generated in Spain (Source: Estudio del impacto macroeconómico de las renovables en España, 2013)

Despite the Spanish Government's current negative position to renewable power generation in general, and to STE in particular, new markets are emerging at across the globe in regions and countries with the objective of increasing its share of renewable energy and that are blessed with high levels of solar radiation and clear skies, such as the U.S., Australia, Turkey, Middle East, North Africa and South Africa, plus others. It is clear that in these new markets, the Spanish STE industry is playing an important role.

A New Look At Concentrating Solar: Solar Heat For Industrial Processes

Spain has been the leader in concentrating solar for power production, and in recent years there has been growing activity to promote applications for industrial processes. In 2010, Solar Concentra (Spanish Concentrating Solar Thermal Technological Platform) was created from a joint initiative of Fundación CTAER (Advanced Technology Centre for Renewable Energies), Andalucía regional government, and the National Economy and Competitiveness Ministry. At present there are 180 members, representing the different stakeholders involved.

IEA SHC Task 49: Solar Process Heat for Production and Advanced Applications (http://task49.iea-shc.org/) was launched in 2012 and Spanish participants, including CIEMAT, are contributing important work on process heat collectors and design guidelines for the integration of solar thermal systems in industrial processes. Main contributions include the design and definition of general requirements and relevant parameters for process heat collectors and tender information for the integration of process heat collector for industrial applications. Spain has identified the potential for solar process heat demand to be 14 million m^2.

Figure 5(b) Gemasolar power plant (Source: www.torresolenergy.com/TORRESOL/gemasolar-plant/en)

continued on page 18

Spain *from page 15*

In addition, as a result of SHC Task 49, Spanish participants from CIEMAT, Tecnalia, and CENER are also involved in the European project STAGE-STE "Scientific and Technological Alliance for Guaranteeing the European Excellence in Concentrating Solar Thermal Energy" (http://stage-ste.eu/), which is strongly connected to issues addressed in SHC Task 49, for example, process heat concentrating solar collectors development, process integration guidelines, and modelling and simulation of specific case studies in the industry. Spanish participants have also led the preparation of a database on concentrating solar collectors that will be available the end of 2015, and which is linked to both projects SHC Task 49 and STAGE-STE.

In addition, in 2014, promoted by Fundación CTAER, a medium temperature concentrating solar working group was created on Solar Concentra. There are 21 members representing the different stakeholders involved in promoting national market development through innovative public procurement. This working group is represented in the RHC Technology Platform Solar Panel Steering Committee. The group is currently developing studies that look to ascertain the potential market for concentration collectors. The group has become a meeting point for public administrations, solar collector manufacturers, research centers, universities, etc. to share their views on the current and future use of this technology.

▲ **Figure 6. View of a parabolic trough solar field for process heat (water desalination) at the Plataforma Solar de Almería.**

Up & Coming Solar Technologies

One of the most promising solar thermal technologies for the future are those coupled to district heating and cooling networks. In Spain, DHC networks are not the rule, but the exception. According to ADHAC (Spanish Association of District Heating and Cooling Companies) census, there are close to 240 networks in Spain (including micro-networks), with a documented installed power of 1,109.3 MW (data from 2014). Heating networks share 37%, heating and cooling networks share 62% and less than 1% cooling networks. Two thirds of the networks include a high percentage of renewables, almost exclusively biomass. Solar thermal is not present at the moment, but that has not stopped Spain from actively in the recently completed IEA SHC Task 45: Large Solar Systems and plans for contributing to the upcoming related activities.

Solar thermal it is not present in a single facility at the moment. IDAE recently published a study that analyzes the technical and economic feasibility of including a solar thermal installation in a DHC plant3and will publish a second study that analyzes the feasibility of including a concentration solar facility in a DHC located in southern Spain. The aim of these studies is to encourage the use of solar thermal energy in existing and future DHC facilities, the numbers for which are expected to grow in the short term.

Spain is also participating in IEA SHC Task 53: New Generation Solar Cooling and Heating Systems (PV or Solar Thermally Driven Systems) and IEA SHC Task 46: Solar Resource Assessment and Forecasting. In SHC Task 46, two Spanish institutions are leading activities in new advanced modeling and improved satellite-derived data for long term analysis.

This article was contributed by Ricardo Enríquez Miranda, Ph.D., of CIEMAT and the alternate Spanish SHC Executive Committee member (ricardo.enriquez@ciemat.es). He would like to thanks the following for their contributions, Dr. M^{a} José Jiménez (Spanish SHC Executive Committee member), CIEMAT's Renewable Energy and Plataforma Solar de Almería (PSA) Divisions researchers, IDAE, ASIT-SOLAR, Solar Concentra and the Spanish participants in different IEA SHC Tasks.

SHC Reports

Don't miss reading, using and referencing these SHC publications and databases

INDUSTRIAL PROCESS HEAT

Integration Guideline

Planners of solar thermal process heat systems (SHIP), energy consultants and process engineers will find this report valuable. It can also be used with other training materials for planners, energy managers and consultants.

Methodologies and Software Tools for Integrating Solar Heat into Industrial Processes

For those in the process integration community, this report covers specific issues and solutions/approaches for the integration of solar heat into industrial processes.

SOLAR COOLING

Report for Self-Detection on Monitoring Procedure

In this report, the reader will get an overview of the typical system errors and possibilities for a fast detection using automated system observation methods. It includes experiences from many different demonstration projects.

Report on Life cycle analysis

This technical report describes the research activities developed within Subtasks A2 "Life cycle analysis at component level" and B3 "Life cycle analysis at system level."

COMPACT THERMAL ENERGY STORAGE

Standard to determine the heat storage capacity of PCM using hf-DSC with constant heating/cooling rate (dynamic mode)

This technical report defines a measurement procedure based on the existing standard RAL-GZ 896 page (www.PCM-RAL.de) to cover PCM-characterization using DSCs.

POLYMERIC MATERIALS FOR SOLAR THERMAL APPLICATIONS

Info Sheets

This series of 34 *Info Sheets* presents the acquired know€how and the state-of-the-art on polymer research on solar thermal applications. These sheets are "add-ons" to the 2012 IEA SHC publication, *Polymeric Materials for Solar Thermal Applications.*

SOLAR RESOURCE ASSESMENT & FORECASTING

Integration of Ground Measurements with Model-derived Data

A review of the different techniques for correcting long-term satellite-derived solar radiation data using short-term ground measurements is given in this report.

Best Practices for Solar Irradiance Measurements with Rotating Shadowband Radiometers

This technical report presents best practices for Rotating Shadowband Radiometers (RSI) and describes RSI performance and accuracy.

SOLAR RENOVATION

Assessment of Technical Solution and Operational Management

The recommendations presented in this report are derived from demonstration projects and the lessons learned during the execution of the projects in the planning, construction and operation phases.

IEA SHC POSITION PAPERS

Before a Task ends, the experts, using the results of their work, prepare a Position Paper. The aim of these papers are to help inform provide policy makers, decision makers and opinion makers about the technologies, the market, the barriers, and the actions needed to accelerate the development and market uptake of specific technologies/practices. In 2015 the following Position Papers were published:

Solar Cooling

Solar Renovation of Non-Residential Buildings

Compact Thermal Energy Storage: Material Development for System Integration

Net Zero Energy Solar Buildings

Polymeric Materials for Solar Thermal Applications

IEA
programme
SHC

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 53 R&D projects (known as Tasks) to advance solar technologies for buildings. 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

Vol. 62, November 2015

Prepared for the IEA Solar Heating and Cooling Executive Committee

by

KMGroup, USA

Editor:
Pamela Murphy

www.iea-shc.org

Current Tasks and Operating Agents

Compact Thermal Energy Storage
Prof. Matthias Rommel
SPF Institute for Solar Technology
University of Applied Sciences
Rapperswil
Oberseestr. 19
Rapperswil CH 8640,
SWITZERLAND
matthias.rommel@solarenergy.ch
mrommel@hsr.ch

Solar Rating and Certification Procedures
Mr. Jan Erik Nielsen
SolarKey International
Aggerupvej 1
DK-4330 Hvalsö
DENMARK
jen@solarkey.dk

Solar Resource Assessment and Forecasting
Dr. David Renné
2385 Panorama Ave.
Boulder, CO 80304
UNITED STATES
drenne@mac.com

Solar Process Heat for Production and Advanced Applications
Mr. Christoph Brunner
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf
AUSTRIA
c.brunner@aee.at

Advanced Lighting Solutions for Retrofitting Buildings
Dr. Jan de Boer
Fraunhofer Institute of Building Physics
Nobelstr. 12
D-70569 Stuttgart
GERMANY
jdb@ibp.fraunhofer.de

Solar Energy in Urban Planning
Ms. Maria Wall
Dept. of Architecture and Built Environment
Lund University
P.O. Box 118
SE-221 00 Lund
SWEDEN
maria.wall@ebd.lth.se

Solar Heat & Energy Economics
Mr. Sebastian Herkel
Fraunhofer Institute for Solar Energy Systems
Heidenhofstr. 2
D-79 110 Freiburg
GERMANY
sebastian.herkel@ise.fraunhofer.de

New Generation Solar Cooling and Heating Systems
Mr. Daniel Mugnier
TECSOL SA
105 av Alfred Kastler - BP 90434
66 004 Perpigan Cedex
FRANCE
daniel.mugnier@tecsol.fr

Price Reduction of Solar Thermal Systems
Dr. Michael Köhl
Fraunhofer Institute for Solar Energy Sytems Heidenhofstr. 2
D-79 110 Freiburg
GERMANY
michael.koehl@ise.fraunhofer.de

IEA Solar Heating & Cooling Programme Members

AUSTRALIA	Mr. K. Guthie	ITALY	Mr. G. Puglisi
AUSTRIA	Mr. W. Weiss	MEXICO	Dr. W. Rivera
BELGIUM	Prof. A. De Herde	NETHERLANDS	Mr. L. Bosselaar
CANADA	Mr. D. McClenahan	NORWAY	Dr. M. Meir
CHINA	Prof. H. Tao	PORTUGAL	Mr. J. F. Mendes
DENMARK	Mr. J. Windeleff	RCREEE	Mr. A. Kraidy
ECI	Mr. N. Cotton	SINGAPORE	Mr. Tan Tian Chong
ECREEE	Mr. H. Bauer	SOUTH AFRICA	Dr. T. Mali
EUROPEAN COMMISSION	Mrs. S. Bozsoki	SPAIN	Dr. M. Jiménez
		SWEDEN	Dr. J. Sjödin
FRANCE	Mr. P. Kaajik	SWITZERLAND	Mr. A. Eckmanns
GERMANY	Ms. M. Heinze	TURKEY	Dr. B. Yesilata
GORD	Dr. E. Elsarrag	UNITED KINGDOM	Dr. R. Edwards

CHAIRMAN
Mr. Ken Guthrie
Sustainable Energy Transformation Pty Ltd
148 Spensley Street
Clifton Hill, Victoria 3068
AUSTRALIA
Tel: +61/412 178 955
chair@iea-shc.org

SHC SECRETARIAT
Ms. Pamela Murphy
KMGroup
9131 S. Lake Shore Dr.
Cedar, MI 49621
USA
Tel: +1/231/620 0634
secretariat@iea-shc.org