SHC

IEA SOLAR HEATING & COOLING PROGRAMME

2014

ANNUAL REPORT

Feature Article on

Solar Renovation of Non-Residential Buildings

IEA Solar Heating & Cooling Programme

2014 Annual Report

Edited by
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IEA Solar Heating and Cooling Programme

www.iea-shc.org

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IEA Solar Heating and Cooling Programme

ABOUT THE SHC PROGRAMME

The Solar Heating and Cooling Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency. The Executive Committee agreed upon the following for the 2014-2018 term:

The SHC Programme **vision**…

By 2050 a worldwide capacity of $5kW_{th}$ per capita of solar thermal energy systems installed and significant reductions in energy consumption achieved by using passive solar and daylighting: thus solar thermal energy meeting 50% of low temperature[1] heating and cooling demand.

The SHC Programme **mission**…

To enhance collective knowledge and application of solar heating and cooling through international collaboration in order to fulfill the vision

The Solar Heating and Cooling Programme's mission assumes a systematic approach to the application of solar technologies and designs to whole buildings, and industrial and agricultural process heat. Based on this mission, the Programme will carry out and co-ordinate international R&D work and will continue to cooperate with other IEA Implementing Agreements as well as the solar industry to expand the solar market. Through international collaborative activities, the will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data and market approaches, and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for industrial and agricultural process heat applications.

The Programme's target audience is the design community, solar manufacturers, and the energy supply and service industries that serve the end-users as well as architects, cities, housing companies and building owners.

The primary activity of the SHC Programme is to develop research projects (Tasks) to study various aspects of solar heating and cooling. Each research project (Task) is managed by an Operating Agent who is selected by the Executive Committee. Overall control of the Programme rests with the Executive Committee comprised of one representative from each member Country and Sponsor organization.
A total of 53 projects have been initiated to date. The Tasks running in 2014 were:

- New Generation Solar Heating and Cooling (Task 53)

1 Low temperature heat up to 250°C

member Country and Sponsor organization.
A total of 53 projects have been initiated to date. The Tasks running in 2014 were:

- New Generation Solar Heating and Cooling (Task 53)
- Solar Heat and Energy in Urban Environments (Task 52)
- Solar Energy in Urban Planning (Task 51)
- Advanced Lighting Solutions for Retrofitting Buildings (Task 50)
- Solar Heat Integration in Industrial Processes (Task 49)
- Quality Assurance and Support Measures for Solar Cooling Systems (Task 48)
- Solar Renovation of Non-Residential Buildings (Task 47)
- Solar Resource Assessment and Forecasting (Task 46)
- Large Scale Solar Heating and Cooling Systems (Task 45)
- Solar Rating and Certification Procedures (Task 43)
- Compact Thermal Energy Storage (Task 42)
- Polymeric Materials for Solar Thermal Applications (Task 39)

In addition to the project work, an international conference on Solar Heating and Cooling for Buildings and Industry was launched in 2012 and the 3rd conference was held October 2014 in Beijing, China. Also, a number of special activities – Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops – have been undertaken.

ABOUT THE IEA

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive program of energy co-operation among 29 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organizations and other stakeholders.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.

The Energy Technology Initiatives, or ETIs (formally organized under the auspices of an Implementing Agreement) function within a framework created by the IEA. The ETIS provide a flexible and effective mechanism for IEA member and non-member countries, businesses, industries, international organizations and non-government organizations to research breakthrough technologies, to fill existing research gaps, to build pilot plants, to carry out deployment or demonstration programs – in short to encourage technology-related activities that support energy security, economic growth and environmental protection. There are currently some 39 ETIs working in the areas of:

- Cross-Cutting Activities (information exchange, modeling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (devices and experiments)
- Renewable Energies and Hydrogen (technologies and deployment policies)

The ETIs are at the core of a network of senior experts consisting of the Committee on Energy Research and Technology (CERT), four working parties and three expert groups – the IEA Energy Technology Network. More than 6,000 specialists from 310 organizations in 51 countries carry out a vast body of research through these various initiatives (more than 1,600 projects to date). The CERT is supported by four expert Working Parties (end-use, fossil fuels, fusion and renewables), which oversee the activities of the IAs and evaluate their outcomes at the end of each term. The Working Parties provide leadership by guiding the ETIs to shape work programs that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed. SHC (formally the Implementing Agreement for a Programme to Develop and Test Solar Heating and Cooling Systems) reports to the Working Party on Renewable Energy Technologies (REWP). Views, findings and publications of SHC do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries. For further information on the IEA, the CERT, Working Parties and the Energy Technology Initiatives, please visit www.iea.org/techinitiatives.

Chairman’s Report

Ken Guthrie
Sustainable Energy Transformation Pty Ltd, Australia

2014 proved to be a year of growth and new frontiers for the SHC Programme. We welcomed four new members from across the globe – Gulf Organization for Research & Development (GORD), Regional Centre for Renewable Energy and Energy Efficiency (RCREEE), Turkey and the United Kingdom. We held our international conference in China. We started two new Tasks to tackle solar thermal and energy economics in urban environments and new generation solar cooling and heating systems. We completed two Tasks that have contributed valuable results in the areas of solar renovation in non-residential buildings and polymeric materials for solar thermal applications.

In 2014, I also began my term as SHC Chairman. I am following in the footsteps of a very active Chairman, Werner Weiss, and look forward to building upon what he accomplished during his term.

In terms of solar thermal technologies, there were many bright spots – solar thermal district heating is booming with Denmark leading the way, installations of solar thermal systems for industrial production processes reached 132 and continues to grow with systems throughout the world, and 120 solar thermal cooling systems were installed and technology innovations are creating a stronger and more sustainable market. All these advances and others are supported by the improvements being achieved in the field of solar resource assessments – forecasting, data collection and solar model improvements.

The SHC Programme, with more than 300 experts from over 20 countries, is dedicated to the growth of solar thermal and through our work and collaboration with other organizations we look forward to sunny future.

Learn more about solar thermal through our activities:

***Solar Heat Worldwide**,* is a primary source for the annual assessment of solar thermal. The report is the leading data resource due its global perspective and national data sources. The installed capacity of the 58 documented countries represents 95% of the solar thermal market worldwide.

SHC 2014: International Conference on Solar Heating and Cooling for Buildings and Industry, our international conference series provides an opportunity for experts to gather and discuss the trending topics and learn about the work others are doing in the field. The 3rd SHC conference was held October 13-15 in Beijing, China and welcomed some 200 participants from 30 countries. The conference program included 84 presentations, including 15 keynote lectures, and 77 scientific posters.

Our prestigious ***SHC Solar Award*** recognizes individuals, companies and institutions that have made significant contributions to the growth of solar thermal. The 2014 SHC Solar

Award recognized an outstanding municipality – the City of Montmélian, a solar thermal pioneer for more than 30 years. The award was presented at SHC 2014 in Beijing.

SHC book series, published by Wiley-VCH, shares our results with a broad audience. The published books include the first book ever published that is devoted to polymers for solar thermal applications and in early 2015 a book on Modeling, Design, and Optimization of Net-Zero Energy Buildings and one on Solar and Heat Pump Systems for Residential Buildings.

Each of these activities serve as a means to inform policy and decision makers about the possibilities of solar thermal as well as the achievements of our Programme.

Please take a moment to learn more about these activities and our work. Our website, http://www.iea-shc.org is a good starting point.

Also, come learn and share in Istanbul, Turkey at ***SHC 2015: International Conference on Solar Heating and Cooling for Buildings and Industry*** on December 2-4. The Executive Committee is happy to organize this conference in cooperation with the Turkish ISES Section, GÜNDER and ESTIF. Conference details can be found at http://www.shc2015.org.

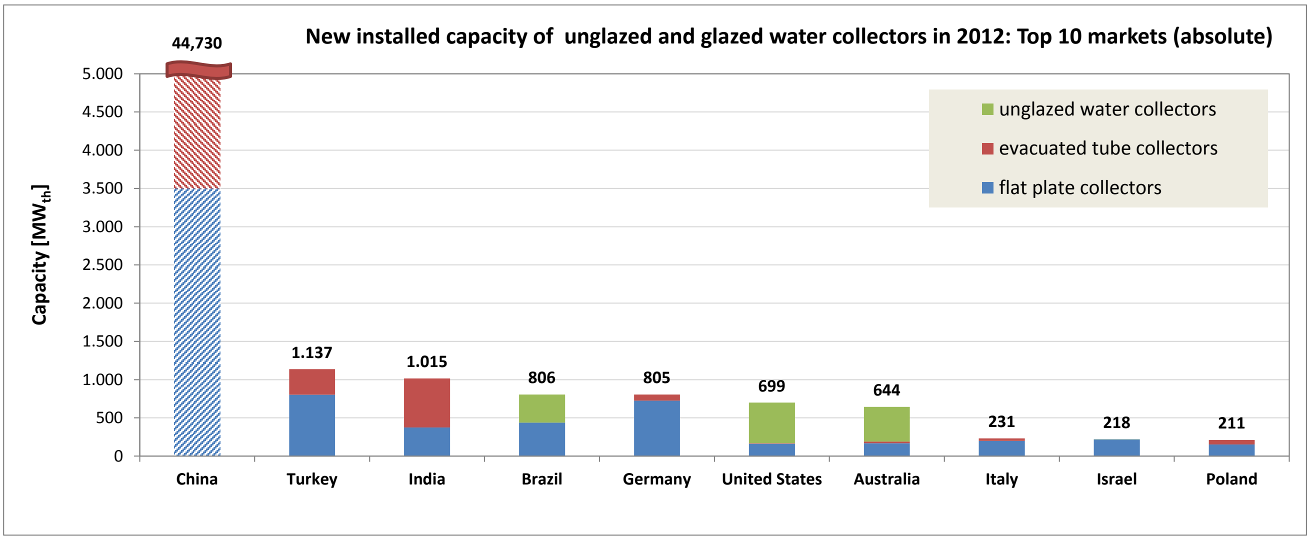
In closing, I would like to thank Werner Weiss for guiding and pushing the SHC Programme to broaden its work, its dissemination activities and its membership for the past four years. I also would like to thank my Vice Chairmen, He Tao and Daniel Mugnier, the members of the Executive Committee, the Operating Agents of the Tasks as well as all the experts working in our projects, the Secretariat, Pamela Murphy, and the Webmaster, Randy Martin. I look forward to my two years as Chairman and to the support of the Executive Committee and Operating Agents as I coordinate this work from Australia.

Ken Guthrie
SHC Executive Committee Chairman

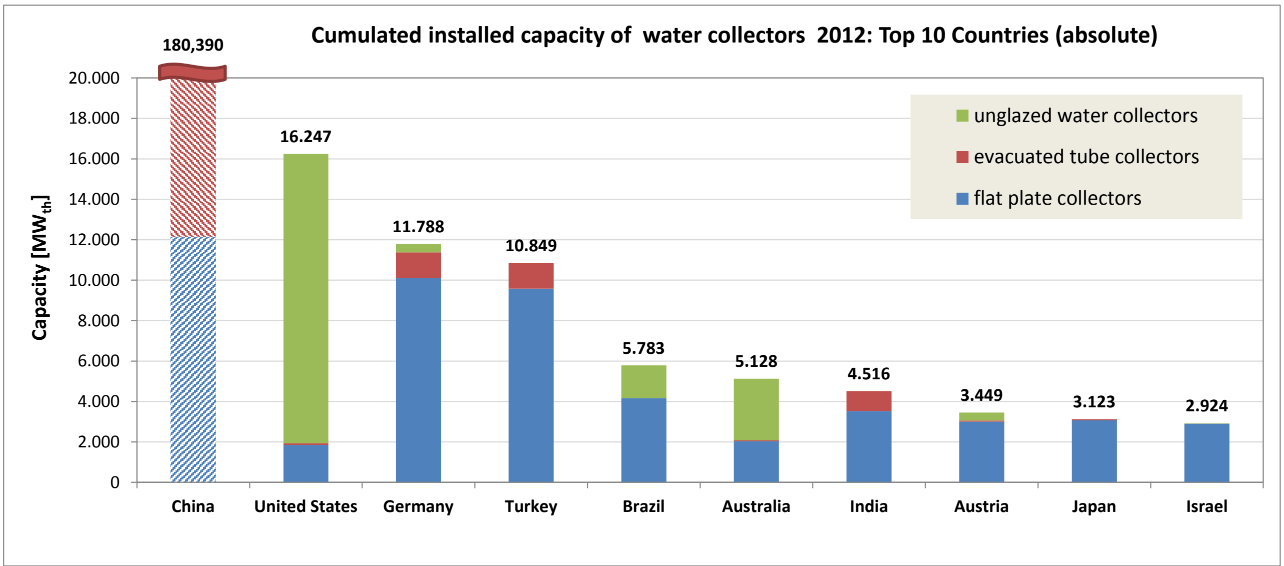
2014 RECAP

Solar Thermal Outlook

The SHC Programme publishes the only annual global solar thermal statistics report, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply*. The 2014 edition reports that in 2012, solar thermal technologies produced 227.8 TWh – which corresponds to an energy savings equivalent of 24.5 million tons of oil and 79.1 million tons of CO_2. The number of new installations grew by 9.4% compared to 2011 with China as a main market driver followed by Turkey, India and Brazil. In terms of the cumulated area installed, China is the absolute leader followed by the United States, Germany and Turkey.



Top 10 countries: New installations of flat-plate and evacuated tube collectors in 2012.



Top 10 countries: Cumulated water collector installations in 2012.

Key Findings from 2012 Data

- Cumulated capacity in operation in 2012 was 269.3 GW_{th} (384.7 million m^2):
    - 64.6% evacuated tube collectors
    - 26.4% glazed flat plate collectors
    - 8.4% unglazed water collectors
    - 0.6% unglazed air collectors

- China and Europe accounted for 92% of the world's new installations.

- Market penetration of newly installed unglazed and glazed water collectors (installed capacity per 1,000 inhabitants) leading countries:
    - China: 33 kW_{th}; Australia: 29 kW_{th}; Israel: 29 kW_{th}; Austria: 18 kW_{th}; Greece: 16 kW_{th}; Denmark: 14 kW_{th}, Turkey 14 kW_{th}, Switzerland: 14 kW_{th}, Cyprus: 14 kW_{th}

- The estimated total capacity in operation by the end of **2013** is 330 GW_{th} or 471 million square meters of collector area. This corresponds to an annual collector yield of 281 TWh.

SHC ACTIVITIES

New Members

Four new members in 2014:

- Gulf Organization for Research & Development (GORD) of Qatar joined as a Sponsor.
- Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) based in Egypt joined as a Sponsor.
- Turkey joined as a Contracting Party.
- United Kingdom joined as a Contracting Party.

The SHC Programme has already begun to benefit from their participation and the Programme's work is expanding to meet the needs of these new members.

Tasks

The Programme continues to push forward on cutting edge topics in solar thermal as well as in the field of solar buildings, architecture and lighting, all of which support our strategic focus on market deployment and R&D.

In 2014, the following Tasks began:

- ***Task 52: Solar Energy and Energy Economics in Urban Environments***
  (Lead Country: Germany)
  This Task is focusing on the analysis of the future role of solar thermal in energy supply systems in urban environments. Based on an energy economic analysis – reflecting future changes in the whole energy system – strategies and technical solutions as well as associated tools will be developed. Good examples of integration of solar thermal systems in urban energy systems will be developed and documented.

- ***Task 53: New Generation Solar Cooling and Heating Systems***
  (Lead Country: France)

This Task is working to support the strong and sustainable market development of solar PV or new innovative thermal cooling systems. It is focusing on solar driven systems for both cooling (ambient and food conservation) and heating (ambient and domestic hot water).

And, the following Tasks ended:

- ***Task 39: Polymeric Materials for Solar Thermal Applications***
  (Lead Country: Germany)

- ***Task 47: Solar Renovation of Non-Residential Buildings***
  (Lead Country: Norway)

SHC Conference

SHC 2014, our 3rd *International Conference on Solar Heating and Cooling for Buildings and Industry,* was held in Beijing, China in October. The conference was in collaboration with CSTIF and hosted by the China Academy of Building Research (CABR).

The level of participation was lower than in 2013, but the audience remained diverse. The conference program included 14 technical sessions, final technical presentations of Task 39: a dedicated industry session and four plenary sessions, technical tours to CABR and Vicor. Just over 200 participants form 30 countries listened to 84 presentations, including 15 keynote lectures, and meet with 77 experts during the scientific posters sessions.

The SHC Executive Committee thanks all the authors for their high quality contributions, and to the Scientific Committee members who reviewed the abstract submissions.

SHC 2015 will return to Europe. On December 2-4 experts and non-experts will gather together in Istanbul, Turkey to share and learn about current solar thermal research, new technology developments and market trends. The SHC Programme, ESTIF and GÜNDER, (Turkey's Section of ISES) are organizing the conference.

SHC Solar Award

The 9th SHC Solar Award was given to the French city Montmélian la Solaire. The Mayor, Mrs. Béatrice Santais, received the award on behalf of city. Currently, the town boasts some 370 m2 of thermal solar panels per 1,000 inhabitants, which is ten times more than the national average. Of the solar thermal collector area, 56% are installed on municipal buildings and 44% on private multifamily houses.

The SHC Solar Award is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements in the field of solar heating and cooling, and that supports the work of the IEA Solar Heating and Cooling Programme.

The 2015 SHC Solar Award will be presented at SHC 2015 in Istanbul, Turkey.

SHC COLLABRATION

To support our work, the SHC Programme is collaborating with other IEA Programmes and solar organizations.

Within the IEA

IEA Energy Conservation through Energy Storage Programme is collaborating in *SHC Task 42: Compact Thermal Energy Storage*. This is the first fully joint Task with Operating Agents from each Programme.

IEA Photovoltaic Power Systems Programme is collaborating in *SHC Task 46: Solar Resource Assessment and Forecasting*.

IEA SolarPACES Programme is collaborating in *SHC Task 46: Solar Resource Assessment and Forecasting* and *SHC Task 49: Solar Heat Integration in Industrial Processes.*

IEA Buildings Coordination Group is represented by the Dutch Executive Committee, Lex Bosselaar, who attends the semiannual meetings.

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC Programme to increase national and international government agencies and policymakers awareness of solar thermal's potential and to encourage industry to use solar thermal R&D results in new products and services.

To support this collaboration, the *9th SHC/Trade Association* meeting was held in conjunction with SHC 2014 in Beijing, China. The 10th meeting is planned for December 2015 in conjunction with the SHC 2015 conference in Istanbul, Turkey.

European Solar Thermal Industry Federation**,** the SHC Programme has signed a Memorandum of Understanding with ESTIF to jointly organize the SHC 2015 conference with the option to collaborate on future SHC conferences.

EXECUTIVE COMMITTEE MEETINGS

2014 Meetings

The Executive Committee will hold two meetings:
- May 16-18 in Calgary, Canada
- October 16-17 in Beijing, China

2015 Meetings

The Executive Committee held two meetings:
- June 15-17 in Rotterdam, Netherlands
- November 30 – December 1 in Istanbul, Turkey

Membership

Contracting Parties

Australia
Austria
Belgium
Canada
China
Denmark
European Commission
Finland
France
Germany
Italy
Mexico
Netherlands
Norway
Portugal
Singapore
South Africa
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

Sponsors

ECREEE *(ECOWAS Centre for Renewable Energy and Energy Efficiency)*
ECI *(European Copper Institute)*
GORD *(Gulf Organization for Research & Development)*
RCREEE *(Regional Centre for Renewable Energy and Energy Efficiency)*

Communication continued with countries invited to join the Programme – Brazil, Chile, India, Japan, Luxembourg, Slovakia, Slovenia, South Korea, Thailand and Tunisia.

Benefits of Membership

The SHC Programme is unique in that it provides an international platform for collaborative R&D work in solar thermal. The benefits for a country to participate in this Programme are numerous.

- **Accelerates** the pace of technology development through the cross fertilization of ideas and exchange of approaches and technologies.
- **Promotes** standardization of terminology, methodology and codes & standards.
- **Enhances** national R&D programs thorough collaborative work.
- **Permits** national specialization in technology research, development, or deployment while maintaining access to information and results from the broader project.
- **Saves** time and money by sharing the expenses and the work among the international team.

How to Join

To learn how your government agency or your international industry association, international non-profit organization or non-government organization can join please see the following chart and contact the SHC Secretariat for questions and add information *(secretariat@iea-shc.org).*

HOW TO JOIN AN IEA ENERGY TECHNOLOGY INITIATIVE (ETI) [1]

Can my organisation participate?

Become a Contracting Party	Become a Sponsor
Contracting Parties (CP) are participants that are: - Governments of both OECD member or non-member countries[2]; - The European Union; and - Inter-governmental organisations. This includes any national agency, public organisation, private corporation or other entity designated by the government of the country wishing to become a CP.	Sponsors are participants that are: - Entities of an OECD member or non-member country that is not designated by the government of its country to participate in a particular IA; -Non-intergovernmental international entity in which one or more countries participate; and - Not eligible to be elected as Chair or Vice-Chair. A government-owned or controlled entity can become a Sponsor as long as the government of the proposed Sponsor has no objection to it being a Sponsor rather than a CP.

What is the process to follow?

Contact the Chair of the MTI

1. My organisation contacts the Chair of the ETI to discuss potential benefits of working together. 2. If there is mutual interest, then terms and conditions of participation are discussed. 3. If there is agreement, then the formal process may begin.	1. My organisation contacts the Chair of the ETI to discuss potential benefits of working together. 2. If there is mutual interest, then terms and conditions of participation are discussed. 3. If there is agreement, then the formal process may begin.

Formal Vote and Letter of Invitation

1. The ETI Executive Committee (ExCo) votes unanimously to invite my organisation to become a participant as a CP, including any specific terms and conditions. 2. The ExCo Chair or his/her representative sends a formal letter of invitation to my organisation, specifying the terms and conditions of participation.	1. The ETI Executive Committee (ExCo) votes unanimously to invite my organisation to become a participant as a Sponsor, including any specific terms and conditions. 2. The ExCo Chair or his/her representative sends a formal letter of invitation to my organisation, specifying the terms and conditions of participation.

Formal Letter of Acceptance

1. If my organisation is a government ministry, office or department that intends to participate directly in the ETI, a letter of acceptance is sent to the IEA Executive Director, naming the individual(s) who will sign the Agreement on its behalf. 2. If my organisation is a government entity that intends to designate another entity to participate on its behalf, my organisation sends a letter of designation to the IEA Executive Director and names the individual(s) who will sign the Agreement on its behalf. The designated entity also sends a letter of acceptance to the IEA Executive Director.	1. If my organisation intends to participate directly a letter of acceptance is sent to the IEA Executive Director, naming the individual(s) who will sign the Agreement on its behalf. 2. If my organisation intends to designate a separate entity to participate on its behalf, it sends a letter of designation to the IEA Executive Director and names the individual(s) who will sign the Agreement on its behalf. The designated entity also sends a letter of acceptance to the IEA Executive Director.

Formal Approval by the Committee on Energy Research and Technology (CERT)

If my organisation represents an OECD non-member country or intergovernmental organisation has never participated in any of the ETIs then it must be approved by the CERT.	If my organisation has never participated in any of the ETIs as a Sponsor then it must be approved by the CERT.

When does my organisation become a formal participant?

The IEA Secretariat in Paris sends a signature page to the individual named in the letter of acceptance. Participation is effective on the date of signature.	The IEA Secretariat in Paris sends a signature page to the individual named in the letter of acceptance. Participation is effective on the date of signature.

Notes:

1. The information in this table draws on the IEA Framework for International Energy Technology Collaboration. For further details, please refer to page xx.

2. OECD refers to the Organisation for Economic Co-operation and Development. A country is defined as a sovereign nation that is recognised as such by the United Nations. Economies that have been declared as protectorates of another state are not sovereign nations and therefore cannot participate in IAs.

Feature Article

Non-Residential Solar Building Renovation – The Potential, Opportunities and Barriers

Fritjof Salvesen
Asplan Viak AS
Operating Agent for Enova SF, Norway

A 50 - 90% reduction in heat consumption and a 50 - 70% reduction in overall energy demand are possible when renovating a building. Twenty exemplary renovation projects highlighted in SHC Task 47: Solar Renovation of Non-residential demonstrate how this can be achieved. Two buildings of these buildings achieved the plus-energy standard and one of them received the highest possible BREEAM score of "Outstanding." And, all these buildings used commercially available products and systems.

The Powerhouse Kjørbo in Sandvika, Norway (the office building of the SHC Task 47 Operating Agent, Fritjof Salvesen) received a BREEAM "Outstanding – As Built" certification. Two office buildings from the early 1980s were renovated using high insulation standard, PV and ground coupled heat pump.

Many studies show that buildings account for about 40% of the total energy consumption in OECD countries. Add to this fact that more than 50% of the existing building stock will still be in use in 2050 and that more than 50% of the buildings in many OECD countries were built before 1970. Recognizing this, in April 2009 the EU Parliament approved a recommendation that member states set intermediate goals for existing buildings as a fixed minimum percentage of buildings to be net zero energy by 2015 and 2020. What does all this mean? That the potential is high and opportunities numerous for renovations that achieve a 50 - 90% reduction in heat consumption and a 50 - 70% reduction in the overall energy demand in the building.

Several of these exemplary renovation projects demonstrate that the total primary energy consumption can be drastically reduced and the indoor climate greatly improved. Because most property owners are not even aware that such savings are possible, they set energy targets that are too conservative, which then leads to buildings being renovated to mediocre performance standards and thus create a lost opportunity for decades.

The experts in SHC Task 47 analyzed highly successful renovation projects by focusing on the development of innovative concepts for the most important market segments. The Task narrowed its scope by working with mainly two types of non-residential buildings – offices and education buildings, including protected and historic buildings.

The primary indicator identified in all the successful renovation projects was a multidisciplinary, highly skilled group working towards a common goal. This group includes the building owner, the architect, consulting engineers as well as builders and contractors.

Key Findings

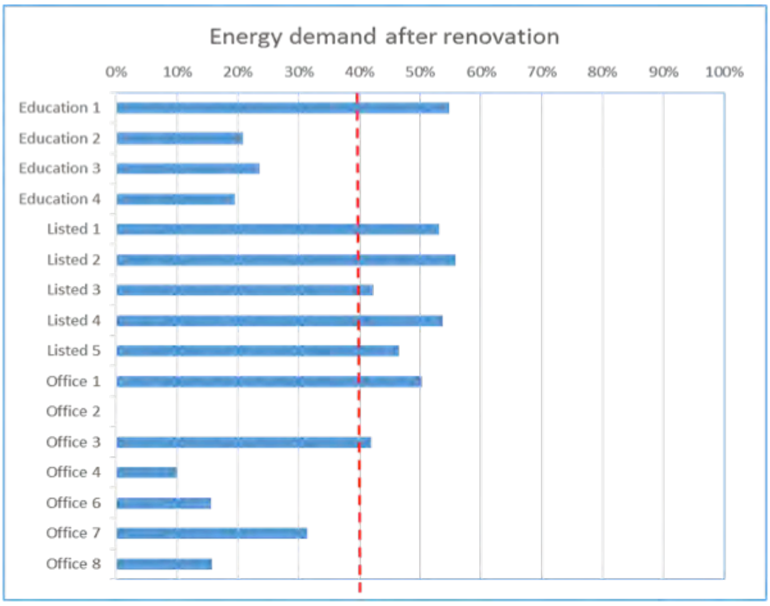
Findings from the 20 projects analyzed included:

- PV seemed to be more interesting for the building owner than solar thermal installations. One obvious reason was that most buildings are offices with limited domestic hot water and heat demand. One exception was a monastery that installed a 360 m^2 building integrated solar system to cover 20% of the space and water heating.

- It is not possible to make a significant relation between energy savings and renovation costs. However, for many projects with cost information available, costs for energy saving measures were between 70 and 210 € /m². The energy savings in these buildings varied from 45-60%.

- The total renovation cost for the two plus-energy buildings were quite similar, respectively 2,600 and 2,700 €/m². Both buildings added large PV installations.

- Windows, in most cases, were upgraded to a U-value of 1.0 W/m²C or less, and often down to the passive house standard 0.7 W/m²C.



Percentage of energy demand after renovation for different building types. The red line represents the IEA SHC Task 47 targets.

- Many buildings were equipped with demand controlled mechanical ventilation systems with heat recovery; often in combination with controlled natural ventilation systems for summer months.

- Limited mechanical cooling was needed as the cooling demand is mostly covered by nighttime ventilation.

- Many buildings installed efficient lamps with daylight control and/or movement sensors.

- Pupils in one school project showed significant improvement in concentration test scores and health and well-being questionnaires after the upgrade of the ventilation system.

Technology Status

A number of relevant energy efficiency products and systems exist on the market. It seems, however, that some countries, such as Austria and Germany, have a better-developed commercial market than many other countries.

There is a need for optimized heating delivery systems for retrofit projects. The reason for this is that it is hard to find products that are adapted and optimized for buildings with very limited heat demand. Usually, the heating demand in retrofitted buildings can be supplied with supply water temperatures in the range of 30 to 40°C. And, this often requires the use of radiant heating systems, such as wall, floor or ceiling heating systems, which are operated with significantly reduced supply water temperatures. However, the installation of radiant heating systems is not always possible or is difficult to do because of the room height and available installation area.

For some buildings, it is not possible to reduce the energy demand as much as wanted due to restrictions or difficulties with the building envelope. To make the climate footprint of these buildings better, increased use of renewable energy may be a favorable option.
For historic and protected buildings, many regular energy saving measures are not compatible with preserving the old buildings character. Listed protected buildings often have requirements to keep the expression and architecture of the building, in some cases a change of the building's architecture expression is not legally possible.

Market Opportunities and Barriers

As SHC Task 47 participants worked to identify the barriers and opportunities in the renovation process, it was important that they also identified the main barriers and how to address them to make the renovations attractive, affordable, cost effective and more accessible.

The methodologies applied to identify the barriers and driving forces included desktop studies of available building stock information and ownership structures in partner countries, interviews and in-depth descriptions of the decision-making processes used in ten case studies from six of the participating countries.

By systematically studying the drivers and barriers, suggestions for how to strengthen the drivers and eliminate or reduce the barriers were developed. The following tables present recommendations to authorities and industry.

Before and after photos of a 1960s school in Schwanenstadt, Austria that was renovated to meet passive house standards.

Source: Claudia Dankl, AEE INTEC

Table 1. How authorities can contribute to increasing the number of nZEB retrofitting projects.

AUTHORITIES	Strengthen drivers	Eliminate barriers
Increase attractiveness	• As part of information campaigns use relevant media and conferences to show good examples. • Place particular spotlight on the enthusiasts (both within owner organization and advisors). • Actors receiving grants also see this as confirmation of a good decision and see this strengthening the organization's image.	• Develop convincing arguments for nZEB. • Endorse serious frontrunners. • In some countries it is obligatory that companies have a statement about their impact on the environment. This could be extended by an obligation to state what energy labels their buildings hold. This increases the awareness of the issue of the energy efficiency of buildings.
Increase competitiveness	• Increased tax on energy. • Energy labelling systems provide a neutral reference for comparing buildings on energy performance and thereby increase the focus on this as a competitive advantage.	• Put in place training programs for all relevant crafts to be updated on nZEB upgrading. • Announce stepwise enforcement of building codes.
Make it more affordable	• Stronger subventions programs for owners upgrading towards nZEB (driver in some projects).	• Stronger subventions programs for owners upgrading towards nZEB standard (barrier in other projects).
Make it more available	• Make sure the top management of building owner companies see the benefits of nZEB upgrading and as a consequence they will be more open for such initiatives within their own projects.	• When public bodies upgrade their own buildings, nZEB ambition should be required. In this way both experience and good examples are developed locally. Tender processes must be defined adequately to avoid pure focus on price. A partnering contact for the design phase seems to be a good solution for this. • Facilitate arenas for the industry to meet with researchers and other companies to share experiences.

Table 2. How industry can contribute to increasing the number of nZEB retrofitting projects.

INDUSTRY	Strengthen drivers	Eliminate barriers
Increase attractiveness	• Identify the owner segments which focus on sustainability. • Use relevant media and conferences to show good examples. • Place spotlight on the enthusiasts (both within owner organization and advisors).	• Develop convincing arguments for nZEB.
Increase competitiveness	• Research projects which focus on combining best innovations on component level in order to make more efficient retrofitting processes. • Smart changes of floor plan can improve the area efficiency per employee. Also smart extensions of the existing building, for instance add an extra floor on the top may also improve the economy of the project.	• Better initial audits of the building will reduce the amount of unforeseen challenges. • Systematic training programs to update the skills of all personnel involved in the projects; from planning, construction and hand over/use. • Use of QA tools to assure the quality of a) products/systems, b) competence of the involved actors and c) processes.
Make it more affordable	• Offer of ESCO contracts where the owner pays in accordance with the energy savings obtained.	• Offer of financing as part of the upgrading package.
Make it more available	• Spread the experiences to new regions so new potential clients can see good examples in their neighbourhood. • Make sure the top management of building owner companies see the benefits of nZEB upgrading and as a consequence they will be more open to such initiatives within their own projects.	• As it is a challenge to do deep retrofitting while the tenants stay in the building, use of prefabricated solutions may reduce the level of disturbance as well as the length of the on site retrofitting process.

The points in red text in Table 2 are the same as the recommendation to authorities, meaning that for these actions joint efforts should be undertaken. Of course, the other points work in conjunction with the measures that need to be taken by authorities.

The owner of the building will always make the final decision regarding a project's level of ambition. Learning from Carlson & Wilmot's "The Five Disciplines for Creating What Customers Want," there are five principles that should be in place for a successful nZEB renovation project:

1. A holistic understanding of the tenant's needs – which normally encompasses more than just energy efficiency,
2. Solutions offering values that completely fulfill the needs,
3. One or more enthusiastic person who is committed to the process,
4. A multi-disciplinary team (including occupants), and
5. Project support by top management and in line with the company strategy.

To learn more about the 20 exemplary renovation projects you can download the corresponding project brochure from [SHC Task 47 webpage](). Here you will also find four technical reports:

- *Lessons Learned from 20 Non-Residential Building Renovations*
- *Market Change: Upgrading of the Non-Residential Building Stock Towards Sustainable Standard*. Recommendations to authorities and construction industry.
- *Sustainable Refurbishment School Buildings – A Guide for Designers and Planners*
- *Assessment of Technical Solutions and Operational Management for Retrofit of Non-Residential Buildings*

Task 39
Polymeric Materials for Solar Thermal Applications

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TASK DESCRIPTION

Solar thermal energy conversion can play a prominent role since about 50% of the primary energy is needed for heating and cooling. The roadmap for solar heating and cooling developed by the International Energy Agency (IEA) estimates a growth of the worldwide solar installations for domestic hot water and space heating by a factor of ten to about 2500 GWth until 2030.

Energy delivered by the sun is free of charge, but the installations for the technical conversion into heat and for the heat transport and storage need some investment. A considerable part of these system components consist of metal. Copper is used for the piping in the solar collectors and heat exchangers, aluminum is used for the absorber and the casing and often steel is used for the storage tank. If we continue to use these standard materials, the demand required to meet the expected market increase will lead to annual copper consumption in the order of the worldwide yearly copper production. There is no extraordinary formula needed to estimate how this would impact the price of copper, especially when considering the existing average increases in copper prices. Market deployment of solar would clearly be jeopardized.

One way out of this dilemma would be to use polymeric materials instead of metals. Seeing that polymer technology is developing stabilized material blends and cost-efficient production techniques for innovative designs, this is a palpable way to go. The raw materials are made of hydrocarbons. Actually about 10% of the oil consumption goes into such technical use. Biomass or even carbon dioxide and water could be a substitute for depleted oil resources one day. A variety of production technologies like extrusion, thermo-forming, vacuum-forming and injection molding could be applied appropriate to the product designs and the market volumes. Mass production clearly facilitates an appreciable cost reduction. The design freedom opens the chance for the production of collectors with high geometrical flexibility that meets the aesthetical requirements of building integration better.

Numerous examples of solar thermal collectors and systems can be found on the market already. Most of them are used without glazing and thermal insulation for swimming pool heating. Some are more advanced and able to reach a better performance and at higher operational temperatures either as integrated storage collectors or as glazed flat-plate collectors with absorbers made of high-performance polymers. Although there are quite a number of solar thermal systems already using polymers, the number and variety of possible applications of polymeric combinations is far greater than these primary examples suggest. For more extensive integration of polymers in this area, however, targeted research on suitable materials and compounds as well as extensive consideration of their characteristics and their special strengths and weaknesses is necessary.

Challenges on the side of the system technology for the use of polymeric materials is the limitation of the maximum temperatures of absorbers during stagnation (when no heat is extracted from the solar system) and lowering the pressure of the heat transfer fluid. Such measures allow the use of less expensive polymeric materials. Another challenge is the long-term weathering of the polymers during operation if the service life should be comparable to the conventional solar-thermal systems. Though polymer technology has made significant progress in developing stabilizers and UV-absorbers, a demonstration of sufficient durability is needed to counteract the traditional image of polymers as one-way products with bad aging properties and bad sustainability. Task 39: Polymeric Materials for Solar Thermal Applications was started in order to work on these issues and to create space for an extensive use of polymeric materials in solar thermal systems.

Objectives

The objectives of this Task were the assessment of the applicability and the cost-reduction potential of solar thermal systems by using suitable polymeric materials and polymer based novel designs, and to promote increased confidence in the use of these products by developing and applying appropriate methods for the assessment of durability and reliability. These goals were to be achieved by either less expensive materials or less expensive manufacturing processes.

Scope

The Task considered solar thermal systems applied for the supply of domestic hot water, hot air, heating, pre-heating and for the storage of thermal energy, and identified important components which can be replaced by designs made of polymeric materials at lower costs in order to make a significant contribution to promoting the further development, uptake and integration of products for the utilization of solar energy based on polymer materials. The work addressed specific fundamental problems and knowledge dissemination issues necessary to provide improved knowledge of solar, visual and thermal performance and to increase confidence in the selection and use of new polymeric products through increased understanding of performance, durability, reliability and environmental quality.

The components made of polymeric materials considered in this Task were selected from the following:

- Dynamic glazing (i.e., thermochromic, thermotropic, and other devices for collector temperature control)
- Glazing for collectors
- Absorbers
- Insulation materials
- Casing for collectors
- Storage materials
- Containers for heat-storage
- Glazed collectors
- Unglazed collectors
- Integrated storage collectors
- Air collectors

The Task emphasized performance assessment methodologies to enable comparison and selection of different products. The main focus was on near market technology, but future developments of applications were not excluded. The selection of materials and components to be investigated was determined in part through industrial collaboration and participation in the Task.

Duration

This Task was initiated on October 2006 and was completed on September 2014.

Participating Countries

Austria, Belgium, Canada, France, Germany, Norway, Portugal, Sweden, Switzerland, United States of America. Observers: Brazil, Slovenia

TASK ACCOMPLISHMENTS

Key Results

The main accomplishments of this Task are highlighted below. Specific deliverables are available on the SHC Task 39 website.

Subtask A: Information

(Subtask Leader: Michaela Meir, Norway)

The objective of Subtask A was to collect, create and disseminate information about the application of polymeric materials in solar thermal systems and their figures or merits, especially in terms of cost/performance ratios for an acceptable lifetime, in order to increase the penetration of good applications into the market. The production of a yearly newsletter, targeted at the solar and polymer industry, a colored flyer for promotion of the present Task and the preparation of an electronic or printed handbook on polymeric materials in solar thermal applications are main results of this Subtask. The Participants achieved this objective through the following activities:

Project A1: State-of-the-art: Polymeric materials in solar thermal applications
In project A1 all Task 39 partners from industry and research institutions contributed to collect an overview of products with polymeric materials in solar thermal applications currently in the market or have been seen in the market during the duration of Task 39. The focus was on polymeric collectors, small and medium-sized heat stores and seasonal thermal heat stores. The overview of applications was reported on in several conference proceedings, papers, presentations and the Task 39 Handbook published in 2012.

Project A2: Taskforce on 'Total cost accounting approach'
In project A2 the life cycle analysis of selected solar thermal collectors of polymeric materials was investigated and compared to reference collectors of conventional materials. As a further step, costs were associated to energy consumption necessary in the production, transport, installation, maintenance and end-of-life phase of such collectors. Different indicators were studied. The focus was on flat plate collectors and thermosiphon collector systems, made of extruded sheets. Additionally, a detailed cost study on the different steps during production of extruded polymeric collectors was performed.

Project A3: Taskforce on 'Standards, regulations and guidelines'
Due to close contact with experts in the standardization committees and accredited test institutes in Europe regular briefings from committee meetings was done at the Task 39 meetings and feedback from Task 39 experts given. The most relevant standards, regulations and guidelines concerning or eventually hindering the use of polymeric materials in solar thermal applications were published in the Task 39 Handbook in 2012 and in the Info Sheets in 2014.

Project A4: Database of successful architectural integration
To promote solar thermal systems an online database was established, maintained and extended during the period of Task 39. The database exhibits the successful integration of solar thermal collector systems in architecture. A special focus was given to exhibit projects where outstanding visual presentation was available. The work was done by a group that included expertise in the fields of architecture, engineering, marketing and communication, and in close collaboration with SHC Task 41: Solar Energy and Architecture.

Project A5: Dissemination of information
The dissemination Task activities and results from all the subtasks was regularly included in the Task 39 newsletters, updates to the public and internal Task 39 website, presentations at national and international conferences, scientific publications and articles targeted to broader professional audience (Section 8 and 9). Several Task 39 workshops were organized where the local solar, polymeric and engineering industry and other professional actors were invited (Section 9). A special highlight was the Task 39 exhibition at the SHC 2013 in Freiburg, Germany where solar collectors and heat stores of polymeric materials from Task 39 experts were presented to an international audience.

Subtask B: Collectors and Components
(Phase 1 (2006-2010): Subtask Leader: Philippe Papillon, France,
(Phase 2 (2010-2014): Subtask Leader: Stephan Fischer, Germany

The objectives of Subtask B were:

- The development of new collectors made completely or partly with polymeric materials, at a profitable cost of ownerships.
- The development of innovative concepts based on polymeric materials (integrated collector storage, thermo-syphon systems) or adapted to specific requirements of polymeric collectors including overheating protection measures.
- The development of other components of a solar thermal system (piping, fitting, storage, drain back vessel, etc.) that could benefit of polymeric materials or processes.

Within Subtask B a detailed assessment of the thermal stresses of the different components of a solar thermal system (e.g., absorber, casing, piping storage system, etc.) was carried out and served as the basis for the requirements on the materials and system designs using polymeric materials. In order to allow for the use of cost efficient plastics, different overheating strategies were developed (thermotropic layers, cooling of the collector by ventilation and cooling of the fluid using a thermosyphonic back cooler), designed and put into operation in demonstration and in mass production.

The work in subtask B has brought solar thermal to another level due to the participation and interest of big plastic producing companies (BASF, Chevron Phillips Chemicals, Du Pont, Borealis, Sabic, EMS, Solvay). This resulted in the first profile extruded with PPS, allowing for a mass production of high performing polymers.

Although the market development in Europe was not supportive during the last years of the Task, the world market was and will continue to be. This is one reason why the big plastic producing companies remain interested. However, the solar thermal industry is not (yet) interested in plastics production or the production of plastic collectors. The main reasons are the lack of processing capacity (see section on industrial participation) and the high investment for production line, compared to conventional production, which will only pay back by means of mass production. Nevertheless, the work in Subtask B has shown that there is a huge potential for polymeric collectors and systems, especially in emerging markets. Solar thermal plastics can be considered as the future because they allow for real mass production, cheaper products and a higher freedom in design and building integration.

Subtask C: Materials
Subtask Leader: Gernot M. Wallner, Austria

The main objectives of Subtask C were the evaluation of novel and advanced components and concepts for solar systems that were still in a state of R&D and not yet ready for market introduction:

- Further development and investigation of multi-functional polymeric materials for various components in solar thermal systems considering different plant types and climate zones.
- Evaluation of polymer processing methods for the production of specimen and components with special focus up to the sub-component level (e.g., multi-layer films and sheets). Full components will be developed in Subtask B.
- Development of testing and characterization methods and modeling tools for the application-oriented assessment of the performance and durability.

The Participants achieved this objective through the following activities:

<u>Project C1: Multi-functional polymeric materials</u>
In project C1 materials for overheating protected and drainback solar collectors as well as liner materials for seasonal heat storages were investigated. As spin-offs polypropylene (PP) and polyphenylene sulfide (PPS) based absorber materials, high temperature resistant

polyethylene (PE) liner materials and spectrally selective coatings (TISS) have been commercialized by globally active raw material manufacturers and converters such as AGRU (AT), Borealis (AT), Chevron Philips (BE) and Color (SI). Furthermore, a fundamental understanding on advanced thermotropic materials for overheating control was established.

Project C2: Processing and evaluation of components
Focusing on collector components, mass production techniques such as extrusion, injection molding or welding were investigated. For polyolefin based absorbers of glazed collectors the company partner MAGEN EcoEnergy (ISR) adopted pipe extrusion and over molding technologies for a novel PP grade with outstanding long-term durability. Furthermore, extrusion, injection molding and welding processes were optimized for high-performance PPS grades by DS Smith (FR) and Aventa (NOR). For integrated storage collectors based on polyamides, a highly automated injection molding technique for large parts was implemented.

Project C3: Methods for testing and characterization
For quality assurance of plastics in solar thermal components a toolbox, including thermo analytical, spectroscopic and mechanical methods, was developed and applied to a variety of materials from project C1. Thereby, a better understanding for polymeric materials was established at the partners from the solar thermal industry and the testing institutes. Regarding the long-term aging behavior, the scientific partners implemented accelerated methods. Applying these methods to PP or PPS absorber materials location and system dependent lifetimes for overheating controlled and drainback collectors were deduced. For both collector types it was shown that tailor-made plastics allow for lifetimes exceeding 20 years.

PUBLICATIONS

The participants of Task 39 have jointly agreed to publish their results in the form of 2-page Info Sheets that will be available as open access documents on the Task 39 website. The Task 39 Info Sheets are seen as updates and add-ons to the official Task 39 Handbook (Koehl et al. *Polymeric Materials for Solar Thermal Applications*, Weinheim: Wiley-VCH, 2012) and serve as final reports of the second phase (2010-2014). Publications and other Task documents can be downloaded from the Task 39 website: Website: http://task39.iea-shc.org

No.	Info Sheet Topic	Author
A1	Market and cost effects	Piekarzyk
A2	100% Energy scenarios	Holzhaider
A3	Life Cycle Analysis (LCA)	Weiss
A4	Total cost accounting approach	Carlsson
A5	Standards, certification and regulations	Fischer
A6	Database of successful architectural integration	Skjelland
A7	Recycling	Resch
B1	Performance requirements for polymeric materials in different solar thermal systems: Reference System (conventional)	Ramschak / Preiss
B2	Temperature stress	Ramschak / Preiss
B3	Pressure stress	Ramschak / Preiss

B4	Overheating protection (general)	Reiter
B5	Overheating protection (backcooler)	Thür et. Al.
B6	Thermal protection ventilation	Plaschkes
B7	Fully polymeric thermosiphon system	Piekarzyk / Weiss
B8	All polymeric thermosiphon system	Rekstad
B9	Temperature measurements	Reiter
B10	Thermotropic materials for overheat protection	Mantell
B11		
B12	Summary Workshop solar domestic hot water systems	Reiter
B13	Info sheet WS scalable systems	Meir
B14	Ideas for polymeric tanks	Plaschkes
B15	Sunlumo concept	Buchinger
B16	Info sheet Aventa systems	Rekstad
B17	UNISOL project	Godhino
B18	UNISOL combistore evaluation	Amorim
C1	PP as absorber material	Povacz Wallner
C2	Polyamide based integrated storage collector	Schnetzinger / Wallner et. Al.
C3	Overheating protection thermotropic layer	Weber / Resch et. Al.
C4	Spectrally-selective coating	Jerman
C5	Bioplastics	Resch
C6	Basic characterization tool box	Wallner
C7	Case study: accelerated UV aging	Piekarzyk / Weiss
C7.1	Stabilization	Beissmann
C7.2	Polymeric liner materials for hot water storage	Grabmayer
C7.3	Case study: testing of twin wall sheets	Piekarzyk
C8	Thermotropic materials for overheat protection: materials	Mantell

Task Reports

Report Title	Publication Date	Access (Public, Restricted)	Web or Print
Polymeric Materials for Solar Thermal Applications (list)	Updated	RE*	Web
Task 39 Handbook: Polymeric Materials for Solar Thermal Applications	2012	PU	Web+Print
Database of successful architectural integration	Since 2008	PU	Web

Standards with Regards to the Use of Polymeric Materials in Solar Thermal Applications	2013	PU	Web*
Total cost approach for all polymeric thermosiphon system	2014	PU	Web
All Info Sheets (downloadable from Task 39 website)	2014	PU	

* Restricted: available only to Task participants via internal Task website

Journal, Magazine Articles

Repor tNo.	Report Title	Publication Date	Access (PUblic, REstricted)	Web or Print
1	Gernot M. Wallner und Reinhold W. Lang, Kunststoffe Neue Möglichkeiten in der Solarthermie, ee-erneuerbare energie 2006-02, March 2006.	2006	PU	Web+Print
2	Köhl, M., Polymere Materialien für Solarthermische Systeme, ee-erneuerbare energie 2006-04, Publisher: AEE - Arbeitsgemeinschaft ERNEUERBARE ENERGIE - Dachverband	2006	PU	Web+Print
3	M.C. Munari Probst, C. Roecker, Towards an improved architectural quality of building integrated solar thermal systems (BIST), Solar Energy 81 (2007) 1104–1116.	2007	PU	Web+Print
4	A. Olivares, J. Rekstad, M. Meir, S. Kahlen, G. Wallner, A test procedure for extruded polymeric solar thermal absorbers, Solar Energy Materials and Solar Cells, 92 (2008) 445-452.	2008	PU	Web+Print
5	K. Resch, G.M. Wallner, R. Hausner, Property and performance requirements for thermotropic layers to prevent overheating in an all polymeric flat-plate collector, Solar Energy Materials and Solar Cells 92 (2008) 614-620.	2008	PU	Web+Print
6	K. Resch, G.M. Wallner, R.W. Lang, Spectroscopic Investigations of Phase-Separated Thermotropic Layers Based on UV Cured Acrylate Resins, Macromolecular Symposia, Special Issue: Modern Polymer Spectroscopy 265 (2008) 1, 49–60.	2008	PU	Web+Print
7	K. Resch, G.M. Wallner, Thermotropic layers for flat-plate collectors—A review of various concepts for overheating protection with polymeric materials, Solar Energy Materials and Solar Cells 93 (2009) 119-128.	2009	PU	Web+Print
8	R. Kunic, M. Kozelj, B. Orel, A. Šurca Vuk, A. Vilcnik, L. Slemenik Perse, D. Merlini, S. Brunold, Adhesion and thermal stability of thickness insesitive spectrally selective (TISS) polyurethane-based paint coatings on copper substrates, Solar Energy Materials and Solar Cells 93 (2009) 630-640.	2009	PU	Web+Print
9	I. Jerman, A. Šurca Vuk, M. Kozelj, B. Orel, Corrosion protection of Sunselect, a spectrally selective solar absorber coating, by (3-mercaptopropyl)trimethoxysilane, Solar Energy Materials and Solar Cells 93 (2010) 1733-1742.	2010	PU	Web+Print
10	I. Jerman, A. Šurca Vuk, M. Kozelj, B. Orel, Comparison of corrosion properties of various multifunctionalised POSS coatings on AA 2024 alloy,	2009	PU	Web+Print

	Vakuumist (2009) 19-25.			
11	G.M. Wallner, K.Resch, R. Hausner, Property and performance requirements for thermotropic layers to prevent overheating in an all polymeric flat-plate collector, Solar Energy Materials & Solar Cells 92 (2008) 614–620.	2008	PU	Web+Print
12	M.C. Munari Probst, C. Roecker, Architectural integration of solar thermal systems, DETAIL Green 01/2010, English Ed., 42-45	2010	PU	Web+Print
13	K. Resch, G.M. Wallner, R. Hausner, Phase separated thermotropic layers based on UV cured acrylate resins – Effect of material formulation on overheating protection properties and application in a solar collector, Solar Energy 83 (2009) 1689-1697.	2009	PU	Web+Print
14	K. Resch, G.M. Wallner, Morphology of phase-separated thermotropic layers based on UV cured acrylate resins Polymers for Advanced Technologies, Polymers for Advanced Technologies 20 (2009) 12, 1163–1167.	2009	PU	Web+Print
15	Meir, M., Brunold, S., Fischer, S., Kahlen, S., Koehl, M, Ochs, F., Peter, M., Resch, K., Wallner, G., Weiss, K.-A. and Wilhelms, C, Kunststoffe unter der Sonne, ee-erneuerbare energie 2010-04, by: Publisher: AEE - Arbeitsgemeinschaft ERNEUERBARE ENERGIE	2010	PU	Web+Print
16	S. Kahlen, G.M. Wallner, R.W. Lang, Characterization of physical and chemical aging of polymeric solar materials by mechanical testing, Polymer Testing 29 (2010) 72-81.	2010	PU	Web+Print
17	I. Jerman, M. Koželj, B. Orel, The effect of polyhedral oligomeric silsesquioxane dispersant and low surface energy additives on spectrally selective paint coatings with self-cleaning properties, Solar Energy Materials and Solar Cells 94 (2010) 232-245.	2010	PU	Web+Print
18	I. Jerman, B. Orel, A. ŠURCA VUK, M. Koželj, J. KOVAČ, A structural and corrosion study of triethoxysilyl and perfluorooctyl functionalized polyhedral silsesquioxane nanocomposite films on AA 2024 alloy. Thin Solid Films 518 (2010) 2710-2721	2010	PU	Web+Print
19	M. Koželj, B. Orel, I. Jerman, M. Steinbücher, M. Vodlan, D. Peros, Coil-coated spectrally selective coatings on copper or aluminium with pigments modified by aminosilanes, WIPO Patent Application WO 2010/133693, May 21, 2010.	2010	PU	Web+Print
20	S. Kahlen, G.M. Wallner, R.W. Lang, J. Rekstad, M. Meir, Aging behavior of polymeric solar absorber materials: Aging on the component level, Solar Energy 84 (2010) 459-465.	2010	PU	Web+Print
21	S. Kahlen, G.M. Wallner, R.W. Lang, Aging behavior of polymeric solar absorber materials – Part 1: Engineering plastics, Solar Energy 84 (2010) 1567-1576.	2010	PU	Web+Print
22	S. Kahlen, G.M. Wallner, R.W. Lang, Aging behavior of polymeric solar absorber materials – Part 2: Commodity plastics, Solar Energy 84 (2010) 1577-1586.	2010	PU	Web+Print
23	S. Kahlen, G.M. Wallner, R.W. Lang, Aging behavior and lifetime modeling for polycarbonate, Solar Energy 84 (2010) 755-762.	2010	PU	Web+Print
24	A. Olivares, J. Rekstad, M. Meir, S. Kahlen, G.M. Wallner, Degradation model for an extruded polymeric solar thermal absorber, Solar Energy Materials & Solar	2010	PU	Web+Print

	Cells 94 (2010) 1031–1037.			
25	M. Koželj, B. Orel, I. Jerman, M. Vodlan, M. Steinbücher, Aminosilane modified pigments for spectrally selective coatings, method for preparation and their use in coatings, Patent Number: EP2261288 (A1), December 2010.	2010	PU	Web+Print
26	Michael Köhl, Michaela Meir, Polymere Materialien für Solarthermische Systeme, ee-erneuerbare energie 2011-01, Publisher: AEE - Arbeitsgemeinschaft ERNEUERBARE ENERGIE - Dachverband	2011	PU	Web+Print
27	R. KUNIČ, M. MIHELČIČ, B. Orel, A. Bizjak, J. KOVAČ, S. Brunold, Life expectancy prediction and application properties of novel polyure-thane based thickness sensitive and thickness insensitive spectrally selective paintcoatings for solar absorbers. Solar Energy Materials and Solar Cells 95 (2011) 2965-2975.	2011	PU	Web+Print
28	Jerman, M. Mihelčič, D. Verhovšek, J. Kovač, B. Orel, Polyhedral oligomeric silsesquioxane trisilanols as pigment surface modifiers for fluoro polymer based TSSS paint coatings. Solar Energy Materials and Solar Cells 95 (2011) 423–431.	2011	PU	Web+Print
29	K. Resch, A. Weber, Smart Windows - Smart Collectors Entwicklung und Charakterisierung von Überhitzungsschutzverglasungen für Gebäudeverglasungen und thermische Solarkollektoren. BHM Berg- und Hüttenmännische Monatshefte 156 (2011) 11, 429 - 433	2011	PU	Web+Print
30	A. Weber, K. Resch, Effect of temperature-cycling on the morphology of polymeric thermotropic glazings for overheating protection applications, Journal of Polymer Research 19 (2012) 6, 5-8.	2012	PU	Web+Print
31	T. Kaltenbach, M. Kurth, C. Schmidt, T. Meier, M. Köhl, K.A. Weiß, Aging tests of components for solar thermal collectors, Energy Procedia 30 (2012) 805-814.	2012	PU	Web+Print
32	A. Weber, K. Resch, Effect of temperature-cycling on the morphology of polymeric thermotropic glazings for overheating protection applications, Journal of Polymer Research 19 (2012) 6, 5-8.	2012	PU	Web+Print
33	H. Ge, G. Singh, S. Mantell, Fracture behavior of degraded polyethylene thin films for solar thermal applications, Energy Procedia 30 (2012) 783-792.	2012	PU	Web+Print
34	A. Weber, K. Resch, Thermotropic glazings for overheating protection, Energy Procedia 30 (2012) 471-477.	2012	PU	Web+Print
35	M. Kurzböck, G.M. Wallner, R.W. Lang, Black pigmented polypropylene materials for solar absorbers, Energy Procedia 30 (2012) 438-445.	2012	PU	Web+Print
36	A. Gladen, J.H. Davidson, S, Mantell, J. Zhang, Y. Xu, A Model of the Optical Properties of a Non-absorbing Media with Application to Thermotropic Materials for Overheat Protection, Energy Procedia 30 (2012) 116-2012124.	2012	PU	Web+Print
37	Weber, A., Resch, K. (2012). Thermotropic glazings for overheating protection, Energy Procedia 30, 471-477.	2012	PU	Web+Print
38	Weber, A.; Schlögl, S.; Resch, K.: Effect of Formulation and Processing Conditions on Light Shielding Efficiency of Thermotropic Systems with Fixed Domains Based on UV Curing Acrylate Resins, Journal of applied polymer science 130 (2013) 5, 3299 - 3310.	2013	PU	Web+Print
39	Michael Köhl, Sandrin Saile, Innovative, zukunftsweisende Gestaltungselemente - Kunststoffe	2013	PU	Web+Print

	in der Solarthermie, ee-erneuerbare energie 2013-01, Publisher: AEE - Arbeitsgemeinschaft ERNEUERBARE ENERGIE - Dachverband			
40	Meir M., Murtnes E., Dursun A.M., Rekstad J., Polymeric Solar Collectors or Heat Pump? – Lessons Learned from Passive Houses in Oslo, Energy Procedia, Vol. 48, 2014, 914-923.	2014	PU	Web+Print
41	T. Kaltenbach, E.Klimm, T. Meier, M. Köhl, K.A. Weiß: Testing of Components for Solar Thermal Collectors in Respect of Saline Atmospheres, Energy Procedia, Vol. 48, 2014, 731-738.	2014	PU	Web+Print
42	Reiter C., Brandmayr S., Trinkl C., Zörner W., Hanby V.I.: Performance Optimisation of Polymeric Collectors by Means of Dynamic Simulation and Sensitivity Analysis, Energy Procedia, Vol. 48, 2014, 181–191.	2014	PU	Web+Print
43	Koehl M., Saile S., Piekarczyk A., Fischer S.: Task 39 Exhibition – Assembly of Polymeric Components for a New Generation of Solar Thermal Energy Systems, Energy Procedia, Vol. 48, 2014, 130-136.	2014	PU	Web+Print
44	Carlsson B., Persson H., Meir M., Rekstad J.: A total cost perspective on use of polymeric materials in solar collectors - Importance of environmental performance on suitability, Applied Energy 125 (2014) 10–20.	2014	PU	Web+Print
45	Weber, A., Resch, K.: Thermotropic Overheating Protection Glazings: Effect of Functional Additives and Processing Conditions on Light-Shielding Efficiency, Journal of Polymer Engineering, 2014, doi: 10.1515/polyeng-2013-0275.	2014	PU	Web+Print
46	Weber, A., Resch, K.: Thermotropic systems with fixed domains exhibiting enhanced overheating protection performance, Journal of Applied Polymer Science 131 (12), 2014; doi: 10.1002/app.40417.	2014	PU	Web+Print
47	Weber, A., Schmid, A., Resch, K.: Thermotropic glazings for overheating protection - II. Morphology and structure-property relationships, Journal of Applied Polymer Science 131 (4), 2014; doi: 10.1002/app.39910.	2014	PU	Web+Print
48	Weber, A., Resch, K.: Thermotropic glazings for overheating protection - I. Material preselection, formulation, and light-shielding efficiency, Journal of Applied Polymer Science Vol. 131(4), 2014; doi: 10.1002/app.39950.	2014	PU	Web+Print
49	Rekstad, J., Meir, M. et al. A comparison of the energy consumption in two passive houses, one with a solar heating system and one with an air-water heat pump; submitted to *Energy and Buildings* in August 2014	2014	PU	Web+Print

WORKSHOPS & CONFERENCES

The following are workshops and conferences Task participants contributed to with results of their work achieved within the frame of the Task or with results of the Task work. Presentations and proceedings can be found on the Task website.

Task 39: Workshops/Symposia	Place	Date
Symposium Polymeric Solar Materials	Leoben, Austria	February 7-8, 2008
Kunststoffe als Wachstumsmotor für die Solarthermie	Linz, Austria	July 6, 2011
Chancen und Anforderungen für Kunststoffe in der Solarthermie	Berlin, Germany	May 16, 2012

IR-Welding of high-temperature Perfomance Polymers (Mini workshop)	Holmestrand, Norway	February 5, 2013
Task 39 Subtask B Workshop: All-Polymeric Solar Thermal Systems	Mallorca, Spain	March 14, 2013
Task 39 Exhibition at SHC2013: On the Road to a New Generation of Solar Thermal Energy Systems	Freiburg, Germany	Sept. 23-25, 2013
Kunststoffe als Wachstumsmotor für die Solarthermie	Linz, Austria	October 11, 2013

Workshop/Conference	Place	Date
CISBAT 2007 - Int. Scientific Conference, École Polytechnique Fédérale (EPFL)	Lausanne, Switzerland	September 2007
ISES Solar World Congress 2007	Beijing, China,	Sept. 18-21, 2007
9th International Symposium Gleisdorf SOLAR 2008	Gleisdorf, Austria	September 3-5, 2008
EUROSUN Congress 2008	Lisbon, Portugal,	October 7-10, 2008
19th Symposium Thermische Solarenergie	Staffelstein, Germany	May 6-8, 2009
4th European Solar Thermal Energy Conference - ESTEC 2009	Munich, Germany	May 25-26, 2009
2nd Solarthermie-Technologiekonferenz	Berlin, Germany,	January 2010
20st Symposium Thermische Solarenergie	Staffelstein, Germany	May 5-7, 2010
EUROSUN 2010 Conference	Graz, Austria	Sept 29-Oct 01, 2010
68th Annual Technical Conference of the Society of Plastics Engineers 2010 (ANTEC 2010)	Orlando, USA	May 16-20, 2010
Colloquium of Optical Spectrometry - COSP 2011	Berlin, Germany	March 21, 2011
21st Symposium Thermische Solarenergie	Linz, Austria,	July 6, 2011
5th European Solar Thermal Energy Conference - ESTEC 2011	Marseille, France,	20-21 October 2011
6th Energy Forum "Solar Buliding Skins"	Bressanone Italy	Dec. 6-7, 2011
Fachforum Kunststoffe: Einsatz in der Solarthermie	Regensburg, Germany,	Febr. 13-14, 2012
IEA SHC Task 39 Industry Workshop, Berlin	Berlin Germany	May 16, 2012
22nd Symposium Thermische Solarenergie 2012	Staffelstein, Germany	May 9-11, 2012
Gleisdorf SOLAR 2012 - International Conference on Solar Thermal Energy	Gleisdorf, Austria,	September 12-14, 2012
SHC 2012 - "Solar Heating and Cooling for Buildings and Industry"	San Francisco, USA,	September 5-7, 2012
SMEThermal 2013 - Solar Thermal Materials, Equipment and Technology Conference	Berlin, Germany, 29	January 2013
Austrian and Slovenian Polymer Meeting	Bled, Slovenia	April 05, 2013
23nd Symposium Thermische Solarenergie 2013	Staffelstein, Germany	April 24-26, 2013
Advances in Polymer Science and Technology 3	Linz, Austria,	September 10, 2013
SHC 2013 - International Conference on Solar Heating and Cooling	Freiburg, Germany,	September 23-25, 2013
Verbreitungstagung: Kunststoffe – die Wachstumsoption für die Solarthermie	Linz, Austria,	October 11, 2013
24th Symposium Thermische Solarenergie 2014	Staffelstein, Germany	7- 9 May 2014
Gleisdorf SOLAR 2014 - International Conference on Solar Thermal Energy	Gleisdorf, Austria,	June 25-27, 2014
SHC 2014 - "Solar Heating and Cooling for Buildings and Industry"	Beijing, China	October 13-15

MEETINGS IN 2014

17th Experts Meeting
April 9-11
Ashkelon, Israel

18th Experts Meeting
September 29-30
Oslo, Norway

SHC TASK 39 NATIONAL CONTACTS

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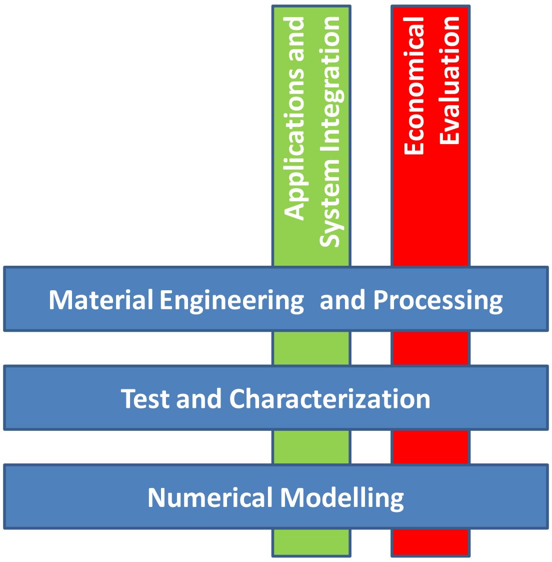
Task 42
Compact Thermal Energy Storage: Material Development for System Integration

Matthias Rommel
SPF, Institute for Solar Technology, Switzerland
Operating Agent for the Swiss Federal Office of Energy

Andreas Hauer
Centre for Applied Energy Research ZAE, Germany

TASK DESCRIPTION

The objective of this Task is to develop advanced materials and systems for an improved performance storing thermal energy, suitable not only for solar thermal systems, but also for other renewable heating and cooling applications such as solar cooling, micro-cogeneration, biomass, or heat pumps. The Task covers phase change materials, thermochemical and sorption materials, and composite materials and nanostructures, and includes activities such as material development, analysis, and engineering, numerical modeling of materials and systems, development of storage components and systems, and development of standards and test methods. A secondary objective of this Task is to further expand and intensify the collaboration between researchers and industry working in the field of thermal energy storage



This Task deals with advanced materials for latent and chemical thermal energy storage, on three different scales:

- Material scale, focused on the behavior of materials from the molecular to the 'few particles' scale, including for example, material synthesis, micro-scale mass transport, and sorption reactions.
- Bulk scale, focused on bulk behavior of materials and the performance of the storage in itself, including for example, heat, mass, and vapor transport, wall-wall and wall-material interactions, and reactor design.
- System scale, focused on the performance of storage with in a heating or cooling system, including for example, economical feasibility studies, case studies, and system tests.

This Task will include multiple application areas, bundled into one application Working Group. During Phase 1 of the Task, three different application Working Groups were established:

Low temperature (up to 20 ºC):

- Building cooling
- Refrigeration

Medium temperature for room heating and hot tap water (20 ºC – 100 ºC):

- Seasonal solar thermal storage
- Cogeneration, tri-generation and heat pumps

Higher temperatures (100 ºC and above):

- District heating
- Industrial waste heat
- Concentrated solar power

These application Working Groups identified reference-operating conditions for the storage materials. In the current Phase 2, these Working Groups have been merged into one group to address the possibilities of new developed materials for heating and cooling applications.

Subtask A: Materials

Working Group A1: Materials Engineering/Processing

Engineering

The activities in this Working Group focus on engineering new materials or composites (i.e., changing the properties of existing materials and developing new materials with better performance, lower cost, and improved stability). Eventually, this should lead to the ability to design new materials tailor-made to specification. The materials under consideration are those relevant to thermal energy storage using sensible mode, phase change, as well as chemical reactions and sorption technologies.

Activities include:

- Synthesis of new materials
- Determining material characteristics such as phase diagrams
- Determining the relation between material performance and material structure and composition, in order to direct the search for improved materials
- Determining the role and importance of material containers

Processing

The activities in this Working Group focus on the processing of raw materials that is required to make these materials function in a realistic environment. In nearly all cases, storage material cannot be used to store heat in its raw form, but e.g. needs to be processed into slurry, encapsulated, or otherwise processed.

Activities include:

- Finding optimal methods for micro- and macro encapsulation of storage materials (particularly phase change, sorption, and thermochemical materials)
- Processing phase-change slurries
- Finding new combinations of materials

Working Group A2: Test and Characterisation

The performance characteristics of novel thermal energy storage materials, like phase-change materials or thermochemical materials, often cannot be determined as straightforward as with sensible heat storage materials. In order to have proper comparison possibilities appropriate testing and characterisation procedures should be developed and assessed. The work in the first period of the Task showed that even the definition of a common procedure for calibrating the measurement instruments did not result in satisfactorily comparable results of measurements of PCM samples in the round robin test. Further work has to be done to understand the factors that influence the quality of the measurements.

The activities of this Working Group are aimed at developing test and calibration procedures and include:

- Comparative testing of materials and their required methods
- Long-term stability determination
- (Pre-) standardization of testing methods

The long-term stability determination will be done as material tests only, it is not thought possible to find a common standard for the stability determination.

Working Group A3: Numerical Modelling

The activities in this Working Group are aimed at developing and testing numerical models that help to understand and optimise the material behaviour and the dynamic behaviour of compact thermal energy storage systems and components. Ultimately, these numerical models could help to find ways to optimise the materials in combination with the system components. The activities in this Working Group are helping to lay the foundation for such models.

The Working Group includes the following activities:

- Material modelling
- Reactor modelling
- System modelling, including (dis)charging apparatus

Subtask B: Applications

There are several applications for compact thermal energy storage technologies, each with a different set of boundary conditions for the technology. Although the applications themselves place very different requirements on storage technology, the steps that must be taken are very similar for all applications. Hence, the activities within the Working Groups in this Subtask are very similar as well.

The activities in these Working Groups serve the underlying guiding principle of the materials development within the limitations of the application. The materials development will be directed by the desired system performance. A constant assessment of performance criteria for a given application will be used to determine the chances for a given material/system combination. These criteria can come from economic, environmental, production technology or market considerations.

Activities in the Application Working Groups include:

- Expand the definition of application boundary conditions, such as load, demand, environment, dimensions, for applications beyond the scope of the Task
- Define required thermophysical properties for each application
- Select relevant candidate materials and system technologies
- Conduct performance assessment and validation
- Conduct numerical modelling on the application level
- Develop new sensor technologies to enable the efficient operation of different applications
- Prepare case studies
- Conduct economical modeling
- Conduct feasibility studies
- Conduct market potential evaluations

This subtask is subdivided in three Working Groups, each representing a particular application or group of similar applications. This subdivision will be kept flexible throughout the Task to allow for new research groups and projects to join and include new topics at a later point in the Task.

- Working Group B1: Cooling
- Working Group B2: Heating / DHW
- Working Group B3: High Temperature Applications

Working Group C: Theoretical Limits

The objective of this Working Group is to determine the theoretical limits of compact thermal storage materials and systems from a physical, technical and economical viewpoint. In short, this Working Group defines the maximum possible performance that can be expected from a thermal storage system in a given application. As such, it gives a reference point with which the performance of lab tests, field tests, and real-life systems can be compared. In a first step, physical limits shall be determined (e.g. the energy stored per volume and per mass as a function of temperature, with respect to different mechanisms as sensible, latent, sorption or chemical storage). In a second step technical aspects shall be evaluated. In many cases the energy storage density and the efficiency of the system are deteriorated when a large specific thermal power must be drawn from the system. In a third step economic constraints of storage systems shall be evaluated.

Common Tasks

Dissemination

One of the objectives of this Task/Annex is to inform the different groups of stakeholders in the development of compact thermal storage of the Task's progress and planned activities. These stakeholders include researchers, industry representatives, and policy makers. This common activity plays a major role in reaching the secondary objective of the Task, that is, the creation of an effective international network for research and development of compact thermal energy storage.

Duration

Phase 1 of the Task ran from January 2009 – December 2012. Phase 2 started January 1, 2013 and will be completed December 31, 2015.

This is a collaborative Task with the IEA Energy Conservation through Energy Storage (ECES) Implementing Agreement. It is managed as a fully "joint" Task according to the SHC Guidelines for Collaboration with other Programs. In the ECES Implementing Agreement, the Task is referred to as Annex 29.

Participating Countries

Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

Change in Management

The SHC Operating Agent responsibility was taken over from The Netherlands by Switzerland on January 1, 2014 when Matthias Rommel from SPF, Rapperswil, Switzerland replaced Wim van Helden as the SHC Operating Agent.

WORK DURING 2014

The Task activities in the subsequent Working Groups were as follows.

Materials Engineering/Processing Working Group

The scope of this working group is investigations on new and improved compact thermal storage (PCM, TCM and sorption) materials and the preparation of a materials database. The table below summarises the ongoing activities contributing to the working group, mainly part of different European FP7 and national projects.

In the Nagoya meeting, it was reported that the materials database is established. Stefan Gschwander (ISE) is responsible for the functionality of the database itself, while Alenka Ristic (NIC) is coordinating the addition of materials data. Stefan Gschwander gave a short overview on the present state of the database during the Nagoya meeting. It has three different material categories (PCM, TCM and sorption materials). Right now there is data available on 16 PCM and 2 TCM materials.

ORGANISATION (Representative)	PROJECT	MATERIAL	APPLICATION
Rubitherm (Andreas Lärz)		PCM (SP21E, SP21E2)	Seasonal storage
TU Wien Thomas Fellner	Solid Heat	TCM (different salts)	District heating
Leuphana Univ. (Holger Rammelberg)	Thermal battery	TCM (different salt hydrates)	TES at low T
TU Wien Andreas Werner	Solid Heat	TCM	Sensible heat storage
ASIC Gerald Englmayr	Flow TCS project	Sorption materials (Zeolite)	TES
IWT TU Graz Christoph Moser		TCM (Sodium acetate)	Seasonal storage
DTU Civil Engineering (Mark Dannemand)	COMTES - FP7	TCM (Sodium acetate hydrate)	Seasonal storage
NIC Tomaž Fakin	National project	Sorption materials (Zeolites)	TES
TH Wildau Thomas Herzog	National project	Sorption materials (Zeolite, mesoporous silicates)	TES at low T
KTH (Saman Gunasekara)	National project	HT-PCM mixtures	TES at low T
ECN Claire Ferchaud	ADEM Project E-Hub	TCM (salt hydrates) Sorption (Zeolites)	Seasonal storage
Bayreuth Univ. Anja Lorenz		PCM macro-encapsulation	Latent heat storage
Gaziosmanpaşa Cemil Alkan	National project	PCM micro-encapsulation	Seasonal storage

Test and Characterization
Important results have been achieved due to the round robin test of DSC measurements on Octadecane which has been carried out and evaluated. The following laboratories have participated:

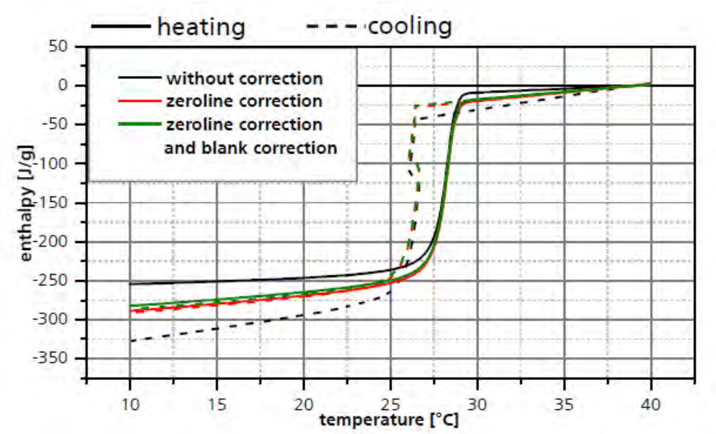
- University of Lleida, Spain
- University of Zaragoza, Spain
- ZAE Bayerisches Zentrum für Angewandte Energieforschung e.V., Germany
- CERTES, France
- University of the Basque Country, Spain
- Austrian Institute of Technology GmbH, Austria
- Fraunhofer ISE, Germany

The laboratories followed the German "RAL GZ 896" procedure, which was refined by the Task 42 experts. Implementing calibration instructions helped to improve the quality of temperature measurements significantly.

A round robin test for octadecane characterization with the T-History method and on thermal conductivity was also carried out. Although the measurements were performed without a standardised procedure, results showed good comparability with the NIST standard and DSC measurements.

A workshop on the further evaluation of the round robin DSC measurement on Octadecane was carried out and concerned DSC-, T-history- and thermal conductivity measurements. The main results of the workshop are:

- An improved draft standard "Measurement procedure Phase Change Materials Task 4229" is now available.
- The test institutes will carry out again round robin measurements on Octadecane in order to check and confirm the standard.
- The final standard will be available up to the next Task 4229 experts meeting in spring 2015 in Vienna.
- New round robin measurements will be carried out by the test institutes with a paraffin material (approx. 60°C) and probably HDPE (approx. 120°C). Again Stefan Gschwander (Fraunhofer ISE) will organize these round-robin measurements.



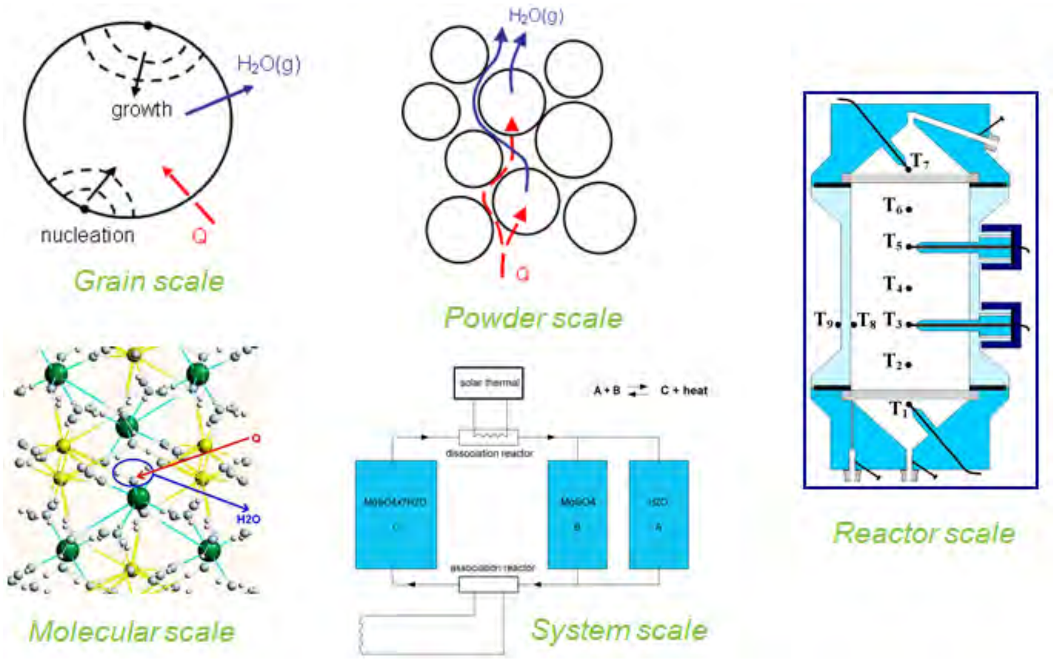
Further improvements in the "Measurement procedure Phase Change Materials Task 42/29" were achieved by introducing a zero-line and blank correction in the evaluation of the measured data.

Numerical Modelling

The activities in this working group are aimed at developing and testing numerical models that help to understand and optimise the material behaviour and the dynamic behaviour of compact thermal energy storage systems and components based on Phase Change Materials (PCM's) and Thermo Chemical Materials (TCM's).

In the Nagoya meeting, the working group leader Camilo Rindt from the University of Eindhoven gave a presentation with various examples on numerical modelling in the different scales from the molecular to the grain, to the powder, to the reactor and finally to the system scale. This covers 10 orders of magnitude, which explains that various different numerical modelling approaches are necessary.

Ultimately, these numerical models could help to find ways to optimise the materials in combination with the system components.



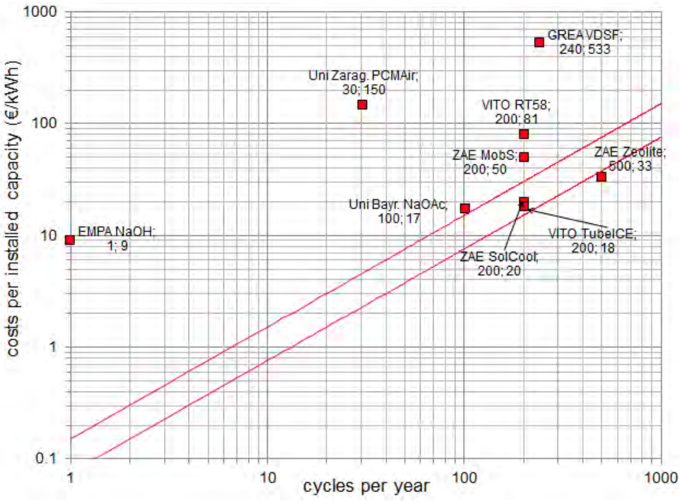
Application Working Groups

A first draft of relevant applications has been made by the group, shown in the following table.

Source	Storage	Demand
Waste Heat	short term high power	Drying Cooling
Solar Thermal	long term high capacity	Heating DHW
Electricity (renewable or „price difference“)	short term high power	Cold (AC) Dehumidification
CSP	short term high temperature	Power Plant (turbine)
CHP	short term high capacity	Heating DHW

The reference conditions for the application Long Term Heating with Solar Thermal have been defined and worked out by the ZAE. A number of institutes will input their modeling and experimental results for their seasonal solar thermal storage technologies as cases for comparison with the reference conditions. The University of Lleida will add their data for high temperature applications (CSP and Waste Heat).

Theoretical Limits
Using a bottom-up approach, economical constraints of thermal energy storage systems will be determined via a questionnaire. The questionnaire was developed to gather information for the economical evaluation of particular systems. It was distributed to the experts to collect necessary data. Twelve questionnaires have been completed (8 systems with PCMs, 4 with TCMs). The results were evaluated and collected in one graph, as shown below.



In this evaluation the operating costs are not yet included. Moreover, the data given by the experts in the different projects need to be consolidated. In order to check the evaluation methodology it was decided to also apply it to conventional hot water storage tanks and to check if the result is consistent with the other storage technologies. The aim is to give answers to the two following questions: (1) How big is the economical gap between actual and acceptable costs? And (2) What are the main cost drivers? (material costs, component costs, or other costs).

Additionally, for assessments with respect to economical evaluation it was discussed that some sort of performance key figures should be defined or formulated. They should serve as indicators for additional advantages on top of purely economical evaluations and data. Industry in particular is interested in these key performance figures. A discussion paper on this topic will be prepared in 2015.

WORK PLANNED FOR 2015

Key activities, planned for 2015 include:

- Further filling of the materials database with experimental data.
- Gathering experimental results with compact thermal storage systems.
- Further work on the test methods for DSC, T-history and thermal conductivity measurement.
- Refine and broaden the bottom-up economical approach for thermal energy storage systems and start the discussion on Key Performance Indicators for these systems.

REPORTS PUBLISHED IN 2014

- Modelling Techniques of TCM/PCM-Materials on Micro-, Meso- and Macro Scale
- Collection of Experimental Data on the Behavior of TCM and PCM Materials to Benchmark Numerical Codes
- Development of Space Heating and Domestic Hot Water Systems with Compact Thermal Energy Storage

REPORTS PLANNED FOR 2015

- New and improved materials for thermal energy storage applications
  Materials and systems for High temperature Thermal Energy Storage
- Projects and activities on high temperature thermal energy storage
- Development of a Test-Standard for PCM and TCM Characterization
- Reference conditions for thermal energy cooling storage applications
- Thermal Storage Apparatus Design
- Physical and technical limits and constraints of Thermal Energy Storage

MEETINGS IN 2014

11th Experts Meeting
April 28-30
Lyon, France

12th Experts Meeting
8-10 October
Nagoya, Japan

MEETINGS PLANNED FOR 2015

13th Experts Meeting
9-11 February
Vienna, Austria

14th Experts Meeting
5-7 October,
Zaragoza, Spain

SHC TASK 42/ECES ANNEX 24 NATIONAL CONTACTS

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Task 43
Solar Rating and Certification Procedures: From International Standardization to Global Certification

Jan Erik Nielsen
SolarKey International
Operating Agent for the Danish Energy Agency

TASK DESCRIPTION

IEA SHC Task 43 aim is to harmonize test methods and certification schemes in order to remove technical trade barriers for solar thermal quality products, hence lowering the testing and certification costs for manufacturers and suppliers. This will lead to less expensive and higher quality solar thermal products, which will in turn lead to larger markets and increased use of solar thermal energy.

Task 43 “Solar Rating and Certification” is working towards international standardization and harmonization of test procedures and certification schemes for solar thermal products. So far, the work has focussed on international standardization and important results have been achieved concerning harmonization of test methods - especially for solar collectors.

Work is continuing on standardization towards harmonizing of standards for system test methods, test methods for internal collector components, and test methods for other relevant solar thermal components and systems in the solar thermal field.

In addition, SHC Task 43 is focussing on the harmonization of requirements in national and regional certification schemes, working towards a global certification scheme for solar collectors.
If and when global harmonized certification of solar collectors is realized, this could pave the way for harmonizing certification schemes for other solar thermal products, including solar water heating systems.

The Task is organized into three Subtasks.

Subtask A: Harmonization of Standards for Solar Thermal Products
(Lead Country: Australia)
This subtask supports ISO/TC180[1] in their work on ISO standards for solar systems and components and promotes the use of these standards in IEA SHC and ISO countries – also keeping in mind the possible future harmonized certification of more solar thermal products, for example, compact solar water heaters.

Subtask B: Harmonization of Certification Schemes for Solar Collectors
(Lead Countries: Spain and United States)
The objective of this subtask is to define the set of requirements national/regional certification schemes shall fulfil in order to be accepted under the global “umbrella” certification scheme for collectors.

Subtask C: Organizational Framework for Global Collector Certification
(Lead Country: Germany)
The objective of this subtask is to set up rules for the organizational framework for the global certification of solar collectors. This includes defining the structure of framework/network, deciding who can/shall participate in the framework/network, defining voting rights, setting meeting frequencies, setting fees, – and establishing the Global Solar Certification Network.

Duration
This Task 43 extension began in July 2013 and will end June 2015.

[1] ISO/TC 180 - Solar Energy deals with *“Standardization in the field of solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning”.*

Participating Countries
Canada, China, Denmark, Germany, Portugal, Spain and the United States

WORK DURING 2014

Subtask A: Harmonization of Standards for Solar Thermal Products

- Questionnaire disseminated and results analysed to prepare for promotion of the collector testing standard in important market countries.
- EN ISO 22975 "Solar Energy - Collector components and materials" Part 1 and 2 on evacuated tubes: Now available as Draft International Standard (ISO/DIS).
- EN ISO 22975 "Solar Energy - Collector components and materials" Part 3 on absorber surface durability: Approved as EN ISO Standard.
- New work item initiated on insulation (in collectors).
- ISO TC 180 and WGs meeting organized in connection with SHC Task 43 meeting in Beijing in October 2014.

Subtask B: Harmonization of Certification Schemes for Solar Collectors

- Final draft scheme rules prepared; but due to change in "concept" no last final version was prepared/approved. A final "Global Certification Scheme Rules" will not be prepared – work already completed could be the basis for guidelines for making certification scheme rules for solar collectors (and other products).
- Draft set of requirements for participating in the Global Solar Certification Network prepared.

Subtask C: Organizational Framework for Global Collector Certification

- Main part of "Internal Working Rules" adapted to "new concept" – and approved (revisions are expected).
- Global Solar Certification Network established.
- Board Officers elected: Chair: H. Drück, Vice Chair: L. Nelson, treasurer: E. Prado, Secretary: Peter Markart.
- Manager appointed: J.E. Nielsen.
- Internal Quality Committee appointed.
- Initial preparations for establishing a legal entity started.
- 2nd MoU (Memorandum of Understanding) signed between Solar Keymark and SRCC at the meeting.
- Document archive/listing established.
- 2nd Global Solar Certification Network meeting organized very successfully in connection with ISO TC 180 meeting in Beijing in October 2014.
- Logo created.

WORK PLANNED FOR 2015

Subtask A: Harmonization of Standards for Solar Thermal Products

- Promotion of EN/ISO 9806 worldwide.
- Support to elaboration on ISO/AWI 22975 series on "Solar Energy – Collector components and materials.
- Review of international and national standards for performance characterization / testing of solar hot water stores – with the perspective of harmonizing.
- Review of international and national standards for reliability/safety of solar systems – with the perspective of harmonizing.
- Support for the harmonization of ISO 9459-4 with EN 12977 series.
- Ideas/inputs to first draft of ISO Standards for test methods for reliability/durability

and safety of solar heating systems.
- Support to ISO/NP 9488 "Solar Energy – Vocabulary".
- Prepare final Subtask A report.

Subtask B: Harmonization of Certification Schemes for Solar Collectors
- Prepare final draft set of requirements for participating bodies.
- Publish approved version of the harmonized requirements.
- Prepare final Subtask B report.

Subtask C: Organizational Framework for Global Collector Certification
- Prepare final set of rules for organizational framework.
- Publish approved version of the set of rules for organizational framework.
- Start operation of the "Global Solar Certification Network".
- 3rd MoU aimed to be signed between Solar Keymark and Chinese certification scheme(s).
- Prepare final Subtask C report.

REPORTS PUBLISHED IN 2014

No reports published in 2014.

OTHER PUBLICATIONS AND PRESENTATIONS IN 2014

Presentations & Collaborative Meetings
- **Keynote Presentation**: Les Nelson, SHC 2014 Conference, October 2014, Beijing, China
- **Presentations:** Jan Erik Nielsen and Harald Drück, SHC 2014 Conference, October 2014, Beijing, China
- **Presentation:** Jan Erik Nielsen, IEA SHC Solar Trade Association meeting in connection with the SHC 2014 Conference, October 2014, Beijing, China
- **Meeting:** Solar Keymark Network meetings March and October 2014
- **Meeting:** ISO TC 180 meeting October 2014

Website
Established new website for "Global Solar Certification": www.gsc-nw.org

Other
Input to IEA Energy Technology Initiatives publication

Connected meetings
Global Solar Certification Network meetings:
- Las Palmas, Spain, March 12th
- Beijing, China, October 8th

REPORTS PLANNED FOR 2015

- Harmonized procedures and reporting templates for certification of solar collectors.
- Set of rules for organizational framework: Requirements for participating bodies.

MEETINGS IN 2014

3rd Task Meeting
March 12-13
Las Palmas, Spain

4th Task Meeting
October 8-9
Beijing, China

MEETINGS PLANNED FOR 2015

5th Task Meeting
March 11-12
Rome, Italy

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Task 45
Large Solar Heating/Cooling Systems, Seasonal Storage, Heat Pumps

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TASK DESCRIPTION

The main objective of IEA SHC Task 45 is to assist in the strong and sustainable market development of large solar district heating and cooling systems. The systems can include seasonal storages and/or heat pumps/chillers.

The main focus is the system level: How to match the actual system configuration to the actual needs and local conditions, including the surrounding regional energy system (free electricity market). In other words, from the given conditions of load and energy prices, which system type and size to choose to have a competitive heat price and a large solar fraction.

It is important that the systems are installed and controlled/operated properly in order to perform well. To ensure that guidelines and standards need to be updated and developed and recognized performance guarantee procedures established.

To push the market development, a strong effort is being placed on promoting the benefits of the technologies and the results of the Task to the decisions makers in the sectors of district heating and cooling and process heating and cooling. The issue of financing the "upfront investment in 25 years of heat production" will be dealt with and models for services of Energy Service Companies (ESCos) will be proposed and tested.

The Task's scope includes large-scale solar thermal systems – pre-heat systems as well as any combination with storages, heat pumps, CHP-units, boilers, etc. for the supply of block and district heating & cooling. It is organized into three Subtasks:

Subtask A: Collectors and Collector Loop
(Lead country: Denmark)
The objectives are to:

- Assure use of suitable components.
- Assure proper and safe installation - including compatibility with district heating and cooling network.
- Assure the performance of the collector field.

Subtask B: Storage
(Lead Country: Germany)
The objectives are to:

- Improve the economy of (seasonal) storage technologies.
- Increase knowledge on durability, reliability and performance of (seasonal) storage technologies.
- Demonstrate cost effective, reliable and efficient seasonal storage of thermal energy.

Subtask C: Systems
(Lead Country: Austria)
The objectives are to:

- Provide decision makers and planners with a good basis for choosing the right system configuration and size.
- Give decision makers and planners confidence in system performance.

Main Deliverables
The Task is creating a series of "Fact Sheets" on design, installation and operation of large collector fields, large scaleq23aW thermal storages, large-scale solar heating and cooling thermal systems with seasonal storage and/or heat pumps.

Duration
The Task started on January 1, 2011 and with a one-year extension ended on December 31, 2014.

Participating Countries
Austria, Canada, China, Denmark, France, Germany, Italy and Spain.

RESULTS IN 2014

Subtask A: Collectors and Collector Fields

- Measurements and theoretical investigations on solar collector efficiencies for large solar collectors with and without a foil between the absorber and the cover glass were carried out at the Technical University of Denmark for different volume flow rates, collector tilts and solar collector fluids. The results are summarized together with similar investigations carried out for small solar collectors in Canada.
- AEE-INTEC prepared guidelines for requirements for solar collector loop installations including precautions for safety and expansion.
- The Technical University of Denmark developed detailed simulation models for solar collector fields.
- The Operating Agent prepared Fact Sheets on procedures for guaranteeing the performance of collector field installation and on the procedure for guaranteeing performance of solar collector loop heat exchanger.

Subtask B: Storages

- A simple design tool for centralized solar district heating plants with seasonal storage was finalized.
- Work was conducted on the translation of the German Knowledge platform.
- Fact Sheets were drafted on seasonal storages.

Subtask C: Systems

- The feasibility tool was revised.

WORK PLANNED FOR 2014

Subtask A: Collectors and Collector Fields

- Proposal for inputs to ISO 9806 based on the above work.
- Finalize Fact Sheets and Subtask A summary report.

Subtask B: Storages

- Finalize Fact Sheets and Subtask B summary report.

Subtask C: Systems

- Finalize Fact Sheets and Subtask C summary report..

REPORTS/FACT SHEETS PUBLISHED IN 2014

- Performance guarantee - Collector field power output (revised version)
- Performance guarantee - Collector field annual output (revised version)

PRESENTATIONS IN 2014

- **Keynote:** SHC 2014, 13-15 October, Beijing, China, Jan Erik Nielsen

- **Presentation**: SHC 2014, 13-15 October, Beijing, China "Analysis for Marketization Development Prospect of Large-scale Solar Heating Combisystems in China", R. Zheng, China Academy of Building Research
- **Presentation:** SHC 2014, 13-15 October, Beijing, China "Towards District Heating with a Solar Fraction above 70%", D. Trier, PlanEnergi
- **Presentation:** SHC 2014 Conference Proceedings, Beijing, China, "Simulation of a solar collector array consisting of two types of solar collectors, with and without convection barrier", Federico Bava, Simon Furbo, Bengt Perers
- **Presentation:** EuroSun 2014 Proceedings, Aix-les-Bains, France, "Thermal performance of solar district heating plants in Denmark", Simon Furbo, Bengt Perers, Federico Bava
- **Presentation:** EuroSun 2014 Proceedings, Aix-les-Bains, France, "Comparative test of two large solar collectors for solar field application", Federico Bava, Simon Furbo

REPORTS/FACT SHEETS PLANNED FOR 2015

The following documents will be available on the SHC website:

- IEA SHC Task 45 FACT SHEETS – overview
- Correction of collector efficiency parameters depending on variations in collector type, fluid type, collector flow rate and collector tilt
- Requirements & guidelines for collector loop installation
- Performance guarantee - Collector field power output
- Performance guarantee - Collector field annual output
- Seasonal storages - Best practice examples
- Seasonal storages – Monitoring
- Seasonal storages – Guidelines for materials & construction
- Categorization of large solar heating and cooling systems
- ESCo models – General
- ESCo models - Best practice
- ESCo models - Energy performance contracts

MEETINGS IN 2014

7th Experts Meeting
April 8-9
Lyngby, Denmark

8th Experts Meeting
October 10-11
Jinan, China

MEETINGS PLANNED FOR 2015

Workshop
A workshop to present the Task results will be held in connection with the SHC 2015 conference.

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Task 46
Solar Resource Assessment and Forecasting

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Operating Agent for U.S. Department of Energy

TASK DESCRIPTION

Task 46: Solar Resource Assessment and Forecasting 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. A major component of the task is to provide this sector with information on how accurately solar resources can be forecast in the near future (sub-hourly, 1-6 hours, and 1-3 days) so that utilities can plan for the operation of large-scale solar systems operating within their systems. Another major component of the task is understanding short-term (1-minute or less) resource variability associated with cloud passages that cause power "ramps", an important concern of utility operators with large penetrations of solar technologies in their system. Although solar heating and cooling technologies are not, in themselves, "grid-tied" systems, the use of these technologies also impacts grid operations since they offset the use of conventional fuels or electricity

Objectives

Task 46 establishes four basic objectives in improving our understanding of solar resources: 1) evaluate solar resource variability that impacts large penetrations of solar technologies; 2) develop standardized and integrating procedures for data bankability; 3) improve procedures for short-term solar resource forecasting, and 4) advance solar resource modeling procedures based on physical principles to provide improved evaluation of large-scale solar systems using both thermal as well as PV technologies. Achieving these objectives will reduce the cost of planning and deploying solar energy systems, improve efficiency of solar energy systems through more accurate and complete solar resource information, and increase the value of the solar energy produced by solar technologies.

Scope

By addressing the four objectives listed above, Task 46 will provide research reports, summary articles, and best practices manuals addressing resource variability that impacts grid operations, data collection and processing procedures, solar resource model and solar forecasting validation results, and approaches for improving model performance.

The audience for the results of the Task includes the technical laboratories, research institutions and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, and building and system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, workshops and journal articles. Key results of this task will be posted to the IEA-SHC Task 46 Publications web site.

Task is organized into four Subtasks.

Subtask A: Solar Resource Applications for High Penetrations of Solar Technologies

(Lead Country: United States)

This Subtask will develop the necessary data sets to allow system planners and utility operators to understand short-term resource variability characteristics, in particular up and down ramp rates, to better manage large penetrations of solar technologies in the grid system. Although this work is primarily focused toward PV systems, which react almost instantaneously to cloud passages over individual panels, the information is also useful for solar thermal and CSP systems where intermittency due to variable solar resources can impact their ability to meet load demands. Subtask A consists of three main activities:

- Short-Term Variability (lead: Uni-Agder/Norway). This activity is concerned with the spatial and temporal characterization of high frequency intermittency (15 minutes or less) and ramp rates, and how this variability may impact he operation of solar technologies and their deployment on local power grids.
- Integration of solar with other RE technologies (lead: CENER/Spain). This activity is concerned with hybrid power generation involving solar and other renewable technologies (e.g., wind, biomass). Hybrid generation has pertinence to various scales from remotely operating hybrid installations, to autonomous and/or interconnected microgrids and larger scales, The focus of this activity will be placed on weather data and irradiance data requirements to address such questions and will initially focus on smaller scale issues – autonomous hybrid systems.
- Spatial and Temporal Balancing Studies of the Solar and Wind Energy Resource (lead: Uni-Jaén/Spain). This Activity is concerned with the analysis and modeling of solar and renewable resource data to address: 1) the spatial balancing of the solar resource (based on technologies using both Global Horizontal Irradiance, or GHI, and Direct Normal Irradiance, or DNI solar resources) across various distance scales; 2) the spatial and temporal balancing of both the solar and wind resources across various distance scales, and 3) the determination of the requirements for, and the eventual improvement of solar radiation forecasting associated with this balancing.

Subtask B: Standardization and Integration Procedures for Data Bankability
(Lead: Spain)

This Subtask addresses data quality and bankability issues related to both measurement practices and use of modeled data. Subtask activities are:

- Measurement best practices (lead: DLR/Spain, Almería/PSA): Manuals on best practices for obtaining measured irradiance data sets that provide bankable data for financial institutions will be prepared. The standardization and characterization of commonly used instruments as the Rotating Shadowband Irradiometers (RSIs) is directly connected to this objective.
- Gap Filling, QC, Flagging, Data Formatting (lead: MINES ParisTech/France). This activity documents best practices in filling missing data gaps, conducting data quality control, and flagging potentially erroneous data values when creating an archive of a database.
- Merging Ground and Modeled Data Sources (lead: CIEMAT/Spain): This activity explores procedures of combining different data sets, such as short-term ground measurements with long term satellite derived data, for extrapolating quality ground data to longer term climatic data sets, allowing for long-term cash flow analyses of projects.
- Uncertainty of model-derived historic solar radiation data (lead: Suntrace/Germany). This activity documents the importance of data

uncertainty for data sets representing various time frames in ways that the risk in financing a project can be quantified.

- Evaluation of meteorological products with focus on Typical Meteorological Year and Time Series (lead: DMI/DTU, Denmark). In this activity the historical use of TMY data will be evaluated in the context of current best practices for simulating solar system design and output. Recommendations for alternative approaches to TMY data will be made, given that TMY data sets do not allow for evaluation of extreme high- and low-resource events. Also higher time resolutions should be considered.

Subtask C: Solar Irradiance Forecasting
(Lead: Germany)

Solar irradiance forecasting provides the basis for energy management and operations strategies for many solar energy applications. Depending on the application and its corresponding time scales different forecasting approaches are appropriate. In this subtask forecasting methods covering timescale from several minutes up to seven days ahead will be developed, tested and compared in benchmarking studies. The use of solar irradiance forecasting approaches in different fields will be investigated, including PV and CSP power forecasting for plant operators and utility companies as also irradiance forecasting for heating and cooling of buildings or districts. Subtask activities are:

- Short-term forecasting (up to 7 days ahead) (co-leads: Univ. Oldenburg/Germany; SUNY/Albany/USA). The development and improvement of methods to forecast GHI and DNI is a major subject of activity C1. Different forecast horizons, ranging from minutes up to several days ahead are addressed using specific methodology and data. Activities C1.1 to C1.5 cover different forecasting approaches, characterized by the used data sources, corresponding methods and time scales. A second focus of this activity, addressed in Sub activity C1.6, is the comparison of these approaches in benchmarking studies focusing on different models, time scales or forecast parameters.
- Integration of solar forecasts into operations (lead: irSOLaV/Spain). This activity examines the important issue of how solar forecasts are used for different applications, including utility operations, management of PV or CSP power plants, and thermal management of buildings. A critical aspect of this task is to seek input from users, e.g. utility operators on the specific types of irradiance or power output forecasts they need in order to improve system operations and reduce the overall cost of energy and maximize the use of renewable energy within the system. In addition, a benchmarking study for different PV power forecasting approaches is planned.

Subtask D: Advanced Resource Modeling
(Lead: France)

Task 46 participants have identified new solar resource methodologies and improvements to existing methodologies, driven by specific information requests from energy developers and planners. They include new data sets required for the control and heating and cooling in buildings, solar resource forecasting for CSP plant operations, and the impact of climate change on solar resources, both from an historical perspective as well as estimates of future impacts. Subtask activities are:

- Improvements to existing solar radiation retrieval methods (lead: Uni-Jaén/Spain). The objective of this activity is to consider state-of-the-art and new solar radiation modeling approaches or other sources for input parameters to improve the accuracy and/or to increase the spatial, spectral and angular resolutions of solar resource data sets derived from satellite and Numerical Weather Prediction (NWP) models. An overview of the different advanced available satellite or NWP-derived solar radiation methodologies will be given as well the corresponding requirements of their input parameters. This activity will also evaluate the latest products coming out of the U.S. National Oceanic and Atmospheric Administration, such as the GOES Surface Irradiance Product, which offers a promising solution for providing near real-time irradiance values throughout the western hemisphere at 4-km resolution.
- Long term analysis and forecasting of solar resource trends and variability (co-leads: NASA-LaRC/USA; Meteotest/Switzerland). In this activity, studies of long-term solar data sets, both observed as well as satellite derived, will continue to asses episodes of “global dimming” and “global brightening”, important for evaluating potential long-term cash flow implications from solar systems. The uncertainties of the variability are characterized from large continental to regional scales. Efforts will be undertaken to link the results of IPCC climate change scenarios to predictions of future solar resource variations.

Task Duration
The Task began July 2011 and will end June 2016.

This is a collaborative Task with the SolarPACES Implementing Agreement (where this Task is referred to as Task V), and the Photovoltaic Power Systems (PVPS) Implementing Agreement’s Task 14 High Penetration of PV Systems in Electricity Grids.

Participating Countries
Australia, Austria, Canada, Denmark, France, Germany, Netherlands, Slovakia, Spain, Switzerland, United States

ACTIVITIES DURING 2014

Overall Task Activities
The 5th Task 46 Expert Meeting was held at the Laboratory-PIMENT, University of La Reunion, St. Pierre, La Reúnion Island (France). Fifteen task members participated, plus guests from the UK and the United Arab Emirates, and several students from the University. Some updates to the Task Work Plan were discussed, and a decision was made on how to handle the Task 36 Final Deliverable. Progress in each of the four Subtasks was presented, and breakout meetings on solar forecast benchmarking methodologies and measurement best practices were held.

The Task participants have agreed that completion of the final deliverable for Task 36, Solar Radiation Handbook, will now be folded into the work already completed under Task 46. The updated “Best Practices Manual for Solar Resource Assessment”, under preparation by the U.S. National Renewable Energy Laboratory NREL (will now be developed as a Task 46 manual and produced in two stages: a first stage, due in early 2015, which will incorporate materials prepared under Tasks

36 and 46, and a second stage to be completed in 2016. Some Task 46 deliverables, especially in Subtask B, will also be folded into one or both of these manuals.

Subtask A: Solar Resource Applications for High Penetration of Solar Technologies

Activity A1: Short Term Variability

In this activity irradiance time series with time resolution down to one minute are collected and analyzed. Data sets based on both PV and CSP systems are inspected for their statistical characteristics in terms of frequency distributions and temporal characteristics. This knowledge is used for the direct analysis of the fluctuating characteristics of the solar energy systems and for the setup of schemes for the generation of synthetic data sets to be used for system studies for sites without measured high-resolution data sets. Groups from Spain, France, Germany, the US and Norway are developing the respective characterization and modeling tools based on various approaches. These tools will then be inter-compared in view of their applicability for system studies involving the system dynamics.

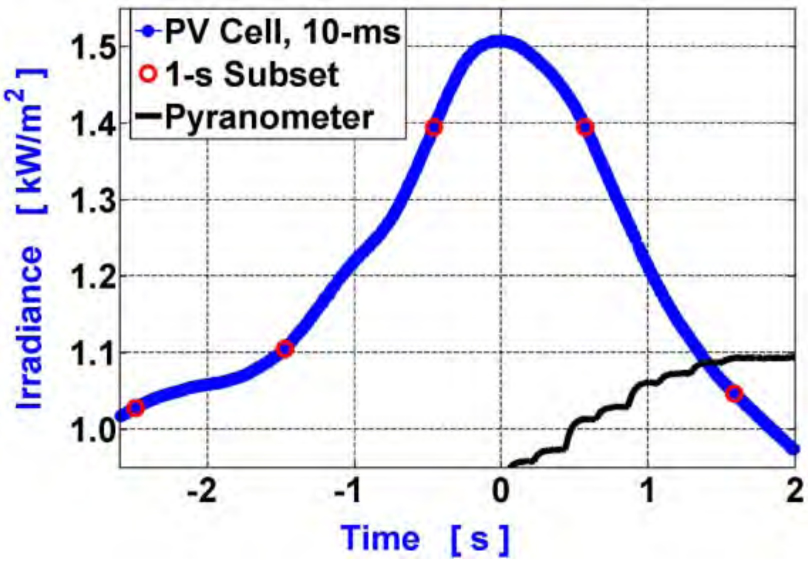


Figure 1. Example of over irradiance showing how sub-second time resolutions are required. Presented at EUPVSEC 2013 by Georgi Hristov Yordanov, Tor Oskar Saetre, and Ole-Morten Midtgård.

For example, CSIRO (Australia) has proposed a procedure for modeling the daily variability of solar irradiance using meteorological records. The daily variability of solar irradiance at four sites (Alice Springs, a desert climate; Darwin, a tropical climate; Rockhampton, a subtropical climate; and Wagga Wagga, a temperate climate) is quantified using observed time series of global horizontal irradiance for 2003-2012. Three statistical techniques (random forest, multiple linear regression and an analog method) with persistence as benchmark are adopted to model the daily variability using meteorological variables selected from the ERA-Interim reanalysis (a reanalysis of the global atmosphere covering the data-rich period since 1989) as predictors. The main conclusions of this study are: 1) The nonlinear regression technique (i.e. random forest) is demonstrated to perform the best while the performance of the simple analog method is only slightly worse; 2) among the four sites, Alice Springs has the lowest daily variability index on average and Rockhampton has the highest daily variability index on average; and 3) the modeling results of the four sites produced by random forest have a correlation coefficient of above 0.7 and a median relative error around 40%.

The State University of New York/Albany (SUNY/Albany) is currently preparing a review article on the spatial and temporal intermittency of solar energy upon request of Foundations and Trends in Renewable Energy, a new journal in the Foundations and Trends series by Now Publishers that specializes in review and survey articles oriented to a large audience. The material assembled for this article will include input from Task 46 experts. The article, to be published by mid-2015 will serve as a basis for an IEA/SHC Task 46 deliverable covering the major achievements by experts to date.

SUNY/Albany (USA) is also investigating how correlations vary over distance and time scales among several ground measurement stations located throughout the United States. Of special interest is the ”decorrelation distance” among stations, which can influence the way utilities might design and site future PV systems to mitigate the influences of ramping on grid power quality. Further, it is shown that 1) mitigation could be accomplished considerably more efficiently and at lesser cost when solar radiation forecasts are available, and 2) state-of-the-art forecasts available today are already sufficiently accurate to serve this purpose.

Meteotest (Switzerland) has conducted two spatial variability studies. One, using data from a high-density solar measurement array in Hawaii, shows that when deploying batteries to mitigate system output variability, battery sizes can be 5 to 30% smaller for central systems than for decentralized systems. In a second study, they show the effects of smoothing on solar output variability due to spatially distributed solar systems.

Laboratory-PIMENT (La Reúnion, France) has been investigating temporal and spatial variability of PV output in an insular grid on Reúnion Island. They found that relationships exist between temporal and spatial variability that can be used to refine coarse solar forecasts derived from NWP or cloud motion vectors. Their studies also show that the temporal and spatial characteristics on Reúnion Island are similar to those in Hawaii, and the effects of spatial smoothing are higher than in continental areas.

Uni-Agder (Norway) is studying very short-term irradiance variability, and the phenomena of ”over irradiances”. During situations with scattered clouds irradiances well above the extraterrestrial irradiance - of up to about 1500 W/m^2 - could be measured. This finding is also reported in the literature for other locations worldwide (see Figure 1). Due to the almost instantaneous reaction of photovoltaic cells, this also defines the maximum expected input to the inverter of a PV-system. This has consequences to inverter sizing, given that the inverter is scaled to the expected clear sky irradiance for the energy gain of the systems. The respective data analysis will continue through the remaining task period with ongoing work in Norway focused on the identification of the basic statistical properties (duration, intermittency) of ‘over irradiance’ (irradiances higher than the expected clear sky irradiance) events.

This study is backed up with dedicated studies based on sky photography to be used to track down the causes of the irradiance enhancement, and to improve the respective modeling capabilities. An all-sky camera system has been operational since the end 2013 (see the short YouTube video of a sample of camera output at http://www.youtube.com/watch?v=MPo9zjWRjpA). Modeling tools for a systematic analysis of the temporal and spatial extension of over-irradiance events making use of radiative transfer codes (LibRadtran) will be set up in the remaining project period. Also in the near future there will be an analysis of short-term variability on a group of 20 houses powered by PV in a residential area in southern Norway.

Subtask B: Standardization and Integration Procedures for Data Bankability

Activity B1: Measurement Best Practices

A key deliverable in this activity is the production of a best practices manual for measurements with Rotating Shadowband Irradiance (RSI) instruments. The draft of this manual has undergone internal review and will be finalized in 2015 as an online publication. A corresponding publication (Geuder et al., 2014) that was presented at the SolarPACES 2013 conference has been reviewed and is now available online. Contributions to the general best practices document for solar resource assessment and forecasting concerning measurement devices, to be published by NREL in 2015, have also been provided.

An important outcome of the work in this activity is that standard broadband irradiance data should always be included in any assessment of solar resources despite the fact that some solar power plants might be modeled more accurately with plant specific resource data. Such plant specific resource data could be represented by DNI measurements for CSP plants with a specific opening angle or by measurements with sensors that have a spectral response that is close to that of the plant. Such plant specific parameters are recommended as optional additional measurements.

The often-discussed problem caused by soiled instrument entrance windows is addressed by a new development by Black Photon Instruments. A new sun tracker allows the separate movement of a reference and a standard pyrheliometer towards the sun. The reference instrument can be parked during most of the time such that the entrance window stays clean. For the control of the status of the standard instrument the reference is then tracked during a short clear sky period. Furthermore, the tracker also includes a cleaning system in order to remove dust on the entrance windows of pyrheliometers.

A case study of the effect of soiling on concentrating mirrors in Morocco was prepared and published in (Alami et al., 2014). Another recent publication by Wolfertstetter et al., (2014) also relates to the soiling of sensors.

A discussion paper on the performance of the SPN1 solar sensor has been published (Badosa et al., 2014). MeteoSwiss presented further results on the SPN1 and RSI accuracy at the BSRN meeting in Bologna. Task members are preparing a detailed report on these results.

This activity is also contributing to the revision of ISO 9060, 9059 and 9846 and 9847 (irradiance sensor specification and calibration). A liaison between the ISO Technical Committee 180 “Solar Energy”, Subcommittee 1 “Climate - Measurement and data” and IEA SHC T46 is being finalized. Suggestions for the required changes were formulated and sent to the subcommittee chairperson.

Activity B2: Gap Filling, QC, Flagging and Data Formatting

Progress has been made on establishing appropriate formats for time series data. The aim of this work is to find best practices or a standard for data formatting in order to find interoperability among a number of data sets. A standard format will permit to manage, exploit and compare data time series from different sources in an easy way. There is general agreement among Task participants to adopt the data format from the MesorFP6 project, even though there is also agreement that further efforts about the grammar are needed. ASCII files are mainly recommended as a first attempt for this subtask. The easy conversion to hdf or NetCdf formats and the usage of these formats will be treated in the future. An update of the MESoR data format with a more detailed data format description is under preparation. A documentation of the format for comments on timestamps has been distributed.

As noted in the discussion under B1 above, a paper on Quality Control (QC) and flagging has been published (Geuder et al., 2014). Besides automatic QC procedures, the importance of manual screening of the data by an expert is discussed, including the required fast methods to document additional information during the daily control. Figure 2 shows a case where a sensor-cleaning event is marked and the effect of the cleaning is determined for data correction.

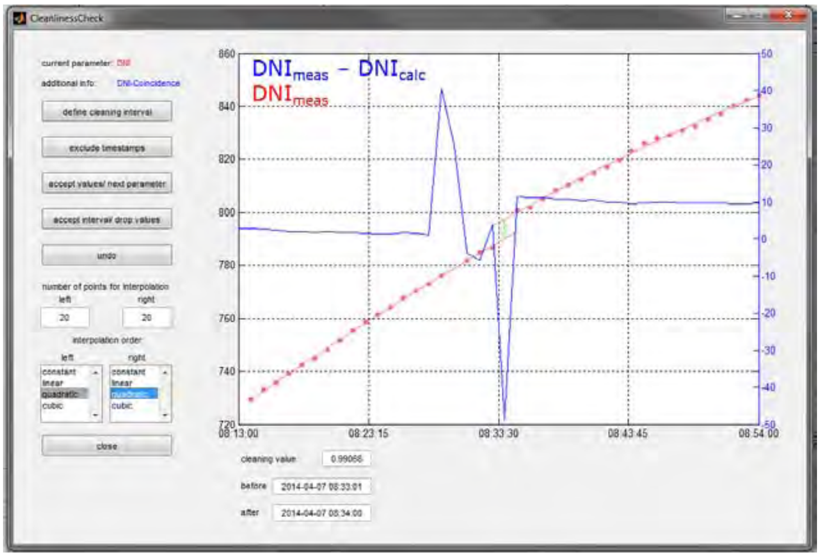


Figure 2. Cleaning event of a pyrheliometer at PSA after a weekend without maintenance that has been marked for flagging, QC and data correction (Geuder et al., 2014).

Activity B3: Merging Ground and Modeled Data Sources

The first draft of a report on the Integration of ground measurements with satellite model-derived data has been distributed to the activity participants and first comments and further contributions were collected. This version of the report was discussed at the 5th Task meeting in La Reúnion and further actions items and responsibilities were defined. An example of the discussed methods for the improvement of the model-derived data is shown in Figure 3.

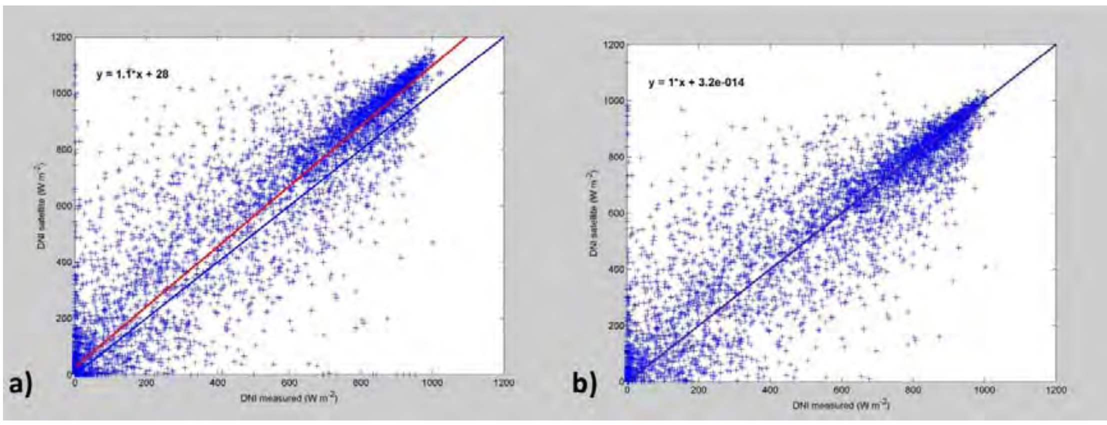


Figure 3. Example of BIAS removal from satellite-derived DNI by subtracting the MBE (Mean bias error). a) Scatter plot of the uncorrected estimations. b) Scatter plot of the corrected estimations

Activity B4: Uncertainty of Model-derived Historic Solar Radiation Data

During the 5th Task Experts Meeting in La Reúnion a report on Standardizing and Benchmarking Model-Derived DNI Products, Phase 1, was presented. The report by Richard Meyer, Chris Gueymard, and Pierre Ineichen, 2014 (see Section "Publications/Reports in 2014, below) falls under the scope of collaboration between SolarPACES Task 5 and IEA/SHC Task 46. The report includes a discussion on the methodology for the benchmarking of model-derived solar irradiance data sets. DNI data products have the largest uncertainty of all solar components, so the results are highly relevant to SHC as well.

Results on the long-term validation of satellite derived irradiance data has been published (Ineichen, 2014). This publication represents a Task 46 deliverable in connection with the previously published report from (Ineichen, 2013; http://archive-ouverte.unige.ch/unige:29606).

A discussion of the effect of hourly and daily averaging on the uncertainty of irradiation data was started at the National Pyrheliometer Comparison at NREL in September/October, 2014. Methods using 95 percentiles of uncertainty and common propagation of errors were discussed with the aim to achieve an international agreement for the determination of the uncertainty for financial calculations. The discussion will be continued.

A relevant publication from the guest participants from Chile on a solar resource assessment for Chile using satellite methods and ground data has been published (Escobar et al., 2014).

Activity B5: Evaluation of Meteorological Products with Focus on Typical Meteorological Year and Time Series

In the past year, updates to TMY datasets for the US and Denmark have been made by Habte et al. (2014) and Grunnet Wang et al. (2013). A common feature of these updated datasets is that they are based on meteorological data from approximately 10-year periods. Thus the new gridded TMY for the US is based on data from the period 1998-2009, while the new Danish Design Reference Years are based on data from the period 2001-2010. Previously, TMY datasets have been based on data from approximately 30-year periods. Thus the first US TMY was based on data from 1948 to 1980, TMY2 was based on data from 1961 to 1990 and TMY3 was based on data from 1976 to 2005.

The rationale behind basing TMY datasets on data from 10-year periods rather than 30 year periods is the clear trends in global dimming and brightening that have been observed in the last decades. Müller et al. (2014) therefore advocates using the 10 most recent years for future solar resource assessment rather than using the 30-year periods.

For larger solar energy system planning, full meteorological time series analyses are performed with a particular focus on also making P90 datasets that represent the data of a typical year, whose values would be exceeded in 90% of all years (*e.g.* Meyer et al. 2012). The metrics of Kolmogorov-Smirnoff statistics have also been noted to be important (Gueymard 2014). Leloux et al. (2014) have noted that even elaborate time series analyses may not account for infrequently occurring high impact events such as major volcanic eruptions. In certain regions strong El-Niño events can also be an issue.

Using 10 years of meteorological data from DMI, DTU Civil Engineering have compared the effect of using TMYs with using multiyear meteorological datasets for simulating the thermal performance of solar collectors for various locations. The results at one of these locations, WMO station 6109 in Askov, are shown in Figure 4. For the tracking solar collectors year-to-year differences in the thermal performances of more than 35% are seen during the period 2001-2010. The thermal performances were calculated with the model of Andersen et al. (2010)[1]. The solar collectors are assumed to have average liquid temperatures of 333 ^{0}K.

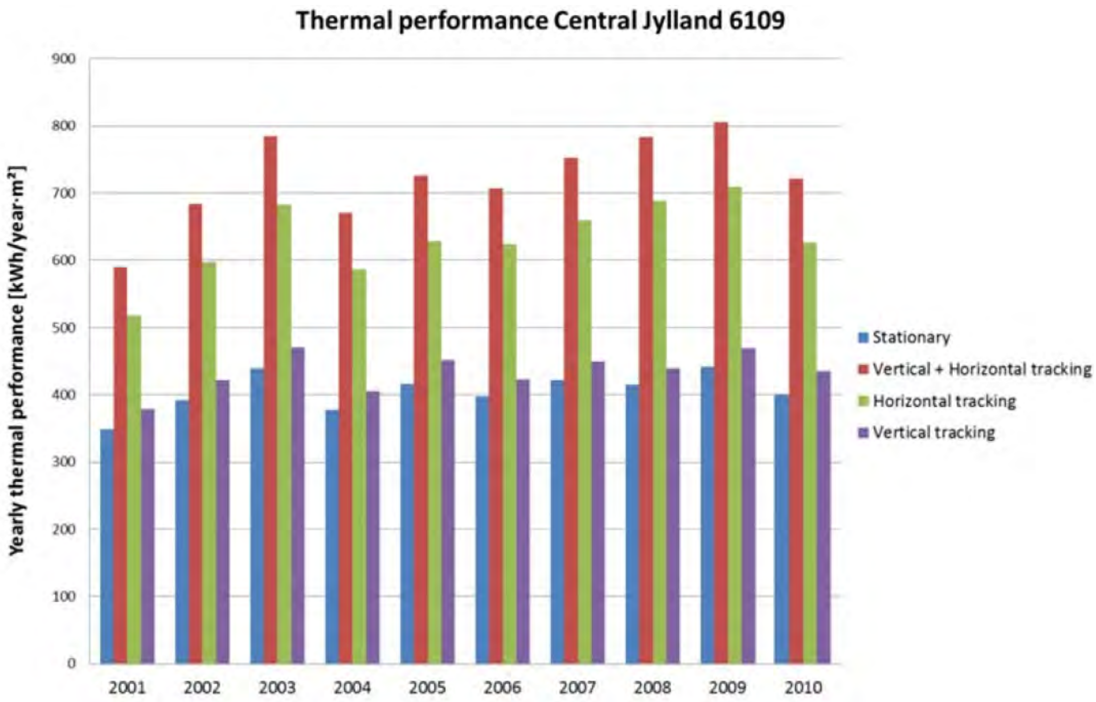


Figure 4. The yearly thermal performances from 2001 to 2010 for tracking and stationary solar collectors based on the 2001-2010 meteorological data from Askov, Denmark (WMO station 6109). The stationary solar collector is tilted 40° toward South.

These results were presented at the 3rd Solar Heating and Cooling Conference in Beijing in October 2014.

Thanks to the initiative of the task members from Ciemat progress has been made with actual standardization of TMY generation in the framework of IEC. In April 2014 the IEC TC117 approved the Spanish proposal for forming a work group. In July 2014 the first meeting was held at Ciemat in Madrid. Comments on the presented suggestion of the standard were collected during the summer and have been submitted for the further change of the standard. Although this standard currently focuses on CSP/STE, it is also useful work for SHC and PV

Subtask C: Solar Irradiance Forecasting

Activity C1: Short-term Forecasting (up to 7-days ahead)

In this activity, a variety of forecasting techniques with timelines ranging from sub-hourly to several days are evaluated and benchmarked. Methodologies include time series models based on ground-measured irradiance networks and total sky images,

[1] Andersen, E., Dragsted, J., Furbo, S., Perers, B. & Fan, J.: “Thermal advantage of tracking solar collectors under Danish weather conditions,” *in*: “Proceedings from the International Conference on Solar Heating, Cooling and Buildings,” Graz, Austria, 2010.

motion vectors from satellite data, Numerical Weather Prediction (NWP) forecasts, and statistical models integrating different data sources.

Time series models based on ground-measured irradiance data: Uni-Oldenburg continues to work on the application of machine learning methods for very short term PV power forecasting. Due to fast changing weather conditions, e.g., clouds and fog, a precise forecast in the minute to hour range can be a difficult undertaking. On the basis of big data sets of PV measurements, methods from statistical learning are applied for one-hour ahead predictions. Nearest neighbors regression and support vector regression are employed for PV power predictions based on measurements and numerical weather predictions. An emphasis is put on the analysis of feature combinations based on PV time series and numerical weather predictions as additional exogenous input. An evaluation of PV power forecasting based on PV power measurements with the machine learning approach support vector regression to PV power forecasting with cloud motion vectors (Lorenz, et al., 2014).

Laboratory-PIMENT (La Reunion, FR) is investigating the performances of forecasting methods based on linear models (Autoregressive Moving Average, or ARMA) and nonlinear models (Neural Networks, etc.) with only past ground measured data (see Figure 5). The University of South Australia is also contributing work on time series forecasting.

The University of South Australia is also contributing work on time series forecasting. (Boland and Soubdhan; 2015; Boland, 2014).

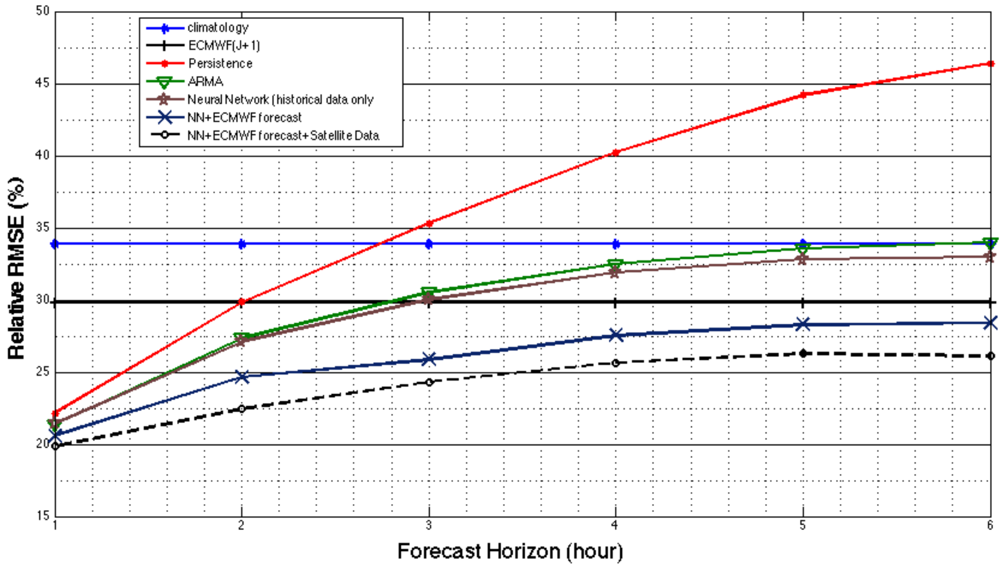


Figure 5. Benchmarking of various forecasting techniques.

Total sky imagers: A workshop dedicated to "Processing techniques for the detection of atmospheric constituents and the estimation and forecasting of solar irradiance from all-sky images" was organized by the COST Action ES1002 WIRE "Weather Intelligence for Renewable Energy" (www.wire1002.ch) in collaboration with the FP7 DNICast project and the IEA SHC Task 46. The workshop took place in June 24th-25th 2014 at the University of Patras, Patras, Greece. A broad overview of the current (but rapidly evolving) state of the art in all-sky cameras applications in meteorology and solar energy forecasting was given in the different sessions (http://www.sky-camera-workshop.info/) covering the topics "sky cameras basics", „estimation of cloud coverage and types", "atmosphere & radiation", and "solar radiation forecasting". The IEA SHC Task 46 partners, University of California at San Diego (UCSD), U of Jaen, DLR, MINES ParisTech, Delft U of Technology, and U of Oldenburg gave presentations at the workshop. As one major conclusion of the workshop the need to defined standards for sky imaging hardware, camera calibration or image processing techniques was expressed.

At UCSD work on sky imager forecasting is continuing. Handa et. al (2014) present a sky imager based site-specific irradiance forecasting method applicable to power plant settings and validated it against sixty-three days of data. Frozen cloud advection was found to superior to image persistence on average and the irradiance forecasts were found to be able to predict major ramp events. Urquhart et al, (2014) report on the development of a high dynamic range (HDR) camera system capable of providing hemispherical sky imagery from the circumsolar region to the horizon at a high spatial, temporal, and radiometric resolution to facilitate the development of solar power forecasting algorithms based on ground-based visible wavelength remote sensing.

U of Oldenburg has presented first results of their in sky imager forecasting approach in (Kalisch, et. al 2014), see also Figure 6. A special feature is the evaluation against measurements with more than 90 photodiode pyranometers distributed over an area of 10x10km close to Jülich in Germany collected from April to July 2013 in the framework of the HOPE campaign (Madhavan, et. al 2014).

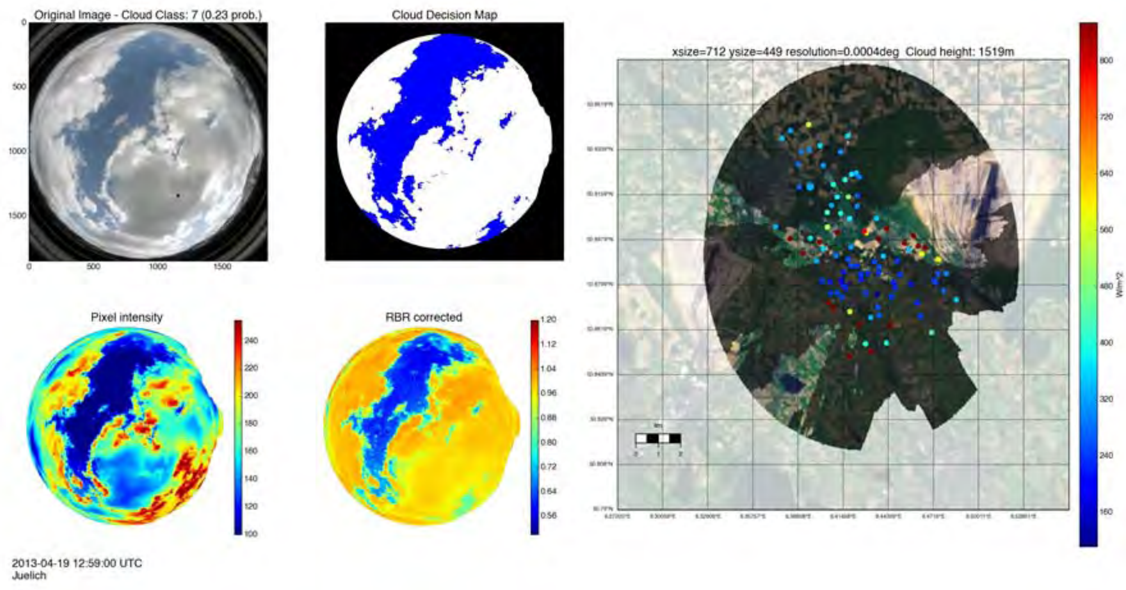


Figure 6. Cloud information from sky imagers: Original images (top left), pixel intensities (bottom left), Red-blue ratio, corrected with a clear sky library (bottom middle), cloud decision map (top middle) and shadow map with irradiance measurements (right). Sky image and irradiance measurements taken in Jülich, Germany on 2013-04-09 at 12:59_00UTC in the framework of the HOPE campaign [Madhavan et al 2014]. Source: Oldenburg University.

Motion vectors from satellite data: Meteotest is continuing their research on the combination of cloud and radiation fields from satellite images with wind fields from the NWP model known as the Weather Research and Forecasting, or WRF model (Mueller et al, 2014). This shortest-term solar forecasting algorithm for 0.5 - 6 hours

ahead, which is updated every 15 minutes, has been evaluated for more than 20 sites in Switzerland, including low lands, alpine and high-alpine stations. The RMSE ranges between 75 – 200 W/m^2 (20 - 60%), depending on season, station and forecast horizon. A regional aggregation forecast including 90 FIT*-installations (8 MW) with measurements leads to RMSE values between 4 – 10% relative to installed power. A particular focus during the reporting period has been on the investigation of Kalman filters to improve the forecasts. This post-processing approach has been found to be useful for correcting for clear sky days.
U of Oldenburg is working on evaluation and further development of their cloud motion vector (CMV) forecasting algorithm based on Meteosat satellite images. Currently, the focus is on the development of a method to derive a cloud index during night based on IR images with the aim to produce several hours ahead predictions also for the early morning hours.

NWP forecasts models: DMI/DTU continues to work on the Grand Limited Area Model Ensemble Prediction System (GLAMEPS). GLAMEPS is a multi-model ensemble system that includes ensemble models from the High Resolution Limited Area Model HIRLAM-ALADIN consortium and the European Center for Mid-Range Weather Forecasting (ECMWF). The resolution of GLAMEPS is 0.15° in rotated latitudinal longitudinal coordinates. Average GHI is output every 3-hours. Recent work is related to the upscaling of benchmarking models and bug fixes of the Hirlam Aladin Regional/Mesoscale Operational NWP In Europe (HARMONIE) 38h1 direct irradiances.

Additionally, DMI runs a rapid update cycle (RUC) model with a resolution of 0.03° and output of GHI and scattered solar irradiance every 10 minutes. A new approach for assimilation of 2D radar precipitation into this high-resolution NWP model is described in Korsholm et al, (2014).

Statistical models integrating different data sources: Uni-Oldenburg is continuously investigating the use of machine learning methods (support vector regression) for improving solar power predictions by integrating different data sources. The different input data are dealt with as exogenous input to time series models (see also discussion on Time series models based on ground-measured irradiance data above).

PIMENT (U. of La Reúnion) is working on the use of machine learning techniques (Neural Networks, Gaussian processes and Support Vector machines). The use of additional inputs (NWP forecasts+Satellite data) greatly improves the accuracy of the forecasts. They have proposed a MOS technique based on Kalman filtering in order to refine WRF forecasts solar forecasts by using hourly high quality ground measurements (Diagne et al, 2014).

MinesParisTech, in cooperation with EDF R&D, is working on short term forecasting with a spatiotemporal AR model. The integration of massive solar energy supply in the existing grids requires an accurate forecast of the solar resources to manage the energy balance. In this context, EDF R&D, the University of Grenoble, and MINES ParisTech have developed a new approach to forecast GHI at ground level from satellite images and ground based measurements. This new and promising approach is based on spatiotemporal multidimensional autoregressive models with Helioclim-3 (HC3) data along with 15-min averaged GHI ground-based time series. Forecast horizons from 15 minutes to 1 hour provide very promising results validated on a one year ground-based pyranometric data set. The performances have been compared to another similar method from the literature by means of relative metrics (see Figure

7). The proposed approach paves the way of the use of satellite-based surface solar irradiance (SSI) estimation as a SSI map now casting method that enables to capture spatiotemporal correlation for the improvement of a local SSI forecast.

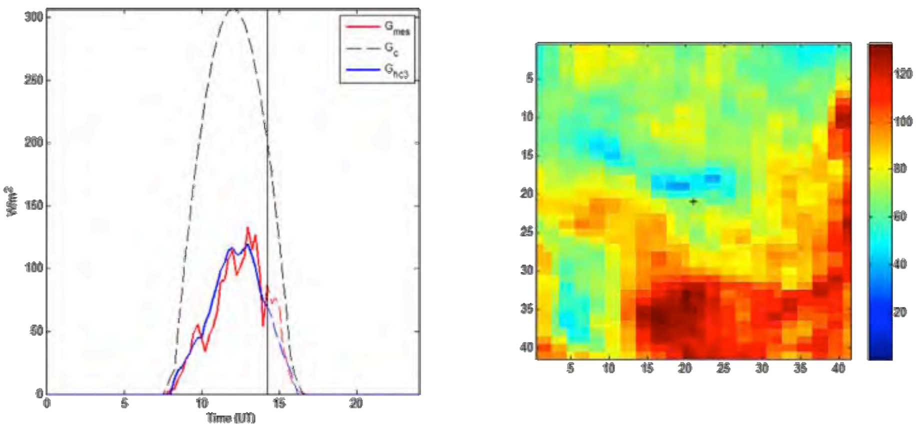


Figure 7. Left: GHI time series at the site of interest from the in-situ sensor (Gmes), the satellite-based estimation HC3 (Ghc3) and the clear-sky modeling ESRA (Gc). Right: spatial information from the local GHI map provided in near-real time by HC3.

U of Oldenburg is investigating the use of machine learning methods (support vector regression SVR) for improving solar power predictions by integrating different data sources. In Lorenz et al. (2014) PV measurements, forecasts based on cloud motion vectors from satellite data and NWP predictions are integrated to derive PV power predictions up to 5 hours ahead. Forecasts derived with SVR directly from PV measurements and irradiance forecasts were compared to a second approach implying PV-simulation in a first step and a bias correction and combination with linear regression in a second step. An evaluation of forecasts derived with the second approach is given in Figure 8. The Root Mean Square Error (RMSE) for the different input models and their combination with linear regression is displayed over the forecast horizon for single site forecast (left) and for the average of 921 sites (right) in Germany, showing the benefit of different input data and different models for different forecast horizons as well as the improvement with the combined approach. Similar results were obtained with the SVR approach, and a further improvement is expected by combining PV simulation and SVR.

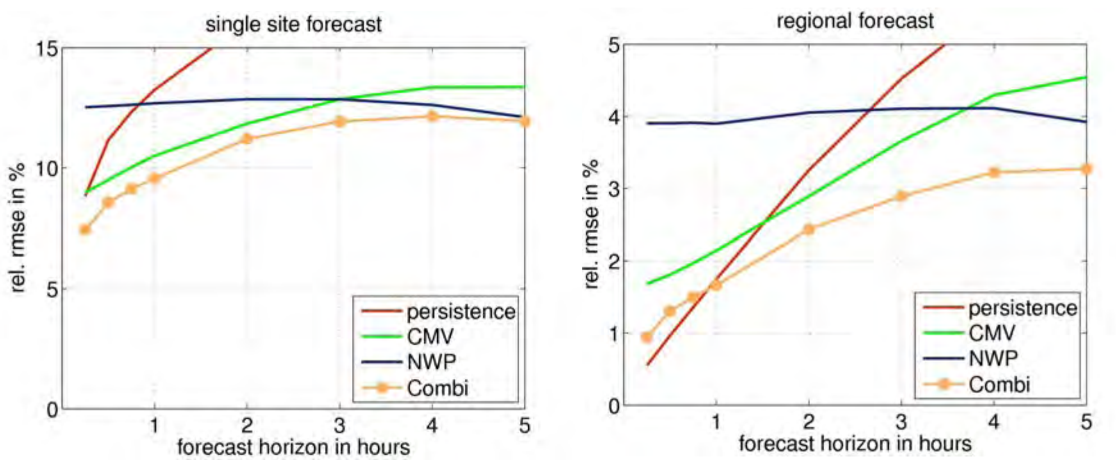
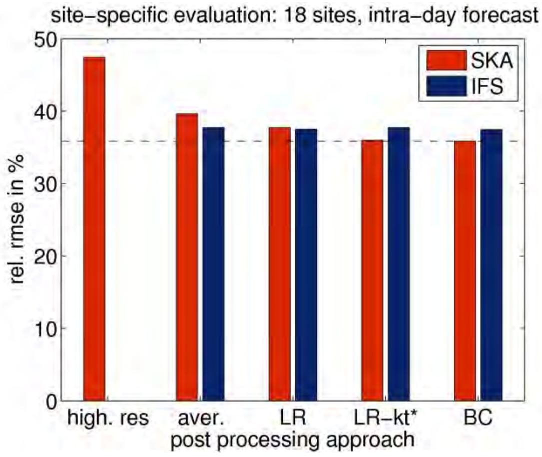


Figure 8. RMSE for the different forecast methods for single site (left) and regional (right) forecasts. Top: Persistence (red), forecasts derived from cloud motion vectors (CMV, green) and NWP model forecasts (blue) with PV simulation and bias correction, combination of these forecasts with linear regression (orange).

Benchmarking studies: The preparation of forecast and measurement data for benchmarking studies has been a major effort of IEA Task 46 members with a focus on the NWP benchmarking studies for Northern and Middle Europe:

- U of Oldenburg and Meteotest have shared measured data as a basis for post-processing with other partners.
- DMI has produced and delivered GLAMEPS, HIRLAM SKA (Scandinavia) and RUC (Rapid Update Cycle) forecast data for Denmark, Germany and Norway
- Meteotest has produced forecast data derived with a GFS MOS (Global Forecast System Model Output Statistics) for Germany and Switzerland
- BlueSky and U of Oldenburg are currently processing their forecasts and will share them with the partners by end of November 2014.
- A first comparison of ECMWF Integrated Forecast System (IFS) and HIRLAM SKA forecasts has been performed for 18 measurement sites in Germany (Figure 9). The focus in this evaluation was on the effect of different post processing approaches for these NWP models. The comparison of irradiance forecasts of the high resolution regional SKA model with the IFS forecasts based on 3 hourly output and averaged over 100km x100km, reveals smaller RMSE values of the IFS forecasts as long as no statistical post-processing is involved. When applying spatial and temporal averaging as well as a bias correction in dependence of the solar elevation and clear sky index, SKA_{BC} forecasts show smaller RMSE values than the IFS_{BC} forecast with the same post-processing. For IFS forecasts the impact the investigated post-processing schemes is only small with an improvement of 7.8 % for regional forecasts using the bias correction, while there is a large improvement for the HIRLAM SKA forecasts around 25% for the regional forecasts



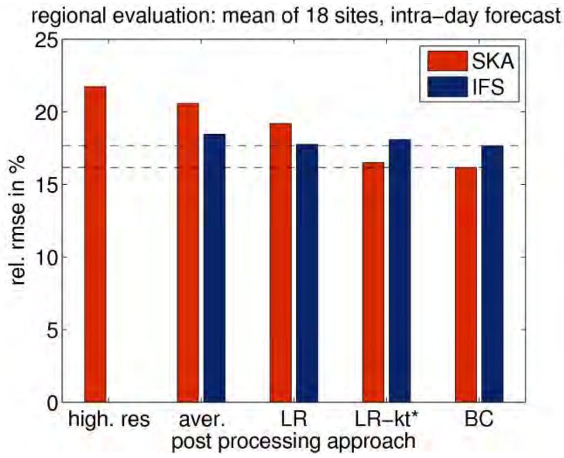


Figure 9. RMSE of SKA forecasts with different post processing approaches (spatial and temporal averaging, linear regression of GHI (LR), linear regression of the clear sky index (LR-kt*), bias correction in dependence of solar elevation and clear sky index (BC)) for single site forecasts (left) and regional forecasts (right), derived as mean value of all sites. Database: 18 sites in Germany, 3.4.2013- 28.2.2014 (Training set: last 30 days, all sites).

Activity C2: Integration of Solar Forecasts into Operations

Link with Industry: A DNICast workshop on "Energy Sector End-User Requirements for Direct Normal Irradiance Nowcasting and Forecasting'' was held in Madrid on 7 May 2014 (www.ifema.es/web/ferias/genera/default_i.html). This workshop provided opportunities to discuss and present to the CST companies the last requirements needed for <4h nowcasts and CSP and CPV systems. These requirements are part

of the DNICast project report: ‘’ Direct Normal Irradiance Nowcasting methods for optimized operation of concentrating solar technologies’’.
Applications of Solar Forecasting: U of Oldenburg is continuously working on PV power predictions for utility applications in Germany (Lorenz et al., 2014).

SUNY-Albany has presented a new operational solar resource forecast service for PV fleet simulation (Perez, et al., 2014).

Subtask D: Advanced Resource Modeling

Activity D1: Improvements to Existing Solar Resource Retrieval Methods
The collaborative peer-reviewed paper on the expert consensus about definitions related to DNI (Blanc, P., B. Espinar, N. Geuder, C. Gueymard, R. Meyer, R. Pitz-Paal, B. Reinhardt, D. Renné, M. Sengupta, L. Wald and S. Wilbert, 2014: “Direct normal irradiance related definitions and applications: the circumsolar issue”) has been accepted for publication in the Solar Energy Journal.

NWP Based Solar Resource Assessment
University of Jaén (UJA) has developed a new parameterization of the shortwave aerosol optical properties for surface solar irradiance assessment in the WRF model that has been recently published (Ruiz-Arias et al., 2014). The parameterization includes the effects of aerosol extinction on the WRF-computed surface solar fluxes by means of the AOD at 550 nm and the predominant aerosol type, although other aerosol optical properties can be also provided. Using this parameterization, UJA has conducted a rigorous sensitivity analysis of the role of MODIS-based AOD observations and their uncertainties in the expected accuracy of the modeled cloudless surface solar fluxes using five different modeling approaches with differing sophistication (Ruiz-Arias et al., 2015a). The study shows that, counter intuitively, the direct and diffuse irradiances predicted by solar radiation models that use empirically adjusted fixed aerosol extinction may be more accurate than more sophisticated radiative transfer models that require AOD inputs. Compared to ground observations, the mean absolute error in satellite-retrieved AOD over the U.S., and possibly elsewhere, should be reduced to less than 0.025 AOD unit to assure improvement over the predictions of a simpler, aerosol-insensitive radiation model.

In collaboration with the activities promoted in Subtask B, UJA has developed a regional site adaption method for the optimal combination of gridded and ground-observed surface solar radiation data (Ruiz-Arias et al., 2015b). It consists of a numerical process by which the modeled solar radiation data, obtained typically from satellite-based techniques or NWP models, and provided as two-dimensional geo-referenced grids, are objectively adjusted at each model grid cell as a function of the reliability of the modeled solar radiation value at that grid cell with respect to the reliability of the nearby ground observations casted onto that grid cell.

DMI/DTU (Denmark) is working on the estimation of short-wave surface solar radiance and irradiance under all-sky conditions (clear sky and clouds) within the framework of the NWP model HARMONIE. In this study, DMI have tested different cloud liquid parameterization (asymmetry factor, cloud water, cloud drop effective radius, etc.) and the IFS delta-Eddington radiative transfer scheme (see Figure 10).

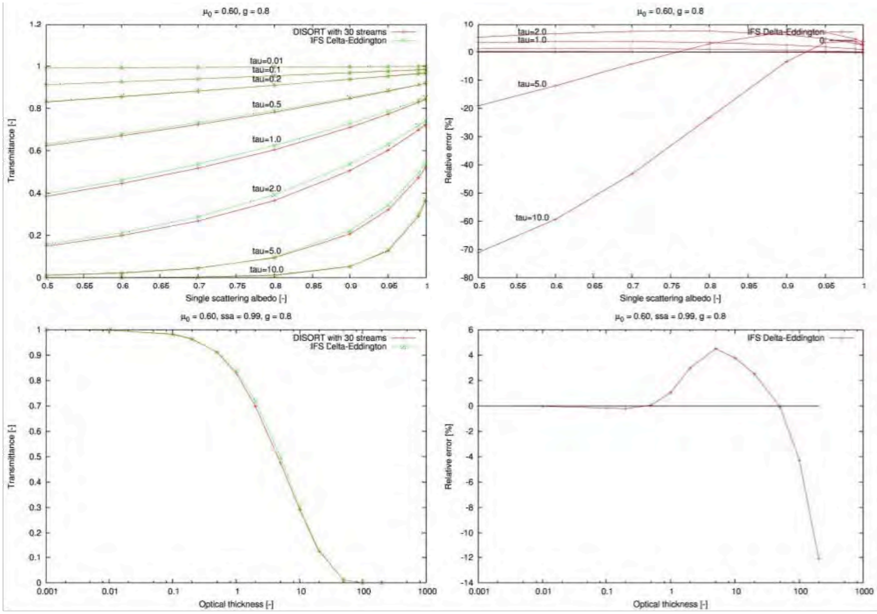


Figure 10. Short wave surface solar irradiance estimation within the NWP HARMONIE: experiment of the IFS delta-Eddington radiative transfer scheme (DMI, DK).

Satellite Based Solar Resource Assessment

MINES ParisTech (FR) and DLR (DE), in the framework of the FP7 project MACC, are working jointly on a new radiative transfer (libRadtran) based approach for surface solar irradiance (SSI) estimation with satellite data, named Heliosat-4. This approach has made the assumption of a possible decoupling of the effects of clear atmosphere and clouds to simplify calculations of the broadband solar irradiance at ground level (Oumbe et al. 2014). The SSI estimation with Heliosat-4 in the field of view of Meteosat since 2014 is provided by the database MACC-RAD available for free at www.soda-is.com.

The component of Heliosat-4 meant to assess SSI under clear-sky condition is named McClear (Lefèvre et al. 2013)[2]. The clear-sky SSI estimation with McClear is available at www.soda-pro.com.

The performance of this model has been assessed by MINES ParisTech in collaboration with the Masdar Institute and the company Total in the United Arab Emirates (UAE). For this assessment, one year (2012) of ground measurements from 7 ground stations was used as a reference and an automatic detection of clear-sky instants have been developed for this purpose. Six of these 7 ground stations belong to the Masdar Institute and the 7th to the company Total. Estimates of the direct normal irradiance exhibit an underestimation that could be attributed to the overestimation of the aerosol optical depth in the MACC data set and not accounting for the circumsolar radiation in McClear. The corresponding bias ranges from −8% to 0%, the RMSE ranges from 9% to 12%, and the coefficient of determination ranges from 0.790 to 0.819. When compared with two other models from literature, McClear performs notably better for the direct normal irradiance. Results are shown in Figure 11.

[2] Lefèvre, M., Oumbe, A., Blanc, P., Espinar, B., Gschwind, B., Qu, Z., Morcrette, J.-J., 2013: McClear: a new model estimating downwelling solar radiation at ground level in clear-sky conditions. *Atmospheric Measurement Techniques*, *6*, 2403–2418. doi:10.5194/amt-6-2403-2013.

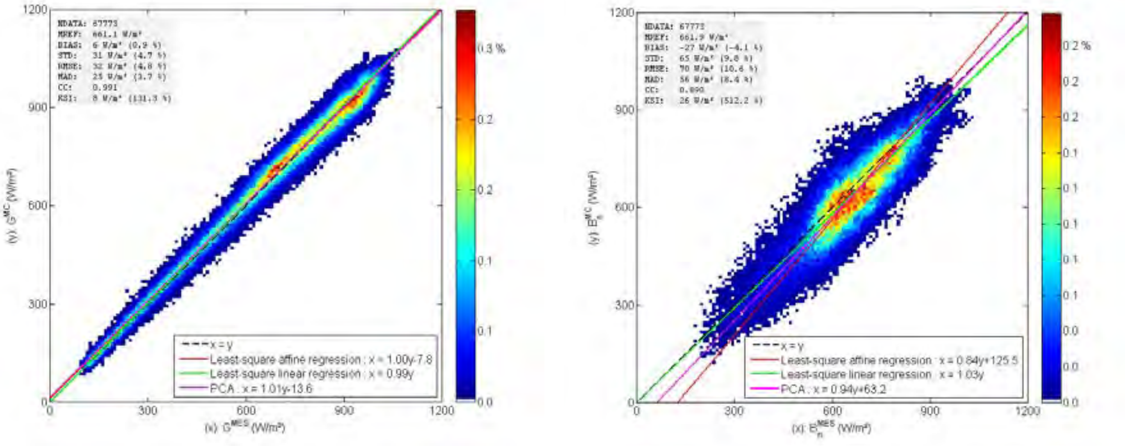


Figure 11. Scattergrams of McClear estimation of 10-min SSI (left: GHI, right: DNI) vs. ground measurements for clear-sky instants from 7 ground stations in the UAE.

The new McClear clear sky model has been validated by UNIGE against data from 22 European and Mediterranean measurements' sites, with various latitude, altitude and climate (Figure 12). The inputs of the model are mainly the aerosol optical depth (AOD) and the water vapor content *w* of the atmosphere. Three sources of the AOD were used for the validation: MACC-2 project, AERONET and Molineaux-Ineichen model retrofit. On the figure, two characteristic plots illustrate the comparison: the diffuse fraction versus the clearness index, and the beam clearness index versus the global clearness index. It shows then coherence between the measurements and the model, and the good accordance of the three components. Obviously, the model gives better results with ground obtained than with modeled input parameters. The bias standard deviation is also very satisfying.

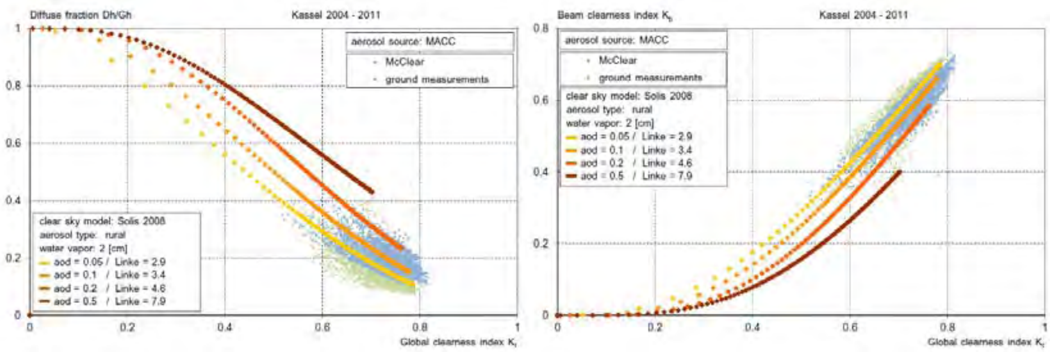


Figure 12. Diffuse fraction (left) and beam clearness index (right) with respect to the clearness index used for the validation of McClear.

A preliminary validation of MACC-RAD and a comparison with previous models have been done by UNIGE for data acquired at four sites. The results show a good improvement of the modeled clearness indices, due to the new clear sky model (McClear) included in the scheme. The overall results are a degradation of the global component, and an improvement of the representation of the DNI. The common statistics represented by the mean bias difference and the standard deviation are slightly improved and are significant, as the difference distribution around the 1:1 axis are nearly normal distributions. This is illustrated in Figure 13.

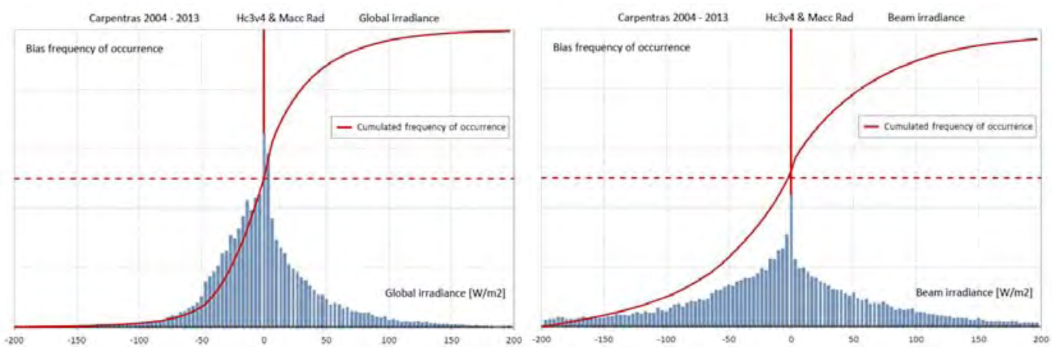


Figure 13. Histograms (left: global horizontal irradiance, right: beam horizontal irradiance) of 1-hour SSI differences between MACC-RAD and the *in-situ* measurements in Carpentras (BSRN station).

MINES ParisTech is being exploring a new approach to estimate the irradiance in specific spectral bands starting from estimates of the total SSI that are currently available. Its concept is based on a) the k-distribution method and correlated-k approximation of Kato et al. (1999) which allows fast and still accurate computations, and b) the decoupling concept which separates the effect of the clear atmosphere on the SSI from those due to clouds. Atmospheric properties for the clear sky conditions are taken from the MACC-II project. Ground albedo originates from an appropriate exploitation of the MODIS products. The clouds properties are obtained with the recent advanced products from AVHRR Processing scheme Over cLouds Land and Ocean (APOLLO) applied to Meteosat images. An important part of the operational method is its performance on the estimates of the spectral distribution in clear sky conditions. The new method provides good results on UV irradiance, Photosynthtetically Active Radiation (PAR) and illuminance in the clear-sky conditions (Figure 14).

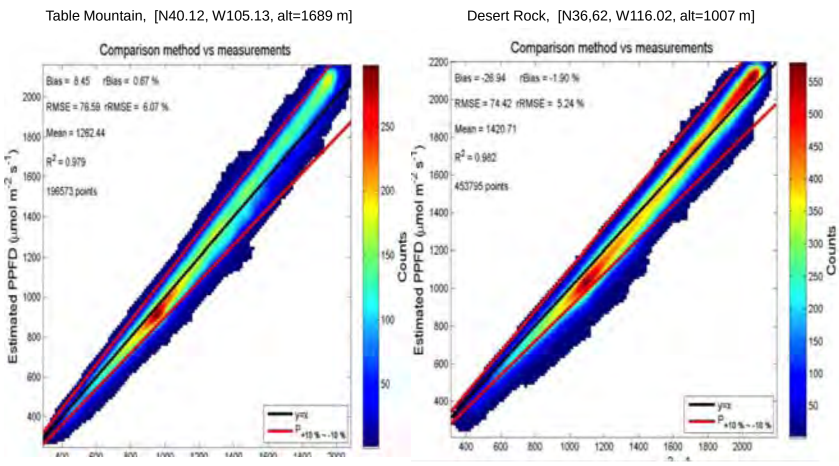


Figure 14. Preliminary performance analysis of the PAR irradiance estimation under-clear sky conditions for two *in-situ* NREL stations (Table Mountain and Desert Rock).

A new system to process data from advanced geostationary satellites to solar resource data has been implemented by the Australian Bureau of Meteorology (the Bureau) with the collaboration of MINES ParisTech for application to the Himawari-8 satellite recently launched by Japan. The system is based on two existing software packages, namely GEOCAT to derive cloud properties (optical depth, phase and height) from the satellite data, and Heliosat-4 to process the cloud information and ancillary data on the clear atmosphere to estimates of surface GHI and DNI.

GEOCAT was developed by US scientists to test cloud algorithms that exploit the improved spectral coverage of the upcoming US advanced satellite GOES-R, but it can be applied to other satellites with similar spectral bands such as Himawari-8, MSG/SEVIRI and MODIS. Heliosat-4 was recently developed by MINES ParisTech to efficiently estimate surface radiation as the product of the McClear clear-sky model and the McCloud cloud factor, and was installed at the Bureau under a collaborative arrangement. The end-to-end GEOCAT plus Heliosat-4 system has been demonstrated on MODIS data. It will be assessed over Australia with Himawari-8 data when it becomes available, using observations from the Bureau's surface network.

Aerosol Properties Needed for Solar Resource Modeling

University of Patras (Greece) and MINES Paris Tech are researching the worldwide-induced uncertainties on cloud-free DNI calculations using Monitoring Atmospheric Composition and Climate (MACC) Aerosol Optical Depth (AOD) re-analysis data. They have identified prominent regional biases in the MACC AOD product at 550 nm and 1240 nm compared to the network of sun photometers operated by the NASA (US) Aerosol Robotic NETwork (AERONET). These conclusions have been extended to the evaluation of the potential error produced by these AOD biases in computed DNI with the clear-sky McClear solar radiation model (Figure 15). The study is funded by the COST Weather Intelligence for Renewable Energy (WIRE, COST ES1002) program. The work has been presented at the 14-th European Meteorological Society Conference (Salamalikis et al., 2014).

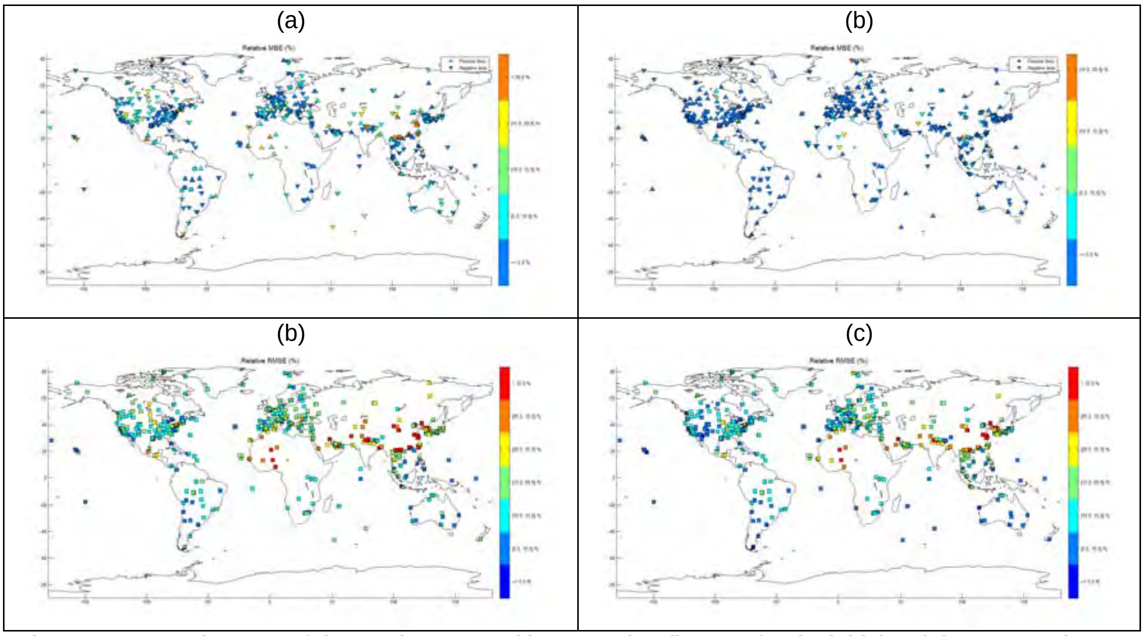


Figure 15. Errors in terms of the McClear DNI. a, b) MBE and c, d) RMSE for the initial and the corrected AODMACC, respectively.

CSIRO (AU) is working on the effect of smoke on solar energy in Australia. Some controlled burns on Black Mountain during clear-sky periods gave CSIRO the opportunity to assess the impact of smoke on DNI and on resulting DNI-based electric production. This impact was been estimated to reduce DNI by up to 29% and to reduce the solar energy production by up to 22% (Figure 16).

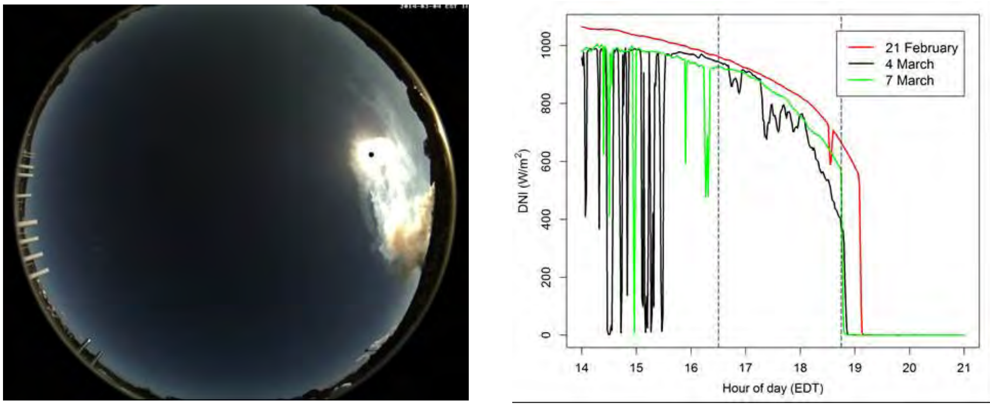


Figure 16. Smoke effect on DNI-based solar energy. Left: fish-eye images with smoke in the vicinity of the Sun. Right: in-situ DNI measurement for clear-sky (i.e. cloud free) condition for three afternoons. The 4 March corresponds to the smoky situation.

DLR is doing research on the aerosol vertical profiles and their impact on concentrated solar tower power plants. Indeed, due to its geometrical design, this technology is presumably more sensitive, compared to other technologies, to the occurrence and distribution of aerosols on the area where the power plant operates. This is because the distance, that the light has to travel from the emitter (each heliostat or mirror) to the central receiver located in the tower, is longer. This study intends to obtain aerosol vertical profiles to provide more information for the currently used tools for radiative transfer calculations that precede energy yield calculations. Currently such profiles are generated by means of LIDAR instruments set in different scenarios, namely, aircraft, satellite, and ground stations. The latter has however shortcomings to deliver reliable values in the proximity of the device because of the so-called incomplete overlap, what implies consequently limitations for the height range of interest. Given the suitability of its nadir-viewing-mounted LIDAR and the advantage of its global coverage, CALIPSO satellite data has been chosen as the source of information. Although other atmospheric constituents like water vapor and clouds contribute to the extinction phenomenon, this study aims to characterize only aerosols. The preliminary results were obtained for North Africa and the Mediterranean region (Figure 17). Maps with a grid of 1°x1° describe annual averaged daytime information to provide: 1) total AOD (assumed from surface to 8.2 km), and 2) the rate of aerosol load that is present in the first 150m compared to the total for each grid cell. Future steps include, extension from regional to global maps, evaluation of sensitivities to determine the influence of the new input in radiative transfer calculations, and comparison of satellite profiles with model. Model data would provide the time flexibility to generate climatologies for site assessment and forecast for real time operational purposes.

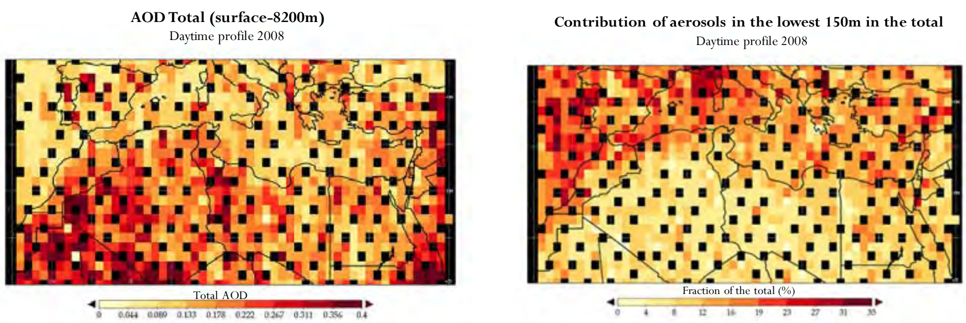


Figure 17. Preliminary results from processed daytime CALIPSO data. Annual averaged information (year 2008). Left: Total AOD (from surface to 8.2 km). Right: Fraction of aerosols located in the lowest 150m for each grid cell.

Solar Angular Modeling (Sky Radiance, Sunshape, Circumsolar Ratio, Diffuse/Direct Modeling)

The research center PIMENT of the University of La Réunion (France) is conducting research on prospects of energy development on concentrated solar systems especially for medium and high temperature heat production. Applications could be for the food industry or electricity production through solar thermal electricity (STE) power plants. These heat generation processes have significant response times relative to DNI variations. Therefore in order to simulate these processes, high frequency DNI data is required. Due to the lack of DNI measured data at this frequency in La Reúnion, PIMENT laboratory, in collaboration with MINES ParisTech, is working on a GHI to DNI decomposition model for high-frequency data. This model was developed from 1-min GHI, DIF (diffuse) and DNI data measured in Saint-Pierre of La Réunion (lat.: 21° S, long. 55° E). This model is based on the analysis of the diffuse fraction (*kd*) probability distribution as function of the clearness index (*kt*) and the solar elevation angle (α_s). Distribution of kd was plotted from ground-based data measurements and for a given *kt* and α_s, the value of *kd* was determined by the highest occurrence probability defined by its distribution. This model was applied only on a few data sets measured in Saint-Pierre and results are encouraging (Figure 18). This model will be applied to other measurement's sites of the territory for validation.

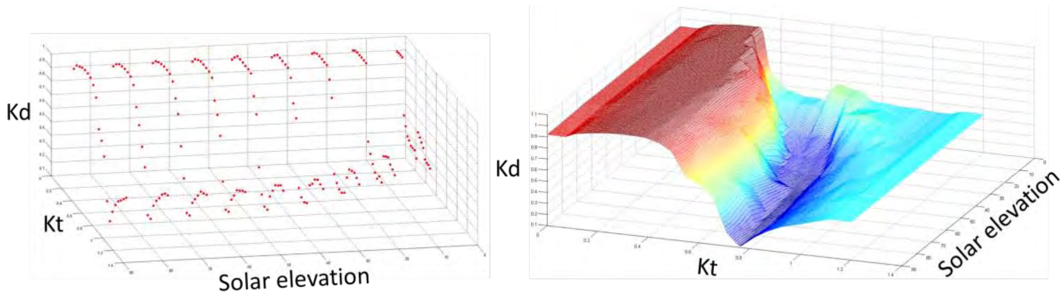


Figure 18. Highest occurrence probability of the diffuse fraction *kd* as function of the clearness index *kt* and solar elevation (left) and fitting surface matching these probability points.

DMI is conducting research on sky radiance and directional irradiance under all-sky conditions. Figure 19 shows 2-min data measured at the DTU climate station plotted as a function of the clearness index k_t and the diffuse fraction, where the clearness index is defined as the global horizontal irradiance at the surface relative to the global horizontal irradiance at the top of the atmosphere, and the diffuse fraction is the ratio between the diffuse horizontal irradiance and the global horizontal irradiance. On top of the measured data calculated synthetic data are plotted. The synthetic data are fitted to the measurements from a basis made up by the cloud optical thickness calculated with a 1-D radiative transfer model and additional (or less) diffuse irradiance coming from inhomogeneous (3-D) clouds. The suggestion of using this basis is a novelty. The point of using this basis is that the cloud optical thickness in the direction of the Sun can be estimated even in cases of inhomogeneous cloud covers. From theoretical calculations, it is well known that the extent and magnitude of circumsolar irradiance vary as a function of this cloud optical thickness. This makes the basis useful for describing the directional distribution of solar irradiances. Additionally the basis can be used to describe the full gamut of measurements in the figure unlike models that estimate the diffuse fraction only as a function of the clearness index and the solar zenith angle.

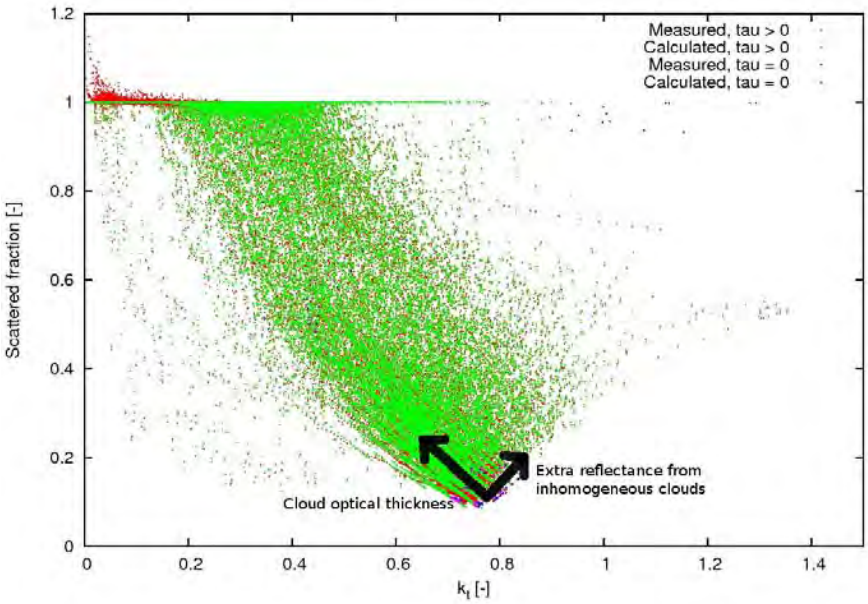


Figure 19. Modeled and measured clearness indexes and diffuse fraction under all-sky conditions, from completely overcast situations to clear-sky conditions, including multi-reflective situations from inhomogeneous clouds.

UJA is collaborating with Solar Consulting Services (US) in a comprehensive study to evaluate the performance of separation models to predict direct irradiance from global irradiance at an intra-hourly frequency over arid regions. A summary of the main conclusions drawn so far was presented at EuroSun 2014 (Gueymard and Ruiz-Arias, 2014). The study includes the evaluation of 36 separation models using multi-year 1-min data from 9 stations over 5 continents. The uncertainty in the predicted DNI appears highly dependent on the local radiation climate, the specific separation model, and the number of predictors used (see Figure 20).

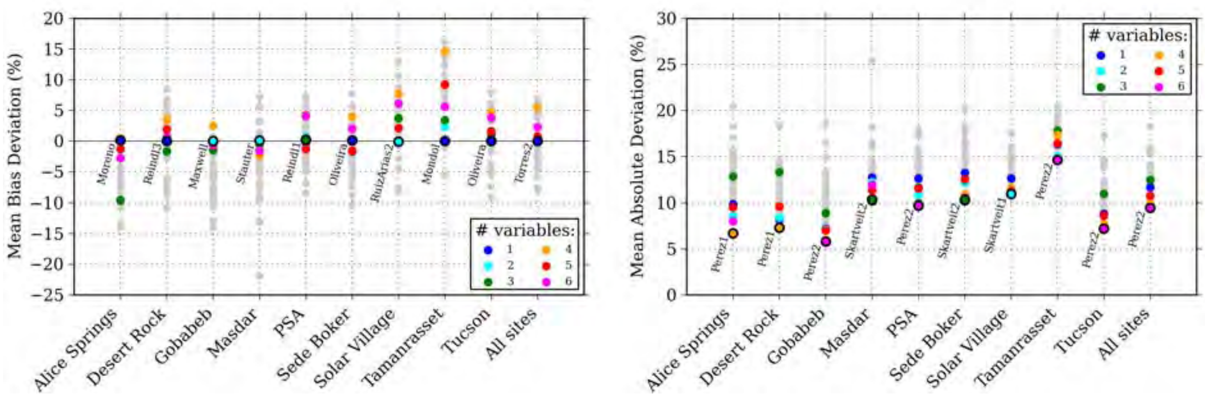


Figure 20. Mean bias deviation (left panel) and mean absolute deviation (right panel) at each radiometric site for various models. In each category, the name of the best model is indicated, along with a color code for the number of variables of the models.

WORK PLANNED FOR 2015

Subtask A: Solar Resource Applications for High Penetration of Solar Technologies

The three current Activities will be consolidated into one subtask. A comprehensive report on short-term resource variability, led by SUNY/Albany, will be published.

Subtask B: Standardization and Integration Procedures for Data Bankability

Activity B1: Measurement Best Practices

In 2015 the uncertainty analysis of Rotating Shadowband Irradiometers will be one of the primary topics. In particular the investigation and definition of the spectral error will be tackled within this uncertainty analysis. The current version of the best practices handbook for solar resource assessment and forecasting will be discussed.

Activity B2: Gap Filling, QC, Flagging and Data Formatting

In 2015 a benchmarking for gap filling will be performed and documented.

Activity B3: Integration of Data Sources

At the beginning of 2015 the first draft report on Integration of ground measurements on model-derived data will be delivered among all the task participants. Additional improvements are expected to the report during the year 2015. In addition to that a specific workshop on this topic will be arranged by the end of the year, in which a review of the contributions will be presented and additional discussions will enrich the document as well.

Activity B4: Data Uncertainties over Various Temporal and Spatial Resolutions

A report on the geographical distribution of uncertainties from satellite-derived solar radiation products will be published and improved further.

Activity B5: Evaluation of Meteorological Products

A best practices document for TMY and P90/P70 calculation will be developed. Furthermore, a proposal and an evaluation of new products for risk analysis are foreseen.

Subtask C: Solar Irradiance Forecasting

Task members involved in irradiance forecasting will continue working on further development of their forecasting algorithms for global horizontal and direct normal irradiance.

A focus of joint work in 2015 will be on the benchmarking studies to compare forecasting algorithms of the different partners and on the definition of a consistent set of forecast metrics. These studies are being done in 4 parts:

1) Benchmarking of irradiance forecasts of global models for worldwide locations
2) Benchmarking study of NWP irradiance forecasts for Central and Northern Europe
3) Benchmarking study of NWP irradiance forecasts for Southern Europe and La Reunion
4) Benchmarking of satellite based irradiance forecasts

For 2) and 4) forecast data have been produced and shared between IEA partners and first evaluations have been performed. The evaluations will be finalized and published in 2015.

For 1) and 3) forecast data will be processed and shared between IEA partners as a basis for first evaluations in 2015.

Subtask D: Advanced Resource Modeling

Activity D1: Improvements to Existing Solar Resource Retrieval Methods

The collaborative work within the activity D1 will focus on three summary reports on our research activities dealing with:

- The solar modeling with the numerical weather model (clear-sky and all-sky);
- The solar modeling combining radiative transfer model and satellite imagery;
- The analysis of the different sources of aerosol retrieval and their performance for solar modeling (notably DNI).

First drafts of these reports are planned before June 2015 and a final version for December 2015.

Activity D2: Long-term Analysis and Forecasting of Solar Resource Trends and Variability
Further work on re-analysis data for the use in measure-correlate-predict models (for adaptation of short to long term averages) of global radiation will be done.

LINKS WITH INDUSTRY

Several small companies involved in solar resource data production and services are directly participating in the Task: Green Power Labs (Canada), Suntrace GmbH (Germany), Black Photon Instruments GmbH (Germany), CSP Services (Germany), Meteotest (Switzerland), Blue Sky Wetteranalyzen (Austria), GeoModel. s.r.o. (Slovakia), IrSOLaV (Spain), Sun to Market Solutions (Spain), Meteotest (Switzerland), Irradiance Corp. (USA), Augustyn and Co. (USA), and Clean Power Research (USA). There is also guest participation by Peak Design (UK), and Solar Consulting Services (USA).

The audience for the results of Task 46 includes the technical laboratories, research institutions, and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, and building and system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, web sites, handbooks and journal articles.

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MEETINGS IN 2014

5th Task Experts Meeting
April 15-16
St. Pierre, La Reúnion Island
This meeting focused on technical progress in each of the four sub-Task areas, as well as developing updates and refinements to the Task 46 work plan.

MEETINGS PLANNED FOR 2015

6th Task Experts Meeting
January 27-28
Plataforma Solar Almería, Spain

7th Task Experts Meeting
Mid-September 2015
Location: Berne, Switzerland

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Task 47
Renovation of Non-Residential Buildings to Sustainable Standards

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TASK DESCRIPTION

The objectives of this Task are:

- Develop a solid knowledge base on how to renovate non-residential buildings towards the NZEB standards (Net-Zero Energy Buildings) in a sustainable and cost efficient way.
- Identify the most important market and policy issues as well as marketing strategies for such renovations.

The Task was originally planned to deal with several types of non-residential buildings, including protected and historic buildings. Due to the available projects from the participating countries, the task has been limited to office buildings and educational buildings.

A broad range of technologies will be included and solar energy will play a significant role in bringing the use of primary energy down to NZEB standard.

Duration
This Task was initiated on January 2011 and was completed on June 2014.

Participating Countries
Australia, Austria, Belgium, Denmark, Germany, Italy, Norway

Task Experts at the Stuttgart meeting April 2014.

TASK ACCOMPLISHMENTS

Key Results
The main accomplishments of this Task are highlighted below. Specific deliverables are available on the SHC Task 47 website.

Subtask A: "Advanced Exemplary Projects - Information Collection & Brief Analysis"
(Subtask Leader: Fritjof Salvesen, Norway)
The objective of Subtask A was to systematically analyze and document renovation projects meeting Task selection criteria in order to quantify which measures achieve the greatest energy savings or improvement in comfort and the corresponding costs.
Twenty exemplary renovation projects from the participating countries show a 50-90% reduction in heat consumption and a 50-70% reduction in overall energy demand. Two buildings have achieved plus-energy standard; the high rise building at the Vienna University and the "Powerhouse" Office Building in Sandvika, Norway. The Norwegian building, in

which the OAs Company is the tenant, shows that it is possible to achieve a plus energy standard combined with the highest possible BREEAM score; "Outstanding".

Findings from these 20 projects:

- For the presented buildings, PV seems to be more interesting for the building owner than solar thermal installations. One obvious reason is that most buildings are offices with limited domestic hot water and heat demand. One exception is a Monastery, which includes a system with 360 m^2 building integrated solar collectors covering 20% of the space and water heating.
- Based on the 20 presented projects, it seems not possible to make a significant relation between energy savings and renovation costs. For many projects with cost information available, costs for energy saving measures lie between 70 and 210 €/m^2. The energy savings in these buildings varies from 45-60%.
- The total renovation cost for the two plus-energy buildings are quite similar, respectively 2600 and 2700 €/m^2. Both buildings include large PV installations.
- Windows are in most cases upgraded to a U-value of 1.0 W/ m^2C or less.
- Many buildings were equipped with demand controlled mechanical ventilation systems with heat recovery; often in combination with controlled natural ventilation systems during summer months.
- Limited mechanical cooling seems to be needed, cooling demand mostly covered by nighttime ventilation.
- Efficient lamps with daylight control and/or movement sensors.
- Multidisciplinary team of experts is necessary in the early stage of planning to achieve a high standard renovation architects, consultants, owner, tenant and contractor. The design method is often described as "Integrated Energy Design – IED" or "Integrated Design Process –IDP" and was first developed in the previous SHC Task 23.
- It is documented that the pupils in one school project showed significant improvement in the concentration test scores, and health and well-being questionnaires, after an upgrade of the ventilation system.

Subtask B: Market and Policy issues and Marketing Strategies
(Subtask Leader: Trond Haavik, Norway)
The objective of Subtask B was to identify barriers and opportunities in the renovation process and to identify segments in the non-residential building stock with high potential for energy efficiency savings.

It was important to develop knowledge about which constraints are the most important and how to address them to make renovations attractive/affordable/cost effective and more available.

The methodologies applied included desktop studies of available building stock information and ownership structures in partner countries, interviews and in-depth descriptions of the decision-making processes used in ten case studies from six of the participating countries, in order to identify barriers and driving forces.

By systematically studying the drivers and barriers, suggestions for how to strengthen the drivers and how to eliminate or reduce the barriers have been developed. In the following two tables, recommendations to the authorities and to the industry are presented. In Table 1 the recommendations to authorities are presented and In Table 2 recommendations to the construction industry are presented.

Table 1. How authorities can contribute to increase the number of nZEB retrofitting projects

AUTHORITIES	Strengthen drivers	Eliminate barriers
Increase attractiveness	• As part of information campaigns use relevant media and conferences to show good examples. • Place particular spotlight on the enthusiasts (both within owner organization and advisors). • Actors receiving grants also see this as confirmation of a good decision and see this strengthening the organization's image.	• Develop convincing arguments for nZEB. • Endorse serious frontrunners. • In some countries it is obligatory that companies have a statement about their impact on the environment. This could be extended by an obligation to state what energy labels their buildings hold. This increases the awareness of the issue of the energy efficiency of buildings.
Increase competitiveness	• Increased tax on energy. • Energy labelling systems provide a neutral reference for comparing buildings on energy performance and thereby increase the focus on this as a competitive advantage.	• Put in place training programs for all relevant crafts to be updated on nZEB upgrading. • Announce stepwise enforcement of building codes.
Make it more affordable	• Stronger subventions programs for owners upgrading towards nZEB (driver in some projects).	• Stronger subventions programs for owners upgrading towards nZEB standard (barrier in other projects).
Make it more available	• Make sure the top management of building owner companies see the benefits of nZEB upgrading and as a consequence they will be more open for such initiatives within their own projects.	• When public bodies upgrade their own buildings, nZEB ambition should be required. In this way both experience and good examples are developed locally. Tender processes must be defined adequately to avoid pure focus on price. A partnering contact for the design phase seems to be a good solution for this. • Facilitate arenas for the industry to meet with researchers and other companies to share experiences.

Table 2. How the industry can contribute to increase the number of nZEB retrofitting projects.

INDUSTRY	Strengthen drivers	Eliminate barriers
Increase attractiveness	• Identify the owner segments which focus on sustainability. • Use relevant media and conferences to show good examples. • Place spotlight on the enthusiasts (both within owner organization and advisors).	• Develop convincing arguments for nZEB.
Increase competitiveness	• Research projects which focus on combining best innovations on component level in order to make more efficient retrofitting processes. • Smart changes of floor plan can improve the area efficiency per employee. Also smart extensions of the existing building, for instance add an extra floor on the top may also improve the economy of the project.	• Better initial audits of the building will reduce the amount of unforeseen challenges. • Systematic training programs to update the skills of all personnel involved in the projects; from planning, construction and hand over/use. • Use of QA tools to assure the quality of a) products/systems, b) competence of the involved actors and c) processes.
Make it more affordable	• Offer of ESCO contracts where the owner pays in accordance with the energy savings obtained.	• Offer of financing as part of the upgrading package.
Make it more available	• Spread the experiences to new regions so new potential clients can see good examples in their neighbourhood. • Make sure the top management of building owner companies see the benefits of nZEB upgrading and as a consequence they will be more open to such initiatives within their own projects.	• As it is a challenge to do deep retrofitting while the tenants stay in the building, use of prefabricated solutions may reduce the level of disturbance as well as the length of the on site retrofitting process.

The points in red text illustrate that they are common with the recommendations to the authorities, meaning that here joint efforts should be undertaken. But also other points work in conjunction with the measures needed to be taken by the authorities.

The owner of the building will always take the final decision regarding ambition level of a project. Learning from Carlson & Wilmot's "The Five Disciplines For Creating What Customers Want", there are five principles that should be in place for a successful nZEB upgrading project:

1. A holistic understanding of the tenant's needs – which normally encompasses more than just energy efficiency.
2. Solutions offering values, which completely fulfill the needs.
3. One or more enthusiastic persons who are committed to the process.
4. A multi-disciplinary team (also involving occupants).
5. The project is supported by the top management and is in line with the company strategy.

Subtask C: Assessment of Technical Solutions and Operational Management
(Subtask Leader: Doreen Kalz, Germany)
The objective of Subtask C was to identify required measuring points for basic monitoring of building and HVAC system and to develop a methodology for evaluating the different building and plant concepts. Successful NZEB concepts should be described building and plant performance should be evaluated.

The individual technical database for the demonstration projects and their energy concepts has been finalized. The database includes performance numbers for monitored buildings as well as technical descriptions. The performance of eight buildings is analyzed in terms of energy consumption and thermal comfort achieved in summer and winter using long-term monitoring data in high time resolution. In particular, a comparison is made between the energy and comfort performance before and after the retrofit. It can be seen, that the buildings studied achieved the ambitious target values set during the design stage of the building.

In detail, a cross-comparison of thermal comfort achieved in summer was carried out. The different cooling concepts applied to the particular building projects were studied. Results on thermal comfort achieved in retrofitted buildings are compared to those in new buildings. The analysis is based on monitoring data in high time resolution. Besides, the daylighting quality and daylighting conditions were analyzed. Success factors and shortcomings were identified. At least one demonstration building per participating country was studied. The situation after the retrofit is compared to the one before retrofit.

Further, a comprehensive cross-comparison of electrical and thermal heat pump systems in retrofit projects was carried out in terms of energy use, efficiency, and operation performance. Results are compared to heat pump systems in new buildings. Again, the analysis is based on monitoring data in high time resolution.

Subtask D: Environmental and Health Impact Assessment
(Subtask Leader: Sophie Trachte, Belgium)
The objective of Subtask D was to develop a global approach for building renovation based on environmental, urban infrastructure, comfort and health impacts for school buildings.
Subtask D addresses sustainable refurbishment of school buildings, especially in terms of comfort and quality of life improvement.

At a time when major climate change and aspiration for sustainable economic and social development have become major issues, the objective of this guide is to consider school retrofitting from a holistic point of view by developing guidelines, not just in terms of energy performances, but also in terms of comfort, quality of life, environmental impact and resource consumption.

Across Europe and worldwide, infant, primary and secondary schools are essential tools in the construction of tomorrow's society and transmission of democratic values. Schools are, primarily, places for opening up to the world, to the acquisition of knowledge and places for socialization: three indispensable foundations for becoming a citizen of tomorrow's world, capable of good governance.

This is a fundamental role in our societies. In order to fulfill this role, schools must provide places for training and teaching that are comfortable and of high quality. This is currently not the situation in Europe. Most school buildings are old, dilapidated and poorly insulated. Heating systems too are old and often cannot be regulated. Ventilation systems, if any, are inefficient. Outdoor spaces and playgrounds are often restricted and of poor quality.
This lack of comfort has negative and scientifically proven consequences on pupils' concentration and learning. This is why school buildings have an urgent need of fundamental refurbishment.

Moreover, sustainable and cost-efficient refurbishment of school buildings provides a real opportunity for making pupils, teachers and parents aware of energy efficiency as well as comfort and the quality of indoor and outdoor environments. School buildings, their technical equipment and operation can be used as a showcase for the pupils and their families, and once experienced, can influence their behavior in a more responsible and public-spirited direction.

The outcome of the subtask D works is a booklet providing designers with information and resources needed to retrofit school buildings in a responsible and efficient way.
The entire booklet is richly illustrated with both explanatory diagrams, photographs and innovative concepts of exemplary projects (subtask A). Some links with BREEAM Assessment methodology have also been made at the end of each section. The large majority of photos are from visits made in Belgian schools, already partially or totally renovated or having the goal of being renovated.
The main difficulty encountered in drafting this handbook lies in the authors' decision to make the guide applicable to all of Europe, from the northern countries to southern Italy. Generally, the authors have taken into account the characteristics of middle European countries: Germany, Austria, Belgium and details are given for the northern countries when necessary.

It is important to realize that there is no standard way of achieving sustainable school renovation, but priority must be given to energy efficiency and comfort of teaching/learning.

Publications

Publications and other Task documents can be downloaded from: http://task47.iea-shc.org

Report No.	Report Title	Publication Date	Access (PUblic, REstricted)	Web or Print
1	Task 47 Glossary and terms	06.11.12	RE	in subt.A rep
	Exemplary Renovation project brochures			
2	Norwegian Tax Authority, Oslo	02.07.12	PU	Web

3	School Renovation Cesena, Italy	02.07.12	PU	Web
4	Kindergarten in Høje Taastrup, Denmark	19.10.12	PU	Web
5	Norwegian Energy Authority, protected building	19.10.12	PU	Web
6	School in Schwanenstadt (Upper Austria)	10.02.13	PU	Web
7	The Osram Culture Centre, Denmark	10.02.13	PU	Web
8	Kampen school building, Oslo, protected building	12.03.13	PU	Web
9	Printing workshop and office building; Germany	14.08.13	PU	Web
10	Plus Energy Office Building – Kjørbo, Norway	14.08.13	PU	Web
11	Office and workshop building, Fraunhofer ISE; Germany	14.08.13	PU	Web
12	Schüco Italian Headquarter, Padova, Italy	25.11.13	PU	Web
13	Boligselskapet Sjaelland Office Building, Denmark	25.11.13	PU	Web
14	Solbråveien Office Building, Norway	01.02.14	PU	Web
15	Rockwool Office Building, Denmark	01.02.14	PU	Web
16	Vienna University of Technology – plus energy; Austria	25.02.14	PU	Web
17	Riva Bella School, Belgium	25.02.14	PU	Web
18	Amthaus Bruck, Austria	25.02.14	PU	Web
19	Kaiserstraße7, Vienna	18.03.14	PU	Web
20	Franciscan Monastery, Graz, protected building, Austria	29.09.14	PU	Web
	Other publications			
21	Task 47 Highlights 2012	12.02.13	PU	Web
22	Task 47 Highlights 2013	03.03.14	PU	Web
	Final technical reports			
23	Sustainable Refurbishment School Buildings – A Guide for Designers and Planners (331 pages)	Jan.2015	PU	Web
24	Lessons learned from 20 Non-Residential Building Renovations (52 pages)	05.02.2015	PU	Web
25	Market change: Upgrading of the Non-Residential Building Stock towards Sustainable standard. Recommendations to authorities and construction industry (59 pages) Annexes to the report (120 pages)	31.12.2014 31.12.2014	PU PU	Web Web
26	Assessment of Technical Solution and Operational Management for Retrofit of Non-Residential Buildings *(to be published by spring 2015)*	Spring 2015	PU	Web

Journal Articles and Conference Papers/Presentations
Journal articles (in many languages) or contributions to relevant external investigations/ studies/reports in which Task participants played leading roles.

Journal	Author/Title	Publication Date	Access (PUblic, REstricted)	Web or Print
	"Innovation meets tradition – Pioneering technologies for renovating historic buildings sustainably"		Austrian Brochure, PU	Print
	Box Type Window	IRECON, Nov. 2013		

Workshops and Conferences
The following are workshops and conferences Task participants contributed to with results of their work achieved within the framework of the Task or with results of the Task work.

Workshop/Conference	Place	Date.
SHC 2012 (Solar Heating and Cooling Conference)	San Francisco, USA	July 2012
SHC 2013 (Solar Heating and Cooling Conference)	Freiburg; Germany	September 2013
SHC 2014 (Solar Heating and Cooling Conference)	Beijing, China	October 2014
Eurosun 2014	Aix-les-Bains, France	September 2014
Passive House Norden	Gothenburg, Sweden	October 2013
Belgium Work of the IEA	Brussels, Belgium	January 2013
How to Reach a NZEB-Building	Vienna, Austria	March 2013
SGB13 (Sustainable Green Buildings)	Vienna, Austria	September 2013
Seminar for Norwegian industry representatives	Oslo, Norway	April 2013
Energy Forum	Brixen, Italy	November 2013
Seminar ENEA; EBC; SHC	Rome, Italy	June 2013

MEETINGS IN 2014

7th Experts Meeting
April 1-2
Stuttgart, Germany

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Task 48
Quality Assurance and Support Measures for Solar Cooling

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TASK DESCRIPTION

A tremendous increase in the market for air-conditioning can be observed worldwide, especially in developing countries. The results of the past IEA SHC Tasks and work on solar cooling (the most recent Task 38: Solar Air-Conditioning and Refrigeration) on the one hand showed the great potential of this technology for building air-conditioning, particularly in sunny regions. On the other hand, they showed that further work is necessary to achieve economically competitive systems and to provide solid long-term energy performance and reliability.

This Task is working to find solutions to make solar thermally driven heating and cooling systems at the same time efficient, reliable and cost competitive. These three major targets should be reached by focusing the work on four levels of activity:

1) Development of tools and procedure to make the characterization of the main components of SAC systems.
2) Creation of a practical and unified procedure, adapted to specific best technical configurations.
3) Development of three quality requirements targets.
4) Production of tools to promote Solar Thermally Driven Cooling and Heating systems.

The scope of the Task is the technologies for production of cold water or conditioned air by means of solar heat, that is, the subject that is covered by the Task starts with the solar radiation reaching the collector and ends with the chilled water and/or conditioned air transferred to the application. However, the distribution system, the building and the interaction of both with the technical equipment are not the main topic of the Task, but this interaction will be considered where necessary.

The Task is divided into 4 subtasks (including the detailed activities corresponding for each as noted below).

Subtask A: Quality Procedure on Component Level
A1: Chiller characterization
A2: Life cycle analysis at component level
A3: Heat rejection
A4: Pumps efficiency and adaptability
A5: Conventional solar collection
A6: State of the art on new collector & characterization

Subtask B: Quality Procedure on System Level
B1: System/Subsystem characterization & field performance assessment
B2: Good practice for DEC design and installation
B3: Life cycle analysis at system level
B4: Simplified design tool used as a reference calculation tool: design facilitator
B5: Self detection on monitoring procedure
B6: Quantitative quality and cost competitiveness criteria for systems

Subtask C: Market Support Measures
C1: Review of relevant international standards rating and incentive schemes
C2: Methodology for performance assessment, rating and benchmarking
C3: Selection and standardization of best practice solutions
C4: Measurement and verification procedures
C5: Labeling possibilities investigation
C6: Collaboration with Task 45 for contracting models

C7: Certification process definition for small systems

Subtask D: Dissemination and Policy Advice
D1: Web site
D2: Best Practices brochure
D3: Simplified short brochure
D4: Guidelines for roadmaps on solar cooling
D5: Updated specific training seminars adapted to the quality procedure
D6: Outreach report

Main Deliverables
The main deliverables include:

- Report on best practices on solar collection components for quality, reliability and cost effectiveness.
- Quality procedure document/check lists guidelines for solar cooling.
- Self-detection on monitoring procedure report.
- Soft tool package for the fast pre-design assessment of successful projects.
- Report and database of existing international standards, rating and incentive systems relevant to solar cooling.
- Report on the rating, measurement and verification of solar cooling performance and quality.
- Report on the selected standard engineering systems.
- Report on alternative uses of the developed standards and rating framework.
- Technical report on the results of the Life Cycle Assessment of Solar Cooling systems and LCA tool.
- Website dedicated to the Task.
- Training material for installers and planners and training seminars feedback report.
- Semi-annual e-newsletter for the industry.
- Industry workshops in national languages in participating countries addressing target groups (related to Experts meetings).
- Best practices brochure.
- Simplified short brochure (jointly edited by the Subtask Leader (Greenchiller) and IEA SHC Programme.
- Guidelines for Roadmaps on Solar Cooling and possibly general international roadmap on solar cooling (optional).

Duration
The Task started in October 2011 and will be completed in March 2015.

Participating Countries
Australia, Austria, Canada, China, France, Germany, Italy and the United States

WORK DURING 2014

Since Task 48 started the end of 2011, three final deliverables are finished (C4 activity: *measurement and verification procedure report,* C1 activity: *review of relevant international standards rating and incentive schemes* and C6 activity*: contracting models report*), but a lot of activities are progressing and 18 milestone reports have been completed (10 in November 2012, 8 in May 2013, 9 in October 2013 and 3 in April 2014).

Main activities in 2014 were the consolidation of the adapted Work Plan with aggregations of activities (no cancellations, but combined activities in working groups):

- A2/B3: Life Cycle analysis on component/system

- C1/C6: Review relevant international standards rating & incentive schemes/ Collaboration with T45 for contracting models
- B7/C2: Quantitative quality and cost competitiveness criteria for systems/ Methodology for performance assessment, rating and benchmarking
- B1/C7/C4: System/Subsystem characterization & field performance assessment/ Certification process definition for small systems/Measurement and verification procedures
- B5/C3: Quality procedure document/check lists/Selection and standardization of best practice solutions

Task Training Seminars and Workshops

AIRAH's first Solar Cooling Workshop
March 27, 2014 - Brisbane, Australia

AIRAH's first Solar Cooling Workshop generated an audible buzz of excitement among its 80 attendees, all eager to join the discussion around one of the HVAC&R industry's most exciting fields.

"The energy in the conference room was just brilliant," says AIRAH CEO Phil Wilkinson, M.AIRAH. "There was leading-edge content from the speakers, a good mix of attendees from different sectors, and some great questions from the audience. And the student 'lightning round' was fantastic – it proved that the future of solar cooling is in very capable hands."

Held at the CSIRO EcoSciences precinct in Brisbane on March 27, the Solar Cooling Workshop honed in on the ever-increasing interest in the field of solar cooling. The one-day event explored new ideas, technology and innovations.

During the Workshop, a broad catalogue of speakers shared their knowledge, ideas and experience. With so many of the field's leading national and international experts stepping up to the lectern, the workshop delivered a full day of invaluable information to delegates.

Covering everything from the international perspective on solar cooling to local innovators and their projects, the Workshop's array of topics had attendees grabbing every opportunity to debate and discuss new ideas and information.

Conference Presentations and Articles

EUROSUN Conference
September 16-19, 2014 – Aix les Bains (France)

Task 48 was significantly represented during the EUROSUN conference in France. Two specific technical sessions were dedicated to solar air-conditioning and more than 70% of the presentations were given by Task 48 experts.
The Task 48 poster had good exposure as well during the conference in the poster area.

SHC 2014 Conference

October 13-15, 2014 – Beijing, China. The Task 48 OA presented a special keynote and there were two sessions on solar cooling.

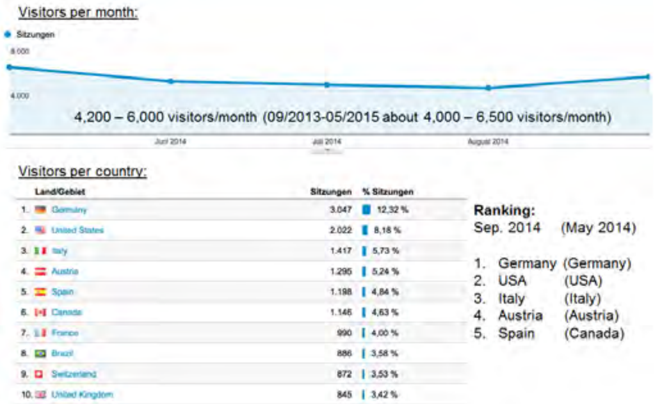
Article for the WILEY Interdisciplinary Review Energy & Environment

The manuscript entitled "Status of Solar Cooling in the World: Markets and Available Products" was accepted by Wiley for publication in Wiley's *Interdisciplinary Reviews: Energy and Environment.*

This article is about the current work of Task 48 and was written jointly by Uli Jakob, Subtask D leader, and Daniel Mugnier, Operating Agent.

Status of the Task 48 Website

The number of visitors according to the IEA SHC website statistics is nearly constant at 5,000 visitors per month, showing that this website is among one of the most visited among SHC.



	Land/Gebiet	Sitzungen	% Sitzungen
1.	Germany	3.047	12,32 %
2.	United States	2.022	8,18 %
3.	Italy	1.417	5,73 %
4.	Austria	1.295	5,24 %
5.	Spain	1.198	4,84 %
6.	Canada	1.146	4,63 %
7.	France	990	4,00 %
8.	Brazil	886	3,58 %
9.	Switzerland	872	3,53 %
10.	United Kingdom	845	3,42 %

Contribution from Task 48 experts to the REN21 Global Status Report 2014

Several Task 48 experts contributed to the solar thermal cooling market analysis. The REN21 report was published in June 2014.

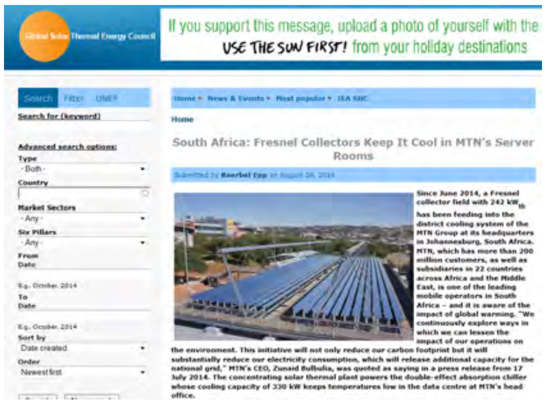
The still-modest global solar cooling market grew at an average annual rate exceeding 40% between 2004 and 2012, and approximately 1,050 systems of all technology types and sizes were installed by 2013.[50] While most of these systems were in Europe (81%), use of solar cooling is rising in many regions with sunny dry climates, including Australia, India, Mediterranean islands, and the Middle East.[51] The availability of small (<20 kW) cooling kits for residential use has increased interest in the residential sector in Central Europe and elsewhere, and large-scale systems are gaining appeal due to their more favourable economics.[52] One of the market drivers for solar cooling is the

Contribution to Solar Heat Worldwide, 2014 Edition

Several Task 48 experts contributed to the solar thermal cooling market analysis.
The Solar Heat Worldwide report was published in June 2014.

Webzine Articles Related to Solar Cooling in Solarthermalworld.org

Two special articles focused on new solar cooling plants written by 2 active Task 48 participants, SOLID and Industrial Solar, are online in www.solarthermalworld.org. These articles deal with a 3.4 MWth solar cooling system in Arizona and a 330 kW double effect absorption cooling system in South Africa for a server room company. Information on these two new systems has been disseminated among the scientific community of Task 48.



Press Releases

Several press releases were prepared by the SHC Information Center.

WORK PLANNED FOR 2015

According to the Work Plan, the following deliverables should be available by the middle of 2015:

Subtask A: Quality Procedure on Component Level

MA1-4: Final report on characterization

Subtask B: Quality Procedure on System Level
M-B1.2: Delivery Report on system/subsystem characterization & field performance assessment
MB6-1: Template for self-detection on monitoring procedure

Subtask C: Market Support Measures
MC2-2: Delivery report: Methodology for performance assessment, rating and benchmarking
M-C4.2: Delivery report on labeling possibilities

Subtask D: Dissemination and Policy Advice
M-D5.4: Report on updated training seminars

REPORTS PUBLISHED IN 2014

Eleven draft reports were completed, which are only available internally at this time. Three final reports/tools were published and posted on the Task 48 webpage.

Subtask A: Quality Procedure on Component Level
MA1-2: Draft report on characterization
MA3-1: Final report on heat rejection
MA4-1: Final report on pumping systems (final version for beginning of 2015)
MA6-3: Updated version of the database

Subtask B: Quality Procedure on System Level
M-B2.2: Second status on good practice for DEC design and installation
M-B3.2: Delivery of LCA Tool report (final version for beginning of 2015)
M-B4.2: Delivery of the draft Design tool

Subtask C: Market Support Measures
MC3-2: Draft of Selection and standardization of best practice solutions
M-C6.2: Final report on contracting models
M-C7.1: Template report structure on certification process definition for small systems

Subtask D: Dissemination and Policy Advice
M-D2.1: Template for best practice installations
M-D3.1: Template for quality procedure methodology
M-D4.2: Template for Roadmap methodology
M-D5.4: Report on updated training seminars

LINKS WITH INDUSTRY

Industry representatives participating in Task Experts Meeting as observers include: CoolGaia Pty Ltd (Australia), SOLID (Austria), TECSOL (France) and Thermosol (Canada).

They represent primarily engineering companies and solar cooling system manufacturers. The results of Task 48 are profitable for their business and their involvement consists of supporting and analyzing the work of Task 48.

MEETINGS IN 2014

6th Experts Meeting
May 12-13 2014
Kingston, Canada

Organized by Queen's University - attached side event was the 11th IEA HPC Heat Pump Conference in Montreal on May 11-16. Twenty-four experts from eight countries (Germany, Austria, Australia, Italy, Canada, USA, France, China) attended the meeting. Ten experts were physically present in Kingston and 14 attended through videoconference.

7th Experts Meeting
September 29-30
Garching, Germany

Organized by ZAE Bayern, with a technical visit of the ZAE Bayern lab facility. Twenty-eight experts from seven countries (Germany, Austria, Australia, Italy, USA, France, China) attended the meeting. Twenty-two experts were physically present in Garching and six were attended through videoconference.

MEETINGS PLANNED FOR 2015

8th Experts Meeting (Final Meeting)
March 23-24
Shanghai, China

A joint Solar Cooling week is planned in conjunction with IEA SHC Task 53. The objective of this solar cooling week is to promote research and applications of solar cooling technologies. This activity includes three parts: Solar Heating and Cooling Task 48 and Task 53 expert meetings (open only to invited experts), and Chinese Solar Cooling Conference 2015 (SCC2015, open to public). The specific objective of SCC 2015 is to situate solar cooling technologies in the context of the environmental pressure developed by growing economies still lacking technologies that fit their economic and cultural needs.

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Task 49
Solar Process Heat for Production and Advanced Applications

Christoph Brunner
AEE INTEC
Operating Agent for The Republic of Austria

TASK DESCRIPTION

The Task is focused on solar thermal technologies for converting solar radiation into heat and is working to further the intelligent integration of the produced heat into industrial processes (that is starting with the solar radiation reaching the collector and ending with the hot air, water or steam being integrated into the application). The Task scope includes aall industrial processes that are thermal driven and running in a temperature range up to 400°C.

Task 49 is structured around three subtasks with the following main activities.

Subtask A: Process Heat Collectors
(Lead Country: Switzerland)
In this Subtask, the further development, improvement and testing of collectors, collector components and collector loop components is being investigated. All types of solar thermal collectors with an operating temperature level up to 400°C will be addressed: uncovered collectors, flat-plate collectors, improved flat-plate collectors (for example, hermetically sealed collectors with inert gas fillings or vacuum) with and without reflectors, evacuated tubular collectors with and without reflectors, CPC collectors, parabolic trough collectors, Fresnel collectors, air collectors, etc.

In addition, an overview of collector output and key figures will be compiled to identify and select the most suitable collector technology for specific boundary conditions. It is assumed that for all activities of this Subtask the temperature range will need to be separated in several segments. For instance up to around 200°C, water and steam can be used as heat carriers with acceptable pressure. But higher temperatures combined with another heat carrier (e.g., oil) the boundary conditions change substantially. A simple up scaling of the results from the investigations and recommendations for the temperature range up to 200°C or 250°C will not be possible. This is true both for the investigations aiming at improvements of the solar loop as well as for recommendations with regards to test rigs, testing procedures and standardization.

Based on existing approaches, methods and parameters for the assessment of the collector and collector loop performance as well as of the impact of the properties of materials and components will be developed and identified. Appropriate durability tests will be applied to specific materials/components to allow for a deeper understanding of the collector and collector loop behavior for a wide range of operation conditions and the prediction of service lifetime. Based on the investigation of the dynamic behavior of solar process heat collectors and loops (both experimentally and theoretically), recommendations for process heat collector testing procedures will be worked out.

Subtask A has three main objectives:

- Improve solar process heat collectors and collector loop components.
- Provide a basis for the comparison of collectors with respect to technical and economical conditions.
- Give comprehensive recommendations for standardized testing procedures.

A Special effort will be made to involve the solar industry in the analysis of all working fields through industry-dedicated workshops.

Subtask B: Process Integration and Process Intensification Combined with Solar Process Heat
(Lead Country: Austria)
The general methodology for the integration of solar thermal energy into industrial processes was developed during SHC Task 33. It was shown that the pinch analysis for the total

production site (with building upon it) and the design of an optimized heat exchanger network for the production system is one of the best approaches for smart integration. Due to the fact that in the identified industry sectors with high potential for solar integration production processes very often run in batches, the developed pinch methodology is only be a rough estimation of the real profile of heat sources/sinks.

Beside the system optimization by the pinch analysis, a technology optimization of the applied process technologies will also reduce the energy demand and increase the potential for solar thermal integration. Process intensification (PI) can be seen as a key word for emerging technologies that achieve the framework conditions for effective, solar (thermal and/or UV) driven production processes.

Subtask B has two main objectives:

- Improve solar thermal system integration for production processes by advanced heat integration and storage management, advanced methodology for decision on integration place and integration types
- Increase the solar process heat potential by combining process intensification and solar thermal systems and fostering new applications for solar (thermal/UV) technologies

Subtask C: Design Guidelines, Case Studies and Dissemination
(Lead Country: Germany)
The main objective of this Subtask is to provide information and planning methodologies to solar manufacturers, process engineers, installers and potential buyers (industry). This shall support the marketing, planning and installation phase of future SHIP plants. Experience and results from pilot projects covering a broad variety of technologies in suitable applications representing a significant part of industrial process heat consumers (in terms of size, temperature levels, heat transfer media, load patterns, etc.) shall be evaluated. The operation of projects will be monitored for a representative period to provide feedback on the design and operation concept as a basis for future development and improvements. "Best practice" reference cases shall encourage other potential users to employ these technologies. Tools for a simplified performance assessment and conceptual planning shall be developed. Regional market surveys, case studies and financing schemes will be investigated which should facilitate the market introduction of solar process heat.

The objectives of Subtask C are to:

- Provide a worldwide overview of results and experiences of solar heat for industrial process systems. This includes the evaluation of completed and ongoing demonstration system installations using monitoring data, as well as carrying out economic analyses.
- Develop a performance assessment methodology for a comparison and analysis of different applications, collector systems, regional and climatic conditions.
- Support future project stakeholders by providing design guidelines and simplified, fast and easy to handle calculation tools for solar yields and performance assessment.
- Investigate system solutions for stagnations behavior, control and hydraulics of large field installations.
- Identify, address and lower the barriers for market deployment by providing examples of successful implementations, by describing suitable financing and incentive schemes, and developing relevant project constellations.
- Disseminate the knowledge to the main target groups involved—solar manufacturers, energy consultants, process engineers, installers and potential buyers (industry), and policy makers and platforms.

Duration
This Task was initiated February 2012 and will end January 2016.

This is a collaborative Task with the IEA SolarPACES Implementing Agreement. It is managed on the “maximum level” according to the SHC Guidelines for Collaboration with other Programs.

Participating Countries
Australia, Austria, Belgium, China, Denmark, Egypt, France, Germany, India, Israel, Japan, Italy, Mexico, Netherlands, New Zealand, Poland, Portugal, Singapore, Spain, South Africa, Sweden, Switzerland, Tunisia, United Kingdom, United States

WORK DURING 2014

Comprehensive Report on Stagnation and Overheating

Solar process heat plants have to operate totally reliable in all the operation modes that may occur. Other than for conventional closed hot water or steam supply systems solar thermal applications in general require specific technical solutions to cope with the phenomenon of stagnation. As explained in detail in this document, stagnation describes the state of a solar thermal system in which the flow in the collector loop is interrupted and solar radiation is further absorbed by the solar thermal collector and thus heating the fluid in the solar thermal collector up to a temperature where the absorbed energy equals the losses. Compared to conventional heat supply technologies this means that in case of technical defects, power blackout or simply due to a lack of heat demand (i.e., temporarily no available heat sink) some solar thermal collector fields (depending on the type pf collector that is being applied) cannot be simply shut down but are further heated up. Without appropriate measures for overheating prevention and / or stagnation handling those solar thermal systems would overheat. Depending on the solar thermal collector concept, different effects have to be avoided for regular operation conditions:

- The loss of heat transfer medium that has to be released to the atmosphere because of too high system pressures.
- Too high temperatures that lead to damage of the solar thermal collector or parts of the collector loop.

A challenge of solar thermal process heat installations is to handle stagnation or overheating situations without any danger of failure and without the need for additional maintenance works. This is not only true for solar thermal collectors, but for the whole installation.

For small to medium scale residential solar thermal applications, measures to control stagnation can be regarded as state of the art. Usually, pressure release through the safety valve can be avoided by larger expansion vessels and, if additionally needed, simple heat dissipaters in the solar loop.

The same concepts may work for larger scale solar thermal applications as well, but particularly when it comes to industrial applications designed for higher supply temperatures and hence equipped with more efficient solar thermal collectors other strategies, such as additional active cooling devices for overheating prevention or de-focusing (in case of tracked collectors) might be favored in order to guarantee a long-term, reliable and low-maintenance operation.

This report gives an overview about topics related to stagnation and overheating in general and specifically with regard to solar assisted process heat applications. The report focusses on the following main topics:

- Definition of terms
- Introduction to stagnation and overheating of collectors and collector fields
- Overheating prevention and control measures for solar process heat applications:
    - Measures for solar process heat applications with non-concentrating collectors

- o Special challenges for concentrating and tracked collectors
- Good-practice examples of implemented measures
- References to related literature

Integration Guidelines
When integrating solar heat into industrial or commercial processes, the aim is to identify the most technically and economically suitable integration point and the most suitable integration concept. Due to the complexity of heat supply and distribution in industry, where a large number of processes might require thermal energy, this task is usually not trivial. The document "Integration Guidelines" provides guidance for planners of solar thermal process heat systems (SHIP), energy consultants and process engineers. It describes a general procedure for the integration of solar heat into industrial processes, including the necessary steps to identify suitable integration points for SHIP and integration concepts. Based on these concepts, SHIP system concepts are given. The document can be used as supporting material in solar process heat trainings of planners, energy managers and consultants, or as additional help for energy experts besides their own practical experiences. *The scope of this document does not include a description of detailed planning steps of the solar thermal system itself.*

Integrating solar heat is possible at several points in the heat supply and distribution network of an industrial production site (see Figure 1). Chapter 2 gives an overview on heat supply and distribution in industry starting with a short description of conventional heating equipment and distribution media. On the process level, basically the existing heat transfer concepts (e.g., type of heat exchanger and control strategies) are decisive on how solar heat can be integrated into the processes. Therefore, the basic existing heat transfer concepts in industry are explained. It is shown that the variety of different thermal processes re-occurring in industry can be classified based on the unit operation concept, specifying suitable integration concepts and solar process heat system concepts (introduced and explained in later chapters) per unit operation. This has been and will further be realized in the online wiki-web database "Matrix of Indicators" (available online), which is an information portal (among others) for solar thermal integration.

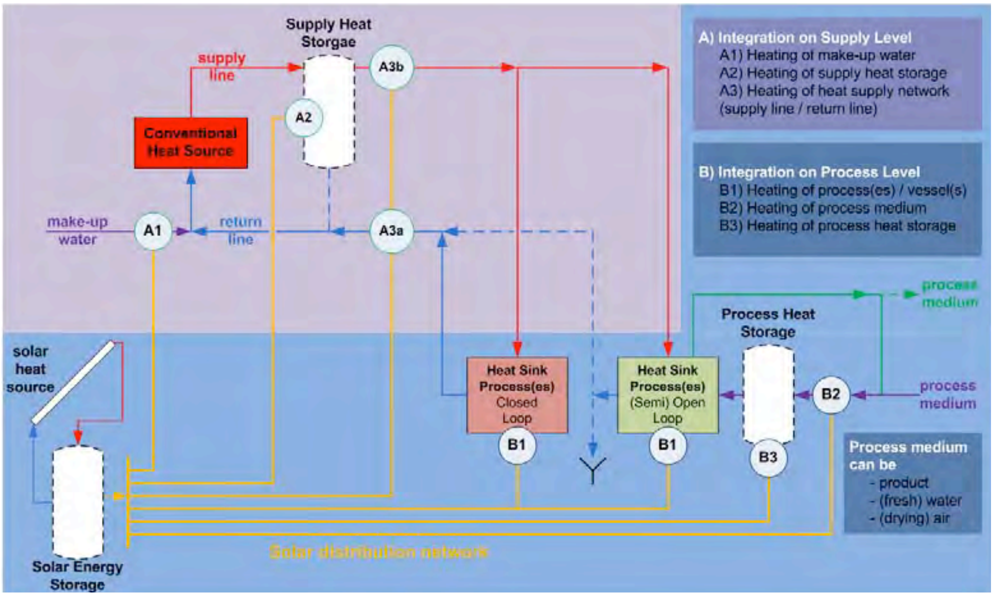

Figure Error! No text of specified style in document.. **Possible integration points for solar process heat (AEE INTEC, 2012)**

After summarizing some basics on heat supply and distribution networks in Chapter **Error! Reference source not found.**, Chapter **Error! Reference source not found.** introduces the "Assessment methodology for solar thermal integration". This methodology builds upon existing strategies (e.g., IEA SHC Task 33) and summarizes the most important steps for planning a solar process heating system. These steps include a pre-feasibility study (steps 1-2), company visit (step 3), analysis of status quo (step 4), energy efficiency considerations (step 5), and identification of integration points (step 6). And for planning a SHIP system, the analysis of the chosen suitable integration points (step 7), where possible solar integration concepts (for one or several integration points) are economically and energetically compared based on technical and economic considerations. At this point, a basic design of the solar thermal system(s) is necessary in order to evaluate an optimum cost/benefit - ratio, including the definition of an appropriate collector field size, the storage volume and the kind of solar thermal collectors used. After the decision (step 8) is taken based on this comparative analysis, the detailed planning begins (step 9).

Chapter **Error! Reference source not found.** is dedicated to energy efficiency considerations in industry and shows how process integration can be used as a basis for identifying possible integration points (see Chapter **Error! Reference source not found.**) for solar thermal systems.

In Chapter **Error! Reference source not found.** concepts for SHIP integration are explained and classified into supply and process level. On supply level the classification is based on the existing heat transfer medium, whereas on process level the basis for classification is the heat transfer technology (type of heat exchanger etc.). The integration concepts show how solar heat can be integrated to the industrial supply network or process(es).

Chapter **Error! Reference source not found.** builds upon these concepts further showing how they can be extended to complete solar process heat system concepts. Hydraulic schemes with details on collector field and loop, buffer storage as well as on the overall control strategy (e.g., charging and discharging strategies) are given. A selection matrix shows how suitable SHIP system concepts and integration concepts are interlinked.

Chapter **Error! Reference source not found.** discusses how suitable integration points can be identified and prioritized. This Chapter builds upon data acquired in the analysis of status quo and/or in the efficiency considerations (see Chapter **Error! Reference source not found.**) and on the possible solar integration concepts taken into account, as their specifications may influence the suitability of one integration point over another.

Methodologies and Software Tools for Integrating Solar Heat into Industrial Processes
Within this work a comprehensive overview of existing tools for Process Integration has been developed. The Process Integration framework (and Pinch Analysis in particular) appears to be best suited for "simultaneously" addressing these two challenging issues in a systematic way and making sure that the solar process heat does not prevent other cost effective improvements (e.g., heat recovery, efficient energy conversion technologies, new process technologies) from being implemented. So far, the benefits and savings potential brought about by Pinch Analysis are often underestimated, especially in SMEs. Indeed, its efficiency and benefits go far beyond the usual trend of gaining a green image by "merely" adding a solar plant or resorting to good housekeeping and best practice actions only.

Framework conditions, technical constraints and degrees of freedom related to the solar plant make solar plant design a complex problem. In addition, the supply of solar heat must comply with essential rules of Pinch Analysis: solar heat must be supplied above the heat recovery pinch (i.e. at a temperature higher than the pinch temperature) and the solar heat rate up to a given temperature should not exceed the net heat deficit as defined by the grand composite curve (provided the process heat recovery is possible and cheaper than solar heat). The combination and/or competition of solar heat with other cost effective improvements increases the number of potentially attractive alternative solutions to be analyzed and compared. Pinch Analysis allows the scoping and screening of the most promising alternative solutions. However, the methodologies are primarily established for continuous processes in grassroots situations (i.e., new plant design), while the integration of solar heat requires time variability of heat flows and heat storage to be tackled, and essentially concerns retrofit projects (i.e., integration in an existing infrastructure). Although methodologies for batch processes and retrofit problems exist, few software tools (e.g., EINSTEIN, PinCH, SOCO, and OBI) provide the engineer with practical features for these issues and help with the heat storage placement and design. Despite attempts of these tools (especially PinCH and SOCO) further progress is needed, most notably in the following areas:

1. Consideration of retrofit constraints in the determination of the possible alternatives and the placement of solar heat,
2. Methodology developments for the supply level integration and total site integration of solar heat, and implementation of methodology into software tools,
3. Analysis and design of variable heat flows and heat storage, and
4. Computerization of assessment and comparison of alternative solutions to speed up and simplify their screening.

Survey and Dedicated Workshop on New Process Technologies
A workshop dedicated on new process technologies was held on June 25th in Austria within the framework of the Gleisdorf Solar Conference. The working party of Process Intensification and the IEA Task 49/IV organized a common workshop to exchange views on the effect of intensified processes on industrial energy supply.

One output of the workshop was that energy supply will change by the impact of new developments (PI) to the processing industries. These effects will be visible on three levels: on the unit operation level, the plant level and regionally via new general processing approaches. While there will be a shift from thermal processes to (at least partly) electrically driven processes on unit operation level, heat supply will remain an important aspect and there will be a trend to lower processing temperatures brought about by continuous processing and new catalysts, enzymes or alternative chemical reaction pathways. On plant level, plant intensification should lead to integrated production sites in which thermal energy is (re-used) at its best and energy conversion losses are minimized. It will be an on-going challenge to realise production sites in which intensification is achieved in such way that process efficiencies are at maximum while the overall plant energy requirement reaches a minimum. The major impact besides a changing energy requirement of unit operations and on plant level, is however the general approach in processing, whether bulk processing will remain the way to go or whether we will see a trend towards distributed small scale processing. This would enable more flexibility and faster reactions to energy supply variations.

Based on these thoughts a sustainable energy supply scenario on the basis of intensified technologies could look as follows: With electricity from various renewable sources forming the main regional energy carrier, flexible consumers with continuous, modulating processes will be most profitable. Heat will be produced locally based on the requirement with heat storages playing a crucial role in bridging the gaps between energy supply and demand. The change from electricity to heat and vice versa will also be crucial to enable flexible energy production for flexible processing. The choice which renewable energy form will supply electricity and heat is basically politically driven by local funding possibilities. But research has to offer different possibilities and an evaluation of these as a basis for these decisions. For solar process heat specifically a few trends can be indicated:

- Flexible small scale processing can increase the solar yield for heating industrial processes, when the process regulation can follow the availability of solar heat. Additionally, there is a huge potential to access the available heat in summer, and if necessary, store it for the winter with new storage concepts.

- Most new energy conversion technologies require a drying step for which solar drying technologies would contribute to the increase of efficiency of the overall conversion process. (This competes with vapour recompression systems, however this heat might be used for other processes at higher temperature levels.)
- The further implementation of advanced heat recovery systems (covering a large share of low temperature heat demand in industry) will increase the demand for solar process heat in the higher temperature range, thus proving the importance for research in collector technology for a temperature range of 100-250°C.
- The shift to electrically driven processes however will eliminate current waste heat streams and could so maybe increase the potential of solar thermal. Studies on the holistic picture of plant intensification and energy supply will be important to realise sustainable processing sites in the future.

The real impact of process intensification on the industrial energy requirement cannot be estimated from today's perspective as it is not sure yet how the technologies will perform on the market and to which extent they will be competitive to current industrial practices. Retrofit costs will hinder implementation of new technology in the industrial countries, while it is hoped that developing countries will adopt new technologies faster. The dissemination of good examples as well as training of experts is, however, vital to prove the potential of new processing concepts.

WORK PLANNED FOR 2015

Key activities planned for 2015 include:

- Definition of general requirements and relevant parameters for process heat collectors (and specific collector loop components) and their improvement
- Brochure on State of the Art of process heat collectors
- Recommendations for different kind of test procedures, reports and test rig configurations
- Extended matrix of indicators (http://wiki.zero-emissions.at)
- Report on potential for enhancement of solar integration with new process technologies (based on (existing) case studies)
- Publication of Design guidelines for solar industrial process heat systems
- Overview and description of simulation tools for solar industrial process heat components
- Report on Performance assessment methodology and simulation case studies

REPORTS PUBLISHED IN 2014

- Integration Guideline (Methodology for Advanced Integration, System Concepts, Guidelines on Integration Types, Checklists, etc.)
- Overheating prevention and stagnation handling in solar process heat applications
- Catalogue of additional required components for advanced integration

REPORTS PLANNED FOR 2015

- Definition of general requirements and relevant parameters for process heat collectors (and specific collector loop components) and their improvement

- Brochure on State of the Art of process heat collectors
- Recommendations for different kind of test procedures, reports and test rig configurations
- Report on potential for enhancement of solar integration with new process technologies (based on (existing) case studies)
- Design guidelines for solar industrial process heat systems
- Overview and description of simulation tools for solar industrial process heat components
- Report on Performance assessment methodology and simulation case studies

MEETINGS in 2014

5th Experts Meeting
January 23-24
Stellenbosch, South Africa

6th Experts Meeting
September 25-26
Mailand, Italy

MEETINGS PLANNED FOR 2015

7th Experts Meeting
March 12-13
San Sebastian, Spain

8th Expert Meeting
September 16.-17.
Montpellier, France

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Task 50
Advanced Lighting Solutions for Retrofitting Buildings

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TASK DESCRIPTION

The scope of the Task is on general lighting systems for indoor environments. The focus is placed on lighting appliances in non-domestic buildings. Technically, the Task deals with:

- daylight harvesting (i.e., replacement of electric light by better façade or roof lighting concepts),
- electric lighting schemes, and
- lighting control systems and strategies (daylight and occupancy dependent controls).

The overall objective of Task 50 is to accelerate retrofitting of daylighting and electric lighting solutions in the non-domestic sector using cost-effective, best practice approaches, which can be used on a wide range of typical existing buildings. The Task targets building owners & investors, governments & authorities, designers & consultants, and industry by providing strategic, technical and economic information and with this helping these stakeholders overcome barriers in retrofitting of lighting installations.

The work in the Task is structured into four Subtasks and a Joint Working Group that is responsible for pulling together the results of all Subtasks' results.

Subtask A: Market and Policies

(Lead Country: Denmark)

This Subtask identifies the various possible approaches of retrofitting daylighting systems and lighting installations in buildings. It proposes to provide key figures concerning costs (Total Cost of Ownership) and identify barriers and opportunities concerning lighting retrofit actions. Beyond costs, barriers could be related to inertia of stakeholders, poor habits or lack of knowledge. Opportunities may go beyond reduction of costs, reduction of energy requirements and may relate to added benefits for investors, building owners, building managers and occupants.

Subtask A has four main objectives:

- To understand, and model, the financial and energy impact associated to retrofitting daylighting and electric lighting of buildings.
- To map the context of building-retrofit, identifying barriers and opportunities, even if they are not directly related to lighting issues.
- To provide a critical analysis of documents used for energy regulation and certification and to make proposals for adjustments.
- To identify possible lack of awareness and know-how in the value chain and to identify strategic information to deliver to stakeholders.

Subtask B: Daylighting and Electric Lighting Solutions

(Lead country: Germany)

This Subtask deals with the quality assessment of existing and new solutions in the field of façade and daylighting technology, electric lighting and lighting controls. For replacement solutions, the Subtask will identify and structure existing and develop new lighting system technologies.

The objectives of Subtask B are:

- To provide a set of criteria to describe lighting technologies appropriate for the retrofit process.
- To provide figures as baseline to classify and rate existing, built-in lighting installations against new retrofit concepts.
- To generate a profound state of the art overview on technology and architectural

measures.
- To generate an overview on emerging new technologies and develop selected new techniques.
- To generate required technical data of selected state of the art and emerging new technologies.
- To publish a source book.

Subtask C: Methods and Tools
(Lead country: Switzerland)

Whether an intended retrofit is technically, from an energy point of view, ecologically and economically meaningful is at the moment not self-evident for the majority of stakeholders and building designers. This Subtask focuses on simple computer design tools and analysis methods in order to improve the understanding of retrofit processes. This incorporates energy and visual comfort analysis as well as the financial aspects of lighting retrofit solutions. Also encompassed are advanced and future calculation methods aiming toward the optimization of lighting solutions, as well as energy auditing and inspection procedures, including lighting and energy performance assessments.

The objectives of Subtask C are:
- To understand the workflows, wishes and needs with respect to tools of the stakeholders by conducting and evaluating a survey.
- To establish a list of tools and methods to assist practitioners and compare their outputs with the criteria and metrics identified in Subtasks B and D.
- To benchmark the appropriateness of tools on case studies/test cases.
- To develop a simple tool (calculation engine) for a holistic approach of potential benefits of lighting retrofit solutions to be among others to be included in the retrofit adviser.
- To investigate energy audit procedures.
- To establish a review of advanced simulations tools for promoting complex fenestration systems and electric lighting (such as LED).
- To list the feature of new simulation tools for different case studies and compare them to the existing tools, and ultimately give a feed-back to the tool developers. To advance tool development for special questions like façade design.

Subtask D: Case Studies
(Lead country: Sweden)

Case studies are essential to communicate lighting retrofit concepts to decision makers and designers. Therefore, the main aim of Subtask D is to demonstrate sound lighting retrofit solutions in a selection of representative, typical case studies.

The selection of case studies is based on a general building stock analysis, including the distribution of building typology in relation to lighting retrofit potential. These case studies will deliver proven and robust evidence of achievable savings and show integrated retrofit strategies. Measurements and assessments will include monitoring of energy savings, lighting quality and operational costs. In addition, Subtask D also provides updated information from an analysis of previously documented case studies in the literature and on websites.

The objectives of Subtask D are:
- To define the building types and categories included in this Task.
- To identify the already existing databases of case studies.
- To update key information regarding energy saving strategies and solutions

demonstrated in the past by research, monitoring or demonstration projects.
- To define an applicable standard assessment and monitoring procedure for all case studies to be investigated.
- To provide a robust analysis of the performed case and derive generalized conclusions.
- To produce a very well documented, e-book of case studies linked with the Lighting Retrofit Advisor.

Joint Working Group: Lighting Retrofit Adviser
(Lead Country: Germany)

All Subtasks will provide major parts of their results as input to this joint activity. Based on these results, the Joint Working Group will develop an electronic interactive sourcebook (Lighting Retrofit Adviser). A central database will include all task results and will allow the users to obtain extensive information, according to their individual focus of interest: design inspirations, design advice, decision tools and design tools. Thus, the user will be able to increase quickly and reliably his knowledge in the respective field of interest. Users will have the choice of analyzing retrofit (design) scenarios themself and/or using the pool of experience gained in the case studies projects (electronic version of case study book) to access information on energy saving potentials and economic approaches.

The objectives of the Joint Working Group are:
- To define a software architecture and design complying with needs of the stakeholders.
- To incorporate results of subtasks A-D.
- To ensure meeting the demands of the target groups.
- To generate a working software tool.
- To ensure a high quality of the tool and generate country specific versions.

Duration
The Task started in January 2013 and will end in December 2015.

Participating Countries
Austria, Belgium, Brazil, China, Denmark, Finland, Germany, Italy, Japan, Norway, Slovakia, Sweden, Switzerland

WORK DURING 2014

Baseline to Harmonize the Subtasks´ Work and Results
The definition of a general baseline to be used for all example calculations and comparisons is a crucial issue for the overall harmonization of the Subtasks' work and results. Respective activities of the Subtasks are for instance: Life cycle cost analysis (ST A), reference case (ST B), tool validation/comparison (ST C) and (energy) calculations with the case studies (ST D). Drafts of baseline documents for the following topics were generated: building types and usage zones, usage profiles, boundary conditions (internal and external), daylighting, electric lighting, costs, financial model and normative framework.

Analysis of Market and Policies
Within the project, four main building categories were chosen: offices, schools, stores and industrial buildings. For these categories typical old lighting situations were identified and compared with new solutions suitable for retrofit. The systematic approach was extended to daylight aspects. Figure 1 shows an overview of systems regarding daylighting and controls.

Development of the Criteria Catalogue

The collection of criteria to describe the retrofit strategies was further developed. Daylighting and electric lighting solutions were assessed by several criteria from the following aspects: energy efficiency, lighting quality, thermal aspects, running and initial costs. Based on these aspects a comparison of different retrofit strategies is possible. Figure 2 shows the structure of the criteria catalogue, which enables comparable performance description and thus evaluation and comparison.

Figure 1. Table illustrating an overview of systems regarding daylighting and controls.

Continued Development of Technology Sheet/Fiche and Collection of Input for Different Technologies

The system and design of the technology fiches was further developed. The fiches are organized in several sections (Figure 3). One gives a description of the retrofit strategy and characterizes the applicability and the performance of the technology. By summarizing the technology description another section gives an overview of the advantages and disadvantages of the different technologies visualized with colored marks.

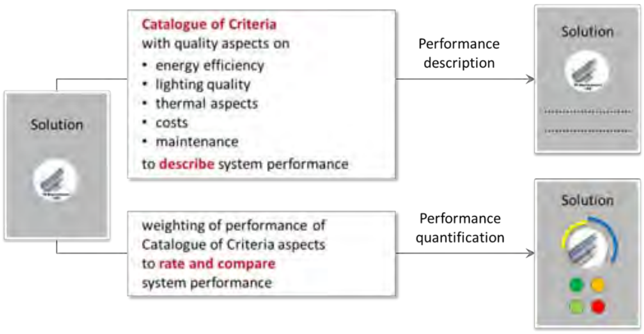

Figure 2. Graphic scheme depicting the structure of the catalogue of criteria, which enables comparable performance description and thus evaluation and comparison.

Figure 3. Example of the technology fiche "skylight."

Evaluation of Questionnaire Results

The online questionnaire to analyze the workflow and needs was evaluated. 1075 answers from all over the world showed several key results. Retrofitting strategies used at the moment mostly deal with artificial lighting solutions, daylight solutions were only rarely applied. The mayor factors influencing the choice of retrofit supporting software are user friendliness, time efficiency and cost. Furthermore in most cases professionals rely on themselves handling design and decision process. Nevertheless if outsiders are involved it is the electric lighting industry.

Lighting Simulation Tools: State of the Art Review

In order to get an overview on the existing tools dealing with daylight and artificial light simulation information on several tools was collected. Among them were for example EPIQR+, Dialux and Relux Pro. A matrix summarizing the features of the tools in order to facilitate their comparison was developed. The different tools were applied as a case study to a classroom in Switzerland that was recently refurbished. With the different tools the daylight factor and the illuminances under only electric lighting were calculated.

Revision of the Monitoring Protocol

For the evaluation of the overall performance of lighting and/or daylighting retrofit projects a monitoring protocol was developed. With the protocol four key aspects are covered: energy efficiency, costs, light environment and users´ satisfaction. For the single aspects the required measurements and the necessary equipment are presented. To make sure that the lighting analysis can be done by non-expert assessors the procedure is well described including five main phases: Initial survey visit, decision phase, preparatory phase, monitoring program and analysis phase.

Description and Evaluation of Case Studies Using the Monitoring Protocol
The monitoring protocol was first tested and in parts adapted in the retrofitting of an office building in Stockholm. Two floors were compared: one already retrofitted and one in the former stage. The results showed that the employees are quite neutral in both floors, though they report a quite positive general appreciation of the lighting (Question "How well can you see in this light?"). The energy use for lighting was just slightly reduced. As a reason for the small reduction in energy use can be mentioned that the lighting control system did not work as expected. For example the light fixtures over the working spaces were on despite sufficient daylight. Currently the monitoring of more than 20 other case studies is on the way.

Structure and Content of the Lighting Retrofit Advisor
The development of the LRA (Lighting Retrofit Advisor) was continued. To achieve a broad applicability a platform independent approach was chosen for the software framework. Regarding the design issues icons and other graphical elements were discussed. To get a positive recognition it was considered as important to have similar designs for all task products. Therefore the design of the LRA should fit to other dissemination activities like website and brochure.

Figure 4. Tablet-view of home screen draft: Different access options are possible.

The navigation scheme will be organized in several levels. The home screen offers both, stakeholder oriented (guided) access as well as direct access to the components. Within the LRA several information components from all Subtasks are planned, e.g. Benchmarking, Technology Viewer, Case Study Viewer, Collection of tools and methods. Furthermore components like "FAQs" (frequently asked questions), technology viewer and the calculation part are currently being worked on.

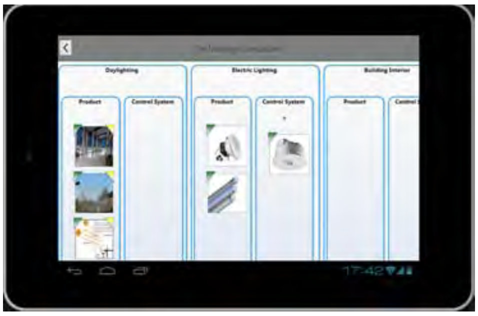

Figure 5. Tablet view of Technology Viewer draft: Structured overview of retrofit solu-tions.

WORK PLANNED FOR 2015

Key activities planned for 2015 include:

- Report "Lighting retrofit marked. Including policy issues and proposal of action"
- Source book available on a website
- Web based Survey toolbox "Set of (simple) energetic and economic rating and calculation methods and tools"
- Electronic case study book "Applied (Advanced) lighting retrofits – released projects and case studies"
- Beta "Lighting retrofit Adviser" Software
- Release "Lighting retrofit Adviser" Software

LINKS WITH INDUSTRY

Industry Workshops

Two Industry Workshops were held with active participation from (mostly) local industry, the first-one on March 10, 2014 at Bartenbach GmbH in Aldrans, Austria, and the second on September 29, 2014 Kyushu University, School of Medicine in Fukuoka, Japan.

The following institutions presented insights and experiences regarding the issue of lighting retrofit:

- ALANOD GmbH & Co. KG, Germany
- Siteco Beleuchtungstechnik GmbH, Germany
- HELLA Sonnen- und Wetterschutztechnik GmbH, Austria
- Zumtobel Lighting GmbH, Austria
- Beckhoff Automation GmbH, Austria
- ESTIA, Switzerland
- Kyudenko Corporation, Japan
- Tsuzuki and Chikushi, architects, Japan

In addition, the workshops were joined by representatives from:

- Kurz Design, Germany
- Future Electronics, Austria
- Bartenbach GmbH, Austria
- Sky Planning Corporation, Japan
- Panasonic Corporation, Japan
- Mitsubishi Electric Living Environment Systems Corporation, Japan

Industry Involvement
Philips Lighting is involved and actively participating in the Task's work as a Level II Partner. A representative from 'Philips Research' is joining the experts' meetings.

REPORTS/DOCUMENTS PUBLISHED IN 2014

- Monitoring protocol for lighting and daylighting retrofits, Draft technical Report.
- Lessons learned from monitoring lighting and daylighting in retrofit projects, Working Document.
- Lighting retrofits: a literature review, Working Document.
- Evaluation of a questionnaire on lighting retrofits in practice. Working Document.

REPORTS/DOCUMENTS PLANNED FOR 2015

- Report, *Lighting retrofit market. Including policy issues and proposal of action.*
- Source Book, *Subtask B Daylighting and Electric Lighting System Solutions*.
- Web-based Survey Toolbox *Set of (simple) energetic and economic rating and calculation methods and tools.*
- Electronic Case Study book, *Applied (Advanced) lighting retrofits - realized projects and case studies.*
- Software, *Lighting Retrofit Adviser*
- Final Report

MEETINGS IN 2014

3rd Expert Meeting
March 10 - 12
Aldrans/Innsbruck, Austria

4th Expert Meeting
September 29 - October 1
Fukuoka, Japan

MEETINGS PLANNED FOR 2015

5th Expert Meeting
March 16 - 18
Ålesund/Hurtigruten, Norway

6th Expert Meeting
September 28 - 30
Brasilia, Brazil

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Task 51
Solar Energy in Urban Planning

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TASK DESCRIPTION

The main objective is to provide support to urban planners, authorities and architects to achieve urban areas, and eventually whole cities, with architecturally integrated solar energy solutions (active and passive), highly contributing to cities with a large fraction of renewable energy supply. This includes the objective to develop processes, methods and tools capable of assisting cities in developing a long-term urban energy strategy. Heritage and aesthetic issues will be taken into account. Also, the goal is to prepare for and strengthen education at universities on solar energy in urban planning by testing and developing teaching material for programs in architecture, architectural engineering and/or urban planning. The material will also be useful for post-graduate courses and continuing professional development (CPD).

To achieve these objectives, work is needed in four main topics:

1. Legal framework, barriers and opportunities for solar energy implementation
2. Development of processes, methods and tools
3. Case studies and action research (implementation issues, test methods/ tools/processes, test concepts for example NZEB, NZEC)
4. Education and dissemination

Task 51 will require a dialogue and cooperation with municipalities in each participating country. This ensures good communication with different key actors, gives the possibility to develop and test methods and tools, to document good examples of how to work (methods and processes) with solar energy in urban planning, and to show inspiring examples of urban planning with solar energy integration. The municipalities are also a target group in the dissemination phase.

The main objectives of the Task are subdivided into four key areas and involve:

Subtask A: Legal Framework, Barriers and Opportunities
(Lead Country: Australia)

- Investigate current legal and voluntary frameworks, barriers and urban planning needs of specific relevance to solar energy implementation.
- Review existing targets and assess the practical potential of solar energy in urban environments to support urban planning design and approval processes.
- Recommend areas in need of attention to improve the uptake of solar energy in urban planning.

Subtask B: Processes, Methods and Tools
(Lead Country: Sweden)

- Identify factors among existing processes and supportive instruments (knowledge/methods/ tools) that enable decision processes for solar energy integration in urban planning, and to elucidate development needs.
- Develop new and/or improve urban planning processes in order to facilitate passive and active solar strategies in urban structures, both in new and existing urban area developments as well as in sensitive/protected landscapes.
- Develop new and/or improve supportive

Solar potential study in Malmö, Sweden (Jouri Kanters)

instruments (knowledge/methods/tools) and show how guidelines along with existing and new supportive instruments regarding active and passive solar energy can be incorporated and at what stage in the planning process.

Subtask C: Case Studies and Action Research
(Lead Country: Norway)

The main objective is to facilitate replication of successful practice. Complementing objectives are to:

- Coordinate a database of best practice case studies and stories across Subtask topics.
- Establish and manage action research in each participating country.
- Facilitate and document the development and testing of supportive instruments and process models in at least one city in each participating country, in cooperation with local decision makers.

Subtask D: Education and Dissemination
(Lead Country: Germany)

- Strengthen the knowledge and competence in solar energy and urban planning of relevant stakeholders such as universities and professionals.
- Develop and make available education material based on e.g. results from the Task. Give information on where to find relevant courses.
- Provide for dissemination and education by developing an e-learning platform, integrating methods, tools and case studies.

Scope
The scope of the Task includes solar energy issues related to:

1. New urban area development
2. Existing urban area development
3. Sensitive/protected landscapes (solar fields)

In all three environments listed above, both solar thermal and photovoltaics will be taken into account within the Task. In addition, passive solar will be considered in the urban environment (1 and 2). Passive solar includes passive solar heating, daylight access and outdoor thermal comfort.

Solar field: Production of solar electricity (PV) and lemongrass essential oil in Reunion Island (Akuo Energy)

In order to achieve a substantial contribution to increased use of solar energy, Task 51 focuses on how to improve and accelerate the integration of solar energy in urban planning that respects the quality of the urban context. The main work will be on active solar strategies due to a great need of development in this area, related to urban planning. The Task will not cover the whole complex context of urban planning.

Subtasks A to C reflect different stages in the urban planning process. Subtask A sets the current boundary conditions for solar integration, deals with the assessment of available potential and elucidates opportunities. Subtask B deals with processes, methods and tools and developments for the applied phase related to specific situations (new development areas, existing urban areas, landscapes). Subtask C focuses on implementation issues; tests of processes, methods and tools, tests of concepts (e.g. NZEB/NZEC) through case stories and showing good examples as case studies. Finally, Subtask D covers the dissemination focused on tertiary education and continuing professional development (CPD).

Main Deliverables

Subtask A: Legal Framework, Barriers and Opportunities

D.A1. Review on existing urban planning legislations and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B) in participating countries.
D.A2. Report on the barriers, challenges and needs of urban planning for solar energy implementation.
D.A3. Report on current solar energy targets and assessment of solar energy potential in urban areas from participating countries.

Subtask B: Processes, Methods and Tools

D.B1. Review on existing urban planning legislations and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B) in participating countries.
D.B2. Improved and/or new supportive instruments (knowledge/methods/tools).
D.B3. Guidelines: Presentation of developed generic process models with recommendations and guidelines on how to use them when adjusting for local planning, based on lessons learnt from Subtask C, as well as recommendations of needs for improved or new supportive instruments (knowledge/methods/ tools).

Subtask C: Case Studies and Action Research

D.C1. Database of best practices.
D.C2. Documentation of activities supporting the creation and management of action research in each participating country: exhibitions, public hearings, quality programmes, jury work, presentations to decision makers, interviews, legislation work, creation of incentives etc.
D.C3. Documentation reports of testing of supportive instruments in partner cities: preparation, implementation and assessment of results (link to Subtask B).

Subtask D: Education and Dissemination

D.D1. Report on the state-of-the-art in education regarding urban planning with solar energy, for countries participating in the Subtask.
D.D2. Make available and inform about teaching material/packages for tertiary education and for CPD.
D.D3. Carry out seminars, workshops, summer schools and symposia, which support the knowledge exchange.
D.D4. A web-based learning platform.
D.D5. Website on innovative solar products.
D.D6. Best practice guidelines for urban planning with solar energy based on, and referring to, developed processes, methods, tools, strategies and case studies/stories – presented in an “umbrella document” with links to Task results and deliverables (joint with all Subtasks).

Task Duration

This Task started on May 1, 2013 and will end April 30, 2017.

Participating Countries

Australia, Austria, Canada, China, Denmark, France, Germany, Italy, Norway, Sweden and Switzerland.

Luxembourg is also participating, while waiting to become a formal member of the IEA SHC Programme. See the list of the participants at the end. Updates on participation and results from the Task are available on the website http://task51.iea-shc.org/.

WORK DURING 2014

The work has been focused on the first planned deliverables. We are reviewing existing urban planning legislation and voluntary initiatives (Subtask A) and urban planning processes (Subtask B) in participating countries. Barriers, challenges and needs have been studied. Development needs regarding methods and tools have been identified to see what we need to focus on in our next developments. Subtask C is collecting potential case studies and identifying key parameters to study and compare between cases. All member countries are reporting on different types of case studies. In Subtask D the work has mainly been centered on the state-of-the-art report on education regarding urban planning with solar energy. Also, the web-based learning platform was tested by students and is in progress, so far in German language. A general structure of the planned guideline (umbrella document) has been developed. A public symposium was held at Ryerson University in Toronto, Canada, in conjunction to the last Task meeting in 2014.

WORK PLANNED FOR 2015

Key activities planned for 2015 include:

- Finalize a review on existing urban planning legislation and voluntary initiatives (Subtask A) and on existing urban planning processes (Subtask B), in participating countries.
- Test supportive instruments (knowledge/methods/tools) (Subtask B linked to Subtask C).
- Develop generic process models in case stories (Subtask B linked to Subtask C).
- Create final templates for case studies and evaluation (Subtask C).
- Identify additional key cases (Subtask C).
- Continue to develop the database for cases (Subtask C).
- Finalize the state-of-the-art in education regarding urban planning with solar energy, for participating countries (Subtask D).
- Continue to develop and test the web-based learning platform. In late 2015, a translation into English is planned (Subtask D).
- Continue to develop the structure of the guideline (umbrella document) (Subtask D with support from all Subtasks).
- Carry out workshops; one workshop with students will be arranged in Trondheim, Norway during the Task 51 meeting in March 2015.
- A public symposium will be arranged in conjunction with the meeting in Trondheim (March 2015).

TASK REPORTS/RESULTS PUBLISHED IN 2014

No main reports were published in 2014.

OTHER PUBLICATIONS AND PRESENTATIONS IN 2014 (examples)

- Kanters, J., & Wall, M. (2014). The impact of urban design decisions on net zero energy solar buildings in Sweden. *Urban, Planning and Transport Research, 312-332. doi: 10.1080/21650020.2014.939297*
- *Website: Kanters, J., & Wall, M. (2014). Solar planning. Guidelines for urban planners., from http://www.solarplanning.org/*

- Paparella,R. & E. Saretta, E. (2014). Photovoltaics in Italian historical city centers: do PV products and building codes have a meeting point? *Proceedings of World Sustainable Buildings Conference*, Barcelona 2014
- Scognamiglio, A & Garde, F. (2014) Photovoltaics' architectural and landscape design options for Net Zero Energy Buildings, towards Net Zero Energy Communities: spatial features and outdoor thermal comfort related considerations. *The 29th European Photovoltaic Solar Energy Conference---EUPVSEC* (Amsterdam, 22---27 September 2014). The paper has also been accepted for publication by the journal *Progress in Photovoltaics*.
- Scognamiglio, A., Garde, F., Ratsimba, T., Monnier, A. & E. Scotto, E. (2014). Photovoltaic greenhouses: a feasible solution for islands? Design, operation, monitoring and lessons learned from a real case study. *The 6th World Conference on Photovoltaic Energy Conversion* (WCPEC---6), Kyoto, 23---27 September 2014.
- Scognamiglio, A. (2014). How the use of solar energy shapes our living environment: forms that buildings and landscape take. Design and Assessment issues. Keynote speech at *The Solar Heating and Cooling Conference SHC 2014* (Beijing, 13---15 October 2014).
- Good, C. S., Lobaccaro, G. & Hårklau, S. (2014). Optimization of solar energy potential for buildings in urban areas – a Norwegian case study. *Renewable Energy Research Conference* (RERC) 2014. Centre for Renewable Energy (SFFE); Oslo. 2014-06-16 - 2014-06-18.

SEMINARS AND WORKSHOPS IN 2014 (examples)

- Symposium: Solar *Energy in the Urban Context: Planning, Design and Implementation* – an all day symposium held on Monday, September 29th, 2014, at The Department of Architectural Science, Ryerson University for students, faculty members and professionals. Coordinator: Miljana Horvat.

MEETINGS IN 2014

3rd Experts Meeting
March 25 - 28
Naples, Italy
(Including workshop and bilateral
Meetings with industry)

4th Experts Meeting
September 25 - 29
Toronto, Canada
(including public symposium)

MEETINGS PLANNED FOR 2015

5th Experts Meeting
March 17 - 20
Trondheim, Norway
(Including student workshop and
public symposium)

6th Experts Meeting
Week of September 28 - October 2
Reunion Island, France

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Task 52
Solar Heat and Energy Economics in Urban Environments

Sebastian Herkel
Fraunhofer ISE
Operating Agent for BMWi

TASK DESCRIPTION

The Task focuses on the analysis of the future role of solar thermal in energy supply systems in urban environments. Based on an energy economic analysis - reflecting future changes in the whole energy system - strategies and technical solutions as well as associated chains for energy system analysis will be developed. Good examples of integration of solar thermal systems in urban energy systems will be assessed and documented.

Subtask A: Energy Scenarios
(Lead Country: Denmark)
The content of Subtask A is about:

- Using energy system analyses and GIS based data for creating scenarios highlighting the use of solar thermal in future energy systems in different types of energy systems
- Identifying balances between heat or cooling savings and supply systems with relation to solar thermal
- Identifying balances between building level solar thermal and solar thermal in local district heating networks
- Identifying the role of solar thermal in integrated renewable energy systems (smart energy systems) and in particular the interrelation with combined heat and power (CPH) and heat pump production.

Subtask B: Methodologies, Tools and Case studies for Urban Energy concepts
(Lead Country: Switzerland)
The content of Subtask B is about:

- Development of methodologies with focus on performance indicators
- Energy planning tools and toolboxes (from Urban planning to neighborhoods)
- Case studies analysis of different regions

Subtask C: Technology and Demonstrators
(Lead Country: Austria)
The content of Subtask C is about:

- Classification of relevant (renewable-based) technologies and demonstrators in urban environments
- Screening of best practice examples
- Analysis and documentation of selected best practice examples
  - Technological and economic analysis
  - Analysis of bottleneck's and success factors, lessons learned
  - Analysis of monitoring data (subject to data availability)
- Further development of (existing) business opportunities with regard to future energy supply systems

Task Duration
This Task started on January 1, 2014 and will end December 31, 2017.

Participating Countries
Austria, Denmark, Germany, Portugal, Switzerland

WORK DURING 2014

Subtask A: Energy Scenarios
The first year activities were on setting the baseline for energy scenarios. For four selected

countries an overall Energy scenario reflecting the role of Solar Heat in four countries will be identified, including Austria, Denmark, Germany and Italy. The following modelling approaches and tools were chosen.

Model	EnergyPLAN	REMod-D	HiRes
Organization	AAU	Fraunhofer ISE	EEG/TUV
Scenarios	100% renewable energy in 2050 Solar thermal share	100% renewable energy in 2050 Solar thermal share	100% renewable energy in 2050 Solar thermal share
Countries	AT, DE, DK, IT	DE	AT

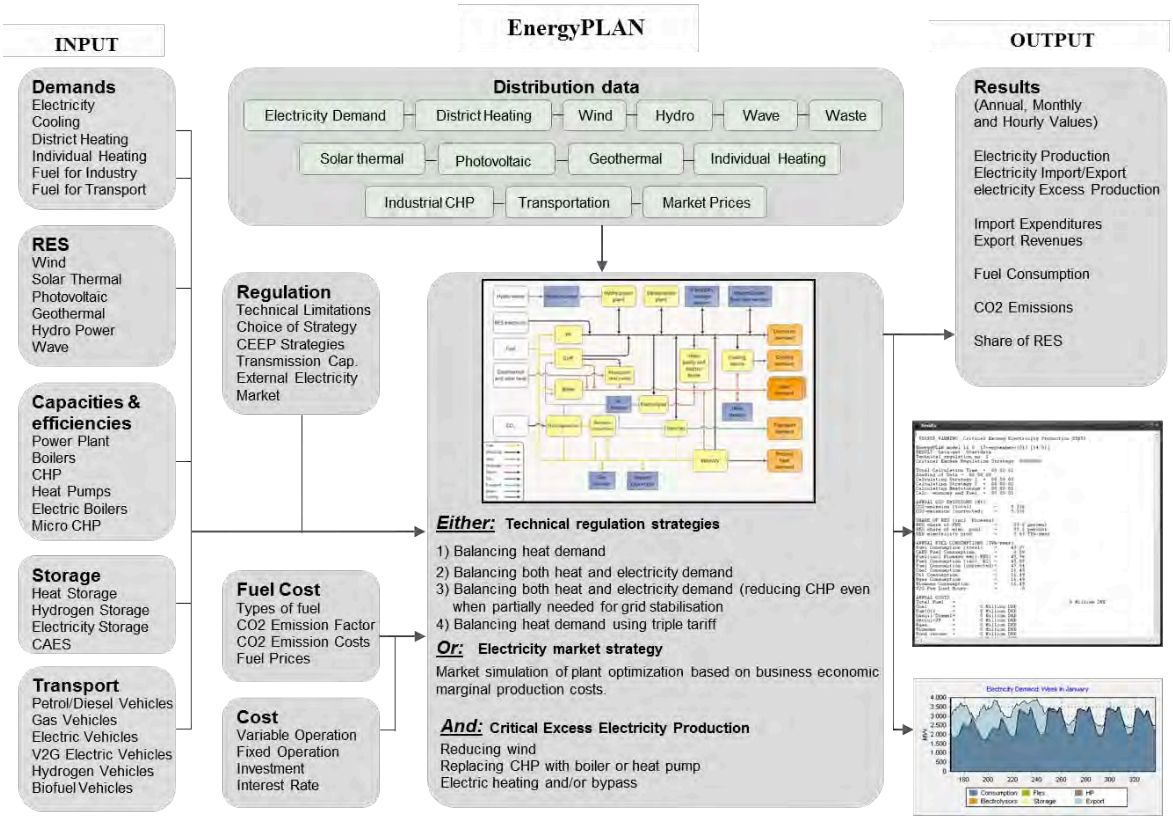

Figure 1. Workflow of EnergyPLAN. ***Source D. Conolly, AAU.***

The Modelling will include 2010 as the reference year and 2050 as time horizon for the scenarios. As it is intended to model Germany in both available environments it is used to bridge the modeling. To set up the scenarios it was necessary to first define the Solar Concepts to be analyzed. AEE Intec developed a first draft on solar thermal technologies for modeling scenarios. Based on the first activities in Subtask C the following were identified:

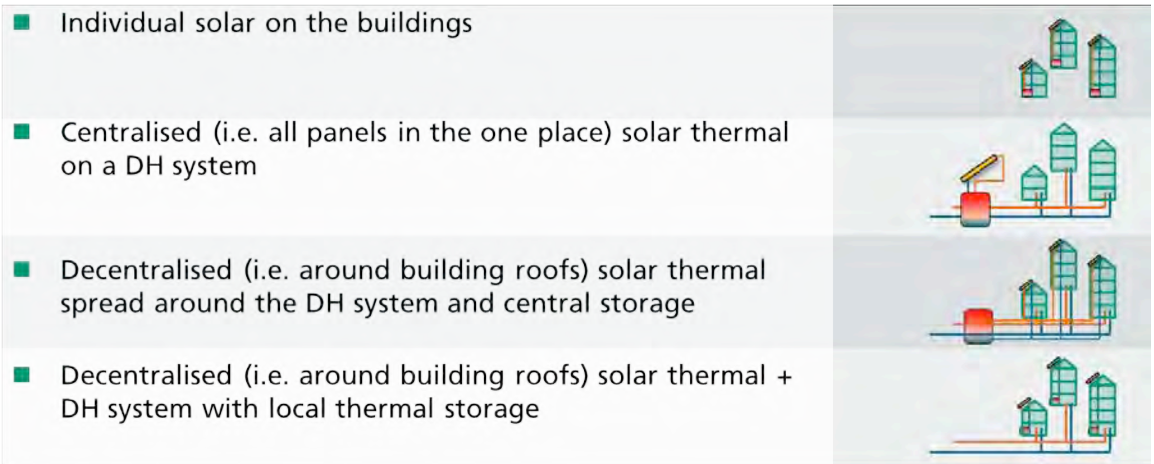

Figure 2. Classification of solar thermal systems. ***Source AEE Intec / Fraunhofer ISE.***

For the Reference Scenario "Germany 2010," cost data and technology data were identified and documented. The results of a first run with the EnergyPlan model show a good agreement with the actual statistics of the German Ministry for Economy and Energy BMWi. In order to reflect different cost for land, a set of simplified urban structures was identified with different needs for solar thermal. For example, large-scale ground mounted systems are more feasible in village structures than in areas with high buildings and roof top mounted systems are more feasible in areas with high building density.

Simplified urban structures for REMod_D	
ST II	Village- and City Suburban areas
ST IIIa	Medium building density
ST IIIb	(Very) high building density and multi-story buildings
ST IV	Industrial and commercial buildings

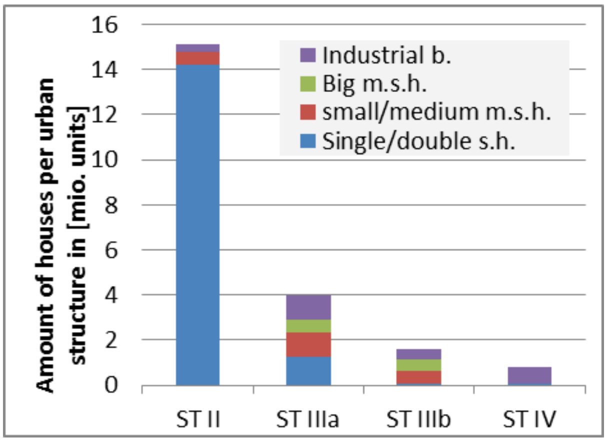

Figure 3. Urban structures and mount of buildings of each type in the different structure to be used in energy system modeling. ***Source UBA / Fraunhofer ISE.***

Subtask B: Methodologies, Tools and Case Studies for Urban Energy Concepts

B1: Methodology

Two main topics were addressed in the first year of the Task. A methodology description is under development to answer the needs of urban actors. First the urban actors were identified (planner, municipalities, investors) and their needs assessed. Based on this the methodology will be developed based to meet the expectations of these actors.

It was identified that different actors will have different roles and different questions to be answered during the process. Design Questions to be addressed include:

- For a given urban area, what is the design of the most suitable distributed thermodynamic systems to consider?
- What are the expectations of the urban actors in terms of solar thermal integration to

the urban environment?
- What is the optimum integration of solar thermal into the 4 categories developed in STC?

One approach developed by UNL/FCT is based on the atom structure (protons, electrons and neutrons). Buildings, or quartiers can be represented as having positive, negative or neutral demand in terms of energy. This method will be evaluated on three different quartiers. The UNL/FCT will lead the methodology activity.

The research method aims to meet the most adequate methodology to identify a planning process that addresses cities' energy needs through a physical-geographical approach to urban system, providing a geo-referenced parameters list for solar potential simulations and energy demand prediction at macro and micro urban scale.

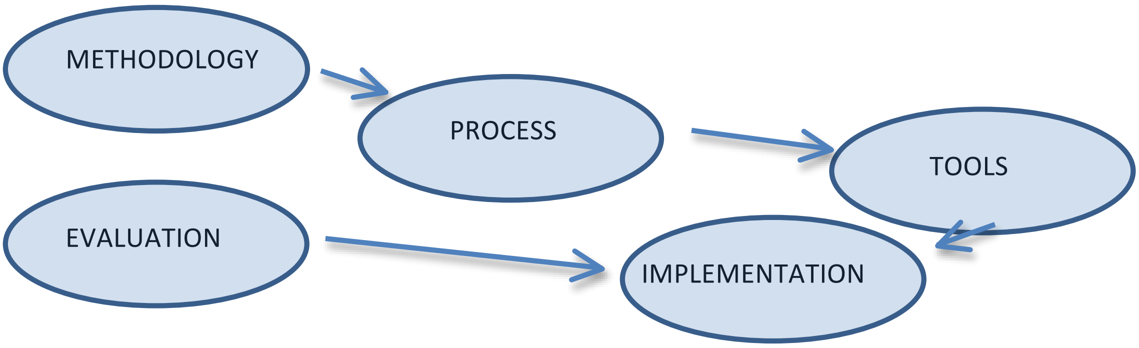

Figure 4. Step 1 of Methodology. ***Source M. Amado, UNL/FCT.***

The second activity is a survey on tool development and achievement. This survey addresses existing tools as follows:

- Production or demand side
- Targeted output description
- Geographical
- Model resolution
- Example of use
- Information exchange potential

A survey template was developed. Up to now six different toolboxes were identified and documented.

B3: Case Studies

The methodology developed and tools assessed will be applied to the case studies (B3). The following potential case studies were collected up to now:

- Oeiras E-CITY (PT)
- Quarter in Berne (CH, tbc.))
- Municipality at Lake Geneva (CH, tbc.)
- Verbier (CH)
- Haslach / Weingarten (DE)
- Leutkirch (DE, tbc.)

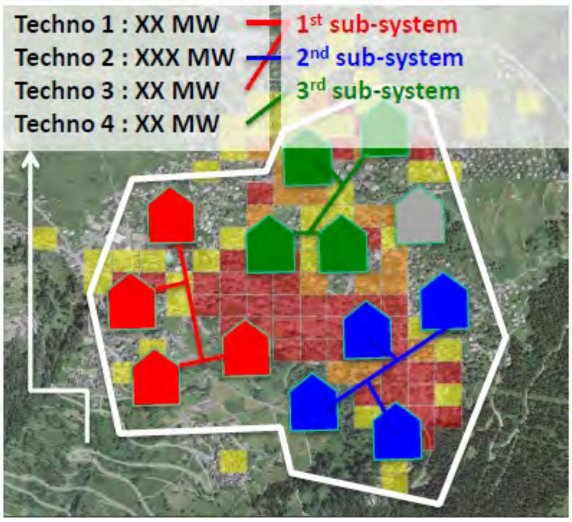

Figure 5. Example of a toolbox for urban energy planning. ***Source G. Ruiz, CREM***

Subtask C: Technology and Demonstrators

In 2014 activities were mainly focused on the classification of system use cases and market analysis needs to be pursued. A first idea for a possible classification of solar thermal systems in urban environments based on the complexity of its interaction with the linked urban energy system was developed. The classification aims to end up with a description of several (five to six) characteristic use cases.

A database for SDH plants was set up by AEE Intec and evaluated regarding installation cost. Based on this evaluation, a first cost curve for collector fields was derived for use in Subtask A (see Figure 6).

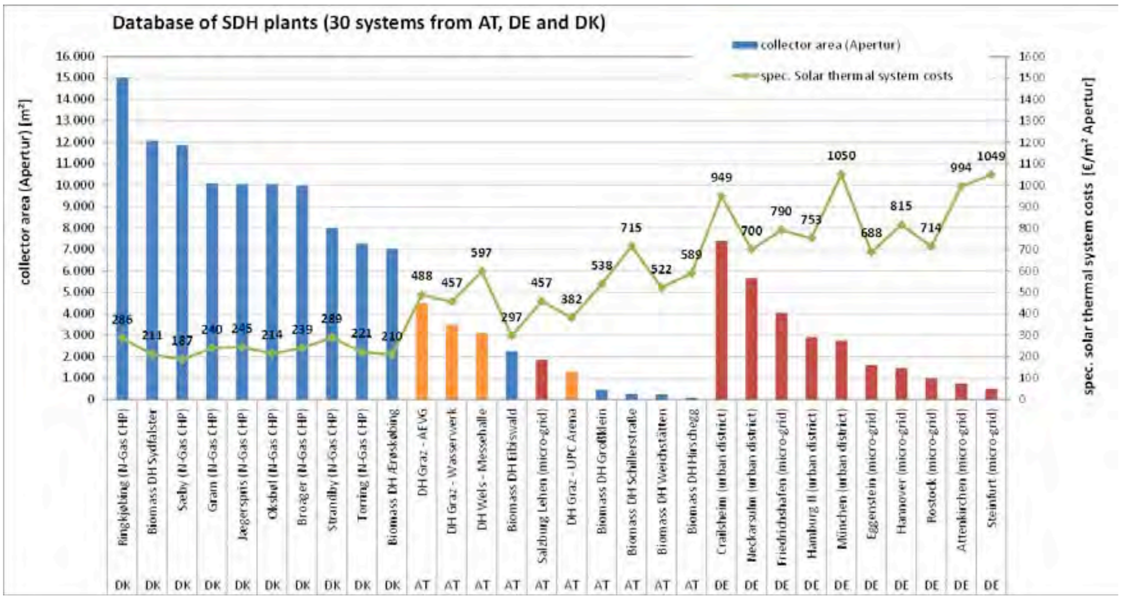

Figure 6. Solar District Heating database will be used for cost estimations. ***Source: F. Mauthner, AEE Intec***

A second evaluation was done by PlanEnergy to determine a relation of population density and installed solar capacity (see Figure 7). This information could be used to better understand the kind of settlements where large solar thermal systems are successful.

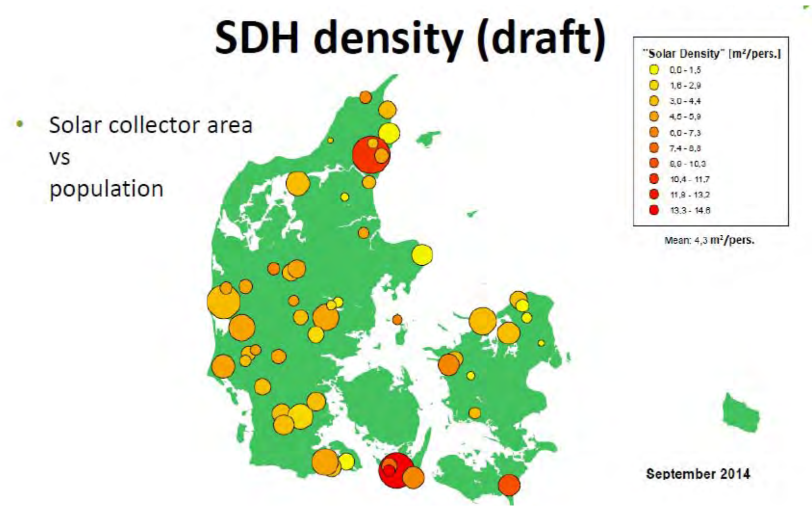

Figure 7. Installed Solar Collector Area vs. population density in Denmark. ***Source: D. Trier, PlanEnergy.***

WORK PLANNED FOR 2015

Subtask A: Energy Scenarios

The first scenarios for the reference case for energy system analysis will be implemented. A first comparison of the different modelling approaches will be available.

Subtask B: Methodologies, Tools and Case Studies for Urban Energy Concepts

The development of methodologies and performance criteria and the review of existing tools will be finalized. Based on this, a tool chain for the integration of solar thermal in design processes on the urban and district level will be identified. First case studies will be performed.

Subtask C: Technology and Demonstrators

The market screening and development of a matrix for best practice example descriptions and analysis will be finalized. The analysis and documentation of best practice examples will be started as well as an analysis and Identification of business opportunities and success factors.

REPORTS PUBLISHED IN 2014

No official Task reports were published.

Conference Proceedings

- S. Herkel: Dezentrale Einbindung von Solarthermie – Eine energiewirtschaftliche Betrachtung, Gleisdorf Solar 2014.
- S. Herkel: Solar Heat and Energy Economics in Urban Environments SHC 2014 Beijing.

REPORTS PLANNED FOR 2015

Report A1: "Report on advanced energy system analyses of solar thermal concepts: Methodology report."

MEETINGS IN 2014

1st Experts Meeting
March 31 - April 1
Lisbon, Portugal

2nd Experts Meeting
September 29 - 30
Bern, Switzerland

MEETINGS PLANNED FOR 2015

3rd Experts Meeting
April 15 - 16
Freiburg, Germany

4th Experts Meeting
September 20 -21 *(to be confirmed)*
Copenhagen, Denmark

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Task 53

New Generation Solar Cooling & Heating Systems (PV or Solar Thermally Driven Systems)

Daniel Mugnier
TECSOL SA
Operating Agent for the French Energy Agency (ADEME)

TASK DESCRIPTION

A tremendous increase in the market for air-conditioning can be observed worldwide, especially in developing countries. The results of the past IEA SHC Tasks and work on solar cooling (for example, SHC Task 38: Solar Air-Conditioning and Refrigeration) on the one hand showed the great potential of this technology for building air-conditioning, particularly in sunny regions. On the other hand, showed that solar thermal cooling has had difficulty emerging as an economically competitive solution. There is therefore a strong need to stimulate the solar cooling sector for small and medium power sizes, which this new Task on new generation PV and solar thermal driven cooling and heating systems will focus on.

Objective and Scope

The Task objective is to create a logical follow up of the IEA SHC work already carried out by trying to find solutions to make the solar driven heating and cooling systems at the same time cost competitive. This major target should be reached thanks to five levels of activities:

1. Investigate new small to medium size PV & solar thermal driven cooling and heating systems and develop best suited cooling & heating systems technology focusing on reliability, adaptability and quality.
2. Proof of cost effectiveness of the above mentioned solar cooling & heating systems
3. Investigate life cycle performances on energy and environmental terms (LCA) of different options.
4. Support market deployment of new solar cooling and heating systems for buildings worldwide.
5. Support energy supply safety and influence virtuous demand side management behaviors.

The Task will focus on technologies for the production of cold/hot water or conditioned air by means of solar heat or solar electricity. That is the Task's scope will start with the solar radiation reaching the collector or the PV modules and end with the chilled/hot water and/or conditioned air transferred to the application. Although the distribution system, the building and the interaction of both with the technical equipment, is not the main topic of the Task this interaction will be considered where necessary. The main objective of this Task is to assist a strong and sustainable market development of solar PV or new innovative thermal cooling systems. It is focusing on solar driven systems for both cooling (ambient and food conservation) and heating (ambient and domestic hot water).

The project is divided into four Subtasks:

Subtask A: Components, Systems & Quality
A1: Reference systems
A2: New system configurations for cooling and heating
A3: Storage concepts and management
A4: Systems integration into buildings, micro grid and central Grid
A5: LCA and techno-eco comparison between reference and new systems

Subtask B: Control, Simulation & Design
B1: Reference conditions
B2: Grid access conditions and building load management analysis
B3: Models of subcomponents and system simulation
B4: Control strategy analysis and optimization for ST and PV
B5: System inter-comparison

Subtask C: Testing and Demonstration Projects
C1: Monitoring procedure and monitoring system selection criteria
C2: System description for field test and demo project
C3: Monitoring data analysis on technical issues & on performances
C4: Best practices / feedback

Subtask D: Dissemination and Market Deployment
D1: Website dedicated to the Task
D2: Handbook and simplified brochure
D3: Newsletters, workshops and conferences
D4: Road mapping and lobbying actions

Main Deliverables
The following documentation or information measures are planned during the course of the Task (corresponding Subtask in brackets):

- State of the art of new generation commercially available products (A)
- Techno-economic analysis report on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Ecolabel sensibility (A)
- Technical report on optimized control strategies for solar cooling & heating systems (B)
- Design tool including a country- and climate-sensitive economic analysis (B)
- Technical report on monitoring data analysis (technical issues + performances) (C)
- Technical report presenting a draft testing method for a quality standard on new generation cooling & heating systems (C)
- Website dedicated to the Task (D)
- Industry workshops addressing target groups (related to Experts meetings) (D)
- Handbook for new generation solar cooling and heating systems (D)
- Simplified short brochure (D) jointly edited by the Subtask Leader and IEA SHC program
- Guidelines for Roadmaps on New generation Solar Cooling and Heating systems (D)

Duration
The Task started in March 2014 and will be completed in June 2017. This is a collaborative Task with the IEA PVPS Programme.

Participating Countries
Australia, Austria, China, France, Italy, Spain, Sweden, Switzerland

WORK DURING 2014

Since Task 53 started in the 2nd quarter of 2014, several activities are progressing and four milestone reports have been achieved. Main activities in 2014 were the consolidation of the adaptation of the Work plan with aggregations of activities (no cancellations but activities grouped into working groups).

Task 53 Logo Project
A project of logo was created for the Task to use in all the communication documents of the Task.

Task 53 Poster
The poster was presented during EUROSUN and SHC 2014 conferences.

Collaboration with IEA PVPS
Activities include:

- Task Liaison-Officers (mainly Task 1 PVPS and Task 53 SHC)
- Joint Task Meetings when possible
- Meetings at same place & time when possible
- Joint Workshops at Conferences

Task Training Seminars and Workshops
IEA PVPS Task 1 Workshop at Ben Gurion University in Tel Aviv in April
PVPS Task 1 organized a workshop to show the latest results obtained by this Task, especially on the situation of solar PV in the world and in Israel. This workshop addressed the question of solar energy implementation and developments in Israel. Organized by the Ben Gurion University of Israel, it confronted the visions of Israel's officials and academics about PV development, together with the international expertise of IEA PVPS and IEA SHC experts. The Task 53 presentation during this event, created strong links between this Task and Task 1 PVPS.

IEA PVPS Task 1 & Task 14 Workshop in Amsterdam in September
As an official event of the 29th EU PVSEC, this IEA PVPS Programme workshop was jointly organized with IEA SHC and EPIA. Daniel Mugnier, Operating Agent of SHC Task 53 presented the Task and what PV for solar cooling and heating means.

IEA SHC Task 53 / SUNCOOL workshop in Karlstad, Sweden in September
EU SUNCOOL Life Project organized, in conjunction with SHC Task 53, a common workshop on Solar Cooling in Karlstad (Sweden) on half a day. Nearly 70 participants took part in this successful event.

The objectives of the workshop were to:

- Present the SUNCOOL/Climatewell concept.
- Present the demo plant at Löfbergs Coffee factory.
- Organize a technical visit of the site.
- Present to the attendees SHC Task 53 and its first results.

The Task 53 presentations from these workshops can be found on the Task 53 webpage

Conference Presentations
EUROSUN 2014
Task 53 was significantly represented during the EUROSUN conference in France. Two specific technical sessions were dedicated to solar air conditioning and one on Task 53 and its first results. Task 53 was also represented in the poster area.


IEA Solar Heating and Cooling Programme
Task 48
SHC
http://task48.iea-shc.org/
www.iea-shc.org

SHC 2014
The Operating Agent presented a special keynote and there were two sessions on solar cooling.

REPORTS PUBLISHED IN 2014

Several draft reports were completed. The final versions will be posted on the Task webpage when completed.

- Draft state of the art of new generation commercially available products including costs, efficiency criteria ranking and performance characterization
- Draft technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's).
- Draft Monitoring procedure for field test & demo systems (depending on size and application)

WORK PLANNED FOR 2015

According to the Work Plan, the following deliverables should be available in 2015.

Subtask A: Components, Systems & Quality
- Draft definition of the existing cooling reference systems
- State of the art of new generation commercially available products including costs, efficiency criteria ranking and performance characterization
- Technical report on best practices for energy storage including both efficiency and adaptability in solar cooling systems (including KPI's).

Subtask B: Control, Simulation & Design
- Template for Definition of reference conditions
- Template for overview on peak demand & demand side management possibilities

Subtask C: Testing and Demonstration Projects
- Monitoring procedure for field test & demo systems (depending on size and application)
- Template for Catalogue of test/demo systems (with full description)

LINKS WITH INDUSTRY

Industry representatives participating in Task Experts Meetings as observers include: COSSECO (Switzerland), CLIMATEWELL (Sweden), ATISYS (France), SOLARINVENT (Italy).

They represent primarily engineering companies and solar cooling system manufacturers. The results of Task 53 are profitable for their business and their involvement consists of supporting and analyzing the Task work.

MEETINGS IN 2014

1st Experts Meeting
March 18-19
Vienna, Austria

2nd Experts Meeting
October 7-9
Mälardalen University, Sweden
Side event: Climatewell LIFE Workshop

MEETINGS PLANNED FOR 2015

3rd Experts Meeting
March 25-26
Shanghai, China

A joint Solar Cooling was held in conjunction with Task meeting. The objective of the solar cooling week was to promote research and applications of solar cooling technologies. The week's activities included Task 48 Experts Meeting, Task 53 Experts Meeting and the Chinese Solar Cooling Conference 2015.

4th Experts Meeting
September 15-16 *(date to be confirmed)*
Innsbruck, Austria or Bolzano, Italy

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