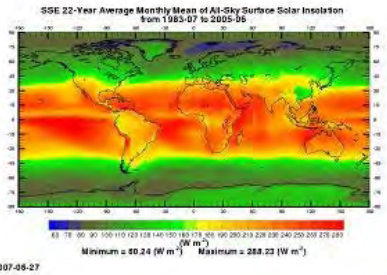
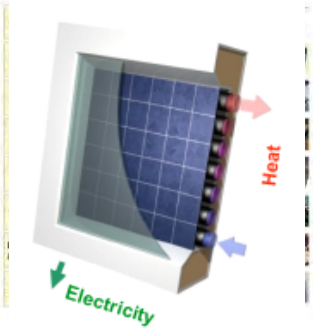
SOLAR HEATING & COOLING PROGRAMME

INTERNATIONAL ENERGY AGENCY





2009 Annual Report

With a Feature Article on PV/Thermal Solar Systems

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INTERNATIONAL ENERGY AGENCY

The *International Energy Agency* (IEA) is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) based in Paris. Established in 1974 after the first "oil shock," the IEA is committed to carrying out a comprehensive program of energy cooperation among its members and the Commission of the European Communities. The IEA provides a legal framework, through IEA Implementing Agreements such as the *Solar Heating and Cooling Agreement*, for international collaboration in energy technology research and development (R&D) and deployment. This IEA experience has proved that such collaboration contributes significantly to faster technological progress, while reducing costs; to eliminating technological risks and duplication of efforts; and to creating numerous other benefits, such as swifter expansion of the knowledge base and easier harmonization of standards.

SHC MEMBER COUNTRIES

Australia
Austria
Belgium
Canada
Denmark
European Commission
Finland
France
Germany
Italy
Mexico
New Zealand
Netherlands
Norway
Portugal
Spain
Sweden
Switerland
United States

SHC PROGRAMME

The Solar Heating and Cooling Programme (SHC) was established in 1977, as one of the first programmes of the International Energy Agency (IEA). The Programme's work is unique in that it is accomplished through the international collaborative effort of experts from Member countries and the European Commission. The benefits of such an approach are numerous, namely, it accelerates the pace of technology development, promotes standardization, enhances national R&D programmes, permits national specialization, and saves time and money.

The Programme is headed by an Executive Committee composed of one representative from each Member country and Sponsor organizations, while the management of the individual projects is the responsibility of project managers (Operating Agents) who are selected by the

Executive Committee. Forty-two Tasks had been initiated since the beginning of the Programme. In 2009, three new Tasks began.

The Programme's work is augmented through collaboration with other IEA Programmes, such as the Energy Conservation in Buildings and Community Systems Programme, the Photovoltaic Power Systems Programme, and the SolarPACES Programme, as well as solar trade associations in Europe, North America, and Australia.

Our Misson

The SHC mission for 2009-2013 is:

> *To advance international collaborative efforts for solar energy and provide significant added value to national R,D & D, and policy and program initiatives related to the built environment and for agricultural and industrial process heat to reach the goal set in the vision of contributing up to 50% of the low temperature heating and cooling demand by 2030.*

This mission assumes a whole building approach to the application of solar technologies and designs. Based on this mission, the Programme 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 Programme will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data, etc. and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for agricultural and industrial process heat applications.

To fulfill this mission, the Programme will direct its results to the design community, the solar manufacturers, and the energy supply and service industries that serve the end-users and building owners.

Our Objectives

The SHC Executive Committee has agreed upon the following objectives and associated strategies to fulfill its mission.

SHC Objective 1
To be the primary source of high quality technical information and analysis on solar heating and cooling technologies, designs and applications.

Strategies

- Assure that technical **information** and **analysis** developed in this Agreement is available and disseminated to the target audiences in useful formats.
- Working through relevant international standards organizations, support the development and harmonization of **standards** necessary for the

widespread use of solar designs and technologies in the building, agricultural and industrial sectors.

SHC Objective 2

To contribute to a significant increase in the performance of solar heating and cooling technologies and designs.

Strategies

- Increase **user acceptance** of solar designs and technologies.
- Continue to develop **cost-effective** designs and technologies in collaboration with appropriate intermediary industries.
- Identify and prioritize **R&D needs** for solar heating and cooling that will lead to expanded markets

SHC Objective 3

To enhance cooperation with industry and government on increasing the market share of solar heating and cooling technologies and designs.

Strategies

- Work with appropriate **intermediary industries** and end users to accelerate the market penetration of solar designs and technologies.
- Work with governments to promote and expand **favorable policies** to increase the market share.
- Work towards or support the greater use of solar designs and technologies in **developing countries**.
- Work to address issues regarding building design, aesthetics and architectural value.

SHC Objective 4

To increase the awareness and understanding on the potential and value of solar heating and cooling systems by providing information to decision makers and the public.

Strategies

- **Communicate** the value of solar heating and cooling designs and technologies in publications, conferences, workshops and seminars to the public and relevant stakeholders.
- Provide **analysis** that links solar heating and cooling designs and technologies to energy security concerns, environmental and economic goals.
- **Quantify and publicize** the environmental, economic and climate change benefits of solar heating and cooling and supporting policy measures solar design and technologies in meeting environmental targets and addressing policies and energy, supply security.
- **Review** our products in relation to our objectives **–** Annual Reports, Solar Update Newsletters, National Programme Review Reports, "*Solar Heating Worldwide: Markets and Contributions to the Energy Supply report."*
- **Present** the SHC Solar Award annually/bi-annually. **Maintain** the SHC web site.

Chairman's Report

Doug McClenahan
CanmetENERGY – Natural Resources Canada

I am pleased to present the 2009 annual report of the IEA Solar Heating and Cooling Programme. In 2009, the SHC Programme began work on several fronts in accordance with it's strategic plan for both R&D and market deployment that we hope will have a significant impact on increasing the use of solar heating and cooling technologies worldwide.

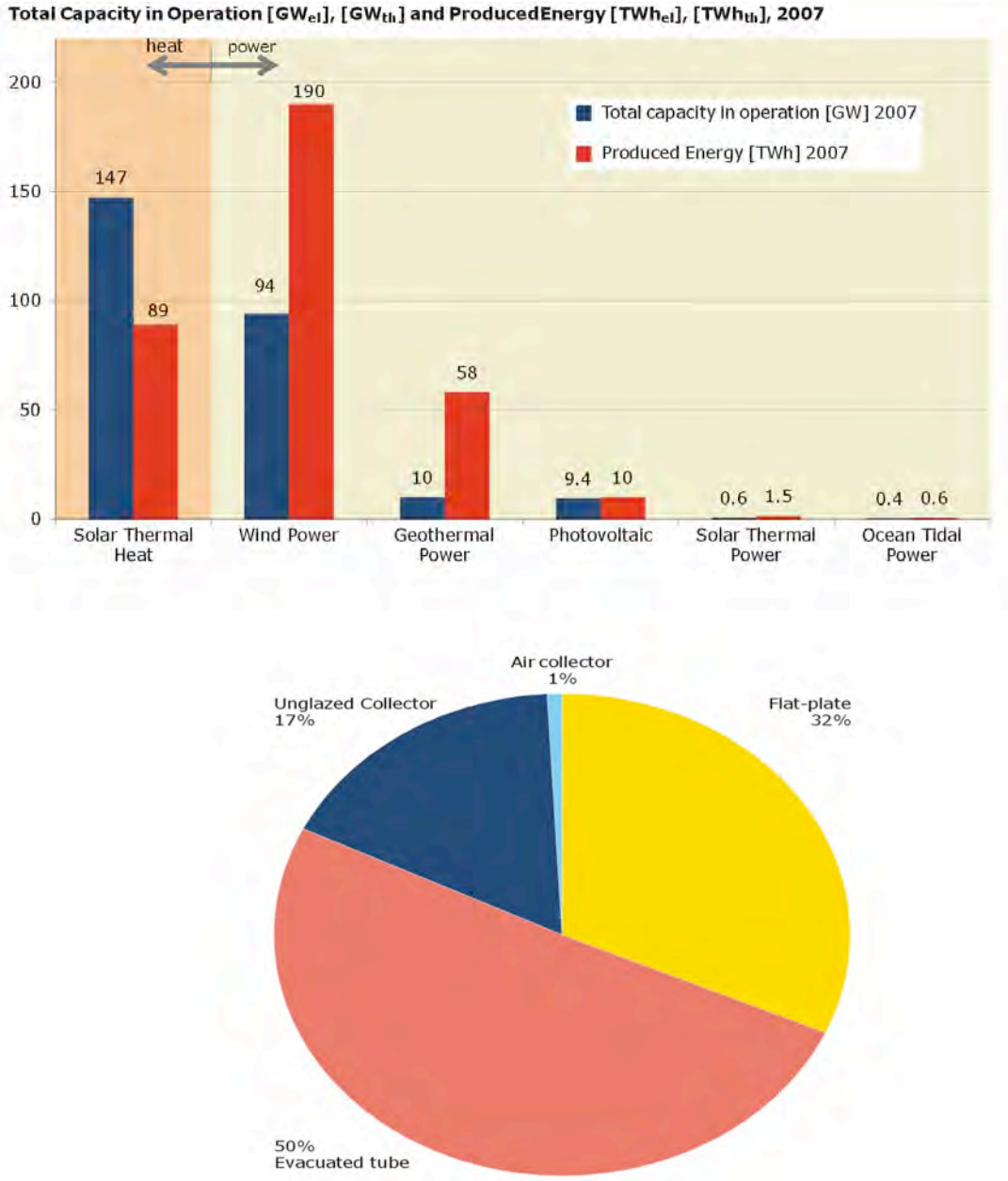
Examples of new R&D initiatives include Task 42, which is focused on assessing new materials for compact heat storage for use in high solar fraction space heating applications. A breakthrough in this field would have a dramatic impact on increasing solar energy utilization in cold climates. Other work in the space heating field includes Task 43, this is the Programme's first initiative to evaluate various concepts of combining solar collectors with thermal storage and heat pumps. It was initiated due to a significant increase in industry activity, and the results are expected to become the reference for recommended system configurations for many years to come.

On the market side, one of the most ambitious new work areas involves Task 43, which is focused on the harmonization of solar thermal standards and certification programs worldwide. This collaboration, involving ISO, SRCC, Solar Keymark and other organizations, will hopefully lead to a reduction in the resource requirements by the solar thermal industry to market their products in different countries. As the market for solar heating and cooling continues to grow despite difficult economic conditions, it is important that we work closely with industry associations to help reduce barriers to market adoption. Other work with a strong market focus includes Task 41, the first initiative under SHC to examine solar energy and architecture. In order to increase market acceptance of solar energy technologies, it is important that the architectural community participate in the development of designs that reflect a high acceptance value in our society.

SHC DATA

To track the growth of solar thermal, the SHC Programme produces an annual statistics report, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply.* The 7th edition reports that in 2007, solar thermal technologies produced **88,845 GWh** – an oil equivalent of 12.09 billion tons and annual avoidance of 39.3 million tons of CO_2

emissions. New installations grew 8.7% compared to 2006 with a huge jump of 23.4% in the global market of evacuated tube collectors from just one year before.



[Source: IEA SHC Programme, Solar Heat Worldwide, 2009 edition]

Key findings:

- Installed capacity in 2007 was 146.8 GW_{th} (209.7 million square meters)
- Market penetration (installed capacity per 1,000 inhabitants) leading countries:
  - Cyprus 651 kW_{th}; Israel 499 kW_{th}; Austria 252 kW_{th}; Greece 224 kW_{th} and

Barbados 197 kW_{th}

- Most dynamic markets:
  - China was the leader with an average annual growth rate of 23.6% between 1999 and 2007 and representing 44% of the world market.
  - Followed by 20% in Europe, 26% in Canada and the USA, and 16% in Australia and New Zealand.
- Initial 2008 data estimate total capacity in operation will be165 GW_{th}.

Worldwide, we are just beginning to scratch the surface of the market for solar heating and cooling. If solar thermal installations increased by 20 fold we would just approach 1% of the annual world energy use. However, the annual energy recoverable from solar is more than one thousand times the current world energy use, so there is tremendous growth potential. What is needed in addition to technology innovation, are very dramatic changes in energy policies around the world so that this potential can be tapped in a significant way in the near future.

SHC TASKS

2009 was the start of key work in the areas of architecture, storage, standards and certification, and heat pumps. The new work includes:

- Task 41: Solar Energy and Architecture
- Task 42: Compact Thermal Energy Storage: Material Development for System Integration
- Task 43: Rating and Certification Procedures: Advanced Solar Thermal Testing and Characterization for Certification of Collectors and Systems.
- Task 44: Solar and Heat Pump Systems: Systems Using Solar Thermal Energy in Combination with Heat Pumps

New work was also proposed to begin in 2010/11.

- Advanced Renovation in Non-Residential Buildings
- Solar Resource Assessment and Forecasting

SHC SOLAR AWARD

The SHC Solar Award was not presented in 2009, but will be in 2010 at the EuroSun Conference in Graz, Austria in September. This 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.

Recipients of this award include:

- Prof. Collares Pereira
- Dr. Volker Wittwer
- Prof. Jan-Olof Dalenbäck
- Prof. William Beckman
- Mr. Torben Esbensen

COLLABORATION WITH OTHER IEA PROGRAMMES & INTERNATIONAL ORGANIZATIONS

To support our work, the SHC Programme is collaborating with other IEA Programmes

and solar organizations.

Within the IEA

IEA Energy Conservation in Buildings and Community Systems Programme is collaborating in SHC Task 40: Net Zero Energy Solar Buildings at a moderate level as outlined in our Policy & Procedures Handbook.

IEA Energy Conservation through Energy Storage Programme is collaborating at a joint level as outlined in our Policy & Procedures Handbook in Task 42: Compact Thermal Energy Storage. This will be the first fully joint Task with Operating Agents from each Programme.

IEA Heat Pump Programme is collaborating at a maximum level as outlined in our Policy & Procedures Handbook in Task 44: Systems Using Solar Thermal Energy in Combination with Heat Pumps.

IEA Photovoltaic Power Systems Programme is collaborating in Task 36: Solar Resource Knowledge Management at a minimum level as outlined in our Policy & Procedures Handbook.

IEA SolarPACES Programme is collaborating in Task 36: Solar Resource Knowledge Management at a minimum level as outlined in our Policy & Procedures Handbook.

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, a SHC/Trade Association meeting was held May 29, 2009 in conjunction with InterSolar and estec. The 5th meeting is scheduled to be held again in conjunction with InterSolar 2010 in Germany in June. The topic the 2010 meeting will be *Standards and Harmonization*.

EU ThERRA (Thermal Energy from Renewables – References and Assessment), the SHC Programme is represented on the Advisory board by Mr. Werner Weiss. The objective of this group is to develop and disseminate a methodology for monitoring the total amount of renewable heat produced in the EU.

ESTTP (European Solar Thermal Technology Platform), the SHC Programme, represented by Mr. Lex Bosselaar and Mr. Werner Weiss, continued to

HOW TO PARTICIPATE

To learn more

Visit our website — www.iea-shc.org — to read about our Tasks, to find publications, to contact Executive Committee members and project managers (Operating Agents).

To join

If your *country is a Member* of the Programme then contact the Operating Agent of the specific Task you are interested in joining or the Executive Committee member from your country.

If your *country is not a Member* of the Programme, but a government agency or an organization is interested in joining, please contact the SHC Secretariat for information.

If you represent an *international industry association or international non-profit organization* and are interested in joining as a Sponsor, please contact the SHC Secretariat.

serve on the ESTTP Steering Group and to support the Platform's objectives.

EXECUTIVE COMMITTEE MEETINGS

2009 Meetings

The Executive Committee held two meetings:

- June 2-4 in Stavanger, Norway
- November 16-18 in Nice, France

2010 Meetings

The Executive Committee will hold two meetings:

- June 21-24 in San Francisco, California, USA
- November 16-18 in Cape Town, South Africa

PROGRAMME PARTICIPATION – WHY JOIN

Participation in the Programme remains strong with 18 Member countries and the European Commission actively involved in the Programme's management and the work of the Tasks. Communication with five target countries that have already been invited to join the Programme–Brazil, China, India, Japan and South Africa—continued. In 2009, the Executive Committee unanimously voted to invite Chile and Singapore to join the Agreement.

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 and include:

- 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.

TO ANOTHER SUCCESSFUL YEAR

I will have completed two terms as Chairman in 2010, and it has been an honor to represent such a significant, far reaching organization. The international collaborative R&D that goes on in this Programme has an impact that truly is too large for us to know. We do know though that experts from a broad range of solar and non-solar professions are working to move solar thermal technology to the forefront of renewables, and that the members of the SHC Executive Committee are pushing this Programme to address key barriers to solar thermal's application.

I would like to take this opportunity to thank one of the founding members of this Programme, Prof. Gerhard Faninger. Gerhard has served on this Executive Committee for 32 years, and as quoted on a pocket sundial that was presented to him, it is with

> *"sincere thanks for your unwavering commitment of 32 years to the IEA Solar Heating & Cooling Programme. You have helped to chart the course for solar internationally and nationally.*

Thank you Gerhard. We will miss you.

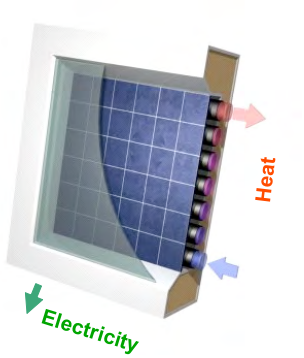
In 2009, we welcomed a new member to our meetings, Prof. Ernst Uken of South Africa, and an old friend, Mr. Jean-Christophe Hadorn, former OA of Task 32: Advanced Storage Concepts for Solar and Low Energy Buildings and new OA of Task 44: Systems Using Solar Thermal Energy in Combination with Heat Pumps.

I look forward to our continued collaboration as we expand the work and impact of the SHC Programme. And I particularly look forward to increasing our collaboration with countries such as South Africa, China, India, Brazil, Singapore and others in our years ahead. It is an exciting time as national and international interest and markets for solar heating, cooling, and daylighting technologies continue to grow.

Doug McClenahan

Task Highlights of 2009

Task 35: PV/Thermal Solar Systems



Task 35 *PV/Thermal Solar Systems* completed its work to catalyze the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector. Reports to published in 2010 include: Outcome Of PV/T Market Survey Interviews; PV-Thermal Collectors Going Commercial; A Review of PV, Solar Thermal, and PV/Thermal Collector Models In TRNSYS; Recommended Standard For Characterization And Monitoring of PV/Thermal Systems, Instructions for Using The Downloadable Package In TRNSYS; TRNSED Simulation Tool For IEA Task 35; Main RD&D Issues for PVT–A Manufacturers Perspective; Reliability and Durability of PV/Thermal Solar Systems; Measurement Report: Test of PVT Module "Pvtwin"; Measurement Report: Test of PVT Module "Solarwall PVT"; Realized PV/T Installations – Experiences and Monitoring Results.

This was a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement.

Task 36: Solar Resource Knowledge Management

Understanding a variety of solar resource forecasting methods is a primary focus of this Task. Solar resource forecasting use is growing in importance for determining cost-effective and successful operation of large-scale grid-tied solar energy systems, both PV and CSP. If operators know with sufficient certainty that the solar energy technologies operating within their system will be on or off, they can determine what other types of back-up systems may be needed to meet forecasted loads.

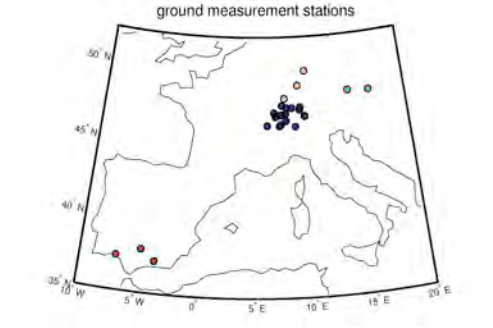


Figure 1: Locations of ground measurement stations for the benchmarking of forecasts. Red: Spanish stations, orange: German stations, blue: Swiss stations,

A published 2009 study, led by Task participants from Oldenburg University (Germany) and team members from Bluesky Wetter (Austria), Meteocontrol (Germany) Meteotest (Switzerland), CENER (Spain), CIEMAT (Spain), and the University of Jaén (Spain), collected high quality ground solar measurement data from throughout Europe, covering the period 1995-2004, with which to compare their various forecasting schemes.

This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement and SolarPACES Implementing Agreement.

Task 37: Advanced Housing Renovation with Solar & Conservation

Over 50 exemplary housing renovation project brochures will be available in mid-2010 on the Task web site. These projects include:

- Apartment buildings
- Penthouses (addition of apartment on existing floor)
- Historic housing
- Row houses
- Single family detached houses

Project results are impressive — the primary energy consumption for space heating and domestic hot water has been reduced by up to 90%.

Task 38: Solar Air Conditioning and Refrigeration

A solar cooling system application installed at a winery in Tunisia by the Politecnico di Milano within the European project MEDISCO (MEDiterranean food and agro Industry applications of Solar COoling technologies) was awarded with the Energy Globe Award Tunisia 2009. This installation is part of the monitoring activities within the framework of Task 38 and several Task 38 participants are contributing to the project.

Task 39: Polymeric Materials for Solar Thermal Applications

Task 39 is in the process of creating a database of "visually appealing" building integrated solar thermal systems. The collection of examples began in 2009, and in 2010 a small team of architects and technical experts will lead the selection process to finalize which systems to include in the database. The database will be available on the Task web site.

Task 40: Towards Net Zero Energy Solar Buildings

Task 40 continues to attract interest from many sectors interested in current net-zero, near net-zero and very low energy buildings and in developing a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. In 2009, it convened its 1st and 2nd Experts meetings in Montreal, Canada and Wuppertal, Germany. Each were attended by about 60 participants from 19 countries. During these meetings, experts further defined the Task work plan and Subtask activities.

This is a collaborative Task with the IEA Energy Conservation in Buildings and Community Systems Implementing Agreement.

Task 41: Solar Energy & Architecture

The Task held its kick-off meeting in May in Malmö, Sweden and a 2nd meeting in Wuppertal, Germany in October. The autumn meeting was held in conjunction with *SHC Task 40, Net Zero Energy Solar Buildings*, and included a joint day of presentations so that participants could learn more about each other's Tasks and identify possible future cooperation. The Task Work Plan was finalized and approved by the ExCo in November.

Task 42: Compact Thermal Energy Storage

The Task held its kick-off meeting in February in Bad Tölz, Germany and a 2nd meeting in Lleida, Spain in September. This Task is bringing together for the first time the research on materials and the research on heat storage applications. To achieve this, the Task is structured into three subtasks on materials research, storage applications and cross-cutting areas. It also has two Operating Agents – one representing the Solar Heating and Cooling Programme and the other the Energy Conservation through Energy Storage Programme.

This is a collaborative Task with the IEA Energy Conservation through Energy Storage Implementing Agreement.

Task 43: Ratings and Certification Procedures

The Experts meeting was held in October in Pretoria, South Africa in conjunction with a meeting of the ISO TC180 meeting and the ISES World Congress 2010. Roadmaps and plans for Subtasks A (Collectors) and B (Systems) were discussed as well as a concept for engaging certification bodies. Specific Task work will begin in 2010.

Task 44: Solar and Heat Pump Systems

This Task was approved at the November Executive Committee meeting. The first Experts Meeting will be held in April 2010.

This will be a collaborative Task with the IEA Heat Pump Implementing Agreement.

Feature Article

PV/Thermal Solar Systems

Henrik Sørensen & Jan Hansen
Esbensen Consulting Engineers A/S
SHC Task 35
Operating Agent and Operating Agent Assistant for the Danish Energy Agency

The EU has set targets for 2010 of 100 million m^2 for solar thermal (corresponding to 70 GW_P thermal) and 3 GW_P for PV. Over the past two decades strayed research and work has been done to combine the two technologies.

PV/Thermal (PV/T) Solar Systems combine photovoltaic technologies and solar thermal technologies into one system with both electricity and thermal energy output. The main component in the systems is a PV/T collector that combines the functions of a solar thermal collector and a PV module, converting the solar radiation into both electricity and heat.

The markets for both solar thermal and PV are growing rapidly globally and PV/T has the potential to experience a similar growth since the technical potential of the technology is large, especially if the market for domestic applications can be reached. A number of issues related to PV/T have been addressed in Task 35, PV/Thermal Solar Systems.

What is a PV/T collector?
As mentioned earlier a PV/T collector converts the solar radiation into both electricity and heat. This principle is illustrated in Figure 1.

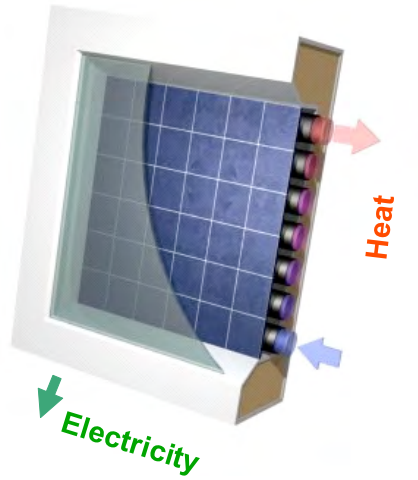


Figure 1. Principle sketch of a PV/T collector

It is essentially a solar thermal module in which PV is integrated in the absorber. In this way, more solar energy is generated per unit surface area than with separate photovoltaic panels and solar thermal collectors side-by-side.

Since only one type of module has to be installed instead of two, one single installer can be responsible for the whole installation and installation costs will be reduced. In addition, the fact that only one building element is required to produce both forms of solar energy has the aesthetical advantage of providing a more homogeneous roof or façade appearance.

The systems are typically integrated in the built environment. Because of their high efficiency per unit surface area, PV/T is particularly well suited for applications with both heat and power demand and with limited roof space available.

Different types of PV/T collectors exist as shown in Figure 2, ranging from flat-plate liquid modules to PV/T air collectors, concentrating PV/T modules and PV facades in which the heat is recovered and put to use. Most of these types can be either glazed or unglazed.

Figure 2. (a) Ventilated PV façade of the Mataro public library in which the heat is recovered and used for space heating and solar cooling, (b) concentrating PV/T system (Vattenfall), (c) PV/T air collector (Grammer KG).

IEA SHC WORK

Task 35 experts worked to catalyse the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector.

The work was organized into five subtasks:

- Subtask A: Market and Commercialisation of PV/T
- Subtask B: Energy Analysis and Modelling
- Subtask C: Product and System Development, Tests and Evaluation
- Subtask D: Demonstration Projects
- Subtask E: Dissemination

Main Results

Experts prepared an overview of commercially available PV/T collectors. At this time, a rather small number of PV/T collectors are commercially available and include both air and liquid collectors. Experts also conducted a market study and interviewed

architects and solar companies. To show the potential of PV/T systems, an overview of realized PV/T installations of both commercial and non-commercial market introduction projects and demonstration projects over the past two decades. From this an inventory of 70 projects was identified, ranging from small PV/T systems to very large ones.

An extensive search was undertaken to identify relevant solar thermal, solar electric, and PV/T system models. TRNSYS was found to be the predominant source of models, and as such, it was decided to focus exclusively on that platform. The required models either didn't exist or did not work well. New models were developed and existing models were modified. All the models can be downloaded in a package.

A PV/T system simulation tool was developed for use by a wide range of players in the market as architects, engineers, manufacturers, etc. It is based on a well-tested TRNSYS/TRNSED model for a solar heating and hot water system including simplified simulation of the house load for each climate chosen. Two options for using the simulation are provided 1) a simplified level opening just a few basic collector and system parameters and 2) an advanced level enabling more detailed input for the PVT collector and system. The simulation tool has been used with success in the winning project in the BOLIG+ competition for Denmark's first energy neutral residential multifamily building, which includes in the concept a liquid based PV/T system, see Figure 3 and 4 below.

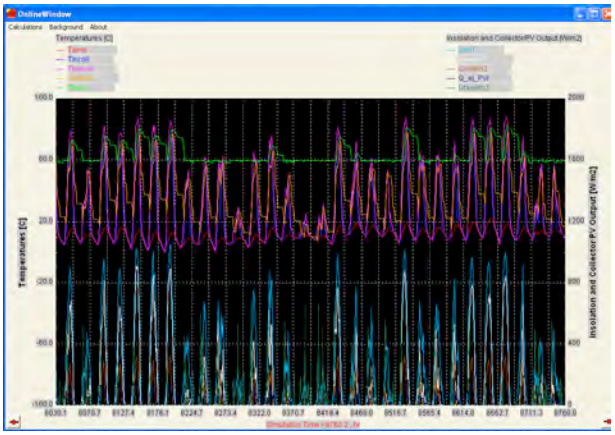


Figure 3. Screenshot from the PV/T simulation tool.

Figure 4. Winner of the BOLIG+ competition.[1]

Figure 5 is an example of the area related advantages for PV/T. Using a PV/T system instead of systems with separate solar collectors and PV modules means that only approximately 60% of the roof area is needed to achieve the same energy production.

PV/Thermal modules produce both electrical and thermal output, and it is important to represent these outputs in a uniform way as to facilitate inter-comparison between PV/Thermal collectors. The required level of detail in the representation of the output depends on the type of user and/or the purpose. On technical expert level, a different type of presentation is required than on the policy level. Three PV/Thermal

[1] Project team: Arkitema Architects, Leif Hansen Engineering A/S & Thornton Thomassetti, Esbensen Consulting Engineers A/S, Faktor 3 ApS, DONG Energy, the housing association Ringgården, Bau-How.

characterization schemes have been developed and recommended within the framework of SHC Task 35:

1. The "*Design Scheme*" contains the most significant level of detail, and is also the most complex. The real value of this approach is as a research tool for individuals well versed in PV/Thermal system design, testing, and operation. The scheme will not be described further in this article.

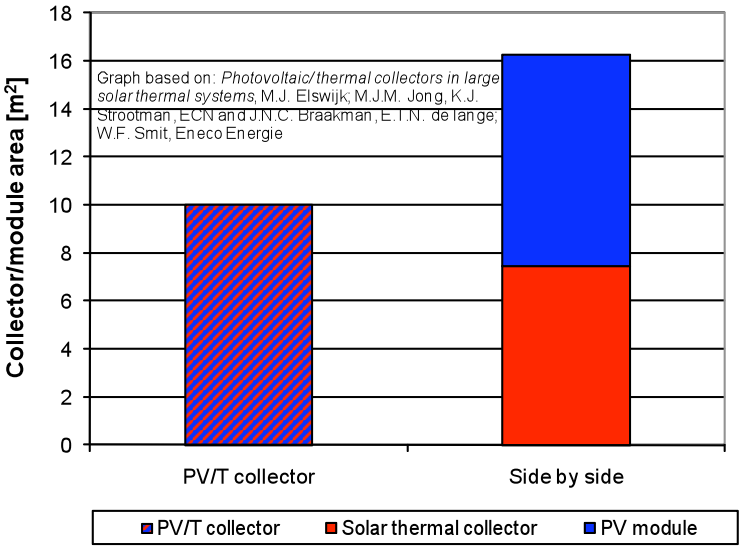


Figure 5. Comparison of the performance of a PV/T system with separate solar heating and photovoltaic systems.

2. The "*Rating Scheme*" is a practical approach that will allow for convenient comparison of systems and good approximations of annual electrical and thermal system output. It was decided only to measure the instantaneous efficiency curve in the same way as normal solar thermal collectors, except with simultaneous production of electricity. The electrical output is presented in a power matrix and is determined under different module temperatures and irradiance levels. For PV/Thermal systems, it is recommended to base efficiencies and output on the collector aperture area.

3. The "*Marketing Scheme*" will simply be a comparative analysis of systems intended for policy and marketing documents. It is intended to show comparative indices such as peak output, and yearly thermal and electrical production values.

System Performance Presentation. Recently, efforts have been carried out within the scope of the EPBD (European Building performance directive), to standardize also the calculation of the annual performance of solar thermal systems (EN 15316-4) and PV systems (EN 15316-6). These calculations include various system losses such as piping heat loss, storage heat loss and inverter electrical loss. With some minor modifications these standards should be used for PV/T.

Nominal Power Rating. If the nominal contribution of PV/Thermal systems is assessed, the system should be evaluated as giving both a thermal installed capacity of 700 W_p/m^2 and an electrical installed capacity corresponding to the measured electrical STC performance in Watt peak.

Combined Thermal and Electrical Output. In some special cases, it may be desirable to give an overall output for the PV/Thermal systems that includes both thermal and electrical yield. IEA SHC Task 35

recommends using use primary energy. The calculation of primary energy depends on the efficiency of the production of electricity and heat from conventional installations. Worldwide, substantial variation exists in this efficiency. It is recommended here to use a value of 40% for the conversion, which implies that the PV/Thermal system electrical output should be multiplied by 2½ to determine the primary energy saved. For the thermal system efficiency, widely varying efficiencies are found, depending on type of heater and type of use. If primary energy yield is presented, it is recommended to also present the values for thermal and electrical yield separately, and to indicate the conversion efficiencies that have been used to calculate primary energy, so that the reader may convert the data to values that correspond better to the specific energy carrier and conversion efficiency typical for domestic heating in his country.

Collector Testing

PV/T collectors of some industries participating in the Task were tested at a variety of institutes and laboratories. This was done to assist the development of recommendations for PV/T collector testing. The practical tests were combined with the documents prepared under the PV Catapult project (D8-6: PVT performance measurement guidelines[2]) and the test standards in IEC WG82 and ISO/CEN.

Figure 6. Testing of PV/T collectors.

[2] PVCatapult, "D8-6: PVT Performance Measurement Guidelines", Contract No 502775(SES6), 2005. www.pvtforum.org

Task 35

PV/Thermal Solar Systems

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TASK DESCRIPTION

PV/Thermal Solar Systems combine photovoltaic technologies and solar thermal technologies into one system with both electricity and thermal energy output. The typical systems are solar collectors with photovoltaic systems integrated in the collector-surface or photovoltaic panels used as collector directly as solar air collector. Through combined production of electricity and heat, the overall efficiency can potentially be higher for a specific collector-area, than the efficiency of traditional "side-by-side" photovoltaic and solar thermal systems. The systems are typically integrated in the built environment.

The EU has set targets for 2010 of 100 million m^2 for solar thermal (corresponding to 70 $GW_{p\ thermal}$) and 3 GW_p for PV. The markets for both solar thermal and PV are growing rapidly globally, and PV/T has the potential to experience a similar growth since the technical potential of the technology is large, especially if the market for domestic applications can be reached. However, very few commercial PV/T manufacturers exist.

The objectives of Task 35 *PV/Thermal Solar Systems* were to catalyse the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector.

The Task was organised in five subtasks, each focusing on key issues identified as being important to meet the overall objective of the Task.

- Subtask A: Market and Commercialisation of PV/T
- Subtask B: Energy Analysis and Modelling
- Subtask C: Product and System Development, Tests and Evaluation
- Subtask D: Demonstration Projects
- Subtask E: Dissemination

COLLABORATION WITH OTHER IEA PROGRAMMES

It was agreed to collaborate with the Photovoltaic Power Systems Programme at a “minimal level” according to the SHC guidelines for coordination with other programmes. The Task was fully defined and managed by the SHC Executive Committee with appropriate input from the PVPS Executive Committee. National experts were assigned to participate in the Task from both IEA SHC and IEA PVPS Executive Committee members or the participants accepted by sponsors of either of the two programmes.

Duration

The Task was initiated on January 1, 2005 and completed in 2008. Final reports from the Task will be published by mid 2010.

ACTIVITIES DURING 2009

All activities in 2009 were focused on concluding the work of the Task, in order to be able to publish the final reports of each subtask.

DOCUMENTS PUBLISHED

DA2-1	Commercially available PVT products
DC1	Overview of PV/Thermal Solar System products and projects
DE2-2	PV/Thermische Solaranlagen, Article – erneuerbare energie 2006-2
DE2-3	IEA SHC Task 35 PV/Thermal Solar Systems, Paper – WREC IX, 2006
DE2-4	PVT collectors combine to increase electrical output, Article – IEA SHC Solar Update Newsletter, Dec 2006
DE2-5	Market, Modelling, Testing, and Demonstration in the Framework of IEA SHC Task 35 on PV/Thermal Solar Systems, Paper – 22nd EU PVSEC, 2007
DE3-1	IEA SHC Task 35 PV/Thermal Solar Systems, Flyer – October 2006

DOCUMENTS TO BE PUBLISHED

DA1-2	Outcome of PV/T market survey interviews
DA2-2	PV-Thermal collectors going commercial
DB1	A review of PV, solar thermal, and PV/thermal collector models in TRNSYS
DB2	Recommended Standard for Characterization and Monitoring of PV/Thermal Systems
DB3-1	Instructions for Using the Downloadable Package in TRNSYS
DB3-2	Documentation Report for TRNSED simulation tool for IEA Task 35
DC2	Main RD&D issues for PVT – A manufacturers perspective
DC4	Reliability and durability of PV/Thermal Solar Systems
DC4-1	Measurement report: Test of PVT module “PVtwin”
DC4-2	Measurement report: Test of PVT module “SolarWall PVT”
DD2/DD3	Realized PV/T installations – experiences and monitoring results

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Task 36

Solar Resource Knowledge Management

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TASK DESCRIPTION

Goal and Objectives

The goal of SHC Task 36 "Solar Resource Knowledge Management" is to provide the solar energy industry, the electricity sector, governments, researchers, and renewable energy organizations and institutions with the most suitable and accurate information of the solar radiation resources at the Earth's surface in easily-accessible formats and understandable quality metrics. The scope of solar resource assessment information includes historic data sets and currently derived data products using satellite imagery and other means.

There are three main objectives of this Task to achieve this goal:

- To provide further standardization and benchmarking of international solar resource data sets to insure worldwide intercomparability and acceptance
- To provide improved data reliability, availability and accessibility in formats that address specific user needs, and
- To develop methods that improve the quality and the spatial and temporal coverage of solar resource products, including reliable solar radiation forecasts.

Achieving these objectives would reduce the cost of planning and deploying solar energy systems, improve efficiency of solar energy systems by more accurate and complete solar resource information, and increase the value of the solar energy produced by solar systems.

Scope of the Task

This Task focuses on the development, validation, and access to solar resource information derived from surface-based and satellite-based platforms. The Task will investigate benchmarking and data quality assessment procedures for data products and validation data sets, examine means by which the data can be made easily available to users through various web-based hosting schemes, and conduct studies on improving the input data sets and algorithms from which satellite-derived products are produced, including the investigation of short term forecasting and past and future climatic variability of the solar resource.

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, web sites, handbooks and journal articles.

Means

Task 36 participants are addressing the objectives through sharing a co-coordinated work plan encompassing three subtasks:

Subtask A: Standard Qualification for Solar Resource Products

The objective of this Subtask is to provide the user community with benchmarked, standardized, validated worldwide solar resource data sets. Key Subtask activities to meet this objective are:

- Select and Qualify Ground Data Sets (lead: NASA, USA)): this activity will include a survey and documentation of existing data sources, and the production and reporting of high-quality surface data sets with which to use in benchmarking and validating satellite-derived data sets.
- Define Measures of Model Quality for Product Validation (lead: H2Magdeburg, Germany): besides defining measures of model quality, this activity includes the establishment and documentation of model intercomparison procedures.
- Develop Methodology for Establishing Coherent Benchmarking of Products (lead: NASA, USA)
- Apply Benchmarking Procedures to Subtask C Products (lead: H2Magdeburg, Germany): this activity will provide results of benchmarking studies conducted on data sets provided by Task 36 participants

Subtask B: Common Structure for Archiving and Accessing Data Products

The objective of this Subtask is to provide a user-oriented information system, such as a distributed data system, for archiving and accessing solar resource data. Key subtask activities to meet this objective are:

- Evaluate the Legal Aspects of Accessing Solar Resource Data (lead: Armines, France): this activity focuses on establishing copyright and proprietary rights of data that will be made available through the distributed data system, and to establish appropriate protocols with each participating institution for making the data generally available to the public.
- Identification of User Requirements (lead: SUNY/Albany, USA and JRC, EU): this activity captures and examines needs expressed by users of the data and the outcomes are specifications for the information system, list of customers serving later as testers of the prototypes and guidance to subtask A for selection of algorithms and methods
- Develop Data Exchange Protocols and Metadata (lead: Armines, France): various data exchange protocols will be examined, and one will be selected and documented.
- Develop Prototype (lead: Armines, France): a prototype web-based system will be developed whereby a user can request information of a certain type and format, and the information system provides the response or responses that most closely addresses the request.
- Develop Network of Resource Providers (lead: NASA, USA): a worldwide network of data providers will be established, and the techniques for data exchange among the providers will be investigated.
- Develop Use of Prototype by Users (lead: Armines, France): this activity defines the prototype that can be accessed by users, and raises the awareness of the data exchange system to external users.
- Define Automatic Access by Commercial Applications (lead: NASA, USA): This activity will enable automatic and fast access of resources through the information system by using commercial applications.
- Develop a Test Application (Solar Micrositing) (lead: JRC, EU): a case study in micro sitting of a solar energy system will be developed to demonstrate the benefits of the information system.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

The objective of this Subtask is to conduct essential R&D to improve the accuracy and the spatial and temporal coverage of current techniques, including the introduction of solar resource forecasting products. Key activities to meet this objective are:

- Improve Satellite Retrieval Methods for Solar Radiation Products (lead: SUNY/Albany, USA): This activity will focus on key model input parameters and methodologies, such as cloud indices, radiative transfer schemes, aerosol data retrievals, and treatment of snow and other surface albedo artifacts. The activity also addresses ways of improving the spatial resolution of satellite-derived broadband solar resource products.
- Conduct Climatological Analysis of Solar Resources (lead: NASA, USA): In order to ascertain future impacts on system performance due to climate variations, this activity includes the analysis of long-term surface and satellite-derived data sets and climate models; specifically addressing natural long-term fluctuations associated within the ocean-atmosphere system, such as the Southern Oscillation/El Nino.
- Evaluate Solar Radiation Forecasting Procedures (lead: EHF, Germany): This activity investigates different approaches for developing solar resource forecasts based on global numerical weather predictions and extrapolation of cloud motion vectors

Collaboration with other IEA Programmes

Knowledge on solar resources is highly important for all forms of solar energy applications. Therefore Task 36 is conducted as a collaborative Task together with the IEA Implementing Agreements SolarPACES (Solar Power and Chemical Energy Systems). It was agreed by both partnering Implementing Agreements, that SHC coordinates the Task. Cooperation is based on "minimum level" according to the SHC "Guidelines for Co-ordination with other Programmes."

Task Duration

The Task was initiated July 1, 2005 and will be completed June 30, 2011. At the 66th ExCo meeting in Nice, France in November 2009 the IEA/SHC ExCo granted a one-year extension of the task to allow for additional benchmarking studies and to transition the web portal from the MESoR (Management and Exploitation of Solar Resources) project to Task 36. The extension does not affect the due dates for the Task deliverables.

ACTIVITIES DURING 2009

Overall Task Activities

Progress on all aspects of Task 36 continues to be made. Progress was improved by the implementation of the EU-funded program Management and Exploitation of Solar Resource Knowledge (MESoR), which paralleled Task 36 activities and involved most of the European Task 36 participants. Project MESoR was completed in June 2009, and the results are being transitioned to Task 36. The presentations from the final MESoR symposium, held in Berlin on May 27, 2009, can be accessed at http://www.mesor.org/seminar.html.

The Task held its sixth Task Experts Meeting in Baeza (Jaén), Spain on 17-19 March 2009, hosted by the University of Jaén and CIEMAT, and its 7th Expert Meeting in Berlin, Germany on 15-17 September 2009. There was also a users' Workshop on Solar Resources held by the MESoR-consortium at the Intersolar trade fair in June in Munich, Germany. It was attended by about 50 participants who participated in a half-day of the trade fare and almost all stayed throughout the seminar. This alone is a sign that the seminar was very well received by the participants. We additionally received very positive feedback from them.

We continue to maintain collaboration with Solar PACES and with PVPS Implementing Agreements on a minimal level, according to SHC rules. Task 36 is also assigned as Task V in Solar PACES. A key presentation on Task 36 was made by the Task's SolarPACES liaison, Dr. Richard Meyer of Epuron GmbH, Hamburg, at the SolarPACES ExCo in Berlin on 13-14 September. Task reports were also submitted to the PVPS ExCo for their meetings held in April and October. The Task continues to maintain liaison with the Global Earth Observation System of Systems (GEOSS) program, and maintains strong ties with other international activities such as Global Energy and Water Experiment (GEWEX), Project GAS (GMES Atmospheric Service), and SWERA, Solar and Wind Energy Resource Assessment, a Program of the United Nations Environment Programme's (UNEP's) Division of Technology, Industry, and Economics (DTIE).

Task 36 participants submitted a number of papers technical papers to the SolarPACES Conference in Berlin on 15-17 September. The Resource Assessment sessions were chaired by Task 36 participants.

Several Task participants attended the Solar 2009 Conference in Buffalo, New York in May and gave papers on recent Task 36 activities.

Specific Technical Achievements

Subtask A: Standard Qualification of Solar Resource Products
The work accomplished and the preparations for further activities include:

Activity A1: Select and Qualify Ground Data Sets. Identification of high quality surface broadband and spectral solar measurement data sets continues. Data used in specific projects were subjected to common formatting and Quality Control (QC) procedures. These format and QC procedures are defined by DLR and CIEMAT. A first set of formats and QC have been defined as deliverable D1.1.2. Existing ground data are included in the database of the European MESoR Project. Within MESoR, a number of data sets from BSRN, IDMP and GAW, which have undergone QC and stored in a common format within the MESoR Wiki, have been gathered, and access has been granted additionally to the IEA Task participants. The data collection will be extended to the IEA Task.

NASA Langley Research Center (LaRC) has refined the quality control procedures applied to BSRN measurements. Data from all BSRN sites from 1992 to present were considered at the hourly average temporal interval (over 4 million hourly values). QC flags are provided for the global, direct normal, diffuse and total (direct horizontal + diffuse) measurements and provide a rudimentary assessment of the measurements. Changes in 2008 dealt with identifying and removing solar tracking and other measurements errors found but not properly identified in the BSRN record for solar irradiance values > 50 W-m^{-2}, using primarily the procedures of Long and Shi (2008). However, it was found that refinements to the QC flags are still insufficient to determine data quality at low sun conditions (i.e., large solar zenith angles) in the hours after and/or before sunrise/sunset. After testing several methods, it was concluded that an additional threshold test was most useful for these conditions. Thus, for solar irradiance measurements < 50 W-m$^{-2,}$ it was decided to accept values when G1 (BSRN total direct + diffuse) and G2 (unshaded pyranometer measurements) agree within +/- 15% of 50 W-m^{-2} (+/- 7.5 W-m^{-2}. A report of these findings will be submitted to Task 36 for evaluation and assessment of other high quality measurements. It is also of note that the determination of the monthly averaged fluxes contains a number of additional difficulties due to gaps in the measurements. These uncertainties and those for other averages such as hourly and daily are summarized. The result of these updated recommended

procedures will be a survey of known QC procedures and the processing of all BSRN and similar high quality data sets with similar assumptions for the production of reliable surface validation data set. Similar approaches have also been developed for the Global Energy Balance Archive (GEBA) data sets containing monthly averaged solar irradiance measurements for sites distributed worldwide.

Environment Canada and Natural Resources Canada continue to develop a CCD fiber-optic spectrometer for the measurement of global, direct, diffuse, reflected and southward-tilted irradiances. The system uses an AvaSpec-2048TEC-2 – a dual channel thermo-electric-cooled spectrometer from Avantes Incorporated. Each channel has a 2048-pixel linear array detector and the system achieves a spectral resolution of 0.7 nm (FWHM) over the spectral range 250 – 1000 nm. An example that compares broadband with spectral characteristics at the BSRN station in Regina, Canada is shown in Figure 1.

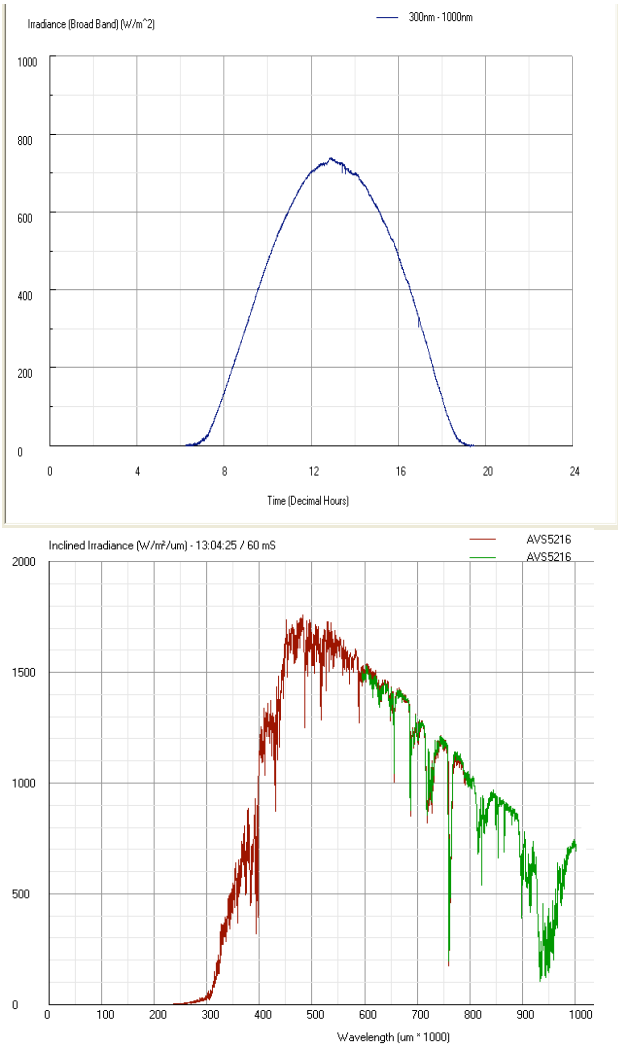


Figure 1. Broadband (300 – 1000 nm) and spectral inclined (i.e. south facing at latitude tilt) irradiance measured at the BSRN Bratt's Lake Observatory, Saskatchewan, Canada on September 19, 2009.

Activity A2: Define Measures of Model Quality for Product Validation. NASA LaRC has applied new QC procedures to measurements and tested the impact of these on the validation plots relative to BSRN measurements. These improved surface measurements are leading to a better understanding of the uncertainties of the SRB/SSE

fluxes at a variety of time scales. These will be finalized once the new QC procedures described above are completed and a report of these results will be submitted.

Activity A3: Develop Methodology for Establishing Coherent Benchmarking of Products. In recent years, there has been an increased interest in considering solar energy availability in the design process of new buildings so as to maximize its contribution to natural lighting and temperature comfort as well as energy production as hot water or electricity. Ray tracing software used for estimating the solar resource available in urban environments needs information regarding the angular distribution of luminance and radiance over the sky dome. The research carried out in UPNA focuses on developing models to estimate such information especially valuable in architecture. At present, efforts focus on radiance estimation although future work will analyze luminance models as well. Some of the results obtained have been published or presented at different congresses.
The methodology, defining common benchmarking measures was set up and published by CIEMAT and H2M.

Activity A4: Apply Benchmarking Procedures to Subtask C Products. Within the project MESoR a number of benchmarking exercises based on the collected data in A.1 and the Measures and methodology in A2. and A.3 have been defined and performed. Each set consisted of at least 10 high quality reference data sets and data from different time periods and satellites (Meteosat First and Second Generation). The results showed some dependency on the selection of the reference data sets, giving the indication that the sample of reference data is too small to derive stable results. This shows the urgent need for more high quality reference data.

A methodology for map-based cross-comparison of spatial products was used for analysis of Global irradiation and Direct Normal Irradiation (DNI) calculated from the existing data sources: HelioClim, SOLEMI, NASA SSE, PVGIS, Satel-light, Meteonorm, and EnmetSol (Figure 2). This analysis is based on the averaging of long-term averages, and uncertainty characterization from calculating of standard deviation. The following publications were presented: Comparison of global irradiation products at the EUROSUN 2008 Conference, Lisbon, October 2008, and the DNI study at the SolarPACES Conference in Berlin, September 2009.

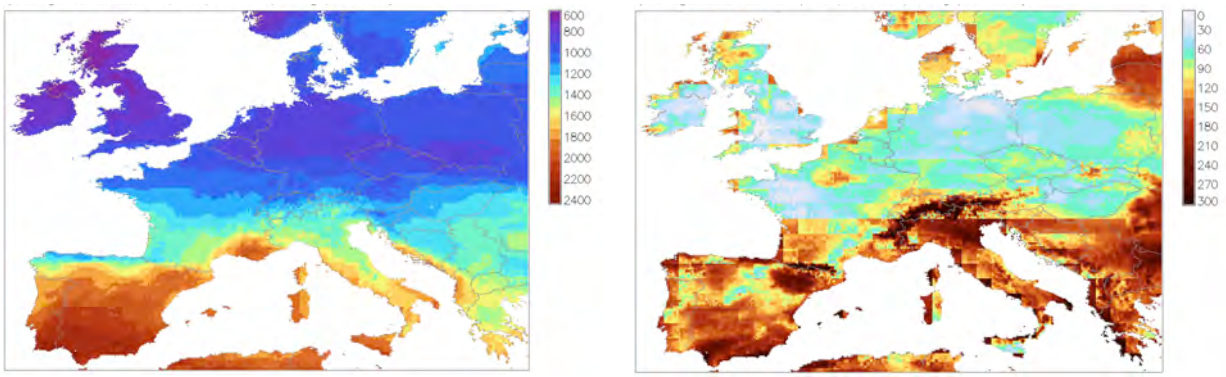


Figure 2. Yearly sum of Direct Normal Irradiation; left: average of five databases: Meteonorm, PVGIS, NASA SSE, Satel-Light, and SOLEMI [kWh/m2]; right: standard deviation calculated from five databases [kWh/m2].

A benchmarking exercise for DNI data has been performed within the German SESK project aiming at the standardization of the database for the handling of CSP projects.

This exercise has revealed that although the bias of satellite-derived data is – in the best case – negligible, the modeled data may show remarkable discrepancies concerning their distribution characteristics. Figure 3, showing the distribution functions of ground measured and satellite derived data indicated this problem.

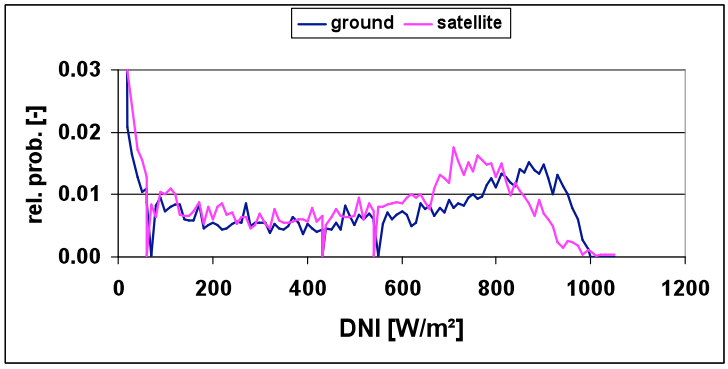
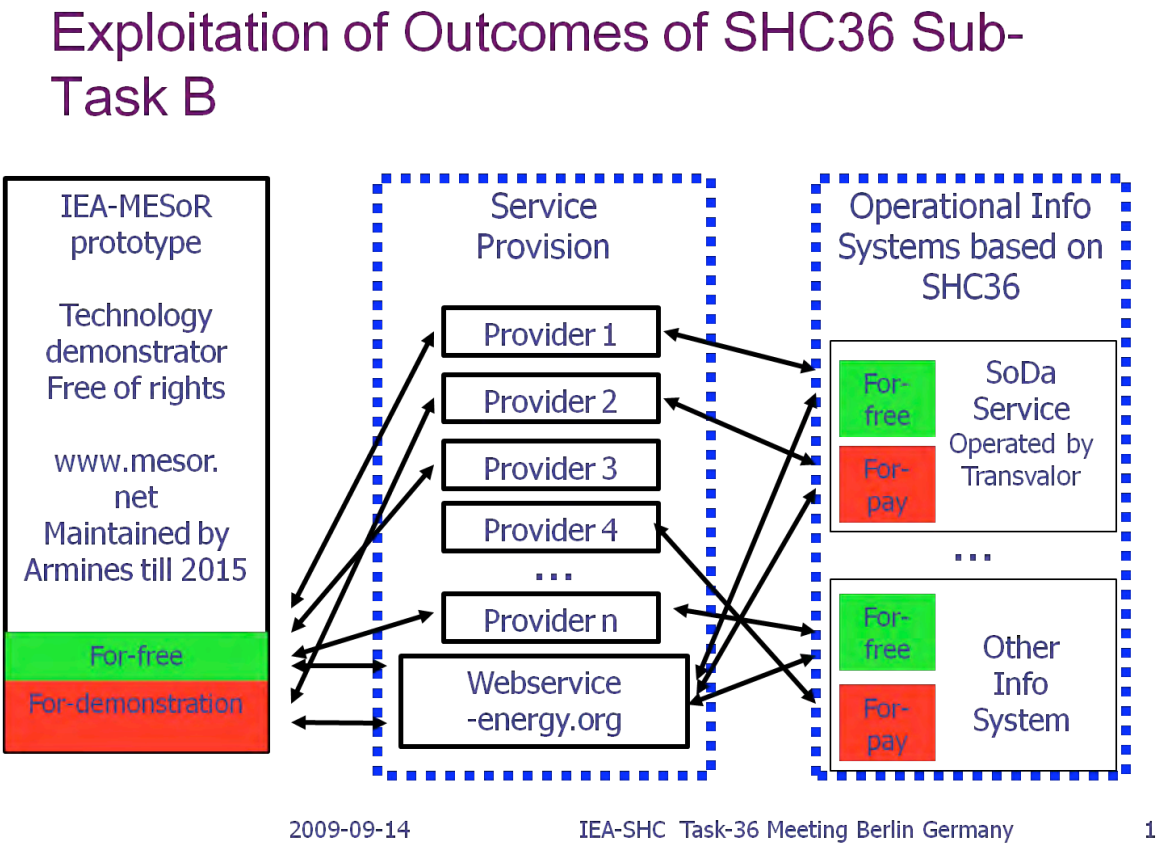


Figure 3: Indication of current insufficiencies in satellite derived data for the case of DNI-sets. The modeled set shows remarkable differences of its distribution function as compared to the one of the respective ground based set. (Source: Hammer et al., Solar PACES 2009).

Subtask B: Common Structure for Archiving, Processing, and Accessing Resource
The work plan is being pursued in several areas. Recent accomplishments that highlight work progress include:

Activity B1: Evaluate the Legal Aspects of Accessing Solar Resource Data. The planned outcome was a clearance on legal aspects about the use of data intellectual property (IPR) and Terms of Use taken into account in the prototype. This activity is completed. A document was issued in July 2009: "Report on activities B1, B3 and B4. Addressing the intellectual property rights. Addressing commercialization of data. Description of the collaborative information system". It reports on the IPR as expected; it also describes the information system and addresses the possible commercialization of data. The diagram below describes a possible schema of the exploitation of the outcomes of subtask B. The current prototype of the information system is considered as a technology demonstrator, free of rights, as it is based on COTs (components-off-the-shelf), the innovation brought by the subtask B being in the assemblage for the specific case of energy. This prototype (left portion of diagram) will be maintained by Armines till 2015; it will provide access to several services for free, and access to other commercial services on a demonstration mode. A few companies are expected to adopt the promoted technologies in order to build operational information systems (right portion of the diagram) that will access the Web services developed by the various providers on a free or commercial basis. Such a company is the French company Transvalor, which is managing the current SoDa Service, and which intends to develop the new generation of the SoDa Service on the subtask B technology and demonstrator.



Activity B2: Identification of User Requirements. This activity was completed in 2008.

Activity B3: Develop Data Exchange Protocols and Metadata. This activity was completed in 2008.

Activity B4: Develop Prototype. As reported previously, a prototype of the proposed broker portal has been established within the MESoR project, and can be accessed at http://project.mesor.net. Although the project MESoR was completed in 2009. the prototype continues to evolve. The most recent versions of the underlying technologies were installed in late 2009.

The data supplied by the providers are actually stored at the provider's premises, and can be placed into any format; data formats are not critical to the functionality of the web portal. In this way, the data providers maintain all control over the Web Services. The prototype has been deployed on a Web Services compliant platform, such as a Community Portal. An example as to how this all works for a European solar resource data set is shown in Figure 4.

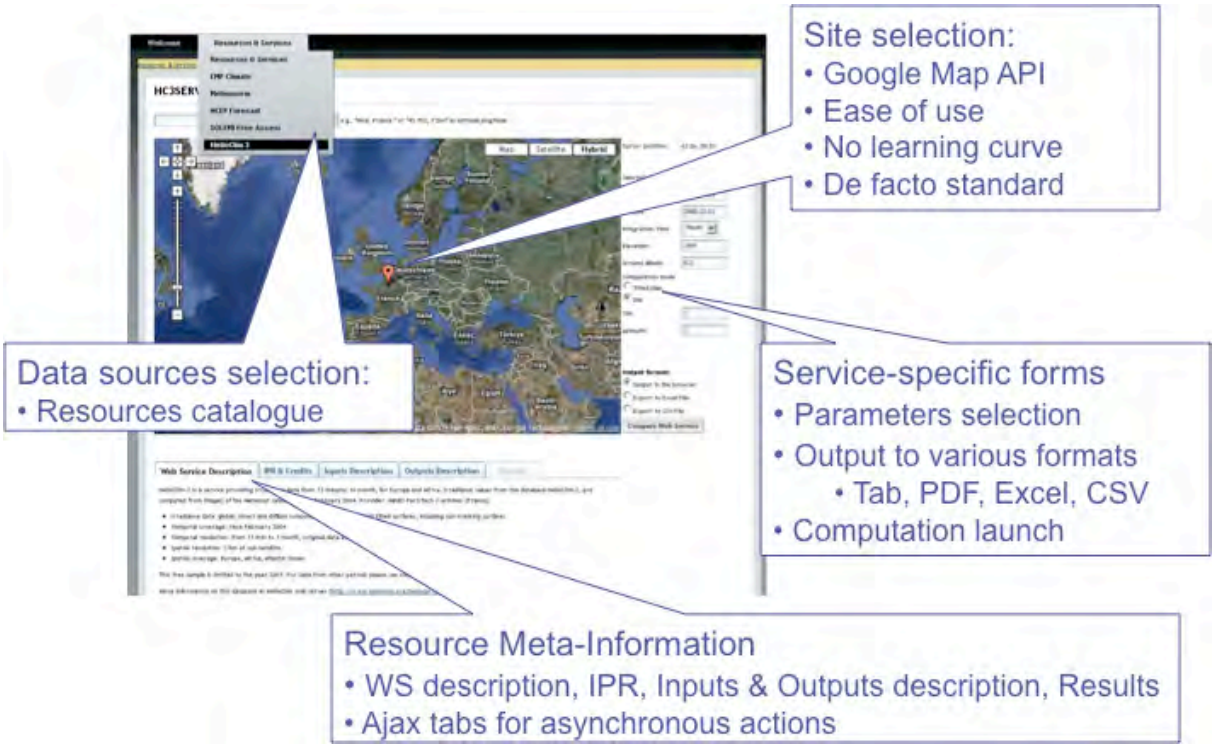


Figure 4: The prototype of the information system of Task 36 (Source: Armines).

Task 36 participants are also working closely with the Group on Earth Observations (GEO) Global Earth Observation System of Systems (GEOSS), specifically as the co-chair of the User Interface Committee (UIC), and working on the Energy Community of Practice and the Architecture Implementation Pilot-Phase 2 (AIP-2). This benefits Task 36 through collaboration with GEOSS on web portal design and with issues dealing with Intellectual Property. The involvement of the participants includes carrying forth a process of evaluating how the web portal services can be used to address specific renewable energy scenarios.

The prototype has been set up and is running continuously since Nov'08. It follows the recommendations of the ISO, EC-INSPIRE directive and GEOSS-ADC (Architecture and Data Committee). Therefore, B4 can be considered as completed though improvements and bug-corrections are dealt with regularly.

Activity B5: Develop Network of Resource Providers. The planned outcome of this activity is a network of resources, enabling the service to users. Current accomplishments:

- A tutorial for developing Web services by providers has been written, 2nd edition available Dec'08.
- A Web site (webservice-energy.org) has been developed by Armines to possibly host Web services for providers if of convenience (e.g., DLR).
- Given a new Web service (WS), Armines agrees to develop the “client”, i.e., the piece of software calling the WS, in the information system.
- Several providers already active (9 WS):
    - Meteotest, Switzerland, 2 WS
    - Meteocontrol, Germany, 1 WS
    - NCEP, USA, 1 WS
    - Armines, France, 3 WS
    - DLR, Germany, 1 WS
    - JRC, EC, 1 WS

The Web services are fully compliant with the GEOSS standards and are therefore invokable by the three GEOSS candidate-portals: ESA (Europe), ESRI (USA) and Compusult (Canada). This increases the dissemination of knowledge in solar resources. In addition, the interoperability capability of the information system -developed with GEOSS- allows also to exploit Web services already proposed by other communities, e.g., in geography. For example, Armines developed a client for scenario of plant siting by calling WS for irradiance, shadowing effects, terrain elevation, hydrography, and land use. This client is part of the information system.

In summary, B5 has already achieved the objective. Nevertheless, B5 is an on-going activity with the following issues to be addressed:

- Discussion is pending between Armines and BOM (Australia), CanMet (Canada), NREL (USA), and CENER (Spain) for the provision of WS
- NASA should take steps to contact other potential providers but is presently experiencing Internet technical problems. Solutions are being brought in connection with GEOSS and now new equipment and capabilities have been added support JBOSS and other service tools.

Activity B6: Develop Use of Prototype by Users. Two series of tests were made in 2009, in February and June, by the European project MESOR. Feedback is documented in a report that can be made available to the Task. Since the prototype of the information system is open to users, feedback is also obtained continuously by the users. B6 is essentially complete.

Activity B7, Define Automatic Access by Commercial Applications. Current accomplishments:

- Outputs of any WS are automatically formatted by the information system, to offer “standard” outputs: XLS, Text file, PDF, or HTML.
- The information system can handle GeoTIFF format, that can be ingested into a GIS (Geographic Information System).
- The output of one WS is an archive (.zip) containing several GeoTIFF files
- Automated access from computers has been tested in the SoDa Service for more than 2 years, and the “wget” tool for 1 year. This could be included in the present information system, if access to data is for free.

Activity B8, Example application using solar micro sitting in GIS. Current accomplishments:

- Modeling the effects of the small scale changes of the terrain on the irradiance (Figure 5).
- Developing tools for disaggregation (up sampling) of satellite-derived data.
- Creating tools for automatic inclusion of these effects in irradiance maps to produce high-resolution maps.
- A paper describing a disaggregation procedure has been accepted for publication in Solar Energy Journal. GeoModel implemented this procedure for calculation of interactive and poster size maps.

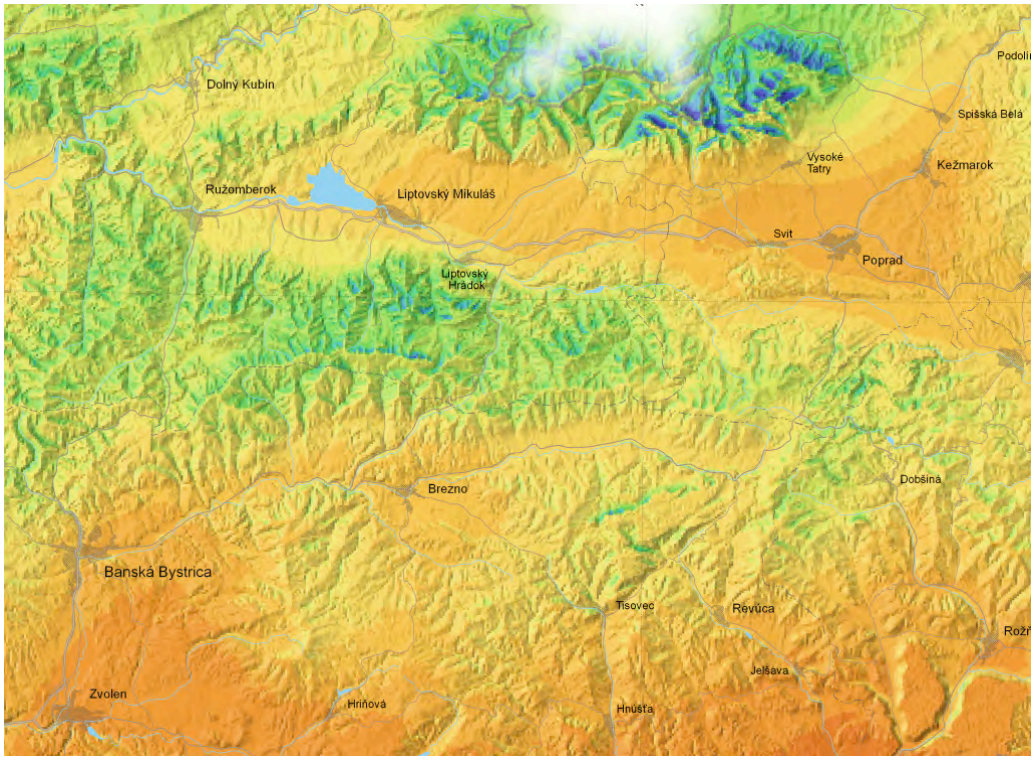


Figure 5: High-resolution map for micrositing of large PV power plants in mountainous terrain of Slovakia (source: GeoModel).

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

Activity C1: Improve Satellite Retrieval Methods for Solar Radiation Products. Several Task participants presented a paper at Eurosun 2008 outlining the uncertainties in solar radiative transfer models that result from inadequate characterization of key input parameters such as aerosols (see Eurosun paper # 406 referenced below).

DLR conducted a study on the accuracy of different satellite-based snow cover products, which are operationally available (Wirth et al., 2010). Such datasets might be used in PV surveillance schemes to avoid false alarms due to snow cover on a PV system which is falsely taken as a system breakdown in sunny conditions.

NASA has worked to address an issue regarding latitudinal discontinuities in the estimates of the monthly averaged direct and diffuse solar fluxes. The discontinuity arose due to disagreements under certain surface and solar angle conditions were two algorithms diverged. After considerable sensitivity study that included an assessment with surface measurements (after application of the new QC procedures), a weighted solution was derived. The ultimate conclusion was that the parameterizations used to estimate these fluxes will be derived and applied to the 3-hourly (full temporal resolution of the NASA data sets). The upgraded monthly averaged data sets will be made available to SSE users in 2010.

NASA is also participating in an activity to develop a methodology that uses the stability of the albedo high thick cirrus clouds to act as an additional calibration anchor for satellite imager data sets. This work is being performed jointly with the International Satellite Cloud Climatology Project (ISCCP) and the Clouds and Earth Radiant Energy System (CERES).

A new version of the satellite model for calculation of global and direct irradiances was developed by GeoModel in collaboration with SUNY. The model is based on Meteosat Second Generation (MSG) data. The background of the model is based on the principles of an operational model from Perez et al, 2002, enhancing the satellite data processing by a number of modifications and improvements based on the use of:

- Multispectral satellite information to improve classification of snow/land/cloud signals.
- Quantile regression to find lower band values - with diurnal variability.
- Variable upper bound for dynamic range and cloud index calculations.
- Improved sun glitter algorithm.
- New simplified SOLIS clear sky model.
- Disaggregation using high resolution DEM to include local variability of solar irradiance.

The work will be presented at ASES National Solar Conference in Phoenix, Arizona, May 2010. A paper on disaggregation was accepted for publication in the Solar Energy Journal. This algorithm was implemented by GeoModel to build a new commercial solar radiation database, SolarGIS, for Europe.

In parallel, Richard Perez and his team at SUNY, in collaboration with Antoine Zelenka, developed an upgrade to the North American SUNY model that substantially improves performance under snow or very high albedo conditions by making use of all four GOES infrared channels. A paper on this approach will also be presented at the 2010 ASES National conference.

Oldenburg University has been working on further improvement of their model to derive direct irradiance from satellite data in the framework of the German project SESK. In addition, Oldenburg University started to evaluate their algorithm to derive spectrally resolved irradiance. Special focus on these studies is the influence of the Spectrum on the performance of thin film photovoltaic modules. First results have been presented at the German conference "24. Symposium Photovoltaische Solarenergie".

Activity C2: Conduct Climatological Analysis of Solar Resources. NASA LaRC has continued to lead several studies assessing the long-term variability of the recently-released 23-year GEWEX SRB data set (used also for SSE Release. 6.0). Part of the analysis involves assessing the long-term anomalies from the satellite-derived estimates compared to the long-term anomalies measured at various surface sites. This work is also part of the Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment Project (RFA). The analysis involved deriving an ensemble monthly averaged surface measurement of solar irradiance from a subset of BSRN surface sites that maintained a high degree of continuity over the period from 1992 through 2007. Figure 6 illustrates the results of this study. The anomaly time series of the monthly ensemble of satellite surface irradiance estimates shows excellent correlation with the surface measurements. Several of the data sets had correlation values > 0.8 with a standard deviation of about 5 W-m^{-2}. This then gives an estimate of the relative precision of those data sets in time. The right panel in Figure 6 shows that the bias between the satellite-derived algorithms and the surface measurements appears to increase toward later years. This may be indicative of calibration issues or of insufficient treatment of some physical processes (such as aerosol properties) within the ISCCP data sets from which the various other data sets were derived. Additionally, it was found that certain BSRN sites contributed more greatly to this change than others. Surface measurement providers have re-evaluated their data sets in the light of these results.

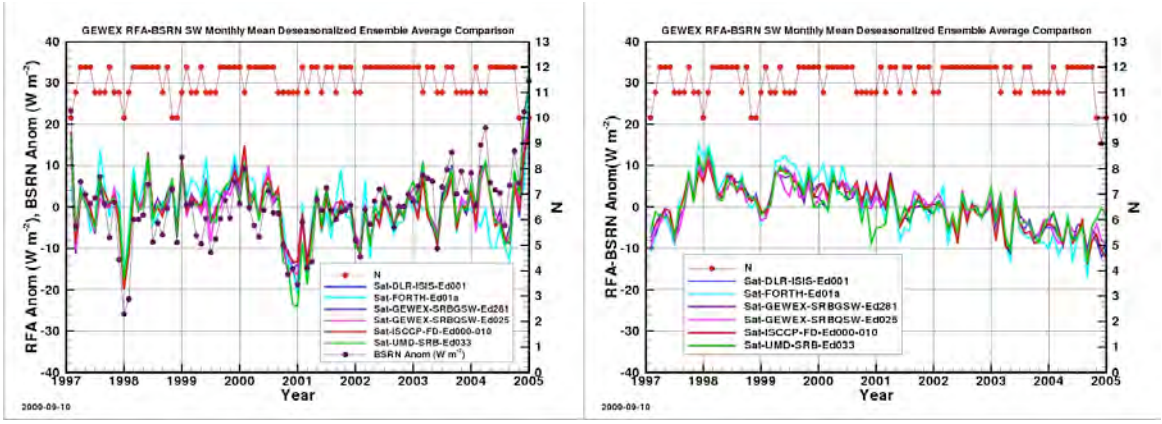


Figure 6. A comparison of the BSRN monthly averaged ensemble anomaly time series against various satellite derived algorithms of global solar irradiance. All the satellite algorithms depicted use the ISCCP intercalibrated radiance, cloud and surface reflectance properties. An ensemble of surface sites are used that represent those BSRN sites that have the most continuity between 1992 and 2007 (see right axis and red line in each panel). The left panel shows the anomaly time series of the ensemble averages showing very good correlation. The right panel shows the relative bias between the BSRN ensemble averages (black lines with filled circles) and the satellite ensemble average (colored lines) for each satellite algorithm as labelled.

Activity C3: Evaluate Solar Radiation Forecasting Procedures. A major emphasis in Subtask C during the year 2009 was the testing and benchmarking of various solar irradiance forecasting approaches.

The benchmarking of eight different forecasting algorithms for several regions in Europe for the period1 July 2007 to 30 June 2008 has been finalized as a joint effort of the European partners. Results have been presented at the 24th European Photovoltaic Solar Energy Conference and Exhibition in Hamburg, and selected results also at the Solar PACES 2009 in Berlin. Figure 7 gives an overview on the locations of the ground measurement stations used for the benchmarking, and Table 1 gives an overview on the forecasting approaches of the task members with the used NWP models.

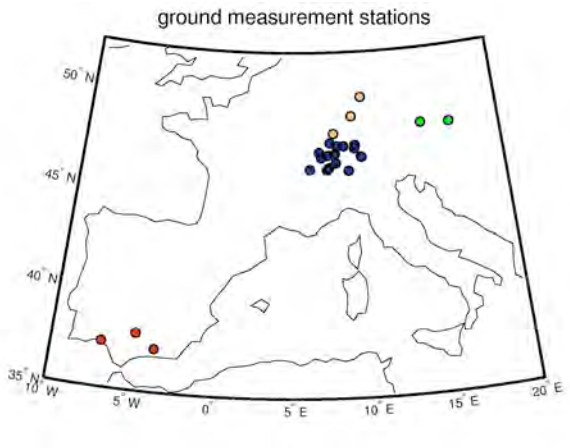


Figure 7: Locations of ground measurement stations for the benchmarking of forecasts. Red: Spanish stations, orange: German stations, blue: Swiss stations, green: Austrian stations.

Team	Approach	NWP model with spatial and temporal resolution
University of Oldenburg, German	Statistical post-processing in combination with a clear sky model	ECMWF - 0.25°x 0.25° - 3 hours
Blue Sky, Austria,	a)"human" cloud cover forecast (by meteorologists) b) BLUE FORECAST: statistic forecast tool	for b) GFS - 1° x 1° and 0,5°x 0.5° - 3 hours and 6 hours
Meteo-control, German	MOS (model Output Statistics) by Meteomedia GmbH	ECMWF - 0.25°x 0.25° - 3 hours
Ciemat, Spain	Bias correction	AEMet-HIRLAM - 0.2°x 0.2° - 1 hour
CENER, Spain	Post-processing based on learning machine models	Skiron/GFS - 0.1°x 0.1° - 1 hour
Meteotest, Switzerland	Direct model output of global irradiance, averaging of 10x10 pixels	WRF/GFS - 5km x 5km - 1 hour
University of Jaen, Spain	Direct model output of global irradiance	WRF/GFS - 3km x 3km - 1 hour

Table 1: Overview on forecasting approaches of the European partners.

Absolute root mean square error (rmse) values for the different approaches are given in Figure 8 for the countries (Germany, Switzerland, Austria, and Spain). The evaluation revealed a strong dependence of the forecast accuracy on the climatic conditions. For central European stations the relative rmse ranges from 40% to 60%, for the Southern Spanish stations relative rmse values are in the range of 20% to 35%. At the current stage of research, irradiance forecasts based on global model numerical weather prediction models in combination with post-processing show best results. All proposed methods perform significantly better than persistence.

In addition to the benchmarking studies for Europe, SUNY and CanMet are continuously evaluating forecasts at high quality ground stations in the U.S. and Canada (see, e.g., the paper by Perez et. al presented at Solar 2009). In addition to some of the forecast models shown in Figure 2, the U.S. is evaluating the National Digital Forecast Database (NDFD). Environment Canada has been evaluating the Canadian Meteorological Centre's GEM solar forecasts. Global horizontal irradiance forecast data from April 2007 to June 2008 has been compared to observed irradiance at 10 North American sites. The GEM forecasts have also been provided to Richard Perez (SUNY Albany) as part of the US portion of the international solar forecast benchmarking exercise.

Besides the benchmarking exercises all Task members involved to irradiance forecasting are continuously working on further development of the forecasting algorithms with respect to forecasting global irradiance. Some institutes (DLR; University of Jaen, University of Oldenburg) also started or continue research with respect to direct irradiance forecasts.

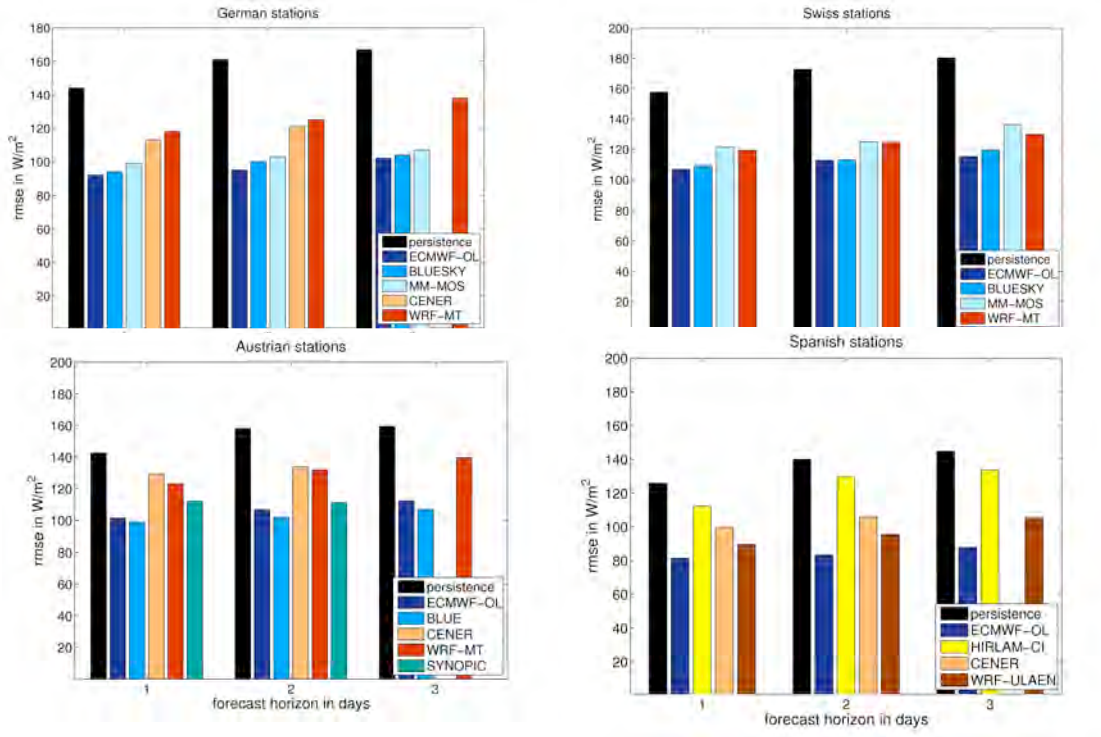


Figure 8: Rmse for the first, second, and third forecast day for stations from Germany (lmean=227 W/m2), Switzerland (lmean=267W/m2), Austria (lmean=222W/m2), and Spain (lmean=391W/m2).

Furthermore different applications of the forecasts are investigated, e.g power forecast for PV systems or solar thermal power plants, or the use of forecast information for load management for the integration of a solar thermal power plant into an existing district heating grid. A short overview on the forecasting activities of the different task members is given in the next paragraphs.

DLR started a feasibility study in collaboration with Solar Millennium AG on the use of Earth observation and satellite communications in a forecasting system for Concentrating Solar Power (CSP) plants as e.g. Andasol. The work is funded by the European Space Agency in its Integrated Application Program (IAP).

Environment Canada and Natural Resources Canada have partnered to evaluate the Canadian Meteorological Centre's GEM solar forecasts, and to develop and test photovoltaic power generation forecasts based on these. In addition to the benchmarking studies, these data have been used to develop photovoltaic forecasts for one location, and have been compared to actual PV power output over an 8-month period.

CENER was working on a solar global irradiance prediction scheme mainly based on the regional weather forecasting system Skiron. This weather forecasting system was developed at the Helenic National Meteorological Service and is used at CENER with initial and GFS boundary conditions, which provide a 1º x 1º horizontal resolution. The execution of Skiron implemented in CENER generates weather forecasts in a grid with a resolution of 0.1º x 0.1º and hourly frequency. The spatial domain includes Europe and

North African regions. To increase the accuracy of the global irradiance predictions, CENER applies a statistical post process based on learning machines.

CIEMAT forecasts are based on time series analysis techniques to obtain half daily values of solar irradiance. The techniques that are being tested are based on autoregressive, neural network and ANFIS models using as predictor clearness index and lost component of accumulated half daily values of solar irradiance divided by solar noon (see Martin et al, CIES 2008, and Martin et al, SOLARPaces 2009,). These authors have also developed studies showing the use of new predictors as input to the statistical models. It is possible to improve predictions from time series models using qualitative information from numerical models describing future states of the atmosphere like cloud cover forecasts (see Martin et al, Eurosun 2008, paper #180).

The model of CIEMAT is based on predictions of the HIRLAM operational model from the Spanish weather service (AEMet). The temporal resolution of the model is 1 hour for the next 72 hours and the spatial resolution is 20 km x 20 km. The solar irradiance predictions of the model are corrected subtracting the bias obtained from a dataset independent of the benchmarking period.

The University of Jaen is using a recent version of the WRF model (version 3) using initial and boundary conditions from the NOAA National Climatic Data Center (NCDC) Global Forecast System (GFS). Calculations for Andalusia, Southern Spain are performed with very high spatial (3 km x 3 km of the final inner domain) and temporal resolution. The integration time step was set to 30 seconds and the time step between successive calls to the radiation scheme was set to 60 seconds. Special focus of the team at the University of Jaen was the investigation of the physical parameterizations of the WRF model, in order to achieve improved irradiance forecasts. Also a model to forecast direct irradiance is currently under development, combining WRF forecasts with a post-processing scheme based on radiative transfer modeling.

BlueSky Wetteranalyzen (Austria) was investigating an operating two forecasting schemes. The first “traditional” method is a result of operational synoptic cloud cover forecasts, using different global and local NWP models in combination with the expert-knowledge of meteorologists. This approach is applicable only for the Austrian stations. The more general second approach is a result of statistical post-processing applied to the GFS-NWP model using different methods of data mining like ridge digression, automatic quadratic models or neuronal networks, based on meteorological inputs.

ASiC is investigating the use of forecast information by BlueSky for the load management for integration of a solar thermal power plant into an existing district heating grid.

Meteotest is working with two different approaches to forecast global irradiance. Results of the WRF model have been provided to the benchmarking exercise. Since the beginning of 2009 also a Model Output Statistics (MOS) system in combination with GFS data is in operation.

Oldenburg University is continuing the investigation of post processing procedures to improve ECMWF global irradiance forecasts. In addition, first studies on the use of ECMWF irradiance and cloud cover forecasts in combination with a statistical model to derive direct normal irradiance have been carried out in the framework of a diploma thesis.

WORK PLANNED FOR 2010

During 2009 efforts began to summarize the results of Task 36 through a Handbook on Solar Radiation. This Handbook, scheduled to be published in mid-2010, at the time of the original completion date for Task 36, is the major deliverable of Task 36. The Handbook will summarize the major findings of each of the three Subtasks and the Activities within these Subtasks, and provide a review of future work that can be accomplished.

Because there are still some ongoing work requirements in the development of the Web Portal (Subtask B) and the benchmarking activities (Subtask A), the IEA/SHC ExCo has agreed to extend the end date of Task 36 by one year, to 30 June 2011. In the mean time the Task Participants prepared a Concept Paper for a new task that would begin in 2011. The Concept Paper, titled "New Task on Solar Resource Assessment and Forecasting", proposes three Subtasks: 1) Solar Resources for High Penetration Solar Applications; 2) Benchmarking and Integrations of Various Solar Resources; and 3) Information System for Access to Solar and Weather Data. At the 66th Meeting of the ExCo in Nice, France in November 2009 the ExCo agreed for the Task Participants to hold a Task Definition Workshop for this new task. The Task Definition Workshop will take place at the Headquarters of the International Energy Agency in Paris, France on 10-11 March, immediately following the 8th Task Experts meeting.

Subtask A: Standard Qualification of Solar Resource Products

Activity A1: Select and Qualify Ground Data Sets

As described above and in previous sections, benchmarking activities will continue, with additional data sets being included in the benchmarking process. NASA will report latest quality control procedures and coordinate with procedures of other institutions for the "Best Practices" report.

Activity A2: Define Measures of Model Quality for Product Validation

The German Ministry of Environment (BMU) funds the project SESK, which aims to propose standards for yield assessments for solar thermal power plants. The main processes for bankable yield prognosis reports shall be developed and tested. Emphasis is on high quality solar resource data, which will be derived from two independent long-term satellite data sets and verified by ground-based measurements at the site. Within this activity a scheme to deal with the problems arising by the incorrect distribution properties of the modeled data sets is under development. The project is coordinated by EPURON and involves DLR, Oldenburg University, H2M, and the certification institution TÜV Rheinland Energiesysteme. Preliminary results from this project were presented by Meyer et al. (2009) at the SolarPACES Symposium in a paper entitled "Towards standardization of CSP yield assessments."

NASA will provide the latest direct/diffuse version to the task with latest uncertainty statistics relative to surface measurement networks.

Activity A4: Apply Benchmarking Procedures

Benchmarking of spatial (map) products of Direct Normal Irradiance was finalized in 2009 for the European subcontinent to provide a relative estimate of the user's uncertainty when assessing potential yearly energy yields. The data products of the following producers were considered: DLR (Solemi), University of Oldenburg, ENTPE (Satel-light), JRC (PVGIS), Meteotest (Meteonorm) and NASA (SSE).

Based on MESor and Task 36 standards, validation of the new solar radiation database for Europe - SolarGIS - will be finalized in early 2010.

DLR offered to share some of its satellite data to set up a common benchmarking exercise for time series products for all model developers.

Subtask B: Common Structure for Archiving, Processing, and Accessing Resource

In the coming period, only Activities B5, B7 and B8 will be active. The prototype of the information system will be maintained; improvements and bug-corrections will be brought regularly as reports on defects are received. Currently there are six providers available to the prototype web portal. Efforts will be made by NASA and Armines to recruit additional providers. In the mean time the operability of the prototype will continue to be tested, especially in conjunction with GEOSS and companies for automated access. JRC will test the portal using a micro-siting example. The SolarGIS database will go online and links to the prototype will be made.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

Activity C1: Improve Satellite Retrieval Methods for Solar Radiation Products
New aerosol products from European projects GEMS and MACC (Monitoring Atmospheric Composition and Climate) in the satellite algorithm will be tested by GeoModel. The targeted application is monitoring of PV power plants.

In the course of the German project SESK, Oldenburg University is revising their satellite retrieval with focus on optimized DNI derivation. Hammer et al. published the first results in the 2009 SolarPACES proceedings. Within SESK DLR also is improving their algorithms with the aim to produce higher quality beam irradiance data. In both cases the main improvement is expected by applying aerosol data of higher quality. A second focus of Oldenburg University will be further development and validation of their procedure to derive spectrally resolved irradiance.

DLR is extending its cloud physical parameter database from Meteosat Second Generation satellites from 2004 to 2009. A 5-year statistical procedure optimized for solar energy users is under development.

DLR is creating a 1984 to 2009 global aerosol data set (MATCH chemical transport model) with hourly temporal resolution on a 1.9° grid as an input layer for improved clear sky models in satellite-based irradiance databases (e.g. SOLEMI, Helioclim-4).

DLR and Armines started to establish solar irradiance databases as part of the European GMES (Global Monitoring of Environment and Security) in the EC project MACC.

Activity C2: Conduct Climatological Analysis of Solar Resources
NASA is continuing its participation in the GEWEX Radiative Flux assessment project that specifically considers long-term solar data sets for a climate analysis context. Identified uncertainties from this project will be used to better quantify uncertainties of the current resource products. In addition, NASA will be analyzing its latest long-term data set to quantify the variability at various temporal scales. A report pertinent to the solar industry first for the United States and then on a global basis will be produced. NASA will coordinate the writing of the section in the “Best Practices” guide on summarizing the results of long-term studies from task participants.

Meyer et al (2009) proposed a method for estimation of the uncertainty of the long-term average depending on the number of years available at a specific site along with the quality of the underlying data sets.
Hoyer-Klick et al. (2009) introduced a new method for preparation of site-specific meteorological years. The presented method allows using undistorted ground-based measurements in high temporal resolution, which well match the long-term monthly average solar irradiation derived from combination with satellites.

CENER has developed a methodology to estimate the most probable monthly and annual values of radiation in a concrete emplacement. This method includes the information coming from all free data bases which information about the location or near to it. (Gastón et al (2009))

Activity C3: Evaluate Solar Radiation Forecasting Procedures
The major focus of the next period will be the completion of the final report on C3 activities and the forecasting contribution to the "Handbook of Solar Resources". In addition, the task participants will continue with the evaluation and further development of the different forecasting algorithms.

Oldenburg University is continuously working on further development of their forecasting procedure based on statistical post processing to ECMWF forecasts.

NREL working with SUNY/Albany will continue and expand the model intercomparison and validation work initiated with NASA. In particular a nation-wide systematic evaluation of short and medium term operational forecasts will be undertaken.

Natural Resources Canada will work on different approaches for post-processing photovoltaic forecasts, and test the photovoltaic forecasts developed against PV power output data from a few Canadian PV systems. Natural Resources Canada will also test three global horizontal forecasts (ECMWF, advanced-WRF and GEM) against data at three Canadian locations as part of the international benchmarking effort. Environment Canada will also evaluate the new solar forecasting model being implemented by the Canadian Meteorological Centre, which will include direct, diffuse and spectral irradiance forecasts.

DLR will continue its research work on coupling different information sources for an optimized direct irradiance forecasting with focus on the Mediterranean region.

The University of Jaén group will evaluate the performance of the WRF NWP in forecasting the global radiation in southern Spain at very high spatial and time resolution. In addition, this group will continue its research to derive the direct normal irradiance forecast based on the global radiation forecast provided by the WRF model.

CIEMAT will continue its efforts developing its solar irradiation forecasting system based on time series analysis. It is planned to include in the predictions information from global forecasting models like GFS to generate hourly predictions with a temporal horizon of up to 72 hours.

CENER will continue with developing of their irradiance forecast system. It is based on the nwp model SKIRON and in some post processes based on Learning Machines. CENER's goal is to include a model to produce short term forecasts.

LINKS WITH INDUSTRY

Several small companies are directly participating in the Task: Suntrace GmbH, Meteotest, Blue Sky Wetteranalyzen, and recently a company formed by two Task participants, GeoModel. s.r.o. Another task participant has formed a cooperative arrangement with Clean Power Research in the U.S. to market satellite-derive data. The audience for the results of Task 36 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.

REPORTS/PAPERS PUBLISHED IN 2009

The following presentation was given by Task 36 participants at the American Meteorological Society Annual meeting, Phoenix, Az, USA, 11-15, January 2009:

Stackhouse, P.W. Jr., W. S. Chandler, C.H. Whitlock, J. M Hoell, D. Westberg and T. Zhang. “Using NASA Satellite and Model Analysis for Renewable Energy and Energy Efficiency Applications.” 16th Conference on Satellite Meteorology and Oceanography, American Meteorological Society Annual Meeting, Phoenix, Arizona, 11-15 January, 2009

The following presentations by Task 36 participants were given at the German 24. Symposium Photovoltaische Solarenergie, 4.3.-6.3. 2009, Bad Staffelstein, Germany.

Lorenz, E., Heinemann, D., Beyer H. G. und Schneider, M., ‘Solarleistungsvorhersage zur Netzintegration von Solarstrom’

T. Behrendt, A. Hammer, E. Lorenz, D. Heinemann: 'Spektrale Solarstrahlung aus Satellitendaten zur Bewertung des Leistungsverhaltens von Dünnschicht-Solarzellen'

The following presentations by Task 36 participants were given at the 33rd International Symposium on Remote Sensing of Environment, ISRSE 33, Stresa, Italy, May 4-8, 2009.

Ménard, Lionel, Wald, Lucien, Blanc, Philippe, and Ranchin, Thierry. Sitting of a solar power plant: development of Web service based on GEOSS data and guidance.

Oumbe, Armel, Blanc, Philippe, Ranchin, Thierry, Schroedter-Homscheidt, Marion, and Wald, Lucien. A new method for estimating solar energy resource.

At the National Solar Conference 2009 in Buffalo, NY (sponsored by the American Solar Energy Society), 13-15 May, the following papers were presented:

“Status of Task 36 Solar Resource Knowledge Management Under the International Energy Agency Solar heating and Cooling Programme”, by D. Renné, NREL

“Validation of Short and Medium Term Operational Solar Radiation Forecasts in the U.S.”, by R. Perez, S. Kivalov, J. Schlemmer, and K. Hemker, Jr., SUNY/Albany

“Relative Data Accuracy of 1-Minute and Daily Total Solar Radiation Data for 12

Global and 4 Direct Solar Radiometers", by D. Myers and S. Wilcox, NREL

""Spatial and Temporal Variability in the Solar Resource: Assessing the Value of Short-Term Measurements at Potential Solar Power Plant Sites", by C. Gueymard, Solar Consulting Services, and S. Wilcox, NREL.

"Comparison of Historical Satellite Based Estimates of Solar Radiation Resources with Recent Rotating Shadowband Measurements", D. Myers, NREL

"Validation of the SUNY Satellite Model in a Meteosat Environment", by R. Perez and J. Schlummer, SUNY/Albany, and D. Renné, R. George, and S. Cowlin, NREL.

The following papers were presented at the 24th European Photovoltaic and Solar Energy Conference and Exhibition, Hamburg, Germany, September, 2009.

Huld T., Gottschalg R., Beyer H. G., Topić M.2009. Mapping the performance of PV modules of different types. Proceedings of the 24th European Photovoltaic Solar Energy Conference and Exhibition, 21-25 September 2009, Hamburg, Germany

Huld T., Sample T, Dunlop E.D.2009. A Simple Model for estimating the influence of spectrum variations on PV performance. Proceedings of the 24th European Photovoltaic Solar Energy Conference and Exhibition, 21-25 September 2009, Hamburg, Germany

Lorenz, E., Remund, J., Müller, S.C., Traunmüller, W., Steinmaurer, G., Pozo, D., Ruiz-Arias, J.A., Fanego, V.L., Ramirez, L., Romeo, M.G., Kurz, C., Pomares, L.M., Guerrero, C.G.: 'Benchmarking of different approaches to forecast solar irradiance',

At the 2009 SolarPACES Symposium held September 15-18 in Berlin, Germany the Operating Agent and the SolarPACES Task representative organized two sessions on solar resources. The following papers were submitted and published by Task Participants:

Fernández-Peruchena1, C. M., Ramirez, L. Pagola, I., Gaston, M., Moreno, S., Bernardos, A. : Assessment of models for estimation of hourly irradiation series from monthly mean values.

Gastesi, R. Iñaki Bernad, Xabier Olano, Lourdes Ramírez, and Manuel Blanco: A new BSRN station in the North of Spain.

Gastón, M., Lorenz, E., Lozano, S., Heinemann, D., Blanco, M., Ramírez, L.: Comparison of global irradiance forecasting approaches.

Gastón, M., Pagola, I., Fernandez, C., Ramírez, L., Mallor, F.: A new adaptive methodology of global-to-direct irradiance base don clustering and kernel machines techniques.

Geuder, N., Janotte, N., Wilbert, S.: Precise measurements of solar beam irradinace through improved sensor calibration.

Hammer, A., Lorenz, E., Kemper, A., Heinemann, D., Beyer, H.G., Schumann, K.,, Schwandt. M.: Direct normal irradiance for CSP based on satellite images of Meteosat Second Generation.

Hoyer-Klick, C., Beyer, H. G., Dumortier, D., Schroedter-Homscheidt, M., Wald, L. Martinoli, M. ,Schilings, C. Gschwind, B., Menard, L., Gaboard, E., Polo, J., Cebecauer, T., Huld, T., Scheidtsteger, T., Suri, M, de Blas, M, Lorenz, E., Kurz, C. Remund, J., Ineichen, P., Tsvetkov, A., Hofierka, J.: MESoR - Management and exploitation of solar resource knowledge.

Hoyer-Klick, C., Hustig, F., Schwandt, M., Meyer, R.: Characteristic meteorological years from ground and satellite data. SolarPACES Symposium, Berlin, Germany.

Lara-Fanego, V.. Pozo-Vazquez, A.D., Ruiz-Arias, J. Santos-Alamillos, F. Alsamamra, H. Tovar-Pescador, J.: Forecasting solar irradiance using NWP models: an evaluation study in Andalusia (Southern Spain).

Martín, L., Zarzalejo, L. F., Polo, J., Navarro, A., Marchante, R.: Comparison of statistical predictive techniques applied on time series of half daily clearness index

Meyer, R., Beyer, H. G., Fanslau, J., Geuder, N., Hammer, A., Hirsch, T., Hoyer-Klick, C., Schmidt, N., Schwandt, M.: Towards standardization of CSP yield assessments.

Moreno, S., Silva, M. Fernández-Peruchena, C. M., Pagola, I.: Comparison of methodologies to estimate direct normal irradiation from daily values of global horizontal irradiation.

Pagola, I. Gastón, M. Fernadez, C. Torres, J.L., Silva, M.A., Ramírez, L.: Comparison and fitting of several global to beam irradiance models in Spain.

Pape, B. Batlles, J., Geuder, N. Zurita Piñero, R., Adan, F., Pulvermueller, B. : Soiling impact and correction formulas in solar measurements for CSP projects.

Pulvermueller, B., Schroedter-Homscheidt, M., Pape, B., Casado, J., Riffelmann, K.J.: Analysis of the requirements for a CSP energy production forecasting system.

Šúri, M., Remund, J., Cebecauer, T. , Hoyer-Klick, C., Dumortier, Huld, T., Stackhouse, Jr., P.W., Ineichen, P.: Comparison of direct normal irradiation naps of Europe.

Trieb, F., Schillings, C. O'Sullivan, M. Pregger, T. Hoyer-Klick,C.: Global Potential of Concentrating Solar Power.

At the V Congreso Nacional y II Congreso Ibérico Agroingeniería, September 28-30 2009, Lugo (Spain) the following papers were presented:

Gracia A.M, Torres J.L, de Blas M, de Francisco A (2009): Comparación enter distintos procedimientos de control de calidad de datos de irradiancia (Comparison of different procedures for quality control of irradianice data)

Gracia A.M, Torres J.L, García A, Illanes R (2009) Aplicación del modelo de Perez de distribución angular de radiación. Diferentes variantes (Implementation Perez's model for angular distribution of radiation. Different versions)

At the ISES Solar World Congress 2009, October 11-14, Johannesburg (South Africa) the following was presented:

García A, Torres J.L, de Blas M, Gracia A.M, Huarte A, Garrués A, Vargas G, Baigorrotegui L (2009) Determination of solar radiation in the urban environments supported by a GIS considering the obstacles incidence (poster)

Sengupta, Manajit, Istvan Laszlo, William Straka, Andy Heidinger, Steven Miller and David Renné (Presenter): Toward a physically based, high resolution surface solar irradiance climatology from geostationary satellites.

The following presentations by Task 36 participants were given at the American Geophysical Union Annual Meeting, San Franciso, CA, USA, Dec 14-18, 2009:

Eckman, Richard S, Paul W Stackhouse, 2009: Space-Based Earth Observations: Informing Energy Management Decision Making. American Geophysical Union Fall Meeting, San Francisco, California, Dec. 14-18. (LF-99)

Hoell, James, Paul W. Stackhouse, Jr., William S. Chandler, Charles H. Whitlock, David Westberg and Taiping Zhang, 2009: Using NASA Satellite and Model Analysis for Renewable Energy and Energy Efficiency Applications. American Geophysical Union Fall Meeting, San Francisco, California, Dec. 14-18.

A Peer-reviewed paper from the Task in the IEEE Journal of Special Topics in Earth Observations and Remote Sensing in its issue 2.1 was published 2009

Lorenz, E; Hurka, J; Heinemann, D, Beyer H.G.: 'Irradiance Forecasting for the Power Prediction of Grid-Connected Photovoltaic Systems', IEEE Journal of Special Topics in Earth Observations and Remote Sensing, 2, 2–10 (2009).

One paper will be published in Progress in Photovoltaics: Research and Applications

Huld T., Cebecauer T., Šúri M., Dunlop E. D., 2009. An analysis of one-axis tracking strategies for PV systems in Europe. Progress in Photovoltaics: Research and Applications (in press)

A paper published in the Journal of Applied Meteorology and Climatology

Breitkreuz, Hanne und Schroedter-Homscheidt, Marion und Holzer-Popp, Thomas und Dech, Stefan (2009) *Short Range Direct and Diffuse Irradiance Forecasts for Solar Energy Applications Based on Aerosol Chemical Transport and Numerical Weather Modeling.* Journal of Applied Meteorology and Climatology , 48 (9) , Seiten 1766-1779. DOI: 10.1175/2009JAMC2090.1

An article published in International Journal of Remote Sensing

Abdel Wahab M., El Metwally M., Hassan R., Lefèvre M., Oumbe A., Wald L., Assessing surface solar irradiance in Northern Africa desert climate and its long-term variations from Meteosat images. International Journal of Remote Sensing, 31(01), 261 – 280, 2009. doi: 10.1080/01431160902882645.

A paper published in the Journal of Geophysical Research: Atmospheres.

Hinkelman, Laura M.; Stackhouse, Paul W., Jr.; Wielicki, Bruce A.; Zhang, Taiping; Wilson, Sara R., 2009: Surface insolation trends from satellite and ground measurements: Comparisons and challenges *J. Geophys. Res.*, **114**, D00D20, doi:10.10129/2008JD011004, 15 August.

A paper accepted for publication by the Renewable Energy Journal

Gastón, Martín and Pagola, Iñigo and Fernánde, Carlos and Moreno, Sara and Ramírez, Lourdes(2009) *New methodology of solar radiation evaluation using free access Data Bases in specific Locations.*Renewable Energy Journal

Two papers published in Renewable Energy

Torres JL., García A., de Blas M., Gracía AM., Illanes R., 2010. A study of zenith radiance in Pamplona under different sky conditions. Renewable Energy, 35(4), 830-838. (doi: 10.1016/j.renene 2009.08.026)

Torres JL., de Blas M., García A., de Francisco A., 2010. Comparative study of various models in estimating hourly diffuse solar irradiance. Renewable Energy, 35(6), 1325-1332. (doi: 10.1016/j.renene 2009.11.025)

One paper published in Journal of Atmospheric and Solar Terrestrial Physics

Torres JL., de Blas M., García A., Gracia AM., de Francisco A., 2010. Sky luminance distribution in Pamplona (Spain) during the summer period. Journal of Atmospheric and Solar Terrestrial Physics (doi: 10.1016/j.astp 2009.12.005)

Other publications:

Hoyer-Klick, Carsten, Trieb, Franz, Schillings, Christoph, Wald, Lucien, Huld, Thomas, and Schroedter-Homscheidt, Marion. Getting solar energy to work: resource assessment by remote sensing as a base for investment decisions. Earthzine, 5 May 2009. Available on line : < www.earthzine.org/2009/05/05>

T. Huld, T. Cebecauer, M. Šúri, 2009**.** Performance of single-axis tracking photovoltaic systems in Europe. Photovoltaics International, Edition 6, November 2009, 155-159.

J.A. Ruiz-Arias, J. Tovar-Pescador, D. Pozo-Vázquez, H. Alsamamra (2009). comparative analysis of DEM-based models to estimate solar radiation in mountainous terrain Autores
International Journal of Geographical Information Science, Vol. 23:8, pp. 1049 - 1076

H. Alsamamra, J.A. Ruiz-Arias, D. Pozo-Vázquez, J. Tovar-Pescador (2009). A comparative study of ordinary and residual kriging techniques for mapping solar radiation over southern Spain. Agricultural and Forest Meteorology, Vol. 149:8, pp. 1343 - 1357

Ruiz-Arias, J., D. Pozo-Vázquez, N. Sánchez-Sánchez, J.P. Montávez, A. Hayas-Barrú, J. Tovar-Pescador (2008). An evaluation of two MM5-PBL parameterizations for solar radiation and temperature estimation in the South-Eastern area of the Iberian Peninsula

Ruiz-Arias J.A., Alsamamra H., Tovar-Pescador J. and D. Pozo-Vázquez, Proposal of a regressive model for the hourly diffuse solar radiation under all sky conditions, Energy Conversion & Management, Article in Press, http://dx.doi.org/10.1016/j.enconman.2009.11.024

MEETINGS IN 2009

Sixth Experts Meeting
17-19 March
Baeza (Jaén) Spain

This meeting focused on a review of Task activities and results in preparation for developing the final task deliverables; there will also be discussions of extending the task beyond July 2010 with additional scope

Seventh Experts Meeting
September, 2009, Berlin, Germany

This meeting developed a detailed outline of the final report. A concept paper for a new task was prepared for submission to the IEA/SHC ExCo.

Project MESoR Symposium
27 May
Berlin, Germany

MEETINGS PLANNED FOR 2010

Eighth Experts Meeting
9-10 March
Paris, France

Ninth Experts Meeting
To be decided

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Task 37

Advanced Housing Renovation With Solar And Conservation

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TASK DESCRIPTION

Buildings are responsible for up to 35 percent of the total energy consumption in many of the IEA participating countries. Housing accounts for the greatest part of the energy use in this sector. Renovating existing housing offers an enormous energy saving potential.

The Task objective is to develop a solid knowledge base on how to renovate housings to a very high energy standard and to develop strategies which support market penetrations of such renovations. Task 37 will include both technical R&D and market implementation as equal priority areas.

The Task will begin by analyzing the building stock in order to identify building segments with the greatest multiplication and energy saving potential. Examples of building segments are year of construction, type of buildings, type of envelope and components. Within these segments important topics for discussions are: - ownership and decision structures, inhabitants and their characteristics and actual groups of retrofit market players.

In parallel, exemplary renovation projects achieving substantial primary energy savings while creating superior living quality, will be analyzed. Important aspects are both energy performance and the owner's motivations behind the renovation. Drawing on this experience package of measures in combination with the most updated research front, new and innovative concepts and components will be developed.

Insights from this international collaboration will be conveyed to target national end users in a deliberate strategy to increase the market penetration of advanced housing renovations.

The Task is organized into four Subtasks.

Subtask A: Marketing and Communication Strategies *(Lead country: Norway)*

This Subtask is planned to be a cross-Task activity to:

- Focus national Task activities on building types and solutions with the greatest multiplication and energy saving potential.
- Develop concrete market strategies together with companies, authorities, research institutes or other market players participating in the Subtask.
- Develop communication plans in accordance with the strategies to maximize the impact of knowledge gained through the Task.

Subtask B: Advanced Projects Analysis *(Lead country: Switzerland)*

This Subtask's objectives are to:

- Systematically analyze and document projects meeting Task selection criteria in order to quantify which measures achieve the greatest energy savings or non energy benefits and at what costs.
- Identify innovative, promising concepts for detailed analysis in Subtask C.
- Provide guidance for national R&D activities by identifying weaknesses and opportunities in high-performance housing renovations.

Subtask C: Analysis and Concepts *(Lead country: Germany)*

This Subtask will start with the analysis of advanced projects (in Subtask B) and then develop new concepts also using new components and systems. Accordingly, the objectives are to:

- Evaluate the performance of advanced housing renovation projects, characterizing performance using methods developed in SHC Task 28.
- Assess the adaptability of new energy supply systems, including renewable energy systems, as part of comprehensive renovation packages.
- Analyze new products and concepts for advanced housing renovations and provide manufacturers feedback to optimize products.
- Develop and publicize optimized renovation concept packages.

Subtask D: Environmental Impact Assessment *(Lead country: Belgium)*

The Subtask will piece together quantifiable and qualitative results to obtain a comprehensive picture of the effectiveness of housing renovation approaches. It will assess the impact of the approaches taken in a selection of advanced housing renovation projects on:

- the environment
- the (urban) infrastructure
- health, safety and quality of life

Task Deliverables

The results of the Task will be brochures and technical reports describing:

- Housing segments with the greatest multiplication and energy saving potentials [A].
- Design and performance of exemplary renovation projects, describing benefits, process and motivations [B].
- Packages of technically and economically robust concepts for housing renovation which could be applied in concrete projects [C].
- Innovative future solutions with great potential of primary energy reduction [C].
- A "basics" on sustainable renovation including principles for the design and realization of renovation projects, connecting the technical point of view at the project scale to factors of a larger scale (environment and resources, infrastructure and equipment, health and well-being) [D].

- Strategies for increased market penetration of housing renovation in selected market segments [A].

Duration

The Task was initiated on July 1, 2006 and will be completed on December 31, 2009.

ACTIVITIES DURING 2009

Two Task Expert meetings were held in 2009, May in Niagara-on-the-Lake, Canada and in October in the Antwerp, Belgium

The day before the expert meeting in Canada, a full day open conference on **"Energy Futures Available Today: Integrating Residential Energy Savings and Solar Initiatives"** was organized in Waterloo. The purpose of the conference was to identify what can be done with regard to building renovation, and included a presentation from each of the four task 37 subtasks. The conference was attended by appr. 50 persons.

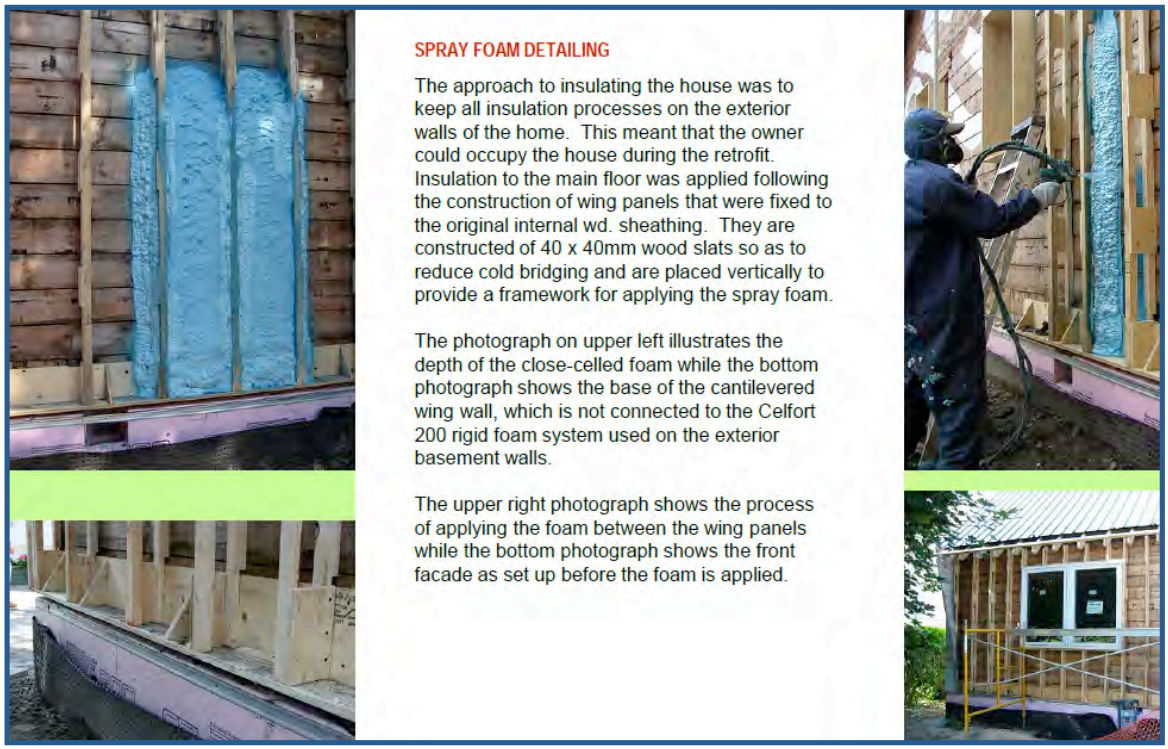
The October meeting was the last expert meeting of task 37. Two days before the meeting, an international symposium and field trip to Roosendaal in the Netherlands was organized. The title of arrangement was "**Energy transition at housing renovation: a successful approach"**. The event was organized in the framework of the Task 37 and the Green Solar Cities project within the EU Concerto program. The focus was renovation of houses to passive-house standard.

The day before the meeting, a full day conference was organized with the title: **"Substantial energy saving in existing housing now. Final results of the IEA SHC task 37 and the IEA ECBCS Annex 50"**. The conference was organized by PassiefhuisPlatform in the Antwerp in collaboration with task 37. The ECBCS Annex 50 was invited to present their results. The task 37 OA made an introductory presentation which was followed by presentations by the subtask-leaders of their work. All presentations are available from the task 37 web site.

Exemplary Renovation Brochures

The public web-site www.iea-shc.org/task37 includes 12 brochures of exemplary housing renovations (Austria, Belgium, Switzerland, Germany, Italy and Sweden). The brochures show reductions in the heat demand from 62-95%, with an average of 75%. Many of these projects include a solar heating system for domestic hot water and space

Examples from the demonstration projects



Spray foam insulation from the Canadian demo project HouseTM, Toronto

Small houses (i.e., detached, semi-detached, vertically divided, and terraced houses) account for approximately 85 % of the dwelling stock's energy use in Norway. This demo project is a typical two-storey house, constructed in 1981-1982 with approx. 100/150 mm mineral wool in walls/roof, direct electric radiators, electric floor heating and wood stove High energy consumption and poor comfort called for a relatively comprehensive renovation. New roofing and a balanced ventilation system with highly efficient heat recovery were installed. All windows were replaced with triple glazed windows close to passive house standard (U value~0.8-1.0 W/m^{2}K). More insulation was added in the attic and walls, and there was a high focus on improving air tightness. A new and highly efficient wood stove and a heat pump was installed, and all electric radiators removed.

Renovation of the three CAYLA apartment towers in Geneva Switzerland. The towers were built in 1954 and had a historic preservation renovation in 2003. The buildings needed an important renovation that included the improvement of the whole thermal envelope. Additional insulation is easy to achieve for roof and basement. But external insulation of the walls, as suggested by the architect, raised the risk of changing the image of this 1950 modern architecture. Commission des Monuments et des Sites obtained that at least one of the tower was renovated with internal insulation.

Each building received a new layout for the bathrooms and kitchens. Insulation (20 cm) was added to the roof. New windows with new thermal-break metal frame with double-glazing were installed. External thermal insulation (4-8 cm) and a coating of 4 – 8 cm or internal insulation of 6 cm was added to the buildings. The towers are heated with a gas fired central heating system.

WORK PLANNED FOR 2010

The Task ended December 31, 2009 and most of the expert work is finished. However, a lot of effort needs to be given to the finalization of the Task reports. During the first half of 2010, the reports will be completed and will be approved by the SHC ExCo.

Several presentations from the work of Task 37 will be given at national and international seminars, including;

- World Sustainable Energy Days 2010, March 4-5, Wels, Austria
- Eurosun 2010, September 29 – October 1 in Graz Austria

A final Task 37 seminar will be organized in San Francisco on 21.June 2010 in connection with the SHC Executive Committee meeting.

At the November 2009 meeting the ExCo decided to start a Task Definition Phase (TDP) for a follow up of Task 37. This new task will focus on advanced renovation in non-residential buildings. A TDP workshop is planned for on March 8-9 in Oslo, Norway.

LINKS WITH INDUSTRY

One third of the Task experts are representing companies and organizations working very close with the housing industry.

The Task will focus on marketable technical solutions, and the market strategies will help the market players to identify the most promising housing segments with the highest potential for renovation projects.

There are also links with the housing industry on the national level. As an example, Norway has established a national Task 37 project. This is organized as a collaborative effort with more than 15 stakeholders from the building sector working together with the Norwegian Task 37 experts. These stakeholders are both manufacturers, consultancies, building contractors, housing cooperatives and local authorities.

REPORTS PUBLISHED IN 2009

No reports were published in 2009.

REPORTS PLANNED FOR 2010

During the spring 2010 the subtask reports will be completed and available from the web-site:

Subtask A:

- From Demonstration Projects to Volume Market (public)
- Building Stock Analysis (internal)
- Marketing Stories (internal)

Subtask B:

- More than 35 new 4-6 pages brochures of the best renovation examples
- A technical report summarizing the lessons learned from all the demonstration projects. (public)

Subtask C:

- Internet based booklet "Advances in Housing renovation – processes, concepts and technologies"
- Guideline "Guideline for passive house renovation in cold regions"
- Tools: Simple calculation tool EN13719

Subtask D:

- Advanced and Sustainable Housing Renovation, a guide for designers and planners (public) This book will be available both in French and English

MEETINGS IN 2009

6th Experts Meeting
20. – 22. May
Niagara-on-the-Lake, Canada

7th Experts Meeting
15. – 16. October
Antwerpe, Belgium

MEETINGS PLANNED FOR 2010

None

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Task 38

Solar Air-Conditioning and Refrigeration

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TASK DESCRIPTION

In many regions of the world air-conditioning is responsible for the dominant part of electricity consumption in buildings. Electrically driven chillers cause high electricity peak loads in electricity grids, even if the systems used have a relatively high energy consumption standard. This is becoming a growing problem in regions with cooling dominated climates. In addition, conventional air-conditioning systems apply refrigerants that have a significant greenhouse impact. SHC Task 38 is working on developing environmentally sound solutions for building air-conditioning and refrigeration using solar thermal energy to operate thermally driven cooling cycles.

The main objective of SHC Task 38, Solar Air-Conditioning and Refrigeration, is the implementation of measures for an accelerated market introduction of solar air conditioning and refrigeration with a major focus on improved components and system concepts.

The market introduction will be supported through:

- Activities in development and testing of cooling equipment for the residential and small commercial sector.
- Development of pre-engineered system concepts for small and medium size systems and development of optimized and standardized schemes for custom made systems.
- Reports on the experiences with new pilot and demonstration plants and on the evaluation and performance assessment procedure.
- Provision of accompanying documents supporting the planning, installation and commissioning of solar cooling plants.
- Analysis of novel concepts and technologies with special emphasis on thermodynamic principles and a bibliographic review.
- Performance comparison of available simulation tools and applicability for planning and system analysis.
- Market transfer and market stimulation activities, which include information letters, workshops and training material as well as the 2nd edition of the “Solar Cooling Handbook for Planners.”

The Task is organized with four Subtasks:

- **Subtask A**: Pre-engineered systems for residential and small commercial applications *(Lead country: Austria)*

  The objective of Subtask A is to support measures for the development of small and medium size pre-engineered systems, characterized by:
  - Cooling capacity < 20 kW.
  - A high degree of pre-fabrication of the entire system.
  - No additional effort in planning is required for this type of systems.
  - Pre-engineered systems, consisting in general of solar collector, storage, back-up system, chiller, heat rejection and control unit as the main components, can be connected directly to the room components by the installer.

- **Subtask B**: Custom-made systems for large non-residential buildings and industrial applications *(Lead Country: Italy)*

  The objective of Subtask B is to overcome the main technology related barriers for a wider implementation of medium and large-scale systems for solar assisted cooling, characterized by:

- cooling capacity > 20 kW.
- Individually planned systems for the particular application with involvement of planning engineers.
- Call for tender typically for single components and not for the system as a whole.

The target markets will be large air-conditioning and refrigeration end-users (large office and other non-residential buildings, hotels, industry etc.).

- **Subtask C**: Modeling and fundamental analysis *(Lead Country: France)*

The main objectives of Subtask C are:
- Further development and evaluation of new and already existing component models and simulation tools with special regards to their applicability to different stages of the design process.
- Evaluation of novel and advanced solar cooling concepts which are still in a state of R&D and not yet ready for installation and market introduction.
- Thermodynamic analysis of solar cooling technologies using different methods such as e.g, exergy analysis.

- **Subtask D**: Market transfer activities *(Lead Country: Italy)*

The main objectives of Subtask D are:
- To identify promising markets for solar air-conditioning and refrigeration technology.
- To ensure that the findings of the Task work are transferred to the important target audiences.

One of the major results with input from work of the entire Task will be a 2nd edition of the "Solar Cooling Handbook for Planners."

Main Deliverables

The results of the Task will be several technical reports and tools, including:
- State-of-the-art report describing market available cooling equipment in the desired capacity range.
- Installation and maintenance guidelines for pre-engineered/package systems.
- Overview of market available thermally driven cooling technologies and suitable new solar components.
- Soft tool package for the fast pre-design assessment of successful projects.
- Analysis tools for the theoretical and technical assessment of new concepts.
- Technical report with developed certification and standardization schemes.
- Second edition of the "Solar Cooling Handbook for Planners."

Duration

The Task started on September 1, 2006 and will be completed by December 31, 2010.

ACTIVITIES DURING 2009

- The 6th expert meeting was held on April 27 to 28 in Freiburg, hosted by Fraunhofer ISE. 69 experts attended the first day and 63 experts the second day of the meeting.

- After the 6th expert meeting on April 29, a joint meeting with the IEA Heat Pump Annex 34 “Thermally driven heat pumps for heating and cooling” was held. Most of the Task 38 meeting participants participated in this joint meeting and in summary 77 experts from Task 38 and Annex 34 participated. The aim of this joint meeting was to discover the possible overlap as well as the complements for both IEA activities and to enhance the cooperation. Several connections resulted from this meeting and some cooperative work has been arranged.

- The 7th expert meeting was held on September 28 to 29 in Palermo, hosted by the University of Palermo – Department DREAM. Sixty-seven experts attended the meeting.

- After 7th the expert meeting the 3rd International Conference Solar Air-Conditioning was held from September 30 to October 2 at the University of Palermo, Italy. Most of the Task 38 participants participated in the conference and a total of 10 oral and 12 poster presentations were given related to Task 38.

Results in 2009

- The monitoring activities are progressing. Many of the monitored systems started operation in the summer of 2008 or spring of 2009, respectively. Up to now, four systems have monitoring data for a period of one complete year available. A final version of the general monitoring procedure has been worked out and provided to all Task 38 participants. In total, there are 13 systems included in the Subtask A monitoring campaign. For 12 of them, monitoring is still in operation. The monitoring results of most of the 13 systems will be included in the final system evaluation and comparison of results.

- At the 3rd International Conference Solar Air-Conditioning in Palermo, Italy monitoring results on 5 systems were published.

- Work on the soft tool package for the fast pre-design assessment of successful projects included a checklist method based on a series of questions with pre-defined answers has been elaborated and distributed. In this method technical, economical and organization issues are considered. In parallel, a pre-design tool was elaborated; the tool consists of a load generator, which produces an annual load file based on hourly values and a pre-design computer tool. A first complete version of the tool was circulated to the participants of the working group for beta-testing.

- A draft policy paper was presented and discussed during a workshop at the 7th expert meeting.

- Within the working group on the 2nd edition of the “Solar Cooling Handbook for Planners,” the final version of the table of content was discussed between the responsible authors and presented at the 7th expert meeting. Deep negotiations were carried out with two potential publishers.

- The first part of the Handbook is currently in work and it was decided to include results of the monitoring activities from summer 2010 in the second part.

The following seven reports will be approved in early 2010.

  - Report A1: Market Available Components for Systems for Solar Heating and Cooling with a Cooling Capacity < 20 kW

- Report A2: Collection of selected systems schemes “Generic Systems”
- Report B1: State of the art on existing solar heating and cooling systems
- Report B2: Solar Cooling System Design and Control
- Report C1: State of the art – Survey on new solar cooling developments
- Report C2-A: Description of simulation tools used in solar cooling New developments in simulation tools and models and their validation - Solid desiccant cooling - Absorption chiller
- Report C2-B: Benchmarks for comparison of system simulation tools – Absorption chiller simulation comparison

WORK PLANNED FOR 2010

In connection to the ASHRAE winter meeting and tradeshow, a Task 38 workshop is being organized in Orlando, Florida to be held on January 27, 2010.

Following the 9th Task 38 expert meeting, the EuroSun 2010 conference will take place on September 29 to October 1 in Graz, Austria. Active participation of Task experts and the presentation of Task results is planned.

The following work is planned in the different Subtasks:

Subtask A: Pre-Engineered Systems for Residential and Small Commercial Applications

- Preparation of the report on monitored plants.
- Common report with Subtask B describing the monitoring procedure.
- Report on results of the interviews with end-users of small scale solar heating and cooling systems.

Subtask B: Custom-Made Systems for Large Non-Residential Buildings and Industrial Applications

- Final report on the monitoring results.
- Report on the checklist method.
- Report on the pre-design tool.
- Final report on the commissioning guideline.

Subtask C: Modeling and Fundamental Analysis

- Final report on exergy analysis.
- Final report on heat rejection.

Subtask D: Market Transfer Activities

- Signature of the contract with the publisher of the handbook.
- Final version of the policy paper and production of short version (“solar cooling position paper”).
- 2nd e-newsletter presenting mainly monitoring results of the operation in 2009.

LINKS WITH INDUSTRY

A number of the Task experts are representing companies active either on planning and installation of solar thermal systems or manufacture of key components such as thermally driven cooling systems. In addition, many involved R&D institutes are closely co-operating

with companies, mainly start-up companies, active in developing new small-scale thermally driven cooling machines (water chillers, open cycle systems). The Task also contributes to workshops for professionals working in the design and installation of HVAC and solar systems for buildings.

REPORTS PUBLISHED IN 2009

No publically available reports were published in 2009.

REPORTS PLANNED FOR 2010

The following reports will be available on the SHC website.

- Report on monitoring procedure
- Report on monitoring results
- Final document on checklist method
- Final document on pre-design tool
- Report on commissioning guidelines
- Report on exergy analysis
- Report on heat rejection

MEETINGS IN 2009

6th Experts Meeting
April 27-28
Freiburg, Germany

In connection to the Task 38 meeting a joint workshop with the IEA Heat Pump Programme's Annex 34 "Thermally Driven Heat Pumps for Heating and Cooling" was held on April 29, 2009.

7th Experts Meeting
September 28-29
Palermo, Italy

Following the Experts Meeting, the 3rd International Conference Solar Air-Conditioning was held from September 30 to October 2 at the University of Palermo, Italy. Most of the Task 38 meeting participants took part in the conference and a number of Task 38 related presentations were given at the conference.

MEETINGS PLANNED FOR 2010

8th Experts Meeting
April 26-27
Aarhus, Denmark

9th Experts Meeting (final meeting)
September 27-28
Graz, Austria

Solar Cooling Workshop in connection with ASHRAE winter meeting and tradeshow in Orlando, Florida on January 27, 2010.

Task presentations at the EuroSun 2010 "International Conference on Solar Heating, Cooling and Buildings", September 29 to October 1 in Graz, Austria.

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Task 39

Polymeric Materials for Solar Thermal Applications

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TASK DESCRIPTION

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

The Task's objectives shall be achieved in the following Subtasks:

Subtask A:	Information	(Norway, Michaela Meir)
Subtask B:	Collectors	(France, Philippe Papillon)
Subtask C:	Materials	(Austria, Gernot Wallner)

Subtask A: Information

The objective of Subtask A is 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 Task and the preparation of an electronic or printed handbook on polymeric materials in solar thermal applications are to be main results of this Subtask.

Activities

- Provide a state-of-the-art overview of existing applications of polymeric materials in solar thermal systems and other relevant industry sectors.
- Investigate standards, regulations and guidelines with regard to the applications of polymeric materials in solar thermal systems and building integration.
- Analyze the challenges of polymeric materials in solar thermal applications from a market perspective
- Disseminate information of the work and results in all Subtasks to a wide audience

These activities are carried out within 4 different projects:

- Project A1: State of the art: Polymeric materials in solar thermal applications
- Project A2: Standards, regulations and guidelines
- Project A3: Challenges of polymeric materials in solar thermal applications from a market perspective
- Project A4: Dissemination of information

Subtask B: Collectors

As the full potential of polymeric materials can only be used when several product functions are integrated into a single component in a fundamentally new design (in contrary to the simple substitution of materials), the work in this Subtask is based on a review and a detailed definition of technical and economic parameters for collectors and the development of novel designs of collectors.

The concept development and the following verification phase with the demonstration of examples should therewith lead to different, polymeric material oriented, collector designs. The benefits of these could be the replacement of expensive materials (e.g. copper), enhanced freedom of design, realization of cost potentials or the integration of several functions into the collector structure.

Considering the prospects of the use of polymeric materials the focus of the Subtask is on the following areas:

- integrated collector structure
- collector absorber for new solar thermal system designs
- thermo-syphon and storage collector systems
- unglazed collectors

The objectives of this Subtask are:

- To analyze the state-of-the-art in polymer based solar collectors and to derive and define the requirements to collectors in given applications.
- To develop concepts for easy to handle, mass producible polymer based collectors with promising prospects regarding costs.

Activities

The main activities include a comprehensive state of the art analysis of solar collectors made from plastics and the system requirements. In a second step, novel designs are developed based on both, new system designs and new materials, for absorbers and entire collectors.

Subtask C: Materials

Polymer engineering and science offers great potential for new products and applications, which simultaneously fulfill technological and environmental objectives as well as social needs. The main components of a solar thermal system are the collector (glazing and absorber), pipes, fittings and pumps, and a storage unit. Polymers are already widely in use for solar thermal systems with an operating temperature range up to 30°C (water preheating and swimming pool heating). For solar thermal domestic hot water systems with intended maximum service temperatures up to 90°C only few polymeric parts and components have been developed and introduced into the market. A main reason is that efficient, spectrally selective glazed flat plate collectors reach stagnation temperatures up to about 200°C, which are not in agreement with the nominal operating temperature range of solar thermal systems for domestic hot water applications. However, if the nominal operating temperature range is ascertained, nearly any component of a collector system can be realized by commodity and engineering plastics with material costs ranging from 1 to 10 €/kg. For a solar thermal system both structural and functional materials are needed. While the main requirement of structural materials is to carry mechanical loads, and thus the mechanical properties are of prime importance, functional materials are defined as solids with special mass and/or energy transfer properties.

An important aspect of all research activities in this Subtask will be the strong focus on the performance, functionality and durability of polymer products with respect to the application in solar thermal systems. As with other materials, final product performance, functionality, durability and costs not only depend on the type of the

polymeric material used, but also on many other factors related to product design, processing and production.

The objectives of this Subtask are:

- To identify appropriate products for existing commercial and novel polymeric materials with high potential (short-, mid-, and long-term) which fulfill sustainability, durability and performance requirements criteria.
- To develop, investigate and establish structure/property-correlation for both, functional polymeric materials and polymer surfaces for solar thermal applications as well as performance defined structural polymeric materials for solar thermal applications.
- To evaluate polymer processing methods for the prototype production and cost-efficient mass production for solar thermal components.

Activities

- Providing information like specific property profiles of plastic materials, design approaches and processing routes to Subtasks A and B.
- Definition of parts and components of solar thermal systems to develop and investigate polymeric materials for (together with Subtasks A and B).
- Screening and evaluation of commercially available functional and structural materials for solar thermal applications.
- Formulation and preparation of novel functional and structural polymeric materials for solar thermal applications.
- Development and implementation of advanced characterization and test concepts and methods for assessment of the performance and durability that reflect the application and service relevant properties of polymeric materials in solar thermal applications.
- Investigation of the behavior of polymeric materials under service relevant loading and environmental conditions.
- Establishment of micro-structure/property/performance relationships and systematic further development and optimization of material formulations for solar thermal systems.
- Design and layout of polymeric components in solar thermal systems.
- Development and manufacturing of prototypes.
- Screening and evaluation of processing routes allowing for the mass-production of polymeric components in solar thermal systems.

Subtask C requires input from Subtasks A and B in terms of components to be developed and requirements to be fulfilled. Vice versa input to Subtasks A and B is given to the specific properties and processing routes of plastics which are due to the macromolecular structure of polymers very different to inorganic materials, such as metal, ceramic or glass (e.g., time/temperature dependent behavior; functional properties; plastics processing).

According to the objectives the work is carried out in the following three projects:

C1: Functional Polymeric Materials and Polymer Surfaces for Solar Thermal Applications
C2: Performance Defined Structural Polymeric Materials for Solar Thermal Applications
C3: Components and Polymer Processing

Duration

The Task was initiated on October 1, 2006 and will be completed on September 30, 2010.

ACTIVITIES DURING 2009

Taskforce "Testing/Standardization/Certification"
The existing European Standard EN 12975:2006 does not reflect with all test procedures the requirements for testing polymeric collectors. In order to include appropriate test procedures within the Standard during the ongoing re-vision of EN 12975 four tests were identified where changes are needed.

- Internal pressure test
- Exposure test
- Stagnation test
- Thermal performance test (in case the thermal performance depends on absolute temperature and not only on temperature difference between collector and ambient)

After the review of existing test methods within the current Standards (EN 12975, ISO 9806, AS/NZS 2712, SANS 6210) alternative test methods suitable for polymeric collectors will be proposed. The alternative test methods will be sent to the national mirror committees in order to be submitted to the CEN TC 312, which is in charge of the revision.
The revised Standard EN 12975 is must be harmonised with the European Construction Products Directive (CPD) according to mandate M369. The corresponding changes within the Standard will be followed closely by the participants of the Taskforce in order to prevent any changes that would penalise polymeric collectors within the Standard.

Taskforce "How to Make Solar Thermal Systems More Desirable"
(Visually appealing solar heating systems)

One of the outcomes of Task 39 is a database, which includes projects where -not only function- but also aesthetics and architectural integration is focused. A small group of 3-4 experts (architects and solar thermal engineers) is proposed to evaluate the incoming projects for the database.
The plan is that the database is hosted by IEA-SHC. Presently a questionnaire has been elaborated for the collection of projects for the database.

If you know of a project that could be of inspiration – please contact: Ingvild Skjelland, AVENTA, Norway; is@aventa.no.

Dissemination and Information

A Glossary on 'solar thermal' and 'polymeric material' terms was prepared, reviewed and is now available on the public Task 39 website http://www.iea-shc.org/task39/glossary.htm.

The experts file an electronic newsletter, which has been prepared from the presentations of Task 39 experts after every experts meeting. The newsletters are distributed to the Task participants, different contact lists and can be downloaded from the public Task 39 website http://www.iea-shc.org/task39/newsletters/index.html The abstracts of Task 39 related presentations can be found in the public website (www.iea-shc.org).

Subtask B: Solar Thermal Collectors

Polymeric Solar Collectors: Field testing of a State-of-the-Art System

In the field of polymeric solar thermal collector development within Task 39, a research project is carried out at Ingolstadt University of Applied Sciences (Germany). Based on a detailed component analysis in existing solar systems, the component as well as the system designs will be adopted to polymer needs. In a field-testing system, a collector operating in the system and a stagnating collector are compared. Especially the distribution of tempera-ture loads for collector parts is essential for the choice of polymeric materials. As Figure 7 shows exemplary for a sunny day, the absorber operating in the system has a temperature higher than 95 °C for almost 7 hours and the stagnating absorber not in the system for nearly 8 hours. The stagnating absorber has a temperature level between 135 °C and 205 °C for the duration of 6.3 hours. The temperature load on the housings of both collectors is on a low level.

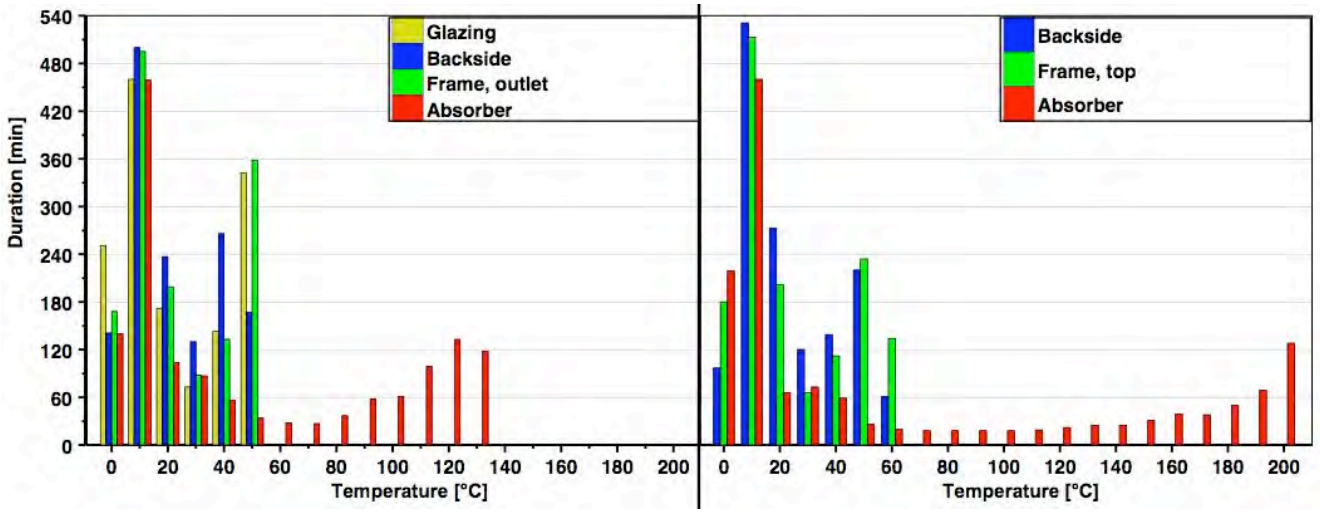

Fig. 7. Distribution of temperature loads on collector parts in the system (left) and not in the system (right) for a sunny day in April.

As considerably higher temperature loads are expected for the summer period, the measurements and analyses will be continued in order to provide temperature distribution information for a period of one year.

Application of Polymer Materials to Solar Thermal Systems

Researchers at the University of Minnesota are investigating the use of polymers for solar thermal systems. The focus of this research includes: prediction of lifetime for polyolefins exposed to hot potable (chlorinated) water, evaluation of CaCO3 scale formation and removal on polymer tubes, and investigation of overheat protection for glazed polymeric collectors. To predict the lifetime of polyolefins, a model for

antioxidant loss was developed. This model includes diffusion of antioxidant and chlorine in the polymer and chemical reaction of chlorine ions and antioxidant. An experimental study, in which polymer samples were exposed to either reverse osmosis water or chlorinated water (5 ppm), showed that the time scale for diffusion of the antioxidant out of the polymer is much slower than the chlorine diffusion or reaction time scales.

There is good agreement between model predictions of antioxidant depletion and the experimental data, as measured by oxidation induction time. An experimental study of scale formation on polypropylene (PP) and copper tubes (Cu) with exposure to mildly supersaturated potable water (typical of municipal water supplies) was conducted. Scale accumulates on both materials at the same order of magnitude, but phosphate ions and other species in the water impact the effect of substrate material on scale formation. In Minneapolis city water, in which phosphate ions are present, the amount of scale as represented by its calcium ion content is slightly higher on copper than on polypropylene. Measurement of removal of scale by fluid shearing forces indicates scale is more easily removed from PP, and by inference other polymeric materials, than copper by flushing with water.

Subtask C: Materials

Overheating Protection Properties of Thermotropic Polyamide

In thermotropic polyamide provided by EMS-CHEMIE AG (Switzerland) core shell polymer particles are embedded statically in a thermoplastic matrix material. The performance properties of this material type for overheating protection purposes of solar collectors were investigated. Solar optical properties were determined as a function of temperature applying UV/Vis/NIR spectroscopy and correlated to thermal transitions within the polymer determined by Differential Scanning Calorimetry (DSC). Furthermore the scattering domain size was characterized using Atomic Force Microscopy phase imaging.

The 2 mm thermotropic layer showed a hemispheric solar transmittance of 82% in clear state at temperatures of 25 °C and of 57 % in the scattering state at temperatures of 95 °C. A broad transition temperature range from 35 to 95 °C was detected. The comparison of the thermal transitions within the layer to the switching characteristics revealed a moderate correlation. AFM phase imaging clearly indicated particles exhibiting a soft shell with a diameter smaller than 150 nm and a hard core, with a maximum diameter of 50 nm. To provide excellent overheating protection and to maximize collector efficiency the switching temperature of the thermotropic polyamide should be adapted to values either between 55 and 60 °C or between 75 and 80 °C for application in the glazing or on the absorber, respectively. Furthermore a steeper transition from the clear to the opaque state within a small temperature range is desirable.

Thickness-insensitive Selective Solar Absorber Paints

Color d.d., is a paint, resin and powder coatings manufacturer based in Medvode, Slovenia. The company operates under ISO 9001, ISO 14001 and ISO 18001 standards. Its yearly sales are 31 960 tones with operating profit of 63 544 000 € and profit of 4 370 00 € (2008). 330 people are employed at the company (as of December 31, 2008). Since 2004 Color is a part of Helios group that belongs among 20 largest paint manufacturers in Europe.

Color's sales program consists of powder coatings, resins, and paints for metal and

wood industry, heavy-duty coatings, car refinishing coatings and decorative paints. A special place belongs to spectrally selective paints for military and solar applications. The later come in two distinctive types, thickness sensitive spectrally selective (TSSS) and thickness insensitive spectrally selective (TISS) paints.

TSSS paints are suitable for metal or metalized substrate absorbers of glazed collectors, offer great value, but no anticorrosion protection. Color's new Suncolor TS S paint is available in black and selected color shades and has a selectivity up to a_S=0.91, e_T=0.06 (black, thickness dependent).

TISS paints are suitable for metal and non-metal absorbers of glazed or unglazed collectors, offer excellent anticorrosion protection (up to C5m (ISO 12944) in a system). Color's Suncolor PUR (polyurethane binder), Suncolor S (silicone binder) and Suncolor CC (coil-coating product, silicone binder) are available in black and non-black color shades and have selectivity up to a_S=0.90, e_T=0.35 (Suncolor S black).

Self-cleaning UV protective clear coating for polymer substrates

Development of a clear polymeric multifunctional UV protective coating suitable for spraying is one of the goals of the MATERA MULTIFUNCOAT project. It should offer good UV protection and an anti-soiling effect.

As a starting material, high solid, low VOC 2-pack polyurethane containing organic UV-absorbers tested for 20 years use as an automotive topcoat was used. Its adhesion to polycarbonate (PC) and poly(methyl methacrylate) (PMMA) was achieved by use of a commercially available Colomix Plastic Primer from Color d.d.

Low coatings' surface energy and thus an anti-soiling effect was achieved by incorporation of a polyhedral olygomeric silsesquioxane provided by National Institute of Chemistry, Ljubljana (SI) into formulation. An addition of 1% of the additive increased static contact angles to 106 ° (water) and 55 ° (n-hexadecane). The same additive increased coatings' hardness (König and Taber tests) and flexibility (Cupping test, Impact resistance test).

The coating is going to be further improved by incomposition of nanofillers and nanotechnology UV-absorbers to achieve good scratch resistance and self-cleaning together with coating service life of 20 years in a solar collector.

MEETINGS HELD IN 2009

6th Experts Meeting
April, 27-29
Rapperswil, Switzerland

7th Experts Meeting
October 6-8
Golden, CO, USA

MEETINGS PLANNED FOR 2010

8th Experts Meeting
April 18-20
Chambery (France)

9th Experts Meeting
September 27 – 28
Blumau (Austria) with Eurosun 2010 in Graz

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Task 40

Towards Net Zero Energy Solar Buildings

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Operating Agent for Natural Resources Canada

TASK DESCRIPTION

The objective of the Task is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical NZEB demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption. These projects aim to equalize their small annual energy needs, cost-effectively, through building integrated heating/cooling systems, power generation and interactions with utilities.

The Task will build upon recent industry experiences with net-zero and low energy solar buildings and the most recent developments in whole building integrated design and operation. The joint international research and demonstration activity will address concerns of comparability of performance calculations between building types and communities for different climates in participating countries. The goal is solution sets that are attractive for broad industry adoption.

The scope includes major building types (residential and non-residential), new and existing, for the climatic zones represented by the participating countries. The work will be linked to national activities and will focus on individual buildings, clusters of buildings and small settlements. The work will be based on analysis of existing examples that leads to the development innovative solutions to be incorporated into national demonstration buildings.

The objectives shall be achieved in the following Subtasks:

Subtask A: Definitions & Large-Scale Implications
(Germany: Karsten Voss, Italy: Assunta Napolitano)
Subtask B: Design Process Tools and Simulation
(USA: Paul Torcellini, Canada: Andreas Athienitis)
Subtask C: Advanced Building Design, Technologies and Engineering
(NZ: Michael Donn, France: François Garde)
Subtask D: Dissemination
(All Subtask Leaders)

Subtask A: Definitions & Large-Scale Implications

The objective of this Subtask (STA) is to establish an internationally agreed understanding on NZEBs based on a common methodology. The Participants shall achieve this objective by the following activities:

- The review and analysis of existing NZEB definitions and data (site/source energy, emissions, exergy, costs, etc.) with respect to the demand and the supply side.
- A study of grid interaction (power/heating/cooling) and time dependent energy mismatch analysis.
- The development of a harmonized international definition framework for the NZEB concept considering large-scale implications, exergy and credits for grid interaction (power/heating/cooling).
- The development of a monitoring, verification and compliance guide for checking the annual balance in practice (energy, emissions and costs) harmonized with the definition.

Subtask B: Design Process Tools

The Subtask (STB) aims to identify and refine design approaches and tools to support industry adoption. The Participants shall achieve this objective by the following activities:

- Documenting processes and tools currently being used to design NZEBs and under development by participating countries.
- Assessing gaps, needs and problems, considering the work of STA and STC, and inform simulation engine and detailed design tools developers of priorities for NZEBs.
- The development and testing of design approaches and simplified NZEB tools or interfaces (e.g. spreadsheet or web-based method) linked to STC Solution Sets to support integration of NZEB technologies and architecture at the early design stage.

Subtask C: Advanced Building Design, Technologies and Engineering

The objectives of this Subtask (STC) are: to develop and test innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration. The Participants shall achieve these objectives by the following activities:

- Documenting and analyzing current NZEBs designs and technologies, benchmarking with near NZEBs and other very low energy buildings (new and existing), for cold, moderate and hot climates considering sustainability, economy and future prospects using a projects database, literature review and practitioner input (workshops).
- Developing and assessing case studies and demonstration projects in close cooperation with practitioners.
- Investigating advanced integrated design concepts and technologies in support of the case studies, demonstration projects and solution sets .
- Developing NZEB solution sets and guidelines with respect to building types and climate and to document design options in terms of market application and CO2 implications.

Subtask D: Dissemination

The objective of the dissemination activity is to support knowledge transfer and market adoption of NZEBs on a national and international level. Subtask leaders will be responsible for the coordination of the individual contributions of Subtask participants and for coordination with the other Subtasks where a combined output is planned. The Participants shall achieve the objectives by the following activities:

- Establishing an NZEB web page, within the IEA SHC/ECBCS Programmes' framework, and a database that can be expanded and updated with the latest projects and experiences.
- Producing a NZEB source book including example buildings for investigated building types and climates.
- Transferring the Task outputs to national policy groups, industry associations, utilities, academia and funding programs.
- Establishing an education network, summer school and contributions to the Solar Decathlon and similar student activities.
- Workshops, articles and features in magazines to stimulate market adoption.

Duration

This Task was initiated on October 1, 2008 and remains in force until September 30, 2013.

ACTIVITIES DURING 2009

- Change in OA from Mark Riley to Josef Ayoub.
- 1st and 2nd Experts Group meetings held in Montreal, Canada and Wuppertal, Germany respectively.
- Two industry/public workshops in conjunction with Task meetings.

- Received National Participation Letters from 12 countries out of 18.
- The core Subtask Working Groups formed.
- Gathering of background and baseline data on existing NZEB buildings and the establishment of a database and analysis of this information have been initiated.
- Joint Task meeting with SHC Task 41.

ACTIVITIES PLANNED FOR 2010

Key activities planned for 2010 include:

- Subtask group meetings .
- Completion of the detailed work for each Subtask.
- Production of 4-6 Subtask-related technical papers.
- Collaborations/info dissemination with other organizations and initiatives (e.g. Asia Pacific Partnership)
- One Industry Workshops in conjunction with the 3rd Experts Group Meeting in Ile de la Reunion.
- Participation in EUROSUN 2010.

REPORTS PUBLISHED IN 2009

No reports were published.

MEETINGS IN 2009

1st Experts Meeting
May 6 – 8
Montreal, Canada

2nd Experts Meeting
October 5 – 7
Wuppertal, Germany

MEETINGS PLANNED FOR 2010

3rd Experts Meeting
May 5 – 7
Ile de la Reunion

4th Experts Meeting
September 27 – 29
Graz, Austria
(in conjunction with EUROSUN 2010)

TASK 40/ANNEX 52 NATIONAL CONTACTS

A "start-up" phase was conducted from October 1st, 2008 to April 30th, 2009. This "start-up" phase focused on the preparation of detailed work plans for each Subtask and the provision of time to establish national teams and secure funding for participation in the Task. Therefore, not all the national team contacts have been confirmed at this time and some of those listed below are subject to change.

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The following is a list of National Experts & Contacts as identified by the member countries National participation Letter as of end of 2009 and Regular Participants of Task meetings. Please go to the Task page on the SHC web site for updates: http://www.iea-shc.org/task40/index.html

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Task 41

Solar Energy & Architecture

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Operating Agent for the Swedish Energy Agency, the Danish Energy Agency and Enova of Norway

TASK DESCRIPTION

The main goals of the Task are to help achieving high quality architecture for buildings integrating solar energy systems, as well as improving the qualifications of the architects, their communications and interactions with engineers, manufactures and clients. Increased user acceptance of solar designs and technologies will accelerate the market penetration. The overall benefit will be an increased use of solar energy in buildings, thus reducing the non-renewable energy demand and greenhouse gas emissions.

To achieve these goals, work is needed in three main topics:

A. Architectural quality criteria; guidelines for architects by technology and application for new products development.
B. Tool development for early stage evaluations and balancing of various solar technologies integration.
C. Integration concepts and examples, and derived guidelines for architects.

The first objective is to define general architectural quality criteria and extract recommendations for solar components/systems, to support manufacturers in developing existing products as well as new products. Specific criteria for the architectural integration of different solar energy components/systems will be developed in cooperation between architects, manufacturers and other actors. New adapted products should result from this activity as well as appropriate ways to use them.

The second objective concerns methods and tools to be used by architects at an early design stage, which need to be developed or improved. An example of such a tool can be how to visualize the solar energy concepts to show e.g. clients. Other examples can be tools needed to quantify and clearly illustrate the solar energy contribution and help balance the use of different active and passive solar technologies on the building envelope.

The last objective is to provide good examples of architectural integration, in the form of both existing projects that can be analysed as well as proposals for new projects. Buildings, installations and products will be included. Case studies will be an important basis to gain experience regarding the level of successful building integration, achieved solar energy contribution and to identify barriers related to e.g. technical and economical aspects and attitudes. New demonstration buildings will be developed in connection with the Task work and followed at least for the first part of the design stage, to learn from and to test guidelines and tools.

Communication tools and guidelines with facts and arguments for architects to help convince their clients to include solar energy systems will be produced. Arguments and facts related to architectural value, energy performance and life cycle costs are essential. Here, the arguments and facts need to be tailored for different building types and owner/user structures. The results will also serve as a basis for teaching material that could be used in e.g. architecture schools. To communicate the value of solar energy designs and technologies, the Task will carry out seminars, workshops and produce articles in architectural magazines, etc.

Scope

The scope of the Task includes residential and non-residential buildings. Both new and existing buildings will be included, for the climatic zones represented by the participating countries. Individual buildings as well as urban areas will be studied. In this way the potential impact of the Task can be large. Already cost-effective systems can, with a successful architectural integration, accelerate the market penetration. But also technologies not yet fully cost-effective can benefit from the work to pave the way to successful integration and user/client acceptance, and make the coming market penetration smoother. The work will build upon past IEA Tasks and other research projects related to building integration of solar systems and development of sustainable buildings.

The Task is organized in three Subtasks, derived from the above described objectives and goals. The integration problems related to the different technologies (product development, method of integration) are treated in subtask A. The balance issues between the different types of solar gains, related to energy and cost impacts, are treated in subtask B. Finally the architectural integration issue is treated as a whole in subtask C, based on case studies.

The objectives will be achieved by the Participants in the following Subtasks and activities:

Subtask A: Criteria for Architectural Integration

This Subtask focuses on architectural integration of *active* solar energy collectors systems (solar thermal, PV and hybrids technologies) that offer an important potential for improvement regarding architectural integration. The objectives are to:

- Establish and communicate architectural criteria for the integration of active solar energy systems in the building envelope.
- Give recommendations to the industry to improve the architectural integration quality and flexibility of active solar products and systems (integrability).
- Bring together architects and product/system developers to understand each others needs.
- Educate/inform architects on integration characteristics for various technologies and on state of the art of innovative products.

Results will consist of:

- Survey on architects needs for an increased/better use of active solar in buildings and to help identify related barriers.
- Document for architects that describes important architectural integration criteria for different categories of solar systems, with good examples.
- Document for product and system developers that describes important architectural integration design criteria for different categories of solar systems, with good examples.
- Initiate collaborations for the development of new products/systems e.g. through local seminars in connection with Task meetings.

- Dissemination of new knowledge to practicing architects and manufacturers through seminars.
- Task web-site page listing and describing available innovative products.
- Survey on active solar use potential based on: available exposed surfaces – structural compatibility – energy use compatibility – architectural sensitivity zoning. (If funding provided to Fraunhofer ISE).

Subtask B: Methods and Tools

This Subtask is focused on methods and tools for architects to use in the early design stage (EDS). The methods and tools should support EDS decisions and allow further development of the project at preliminary design and construction phases. The use of the building envelope to achieve a good balance of both active and passive solar utilisation is a central concern in this subtask and in the development of methods and tools. The work includes the collection of output material from existing tools used in demonstration projects to produce material for the Communication Guidelines (Subtask C).

The objectives are to:

- Achieve a comprehensive review of existing methods and tools (state-of-the-art) that architects currently use at EDS when designing buildings which integrate active/passive solar components.
- Identify current barriers that prevent architects from using the existing methods and tools for solar building design.
- Identify important needs and criteria for new or adapted methods and tools to support architectural design and integration of solar components at EDS.
- Provide clear guidelines for developers of methods and tools for architects designing solar buildings.
- Initiate communication with tool developers (industry) in order to stimulate the development of tools based on the guidelines written as a result of this Subtask.
- In collaboration with Subtask C, collect output data, figures, illustrations and facts produced by various tools in demonstration projects, to be included in the Communication Guidelines.

Results will consist of:

- State-of-the-art presenting existing methods and tools for architectural design and solar building design.
- Survey on architects' barriers, needs and criteria for new methods and tools to support architectural design and integration of active/passive solar components at EDS.
- Guidelines for the development of methods and tools for architects.
- Element libraries (method and examples) that could be used in design tools showing the visual impact of various solar options.
- Output material collected from existing tools used in demonstration projects to support the Communication Guidelines (Subtask C).
- Local seminars for invited architects in connection to Task meetings. Regional/national seminars (Subtask A, C).

Subtask C: Concepts, Case Studies and Guidelines

This Subtask is looking at concepts for architectural integration as well as case studies, with a whole building perspective. The Subtask also condenses the results into communication guidelines, with support from Subtask A and B.

The objectives of this Subtask are:

- Develop concepts and principles for high quality architectural integration of solar systems, based on analyses of existing systems as well as proposals for future

systems through national, and later on, international architectural colloquiums and workshops.

- Develop building concepts that utilize active and passive solar energy, achieving high quality architecture, sustainable solutions, attractive indoor climate and high energy performance. The developed concepts should aim at reducing the energy demand in buildings and increasing the fraction of renewable energy use such as solar energy.
- Develop knowledge and strategies to promote and implement high quality architecture using solar energy.

Results will consist of:

- Comprehensive collection and selection of case studies of high quality architecture and energy efficient building designs including solar solutions for new build and renovation for various building types (housing, offices, schools, etc.).
- Working method illustrated through selected examples of energy efficient or sustainable urban planning: Use tools to identify energy needs (Subtask B). Use other tools to identify attractive solar technologies to utilise the technical potential. Identify architectural design “rules” (orientation, slope, shading avoidance) to be followed to enable utilisation of the solar potential (Subtask A). These activities are to be combined when developing complete building designs.
- Presentation of working methods, designs, solar energy potentials through exemplary buildings in communication guidelines, in an IEA SHC web page, articles, architecture magazines, and at seminars for architects, engineers, component and system developers, clients, planners etc. The communication guidelines will include convincing arguments and facts with support from Subtask A and B.

Duration

This Task was started on May 1, 2009 and remains in force until April 30, 2012.

ACTIVITIES DURING 2009

The first two Task Expert meetings were held in 2009; the kick-off meeting in Malmö/Sweden in May and the 2nd meeting in Wuppertal/Germany in October. The autumn meeting was linked to the Task 40 meeting with a joint day of presentations in order to learn more about each others Tasks and identify possible future cooperation. The Work Plan was finalized in November and approved by the ExCo.

The survey on barriers, needs and criteria was developed within Subtask A and B and national contact lists of professionals are in progress to be used for the survey, interviews, planning of seminars etc during the whole length of the Task. A state-of-the-art of methods and tools for architects related to solar design is in progress (Subtask B).

Formats for collecting information about case studies were started within Subtask C and will be continued during 2010. Also the process of collecting and then selecting Task 41 case studies was planned.

Still many experts are in the process of applying for funding for the Task and the final participants and NPLs will be clarified during spring 2010.

A website: http://iea-shc.org/task41 has also been established.

ACTIVITIES PLANNED FOR 2010

Key activities planned for 2010 include:

- Finalize a state-of-the-art report presenting existing methods and tools for architectural design and solar building design. (Subtask B).
- Carry out a survey on architects' barriers, needs and criteria related to architectural integration of solar systems and related to methods and tools. (Subtask A and B).
- Develop drafts on guidelines for architects and product and system developers, related to architectural design criteria. (Subtask A).
- Develop draft on guidelines for the development of methods and tools for architects. (Subtask B).
- Work on element libraries showing the visual impact of various solar options. Subtask B).
- Identify potential case studies of buildings and urban areas, work on the selection process and organize seminars and workshops (Subtask C).
- Work on draft format for the Communication Guidelines (Subtask C).
- Finalize national funding and approval of national participation letters.

REPORTS PUBLISHED IN 2009

No reports were published in 2009.

MEETINGS IN 2009

1st kick-off Meeting
May 5-6
Malmö, Sweden

2nd Experts Meeting
October 7-9
Wuppertal, Germany

MEETINGS PLANNED FOR 2010

3rd Experts Meeting
March 17-18
March 19; Workshop in Italian
Bolzano, Italy

4th Experts Meeting
September 27-28
Graz, Austria
(in connection to EuroSun 2010)

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Not all the national team contacts have been confirmed at this time and some of those listed below are subject to change.

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Task 42

Compact Thermal Energy Storage: Material Development for System Integration

Wim van Helden & Andreas Hauer
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TASK DESCRIPTION

The objective of this Task is to develop advanced materials for compact storage systems, 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. The main added value of this Task is to combine the knowledge of experts from materials science as well as solar/renewable heating and energy conservation.

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 e.g. 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 e.g. heat, mass, and vapor transport, wall-wall and wall-material interactions, and reactor design; and
- system scale, focused on the performance of a storage within a heating or cooling system, including e.g. economical feasibility studies, case studies, and system tests.

The work in the Task is structured in materials oriented, application oriented and cross-cutting working groups. These are:

	Materials	**Working Group Leader**
WGA1	Material Engineering and Processing	Elena Palomo (Univ.Bordeaux, FR) and Viktoria Martin (KTH, SE)
WGA2	Test and Characterization	Stefan Gschwander (ISE, DE)
WGA3	Numerical Modelling	Camilo Rindt (TUE, NL)
WGA4	Apparatus and Components	Wim van Helden (a.i.) (ECN, NL)
	Applications:	
WGB1	Cooling (0 °C – 20 °C)	Halime Paksoy (Cukurova Univ, TR)
WGB2	Heating / DHW (20 °C – 100°C)	Jane Davidson (Univ.Minnesota, US)
WGB3	High Temp. Appl. (> 100 °C)	Luisa Cabeza (Univ.Lleida, ES)
	Cross Cutting:	
WGC1	Theoretical Limits	Eberhard Lävemann (ZAE, DE)
WGC2	System Integration	Wolfgang Streicher (TUGraz, AT)

Subtask A – Materials

Working Group A1: Material Engineering and Processing

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.

With respect to materials processing, the work focuses 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 a slurry, encapsulated, or otherwise processed.

This Working Group includes the following activities:

- 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;
- creating material safety data sheets;
- determining the role and importance of material containers.
- finding optimal methods for micro- and macro encapsulation of storage materials (particularly phase change, sorption, and thermochemical materials);
- processing phase-change slurries; and
- finding new combinations of materials.

Working Group A2: Tests 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 activities of this Working Group are aimed at developing these new procedures and include:

- comparative testing of materials and their required methods;
- long-term stability determination; and
- (pre-)standardisation of testing methods.

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 help to lay the foundation for such models.

The Working Group includes the following activities:

- Micro-scale modelling
- Meso-scale modelling
- Macro-scale modelling

- Multi-scale approach
- Thermo-mechanical modelling
- Reactor models

Working Group A4: Apparatus / Components

The storage apparatus is composed of the storage material and the equipment necessary to charge and discharge the storage material in a controlled and optimal way. This includes heat and mass transfer equipment like heat exchangers and pumps or fans and (chemical) reactors. Methods for the design and optimisation of components and apparatus should be developed, together with appropriate testing methods and procedures to assess the long-term behaviour of an apparatus:

- storage container and reactor design;
- storage apparatus design, based on the selected storage materials;
- improve heat transfer from material to reactor wall or heat exchanger wall;
- apparatus performance assessment;
- assessment of durability of components; and
- develop and apply test and validation methods for storages.

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 guidance 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:

- definition of application boundary conditions, such as load, demand, environment, dimensions, etc.;
- definition of required thermophysical properties for each application;
- selection of relevant candidate materials and system technologies;
- performance assessment and validation;
- numerical modelling on the application level;
- case studies;
- economical modelling;
- feasibility studies;
- market potential evaluations.

This subtask is subdivided in three Working Groups, each representing a particular application or group of similar applications:

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

Subtask C – Cross-Cutting

Working Group C1: 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 economical constraints of storage systems shall be evaluated.

Working Group C2: System Integration

The storage apparatus is part of a larger thermal system. Next to the apparatus, the thermal energy supply, the control, the thermal transport components and the thermal energy user are elements of the thermal system. Methods for the design and optimization of components and systems should be developed, together with appropriate testing methods and procedures to assess the long-term behavior of a system.

This Working Group includes the following activities:

- inventory and analysis of existing store types, their theoretical and practical energy and power density, their possible application and their costs (if available) following the results of IEA SHC Task 32 and IEA-ECES Tasks;
- storage system design, based on the selected storage materials (link to A2) and applications;
- system performance assessment for various applications;
- assessment of durability of components; and
- develop and apply test and validation methods for storages (starting with the existing test methods for hot water stores).

Duration

This is a fully Joint Task with the IEA Energy Conservation through Energy Storage Programme. The Task started on January 1, 2009 and remains in force until December 31, 2012.

ACTIVITIES DURING 2009

This is a new Task that started in January 2009. Two expert meetings were held. The Task website is: http://iea-shc.org/task42.

ACTIVITIES PLANNED FOR 2010

Key activities planned for 2010 include:

- Completion of project descriptions for all the projects contributing.

- Inventory of existing standards for heat storage materials and systems.
- Report on the state-of-the-art modeling techniques of PCM/TCM materials.
- Preparation work for a repository of reactor designs.
- Setting up a list of boundary conditions and requirements for each application area.

REPORTS PUBLISHED IN 2009

No reports were published.

MEETINGS IN 2009

1st Experts Meeting
February 11-13
Bad Tölz, Germany

2nd Experts Meeting
September 21-23
Lleida, Spain

MEETINGS PLANNED FOR 2010

3rd Experts Meeting
April 21-23
Bordeaux, France

4th Experts Meeting
September 26-28
Graz, Austria
(in conjunction with EuroSun 2010)

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SHC Projects & Lead Countries

Task 1	Performance of Solar Heating and Cooling Systems, 1977-83 (Denmark)
Task 2	National Solar R & D Programs & Projects, 1977-84 (Japan)
Task 3	Solar Collector and System Testing, 1977-87 (Germany and United Kingdom)
Task 4	Insolation Handbook and Instrumentation Package, 1977-80 (United States)
Task 5	Existing Meteorological Information for Solar Applications, 1977-82 (Sweden)
Task 6	Evacuated Tubular Collector Performance, 1979-87 (United States)
Task 7	Central Solar Heating Plants with Seasonal Storage, 1979-89 (Sweden)
Task 8	Passive Solar Low Energy Homes, 1982-89 (United States)
Task 9	Solar Radiation and Pyranometry, 1982-91 (Canada and Germany)
Task 10	Solar Materials R & D, 1985-91 (Japan)
Task 11	Passive Solar Commercial Buildings, 1986-91 (Switzerland)
Task 12	Solar Building Analysis Tools, 1989-94 (United States)
Task 13	Advanced Solar Low Energy Buildings, 1989-94 (Norway)
Task 14	Advanced Active Solar Systems, 1990-94 (Canada)
Task 15	Advanced Central Solar Heating Plants, not initiated
Task 16	Photovoltaics for Buildings, 1990-95 (Germany)
Task 17	Measuring and Modeling Spectral Radiation, 1991-94 (Germany)
Task 18	Advanced Glazing Materials, 1991-97 (United Kingdom)
Task 19	Solar Air Systems, 1993-99 (Switzerland)
Task 20	Solar Energy in Building Renovation, 1993-98 (Sweden)
Task 21	Daylight in Buildings, 1995-99 (Denmark)
Task 22	Building Energy Analysis Tools, 1996-00 (United States)
Task 23	Optimization of Solar Energy Use in Large Buildings, 1997-02 (Norway)
Task 24	Solar Procurement, 1998-03 (Sweden)
Task 25	Solar Assisted Air Conditioning of Buildings, 1999-04 (Germany)
Task 26	Solar Combisystems, 1998-02 (Austria)
Task 27	Performance of Solar Facade Components, 2000-05 (Germany)
Task 28	Solar Sustainable Housing, 2000-05 (Switzerland)
Task 29	Solar Crop Drying, 2000-06 (Canada)
Task 30	Solar Cities, not initiated
Task 31	Daylighting Buildings in the 21st Century, 2001-05 (Australia)
Task 32	Advanced Storage Concepts for Solar and Low Energy Buildings, 2003-07 (Switzerland)
Task 33	Solar Heat for Industrial Processes, 2003-07 (Austria)
Task 34	Testing and Validation of Building Energy Simulation Tools, 2003-07 (United States)
Task 35	PV/Thermal Systems, 2005-07 (Denmark)
Task 36	Solar Resource Knowledge Management, 2005-10 (United States)
Task 37	Advanced Housing Renovation with Solar & Conservation, 2006-09 (Norway)

Task 38 Solar Air-Conditioning and Refrigeration, 2006-09 (Germany)
Task 39 Polymeric Materials for Solar Thermal Applications, 2006-10 (Germany)
Task 40 Towards Net Zero Energy Solar Buildings, 2008-13 (Canada)
Task 41 Solar Energy and Architecture, 2009-12 (Denmark, Norway, Sweden)
Task 42 Compact Thermal Energy Storage, 2009-12 (Netherlands)
Task 43 Rating and Certification Procedures, 2009-12 (United States & Denmark)
Task 44 Solar and Heat Pump Systems, 2010-13 (Switzerland)