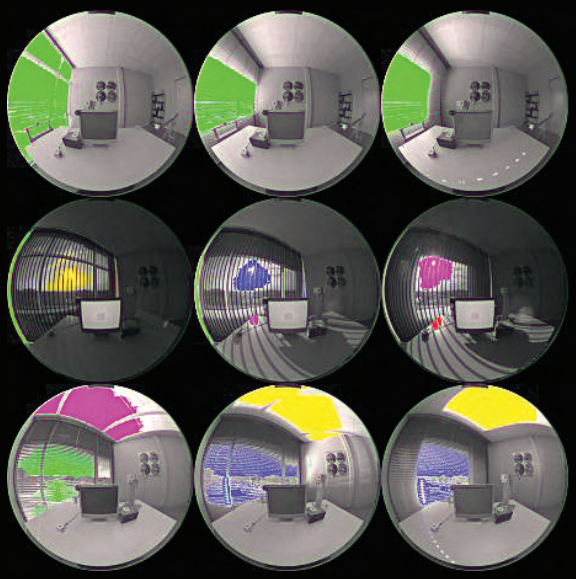
Solar Heating and Cooling

2006 ANNUAL REPORT

WITH AN OVERVIEW OF

Daylight for the 21st Century
New Opportunities with Daylighting Techniques



IEA Solar Heating & Cooling Programme

2006 Annual Report

Edited by
Pamela Murphy
Executive Secretary
IEA Solar Heating and Cooling Programme

Morse Associates, Inc.
236 Massachusetts Ave. NE
Suite 605
Washington, DC 20002
USA

March 2007

Table of Contents

Implementing Agreement

IEA

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 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. By the end of 2006, thirty-nine Tasks had been imitated since the beginning of the Programme. In 2006, three Tasks were completed, three Tasks were initiated, and five Tasks were in operation.

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.

SHC MISSION

To continue to be the preeminent international collaborative programme in solar heating and cooling technologies and designs.

Based on this mission, the Programme will continue to take a whole buildings perspective, and success is to be measured by how well the Programme facilitates the greater use of solar design and technologies.

SHC OBJECTIVES

To fulfill its mission, the SHC Executive Committee has agreed upon the following objectives and associated strategies. As noted in the table above, these

objectives complement the objectives of the IEA CERT. Acknowledging the importance of coordinated efforts by IEA Implementing Agreements, the SHC objectives also support those of the IEA Renewable Energy Working Party.

1. To help achieve a significant increase in the performance of solar heating and cooling technologies and designs by:

- Increasing user acceptance of solar designs and technologies.
- Continuing to develop cost-effective designs and technologies in collaboration with appropriate intermediary industries.
- Identifying and prioritizing R&D needs for solar heating and cooling that will lead to expanded markets

2. To help industry and government increase the market share of solar heating and cooling technologies and designs by:

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

3. To be the primary source of technical information and analysis on solar heating and cooling technologies, designs and applications by:

- Assuring that technical information and analysis developed in this programme 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.

4. To help educate decision makers and the public on the status and value of solar heating and cooling by:

- Communicating the value of solar heating and cooling designs and technologies in publications, conferences, workshops and seminars to the public and relevant stakeholders.
- Providing analysis that links solar heating and cooling designs and technologies to energy security concerns, environmental and economic goals.
- Quantifying and publicizing 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.
- Reviewing 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." Presenting the SHC Solar Award annually. Maintaining the Progamme web site.

HOW TO PARTICIPATE

Visit the SHC Programme web site at www.iea-shc.org to learn more about the Programme's work and publications and to find contact information for the Executive Committee members and Operating Agents.

If your country is a Member 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, but a government agency or an organization is interested in joining, please contact the SHC Executive Secretary 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 Executive Secretary, who will provide the required information.

SHC MEMBER COUNTRIES

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

Chairman's Report

Doug McClenahan
Chairman

I am pleased to present the 2006 annual report of the Solar Heating and Cooling Programme. This was another year of steady growth in the global market for solar thermal. And, the Programme took on new work and collaboration with other organizations to support our vision of increasing the use of solar designs and technologies in the built environment, and for agricultural and industrial process heat.

SHC TASKS

As work in the area of solar crop drying, daylighting buildings and solar façade components was completed, three new Tasks got underway in 2006. The new work will address buildings, systems and materials – Task 37: Advanced Housing Renovation with Solar & Conservation, Task 38: Solar Air Conditioning and Refrigeration and Task 39: Polymeric Materials for Solar Thermal Applications.

The Executive Committee extends a well deserved "thank you" to the Operating Agents of Task 29, Mr. Doug Lorriman; Task 27, Mr. Michael Köhl; and Task 31, Dr. Nancy Ruck. Mr. Köhl will continue as an Operating taking on the lead of Task 39.

SOLAR THERMAL STATISTICS

The SHC Programme produced another edition of the report, Solar Heating Worldwide: Markets and Contribution to the Energy Supply. This year's edition reported that the solar thermal sector has become a market leader in the past five years, growing 10 times faster than the overall economy. The annual collector yield (energy produced) in 2004 was 58,117 GWh – an oil equivalent of 9.3 billion liters and annual avoidance of 25.4 million tons of CO_2 emissions.

Data showed:

- Installed capacity in 2004 was 98.4GWth.
- Market penetration (installed capacity per 100,000 inhabitants) leading countries:
  - Cyprus at 63 MWth
  - Israel at 52 MWth
  - Greece, Austria and Barbados at 19 MWth
- Most dynamic markets:
  - China is the leader with an average growth rate of 25% annually between 1999 and 2004 and representing 44% of the world market.
  - Followed by Australia and New Zealand at 19% and Europe at 13%.

- Initial 2005 data estimates an annual collector yield of 68 GWh, second only to wind.

SHC SOLAR AWARD

The recipient of the 2006 SHC Solar Award was Dr. Volker Wittwer, Deputy Director of Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany. Dr. Wittwer received the IEA Solar Heating & Cooling (SHC) Programme's award during a ceremony at the Renewable Heating & Cooling conference at the World Energy Sustainable Days in Wels, Austria.

The SHC Solar Award is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements in the field

of solar heating and cooling, and that supports the work of the IEA Solar Heating and Cooling Programme.

Dr. Wittwer was the fourth recipient of the SHC Solar Award. He was selected for his role as a pioneer in the development of solar thermal collectors, for his contributions to low energy buildings and their components, and for his commitment to SHC work from his participation as a project expert in the 1980s to his support of German participation in many SHC projects.

COLLABORATION WITH OTHER IEA PROGRAMMES AND 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 three SHC Tasks:

- At a minimal level of collaboration in Task 27: Performance of Solar Façade Components and Task 31: Daylighting Buildings in the 21st Century.
- At a maximum level of collaboration in Task 34: Testing and Validation of Building energy Simulation Tools

In addition, joint meetings are held every 2-3 years. The next joint meeting will be held in 2008.

IEA Energy Conservation through Energy Storage Programme and our Programme continue to share information on relevant current Tasks. This Programme is collaborating in one SHC Task:

- At a minimum level of collaboration in Task 32: Advanced Storage Concepts for Solar and Low Energy Buildings

IEA Photovoltaic Power Systems Programme is collaborating in two SHC Tasks:

- At a minimal level of collaboration in Task 36: Solar Resource Knowledge Management and Task 35: PV/Thermal Solar Systems

SolarPACES Programme is collaborating in two SHC Tasks:

- At a minimal level of collaboration in Task 36: Solar Resource Knowledge Management
- At a moderate level of collaboration in Task 33: Solar Heat for Industrial Processes

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC Programme to increase the awareness of national and international government agencies and policy makers and to encourage industry to use solar thermal R&D results in new products and services. To support this collaboration, a meeting was held in conjunction with ESTIF's annual meeting in May in Spain. A follow up meeting is tentatively planned for 2007.

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

PROGRAMME PARTICIPATION – BENEFITS & HOW TO 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. The Programme extended invitations for membership to Luxembourg, Malta and Poland in 2006, and there was ongoing communication with four target countries that have already been invited to join the Programme – Brazil, China, India and Japan.

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 programmes 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.

The steps to take to join the Programme differ depending on the country.

- If your country is a Member and you are interested in participating in a current Task then contact the Executive Committee member from your country or the Operating Agent of the specific Task you are interested in joining.
- If your country is not a Member

and your government agency or organization is interested in joining, please contact the SHC Executive Secretary.

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

TO ANOTHER SUCCESSFUL YEAR

It is with pleasure that I have stepped into the role of chairman. Thank you, Michael Rantil for your two terms as chairman. I would also like to take this opportunity to thank Volkmar Lottner who has stepped down as the German Executive Committee member after years of dedication to this Programme's work. And, welcome to Markus Kratz who will now represent German on the Committee. A thank you also to the Operating Agents who completed their Tasks in 2006 ^ Michael Køhl, Doug Lorriman and Nancy Ruck. And, to the current Executive Committee members, Operating Agents, Advisor and Executive Secretary, I look forward to our collaboration as we expand the work and impact of the SHC Programme during a time when the interest and market for solar heating, cooling, and daylighting technologies is ever increasing.

Doug McClenahan
Chairman

Highlights of 2006

TASKS

Task 27: Performance of Solar Façade Components

This Task was completed in 2005. Experts worked in 2006 on finalizing reports. *This is a collaborative Task with the IEA Energy Conservation in Buildings and Community Systems Implementing Agreement.*

Task 29: Solar Crop Drying

This Task was completed in 2006. Monitored data from the Task projects demonstrated that solar air preheat systems, in combination with the efficiency improvements, can provide a cost effective solution to rising fuel costs and/or depleting fuel supplies. The results and experiences of SHC Task 29 provide an excellent resource for replicating the application of this technology.

Task 31: Daylighting Buildings in the 21st Century

This Task was completed in 2006. A small IEA SHC working group has been formed to develop a digital roadmap for the daylight design of buildings. This will be an extension of the Task 31 web site into a wiki-based interactive contribution to the development of 1) understanding of the multiple criteria upon which good daylight design must be based; and 2) knowledge of the design tools available to evaluate building designs against these criteria. The objective is to ensure that the multiple audiences that may be interested in good daylight design—architects, engineers, students, code writers and researchers—have access to up-to-date information. *This is a collaborative Task with the IEA Energy Conservation in Buildings and Community Systems Implementing Agreement.*

Task 32: Advanced Storage Concepts for Solar and Low Energy Buildings

The final reference conditions and the final reference system for comparing different storage options were completed by the Austrian team. It is an important outcome of the Task and will be used in the simulation work on solar combisystems for a single family house in four different climates. *This is a collaborative Task with the IEA Energy Conservation through Energy Storage Implementing Agreement.*

Task 33: solar Heat for Industrial Processes

Four new pilot systems were erected in the field of seawater desalination (Fraunhofer ISE), breweries (AEE INTEC) and cooling (PSE). Results of investigations at one Austrian and three German breweries were presented and discussed at the Experts Meeting in Rome. The investigated breweries cover a wide range of company sizes and different applications within the processes. *This is a collaborative Task with the IEA SolarPACES Implementing Agreement.*

Task 34: Testing and Validation of Building energy Simulation Tools

In-depth test cases were completed to determine the causes for disagreements among detailed-model results found in preliminary test cases developed during SHC Task 22. The new cases are divided into "a"-series, "b"-series and "c"-series cases. The "a"-series test cases check proper implementation of 3-d numerical-methods ground heat transfer models run independently of whole-building simulations (independent models). The less idealized "b"-series and "c"-series cases compare typically more constrained ground heat transfer models integrated with whole-building simulations to the independent detailed models.

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

Task 35: PV/Thermal Solar Systems

Market survey interviews of architects and solar dealers were conducted in the USA to obtain information from the market place about which things will affect or influence the purchase design, supply and installation of future PV/T projects. More interviews will be made in the USA, Canada, Netherlands, Belgium, Sweden, Germany, and possibly Hong Kong, Denmark, Thailand, Greece, and Italy. Articles on the interviews will be published in the beginning of 2007.
This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement.

Task 36: Solar Resource Knowledge Management

An on-line questionnaire, hosted by a server at JRC, is still available to the public. Several servers, e.g., NASA, Satel-Light, SoDa, PVGIS, are pointing to the questionnaire to create awareness and increase the number of responses. Results will be published on the various web sites that advertised for the questionnaire in order to give feedback to those having filled in the questionnaire. An article in Solar Energy will also be published. Since solar projects are often requested to perform an analysis of needs of users/customers, this publication is expected to establish a baseline that could be used by many projects without duplicating efforts.
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

This Task started in July 2006. Projects for whole building concept analysis and technology analysis have been identified in several participating countries. The first projects to be monitored are in Freiburg, Germany. These projects and the others will be presented on the Task web site in mid-2007.

Task 38: Solar Air Conditioning and Refrigeration

This Task got underway in September 2006 and experts have been laying the ground work to begin specific tasks in 2007. The first Experts Meeting was held on October 18-19 in Bolzano, Italy. Sixty-five people participateds from 13 countries.

Task 39: Polymeric Materials for Solar Thermal Applications

This Task began in October 2006. A draft state of the art report was prepared. It includes products that are completely or partly made of polymeric materials in solar thermal applications. Among them are patents and products in the market or had been in the market: solar collector components, glazing materials, pool absorbers, heat store (components), seasonal heat stores, and other components as well as a literature list.

EXECUTIVE COMMITTEE MEETINGS

2006 Meetings

The Executive Committee held two meetings:

- June in Seville, Spain
- December in Rome, Italy

2007 Meetings

The Executive Committee will hold two meetings:

- June in the Netherlands. This meeting will include a 30 year anniversary celebration for the Programme.
- October/November, location to be finalized.

INTERNET SITE

A new web contract was finalized with the US firm, R.L. Martin & Associates, Inc. The site will be redesigned and moved in early 2007. The Programme's site plays an important role in the dissemination of Programme and Task reports and information. The web address is www.iea-shc.org.

Daylight for the 21st Century New Opportunities with Daylighting Techniques

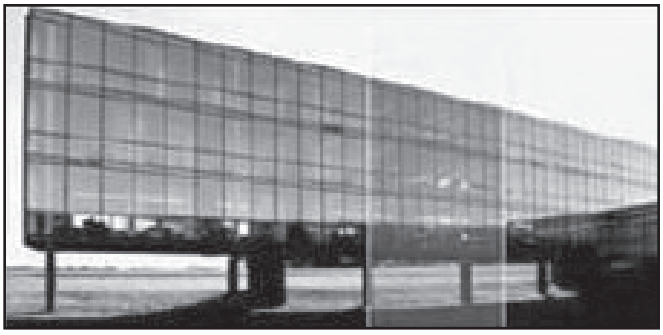
Research into the use of daylight could be argued as unnecessary, or unreasonable. It was after all the principal means of lighting buildings until the middle of the 20th century. Adopting 'old-fashioned' approaches to design will, it is sometimes argued, not improve the quality of the indoor environment. However, even during the course of the Solar Heating and Cooling (SHC) Programme's most recent work in this area, the need for further research has become critically obvious. This is not just because there is a significant and growing backlash against late 20th century electrically lit buildings. If that were the problem then we could return to the (day)lighting design approaches of the late 19th and early 20th centuries. Today, however, we have higher expectations for human health and safety in the workplace, and a far wider range of tasks to light (e.g., a mix of paper and digital tasks).

Two years into this SHC project, an article in Architectural Lighting by James Benya ironically with the same title as the SHC Programme's daylighting project (Daylighting for the 21st Century) stated: *"The problem is the modern architect is generally ill-equipped to evaluate the performance of daylighting design. Crucial decisions concerning daylighting are made in the schematic design phase, but most architects have no tools, other than common sense and experience, to measure the final effect. During early schematics, for example, it is hard—or even impossible—to thoroughly compare the ultimate performance of alternative fenestration proposals. Yet this very aspect is often the difference between one LEED level and another, with up to 12 precious LEED points at stake. "Mainstream practitioners think they are doing daylighting, just because their building has windows. They have such a simple view of daylight that they don't know how to think about it usefully,"* says Lisa Heschong, architect and principal of the Heschong Mahone Group, a Sacramento-area firm specializing in building science research.

The problems arise because of excessive reliance of these 20th century buildings on electrical lighting, recent increases in the cost of electricity generation, higher levels of expectation among designers and building occupants with respect to the comfort conditions buildings provide, and the availability of window and daylight control components promising higher performance. In the European Union, this problem has been exacerbated by the legislative push of the EU Directive on the Energy Performance of Buildings.

The reality in architectural practice is that too often voluntary and mandatory systems like LEED and the EU Directive compliance tools are 'rule-of-thumb' based assessments and they inevitably produce in the typical practitioner's mind a risky relationship: good daylight equates to bigger windows. Too often bigger windows actually equate to reduced environmental quality not just in lighting but also in temperature and air quality for the individual in his or her office.

In addition, recent research has shown clear connections between the quality of work performed in schools and workplaces and the quality (note: NOT merely the quantity) of daylight available. Added to this, more and more clients are reading of this work and demanding daylit buildings, and "bigger windows" is the call. In the face of this increasing risk that more daylight is confused with good daylight there is a need to integrate the work of the architectural and engineering professions and inform this integration with the type of targeted



The north and south facades of the Bang & Olufsen Headquarters in Denmark. B&O's building is an energy efficient building with good daylight, natural ventilation, and only the north facade is completely glazed. (© Steen Traberg-Borup, The Danish Building and Urban Research)

research completed for this project.

Another area that has been researched by IEA SHC Task 31 includes a wide range of new daylight technologies such as:

- new glazing systems;
- improved responsiveness and programmability of integrated electric lighting controls; and
- a greater claimed accuracy in lighting design software.

These products allow modern buildings to gather a lot more light than similar buildings have in the past and the software makes lighting performance prediction much more accessible than in the past. However, careful laboratory testing is required to characterize the actual performance of these, both the physical products and the software. Reliable performance simulation requires trusted data and design tools. Production of reliable data, trusted design tools and their integration into the design process was the overall aim of the SHC project, "Daylighting Buildings in the 21st Century."

Key SHC Research Issues

The aim of the SHC daylighting Task was to address daylight in building issues that had arisen in the 1990s, particularly the need to integrate human response with the application of daylighting systems and controls. Daylight systems are defined to include the associated shading and electric light control strategies. The Task research focused on non-residential buildings, such as offices and retail stores, and institutional buildings such as schools.

The two key research issues identified were:

- The determination of occupant response towards the luminous and thermal environments in buildings that use daylighting systems and daylight responsive controls.

- The integration of daylighting systems, electric lighting, and shading controls in order to optimize energy savings while taking into account occupant response.

Key SHC Research Results

The SHC Task participants expended a considerable amount of time examining how their research relates to the state of the art in daylighting of buildings and how designers could use it. In a world of changing technology, of constant improvements in physical and digital modeling capability, and of developing an understanding of the social/cultural mix of user needs and desires, yet another technology focused 'design guide' seemed likely to be out of date when it was produced. There was however a clear need for information that would allow people to produce daylight designs that are more user-responsive than is achievable through the application of a simple checklist or rule-of-thumb.

The results of this SHC research Task have been grouped by steps in the design process as follows, to assist their application in design. Under each daylighting design step are a series of pointers to the issues, descriptions of relevant technology, and identification of the debate where issues are incompletely resolved.

Daylight Design Step 1: Establish the Lighting Need

An SHC Task on Optimization of Solar Energy Use in Large Buildings established that the most important first step in designing a successful low energy solar building was to establish what metrics might be used. For example, with lighting quality, the client, the energy analyst and the lighting

analyst and the architect (who may be one and the same person!) must establish how they are to measure success in the context of the work or activity in the building. The whole design team should be involved in establishing and agreeing what the daylight and energy efficiency performance targets are and how the team are to measure (the 'metrics') and whether they have been met. The daylight metrics that could be useful are:

- daylight autonomy and useful daylight index
- glare
- thermal comfort needs
- desirability of variation / constancy of illumination conditions

Glare criteria and calculation tools

One of the principal reasons for the overglazing of buildings is the lack of easy to use criteria and tools to identify and assess glare conditions. One of the fascinating aspects of this SHC Task has been to discover that the current glare formulae are based on a rough correlation between window and glare that has been used in computer software. SHC experts investigated the relationship between luminance distributions in over 70 subjects' field of view and their self-reported perception of glare. The outcome – a new glare prediction model called 'Daylight Glare Probability' that has been implemented into a RADIANCE-based evaluation tool.

Controls

No matter how well the building is daylit, if the goal is also to achieve energy savings then there needs to be good electric lighting controls. In predicting energy savings from daylight one of the larger unknowns has been the dearth of information available on real switching behavior in real buildings. The results from all of these human subject studies were encouraging as they showed while our understanding of office workers' use of personal controls remains limited, findings from earlier studies could be confirmed in different buildings and countries. The international collaborative work of this Task made these human subject studies possible as they are expensive to conduct.

Is the 'daylight factor' enough when dynamic simulation is possible?

The daylight factor has long been criticized. As a metric of daylight performance it suffers from being referenced to a single overcast sky condition - not only not taking account of sunny days and therefore orientation of the building, but also often defined as some international general 'CIE sky' that bears no relation to the local climate. Task work compared daylight factor simulations with two dynamic metrics, daylight autonomy and useful daylight index (UDI). UDI is an interesting new metric that provides a measure of both whether minimum illuminance levels are maintained in a space through daylight, as well as how often daylighting levels might be too high.

Daylight Design Step 2: Find Design Ideas Appropriate for the Situation

Identifying suitable design options requires good documentation of the design opportunities, their advantages and disadvantages, the energy performance and the user perceptions, and finally the suitability to different climates. Some obstacles to good daylighting are the costs and lack of knowledge, etc. To overcome it has been necessary to:

- Document exemplary buildings, and their performance
- Create new design ideas and principles
- Document the most appropriate design of the electric lighting and its controls
- Document the most appropriate blinds and external shades

Smart glazing systems

In recent years, light redirecting materials have become common in well-designed daylit buildings. These systems typically bounce light from the sun, and diffuse light from the sky deep into a room above head height making the ceiling a light source for people further back in the room than the window alone can achieve. They also reduce glare and intensity of illumination near the window, making the light levels more even in the room and thus making it far less likely that people in the back of the room will turn on the lights just to reduce glare by evening up the illumination rather than because they are poorly illuminated. The development of these systems has far outstripped the ability to measure their performance in the laboratory and to predict their performance in computer simulations. The Task has now simulated many of these complex systems.

It is still possible to model many of these systems with physical models, as all one needs is a large enough model to be able to place samples of the material into the window apertures. In fact, many of the best designers mix physical and digital models – using the physical model to calibrate the digital – to ensure a reasonable level of Quality Assurance.

Good daylight is not just good glazing, but also glare and shading control
Increasingly the design response to achieving good daylighting is a combination of large areas of insulated but clear glazing with adjustable shading systems that also function to redirect the light from outside deeper into the building. At the experimental edge, adjustable shading in daylight systems includes electrochromic glazing, a Task

Exterior and interior views of the New York Times full-scale building mockup. The interior view shows the shades deployed to the lower edge of the upper exterior shading rods.

research topic At the high end of practice also, one of the most extensive specifications of automatic controlled blinds in a perimeter daylight system is the New York Times building was produced by Task research. This work was not only developing with the client a performance specification for the daylighting but has also involved the owner in full scale mock-up testing of the combinations of blinds and windows and exterior shading that simultaneously permit good visibility of computer screens and desktops, low glare and view.

Shading systems require good controls for optimal daylight

Exterior shading systems have long been identified as optimal light and shade modifiers in buildings, particularly if they are adjustable to account for the movement of the sun. However, for many reasons these are often found to be impractical (wind induced noise, planning laws, maintenance of moving parts) Developing blind systems that preserve views, adjust all the time not just when someone is there or when they remember has been the focus of this research project and of blind and control manufacturers worldwide. Of particular interest has been the interaction between the response of office users and the blind controls systems. Ingenious systems not only for measuring the amount of light in a space but for measuring the tilt and the position of blinds have been used. Similarly, careful and scientifically replicable, surveys have been conducted of the user preferences in this SHC Task. It would appear that as with electric light people are very good at operating the blind controls when they enter the office. However, the ongoing adjustment of the light levels across the day is rather better handled with automated controls.

User response to daylight and daylight systems

The user response seems to be that if the light levels are continuously dimmed in response to the available daylight and glare from the windows, then users respond favorably. Switched systems, even those that only switch a lamp at a time in a 3 or 4 lamp light fitting are less favorably viewed by building occupants. What works best for the users and for low energy use is a combination of external shades, to keep the solar heat outside the offices, glazing as clear as possible above eye height for good light penetration, glazing at eye height for view, blinds that work to provide extra adjustable shading, light redirection (especially above the eye height) and some view at eye height even when blinds are fully closed (e.g., with small perforations). All systems of this type require a measure of user-override.

Intelligent controls work best

Of interest in the near future will be adaptive controls. These are controls that have intelligence. They measure the glare and the lighting conditions; detect the user override response; measure blind settings and correlate them. These settings are remembered and reused when similar outdoor lighting conditions are encountered in the future. The goal is to ensure that the "building" responds to the users' needs and wishes as closely as possible. This of course automates the "negotiation" that often happens when more than one person shares an office with a window: What are optimum blind and lighting settings for one person are not optimum for all. The Task research has focused on the simulation of adaptive controls

and energy savings. Research is now needed on issues of how to deal with the automation of the "voting".

Exemplary buildings

During the Task the participants have built up a library of example buildings, technology illustrations and computer renderings. The images from these are available for download either as a PDF version of a PowerPoint presentation, as a jpeg picture format file, or as a PowerPoint presentation. They are free for use, so long as their source is appropriately acknowledged, the IEA logo is not removed from the picture itself, and they are presented with, not divorced from, the accompanying text notes.

The value of daylight

Buildings with good daylighting satisfy the visual requirements of the occupants as often as possible with daylight, without generating drawbacks such as glare, overheating or losing excessive quantities of heat. Today, in OECD countries office buildings could be designed so that the electric lighting could be turned off 40% of the time.

Single storey buildings and top-lighting

Single storey buildings are easy to daylight. All single storey non-residential buildings can save on high cost electric light and gain productivity by installing top lighting from say skylights. This is already happening extensively in places like California where the opportunity is high because around 80% of retail floor area is single storey. There Title 24 from October 2005 requires facilities of 3000 sq m (~30000sq ft) or greater to have at least 30% of the floor area daylit with appropriate electric lighting controls. Subsidies are also offered by utility companies to go even further by having design that exceed Title 24 by at least 10%. Experience seems to show that this rewards those who were looking at these options, but does not encourage people otherwise.

Multi-storey – sidelit - buildings

Sidelit buildings are more difficult. The research evidence seems to indicate that people are more productive (make less mistakes, work faster and for longer) when they have a view. Whether the daylight itself has as significant an effect is unknown at present. Much of the research difficulty – the applications of new technologies, control systems and variations in human response – derive from the problem of delivering daylight by sidelighting from the perimeter wall. Large windows are helpful in ensuring whatever light that is available from the sun or sky reaches the interior. However, large windows often introduce excessive light.

Daylight Design Step 3: Determine the Appropriate Lighting Design Tools for Evaluating Design Performance

Working on a building design to examine the options for balancing heat gain/ loss / lighting requires the following:

- Typical sky conditions in the location and appropriate climatic data
- Appropriate energy use assessment tools to integrate with the lighting tool(s)
- Appropriate models for user behavior
- Validation procedures,
- A data base of glazing materials

Rules of thumb

Traditional rules of thumb widespread in text books and used in industry sustainability certification processes like LEED are singularly unhelpful in this regard. The consensus of these various expressions of daylight rules of thumb seems to be that if you have clear glazing and windows unobstructed inside and out then adequate daylight for many office applications is achievable in temperate climates up to 1.5-2 times the head height of the window back in from the window. A paper presented at the Berkeley workshop for this SHC Task confirmed that this guidance seems to be about right in terms of light quantity. If the window is obstructed by blinds say, then the depth to which good daylight can be achieved falls to only 1x the head height of the windows. As with all rules of thumb a lot goes unsaid.

State of the art in daylight design tools

In the special issue of Energy and Buildings, Reinhart and Fitz "provide a snapshot of the current use of daylight simulations during building design based on an online survey of 185 individuals from 27 countries. The paper confirms the existence of a growing group of designers, engineers, and consultants who routinely use daylight simulations during building design. It further provides an overview of which tools these individuals use, how they use them, and why."

Data on advanced light redirecting materials

Validation studies have shown that lighting conditions can be simulated in buildings with standard façade elements, such as glazing, lightshelves and diffusing blinds. Some modeling of advanced, light re-directing complex fenestration systems has been accomplished in the Task.

Data on the algorithms that can be used to represent advanced glazing systems

One of the major concerns of the participants in SHC Task 31 was ensuring that simulation of building properties in design studies would be as accurate as possible. This has

meant a systematic documentation of the algorithms that exist for the characterization of the interactions of light and complex glazing systems. A library of formulae that can be used by lighting simulation computer program developers has been compiled and is available on the Task web site.

Performance prediction requires accurate models of the sky relevant to local climates

In daylight, a common problem shared by physical models and digital models is the definition of a sky that is representative of all the skies that a proposed building will experience in even a year of operation. As noted earlier, new techniques have been developed that permit lighting simulations to be completed for every daylit hour of a standard year such as happens in thermal design. A standard set of sky descriptions has been developed, in conjunction with the CIE.

LIGHTSWITCH - a model of user behavior

Early within this SHC Task a model of user behavior called 'Lightswitch' was proposed and developed. It describes occupant use of lighting and shading devices in offices. It can now be used with the help of a sub-hourly occupancy based control (SHOCC) model in whole building simulation programs

Validation / calibration tests of the accuracy of light rendering software

Tests have been developed in collaboration with the CIE for the validation of computer simulation software for both daylight and artificial light simulations. The full report on the tests is available from the CIE. The results of the application of these tests to some common software packages has been summarized on a separate page on the Task web site.

New SHC Work: A Roadmap for the Daylighting Design of Non-residential Buildings

This daylighting design roadmap is targeted at design practitioners with some knowledge of daylighting and also those with no expert knowledge but with an interest in daylighting As there can never be one daylighting design tool that will suit every country, as design practice, codes and standards and tool availability vary country by country, it is not possible to create a single design guide that solves all problems and that all can use.

The intent of the roadmap is to provide a daylighting design basic infrastructure that lays out, for several different users and design use scenarios, the sequence of key decisions that must be made at critical points in the design process, and what types of information and tools might be used to address them. It is intended that countries will use the design framework with their own national resources to develop better tools in the years ahead. Each country will provide links at the various stages of the design process to assist their users.

Research on non-residential building projects have shown that an integrated design process is a necessary prerequisite for successfully achieving sustainable buildings, and it should be noted that this precondition cannot be met without the contribution of an interdisciplinary design team acting as a competent partner to a client from the outset of the project.

The roadmap has only a few basic steps. It is intended to indicate to the designer at each design stage how to follow up performance. It specifies what to do but includes only limited design advice.

All the publicly available outputs of the Task 31 research are available from the IEA Solar Heating and Cooling Programme web site http://www.iea-shc.org/task31 . The list in the outputs section of this Task web site includes reports that are published by the SHC Programme and by others. Courtesy of the publisher's internet citation system even the individual papers in the Energy and Buildings special issue on daylight (Vol 38, Issue 7) are linked to the site. For example, the internet digital link (URL) of the editorial by Reinhart and Selkowitz in the special issue has the following address: doi:10.1016/j.enbuild.2006.03.005 (find this 'digital identifier for any object of intellectual property' at: http://dx.doi.org/).

Ultimately the roadmap is about providing ready access to reliable data, trusted design tools and advice about how they might be integrated into the design process – meeting the overall aim of the SHC Daylighting Buildings in the 21st Century project.

Based on the paper, Education Package, IEA - Solar Heating & Cooling Programme, Task 31, Daylighting Buildings in the 21st Century by Michael Donn, Marc Fontoynont, Steve Coyne, Phillip Greenup Peter McLean, Roman Jakobiak and Nancy Ruck.

TASK 27
Performance of Solar Facade Components

Michael Köhl
Fraunhofer Institute for Solar Energy Systems
Operating Agent for the Forschungszentrum Jülich

TASK DESCRIPTION

The objectives of this Task were to determine the solar visual and thermal performance of materials and components, such as advanced glazing, for use in more energy efficient, comfortable, sustainable buildings, on the basis of an application oriented energy performance assessment methodology; and to promote increased confidence in the use of these products by developing and applying appropriate methods for assessment of durability, reliability and environmental impact.

Scope

The work focused on solar facade materials and components selected from the following:

- Coated glass products
- Edge sealed glazings, windows and solar façade elements
- Dynamic glazing (i.e., electrochromic, gasochromic and thermochromic devices, thermotropic and other dispersed media)
- Antireflective glazing
- Light diffusing glazing
- Vacuum glazing
- Transparent insulation materials
- Daylighting products
- Solar protection devices (e.g., blinds)
- PV windows
- Solar collector materials, including polymeric glazing, facade absorbers and reflectors.

Means

The work in Task 27 was carried out in the framework of three subtasks.

- Subtask A: Performance (Lead Country: Netherlands)
- Subtask B: Durability (Lead Country: Sweden)
- Subtask C: Sustainability (Lead Country: France)

Main Deliverables

Subtask A:

- A further developed coherent energy performance assessment methodology to enable comparison and selection of different products and to provide guidance for their assembly and integration into building envelope elements.
- A structured data base of components and façade elements to present data in a consistent and harmonised form, suitable for product comparison and selection and for simulation of performance in specific applications.
- Recommended calculation and test methods for solar and thermal performance parameters in support of international standards development.

Subtask B:

- A validated methodology for durability assessment of advanced solar building materials.
- An estimation of the service lifetime based on degradation of performance for selected materials tested.
- Recommended standard test procedures for service life testing of selected materials and components.

Subtask C:

- A review of international knowledge base, tools, actions and requirements related to glazing, windows and solar components.
- An overview of the FMEA tool capabilities, adaptation to the field of glazing, windows and solar components, and guidelines for using it in the assessment of possible shortening/reduction of the service life.

Duration

The Task was initiated in January 2000. Subtask C and parts of Subtask A and B were completed in December 2003. Parts of Subtask A were extended until end of 2004. Parts of Subtask B were extended until the end of 2005.

ACTIVITIES DURING 2006

Task work focused on the completion of the Subtask final reports. Final reports for Subtask A and Subtask C were completed.

The final report for Subtask B will be completed in 2007. The report, "Service life prediction tools for complete systems" was completed.

Reports and other information on the Task's work can be found on the Task 27 section of the SHC web site.

TASK 29
Solar Crop Drying

Doug Lorriman
Namirrol Ltd.
Operating Agent for Natural Resources Canada

TASK DESCRIPTION

One of the most promising applications for active solar heating worldwide is the drying of agricultural products. In a recent study, the potential amount of energy that could be displaced using solar in this market was estimated to be between 300 PJ and 900 PJ annually, primarily in displacing fuel-fired dryers for crops that are dried at temperatures less than 50°C. The use of solar energy for these markets is largely undeveloped. Wood and conventional fossil fuels are used extensively at present. In many countries, more expensive diesel and propane fuels are replacing wood. Three key barriers to increased use of solar crop drying are the lack of awareness of the cost-effectiveness of solar drying systems, the lack of good technical information and the lack of good local practical experience.

The objective of the Task is to address the three barriers above by providing technical and commercial information and experience gained from the design, construction and operation of full-scale, commercially viable solar drying systems for a variety of crops and a number of geographical regions where solar is expected to have the greatest potential.

TASK SUMMARY

The task objectives were clearly ambitious and the experts put in a great deal of work to realize the successful projects. Over 14 projects were identified during the course of the Task and of these, six were constructed and operated. The reasons for not completing the remaining projects were primarily related to financial constraints on the part of the customers or, in one case especially, deteriorating political conditions. All activities of the Task were completed in 2006 except for the final technical report which is scheduled for completion in 2007.

Completed Projects

Panama – Coffee Drying

This was the first major project of the Task. The facility was constructed in conjunction with a new plantation which was also part of a social experiment initiated by the client company. The project involved two solar systems, one to provide preheated air to the vertical dryers and the other to provide primary air to the storage silos. The project saw early delays due to construction issues and poor harvests and ultimately the full design capacity of the plant was not reached in the time frame of the Task. Nonetheless, the solar systems were operated and monitored for two drying seasons.

Results showed that the solar systems were performing as would be expected under the given operating conditions and the Task experts believe that the projected performance of meeting approximately 30% of the load would be met once the plant was operating at capacity. There was a chance that this would be achieved in 2006 and the Task was prepared to monitor for an additional season with full operation. However, the attention of the customer was diverted to other matters and the project was not completed during the year.

Costa Rica – Coffee Drying

Another major install in Latin America was the solar drying system on the Coopeldos drying facility in Costa Rica. The project was started later in the Task

but there was sufficient time to complete the installation and monitor for a drying season. The monitoring data revealed problems in the efficiency of the existing furnace and ducting. These were corrected but limited the ability of the Task experts to get a full season results for the efficiently operating system. Also, the facility did not have an automatic control system which further hampered the ability to get the best results from the solar system.

In late 2005 discussions were held with the owners regarding further improvements to the existing system and the installation of automatic controls but, in the end, no action was taken.

India – Coir Pith Drying
It is believed that the Coir Pith system continues to operate satisfactorily. No monitoring was conducted at this site due to the distances involved and budget constraints. Task experts were hoping that another project in India would be successfully completed, in which case, both projects would be monitored. In spite of a number of promising signs, no other project was started.

China – Moyu Drying
In a way, this was a good news/bad news project. The opportunity was identified late in the Task after company corporate problems another project nearby. The late start was somewhat compensated for by the enthusiasm of the customer and the solar panels were installed in good time. The bad news was that the customer was over ambitious from the point of view of the Task. As last reported, the client installed more solar panels than had been recommended for the first phase of the project. The client installed the larger array to meet full plant demand once phase two is completed but this was not done before the end of the Task. Task experts agreed that there was no point in monitoring the system while only phase one was operating since design conditions would not be met.

China – Jujube Drying
The building structure for the primary project was not completed during the life of the Task, but a small 66m^2 pilot project was built by the customer. However, the pilot plant was not monitored by the Task since the cost to do so was not warranted.

Zimbabwe – Tobacco Drying
An installation at the Tobacco Research Centre in Zimbabwe was successfully completed very early in the Task. Initial monitoring showed that the solar systems (both an air and hydronic systems were being tested) were operating satisfactorily but there was a great deal of air leakage in the drying barns which led to inefficient use of the solar heat. Recommendations to improve the system were made but before these could be implemented, the Task team abandoned the project due to the deteriorating political situation.

India – Tea Drying
This is the second Indian project which the Task was hoping to complete. Unfortunately, the client financing conditions discussed in the last report had not been met in the time allowed for by the Task and the project did not proceed. This was very disappointing since the project looked very promising and the solar panels had been manufactured and prepared for shipping.

ACTIVITIES PLANNED FOR 2007
Completion of the final technical report was delayed and is now expected to be completed in 2007.

LINKS WITH INDUSTRY
The Task was very successful in establishing links with industry. These links were formed on a number of different levels.

First – Five companies and industry organizations participated in the Task by providing experts.

Second – As a result of the work of the Task, one of these companies established representatives in three of the project countries.

Third – All Task projects were installed at the sites of companies which are leaders in their business communities.

Fourth – Task experts had direct contact with industry trade associations in four countries where work was done.

Fifth – The Task organized seminars in two of the countries where expert meetings were held. Participants at the seminars included representatives from industry, government and academia.

CONCLUSIONS
Although the Task was not able to produce the volume and detail of technical information that had been anticipated, enough work was done to conclude that:

- Solar crop drying can be feasible in many large scale applications.
- Solarwall® panels are capable of supplying heat to drying process as predicted in the feasibility studies.

RECOMMENDATIONS
Task experts have made the following recommendations regarding the conduct of future work in this area:

- That on-site meteorological data be collected for at least one year prior to design. This is especially true for

sites where good accurate information is not readily available.
- That accurate local cost data for labor and materials be obtained.
- That experts take the time to fully understand all aspects of the candidate facility. This time should include at least one drying season.
- That the facility be upgraded and measures taken to reduce energy waste before solar is added.
- That a full drying season be allowed for commissioning.
- That a local expert be engaged.
- That a design manual be prepared in conjunction with on-site staff.
- That on-site staff be made comfortable with automatic operation.
- That monitoring be used to help refine the operation.
- That the necessary resources be committed to see the project through.
- That clustering projects in the same geographic area be considered.

TASK 29 NATIONAL CONTACTS

Operating Agent
Doug Lorriman
Namirrol Ltd.
20 Tiny Beaches Rd. N.
Site 8, Comp. 8
Perkinsfield, ON
Canada L0L 2J0

Canada
Doug McClenahan
Alternative Energy Division
CANMET
Natural Resources Canada
580 Booth St.
Ottawa, ON K1A 0E4

John Hollick
Conserval Engineering Ltd.
200 Wildcat Road
Downsview, ON M3J 2N5

Netherlands
Egbert Gramsbergen
Gramsbergen Solar
Tus 7
5507 MG Veldhoven

United States
Peter Lowenthal
Solar Energy Industries Association
1616 H Street N.W., 8th Floor
Washington, DC 20006-4999

TASK 31
Daylighting Buildings in the 21st Century

Nancy Ruck
University of Sydney
Operating Agent for Standards Australia International

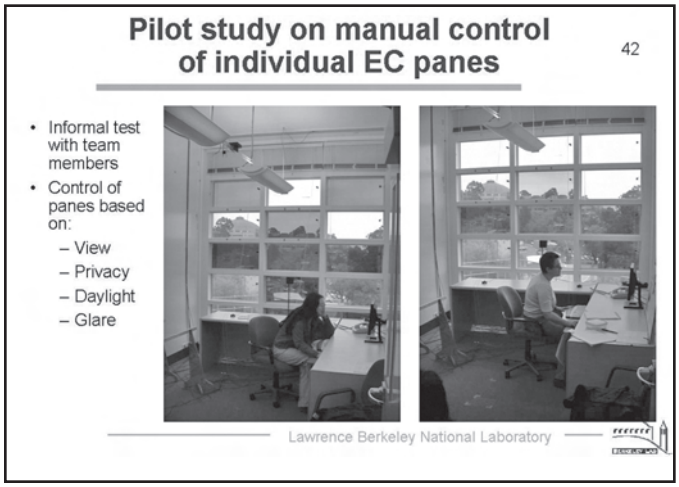
TASK DESCRIPTION

SHC Task 31, Daylighting Buildings in the 21st Century, has sought to make the use of daylighting with controls the typical and preferred design solution for lighting buildings. The Task's intent was to balance innovation and practicality by creating integrated daylighting solutions that are technically feasible and that take user response into account particularly in commercial buildings Conclusions from a previous IEA SHC Task on daylighting (IEA SHC Task 21) inferred that improved daylighting optical systems can provide better daylighting performance in buildings and increased energy savings potential as compared with conventional systems without daylight responsive controls. However, some critical elements of daylighting design in buildings were not fully addressed. Remaining challenges were the successful integration of daylighting systems with lighting and shading controls that are acceptable to the user and created viable low energy solutions. A strong focus in SHC Task 31 was therefore placed on how occupants use lighting and shading controls in daylit buildings. The SHC Task 31 web site with its links to reports and a special daylighting issue of Energy in Buildings now represents the state of the art at the end of 2006.

SHC experts from 14 countries in Europe, North America, Asia, Australia and New Zealand have collaborated in the Task 31 work programme. The work of the Task 31 research team was organized into four streams:

■ *Subtask A: User Perspectives and Requirements (Lead Country Canada)*
This subtask was concerned with human response to daylighting systems, occupant preferences and switching behaviour. It also produced a special daylighting issue of Energy and Buildings on Task 31's research results.

■ *Subtask B: Integration and Optimization of Daylighting Systems (Lead Country: USA)*
This stream was concerned with the creation of a 'framework' for daylighting-related design decisions (with Subtask D) and the development and integration of smart controls that combine and optimize shading and lighting controls according to user response. The intent for the framework is to function as a blueprint or roadmap for a series of daylighting design guides that are tailored to the needs of the different Task 31 participant countries. Subtask B also created an advanced controls design guide, and a commissioning and calibration guide. With Subtask A there were a series of field and laboratory studies featuring integrated facade and lighting controls, some of which are reported in the special issue of Energy and Buildings.



■ *Subtask C: Daylighting Design Tools (Lead Country: Germany)*
Subtask C was concerned with the improvement of daylighting and lighting tools to predict the characteristics of

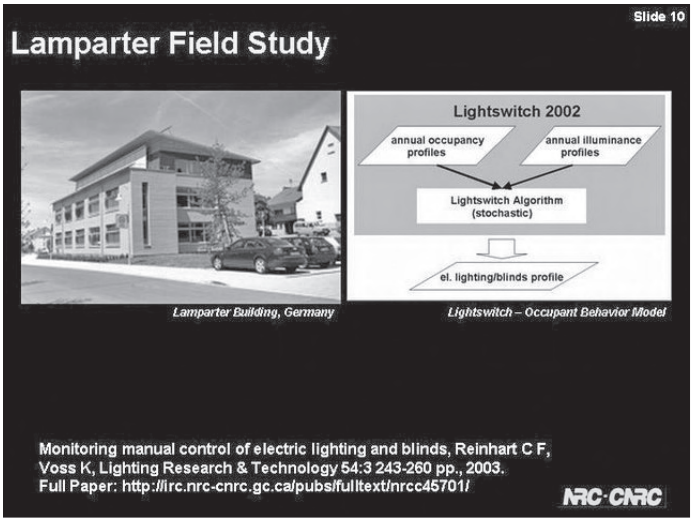


Diagram of Lightswitch 2002

the luminous environment indoors, as well as the energy performance and visual comfort conditions of complex fenestration systems. Most of the deliverables including a numerical goniophotometer for determining fenestration optical properties, a method for modelling indoor lighting from complex fenestration systems, and test cases for the validation of lighting simulation programs were reported in the special issue of Energy and Buildings.

- ***Subtask D: Daylight Performance Tracking Network and Design Support (Lead Country: France).***

This subtask was concerned with technology transfer activities related to SHC Task 31 including the construction of the SHC Task 31 web site and an educational package for use by design professionals and building developers which includes the framework for a road map.

Significant Achievements of Task 31

- ***Subtask A: User perspectives and requirements***

A special issue on daylighting in Energy and Buildings (Vol 36 N0. 7) containing Task 31 results from 3 field studies and 1 Laboratory study (carried out with Subtask B), the development of a daylight glare index, and SHOCC, modeling occupant behaviour enabling the input of the LIGHTSWITCH algorithm in total energy simulations. Another significant achievement was the use of dynamic daylight simulations. As opposed to a static simulation that only considers one sky condition at a time; dynamic daylight simulations generate annual time series of interior illuminances and/or luminances.

Other deliverables were an annotated bibliography of significant literature on daylighting research, an international survey on the role of daylighting in sustainable design, and a Belgium survey on the use and type of shading controls available in office buildings.

- ***Subtask B: Integration and optimization of daylighting systems***

The work programme concerned a preliminary design framework for a roadmap (with Subtask D) advanced controls and calibration and commissioning guides, the introduction of cost effective lighting controls in a demonstration building in New York and field and laboratory studies. The participants in Subtasks B and D identified a strong need for a roadmap to assist in communicating the significance of the Task outputs in Daylight design, and its place in the context of others' research (e.g. the SHC Task 21 research on daylight). A small IEA SHC working group has been formed to develop the digital roadmap for the daylight design of buildings. This will be an extension of the Task 31 web site into a wiki-based interactive contribution to the development of 1) understanding of the multiple criteria upon which good daylight design must be based; and 2) knowledge of the design tools available to evaluate building designs against these criteria. This goal is to ensure that the multiple audiences that may be interested in good daylight design—architects, engineers, students, code writers and researchers—have access to up-to-date information.

The roadmap web site will guide people through the plethora of material available on daylight design in a manner that presents only what is needed by the particular audience at a particular time to ensure clarity, but which also ensures that all the other information available on the topic can be found readily linked to the higher level map of the information.

The output will be a web site that provides different views of the same material to the different 'audiences'. The architect should be able to find precedents of good daylight design accompanied by good data on performance such as that produced in Task 21. The engineer should be able to understand that there have been major innovations in daylight performance evaluation during the 4 years of Task 31; two examples of these innovations are: development of a database of daylight transmission functions for windows and invention of a way to model daylight on an hourly basis for a full year. Students will be able to find a complete bibliography of the publications produced by the Task.

- ***Subtask C: Daylighting design tools***

The creation of a numerical goniophotometer, models of indoor lighting from complex fenestration systems and the production of test cases for the validation of simulation programs.

■ *Subtask D: Daylight performance tracking network and design support*

An international web site and education package are significant contributions. All the publicly available outputs of the Task 31 research are available from the SHC Programme web site http://www.iea-shc.org/task31. The list in the outputs section of this Task web site includes reports that are published by the IEA and by others. Courtesy of the publisher's internet citation system even the individual papers in the Energy and Buildings special issue on daylight (Vol 38, Issue 7) are linked here. For example, the internet digital link (URL) of the editorial by Reinhart and Selkowitz in the special issue has the following URL: doi:10.1016/j.enbuild.2006.03.005 http://dx.doi.org.helicon.vuw.ac.nz/10.1016/j.enbuild.2006.03.005

Those who are not subscribers to Energy and Buildings still have to pay for the copy of the paper, but they have the citation/link and can read the abstract.

Duration of Task

SHC Task 31 was initiated in September 2001 and completed in November 2006.

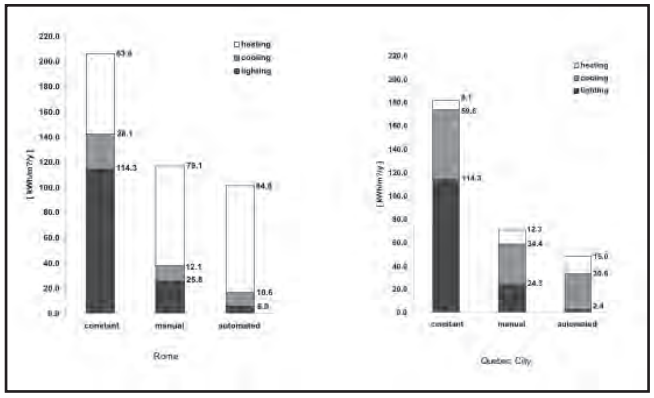
The Task was extended to June 2006 to enable a preliminary framework for the road map to be completed and included in an education package. The framework for the road map will be further developed in a new IEA SHC Working Group lead by Michael Donn, Victoria University, Wellington, New Zealand.

ACTIVITIES DURING 2006

Subtask A: User Perspectives and Requirements

Special issue of Energy and Buildings, Vol 38, No. 7, June 2006

This special issue contains results from Task 31 and includes 2 invited papers, 16 research papers, 1 editorial and 1 research communication



Advanced behavioral models in whole building simulations -a study of the use of automatic and manual controls in Rome and Quebec City

Literature reviews

Literature reviews included:

1. Non visual effects of light (Ann Web)
2. Occupant preferences and satisfaction with the luminous environment and control systems in daylit offices, (A. Galasiu, A Veitch)
3. A field investigation of intermediate light switching by users (D Lindelof, N Morel)
4. Using field measurements of desktop illuminances in European offices (F Nicol, M Wilson, C Chiancarella). An invited paper in the special issue of Energy and Buildings.

New daylight glare probability index The results have now been published in the special issue of Energy and Buildings, vol. 38 No. 7 June 2006. This index is based on vertical eye illuminance, the source luminance, its solid angle and a position index. The evaluations of the results from the experiments showed a very strong correlation between the DGP and the user's response. This probability model should be extended with other solar shading systems besides Venetian blinds as well as with additional parameters such as quality of view to the outside.

User behaviour modeling

A description on a user behaviour model LIGHTSWITCH is now published in the special issue of Energy and Buildings. The LIGHTSWITCH model has been integrated into the dynamic thermal simulation program ESP-r by means of SHOOC. It is intended that the model be integrated into other daylight analysis software packages in the future.

Survey on role of daylighting in sustainable design

The results are now published in the special issue of Energy and Buildings The National Research Council of Canada conducted an online survey on "the role of daylighting in sustainable design. The survey has provided guidance for the daylighting design framework The main objectives for the survey were to understand which daylight performance indicators, rules-of thumb and design tools practitioners are currently using to integrate daylighting with electric light and shading devices There were nearly 200 respondents to the survey predominantly from Australia, Canada and the USA, and mostly from architectural and engineering design professions.

Laboratory and field studies

The following were carried out with Subtask B in 2006. The results have been published in the special issue of Energy and Buildings.

1. Subject response to electrochromic windows (R.D. Clear, V. Inkarojrit, E.S. Lee)

2. Use of shading systems in VDU offices (Y. Sutter, D. Dumortier, M. Fontoynont)
3. A field investigation of intermediate light switching by users (D. Lindelof, N. Morel)
4. Using field measurements of desktop illuminance in European offices (P. Nicol, M. Wilson, and C. Chiancarella).

Subtask B: Integration and Optimization of Daylighting Systems

Daylighting design roadmap

The daylighting design roadmap provides a framework for design decisions and provides access to information and tools developed in the Task. The framework is to be shared by all countries, even though its specific implementation will vary between countries, by their specific tools, code requirements, and available data. The framework lays out, for several different users and design use scenarios, the sequence of key decisions that must be made at critical points in the design process, the types of information and tools that might be used to address them, and how the information and tool output might be used by designers to address the specific design challenges. The framework is an electronic document with hyperlinks to referenced documents and tools.

Controls design guide

The controls design guide is available on the web. It takes into account user response. The target audiences are designers and planners of control systems (i.e., the control systems manufacturers, the manufacturers of technical equipment, or the specialized engineers concerned with building services).

Commissioning and calibration guide

The commissioning and calibration guide is available on the web. The control systems using network based architecture and wireless technologies should be more fully addressed.

Field and laboratory studies

Refer Subtask A

1. Advancement of electrochromic windows LBNL, Berkeley, USA
2. Cost effective daylighting NewYork, New York, USA http://windows.lbl.gov/comm_perf/newyorktimes Results demonstrated that electric lighting can be turned off for 40% of the time.
3. ENTPE Field study Vaulx en Velin, France Shading controls
4. ECCO-Build project Lausanne, Switzerland–Intermediate Switching
5. ECCO-Build project Horsham, Denmark ' Freeburg, Germany-Glare Index

Subtask C: Daylighting Design Tools

1. A working document was completed on a tools survey. (Refer special ISSUE OF Energy and Buildings)
2. Additional funding was received for a revision of the ADELINE GUI. This work will be performed beyond the scope of IEA SHC Task 31
3. Reports on goniophotometry, modeling, and indoor illumination from complex fenestration systems, all sky validation and implementation have been published in the special issue of Energy and Buildings
4. The software DELight was integrated into the EnergyPlus simulation program. EnergyPlus, a new building simulation program, is replacing DOE2. The US Government is promoting a free download-end use license. It has a weather conversion utility converting hourly data into an EnergyPlus format with 800 weather files around the world including European and Australian cities. The DELight engine includes the daylighting factor and electric lighting control calculations. The Institute of Building Physics (IBP) in Germany will provide a program allowing the filtering of the BTDF (Bidirectional transmittance distribution function) exporting data in Reformat.
5. There is now a report on the experimental validation of simulation methods at the daylighting performance level and on the application of CIE test cases to assess the accuracy of lighting computer programs. The results of the validation work are available on the SHC Task 31 webpage. This online site can be used as a validation and benchmark site. In the future, new validation datasets will be included according to a defined procedure and compared to other already performed validation runs. The database on systems will be made publicly available via a website hosted by IBP of Germany. For ongoing inclusion of datasets beyond the scope of SHC Task 31, IBP is to seek collaboration with LBNL of the USA and LESO of Switzerland.

Subtask D: Performance Tracking Network and Design

Work has been carried out on the education package. It is composed of two packages.

A document for researchers, academics, and educators defining the current status of daylight in buildings, and identifying future issues and areas of research. The framework of a daylighting design roadmap for design (with Subtask B). This document will be linked to research papers, working documents, reports and tools.

WORK PLANNED FOR 2007

The framework for the road map will be further developed in a new IEA SHC Working Group lead by Michael Donn of Victoria University in Wellington, New Zealand.

LINKS WITH INDUSTRY

In Australia, a Lighting Innovation Centre, a collaborative network of associations, universities and state government, has been created to provide services for the research, development, commercialization, education and provision of information and expertise in best practice lighting solutions (satisfying human, environmental and economic outcomes). The Centre aims to lift the knowledge of lighting amongst the greater community in order to facilitate demand for more sustainable quality lighting solutions and technologies its activity in 2006 involved a best practices in lighting program delivered via a seminar series in Australian cities lead by Peter Boyce (UK).

REPORTS PUBLISHED IN 2006

Special issue of Energy and Buildings, Vol. 38, No. 7, June 2006
This special issue contains results from Task 31 and includes 2 invited papers, 16 research papers, 1 editorial and 1 research communication

TASK 31 NATIONAL CONTACTS

Operating Agent
Nancy Ruck
School of Architecture, Design Science and Planning
University of Sydney
Sydney NSW 2006
ncr1@austarnet.com.au

Australia
Stephen Coyne
Centre for Medical, Health Environment Physics
School of Physics & Chemical Sciences
Queensland University of Technology
GPO Box 2434
Brisbane, Queensland 4001

Belgium
Magali Bodart
Université Catholique de Louvain
Architecture et Climat
Place de Levant 1
1348 Louvain-la-Neuve

Arnaud Deneyer
Belgian Building Research Institute

Canada
Christoph Reinhart
National Research Council,
Canada Institute for Research in Construction
1500 Chemin Montreal Road
Ottawa, Ontario KIA OR6

Denmark
Kjeld Johnsen and Jens Christoffersen
Danish Building and Urban Research
Energy and Indoor Climate Division
Postboks 119
DK-2970 Hørsholm

Finland
Liisa Halonen
Helsinki University of Technology
Otakaari 5 A
02150 Espoo

Jorma Lethovaara
Helsinki University of Technology
Lighting Laboratory
PO Box 3000
FIN-02015 HUT

France
Marc Fontoynont and Fawaz Maamari
ENTPE/DGCB
Rue Maurice Audin
69518 Vaulx-en-Velin, Cedex

Germany
Jan de Boer and Hans Erhorn
Fraunhofer-Institut für Bauphysik
Nobelstrasse 12
70569 Stuttgart

Dr. Alexander Rosemann
University of British Columbia
Department of Physics and Astronomy
6224 Agricultural Road
V6T 1Z1 Vancouver
British Columbia, Canada

Italy
Valentina Serra
Politecnico di Torino
Viale Mattioli 39
10125 Torino

Anna Pellegrino
Dipartimento di Energetica-
Facolta di Architettura-
Politecnico di Torino
Viale Mattioli 39
10125 Torino

Japan
Koga, Yasuko
Dept. of Architecture and Urban Design
Kyushu University

New Zealand
Michael Donn and Werner Osterhaus
Victoria University of Wellington
Centre for Building Performance
P.O. Box 600
Wellington 1

Norway
Barbara Matusiak
Norwegian University of Science and Technology
Faculty of Architecture, Planning and Fine Arts
7034 Trondheim

Sweden
Helena Bülow-Hübe
Lund University
Division of Energy and Building Design
Department of Construction and Architecture
P.O. Box 118
S-221 00 Lund

Nils Svendenius
Lund University
Department of Atomic Spectroscopy
Sölvegatan 14
S-223 62 Lund

Lars R Bylund
PELK Design Group
Drottningsgatan 71 C
SE-11136 Stockholm

Switzerland
Nicolas Morel and Jean-Louis Scartezzini,
Antoine Guillemin, and Marilyne Andersen
Solar Energy & Building Physics Lab.
École Polytechnique Fédérale de Lausanne
1015 Lausanne

Prof. Marilyne Andersen
Massachusetts Institute of Technology
(MIT)
Department of Architecture
Room 5-418
77 Massachusetts Avenue
Cambridge MA 02139-4307 USA

United Kingdom

John Mardaljevic
Institute of Energy & Sustainable
Development
Leicester
UK LE7 9SU

United States

William Carroll, Steve Selkowitz and
Eleanor Lee
Lawrence Berkeley National
Laboratory
Building 90-Room 3111
Berkeley, California 94720

TASK 32
Advanced Storage Concepts for Solar and Low Energy Buildings

Jean-Christophe Hadorn
BASE Consultants SA
Operating Agent for the
Swiss Federal Office of Energy

TASK DESCRIPTION

The main goal of this Task is to investigate new or advanced solutions for storing heat in systems providing heating or cooling for low energy buildings.

The first objective is to contribute to the development of advanced storage solutions in thermal solar systems for buildings that lead to high solar fraction up to 100% in a typical 45N latitude climate. The second objective is to propose advanced storage solutions for other heating or cooling technologies than solar, for example heat pumps or fossil boilers in order to reduce cycling and thus to reduce pollutant emissions due to partial combustion.

The ambition of the Task is not to develop new storage systems independent of a system application. The focus is on the integration of advanced storage concepts in a thermal system (solar, heat pump or boiler) for low energy housing. This provides both a framework and a goal to develop new technologies.

The Subtasks are:

- Subtask A: Evaluation and Dissemination (Subtask Leader in 2006: Switzerland)
- Subtask B: Chemical and Sorption (Subtask Leader: Chris Bales, Sweden)
- Subtask C: Phase Change Materials (Subtask Leader: Wolfgang Streicher, Austria)
- Subtask D: Water (Subtask Leader: Harald Drueck, Germany)

The teams within Subtasks B, C and D are asked to set up a TRNSYS model of their system based on experimental work in order for Subtask A to compare all the options in terms of heat and cold storage for a reference case of a single family house in four climates.

Duration

The Task was initiated in July 2003 and was initially planned to be completed in December 2006. The Task has been extended 12 months until December 2007 in a decision at the 58th Executive Committee meeting in December 2005.

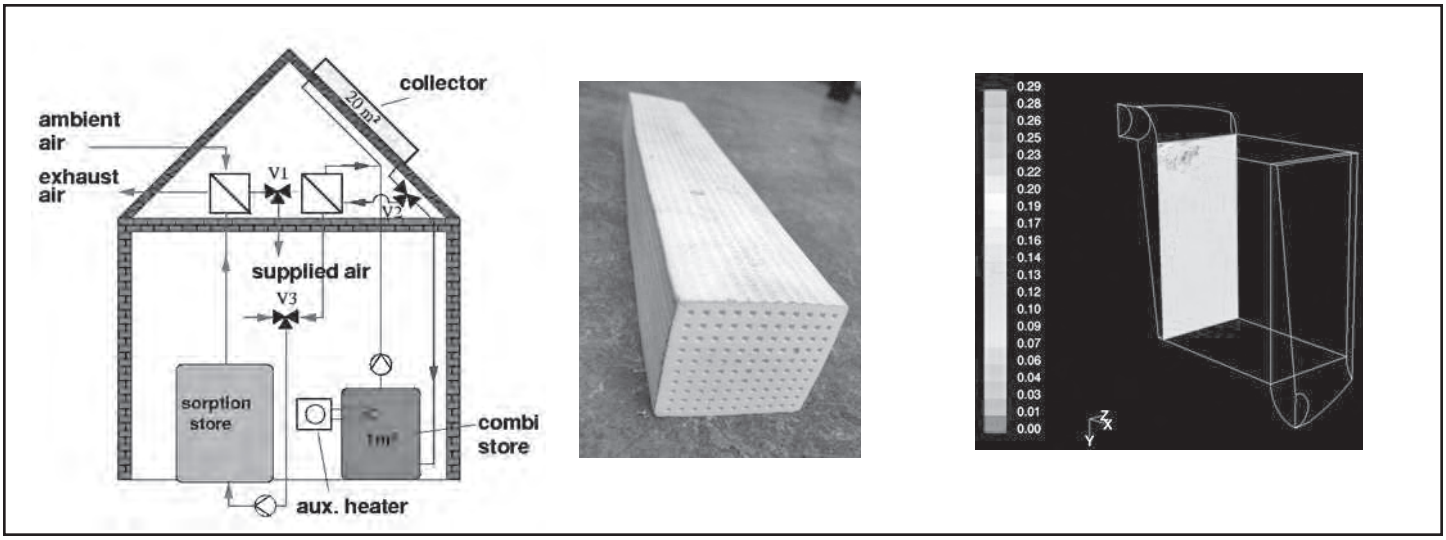
ACTIVITIES DURING 2006

General

In 2006, two meetings gathered 20 experts from 7 countries, with an official participation from 7 countries (Austria, Denmark, Germany, Netherlands, Spain, Sweden and Switzerland) and the input from 1 other (France). We have had 2 new teams in the Task: a group from Kassel University in Germany and a group from TNO in the Netherlands. EMPA from Switzerland was also able to officially participate from the last quarter on.

Subtask A: Evaluation Method and Dissemination of Results

The main activity of Subtask A during 2006 has been the follow-up of the sales of our "State of the Art" handbook on short term heat storage. It has been sold through the internet since the beginning of 2006 for a price of 35 euros plus shipping. Sales went smoothly about 1 copy per week without strong promotion.



The final reference conditions and the final reference system for comparing different storage options with the same framework was completed by the Austrian team. It has been pre-tested by some of the participants and will be used intensively in 2007 by all teams. It is an important outcome of this Task and will be used in the simulation work on solar combisystems for heating and cooling a single family house in four different climates.

The Task web site can be found at www.iea-shc.org under Task32. It has been updated with working documents and is the Task platform for exchanging information with more than 230 documents, meeting presentations and articles on heat storage.

An electronic Newsletter will be issued at the beginning of 2007.

Subtask B: Chemical and Sorption Storage

Six projects are being investigated. Subtask B has promising technologies for dense storage. However the task is difficult. Material characterisation at SPF Switzerland and setting up of projects was longer than anticipated. Project TCA in Sweden is the most advanced and suited mainly for cooling applications. Project Modestore in Austria came to disappointing field results for a seasonal storage with silica gel. The material appears not to be suited to this application. At SPF in Switzerland, a project aims at understanding how a zeolite or silica gel bed is behaving. The German project called Monosorp has the potential to give a seasonal storage with only 8 m3 of zeolite for a passive house. Theoretical concept is now proven and laboratory tests started in July 2006. Two new projects (thermochemical storage in the Netherlands and NaOH storage in Switzerland) joined our Task during 2006. The work on chemical heat storage is unfortunately still in its infancy due to low budgets in all countries on this topic.

Subtask C: Phase Change Materials

Six projects are being developed. Most of them use sodium acetate as the phase change material. Subtask C is progressing well with combisystems in focus. The Danish project shows that a 10 m3 only PCM seasonal storage using super cooling effects is theoretically possible. Experimental setup will assess some assumptions on heat transfer in a bulk PCM tank. The Austrian team on PCM in tanks tried to tackle the thermal properties of sodium acetate with graphite

The Monosorp project of ITW in Germany is seasonal storage based on an open adsorption principle in an extruded zeolite. A prototype will be tested in 2007.

problems and the power rating of several heat exchanger arrangements: with a 30% SA+G PCM tank, can be achieved a 1.4 to 2 density compared to water over 50-90C. Project CosyPCM in Switzerland is similar but focuses on the number of cycles that can be achieved by a tank with 14% volume of PCM in the upper part. The Spanish team has shown that the cost of a PCM tank in a combisystem can double the price of the tank, but save 25% space in a Spanish cellar. The team at the University of Lleida is also working on the enhancements of the heat exchange quality for sodium acetate in aluminium bottles.

Subtask D: Water Tanks

Six projects are under investigation. Subtask D is focusing on improving tank storage and regular combisystems. ITW has already done a lot of work in this area and will contribute more to Task 32. The Danish project is well advanced in comparing several devices to enhance stratification effects and several ways to produce

tap water from the storage tank. The SPF team in Switzerland is studying a drain back-pressureless tank. New TRNSYS types are being developed for flue gas so able to have accurate CO_2 emission calculations for combi-systems. Two new projects from the Netherlands and Germany started recently. In Spain, a theoretical project showed interesting results in dimensionless numbers analysis to evaluation stratification effects.

WORKED PLANNED FOR 2007

The work is progressing slowly due to the difficulty of the tasks. Validation of storage models is on the way, but they will be as good as the quality of the laboratory testing for which all the teams are committed. We plan to have at least 10 different cases simulated and compared. Although this is ambitious, it will result in more information on new systems and materials that can be used in further work. Subtasks B and C have already experienced difficulties in some technologies and that has brought new light and experience to the scientific community.

We are observing more and more interest in new heat storage solutions in different countries and R&D programmes. Task 32 initiated in 2003 will have helped to this situation.

LINKS WITH INDUSTRY

An industry day was held November 14, 2006 at the Technical University of Denmark. It was attended by about 30 representatives of the Danish storage industry and 15 Task experts.

Within an EU Project, Preheat, a workshop was organised in Lyon, France in July 2006 and Task 32 status was presented by the Operating Agent. About 25 people attended from engineering companies, utilities, municipalities and the heat storage industry.

REPORTS/PAPERS PUBLISHED IN 2006

- Report on laboratory prototypes of storage units (December 2006)
- Task presentation at the National Austrian Innovative Storage Conference
- Task presentation and 10 scientific papers at Ecostock

REPORTS PLANNED FOR 2007

- Report on boundary conditions and reference conditions
- Report on method of comparison and criteria
- Report on criteria assessment for advanced combisystem with new storage designs
- Report on identifications and selection of projects. Revised final version
- Report on update of B3 on laboratory prototypes of storage units
- Report on simulation models
- Report on systems simulations with ref conditions
- Report on improved designs
- Report on final Subtask work
- Report on laboratory prototypes of storage units
- Report on lab tests. Will be an update on laboratory prototypes of storage units
- Report on simulation models
- Report on system simulations
- Report on improved design
- Report on final Subtask work
- Report on review of advanced concepts and dream systems for tank storage
- Report on laboratory testing of advanced or new devices
- Report on lab tests of water tank stores
- Report on development of simulation models
- Report on system simulation with reference conditions
- Report on next generation design
- Report on final Subtask work

MEETINGS IN 2006

Seventh Experts Meeting

May 29-30, in conjunction with the international Ecostock'06 conference
Stockton, New Jersey, USA

Eighth Experts Meeting

November 15-17 in conjunction with a national Danish industry day on heat storage
Lyngby, Denmark

MEETINGS PLANNED FOR 2007

Ninth Experts Meeting

April 18-20, in conjunction with a German industry day on April 17th
Stuttgart, Germany

Tenth Experts Meeting

October 3-5
Dübendorf, Switzerland

TASK 32 NATIONAL CONTACTS

Operating Agent

Jean-Christophe Hadorn
BASE Consultants SA
51 Chemin du Devin
CH-1012 Lausanne, Switzerland
jchadorn@baseconsultants.com

Austria

Wolfgang Streicher, Andreas Heinz, Richard Heimrath, Peter Puschnig
Institute of Thermal Engineering
Graz University of Technology
Inffeldgasse 25 B
A-8010 Graz
w.streicher@tugraz.at
andreas.heinz@tugraz.at
Peter.puschnig@tugraz.at

Waldemar Wagner, Dagmar Jaehnig
AEE INTEC
Arbeitsgemeinschaft
ERNEUERBARE ENERGIE
Feldgasse 19
A-8200 Gleisdorf
w.wagner@aee.at

Denmark

Simon Furbo, Elsa Andersen, Jorgen Schultz
Department of Civil Engineering
Technical University of Denmark
Building 118, Brovej
DK-2800 Kgs. Lyngby
sf@byg.dtu.dk

France

Thomas Letz
Maison des énergies - ASDER
562 Avenue du Grand Arietaz
BP 99499
F-73 094 CHAMBERY Cedex
thomas.letz@asder.asso.fr

Observer : Laurent Barthel
EDF R&D
Site des Renardières
F – 77818 Moret/Loing
Laurent.barthel@edf.fr

Germany

Harald Drueck, Henner Kerskes
Institut fuer Thermodynamik und Waermetechnik (ITW)
Pfaffenwaldring 6
D-70550 Stuttgart
drueck@itw.uni-stuttgart.de
kerskes@itw.uni-stuttgart.de

Hans-Martin Henning, Thomas Nunez
Thermal Systems and Components
Fraunhofer Institute for Solar Energy Systems ISE
Heidenhofstr. 2
D - 79110 Freiburg
hansm@ise.fhg.de
nunez@ise.fraunhofer.de

Klaus Vajen, Ulrike Jordan, Claudius Wilhelms
Universitaet Kassel
Institut fuer Thermische Energietechnik, D-34109 Kassel
vajen@uni-kassel.de
jordan@uni-kassel.de
wilhelms@uni-kassel.de

Spain

Luisa F. Cabeza, Cristian Solé
Escola Politècnica Superior
Universitat de Lleida
Jaume II, 69
SP - 25001 Lleida
lcabeza@diei.udl.es

Sweden

Chris Bales
Solar Energy Research Center (SERC)
Dept. of Mathematics, Natural Sciences and Technology
Högskolan Dalarna
S-78188 Borlänge
cba@du.se

Switzerland

Stéphane Citherlet, Jacques Bony
Applied University of West Switzerland
Laboratory of Solar Energetics and Building Physics
Route de Cheseaux 1
CH - 1401 Yverdon-les-Bains
stephane.citherlet@eivd.ch
Jacques.Bony@eivd.ch

Peter Vogelsanger, Paul Gantenbein
SPF Hochschule für Technik Rapperswil
Oberseestr. 10
CH-8640 Rapperswil
peter.vogelsanger@solarenergy.ch
paul.gantenbein@solarenergy.ch
michel.haller@solarenergy.ch

Robert Weber
EMPA Duebendorf
Abteilung Energiesysteme / Haustechnik
Ueberlandstrasse 129
CH-8600 Duebendorf
robert.weber@empa.ch

The Netherlands

Klaas Visscher, Wim van Helden, Marco Bakker
Energy Research Centre of the Netherlands (ECN)
P.O. Box 1
NL - 1755 ZG Petten
visscher@ecn.nlvanhelden@ecn.nlm.
bakker@ecn.nl

Lucienne Krosse, Huib Visser
TNO Delft
P.O. Box 49
2600 AA Delft
The Netherlands

TASK 33
Solar Heat for Industrial Processes

Werner Weiss
AEE - Institute for Sustainable Technologies
Operating Agent for the Austrian Ministry of Transport, Innovation and Technology

TASK DESCRIPTION

Around 150 million square meters of solar thermal collectors, corresponding to an installed capacity of 105 GWth, were installed by the year 2004 worldwide. Until now, the widespread use of solar thermal plants has focused almost exclusively on swimming pools, domestic hot water preparation and space heating in the residential sector.

The use of solar energy in commercial and industrial companies is currently insignificant compared to the use in swimming pools and the household sector. Most solar applications for industrial processes have been used on a relatively small scale and are mostly experimental in nature. Only a few large systems are in use worldwide. However, if one compares the energy consumption of the industrial, transportation, household and service sectors in OECD countries, the industrial sector has the highest energy consumption at approximately 30%, followed closely by the transportation and household sectors.

The major share of the energy, which is needed in commercial and industrial companies for production processes and for heating production halls, is below 250°C. The low temperature level (<80°C) complies with the temperature level that can easily be reached using solar thermal collectors already on the market. The principles of operation of the components and systems apply directly to industrial process heat applications. The unique features of these applications lie on the scale on which they are used, system configurations, controls needed to meet industrial requirements, and the integration of the solar energy supply system with the auxiliary energy source and the industrial process. For applications where temperatures up to 250°C are needed, the experiences are rather limited and suitable components and systems are missing. Therefore, for these applications the development of high performance solar collectors and system components is needed.

To be able to make use of the huge potential for solar heat in industry and to open a new market sector for the solar thermal industry, SHC Task 33 is carrying out potential studies—it will investigate the most promising applications and industrial sectors for solar heat and will optimize, develop and test solar collectors for medium temperature applications (up to approximately 250°C). The development of integral solutions for solar thermal energy applications for given industrial processes (based on the "PINCH-concept") is also one of the main topics of this Task. In addition, the development of design tools (based on TRNSYS simulations) and a software tool for fast feasibility assessment, economic analyses as well as the design and the erection of pilot plants in co-operation with industry are planned.

Scope of the Task

The scope of the Task is on solar thermal technologies for converting the solar radiation into heat, (i.e., starting with the solar radiation reaching the collector and ending with the hot air, water or steam transferred to the application). The distribution system, the production process and/or the optimization of the production process are not the main topics of the Task. However, influences on the production process and the distribution system arising from the character of the solar heat source will be studied in the framework of the Task.

Applications, systems and technologies, which are included in the scope of this Task, are:

- All industrial processes where heat up to a temperature level of approx. 250°C is needed.
- Space heating of production or other industry halls is addressed, but not space heating of dwellings.
- Solar thermal systems using air, water, low pressure steam or oil as a heat carrier, i.e. not limited to a certain heat transfer medium in the solar loop.
- All types of solar thermal collectors for an operating temperature level up to 250°C are addressed: uncovered collectors, flat-plate collectors, improved flat-plate collectors - for example hermetically sealed collectors with inert gas fillings, evacuated tube collectors with and without reflectors, CPC collectors, MaReCos (Maximum Reflector Collectors), parabolic trough collectors.

To accomplish the objectives of the Task, the participants are carrying out research and devel-opment in the framework of the following four subtasks:

- Subtask A: Solar Process Heat Survey and Dissemination of Task Results (Lead Country: Italy)
- Subtask B: Investigation of Industrial Energy Systems (Lead Country: Austria)
- Subtask C: Collectors and Components (Lead Country: Germany)
- Subtask D: System Integration and Demonstration (Lead Country: Germany)

Collaboration with other IEA Programmes

Due to the complementary background and know-how of the participants of the SHC and the SolarPACES Programmes, significant synergies were expected from collaboration. Therefore, it was agreed to co-operate with the SolarPACES Program on a "moderate level" according to the SHC "Guidelines for Co-ordination with other Programs."

The PSE Fresnel collector installed on the rooftop to power a NH3/H2O absorption chiller (Source: PSE, Germany)

Duration

The Task was initiated on November 1, 2003 and will be completed on October 31, 2007.

ACTIVITIES DURING 2006

Subtask A: Solar Process Heat Survey and Dissemination of Task Results

Existing plants and Potential studies

Currently about 84 solar thermal plants for process heat are reported worldwide, with a total installed capacity of about 23.8 MWth (33,991 m^2). These plants are located in 19 countries and cover 11 different industrial sectors, showing that solar thermal can be fruitfully used for several applications in industry. In 2006, several new plants have been reported from India, Italy, Spain Switzerland and Austria.

The results of the performed potential studies in the participant countries have been updated, including the potential study for the Australian state of Victoria. According to the last assessment, extrapolating the outcomes of the studies carried out (Austria, Germany, Italy, Portugal, Spain, Netherlands), the overall potential for solar thermal in industry in the EU25 is between 90 and 112 GWth (128 - 160 million m^2). This would cover 2.5% of the total heat demand of the industrial sector.

This figure represents a relevant contribution to fulfill the EU target for solar thermal. For instance, solar process heat plants could deliver to industry up to 64 TWh/year, a remarkable contribution. This would be about 25% of the Renewable Energy Target for Europe defined by EREC (European Renewable Energy Council), which equals to 279 TWh/year by 2020.

Also the potential market volume sounds astonishing: 112 GWth (160,000,000 m_) of new capacity installed for the European solar industry, while at the end of 2005 the total installed capacity of solar thermal collectors in Europe was about 11 GWth.

Therefore, also considering a conservative scenario (for example, a penetration rate of 10% of the above described potential), it would lead to a total market volume of 11.2 GWth (16,000,000 m_). If this global figure is split in a 10-year installation program, an annual market of 1,600,000 m_ will be reached (European market in 2005 was: 2,000,000 m_). Also the impact on new jobs would not be negligible—160,000 new jobs in 10 years.

Industry Workshops

In 2006, two industry workshops were carried out. The first industry workshop, "Solar Thermal for Heat

Production in Industries," was held on March 31st at the University of Rome "La Sapienza." The seminar, promoted by the Province of Rome, the Region Lazio and the Italian Ministry of Industry, was attended by about 150 participants. The speakers panel included policy makers, Task 33/IV experts and also representatives from solar thermal industry and small and medium enterprises.

The second industry workshop was held on October 13th at INETI in Lisboa, Portugal and it was attended by about 70 participants. The speakers panel included Task 33/IV experts, experts on eco-design and sustainable efficiency measures for industry from INETI and also a solar thermal industry representative of a Portuguese manufacturer of CPC collectors. The presentations of both workshops are available for download at www.iea-ship.org.

Industry Newsletter

The third issue of the industry newsletter was prepared and it will be published by the end of January 2007 in English and in the languages of all participating countries. It will be also available for download at www.iea-ship.org.

Subtask B: Investigation of Industrial Energy Systems

Matrix of Indicators

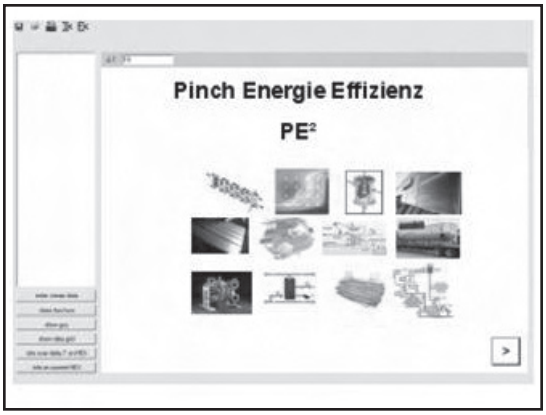
A "Matrix of indicators" (MATRIX), which is a comprehensive database, was developed in Subtask B as a decision support tool for solar experts. With this matrix the work with industry and the identification of suitable solar applications will be facilitated. With the MATRIX it should be possible to investigate and calculate the installation of solar heat in production processes without detailed knowledge of the relevant unit operations.

Some industry sectors such as food, chemistry, plastic processing, textile industry and surface treatment industry can be identified as very promising sectors for solar thermal applications. For these industries detailed information like general benchmark data, temperature levels of the processes, flow sheets of production lines and generic hydraulic schemes for solar integration can be found in the MATRIX.

The investigation of these relevant industries has to focus on an integrated analysis of cooling and heating demands taking into account competitive technologies, when assessing the (economic) feasibility of solar thermal energy. Among those competing technologies are heat integration, co-generation, new technologies and heat pumps, which also have been described in the relevant parts of the MATRIX.

Expansion of the Existing Heat Integration Models

Most industries have a heat demand in the production and at the same time a lot of waste heat. The use of this waste heat has the advantage of being in competition with the heat demand of other processes. The reuse of this waste heat has to be done at as a high temperature as possible. The most promising methodology to identify the maximum heat recovery in a defined system is the pinch analysis. With this tool the minimum heating demand and the minimum cooling demand can also be identified. Within the work of Subtask B a computer program (Pinch Energy Efficiency – PE_), which calculates the recovery potential and designs the technically and economically feasible heat exchanger network for given processes has been developed. The



Front page of the PE_ software, which was developed within Task 33/IV by JOINTS.

new software PE_ fulfills the needs of heat integration calculations in the promising industries.

Subtask C: Collectors and Components

Medium Temperature Collector Developments

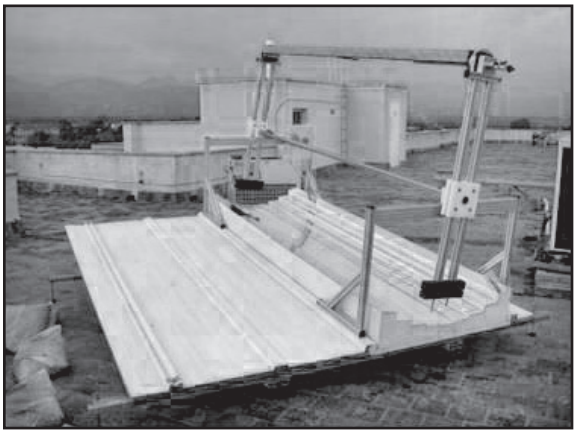
The reports and discussions during the two 2006 experts meetings in Rome and Lisbon showed that many development projects are now in progress. And still even more projects are starting and new concepts for concentrating collectors in the temperature range from 150 to 250°C are being investigated. This is a very positive situation, and is considered to also be a result of the successful work of Task 33/IV.

For example, AEE INTEC reported on the further development of the Parasol One collector from the company Button Energy in Austria. This is a parabolic trough collector, which is designed for the temperature range up to 200°C. Successful experiments on the direct steam generation were carried out during summer 2006. Suitable heat transfer media for a first application of the collector in a solar cooling system were investigated.

The company PSE GmbH from Germany develops a Fresnel process

heat collector for the temperature range of 150 to 250°C. The first experimental collector was erected in December 2005 in Freiburg, Germany. The total reflector area of this collector is 88 m_. It is operated in a testing loop for experimental investigations. And already during the summer of 2006 the second Fresnel process heat collector with a reflector area of 132 m_ was setup in Bergamo, Italy. This collector is installed in a system for solar cooling. The heat of the collector is used to operate an absorption chiller of the Italian company, Robur. First operating experience was gathered during the summer 2006 with respect to the collector, the absorption chiller and their common interaction. The measured monitoring data of the collectors and the cooling system are now evaluated and the development work will be continued.

A new collector development was also started in Spain; the CCStaR collector is following the concept of fixed Fresnel reflectors and a moving receiver. The work was started at the Universitat de les Illes Balears in Mallorca. In June 2006, the company Tecnologia Solar Concentradora S.L. has been constituted with the purpose of developing the CCStaR concept to an industrial stage.



The CCStaR collector developed by the Universitat de les Illes Balears, Spain.

Finally it has to be mentioned here that a new parabolic trough collector was developed in Australia. The NEP SOLAR Polymer Carrier PTC has an aperture width of about 1m and a new reflector design. It was set up for testing during the summer 2006 and it is planned that in 2007 it may come to the market.

Medium Temperature Collector Testing

New medium temperature collectors require new testing facilities for collector performance measurements in the temperature range up to about 200 °C. An important step was taken during summer 2006 concerning testing of process heat collectors. A "Round Robin" or intercomparison test among test labs was initiated. The testing institutions Fraunhofer ISE in Freiburg, Germany, ITW in Stuttgart, Germany and INETI in Lisbon, Portugal will carry out thermal performance tests on a vacuum tube collector with CPC reflector. Three collectors were acquired for the Round Robin test and the thermal performance of all three of them was measured at Fraunhofer ISE with a newly designed Medium Temperature Test Stand (MTTS) using the indoor test facility with solar simulator. The highest collector inlet temperature in these tests was 185°C. The laboratories at ITW and INETI will now perform their tests so that the results can be compared in the meetings in 2007. Conclusions with regard to testing recommendations for medium temperature collectors will be drawn from the experience gained in these tests.

The stagnation behavior of large (medium temperature) collector fields is still a very crucial point which needs much more attention and further investigation in order to avoid stagnation problems in industrial applications of solar collectors. For example, Aiguasol Engineering in Spain, reported on the operation experience and the stagnation behavior of the CONTANK system. Stagnation problems occurred there because the load of the system is considerably less than it was assumed in the planning phase of the system. The safety valve was activated several times already due to excessive steam volume produced in the collector. Nighttime cooling trough the collector field is applied and reduces the problems a little bit but not sufficiently. Calculations were carried out for a more appropriate dimensioning of the membrane expansion vessel. The investigations will be continued.

The results from the ongoing German stagnation proof projects indicate that the degradation of the water-glycol fluid is mainly caused by high temperatures. A danger of blocking by degraded glycol residue is caused especially when small absorber tubes are used in collectors with absorbers that have an unfavorable emptying behavior and low heat losses. The discussions showed that still a lot of experience is missing and no standard procedures to solve stagnation problems in existing plants are known. This is especially true for large systems with collector areas of hundreds to thousands of m_ that are aimed at in process heat systems. As a result more experience is needed and solid experimental experience and knowledge has to be elaborated.

Subtask D: System Integration and Demonstration

Up to now, nine pilot systems have been installed. In the 2006, four new pilot systems were erected in the field of seawater desalination (Fraunhofer ISE), breweries (AEE

INTEC) and cooling (PSE). A special focus in 2006 was on breweries and seawater desalination.

Results of investigations at one Austrian and three German breweries were presented and discussed at the Experts Meeting in Rome. The investigated breweries cover a wide range of company sizes and different applications within the processes. In Austria, one brewery was equipped with a solar thermal system and the first monitoring results are available. The solar heat, which is produced with a newly developed anti-reflective double glazed flat plate collector, is also used for the brewing process.

Ongoing work in the laundry and metal surface treatment sectors, respectively, will be discussed in more detail at the next Experts Meeting scheduled for March 28-30, 2007 in Cologne, Germany.

Another promising application is space heating of factory buildings. A review of 10 systems in Austria with solar fractions between 10 and 100% was prepared by AEE INTEC.
Design guidelines for space heating of factory buildings based on TRNSYS simulations are currently under preparation and will be available in a printed version by spring 2007.

Sea water desalination in Gran Canaria, Spain
(Fraunhofer ISE, Germany).

The following table gives an overview of the pilot systems.

Plant, Country	Application	Installed capacity Collector type	Monitoring data available
Contank Spain	Container washing	357 kWth flat plate collector	YES
Carcavelos (BRISA) Portugal	Space heating and cooling	466 kWth CPC	NO
ROBUR Italy	cooling	65.5 kWth (132 m_) 132 m_ fresnel collector	YES
Sea water desalination Gran Canaria, Spain	Sea water desalination	70 kWth anti-reflective double glazed flat plate collector	YES
Sea Water desalination plant, Aqaba, Jordan	Sea water desalination	50.4 kWth flat plate collector	YES
Fruit juices Gangl, Austria	Pasteurising bottle washing	42 kWth flat plate collector	YES
Sunwash, Köflach, Austria	Car wash	30 kWth flat plate collector	NO
Sunwash, Gratkorn, Austria	Car wash	30 kWth flat plate collector	YES
Brewery Neuwirth Austria	Brewing process	14 kWth anti-reflective double glazed flat plate collector	YES

WORK PLANNED FOR 2007

Subtask A: Solar Process Heat Survey and Dissemination of Task Results

Two booklets will be prepared, summarizing the main outcomes of the survey of existing plants for solar process heat and of the performed potential studies.

The next industry workshop will be organized in the framework of the 8th Task 33/IV experts meeting in Cologne (Germany) on 30 March 2007.

The third issue of the industry newsletter will be available by the end of January 2007 in English and in the languages of all participating countries.

Subtask B: Investigation of Industrial Energy Systems

In 2007, the focus of the work in Subtask B will be on the development of a tool for a cost analysis suitable for detection of all parameters that influence the economic performance of energy efficiency measures and the installation of a solar plant in an industrial process. Total Cost Assessment (TCA) was chosen as a method, because particular emphasis is on the costs related to environmental and health issues, which especially for solar energy use can result in a very different appraisement of costs and investment projects than conventional methods.

In addition to the TCA tool, a road

map will be developed to provide companies with a decision making tool to find a tailor-made procedure for investments and/or operating options for consecutive projects protracted over a long period with several investment phases or changes in operation. This road map will be an instrument to visualize the differences, advantages and disadvantages of viable investment or operating options and the expected results in terms of either costs or energy use for the different approaches.

Further the matrix of indicators will be completed with detailed data of the textile, electroplating and chemical industry.

Subtask C: Collectors and Components

The work on the development of medium temperature collectors will continue in the different projects involved in the Task.

Activities on the testing of medium temperature collectors and on the round robin test will be intensified. The experiences from the testing investigations will be used to elaborate recommendations for testing of medium temperature collectors in general.

The investigations on material tests will concentrate on reflectors for concentrating medium temperature collectors.

Regarding system aspects, more field test results will be discussed in the experts meetings in 2007. Data from monitoring of pilot plants will be analyzed. This work will contribute to the development of adequate collector testing and inter-comparison.

The brochure "Medium Temperature Collectors" will be revised and supplemented with additional general information on the different categories of process heat collectors.

Subtask D: System Integration and Demonstration

The main focus in 2007 will be the finalization of contributions to the final deliverables, particularly the design guidelines on the Task website and the pilot plant booklet. A numerical tool to evaluate the annual performance of potential applications at an early design stage including economic analyses will be developed to complement the process analysis and design support tools provided from Subtask B.

In Germany, the design of a pilot installation of a solar process steam generator with parabolic trough collectors at the site of a metal surface treatment plant will be developed. However, the installation of the system will be beyond the time frame of this Task. It is endeavored to identify additional potential applications for concentrating and non-concentrating collectors and bring together consortia for the realization of further pilot installations in the most promising sectors as a follow-up activity, for which funding support will be sought.

LINKS WITH INDUSTRY

The Task defines two levels of participation for the solar industry:

- Level 1. An industrial participant at this level should expect to participate in an annual workshop organized by SHC Task 33 and to receive at least once during the task duration a visit from a task participant, and to answer technical and marketing questions on solar heat for industrial applications (this activity is part of the system survey and the dissemination activity of Subtask A).
- Level 2. An industrial participant at this level should expect Level 1 commitment and to participate in all task meetings and to bring information and feedback from the market. Level 2 participation should be seen in close connection with the main participant of the country of origin of the industry.

A total of 15 companies from Austria, Italy, Spain, Portugal, Germany, Belgium, France and Brazil participate in the Task.

REPORTS PUBLISHED IN 2006

- State-of-the-art report on medium temperature collectors
- Subtask B report

REPORTS PLANNED FOR 2007

- Report on medium temperature collector designs
- Report on pilot projects
- Report on potential Studies
- Report on design Guidelines – Space Heating of Factory Buildings
- Furthermore a CD will be published with the following content:
  - Demo version of the Pinch program PE_
  - Matrix of Indicators
- Final Task report
- Final management report

MEETINGS IN 2006

Sixth Experts Meeting

March 29 – 31
Rome, Italy

Seventh Experts Meeting

October 11 – 13
Lisbon, Portugal

PLANNED MEETINGS FOR 2007

Eighth Experts Meeting

March 28 – 30, 2007
Cologne, Germany

Ninth Experts Meeting

September 12 – 14, 2007
Graz, Austria

TASK 33 NATIONAL CONTACTS

Operating Agent
Werner Weiss
AEE INTEC
AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf

Australia
Wes Stein
Lucas Heights Science & Technology Centre
New Illawarra Rd, Lucas Heights
NSW, PMB 7
Bangor NSW 2234

Austria
Dagmar Jähnig, Thomas Müller
AEE INTEC
AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf

Hans Schnitzer and Christoph Brunner
Joanneaum Research
Elisabethstrasse 16/1
A-8010 Graz

Gernot Gwehenberger
Technical University of Graz
RNS
Inffeldgasse 25c
A-8010 Graz

Germany
Klaus Vajen and Elimar Frank
Kassel University
Department of Mechanical Engineering
Solar and System Technology
D-34109 Kassel

Andreas Häberle
PSE GmbH
Emmy-Noether Str. 2
D-79110 Freiburg

Klaus Hennecke
DLR
Institut für Technische Thermodynamik
D-51170 Köln

Matthias Rommel
Fraunhofer ISE
Heidenhofstrasse 2
D-79110 Freiburg

Stephan Fischer
ITW, Stuttgart University
Pfaffenwaldring 6
D-70550 Stuttgart

Markus Peter
dp2 - Energienutzung mit Verstand
Michelsweg 29
D- 59494 Soest

Italy
Riccardo Battisti, Annalisa Corrado
Claudia Vannoni, Serena Drigo
University of Rome "La Sapienza"
Department of Mechanical and Aeronautical Engineering
Via Eudossiana
18 00184 Rome

Mexico
Claudio Estrada
CIE-UNAM
Privada Xochicalco, S/N, Col. Centro
Cuernavaca, Mor., Mexico

Portugal
Maria Joao Carvalho
INETI
Edificio H, Estrada do Paço do Lumiar, 22
1649-038 Lisboa

Spain
Esther Rojas Bravo
CIEMAT-PSA
Avda. Complutense, 22, Edificio 42
28040 Madrid

Gonzalez i Castellví
AIGUASOL Engineering
C/ Roger de Llúria, 29 3er 2a
08009 Barcelona
Hans Schweiger
Ingeniería Termo-energética y Energías Renovables
Creu dels Molers, 15, 2o 1a
08004 Barcelona

TASK 34
Testing and Validation of Building Energy Simulation Tools

Ron Judkoff
National Renewable Energy Laboratory
Operating Agent for the U.S. Department of Energy

TASK DESCRIPTION

The goal of this Task is to undertake pre-normative research to develop a comprehensive and integrated suite of building energy analysis tool tests involving analytical, comparative, and empirical methods. These methods will provide for quality assurance of software, and some of the methods will be enacted by codes and standards bodies or other regulatory agencies to certify software used for showing compliance with building energy standards, tax credits, or other building energy incentive programs. This goal will be pursued by accomplishing the following objectives:

- Create and make widely available a comprehensive and integrated suite of IEA Building Energy Simulation Test (BESTEST) cases for evaluating, diagnosing, and correcting building energy simulation software. Tests will address modeling of the building thermal fabric and building mechanical equipment systems in the context of innovative low-energy buildings.
- Maintain and expand as appropriate analytical solutions for building energy analysis tool evaluation.
- Create and make widely available high quality empirical validation data sets, including detailed and unambiguous documentation of the input data required for validating software, for a selected number of representative design conditions.

This work is the combined effort of SHC Task 34 and the Energy Conservation in Buildings and Community Systems (ECBCS) Annex 43.

Scope

This Task is investigating the availability and accuracy of building energy analysis tools and engineering models to evaluate the performance of innovative low-energy buildings. Innovative low-energy buildings attempt to be highly energy efficient through use of innovative energy-efficiency technologies or a combination of innovative energy efficiency and solar energy technologies. To be useful in a practical sense such tools must also be capable of modeling conventional buildings. The scope of the Task is limited to building energy simulation tools, including emerging modular type tools, and to widely used innovative low-energy design concepts. Activities include development of analytical, comparative and empirical methods for evaluating, diagnosing, and correcting errors in building energy simulation software. The audience for the results of the Task/Annex is building energy simulation tool developers, and codes and standards (normes) organizations that need methods for certifying software. However, tool users, such as architects, engineers, energy consultants, product manufacturers, and building owners and managers, are the ultimate beneficiaries of the research, and will be informed through targeted reports and articles.

Means

A number of projects have been defined. For the purpose of describing the work, it is useful to define the terms "comparative tests" and "empirical validation." In comparative testing, a BESTEST-type comparative/diagnostic evaluation test procedure is written and software programs are compared to each other. Advantages of comparative tests include ease of testing many parameters, and that simple building descriptions may be used; the major disadvantage is lack

of any truth standard for cases where analytical solutions are not possible. In empirical validation, software is compared with carefully obtained experimental data. The advantage of empirical tests is that true validation of the models may be accomplished within the uncertainty of the experimental data; disadvantages are that gathering high quality experimental data is expensive and time consuming, making it difficult to test the individual effects of many parameters.

Comparative tests include:
- BESTEST ground-coupled heat transfer with respect to floor slab construction
- BESTEST multi-zone heat transfer and shading
- BESTEST airflow, including multi-zone airflow
- Chilled-water and hot-water mechanical systems and components
- Buildings with double-skin facades.

Within the comparative test cases, analytical verification tests for evaluating basic heat transfer and mathematical processes in building energy analysis tools will be included where possible. Analytical verification tests are comparisons with closed-form analytical solutions or with generally accepted numerical methods solutions performed outside of the environment of whole-building energy simulation software. Such solutions represent a "mathematical truth standard" based on the underlying physical assumptions given in the test specifications.

Empirical validation tests include:
- Shading/daylighting/load interaction
- Chilled-water and hot-water mechanical systems and components
- Buildings with double-skin facades.

When a number of building energy simulation programs are tested against the same empirical data set, comparative tests are also possible. Such comparative tests can help identify deficiencies in the empirical experiment if they exist, or broad-based deficiencies in the current modeling state of the art.

To effectively disseminate the results of the Task a single web site is under development that will consolidate IEA tool evaluation tests from SHC Task 12 / ECBCS Annex 21, SHC Task 22, and SHC Task 34 / ECBCS Annex 43.

Duration
The Task was initiated in September 2003 and will be completed in December 2007.

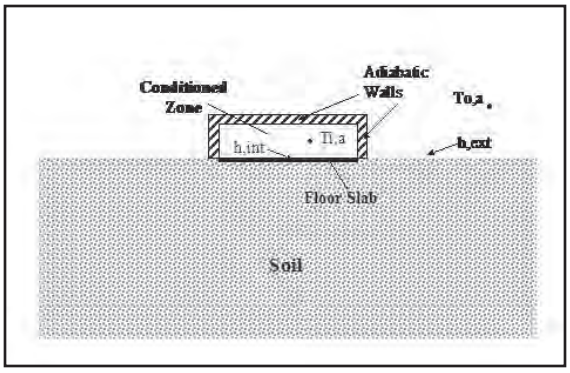
Participation
During 2006, a total of 35 participants from 23 organizations in 13 countries participated in this Task. The participating countries are: Australia, Belgium, Canada, Denmark, France, Germany, Ireland, Japan, Netherlands, Sweden, Switzerland, United Kingdom, and the United States.

ACTIVITIES DURING 2006
A summary of Subtask research and codes & standards activities completed is presented below.

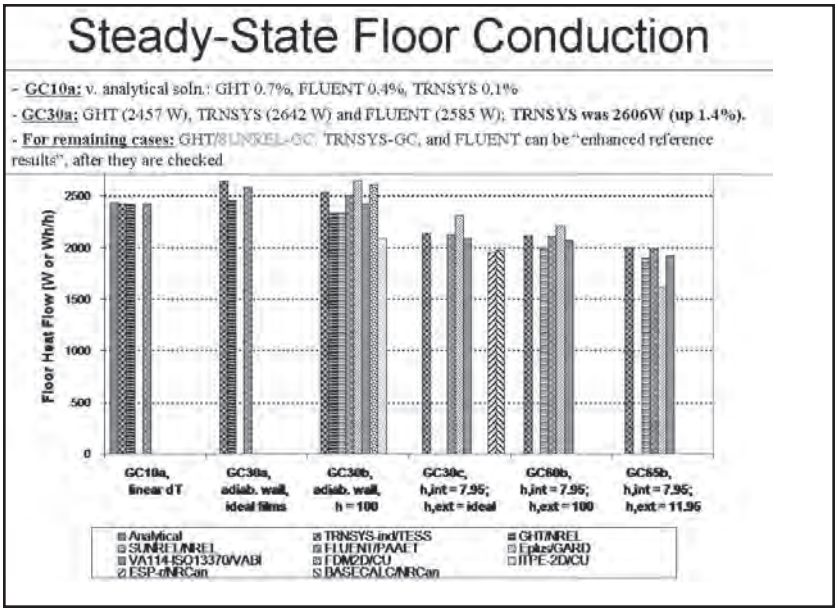
Projects
Activities during 2006 consisted of finalizing project plans, development of test specifications, acquiring empirical test data, simulations of test cases, improving test cases based on participants' comments, further simulations of improved test cases, and submittal of one final report for approval by the SHC and ECBCS Executive Committees.

Ground Coupled Floor Slab and Basement Comparative Tests (Leader: US/NREL)
NREL (US) revised and distributed the in-depth test specification in March 2006; the test specification is now complete. The objective of the in-depth test cases is to determine the causes for disagreements among detailed-model results found in preliminary test cases developed during SHC Task 22. The new cases are divided into "a"-series, "b"-series and "c"-series cases. The "a"-series test cases are for checking proper implementation of 3-d numerical-methods ground heat transfer models run independently of whole-building simulations (independent models). They include a steady-state 3-d analytical verification test case, and two other idealized steady-state and periodically-varying comparative test cases. The less idealized "b"-series and "c"-series cases (see Figure 1) compare typically more constrained ground heat transfer models integrated with whole-building simulations to the independent detailed models. Parametric variations in these cases include: periodic ground surface temperature variation (versus steady-state), floor slab aspect ratio, slab size, deep ground temperature depth, and interior and exterior convective coefficients (realistic versus high values to test the effect of surface temperature uniformity).

Simulation results were received for: EnergyPlus (GARD Analytics, US), TRNSYS (TESS, US), VA114 using ISO 13370 calculation (VABI, Netherlands), HOT3000/Basesimp (NRCan, Canada), Basecalc (NRCan, Canada), FLUENT (PAAET, Kuwait) and SUNREL-GC/GHT (NREL, US). A set of results for a small subset of the cases using 2 models was received from University of Colorado, US. An additional set of results using a



Ground Coupling Test Case Schematic Diagram, Case GC30



Ground-Coupled Floor Slab Sample Results, Floor Conduction. Establishing Numerical Methods Results as "Enhanced Reference Results" using Steady State Analytical Verification (GC10a) "Touchstone"

MATLAB based numerical-methods model is expected from Ireland (DIT) in early 2007.

The more detailed/less constrained numerical-methods models of GHT/SUNREL-GC, TRNSYS-GC, and FLUENT are able to produce results in good agreement with the analytical solution case. As shown in Figure 2, these models provide "enhanced reference results" for the other cases and are useful for diagnosing disagreements of the models integrated with whole-building simulations. So far the work has resulted in diagnosis of 10 software issues resulting in improvements to four of the simulation programs, including: EnergyPlus, SUNREL-GC, TRNSYS-GC, and VA114.

Multi-Zone and Airflow Comparative Tests (Leaders: US/NREL, Japan)

This project is divided into two sub-projects: Multi-Zone Non-Airflow Tests led by US/NREL and Airflow Tests including Multi-Zone Airflow led by Japan.

Non-Airflow Tests

The objectives of the current test cases are: a) test models' ability to correctly keep account of inter-zonal conduction heat transfer and to help define a starting point for multi-zone airflow cases; b) to test the ability of programs to account for multi-zone shading by a single shading object (see Figure 3) and self-shading of the building by zones that shade other zones; and c) to test the ability to model internal windows between zones. Shading and internal window test cases employ idealized glazing and building zones designed as calorimeters for testing shading and solar gains effects. So far, results have been submitted for 9 simulation programs, including: CODYRUN (U. Reunion Island, France), COMFIE (Ecole des Mines de Paris, France), EnergyPlus (GARD, US), ESP-r (U. Strathclyde, UK), KoZiBu (JNLOG, France), HTB2 (Cardiff U., UK), TRNSYS-TUD (Dresden U. of Technology, Germany), TRNSYS 16 (University of Liege, Belgium), and VA114 (VABI Software, The Netherlands). For the multi-zone conduction case, all but one of the simulation programs agree within 1% of the analytical solution, so that case is done.

In August 2006, NREL distributed to all participants an updated test specification that included refinements to the shading and internal windows test cases. The objectives of the refinements are to improve shading diagnostics beyond what currently exists in the IEA BESTEST single-zone cases originally published in 1995, to allow more robust testing of internal windows in series, and to include an option in the internal-window test case so that more simulation tools can run it.

For the shading cases, individual zone results indicate most programs are properly accounting for multi-zone and building-self shading after some disagreements have been diagnosed and fixed. Annual results for transmitted beam and diffuse solar radiation and hourly results for high direct-normal solar and low direct-normal (high diffuse) solar days indicate that shading models for both direct beam and diffuse radiation are working in a multi-zone context. The improved shading diagnostics for the revised cases allowed identification

of software errors that have reduced ranges of disagreement to about 1/3 of the disagreement range evident in October 2005. For the internal window cases trend agreement between results for ESP, TRNSYS-TUD, and VA114 is encouraging; disagreements for other programs remain to be diagnosed.

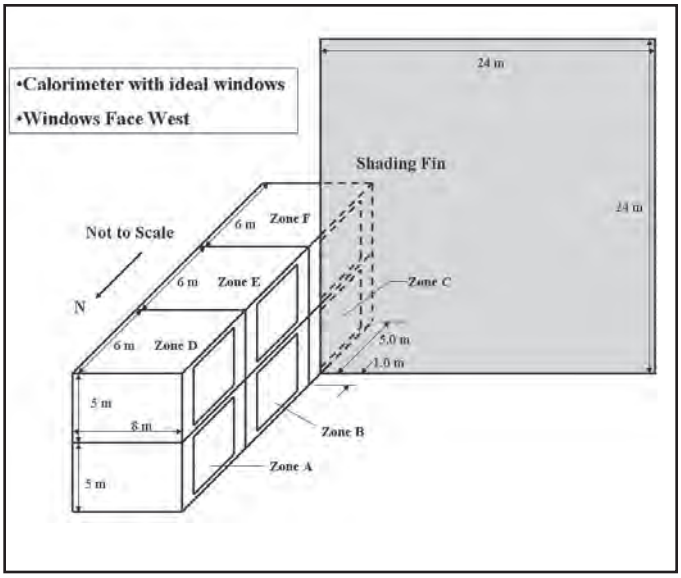
Since 2004, the multi-zone work has resulted in diagnosis of 19 software issues related to conduction, shading, and internal windows, resulting in improvements to 6 of the simulation programs including: CODYRUN, EnergyPlus, ESP-r, HTB-2, TRNSYS-TUD, and VA114.

Airflow Tests including Multi-Zone Airflow

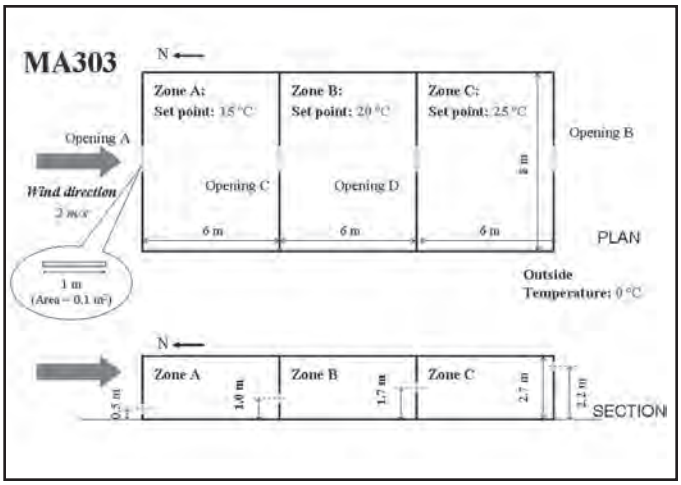
The current cases under development are based on the geometry of the multi-zone non-airflow cases, are simpler (potentially more diagnostic) than the ECBCS Annex 23 (COMIS airflow) cases, and allow use of nodal, zonal, and CFD models (not possible with COMIS cases). Japan has completed a draft of the initial test specification. The airflow cases emphasize natural ventilation, buoyancy, wind driven, and temperature-difference driven flows; further cases will include interaction of airflow and thermal models.

The revised test specification was distributed, after obtaining Task 34 participant reviews of the current initial test specification, and incorporating participant comments. The field trials were conducted using the test specifications with several hourly (or sub-hourly) building energy simulation software programs, some of which may be linked to zonal, network, coarse CFD, or full CFD models. So far there are four calculated results from TUD, Germany (TRNSYS-TUD); Sumitomo-Mitsui Construction Co., Ltd., Japan (VentSim); Welsh School of Architecture, UK (HTB2); and Ashikaga Institute of Technology, Japan (COMIS3.2).

Cases have been developed in 1-zone, 2-zone and 3-zone contexts (3-zone cases are shown in Figure 4), and include a case with fan-driven mechanical ventilation. The current results show some differences. The reason for differences may be the modeling by the simulator, input data error, etc., and further investigation is necessary.



Multi-Zone Shading Test Case Schematic Diagram.



Combined Wind and Temperature Driven Airflow Test Case (MA303) Schematic.

Shading/Daylighting/Load Interaction Empirical Tests (Leaders: Switzerland, US/Iowa)

This project is divided into two subprojects: EMPA Shading/Daylighting/Load Interaction led by EMPA in Switzerland and ERS Shading/Daylighting/Load Interaction led by ERS in the U.S.

EMPA Shading/Daylighting/Load Interaction

The goals of the project are:

- Collection of empirical data in EMPA test cells for the validation of thermal performance models of windows with/without shading devices in building energy simulation codes
- Comparison of simulation results with empirical data.

The suite of eight experiments includes: 1) Overall test cell conductance, 2) Overall test cell internal capacitance, 3) Glazing only, 4) Glazing with external textile shading screen, 5) Glazing with internal textile shading screen, 6) Glazing with external Venetian blinds, 7) Glazing with internal mini-blinds, and 8) Window, i.e. glazing with frame.

EMPA has completed all of the experiments in the suite of experiments. In the last six months, simulations of Experiments 7-8 have been run. So far, simulation results have

EMPA Test Cells in Duebendorf, Switzerland

been obtained from EnergyPlus (EMPA/ISU) and DOE-2.1E (EMPA/ISU). Simulation results of previous experiments included results for these programs as well as results for TRNSYS-TUD (TUD, Germany), KoZiBu (JNLOG, France), and HELIOS (EMPA, Switzerland).

The simulations for the solar gain experiments were designed to predict the cooling power required to maintain the constant zone temperature. Based on uncertainty ranges presented in results plots at the meeting, overall uncertainty in various input parameters causes roughly ±3% uncertainty in simulated cooling load results. Experimentally determined cooling loads have similar uncertainty. For the recent simulations of Experiments 7-8, EnergyPlus was within 95% credible limits of the empirical data and the propagated error for Experiment 7. It is therefore believed that the experiments are well suited for empirical validation.

ERS Shading/Daylighting/ Load Interaction

The purpose of the work being done at Iowa Energy Resource Station (ERS) in the United States is to create an empirical validation data set for daylighting controls. Equipment used includes dimmable ballasts, fabric shades, mini-blinds, exterior shading fins, and equipment for scheduled internal gains. Electric lights are controlled to maintain a minimum illuminance level; when enough natural daylight is available electric lighting is reduced. Daylighting tests were performed at ERS during July 1 to July 7, 2005 and June 1 to June 14, 2006.

Simulation results were received from ISU/EMPA, US/Switzerland (EnergyPlus, DOE-2.1E). Conclusions are that overall predictions for daylighting performance were within acceptable ranges, and that uncertainty in the ERS – a real building – is greater than in a controlled laboratory experiment. This is a good exercise to see how accurate predictions for a real building can be.

Table 2: Components of the building systems related to Mechanical Equipment Empirical Tests

Test case	Simulation Exercises
Chilled water system	- Chiller (two scroll compressors) - cooling coil (dry / wet regime with condensing water flow rate measurement) - hydronic network (pipes, pump, valve)
Hot water system	- Boiler (Condensing atmospheric natural gas boiler with variable firing rate) - Heat exchanger (terminal re-heat) - hydronic network (pipes, pump, valve)

Systems, Components, and Controls Empirical Tests (Leader: Germany/ TUD)

This work is for testing and validating energy simulation software related to chilled- and hot-water building energy systems. The tests are separated into several sub-exercises to focus on single components as shown in Table 2. Along with a set of comparative tests, the experimental and measurement facilities at the Iowa Energy Resource Station/US are used for empirical studies.

The work has begun with comparative test cases for the coils (both cooling and heating coil) and the hot water boiler. The coil comparative tests are designed to predict coil performance to maintain a given leaving air temperature when temperature and humidity of entering air and water are given. Figure 6 shows different types of coil control strategies (variable water mass flow vs. variable water inlet temperature) used for comparative test cases.

In all, there are now 16 comparative test cases for the cooling coil, 8 test cases for the heating coil and 8 test cases for the hot water boiler. Simulation results for these tests have been obtained from: TRNSYS-TUD (TUD), MATLAB/Simulink (TUD), EES (University of Liege), VA114 (VABI Software). Some diagnostics are done to analyze the impact of parameters.

Empirical data for both the hot-water and the chilled-water systems were obtained from several experiments conducted at the Iowa Energy Resource Station (ERS):

- October 2, 2004: cooling coil
- August 24-28, 2005: chilled water system
- February 21-28, 2006: heating water system & cooling coils

- August 8-23, 2006: chilled water system

The empirical tests were carried out by the same simulation participants as for the comparative tests. The goal is to predict loads as well as leaving air and water conditions for the hot water boiler and the coils. As an example Figure 7 shows the predicted heating load compared the experimental data.

Double-Facade Empirical Tests (Leader: Denmark/Aalborg University)

This project is divided into two sub-projects: a literature review led by Lund University and development of comparative and empirical validation test procedures led by Aalborg University. The objective for this project is to assess suitability and awareness of building energy analysis tools for predicting heat transfer, ventilation flow rates, cavity air and surface temperatures and solar protection effect and interaction with building services systems in buildings with double facade. Project activities were defined to include:

1. Collection of available literature on typologies, modeling approaches, measurements, tools, etc.
2. Description of test facility and test cases used for validation, and documentation of the measured standard data sets
3. Development of a user guide for tools, including sensitivity analysis on the main influences.

Empirical tests are led by Aalborg University (AAU), Denmark, using a new facility constructed at AAU. Additionally, Lund University, Sweden has been sharing their work on a literature survey being done in conjunction with a Swedish project on double-skin buildings.

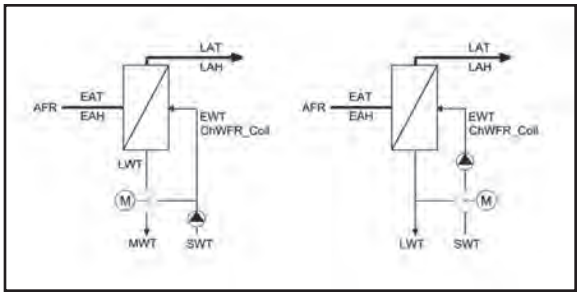
Double-Skin Buildings Literature Survey

Lund University's literature review covers building energy consumption, thermal and visual comfort, acoustics, environmental impacts during construction and operation, and application of new technologies. They have studied several categories of double-skin building construction types; advantages and disadvantages of double-skin facades (DSF); and modeling issues including airflow, thermal and daylighting simulations. The literature review found roughly 50 case studies. Aalborg University reviewed the literature survey, commenting that it is generally quite good and includes all important literature in the area. To serve as a literature report for Annex 43, AAU agreed to enlarge the description of modeling approaches and methods for DSF as a separate chapter, which they have recently completed.

Lund University has finalized the literature review report after receiving comments from the other Task 34 participants. The literature review report has been submitted to the SHC and ECBCS Executive Committees' designated reviewers for their comments and approval recommendations.

Double-Skin Buildings Empirical Validation Tests

Although test facility construction is now complete, Aalborg University had earlier experienced a 9-month construction delay on their test facility that caused a corresponding delay



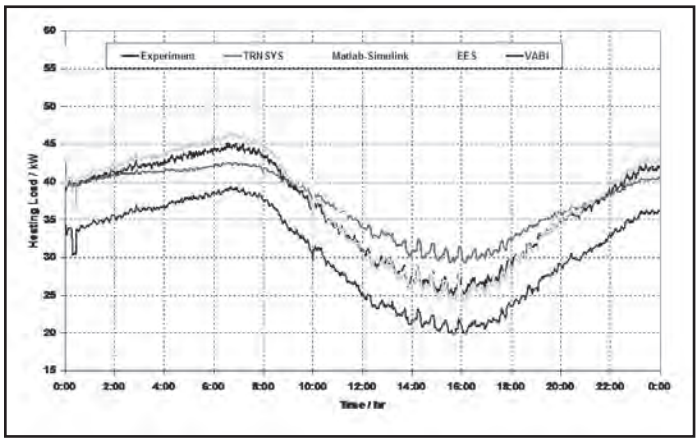
Coil control strategies used for the comparative test cases.

in their overall progress on empirical experiments. The test cases are:

- DSF100. All façade openings closed
- DSF200. Openings are open to the outside
- DSF400. Bottom opening open to outside; top opening open to inside

Within the test cases are a number of variations to check the influence of various parameters, including:

- Solar shading
- Driving force of airflow (buoyancy, wind, mechanical fan, combined forces)
- Internal (thermal)/External (thermal, solar, wind) boundary conditions
- Opening area (fully opened, opening area controlled by temperature and/or airflow rate)



Results for predicted heating load and experimental data (averaged data).

Aalborg University Double-Skin FacadeTest Facility in Aalborg, Denmark

Four comparative test cases have been defined. Comparative test weather data is 2 weeks (from April 2002) of the Danish reference weather year. Simulation results for four comparative tests were received for BSim (Aalborg U., Denmark), VA114 (VABI, Netherlands) and TRNSYS-TUD (TUD, Germany). Three experimental test cases have been defined. Preliminary results for one of the three experimental test cases are available.

Web Site for Consolidation of Tool Evaluation Tests (Leader: Operating Agent [US/NREL])

The objective of this project is to consolidate the tool evaluation tests from IEA SHC Task 12 / ECBCS Annex 21, SHC Task 22, and SHC Task 34 / ECBCS Annex 43 to a single web site. Currently test procedures are posted or listed at: IEA SHC Task 22 website (www.iea-shc.org/task22/deliverables.htm), SHC Task 12 (www.iea-shc.org), and ECBCS Annex 21 (www.ecbcs.org/annexes/annex21.htm). We are looking to consolidate (with links) PDF reports containing procedures currently listed at the Task 22 website (which includes IEA BESTEST 1995 of Task 12/Annex 21) with the new procedures to come from IEA 34/43. Task 22 and 34/43 reports that do not include test procedures (e.g., methodology studies, literature surveys, etc.) will not be included with the consolidated "Software Tests" page. We will also include a note identifying IEA procedures that have been adapted into ANSI/ASHRAE Standard 140, and a link to the Standard-140 web page.

Codes and Standards Activities

A key audience for the research undertaken within this Task is national and international building energy standard making organizations. These organizations can use the test cases developed in SHC Task 12/ECBCS Annex 21 and SHC Task 22, and test cases that are being developed in this Task to create standard methods of tests for building energy analysis tools used for national building energy code compliance.

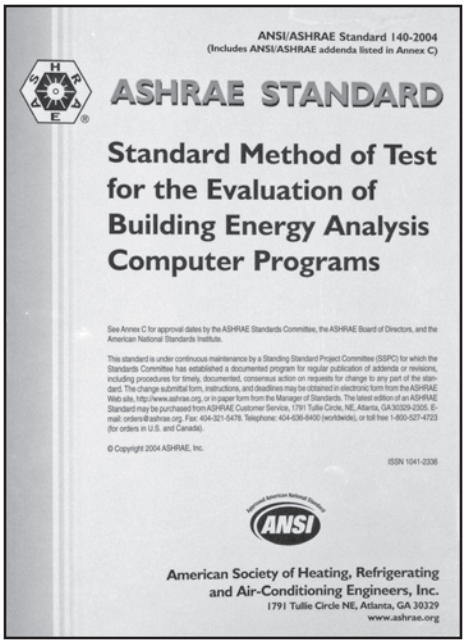
ANSI/ASHRAE Standard 140-2004, published December 2004, includes previous adaptations of:

- IEA BESTEST (NREL/SHC Task 12)
- HVAC BESTEST Volume 1 (NREL/SHC Task 22)
- Will include in 2007 (see below):
  - Furnace BESTEST (Canada)
  - HVAC BESTEST Volume 2 (US).

The Standard-140 adaptation of the HVAC BESTEST Furnace Cases (NRCan, Canada/SHC Task 22 analytical verification and comparative tests) completed public review in May 2006 and will be published by ASHRAE as Addendum a to Standard 140-2004 after January 2007. HVAC BESTEST Volume 2 (NREL, US/SHC Task 22 space cooling comparative tests) was adapted for Standard 140 by NREL as Addendum b to Standard 140-2004. Addendum b completed public review in November 2006, and will be published by ASHRAE after January 2007.

ASHRAE Standard 90.1-2004, which is used for regulating energy efficiency in commercial and non-low-rise residential buildings requires use of Standard 140-2004 for testing software used in building energy efficiency assessments. In June 2006, the US Internal Revenue Service issued a notice that cites Standard 140-2004 to certify software used for commercial building energy efficiency tax credits in the U.S. The International Energy Conservation Code is also referencing Standard 140. These citations are important because they mandate software evaluation using test procedures developed under IEA research activities. For example, because of the ASHRAE Standard 90.1 requirement to test software using ASHRAE Standard 140, two of the largest suppliers of building HVAC equipment in the world, Carrier and Trane Corporations, are testing their respective software packages HAP and TRACE with Standard 140. Also, EnergyPlus, the USDOE's most advanced simulation program for building energy analysis, maintains their Standard 140 validation results on their website.

Various BESTEST suites are cited for simulation certification by a number of countries and codes/standards authorities throughout the world. The Netherlands (TNO) has developed their Energy Diagnosis Reference (EDR) based on BESTEST. TNO has developed the EDR to satisfy the European Performance Directive (EPD) of the European Union. The EPD emphasizes performance-based standards and requires certification of software used to show compliance with energy performance standards



ANSI/ASHRAE Standard 140-2004

(normes). Portugal is also using BESTEST as their basis for software quality control under the EPD. Elsewhere, IEA BESTEST has been referenced in codes and standards in Australia and New Zealand. France (CSTB) has used BESTEST to test simulation tools used in conjunction with development of CEN Standards. Futhermore, NREL's overall validation methodological framework has been included in the 2005 ASHRAE Handbook of Fundamentals. As a result of these and other activities, many major software providers worldwide are using BESTEST and ASHRAE Standard 140.

The UK's Chartered Institute of Building Services Engineers (CIBSE) is compiling tests (CIBSE TM33) for software accreditation and verification. The tests address "a need for UK regulators to have a mechanism for the technical accreditation of detailed thermal models as part of their formal approval for use in the [UK] National Calculation Methodology." CIBSE notes that the TM33 tests are primarily meant to instill confidence in users rather than to provide comprehensive validation of a program. For those intending more detailed program validation, CIBSE TM33 cites tests and benchmarks available from ASHRAE Standard 140, IEA, ASHRAE Research, and CEN. For example, papers recently published by U. Strathclyde, UK, describe how many of the BESTEST suites have been directly integrated within ESP-r for automated testing of revisions to the software.

WORK PLANNED FOR 2007

Ground Coupled Floor Slab and Basement Comparative Tests (Leader: US/NREL)
Finish iterations of field trials for both user's manual and simulation software improvements, and finish the draft final report.

Multi-Zone Heat Transfer Comparative Tests

Non-Airflow Test Cases (Leader: US/NREL)
Continue field trials using the test specifications. Use the results from the simulations to improve the simulation programs and the test specifications. Finish the draft final report, although US funding uncertainties for 2007 could cause a delay.

Airflow Test Cases (Leader: Japan)
The test specification will be revised according to the modeling procedure for analytical solution of one of the cases. Also, later work would develop cases to address the coupling of CFD airflow simulation tools. Japan may also consider developing cases for 2- or 3-story buildings. This all leads to production of a final report during the second half of 2007.

Shading/Daylighting/Load Interaction Empirical Tests

EMPA Shading/Daylighting/Load Interaction (Leader: Switzerland)
Finish draft final report.

ERS Shading/Daylighting/Load Interaction (Leader: Iowa)
Distribute test specifications and inputs to the participants and then process the results. Finish draft final report.

Systems, Components, and Controls Empirical Tests (Leader: Germany/TUD)
The following items have to be done:

- Find some appropriate points for both hot water and chilled water systems derived from experimental data that can be used to calibrate the models. These points are required because single point data given by manufacturer is of poor quality and does not fit reality
- Revise specifications
- Re-run simulation as often as possible and as often as needed
- Complete the final report.

Double-Skin Facade Empirical Tests

Double-Skin Buildings Literature Survey (Leader: Sweden)
Final report approval by SHC and ECBCS Executive Committees; this includes incorporation of executive committee comments that may be requested.

Double-Skin Buildings Empirical Validation Tests (Leader: Denmark)
AAU will distribute test specifications for comparative tests (DSF100, DSF200 and DSF400). After receiving comparative test results from the participants AAU will analyze the simulation results, write 1st draft of the modelers report and call for final simulation results. AAU will write the final draft of the modelers report on comparative test cases before the next IEA-34/43 meeting (26-28 March 2007)

AAU is finishing the measurements of the experimental cases and will write test specifications for these before December 1, 2006. Preliminary simulations results and a 1st draft of the modelers report for experimental test cases will be written before the March 2007 meeting.

Because of test facility construction delays experienced earlier, the final report for the empirical validation tests may be late.

Web Site for Consolidation of Tool Evaluation Tests

The Operating Agent will work with SHC and ECBCS Web Coordinators to develop the new web site, and explore adding a primary menu listing on both website cover pages labeled "Software Tests".

Other

Continue work outside the scope of this Task related to bringing evaluation test procedures developed under IEA research into codes and standards (normes). Recently, two test procedures developed within SHC Task 22 have been fully approved for inclusion with ANSI/ASHRAE Standard 140:

- HVAC BESTEST Fuel-Fired Furnace Tests (analytical verification and comparative tests), by Natural Resources Canada (NRCan), Canada
- HVAC BESTEST Volume 2: Cases E300-E545 (space cooling comparative tests), by National Renewable Energy Laboratory (NREL), United States.

The only remaining work to finish inclusion of these test suites are the final publication galley reviews, which will be completed in early 2007.

During 2007, the ASHRAE project committee for Standard 140 (SSPC 140) will begin to consider additional test suites for Standard 140; new test suites nearing completion under IEA 34/43 will be considered for inclusion along with other test suites developed within ASHRAE research projects and elsewhere.

LINKS WITH INDUSTRY

The primary audiences for the IEA tool evaluation research are building energy analysis tool authors and national and international building energy standard (norme) making organizations. For tool authors, a number of links have been established. Activities of previous related SHC Task 22 and SHC/ECBCS Task 12/Annex 21 research effectively are linked to the needs and recommendations of the world's leading building energy analysis tool developers. This link continues in SHC/ECBCS Task 34/Annex 43. For example, a recent study comparing 20 whole building energy simulation tools indicates that 19 of the 20 tools reviewed had been tested with at least one of the IEA BESTEST procedures; 10 of the tools had been tested with more than one of the BESTEST procedures. The study also indicates that test procedures developed by the IEA dominate the set of available tests.

Further examples of industry links are evident from recent citations in conference papers. Within the 2006 ESim conference proceedings, 5 of 32 papers cite BESTEST. Additional papers by software developers related to use of SHC Task 22 and SHC Task 12 test procedures have appeared regularly at ASHRAE meetings in the US. As the work of Task 34 begins its final year a number of papers previewing its work have already been published or are in progress. Conferences and meetings in 2006 where the work of Task 34 has been presented include TRNSYS User Day, organized by TRANSSOLAR in Stuttgart, Germany; the EPIC2006AIVC Conference in Lyon, France, and the ASHRAE summer meeting in Quebec City, Canada. In addition, Japan is organizing the IAQVEC 2007 Conference in Sendai, Japan and is planning to present papers there related to Task 34.

The results of IEA tool evaluation research are used as pre-normative information in the establishment of national and international building energy codes and standards, as discussed above under codes and standards activities. The Operating Agent has been acting as liaison with, and is the Chair of, ASHRAE SSPC 140 (the ASHRAE project committee responsible for ANSI/ASHRAE Standard 140). The IEA BESTEST cases were used by ASHRAE to develop a standard method of test for evaluating building energy analysis programs (Standard 140). Also, the U.S. National Association of State Energy Officials has referenced HERS BESTEST for certification of home energy rating software. HERS BESTEST, which is conceptually based on IEA BESTEST, was developed for use specifically in detached-residential applications. A number of other countries, such as the Netherlands, Portugal, Australia and New Zealand are using BESTEST as a standard method of testing building energy analysis tools for their national energy codes or home energy rating software. As part of their building energy performance assessments under the European Community's Energy Performance Directive, Austria, Denmark, Greece and The Netherlands are using a new software tool that includes algorithms that have been checked with BESTEST. Also, CEN has utilized BESTEST to

check their reference cooling load calculation general criteria of prEN ISO 13791 (CEN 2004a) and simplified methods of prEN ISO 13792 (CEN2004b).

The popularity and utility of the BESTEST procedures developed within various SHC Tasks is also evident from language translations undertaken within various countries using their own resources, including translations into Japanese, Dutch and German. Japan distributed a recently completed Japanese-language translation of HVAC BESTEST Volume 1 (NREL/SHC Task 22). This translation and an earlier translation of IEA BESTEST (NREL/SHC Task 12/ECBCS Annex 21) have been distributed to about 25 researchers and engineers in Japan. Several Japanese papers have already been published that refer to these BESTEST translations. Translation of HVAC BESTEST Volume 2 (NREL/SHC Task 22) into Japanese is in progress. The Netherlands (TNO) has developed their Energy Diagnosis Reference (EDR) based on the IEA BESTEST building thermal fabric test suite, which was revised for Netherlands-specific buildings, and is written in Dutch. A journal article on HVAC BESTEST Volume 1 was translated into German and published in a German HVAC engineering journal.

REPORTS PUBLISHED IN 2006

Only internal documents.

REPORTS PLANNED FOR 2007

In the final year of the work, draft final reports covering the following topics are expected:

- Slab-on-grade ground coupled heat transfer analytical verification and comparatives tests: test specification and results
- Multi-zone non-airflow analytical verification and comparative tests: test specification and results
- Airflow analytical verification and comparative tests: test specification and results
- Shading/daylighting/load interaction: test procedures, test cell specifications, empirical data sets, and simulation results
- Chilled water and hot water mechanical equipment and control comparative and empirical validation tests: test procedures, test apparatus specifications, empirical data sets, and simulation results.
- Double-skin buildings:
  - Literature review (is in final phase Executive Committee review)
  - Comparative tests: test specification and results
  - Empirical Validation tests: test procedures, test cell specifications, empirical data sets, and simulation results (expected first half of 2008).

MEETINGS IN 2006

Sixth Experts Meeting

April 10-12, 2006
Ankeny (DesMoines), Iowa, US

Seventh Experts Meeting

October 4-6, 2006
Lund, Sweden

MEETINGS PLANNED FOR 2007

Eighth Experts Meeting

March 26-28, 2007
Golden (Denver), Colorado, US

Ninth (final) Experts Meeting

September - November 2007
Dates and location to be determined.

TASK 34 NATIONAL CONTACTS

Operating Agent
Ron Judkoff
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
United States

Australia
Angelo Delsante
CSIRO Manufacturing & Infrastructure Technology
PO Box 56, Highett. Vic. 3190,
(Street address: Graham Rd, Highett, Vic. 3190)

Belgium
Jean Lebrun, Vincent Lemort
University of Liege
Thermodynamics Laboratory
Building B49
B4000 Liege

Phillipe Andre, Julien L'Hoest
University of Liege
Department of Environmental Management and Science
Avenue de Longwy, 185
B-6800 Arlon

Canada
Ian Beausoleil-Morrison, Hajo Ribberink
CANMET Energy Technology Centre
Natural Resources Canada
580 Booth Street, 13th Floor
Ottawa, Ontario K1A 0E4

Denmark
Per Heiselberg, Olena Kalyanova
Aalborg University
Hybrid Ventilation Centre
Sohngaardshdmsvej 57
9000 Aalborg

France
Peter Riederer
Centre Scientifique et Technique du Bâtiment
CSTB - DDD/AGE
84 Avenue Jean Jaurès, B.P. 2
77447 Marne la Vallée cedex 02

Harry Boyer, Frederic Maranville
Civil Engineering and Building Physics research Team
University of Technology
40, avenue de Soweto
97410 Saint-Pierre

Bruno Peuportier
Centre d'Energetique,
Ecole des Mines de Paris
60, Bd St Michel 75272 Paris cedex 06

Jean NOEL
CETHIL - ETB
INSA de Lyon - Bât. Freyssinet
40 avenue des Arts
F-69100 Villeurbanne
France

Germany
Clemens Felsmann
Technische Universität Dresden
Institut für Thermodynamik und Techn. Gebäudequsrüstung
Helmholtzstr. 14
01062 Dresden

Hans Erhorn
Fraunhofer-Institut für Bauphysik
Nobelstr. 12
D-70569 Stuttgart

Ingo Heusler, Erwin Lindauer, Herbert Sinnesbichler
Fraunhofer-Institut für Bauphysik
Postfach 1152
D-83601 Holzkirchen
Fraunhoferstrasse 10

Ireland
Michael Crowley
Department of Building Sciences and Engineering
Dublin Institute of Technology
D.I.T, Bolton Street
Dublin 1

Japan
Yasuo Utsumi
Department of Architecture
Institutes of National Colleges of Technology
Natori, Miyagi, 981-1239

Teruaki Mitamura
Ashikaga Institute of Technology
268-1 Omae-Cho, Ashikaga City,
Tochigi, 326-8558
JAPAN

Yukiko Yoshida
National Institute of Environment Studies
16-2 Onogawa
Tsakuba, Ibaraki

Netherlands
Aad Wijsman
VABI Software
Kleveringweg 12
2616 LZ Delft
P.O. Box 29 2600 AA Delft
The NETHERLANDS

Sweden
Harris Poirazis, Ake Blomsterberg, Maria Wall,
EBD, LTH
Lund University
P.O. Box 118
SE-221 00 Lund

Switzerland
Heinrich Manz, Thomas Frank, Peter Loutzenhiser
EMPA
Laboratory for Applied Physics in

Buildings
Uberlandstr. 129
CH-8600 Duebendorf

Gerhard Zweifel
Hochschule Technik + Architektur
Luzern
Abt. HLK
CH-6048 Horw

Mike Witte, Robert Henninger
GARD Analytics
1028 Busse Highway
Park Ridge, IL 60068-1802

Michael Deru
National Renewable Energy
Laboratory
1617 Cole Boulevard
Golden, Colorado 80401

United Kingdom

Donald Alexander
Welsh School of Architecture
Cardiff University
Cardiff, Wales

Paul Strachan
ESRU, Dept. of Mechanical Eng
University of Strathclyde
Glasgow G1 1XJ, Scotland

United States

Joel Neymark
J. Neymark & Associates
3000 Youngfield St., #163
Lakewood, Colorado 80215

Gregory Maxwell, Som Shrestha
Mechanical Engineering Department
Iowa State University
2025 Black Engineering Building
Ames, Iowa 50011

Curtis J. Klaassen
IEC Energy Resource Station
DMACC, Building 23
2006 S. Ankeny Boulevard
Ankeny, Iowa 50021

Jeff Thornton, Tim McDowell
Thermal Energy Systems Specialist
2916 Marketplace Drive, Suite 104
Madison, WI 53719

TASK 35
PV/Thermal Solar Systems

Mr. Henrik Sørenson
Esbensen Consulting Engineers Ltd.
Operating Agent for the Danish Energy Authority

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 m2 for solar thermal (corresponding to 70 GWp thermal) and 3 GWp 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 are 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 is organised in 5 Subtasks, each focusing on the key issues identified 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 has been 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 is fully defined and managed by ExCo SHC with appropriate input from ExCo PVPS. National experts can be assigned to participate in the Task from both IEA SHC and IEA PVPS Executive Committee members or the participants can be accepted by sponsors of either of the two programmes.

Duration

The Task was initiated on January 1, 2005 and will be completed December 31, 2007.

ACTIVITIES DURING 2006

The 3rd Task meeting was held June 1-2, 2006, hosted by Lund University in Sweden with participation of 11 experts from Canada, Denmark, Hong Kong, The Netherlands, and Sweden. The meeting focussed on co-ordination of

work and also included a mid-term Task evaluation.

The 4th Task meeting was held October 2-4, 2006, hosted by University of Toronto in Canada with participation of 9 experts from Canada, Denmark, Thailand, The Netherlands, Sweden, and USA. There was a joint session with the Canadian Solar Buildings Research Network (SBRN) which consists of 24 researchers from 10 Canadian universities. They have joined forces to develop the solar-optimized homes and commercial buildings of the future. SBRN also include experts from Natural Resources Canada (NRCan), the Canada Housing and Mortgage Corporation (CMHC) and Hydro Québec. The joint session was used for presentations and discussion of how activities of the two groups, SBRN and IEA SHC Task 35, can be coordinated. It was agreed to set up a Letter of Understanding on the planned collaboration between IEA SHC Task 35 and SBRN. Specific collaboration was agreed on review of the proposals for Net Zero Energy Healthy Homes Demonstration program, in order to identify possible PV/Thermal Solar Energy systems demonstration sites.

In the following, the main work carried out during 2006 is presented.

Subtask A : Market and Commercialisation of PV/T

Market survey interviews of architects and solar dealers were conducted in the USA to obtain information from the market place about which things will affect or influence the purchase design, supply and installation of future PV/T projects. More interviews will be made in USA, Canada, Netherlands, Belgium, Sweden, Germany, and possibly Hong Kong, Denmark, Thailand, Greece, and Italy. Articles on the interviews will be published in the beginning of 2007.

A PDF-file with an overview of commercially available PV/T collectors will be made available on the Task website in early 2007.

Important input to the Task work has been provided from the PVT Forum project, which is part of the EU-supported project PV Catapult. A main deliverable is an overall road-map for commercialisation of PV/T. The focus of the EU-funded work is naturally with the focus on the European situation, but non-European countries are now reviewing and commenting on the roadmap. The work will be concluded in a more world wide oriented article.

Subtask B: Energy Analysis and Modelling

The preparation of a report on heat transfer models and electrical performance of PV/Thermal Solar Systems is on-going. Here an investigation of already available simulation models, TRNSYS components and theoretical models is being described and the document will be relevant to all experts interested in starting modeling PV/Thermal Solar Systems.

It has been found that the vast majority of PV/T, PV, and Solar Thermal Models have already been developed in TRNSYS, and it has been decided that the Task would make this the platform of choice. Two new models for transpired air PV/T collectors and non-tracking PV/T concentrators are currently being developed.

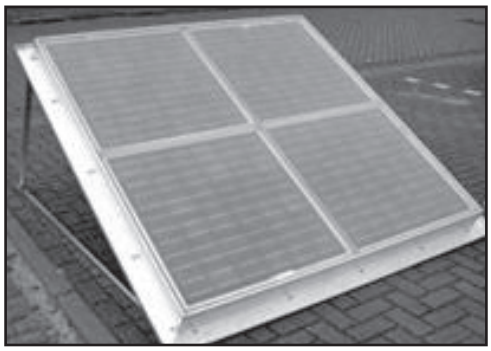


Figure 1. Liquid PV/T collector (PVTWIN 422 from PVTWINS, The Netherlands) which was tested at the Danish Technological Institute in Denmark.

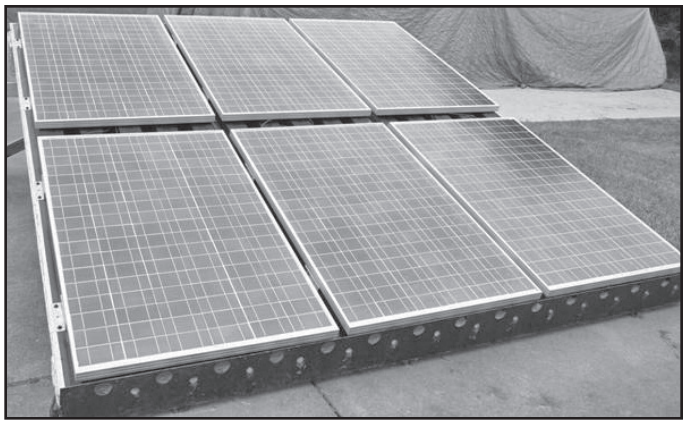


Figure 2. Air PV/T collector (PV Solarwall from Conserval Engineering, Canada) ready for testing.

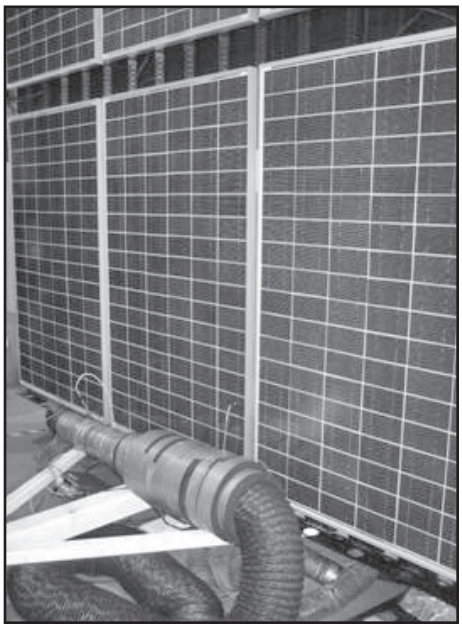


Figure 3. Preparation of test stand for the air PV/T collector at the National Solar Test Facility in Canada.

All the PV/T collector models will be compiled into a standard downloadable package of models for researchers and a standard downloadable package(s) for non-researchers, the latter based on TRNSED.

Development of a standardized method for characterization and monitoring of PV/T-modules is now on-going and different approaches have been discussed. A method that would catch the interaction of the thermal and PV systems has been devised and will need to be further developed to ensure its suitability.

In terms of control strategies needed for PV/Thermal Systems, a number of possible schemes can be devised that range from simple to complex. Further discussion has been put off until the schemes can be modeled or tested.

Subtask C: Product and System Development, Test and Evaluation

An MS Excel spreadsheet with an overview of PV/T components and projects will be available on the Task website in early 2007.

Important input has been provided to the PV Catapult deliverable, PVT performance measurement guidelines. This document deals with performance testing issues for liquid cooled non-concentrating PV/T collectors. From this work it will be possible to characterize a PV/T collector in such a way that the annual energy production, both thermal and electrical, can be predicted for any given site.

Test of a flat plate liquid PV/T collector from the Dutch manufacturer PVTWINS, see Error! Reference source not found., was completed in September by the Danish Technological Institute. The same collector will now be tested at the University of Padova in Italy.

Tests of a transpired air PV/T collector from Conserval Engineering, Canada is now being prepared for at the Danish Technological Institute. Another collector of this type is currently being tested at the National Solar Test Facility in Canada.

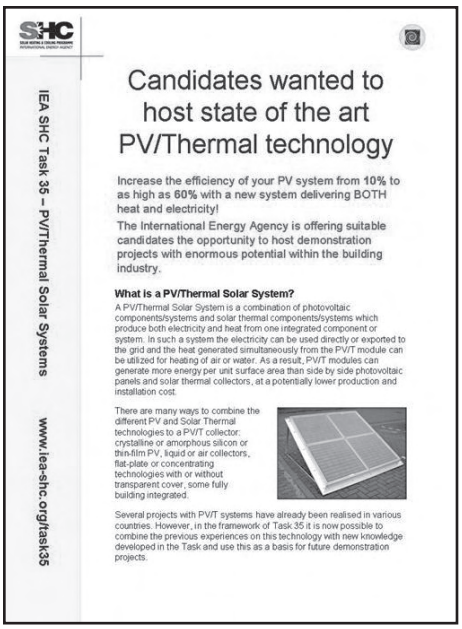


Figure 4. Advertisement for demonstration projects.

Test of other categories of PV/T collectors are planned for in Sweden and Italy. Different test methodologies based on the experiences from the participating laboratories and the PV Catapult deliverable D8-6: PVT performance measurement guidelines mentioned earlier have and will be used. The aim of the activities is to achieve a much better understanding of the performance of already existing systems and to define standard methods for testing of the characteristics and durability of PV/T systems.

Regarding the investigation for the need of development of PV/T components, experts have spoken to industry, manufacturers, and designers. The experts in the Task group will now point out the issues they see as most important including the need for new materials.

Subtask D: Demonstration Projects

Interviews of stakeholders for realized PV/T systems are being carried out on a national basis to learn from their experience and to make recommendations for the next generation of demonstration projects. Monitoring results for existing PV/T projects will be collected to the extent where it is practically possible and of value to the Task. The results of the interviews will be included in a brochure.

In order to be able to gain knowledge from demonstration projects within the time schedule of the Task, the planning of work in Subtask D is focusing on the identification of potential projects to be realised in the beginning of 2007, allowing for monitoring of the realised projects and comparison with simulated performance of the systems.

An advertisement for demonstration projects explaining the interest of the Task and benefit of hosts by having demonstration projects within the PV/T-sector has been made, see Error! Reference source not found.. The advertisement has undergone a review process from the SHC and the Executive Secretary Task Publication Review Committee and will be made available at the public Task website and distributed to national contacts.

Subtask E: Dissemination

An article (in German) presenting an overview of PV/Thermal Solar Systems and the research work IEA SHC Task 35 was published in the Austrian journal "erneuerbare energie" 2-2006, see Error!

PV/Thermische Solaranlagen

Stand der Entwicklungen in der IEA Task 35

Von Jan Hansen und Henrik Sørensen*

Figure 5. Austrian journal article.

Reference source not found.. The journal reports about research and development in the field of renewable energies. The article is available at the public Task website.

A paper on the Task and PV/Thermal Solar Systems was presented at the World Renewable Energy Congress IX, 19-25 August 2006 in Florence, Italy and the abstract was published by Elsevier in World Renewable Energy Congress IX, Book of Abstracts, 19-25 August 2006, Florence, Italy.

A Task 35 flyer was distributed from the ECN stand and IEA PVPS stand at the 21st European Photovoltaic Solar Energy Conference and Exhibition in Dresden, 4-8 September 2006. Also a Task logo was designed in cooperation with a Danish architect and lithographic artist, see Figure 6.

The symbol of the logo is to illustrate the potential of harvesting electrical power, as well as heating and cooling from the same solar system.

A Task 35 brochure is under preparation and a general presentation template (MS PowerPoint) has been developed for Task experts to ease the presentation of the Task in general, ongoing and completed activities and scientific material regarding PV/T.

The internal Task website is a key tool in the Task work. All documents produced within the Task and all communication within the Task 35 project group is uploaded here to facilitate dialogue between the Task experts and to provide a hub for information exchange on PV/Thermal Solar Systems.

The public Task website http://www.iea-shc.org/task35 is continuously being updated to give access to Task results and information related to PV/T. The website has recently undergone graphical changes, see screen dump below, and will also be subject to some changes in the coming period.

WORK PLANNED FOR 2007

Subtask A: Market and Commercialisation of PV/T

Market survey interviews of architects and solar dealers will be continued and articles on the interviews will be made in the beginning of 2007.

During and after interviews more work will be done on identification of key persons/groups (decision makers) and order qualifiers and order winners. This will be concluded in an article.

A PDF-file with an overview of commercially available PV/T collectors will be made public available at the Task website.

The review of the EU-supported project PV Catapult road-map for commercialisation of PV/T will be concluded in a more world wide oriented article.

Figure 6: IEA SHC Task 35 logo

Subtask B: Energy Analysis and Modelling

The development of two new models for transpired air PV/T collectors and non-tracking PV/T concentrators will be completed and the deliverable DB1: Report on heat transfer models and electrical performance of PV/Thermal Solar Systems will be finalized.

All the PV/T collector models will be compiled into a standard downloadable package of models for researchers and a standard downloadable package(s) for non-researchers, the latter based on TRNSED.

The on-going development of a standardized method for characterisation and monitoring of PV/T-modules will be finalized.

Control strategies needed for PV/Thermal Systems will be investigated based on models or tests.

Monitoring of PV/Thermal Solar Systems to be simulated in whole building context is planned to be carried out and Report on comparison between the simulated performance

and monitored performance of PV/Thermal Solar Systems will be made.

Subtask C: Product and System Development, Tests and Evaluation

Test of different PV/T collectors will be continued in a number of countries and different test methodologies based on the experiences from the participating laboratories and most recent international standardisation of testing procedures of solar systems will be used. The aim of the activities is to achieve a much better understanding of the performance of already existing systems and to define standard methods for testing of the characteristics and durability of PV/T systems.

Furthermore, test results of existing PV/T systems will be compared to data for side-by-side systems. The experts in the Task group will also point out the issues they see as most important regarding development for PV/T components including the need for new materials.

Finally, work on recommendations for standards for durability tests of PV/T collectors and development of a certification process will be carried out.

Subtask D: Demonstration Projects

Initiated interviews of stakeholders for PV/T systems will be finalized and monitoring results for existing PV/T projects will be collected to the extent where it is practically possible and of value to the Task. The results of the interviews will be included in a brochure.

Monitoring of existing PV/T projects will also be considered.

An advertisement for demonstration projects explaining the interest of the Task and benefit of hosts by having demonstration projects within the PV/T-sector will be made available at the public Task website and distributed to national contacts in the beginning of 2007.

During 2007, this Subtask will organize workshops for design teams and Task participants in projects where PV/T is planned to be included.

Subtask E: Dissemination

The internal Task website is a key tool in the Task work and will also be used throughout the rest of the project period in order to facilitate dialogue between the Task experts and to provide a hub for information exchange on PV/Thermal Solar Systems.

The public Task website http://www.iea-shc.org/task35 is continuously being updated to give access to Task results and information related to PV/T.

Work related to the publishing of a number of articles and reports will be co-ordinated with the publisher.

The Task 35 flyer will be printed and distributed to national contacts. Brochure/s describing the work and results achieved in the Task is under preparation and will be finalized during 2007.

LINKS WITH INDUSTRY

A number of manufacturers of PV/T components joined the Task expert meetings in 2006 and have been active in the planning and performance of work. It is the aim to have their continued involvement through the entire duration of the Task.

REPORTS PUBLISHED IN 2006

No reports were published in 2006 and a number of originally planned reports were changed to articles or brochures, or postponed to 2007.

REPORTS PLANNED FOR 2007

- Report on heat transfer and electric performance models in PV/Thermal Solar systems
- Report on recommended standard for characterisation and monitoring of PV/Thermal Solar systems
- Report on comparison between the simulated performance and monitored performance of PV/Thermal Solar Systems
- Report on recommended control strategies for PV/Thermal Solar Systems
- Report on reliability and durability of PV/Thermal Solar Systems
- Monitoring report for selected PV/Thermal Solar System projects
- Report on workshop and design review with design teams on initiated and realised demonstration projects

MEETINGS IN 2006

Third Task Experts Meeting

June 1-2
Lund University, Lund, Sweden

Fourth Task Experts Meeting

October 2-4
University of Toronto, Toronto, Canada

MEETINGS PLANNED FOR 2007

Fifth Task Experts Meeting

March 12-15
Thailand

Sixth Task Experts Meeting

Date and location to be decided.

Final Task Experts Meeting

Date and location to be decided.

TASK 35 NATIONAL CONTACTS

Operating Agent
Henrik Sørensen
Esbensen Consulting Engineers Ltd.
Carl Jacobsens Vej 25 D
DK-2500 Valby, Denmark

Project Manager
Jan Hansen
Esbensen Consulting Engineers Ltd.
Carl Jacobsens Vej 25 D
DK-2500 Valby, Denmark

Australia
Joe Coventry
Australian National University
Dept. of Engineering
Canberra 2000 ACT

Canada
Michael R. Collins
University of Waterloo
200 University Ave West Waterloo
Ontario N2L 3G1

John Hollick
Conserval Engineering Inc
200 Wildcat Road
Toronto, Ontario

Denmark
Ivan Katic, Søren Poulsen
Danish Technological Institute
Gregersensvej
Postboks 141
DK-2630 Taastrup

Yakov Safir
RAcell Solar A/S
Frb. Alle 28
DK-1820 Frederiksberg C

Greece
Yiannis Tripanagnostopoulos, Manolis Souliotis
Physics Department, University of Patras
Patras 26500

Stathis Tselepis
CRES
19th km Marathonos Ave.
19009 Pikermi Attiki

Hong Kong
T.T. Chow
City University of Hong Kong
Tat Chee Avenue
Kowloon
Hong Kong SAR

Israel
Ami Elazari
Millennium Electric T.O.U. Ltd.
8 Abba Eban Blvd.
P.O. Box 12346 Herzelia Industrial Zone, 46733

Italy
Lorenzo Zamboni
Universita' Di Padova
Dipartimento di Tecnica e Gestione dei sistemi industriali [DTG]
stradella S.Nicola, 3
36100 Vicenza

Sweden
Bjørn Karlsson, Johan Nilsson, Bengt Perers
Lund University
Div. Energy and Building Design
P.O. Box 118
221 00 Lund

Thailand
Thipjak Nualboonrueng
Institute of Solar Energy Technology Development (ISET)
National Science and Technology Development Agency (NSTDA)
111 Thailand Science Park
Paholyothin Rd.,
Klong 1, Klong Luang
Patumthani 12120

The Netherlands
Wim Van Helden, Herbert Zondag, Marco Bakker, Marcel Elswijk
ECN - Energy research Centre of the Netherlands
P.O. Box 1
1755 ZG PETTEN

Marcel Elswijk
PVTWINS
P.O. Box 9308
1800 GH Alkmaar

USA
F. Scott Cicora
Conserval Systems Inc.
4242 Ridge Lea Rd, Suite 28
Buffalo, New York 14226

TASK 36
Solar Resource Knowledge Management

Mr. Dave Renné
National Renewable Energy Laboratory
Operating Agent for U.S. Department of Energy

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, 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 through 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 distributed networks, 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.

Means

The 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:

a) Select and Qualify Ground Data Sets: this activity will include a survey and documentation of existing data sources, and the production and reporting of validation data.
b) Define Measures of Model Quality for Product Validation: besides defining measures of model quality, this activity includes the establishment and documentation of model intercomparison procedures.
c) Develop Methodology for Establishing Coherent Benchmarking of Products;
d) Apply Benchmarking Procedures to Subtask C Products: this activity

includes a characterization of model performance as a function of input data sets.

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:

a) Evaluate the Legal Aspects of Accessing Solar Resource Data: 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;
b) Identify Commonly-Used Software by End Users: this activity examines available or needed software for use by industry and other users to access the information system;
c) Develop Data Exchange Protocols and Meta-Data: various data exchange protocols will be examined, and one will be selected and documented;
d) Develop Prototype Data Networking Procedure: 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 address the request.
e) Identify Resource Providers: a worldwide network of data providers will be established, and the techniques for data exchange among the providers will be investigated.
f) Test the Prototype by Users: this activity defines the prototype that can be accessed by users, and raises the awareness of the data exchange system to external users.
g) Define Automatic Access by Commercial Applications: This activity will enable automatic and fast access of resources through the information system by using commercial applications.
h) Develop a Test Application (Solar Micrositing): a case study in micro siting 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:

a) Improve Satellite Retrieval Methods for Solar Radiation Products: 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.
b) Conduct Climatological Analysis of Solar Resources: In order to ascertain future impacts on system performance due to climate variations, his 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.
c) Evaluate Solar Radiation Forecasting Procedures: 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) and PVPS (Photovoltaic Power Systems). It was agreed by both partnering Implementing Agreements, that SHC co-ordinates the Task. Co-operation 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, 2010.

ACTIVITIES DURING 2006

Second Experts Meeting

The Second Experts Meeting was held in Denver, Colorado on 7-8 July 2006, in advance of the Solar 2006 Conference. There were 12 experts attending the meeting plus two additional participants via video conference call, representing all participating countries except Spain. Each subtask leader led detailed discussions on ongoing activities and plans within their Subtask. In addition, there were additional discussions regarding the relationship of Task 36 to the Global Earth Observing System of Systems (GEOSS) Programme, the Global Energy and Water Experiment (GEWEX) Program, and the Solar and Wind Energy Resource Assessment (SWERA) Program, as well as discussions on papers to be presented at upcoming conferences. A key outcome of the meeting was a

more clear focus on critical Subtask activities with subsequent modifications to the Task 36 Work Plan. Following the meeting many of the participating experts stayed to attend the Solar 2006 Conference, which was organized by the American Solar Energy Society (ASES).

Data User's Questionnaire

During 2005, a Data User's Questionnaire was developed to gather key information for Task 36 on the data requirements and how government agencies, universities, and the private sector are using data. Results of the survey will be used as input to the design of the information system (Subtask B) as well as some of the products coming out of all the Subtasks. During the transition to the new SHC website currently under preparation, the JRC in Ispra, Italy has agreed to support the Task 36 website at http://re.jrc.cec.eu.int/iea-shc-task36, specifically for purposes of hosting the Questionnaire and other critical Task 36 documents.

Collaboration with the Group on Earth Observations

On August 28-29 Marion Schroedter-Homscheidt of DLR/Germany, a Task 36 participant, attended the Group on Earth Observations (GEO) Earth Observation and Energy Management Expert Meeting in Geneva, Switzerland, organized by the GEOSS Secretariat. The Task 36 Operating Agent was also involved in a conference call with the Meeting Organizer and Task Participant during this meeting. Although there is currently no formal relationship between the IEA and the GEO, there appears to be an advantage to have Task 36 collaborate with the Energy Management Group in the area of use of satellite-based remote sensing and ground-based observations to address energy-related issues, such as renewable energy resource assessments. Thus an agreement was established for IEA Task 36 to participate, at no cost, to the solar working group of the GEOSS Energy Community of Practice, specifically within Item EN-07-P1 of the draft work plan. A brief document will be prepared by Task 36 to for incorporation into the work plan. In addition, the results of the Task 36 Questionnaire will be provided to the GEO in November 2007 as a contribution to the GEOSS Strategic 5-10 year plan.

New Subtask C Leader

During 2006, the original Leader of Subtask C, Dr. Richard Meyer, transferred from DLR to SunTechnics GmbH in Hamburg. Although Dr. Meyer remains active in Task 36 and provides an additional direct participation of the private sector in the Task, he is no longer able to lead Subtask C. Responsibilities for leading this Subtask have bee assumed by Dr. Detlev Heinemann of Carl von Ossietzky Universität Oldenburg, EHF, Germany.

Specific Technical Achievements

Subtask A: Standard Qualification of Solar Resource Products

A common structure of the presentation of first order measures for the model quality (mb- and rms-errors) was agreed upon. Two different procedures for the characterization of second order measures (match of modeled to measured distribution functions) had been applied to various data ensembles. Both methods offer qualitatively similar results. A qualitative ranking of the procedures is ongoing.

The algorithm of the European Solar Radiation Atlas for computing irradiance on inclined surfaces was implemented as a prototype service in SoDa. It applies to the databases HelioClim-1 or –2. It was tested recently against measurements made in PVPS Task 2. Preliminary results show a fairly good agreement between measurements and satellite estimates. This agreement is better than that observed between measurements and outcomes from RetScreen (which exploits ground stations) which is encouraging. Nevertheless, it was concluded that further checks should be made on the software before performing deeper analysis.

As a forerunner for the possible outcome of a benchmarking scheme taking into account the end use accuracy, an inter-comparison applying radiation maps from different sources has been performed for a selected region in Germany, using data for the year 2005. As an end use metric, the yield of PV-systems in that region was analyzed. The results had been presented at the 21st European Photovoltaic solar energy conference. [Beyer, H. G., Drews, A., Rindelhardt, U. (2006): 'Irradiance maps applied for the performance assessment of PV systems - a case study for the federal state of Saxony', 21st European Photovoltaic Solar Energy Conference & Exhibition, Dresden, Germany, 04.09. -08.09.2006]

As an example for the analyses of the long-term accuracy of satellite derived irradiance products a study was performed using 9 years of data from a large number of radiation stations operated by the German weather service. The results had been submitted to Theoretical and Applied Climatology, 2006. Within the GMES program, a new Atmosphere Service is under preparation, which includes also provision of solar radiation data for development of services targeted at renewable energy users. JRC and DLR were involved in the preparation

of the background document and together with EdM and University of Oldenburg participated at the workshop to discuss scope, requirements from different user communities, implementation of the services and issues of long-term sustainability.

A European map of global irradiation at the optimally inclined PV modules (100x70 cm) was published by EC JRC for wide distribution.

HelioClim-1 database was analyzed to geographically analyze monthly (seasonal) and year-by-year variability in Europe and Africa and to calculate improved probability statistics results to be published in 2007).

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

The on-line questionnaire, hosted by a server at JRC, is still available to the public. Several servers of relevance, e.g., NASA, Satel-Light, SoDa, PVGIS, are pointing to the questionnaire in order to create awareness and increase the number of responses. Results will be published in several forms. One will be a document on the various web sites that advertised for the questionnaire in order to give feedback to those having filled in the questionnaire. Another form will be an article in Solar Energy. Since solar projects are often requested to perform an analysis of needs of users/customers, this publication is expected to establish a baseline that could be used by many projects without duplicating efforts.

Metadata procedures recommended by the WMO are being evaluated. A first implementation of metadata was performed in a SQL database containing ground measurements.

The Open Source Jonas was implemented and tested. It is a middleware and it may be the candidate for the final prototype to ensure communications among web services.

One problem identified in the SoDa Service and in web services in general, is the inability of web services to handle cases when one service in a chain, or plan, of services, is removed. Using a manually defined plan, we made a prototype based on SoDa that is capable of selecting an equivalent service to answer the request. This prototype is fully working but it has not been decided to make it the new version of the SoDa Service.

An article "Converting a successful research project into a sustainable service: the case of the SoDa Web service" by B. Gschwind , L. Ménard, M. Albuisson, and L. Wald was published in the Journal of Environmental Modeling and Software, 21, 1555-1561, 2006. Of particular interest are the lessons drawn from customers to re-engineer such a service. They will be applied to Subtask B.

A web service was developed to permit to companies to create ASCII files that can be entered into GIS software for producing maps. This service exploits the database HelioClim-1. The customers produced maps for the Balkans, Gambia, Mali and Sicily. There is an ongoing effort for an automated exploitation of the database HelioClim-2 by JRC to feed the PVGIS tools.

A web service was developed to automatically connect to NCAR / NCEP forecasts. The next step will be to include this service in SoDa. This may serve as a baseline to test performances of forecast models.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

C.1: Improving Satellite Methods for Solar Radiation Products

- NASA/LaRC and SUNY/A evaluated the use of sub grid variability to increase resolution of long-term data products).
- During a visit of a scientist from NASA/LaRC to DLR IPA in Oberpfaffenhofen, work on a concept paper for solar micro siting has begun. The paper discusses options for a field campaign, which should give new insights into the nature of the solar radiation field at highest temporal and spatial resolution. The basic plan is to spread many radiometers with roughly logarithmically increasing spacing around a central station. Intervals should start with around 100 m and increase to several kilometers to bridge the gap from the very high resolution in the center up to large boxes as covered by the NASA ISCCP or SSE data set. This work will contribute to the development and validation of new retrievals utilizing operational satellite data with a spatial resolution in the 1 km range, and allow for better understanding of the scaling effects and the representation of single sites for large boxes, which improves validation options also for the medium to large-scale solar maps.

C.2: Climatological Analysis of Solar Resources

- NASA/LaRC prepared for the reprocessing of SSE Release 6.0. This shall result in improved solar irradiance maps based on more than 20 years of data. This is an action, which is also part of the Radiative Flux Assessment (RFA) of GEWEX (Global Energy and Water Cycle Experiment), which also

covers analysis of satellite data sets vs. long-term surface measurements sites, and inter-comparison to other products like DLR-ISIS (presented at ASES).

- NASA/LaRC manages databases and results of the GEWEX Radiative Flux Assessment.
- The DLR-ISIS (Irradiance at the surface based on ISCCP) data set was released at the web-site http://www.pa.op.dlr.de/ISIS/
- The PhD thesis of Sina Lohmann and a related paper in Solar Energy by Lohmann, et al. went to press, which describe the DLR-ISIS method and first results with inter-comparisons to reanalysis data. Results on solar irradiance derived from atmospheric models seem not to be able to reproduce observations. This reduces chances that climate models and seasonal forecasting of solar irradiance will succeed soon.
- The collaboration of DLR IPA with University of Oregon in Eugene lead to two papers describing long-term changes of solar irradiance in the USA Pacific Northwest (see Figure 1). The paper of Lohmann et al. accepted for publication in Geophysical Research Letters shows an increase in availability of direct irradiance since the late 1970s, while the additional paper by Riihimaki et al. at the ASES conference reveals relatively stable conditions for global horizontal irradiance.

C.3 Forecasting of Solar Radiation

- A conference paper on now-casting and short-term forecasting (Proc. of the ASES Solar 2006 conference, Denver July 2006) was presented.
- A PhD thesis 6/2006 (M. Girodo) and paper (7/2007) on mesoscale modeling for short-term forecast of solar irradiance has been completed.
- NASA/LaRC, together with SUNY/A, evaluated NOAA's digital forecast database for applicability for solar energy forecasts (paper presented at Solar 2006).

Revision of the Subtask C Work Plan

Following the outcome of the 2nd Experts Meeting in Denver, the new structure, of Subtask C is as follows:

C.1 Improving Satellite Methods for Solar Radiation Products. This now includes the 'solar micro-siting' action, which is the improvement of mainly satellite based methods towards the 1 km scale. Optionally this activity also covers the development of spectral and angular resolved solar products derived from satellite data. This Activity is lead by Paul W. Stackhouse, NASA, USA.

C.2 Climatological Analysis of Solar Resources. This activity analysis long-term changes of solar radiation conditions based on measurements, satellite data and climate and weather models (see Figure 1 for an example of the output of this task). In case solar energy becomes more important and funding would be available actions towards seasonal forecasting and decadal predictions would be added to this activity. This Activity is lead by Richard Meyer, SunTechnics GmBH, Germany.

C.3 Forecasting of Solar Radiation. This activity now covers all forecast horizons from now casting up to few hours to short-term forecasting up to 3 days and mid-term forecasting up to 2 weeks. Most emphasis at the moment is on now casting and short-term forecasting. The mid-term horizon could be added in case funds get available. This Activity is lead by Elke Lorenz, University of Oldenburg, Germany.

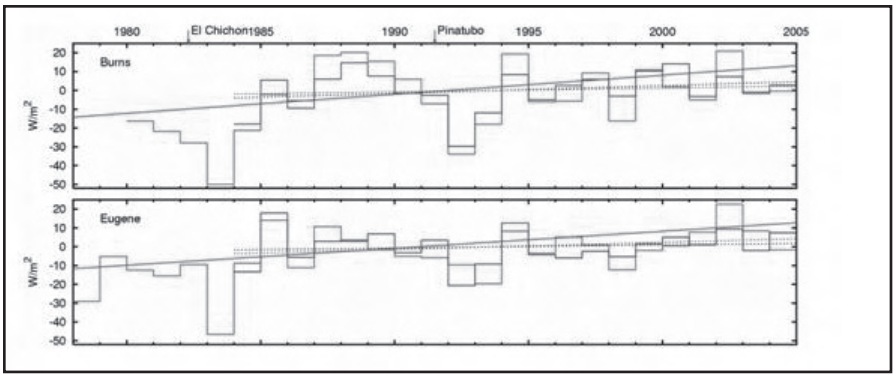


Figure 1: Comparison of DLR satellite-derived direct normal irradiance estimates with ground measurements collected at Burns and Eugene, Oregon (USA): From Stackhouse, et al., IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Denver, July- August 2006.

WORK PLANNED FOR 2007

Subtask A: Standard Qualification of Solar Resource Products

Hochschule Magdeberg (H2M) and Ciemat will continue the comparison of the procedures to check the quality of modeled distribution functions to end up with a common method. The application of the proposed measures and schemes will be tested for various data sets, building upon the work on the long-term accuracy started at Oldenburg. University of Oldenburg, H2M, Meteocontrol and Ciemat will continue to analyze models for the spectral characteristics of the irradiance. This will include the development of respective measures of model quality, applicable for benchmarking.

The test of the estimates of irradiance by using the measurements made by PVPS Task 2 will be continued. This will cover both the irradiance on inclined surfaces and the resulting energy yield of the PV-systems (Ecole desMines/Armines, H2M).

NASA/LaRC is making available data sets from GEWEX Radiative Flux Assessment to Task 36. These include:

- The intention of making the extended GEBA data base available for validation
- The PNNL analysis of BSRN measurements for use in SRKM validation and benchmarking activities

This activity will implement and validate current and new NASA products with agreed upon sets of statistics and using common surface radiometer measurements. Contribute results to team for validation in clear and cloudy conditions as a function of location.

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

- SSE Release 6.0 is scheduled for this year providing latest data sets and large sets of parameters for solar energy industry. Provides interactive prototype to access data set parameters via the Internet.
- Provide link to IEA task and to user survey on next NASA SSE release
- Proceed with writing documentation on the prototype. This documentation is for non-specialist and will be disseminated among the Task.
- Prepare an article for Solar Energy based on this documentation.
- Based on this same documentation and on experience gained by the Task (NASA, SoDa, PVGIS, Satel-Light, SolEMi), prepare documentation of property rights.
- Analyze questionnaire returns and produce a document on user requirements. This document will irrigate the subtasks. Prepare an article for Solar Energy.
- Proceed with the specifications document for the first prototype.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

C.1: Improving Satellite Methods for Solar Radiation Products

- University of Oldenburg is further improving a scheme to better account for cloud shadow effects. This strongly enhances correlation of ground-based measurements and satellite retrieved solar irradiance in hourly and shorter time resolution.
- DLR IPA will process a synthetic satellite image based on 1-D and 3-D radiative transfer calculation to provide a test bed for further development of new retrieval schemes.
- NASA's new SSE Release 6.0 is to include results from the GEWEX SRB SW Rel 2.7 that is scheduled for release Dec 2006/Jan 2007. Release is a complete list of atmospheric inputs used to generate current version that will be provided to team as necessary.
- In collaboration with SUNY/A, NASA/LaRC plans to analyze methods to improve direct and diffuse SW irradiance estimates for clear and cloudy sky conditions.
- Development and evaluation of the effect of improving angular distribution models on the solar irradiance estimates for the NASA method. Angular Distribution Models inherently include uncertainties due to inhomogeneity.
- Development and evaluation of new aerosol inputs to solar irradiance (NASA/LaRC, and DLR DFD)
- Meteotest plans to generate world-wide climatologies of AOT550 and TL (2000-2005) based on MODIS, MISR and AERONET.
- Continued testing and development of method to impose higher resolution solar resource maps with long-term data sets (collaboration with SUNY/A)
- JRC, EC, is implementing high-resolution digital elevation models (SRTM-3) to study the influence of terrain on modeling the solar radiation at various resolutions.
- New algorithms for calculating terrain shadowing have been implemented in PVGIS to provide interactive assessment of the terrain horizon and attenuation of global irradiation by terrain shadowing for any chosen point in Europe. The resolution of the query functions will be enhanced by implementation of the high resolution DEM (SRTM-3) in Europe.
- Maps showing the fraction of grid-cells of the Meteosat Prime satellite shadowed by terrain were calculated for each time slot of data acquisition of the satellite's radiometer. These maps will be used for improving models for solar radiation calculation using Meteosat Prime data. This work was done in collaboration with the University of Oldenburg.

C.2: Climatological Analysis of Solar Resources

- Report on results of the GEWEX Radiative Flux Assessment project relevant to the Task in terms of long-term data sets. This project aims at benchmarking the accuracy and precision of long-term top-of-atmosphere and surface radiation fluxes of which the solar irradiance is a key component. GEWEX-RFA will study many solar irradiance data sets participating in the Task and will provide a framework for evaluation of other data sets.

- Meteotest will provide data after 1990 from the GEBA (Global Energy Balance Archive) data set to Task 36. These time-series should be analyzed for changes.
- Long-term time series analysis of NASA's solar irradiance data sets using GEBA and other measurements (see Subtask A).
- Begin evaluation of possible use of NASA Seasonal to Interannual Forecast Model for Seasonal irradiance forecasts. (Collaboration with NASA Goddard Space Flight Center (GSFC))
- Begin evaluation of Climate scenario solar irradiance forecasts (collaboration with NASA Goddard Institute for Space Science (GISS)
- Meteocontrol, Germany plans to better describe year-to-year variability of solar radiation, as input for risk calculation.

C.3: Forecasting of Solar Radiation

- Report by University of Oldenburg on now-casting up to 6 hours based on extrapolation of cloud motion vectors derived from satellite images (12/2006)
- Continued evaluation of short-term forecasts comparing the USA NOAA National Digital Forecast Database parameters with measurements. Identify other short-term models and missing parameters needed for improved solar irradiance forecasts (collaboration with SUNY/A)
- Continued evaluation of operational global radiation forecasts with WRF / MM5 model (Meteotest).
- Building up of a model for model output statistics of WRF global radiation output (Meteotest).

LINKS WITH INDUSTRY

Several small companies are directly participating at the Task: Meteocontrol, GmBH, SunTechnics, GmbH, and Meteotest. Blueskywetter of Austria also joined the task at the end of 2006. 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/PAPAERS PUBLISHED IN 2006

- Four papers presented at the American Solar Energy Society's Solar 2006 conference in Denver, July 2006 and published in the Proceedings. These papers include: "Solar Resource Knowledge Management: A New Task of the International Energy Agency", by David S. Renné, Richard Meyer, Hans-Georg Beyer, Lucien Wald, Richard Perez, and Paul Stackhouse
- Paper on the IEA Task and its connection to GEOSS presented at the IGARSS conference, July-August 2006 titled "Towards Designing an Integrated Earth Observation System for the Provision of Solar Energy Resource and Assessment" by P.W. Stackhouse, Jr., D. Renné, H. -G. Beyer, L. Wald, R. Meyer, M. Schroedter-Homscheidt, R. Perez, and M. Suri (see Figure 1 below)
- Solar Energy paper in press (Lohmann et al., 2006a)
- Geophysical Research Letters paper accepted (Lohmann et al., 2006b)
- Paper published in Journal of Environmental Modeling and Software (Gschwind et al. 2006)
- At the end of 2006, the joint publication has been released with contribution of 42 authors, most of them active in IEA SHC Task 36: Dunlop, E., Wald, L., _úri, M. (Eds.), 2006. Solar Energy Resource Management for Electricity Generation from Local to Global Scale. Nova Science Publishers, Hauppauge, ISBN: 1-59454-919-2.
- Performance of solar energy technology based on PVGIS solar radiation and temperature data was demonstrated in a conference paper: Huld T.A., _úri M., Dunlop E.D., 2006. A GIS-Based System for Performance Assessment of Solar Energy Systems over Large Geographical Regions. Solar 2006 Conference: Renewable Energy, key to climate recovery, 7-13 July 2006, Denver CO, USA
- New tools that link HelioClim-1 database with PVGIS, including plots of probability distribution of daily horizontal irradiance were presented at the EUPVSEC21 Conference: _úri M., Huld T.A., Dunlop E.D., Albuisson M., Wald L, 2006. Online data and tools for estimation of solar electricity in Africa: the PVGIS approach. Proceedings of the 21st European Photovoltaic Solar Energy Conference and Exhibition, 4-8 October 2006, Dresden, Germany);
- The HelioClim-2 database was used to analyze hourly irradiance fluctuation in summer 2005 and the possible impacts on the regional electricity grid. Under the significant increase of PV capacity, a reinforcement of the grid and/or the introduction of local short term storage has to be considered to manage summer peak generation of PV in the Southern Italy: Jäger-Waldau A., Huld T.A., _úri M., Cebecauer T., Dunlop E.D., Ossenbrink H., 2006. Challenges to realise 1% electricity from photovoltaic solar systems in

the European Union by 2020. 4th World Conference on Photovoltaic Energy Conversion, 7-12.5.2006, Waikoloa HI, USA

MEETINGS IN 2006

Second Experts Meeting

July 7-8
Denver, Colorado

MEETINGS PLANNED FOR 2007

Third Experts Meeting

March 12-14
Ispra, Italy

This meeting may also include a one-day session devoted to the newly funded MESoR (Management and Exploitation of Solar Resource Knowledge) Project. The EU-funded MESoR Project involves many of the Task 36 participants and will provide significant funding for the Task.

TASK 36 NATIONAL CONTACTS

Operating Agent
Dave Renné
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393 USA
David_renne@nrel.gov

Canada
L. J. Bruce McArthur
Experimental Studies Division, Air Quality Research Branch
Meteorological Service of Canada
4905 Dufferin Street
CAN-M3H 5T4 North York, Ontario
Bruce.McArthur@ec.gc.ca

European Commission
Marcel _úri
European Commission - DG Joint Research Centre
Institute for Environment and Sustainability
I-21020 Ispra (VA)
Italy
marcel.suri@jrc.it

France
Lucien Wald (Subtask B Leader)
Centre Energetique et Procedes
Ecole des Mines de Paris / Armines / CNRS (FRE 2861)
BP 207
F-06904 Sophia Antipolis cedex
lucien.wald@ensmp.fr or lucien.wald@cep.cma.fr

Dominique Dumortier
LASH-ENTPE
Rue Maurice Audin
F-69518 Vaulx-en-Velin
dominique.dumortier@entpe.fr

Germany
Hans Georg Beyer (Subtask A Leader)
Fachbereich Elektrotechnik
Hochschule Magdeburg-Stendal (FH)
Breitscheidstrasse 2
D-39114 Magdeburg
hans-georg.beyer@et.hs-magdeburg.de

Richard Meyer
Team Leader Technical Analysis Solar Energy
SunTechnics GmbH
Anckelmannsplatz 1
20537 Hamburg
R.Meyer@suntechnics.de

Detlev Heinemann (Subtask C Leader) and Elke Lorenz
Carl von Ossietzky Universität Oldenburg, EHF
D-26111 Oldenburg
detlev.heinemann@uni-oldenburg.de
elke.lorenz@uni-oldenburg.de

Gerd Heilscher and Stefan Bofinger
meteocontrol GmbH
Spicherer Str. 48
D-86157 Augsburg
heilscher@meteocontrol.de
bofinger@meteocontrol.de

Carsten Hoyer-Kick
DLR Institut für Technische Thermodanamik
Pfaffenwaldring 38-40
D-70503 Stuttgart
carsten.hoyer@dlr.de

Marion Schroedeter-Homscheidt
DLR-DFD
Oberpfaffenhofen
D-82234 Wessling
marion.schroedter-homscheidt@dlr.de)

Spain
Lourdes Ramirez and Jesús Polo
Plataforma Solar de Almeria
Departmento de Energia
CIEMAT Avd
Complutense
E-2228040 Madrid
Lourdes.Ramirez@ciemat.es
jesus.polo@ciemat.es

Switzerland
Pierre Ineichen
University of Geneva, CUEPE
7 rte de Drize
CH-1227 Carouge Geneva
pierre.ineichen@cuepe.unige.ch

Jan Remund
Meteotest
Fabrikstr. 14
CH-3012 Bern
remund@meteotest.ch

United States
Paul Stackhouse
NASA Langley Research Center
MS 420
Hampton, VA 23681 USA
Paul.w.stackhouse@nasa.gov

Richard Perez
State University of New York/Albany
Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203 USA
perez@asrc.cestm.albany.edu

TASK 37
Advanced Housing Renovation with Solar and Conservation

Mr. Fritjof Salvesen
KanEnergi AS
Operating Agent on behalf of
Royal Norwegian Ministry of
Industry and Energy

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 targeted national end users in a deliberate strategy to increase the market penetration of advanced housing renovations. Contributors and participants in this Task will be:

- Universities and research institutes active in the building sector
- National and regional government planning authorities
- Market players (industry, institutions and others) in the building sector

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 realisation 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]

The Wengistrasse 6 in Zürich, Switzerland was built in 1898 with 10 apartments and 2 shops. It was renovated during October 2004 to March 2005 to have a factor 4 energy reduction and to use renewables. It has 100% solar coverage in the summer using a 29 m2 solar collector and a 4,000 liter storage tank.

DURATION

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

ACTIVITIES DURING 2006

The Task started mid-2006 and the first Experts Meeting took place in September.

A Task 27 web page was established, address: www.iea-shc.org/task37

Building stock analyses have started in several countries, and preliminary work has been presented. Relevant projects dealing with strategies and communication plans are going on in Norway, Canada and New Zealand.

The Task participants have agreed on the following criteria for selecting

Renovation of a multi-family house in Linz, Austria lead to a reduction in the annual heating costs by 88% (from 150 to 20 kWh/m2) which is close to the passive house standard. Other renovations were reinforced insulation and a prefabricated solar façade.

advanced demonstration projects:

- Occupancy type: All forms of housing including mix uses
- Concept: Something enough innovative for international publication
- Energy: At least factor 4 reductions in space heating and energy demand
- Max primary energy for space heating is 60 kWh/m^2
- Opaque envelope insulation < 0.25 W/m2K (if possible as this should not exclude special buildings, e.g. historical buildings)
- Economics: Marketable solutions
- Design: Substantial improved living quality

A draft template for systematically collecting data from selected demo-projects has been completed and is ready for test use.

Projects for whole building concept analysis and more specific technology analysis in Subtask C have been identified in several participating countries. The first projects in Freiburg, Germany have been chosen to be monitored. A template for the project description was developed and some projects described. The projects will be presented on the Task web site in mid-2007.

Criteria for selecting projects for environmental impact assessment also have been defined.

WORK PLANNED FOR 2007

There will be continuous work on the building stock analyses and strategies and communication plans. A workshop with industry representatives will be organized in connection with the Experts Meeting in Switzerland in April. It will include a one-day workshop to present and discuss approximately 10 advanced renovation projects according to the agreed template. Key architects and building industry representatives will be invited to the workshop.

Advanced example projects from Subtask B and projects to be monitored under subtask C will be presented on the Task web site.

A workshop on environmental impact assessment will be organized in October. A Belgian project will be identified to explain the work, and architects will be invited to comment on the different aspects of the renovation process.

The output of Subtask D will be a booklet describing renovation basics. The content of this booklet will be worked out in 2007.

LINKS WITH INDUSTRY

More than 50% of the Task experts are representing companies and organisations 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 2006

Only internal documents.

REPORTS PLANNED FOR 2007

The final results from the building stock analyses will be reported in October.

The first brochure of advanced demonstration projects will be completed and presented on the web site.

The first concepts and solution sets will be published on the web site.

MEETINGS IN 2006

First Experts Meeting

27-29 September
Mannheim, Germany
Two internet Subtask A meetings were organized prior to the Mannheim meeting for experts unable to attend the meeting.

MEETINGS PLANNED FOR 2007

Second Experts Meeting

16-18 April
Switzerland
In connection to this meeting, a Subtask B workshop on demonstration projects will be held on the 16th for invited architects and other key representatives from the building industry.

Third Experts Meeting

September/October
Location to be decided
Workshops with industry participation for Subtasks A and B will be organized September-November 2007.

TASK 37 NATIONAL CONTACTS

Operating Agent
Fritjof Salvesen
KanEnergi AS
Hoffsveien 13
0275 Oslo, Norway
fs@kanenergi.no

Austria
Thomas Mach
Graz University of Technology
Inffeldgasse 25B
AT-8010 Graz
thomas.mach@tugraz.at

Belgium
Sophie Trachte (Leader subtask D)
Fre-lance for MATRI-ciel company
Avenue Coghen, 140
BE-1180 Brussels
sophie.trachte@archi2000.be

Caroline Kints
Université Catholique de Louvain
Place du Levant. No.1 Bat. Vinci
BE-1348 Louvain-la-Neuve
kints@arch.ucl.ac.be

Andre De Herde
Université Catholique de Louvain
Place du Levant. No.1 Bat. Vinci
BE-1348 Louvain-la-Neuve
andre.deherde@uclouvain.be

Erwin Mlecnik
Passiefhuis-Platform vzw
Gitschotellei 138
B-2600 Berchem
erwin.mlecnik@passiefhuisplatform.be

Canada
Anil Parekh
CANMET Energy Technology Centre
Natural Resources Canada
580 Booth Street 13 A9
Ottawa, Intario Canada KIA OE4
aparekh@nrccan.gc.ca

Paul Parker
University of Waterloo; Fac. of Environmental studies
200 University Ave.
Waterloo ON, Canada N2T 1G3
pparker@uwaterloo.ca

Finland
Mia Ala-Juusela
VTT
P.O.Box 1000
FI-02044 VTT
mia.ala-juusela@vtt.fi

Germany
Sebastian Herkel (Leader subtask C)
Fraunhofer - Inst. Solar Energy Systems
Heidenhofstrasse 22
DE-79110 Freiburg
sebastian.herkel@ise.fraunhofer.de

Johann Reiss
Fraunhofer - Inst.Bauphysik
Nobelstrasse 12
DE-70569 Stuttgart
re@ibp.fraunhofer.de

Berthold Kaufmann
Passivhaus Institut
Rheinstr. 44/46,
DE-64283 Darmstadt
berthold.kaufmann@passiv.de

Italy
Valerio Calderaro
University La Sapienza of Roma
Via Flaminia 70
IT- Rome
valerio.calderaro@uniroma1.it

The Netherlands
Chiel Boonstra
DHV B.V.
P.O. Box 80007
NL-5600 JZ Eindhoven
chiel.boonstra@dhv.nl

Erik Franke
Franke Architekten B.V.+ Dutch PassiefHuis Holland
Postbus 151
NL-3360 AD SLIEDRECHT
e.franke@frankearchitekten.nl

Henk F. Kaan
ECN Energy Research Centre of the Netherlands
P.O.Box 1 Westerduinwag 3
NL-1755 ZG Petten
kaan@ecn.nl

Ivo J. Opstelten
ECN Energy Research Centre of the Netherlands
P.O.Box 1 Westerduinwag 3
NL-1755 ZG Petten
opstelten@ecn.nl

New Zealand
Albrecht Stoecklein
BRANZ Ltd
albrechtstoecklein@branz.co.nz

Norway
Tor Helge Dokka
SINTEF Building Research
Budstikka 18
NO-3612 Kongsberg
Tor.H.Dokka@sintef.no

Trond Haavik
Segel AS
Box 284
NO-6770 Nordfjordeid
trond.haavik@segel.no

Are Rødsjø (Leader subtask A)
Norwegian State Housing Bank
Peter Egges Plass 2
NO-7005 Trondheim
are.rodsjo@husbanken.no

Ulla Hahn
Norwegian State Housing Bank
P.O.B. 1243 Vika
NO-0110 Oslo
ulla.hahn@husbanken.no

Michael Klinski
Norwegian State Housing Bank
P.O.B. 1243 Vika
NO-0110 Oslo
michael.klinski@husbanken.no

Arne Morten Johnsen
Enova
Abelsgt. 5
NO-7030 Trondheim
arne.morten.lundhaug.johnsen@
enova.no

Sweden

Ulla Janson
Lund University - energy and building
design
Box 118
SE-221 00 Lund
ulla.janson@ebd.lth.se

Switzerland

Robert Hastings (Leader subtask B)
AEU GmbH
Bahnhofstrasse 26
CH 8304 Wallisellen
robert.hastings@aeu.ch

TASK 38
Solar Air-Conditioning and Refrigeration

Hans-Martin Henning
Fraunhofer Institute for Solar Energy Systems
Operating Agent for Forschungzentrum Jülich GmbH

TASK DESCRIPTION

In many regions of the world room air-conditioning is responsible for the dominant part of electricity consumption of buildings. Electrically driven chillers cause high electricity peak loads in electricity grids, even if systems are used that reached a relatively high standard concerning energy consumption. This is becoming a growing problem in regions with cooling dominated climates.

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 optimised and standardised 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 Handbook for Solar Cooling for Planners.

The Task is organized with four subtasks:

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

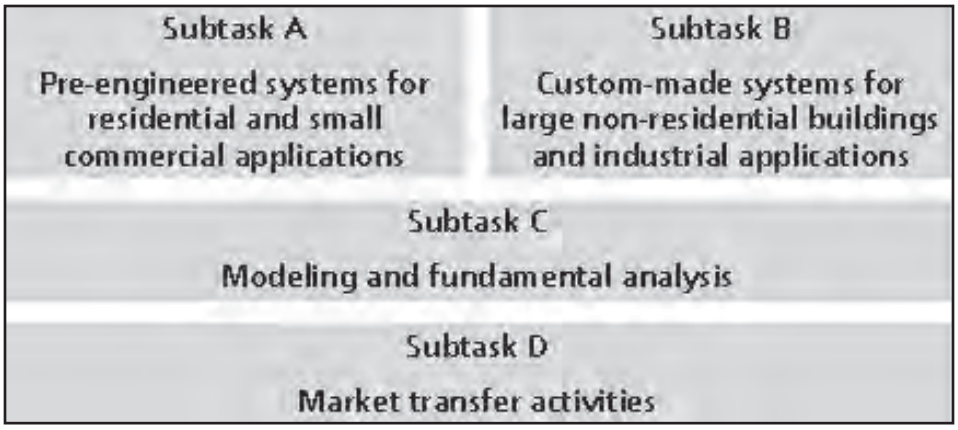
The objective of Subtask A is to support measures for the development of small and medium size pre-engineered systems, characterised by:

- Cooling capacity < 20 Kw.
- Ahigh 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, characterised by:

- cooling capacity > 20 kW.
- Individually planned systems for the particular application with involvement of planning engineers.



Task structure

- 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: Modelling and fundamental analysis (Lead Country: France)

The main objectives of Subtask C are:

- Further development and examination of new and already existing component models and simulation tools with special regards to their applicability to different stages of the layout 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.

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 and
- 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 Handbook for Solar Cooling for Planners.

Main deliverables

The results of the Task will be technical reports and tools like the followings:

- State-of-the-art report describing market available cooling equipment in the desired capacity range in a comparative and standardised way
- 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 standardisation schemes
- Second edition of the Solar Cooling Handbook for Planners

Solar collector field of the solar cooling system at European Academy in Bolzano/Italy. The first expert meeting took place in this building.

Duration

The formal start of the task was September 1, 2006, and it will be completed by August 31, 2009.

ACTIVITIES DURING 2006

- The 2nd Task Definition Workshop was held on March 6-7 in Milan, Italy.
- An international conference was organized in Bolzano/Italy with 120 participants on October 17, 2006.
- The first Experts Meeting was held on October 18-19 in Bolzano, Italy with 65 participants from 13 countries.

WORK PLANNED FOR 2007

General

In connection with the Expert Meeting in Chambery/France in April 2007, a one-day workshop will be organized for local professionals and R&D experts. National/regional/local architects and building industry representatives will as well be invited to the workshop. At this workshop, the official parts for the Task web pages on the SHC web site will be presented.

Subtask A: Pre-engineered systems for residential and small commercial applications

- Survey on market available equipment suitable for small-scale systems.
- Development of a comprehensive list of generic systems.
- Selection of pilot installations studied within Subtask A of Task 38.
- Definition of performance figures for the system measurement.
- Outline of a common monitoring scheme in order to ensure that proper evaluation of systems and comparison.
- Start of monitoring as appropriate.

Subtask B: Custom-made systems for large non-residential buildings and industrial applications

- Survey on market available equipment suitable for large-scale systems.
- Selection of pilot installations to be studied within Subtask B of Task 38.
- Definition of performance figures for the system measurement.
- Outline of a common monitoring scheme in order to ensure that proper evaluation of systems and comparison.
- Start of monitoring as appropriate.

Subtask C: Modelling and fundamental analysis

- Survey on new technology developments suitable for solar cooling and air-conditioning.
- Development of methodology for life cycle analysis.
- Development of methodology and carry-out of survey on heat rejection concepts.

Subtask D: Market transfer activities

- Development of a methodology for market study.
- First concept for the new handbook edition.

LINKS WITH INDUSTRY

A number of the Task experts are representing companies and organisations working either on installation of solar systems or 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 addressing professionals working in the design and installation of HVAC and solar systems for buildings.

REPORTS PUBLISHED IN 2006

No reports were produced in 2006.

REPORTS PLANNED F OR 2007

- State-of-the-art report describing market available cooling equipment in the desired capacity range in a comparative and standardised manner and market overview of pre-engineered solar cooling systems
- Collection of selected systems schemes (generic systems)
- Overview of market available thermally driven cooling technologies and suitable new solar components (i.e., mid temperature solar collectors)
- Bibliographic/technical review on the new Solar Cooling developments suitable for the application in air-conditioning and refrigeration sectors

MEETINGS IN 2006

Second Task Definition Workshop
March 6-7
Milan, Italy

First Experts Meeting
October 18-19
Bolzano, Italy

MEETINGS PLANNED FOR 2007

Second Experts Meeting
April 23-24
Chambery, France
In connection to this meeting, a workshop will be organized on April 25.

Third Experts Meeting
October 15-16
Barcelona, Spain

TASK 38 NATIONAL CONTACTS

Operating Agent

Hans-Martin Henning
Fraunhofer Institut für Solare Energiesysteme
Heidenhofstr.2
79110 Freiburg, Germany
Hans-Martin.Henning@ise.fraunhofer.de

Austria

Dagmar Jähnig (Leader Subtask A)
AEE INTEC, AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf
d.jaehnig@aee.at

Tim Selke
arsenal research
Business Field Sustainable Energy Systems
Giefinggasse 2
1210 Wien, Austria,
tim.selke@arsenal.ac.at

Hilbert Focke
ASIC- Austria Solar Innovation Center
Durisolstraße 7/Top 50
4600 Wels, Austria
focke.hilbert@asic.at

Philip Ohnewein
S.O.L.I.D. Gesellschaft für Solarinstallation und Design m.b.H.
Puchstraße 85
8020 Graz
Austria
p.ohnewein@solid.at

Prof. Wolfgang Streicher
Institute of Thermal Engineering
Graz University of Technology
Inffeldgasse 25, 8010 Graz, Austria
w.streicher@tugraz.at

Canada

Lúcio Mesquita
Queens University - Department of Mechanical and Material Engineering
Canada
mesquita@me.queensu.ca

Denmark

Klaus Ellehauge
Ellehauge & Kildemoes
Vestergade 48H, 2.tv.
8000 Århus C, Danmark
klaus.ellehauge@elle-kilde.dk

France

Etienne Wurtz (Leader Subtask C)
INES - Université de Savoie
BP 332 - Savoie Technolac
50 Avenue du Lac Léman
F-73377 Le Bourget du Lac
Etienne.Wurtz@univ-savoie.fr

Nadège Chatagnon
EDF R&D
Department EnerBat
Site des Renardières - Ecuelles
77 818 Moret-sur-Loing
France
nadege.chatagnon@edf.fr

Daniel Mugnier
TECSOL SA.
105 av Alfred Kastler - BP 90434
66 004 PERPIGNAN Cedex
- FRANCE
daniel@tecsol.fr

Germany

Hans-Martin Henning, Alexander Morgenstern, Edo Wiemken
Fraunhofer Institut für Solare Energiesysteme
Heidenhofstr.2
79110 Freiburg, Germany
Hans-Martin.Henning@ise.fraunhofer.de
Alexander.morgenstern@ise.fraunhofer.de
Edo.wiemken@ise.fraunhofer.de

Uli Jacob
Solarnext AG
Nordstr. 10
83253 Rimsting
Germany
uli.jakob@solarnext.de

Roland Heinzen
Institute of Thermal Engineering
University of Kassel
Kurt-Wolters-Str. 3
34125 Kassel, Germany
heinzen@uni-kassel.de

Christian Schweigler
ZAE Bayern
Walther-Meißner-Str. 6
85748 Garching, Germany
schweigler@muc.zae-bayern.de

Italy

Wolfram Sparber (Leader Subtask B)
European Academy Bolzano
Viale Druso/Drususallee 1
39100 Bolzano/Bozen
wolfram.sparber@eurac.edu

Mario Motta (Leader Subtask D)
Politecnico di Milano
Dip. Energetica
Piazza Leonardo da Vinci 32,
20133, Milano
mario.motta@polimi.it

Marco Beccali, Pietro Finocchiaro and Bettina Noke
University of Palermo
Viale delle Scienza 9
90128 Palermo
marco.beccali@dream.unipa.it
pietro.finocchiaro@dream.unipa.it
bettina@dream.unipa.it

Sufia Jung
OLYMP ITALIA SRL
Via Orbassano, 16
10090 BRUINO - TO
ITALY
olympitalia@olympitalia.it

Rajendra S. Adhikari
Politecnico di Milano
Dept. Building Environment Sciences
& Technology (BEST)
Via Garofalo 39
20133 Milano, ITALIA
Rajendra.Adhikari@polimi.it

Prof. Luigi Marletta
UNIVERSITA' DI CATANIA
Dipartimento di Ingegneria Industriale
e Meccanica (DIIM)
Viale A. Doria 6
95125 CATANIA (ITALY)
luigi.marletta@diim.unict.it

Mexico

Roberto Best y Brown
CIE-UNAM (Centro de Investigacion
en Energia,
Universidad Nacional Autonoma de
Mexico)
Mexico
rbb@cie.unam.mx

Portugal

João Farinha Mendes
DER/INETI, Edificio G
Estrada do Paço do Lumiar
1649-038 Lisboa, Portugal
farinha.mendes@ineti.pt

Spain

Manuel Romero
Ciemat
Avenida Complutense 22
E-28040 Madrid, Spain
manuel.romero@ciemat.es

Marcos Lucena Martin
INTA
Ctra. San Juan del Puerto-
Matalascañas, km. 34
21130 Mazagón,Huelva (Spain)
lucenamm@inta.es

Marcelo Izquierdo, Antonio Lecuona,
Pedro Acisclo Rodríguez Aumente
Universidad Carlos III de Madrid
Spain
mizquier@ing.uc3m.es
Lecuona@ing.uc3m.es
aument@ing.uc3m.es

Switzerland

Stéphane Citherlet
HEIG-VD
Rte de Cheseaux 1
CH-1401 Yverdon
Switzerland
stephane.citherlet@heig-vd.ch

TASK 39
Polymeric Materials for Solar Thermal Applications

Michael Köhl
Fraunhofer ISE
Operating Agent for the Projektträger Jülich

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 objectives shall be achieved in the following Subtasks:
- Subtask A: Information (Norway, Michaela Meir)
- Subtask B: Collectors (Germany, Wilfried Zörner)
- 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 present Task and the preparation of an electronic or printed handbook on polymeric materials in solar thermal applications are 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 will be 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 this Subtask will focus 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 will 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 development based on both, new system designs and new materials, for absorbers and entire collectors.
Design examples will be produced in order to show the feasibility, performance, durability and cost savings.

These activities will be carried out within 2 different projects:

- B1: Integrated Collector Structure
- B2: Absorber

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 reaches 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:

- Identification of 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.
- 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.
- Evaluation of 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 will be 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 will be 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.

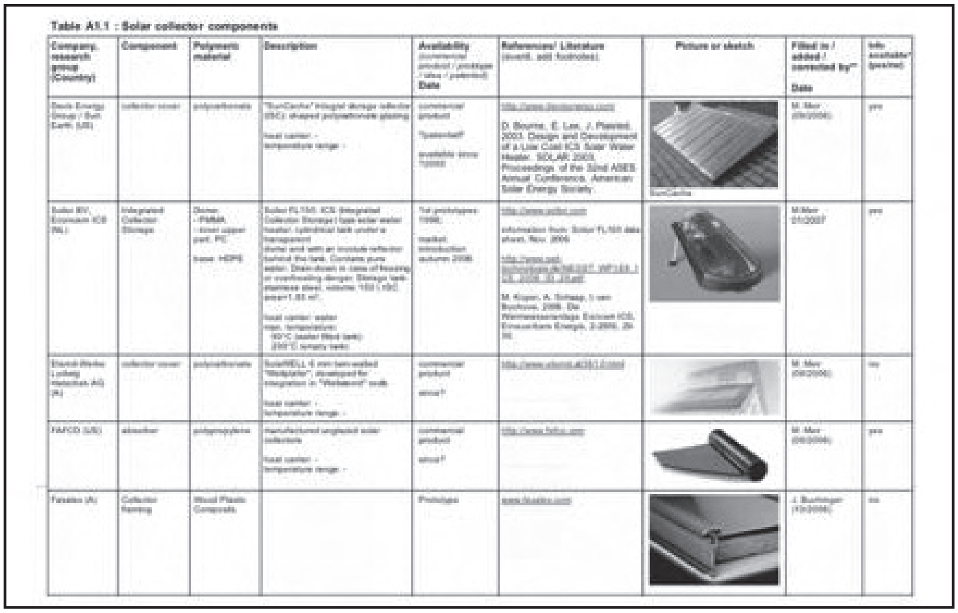


Figure 1. Layout of the present state of the art overview on polymeric materials in solar thermal applications (excerpt).

ACTIVITIES DURING 2006

The Task was in operation only for 3 months in 2006; therefore activities have only just begun.

Subtask A: Information

State of the Art Report on "Polymeric Materials in Solar Thermal Applications"

In Project A1 a "state of the art report" on "Polymeric materials in solar thermal applications" is under preparation in Subtask A and will be used in the other Subtasks. A call for input was made at the beginning of Task 39 and many Task participants contributed with valuable input.

A preliminary version was prepared for the Kick-off meeting on October 25-26, 2006 in Ingolstadt, Germany. The Task participants decided to keep the presented layout in table format as work version (see Figure 1). The state of the art table includes products that are completely or partly made of polymeric materials in solar thermal applications. Among them are patents and products in the market or had been in the market: solar collector components (46), glazing materials (10 examples), pool absorbers (17), heat store (components) (12), seasonal heat stores (25 examples) other components (14) and a literature list. The time schedule is to update the information at the end of the Task.

Further plans within Subtask A:

- An overview of the lists will be available to all Task 39 participants on the password-protected server at Fraunhofer ISE.

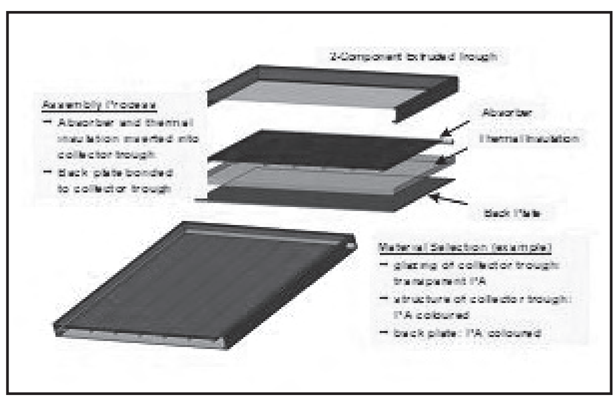


Figure 2. This shows the version obtained after the first round of feedback.

Figure 3. Preliminary version of the Task 39 logo: Logo-button (top) and in landscape format (bottom).

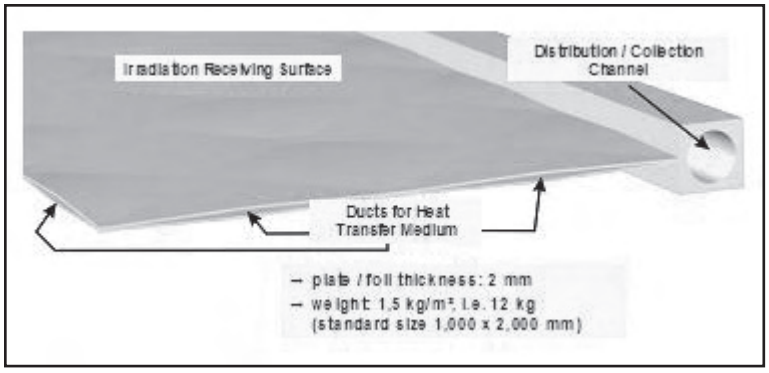


Figure 4. Possible use of polymeric materials for the collector structure.

- Prepare a Task report, coordinated with the needs in other subtasks, which classifies the reported applications e.g. according to the degree of innovativeness and exposure to various loads. Presentation of this outcome at conferences and/or publication in magazines, papers;

Design of Task 39 Logo

A logo was designed for the unique identification of various outcomes and deliverables of Task 39. We made a call for proposals among the Task participants.

Task 39 Flyer and Web Site

The Operating Agent and the Subtask leaders started on a draft for text and potential graphic material of the Task 39 Flyer. Help with the final layout of the flyer is available through the Operating Agent from the marketing department at Fraunhofer ISE. A printed and electronic version of the flyer is aimed to be finished early in 2007.

Parts of the text and graphic material in the flyer will be used for the first version of the Task 39 website. The official website of Task 39 is here: http://www.iea-shc.org/task39/index.html.

A first version of the Task 39 website will be built up (under: http://www.physics.uio.no/energy/task39/) und gradually be transferred to the official web location.

A large contribution of the work in Subtask A was scheduled at the start of Task 39. Due to the fact that the feedback from the national funding agencies came later than initially hoped, the work in Project A3, challenges of polymeric materials from a market perspective, will be somewhat delayed. However it is realistic to state that the follow-up of Project A3 will be according to time schedule in the first half of 2007.

Subtask B: Solar Thermal Collectors

The presentations, reports and discussions during the kick-off meeting in Ingolstadt clearly showed that there are many opportunities for polymeric materials in solar-thermal applications, but there still remain open items to be thoroughly investigated.

Solar thermal manufacturers want to reduce their production cost by replacing metal components by polymeric materials. However, the manufacturers lack the knowledge, where and how to initialize this process, because the specific advantages and disadvantages of polymers are not commonly known in the solar thermal business.

Within Subtask B, two projects, one concerning the absorber, the other the concerning the collector structure, were presented. The projects are initiated by Ingolstadt University of Applied Sciences in cooperation with several industrial partners (polymer and collector manufacturers). Both projects are supposed to be funded by German research funding programmes and are expected to start in early 2007.

Project B1: Polymers in the Collector Structure

The use of an aluminum housing, a transparent low iron glazing and a thin aluminum layer as back plate constitutes the current state-of-the-art of solar-thermal collectors. On the one hand, this design results in high mechanical strength, on the other hand it means the use of expensive raw materials and makes solar collectors heavy and bulky to install.

The R&D targets and steps of the project can be summarized as follows:

- *Concept description*

In a first step, a market analysis dealing with commonly used collector structures, state-of-the-art of collectors with polymeric applications is carried out. Secondly, different concepts for the collector structure are developed. There are two options: the first one is a "low-degree" substitution of parts of the collector structure by polymer materials, the much more promising approach is to develop a

completely polymer based integrated structure (figure 4).

- *Selection of applicable polymers and production technologies*

Following the concept development, applicable polymers can be chosen depending on the operating conditions. Within this step, tests are carried out with samples in order to proof the characteristics of the material and its applicability for solar-thermal components.

Special attention has to be attributed to potential production technologies in order to keep costs for machines and tools within a specified cost limit. Eventually, the design concepts are evaluated concerning technological and economic aspects in order to provide an optimized product for innovative solar-thermal collectors.

Project B2: Polymer Based Absorber for Solar-Thermal Flat-Plate Collectors – System and Component Research

The R&D targets and steps of the project can be summarized in as follows:

- *Development of a low-temperature solar system according to the technical possibilities of polymer materials*

In a first step, the use of collectors in solar hot water and heating systems has to be reviewed. Hence, a thorough analysis of a commonly used closed loop systems has to be carried out in order to develop new system approaches.

This step appears to be very important as it opens the way for cost-effective polymer materials "accepting" their thermal and mechanical weaknesses.

- *Development of a polymer absorber*

The design principle of most of today's absorbers, the pipe/plate design using copper/ copper or copper/aluminum for pipes and plates, requires a complete reengineering. There are still many thermodynamic weaknesses and problems associated with production that can be solved by using a completely different design principle, i.e. the so-called volumetric flow absorber as shown in Figure 5.

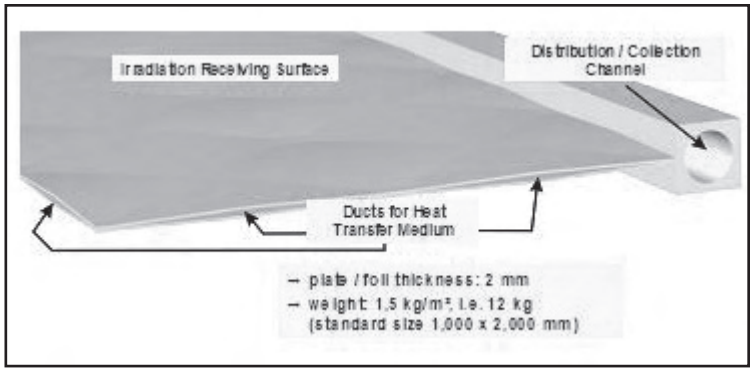


Figure 5. Design example of polymer based volumetric flow absorber

Conclusions

Carrying out the two projects as described above, it will be possible to "melt" the two resulting designs into a fully polymer solar-thermal collector. In the future, only a single production process might be necessary to generate most of the whole solar collector, due to for example a multi-component extrusion as already used in the automotive sector for rear lights.

Subtask C: Materials

Project C1: Functional Polymeric Materials and Polymer Surfaces for Solar Thermal Applications

Within C1 activities focusing on thermotropic polymeric materials and spectrally selective solar absorber coatings are already ongoing at the Polymer Competence Center Leoben (PCCL, A) and the National Institute of Chemistry (NIC, SI). First results of a literature study and the development and characterization of formulations were provided by Dr. Wallner (PCCL) and Prof. Orel (NIC) within the kick-off-meeting at the University of Applied Sciences Ingolstadt in October 2006.

Regarding potential further contributions the following inputs were ascertained and compiled:

- Thermotropic polymeric materials:
- The company partners General Electric (GE) and EMS Chemie are planning to establish research projects dealing with thermotropic polymer blends.
- Spectrally selective solar absorber coatings:
- NIC will pay special attention to the implementation of further functionalities, such as hydrophobic or oleophobic behavior and abrasion resistance.
- UV-absorbing coatings to ensure long-term stability:
- An effective UV-protective coating is a prerequisite for the use of many polymeric materials, which are in the unstabilized state susceptible to UV-induced degradation. GE or partner companies (e.g., Degussa) will prepare a state-of-the-art overview on UV-protective coatings for polycarbonate. Furthermore, the topic "UV-protected paints for unglazed absorbers" was discussed and contributions of NIC and Prirev.
- Barrier layers for collectors and storage tanks:
- As to barrier layers Prirev (PVDC), Chevron (PPS) and Conti (alumi-

num) declared interest to provide materials. ITW, UiK (University of Kassel) and FhG-ISE referred to the measuring equipment available at these institutions.
- Adhesion of functional polymeric materials to polymeric substrates
- Regarding the adhesion of spectrally selective coatings on polymeric solar absorber materials cooperation between NIC and PCCL was ascertained. While NIC will provide functional materials, the adhesion tests will be carried out by PCCL. Chevron proposed to include high temperature resistant PPS grades.
- Ageing behavior of functional polymeric layers
- Within this work package focus will be given to spectrally selective and UV-absorbing coatings. NIC, ISE, SPF and SP (in the previous meeting) evinced potential contributions. PCCL announced that currently no thermotropic materials will be made available for interdisciplinary ageing tests.

Project C2: Performance Defined Structural Polymeric Materials for Solar Thermal Applications

Within C2 one activity focusing on the ageing behavior of commodity and engineering polymeric materials for solar absorber applications is already ongoing at the Polymer Competence Center Leoben (PCCL, A), the University of Oslo (UiO, N) and Solarnor AS (Oslo, N). Results of a literature study and the ageing behavior of various polymeric materials were provided by Dr. Wallner (PCCL) within the kick-off-meeting.

Regarding potential further contributions the following inputs were ascertained and compiled:
- Material development and ageing behavior of stiff polymeric materials
- Further research topics within this work package depend on the solar collector concepts to be developed by Gasokol/Greenonetec/Arsenal, Prirev, Citrinsolar/FHI (FH Ingolstadt) and Consolar/FhG-ISE within Subtask B. Chevron announced to make high temperature resistant PPS material available, which allows for high stagnation temperature collectors.
- Material development and ageing behavior of soft polymeric materials
- Within this work package contributions of ContiTech/UiK (University of Kassel) and ITW were ascertained. While ContiTech/UiK focus on flexible storage tanks, ITW investigates structural materials for pit stores. ITW suggested to encourage AGRU (supplier of liners) to participate in the task.

Project C3: Components and Polymer Processing

Within C3 the following activities are currently established:
- Evaluation of plastics processing technologies for the production of collectors and storage tanks
  Based on the input of company partners (Roth Werke, Rehau, EMS Chemie, Chevron, GE, Solarnor, Solartwin) the following topics were accentuated:
  – Blow molding of collectors and storage tanks (Roth Werke, Solartwin, Chevron)
  – Injection molding of collectors (EMS, Rehau, Solarnor, GE)
  – Joining technologies (Solartwin, Solarnor, GE)

Potential contributions of the scientific partners were expressed by FHI (FH Ingolstadt) and FHO (Osnabrück). Within this work package prototypes will be designed and produced in cooperation with company partners.

WORK PLANNED FOR 2007

Subtask A: Information (Norway)

Looking for funding.

Subtask B: Collectors (Germany)

Looking for funding.

Subtask C: Materials (Austria)

- Estimation of product costs depending on quantities
- Special attention on this topic will be paid in a diploma thesis (Eva Stricker) to be carried out at FhG-ISE. Support of the company partners GE Plastic, Roth Werke, Solartwin, Chevron and Rehau was ascertained.
- Evaluation of state-of-the-art polymeric components in solar systems from a plastics point of view
- To enhance the know-how transfer and to achieve progress in appropriate designing of plastics parts and components for solar thermal systems, PCCL announced to carry out a study to evaluate currently used polymeric components in solar systems from a plastics point of view.

REPORTS PUBLISHED IN 2006

Publications

- M. Köhl, Polymere Materialien für Solarthermische Systeme, Erneuerbare Energie, 2007.

Press & media, newsletters

- Polymeric Materials. Solar Update, Newsletter of the International Energy Agency Solar Heating and Cooling Programme, vol. 46, December 2006.
- IEA SHC Task 39: Polymeric Materials for Solar Thermal Applications, EET-newsletter 10/2006, http://www.arsenal.ac.at/products/products_en_st_cs_t39_de.html
- Website of Eco World Styria, see: http://www.ecoundco.at/cms/120/4452/

MEETINGS IN 2006

First Experts Meeting

October 26, 2006
Ingolstadt, Germany.
39 experts from 27 institutions and companies from 8 countries were present. An industry workshop with 42 participants was held in conjunction on October 25.

MEETINGS PLANNED FOR 2007

Second Experts Meeting

May 2-4
To be decided

Third Experts Meeting

September 24-26
Blumau/Leoben, Austria

TASK 39 CONTACT PERSONS

Operating Agent
Michael Köhl
Fraunhofer Institut für Solare Energiesysteme
michael.koehl@ise.fraunhofer.de

Austria
Josef Buchinger
Arsenal Research
josef.buchinger@arsenal.ac.at

Robert Hausner
AEE Intec
r.hausner@aee.at

Gernot Wallner
Polymer Competence Center Leoben
wallner@unileoben.ac.at

Robert Buchinger
Gasokol GmbH
office@gasokol.at

Belgium
Vania Dobreva
Chevron-Phillips Chemicals
dobreva@cpchem.com

France
Philippe Barq
Pôle of Plasturgie

Philippe Papillon
INES/CEA
philippe.papillon@cea.fr

Germany
Rainer Aubele
Citrinsolar
rainer.aubele@citrinsolar.de

Ralf Koebbemann-Rengers
BBT-Solar Diamant
ralf.koebbemann-rengers@buderus.de

Fabian Ochs
ITW Uni Stuttgart
ochs@itw.uni-stuttgart.de

Claudius Wilhelms
University of Kassel
wilhelms@uni-kassel.de

Wilfried Zörner
Fachhochschule Ingolstadt
wifried.zoerner@fh-ingolstadt.de

Maruan Matjak
Consolar GmbH
maruan.matjak@consolar.de

Netherlands
Bert Groothuis
GE Plastics
bert.groothuis@ge.com

Norway
John Rekstad
University of Oslo, Department Of Physics
mmeir@fys.uio.no

Portugal
Luis Godinho
Prirev, LDA
luisgodinho@prirev.com

Barry Johnston
Solar Twin Ltd.
barry@solartwin.com

Sweden
Kenneth Möller
SP
kenneth.moller@sp.se

Switzerland
Stefan Brunold
Institut für Solartechnik SPF
stefan.brunold@solarenergy.ch

Christian Roecker
EPFL
Christian.Roecker@epfl.ch

International Energy Agency

Solar Heating and Cooling Programme

EXECUTIVE COMMITTEE MEMBERS

AUSTRALIA
Mr. Max Maffucci
Standards Australia International
GPO Box 5420
Sydney, NSW 2001
max.maffucci@standards.org.au

Alternate
Mr. Ken Guthrie
Sustainability Victoria
Urban Workshop
Level 28
50 Lonsdale Street
Melbourne 3000
Ken.Guthrie@sustainability.vic.gov.au

AUSTRIA
Prof. Gerhard Faninger
c/o Universität Klagenfurt, IFF
Sterneckstraße 15
A-9020 Klagenfurt
gerhard.faninger@uni-klu.ac.at

BELGIUM
Prof. André De Herde
Architecture et Climat
Université Catholique de Louvain
Place du Levant, 1
B-1348 Louvain-la-Neuve
deherde@arch.ucl.ac.be

CANADA
Mr. Doug McClenahan
(Chairman)
CANMET - Natural Resources Canada
580 Booth Street
Ottawa, Ontario K1A 0E4
dmcclena@nrcan.gc.ca

DENMARK
Mr. Jens Windeleff
Danish Energy Authority
Amaliegade 44
DK-1256 Copenhagen K
jew@ens.dk

Alternate
Mr. Poul E. Kristensen
IEN Consultants
Hasselvej 30
2830 Virum
poul@ien.dk

EUROPEAN COMMISSION
Mr. Jose Riesgo
European Commission
DM24 3/1442
B-1049 Brussels, BELGIUM
Jose.Riesgo@cec.eu.int

FINLAND
Mr. Jarkko Piirto
TEKES, National Technology Agency
Energy and Environment
Employment & Economic Development Centre for Ostrobotnia
FIN-00101 Helsinki
jarkko.piirto@tekes.fi

FRANCE
Mr. Yves Boileau
French Agency for the Environment and Energy Management (ADEME)
500 Route des Lucioles - Sophia Antipolis
F-06565 Valbonne Cedex
yves.boileau@ademe.fr

GERMANY
Mr. Markus Kratz
Forschungszentrum Jülich - PTJ
D-52425 Jülich
m.kratz@fz-juelich.de

Alternate
Mr. Tobias Petrovic
Forschungszentrum Jülich GmbH
D-52425 Jülich
t.petrovic@fz-juelich.de

ITALY
Dr. Paolo Zampetti
Division of Systems for Energy Conservation
ENEA
Via Anguillarese 301
I-00060 S. Maria di Galeria (Rome)
zampetti@casaccia.enea.it

MEXICO
Dr. Wilfrido Rivera Gomez-Franco
Center for Energy Research
National University of Mexico
Apdo. Postal #34
62580 Temixco, Morelos
wrgf@cie.unam.mx

Alternate
Dr. Camilo Arancibia Bulnes
same address as above
caab@cie.unam.mx

NETHERLANDS
Mr. Lex Bosselaar
SenterNovem
P.O. Box 8242
3503 RE Utrecht
L.Bosselaar@SenterNovem.nl

NEW ZEALAND
Mr. Michael Donn
School of Architecture
Victoria University of Wellington
P.O. Box 600
Wellington 1
michael.donn@vuw.ac.nz

NORWAY
Dr. Anne Gunnarshaug Lien
(Vice Chair)
Enova SF
Abelsgate 5
7030 Trondheim
anne.g.lien@enova.no

Alternate
Mr. Fritjof Salvesen
KanEnergi AS
Hoffsveien 13
0275 Oslo
fs@kanenergi.no

PORTUGAL
Mr. Joao A. Farinha Mendes
INETI – Edificio H
Departamento de Energias Renovaveis
Estrada do Paco do Lumiar, 22
1649-038 Lisboa
farinha.mendes@ineti.pt

SPAIN
Dr. Manuel Romero
Director Renewable Energy Division
CIEMAT
Avenida Complutense 22
E-28040 Madrid, Spain
manuel.romero@ciemat.es

Alternate
Dr. Esther Rojas
Concentrating Solar Systems
Plataforma Solar de Almería
CIEMAT
Avenida Complutense 22
28040 Madrid
esther.rojas@ciemat.es

SWEDEN
Mr. Michael Rantil
Swedish Energy Agency
Box 310
631 04 Eskilstuna
Michael.Rantil@energimyndigheten.se

SWITZERLAND
Mr. Urs Wolfer
Federal Office of Energy
CH-3003 Bern
urs.wolfer@bfe.admin.ch

Alternate
Mr. Robert Hastings
Architecture, Energy & Environment GmbH
Bahnhofstr. 26
CH 8304 Wallisellen
robert.hastings@aeu.ch

UNITED STATES
Mr. Drury Crawley
(Vice Chair)
U.S. Department of Energy
Energy Efficiency and Renewable Energy
EE-2J, Office of Building Technologies
1000 Independence Ave. S.W.
Washington, D.C. 20585-0121
Drury.Crawley@ee.doe.gov

EXECUTIVE SECRETARY
Ms. Pamela Murphy
Morse Associates, Inc.
9131 S. Lake Shore Dr.
Cedar, MI 49621
UNITED STATES
pmurphy@MorseAssociatesInc.com

ADVISOR
Dr. Frederick H. Morse
Morse Associates, Inc.
236 Massachusetts Ave., NE
Suite 605
Washington, DC 20002
UNITED STATES
fredmorse@MorseAssociatesInc.com

IEA SECRETARIAT LIAISON
Mr. Nobuyuki Hara
International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15
FRANCE
Nobuyuki.Hara@iea.org

TASK OPERATING AGENTS

PERFORMANCE OF SOLAR FAÇADE COMPONENTS

Mr. Michael Köhl
Fraunhofer Institute for Solar Energy Sytems
Heidenhofstr. 2
D-79 110 Freiburg
GERMANY
michael.koehl@ise.fraunhofer.de

SOLAR CROP DRYING

Mr. Doug Lorriman
20 Tiny Beaches Rd. N.
Site 8, Comp. 8
Perkinsfield, Ontario, LOL 2JO
CANADA
douglorriman@rogers.com

DAYLIGHTING BUILDINGS IN THE 21ST CENTURY

Dr. Nancy Ruck
Unit 88, 1-29 Bunn St.
Pyrmont, NSW 2009
AUSTRALIA
ncr1@austarnet.com.au

ADVANCED STORAGE CONCEPTS FOR SOLAR AND LOW ENERGY BUILDINGS

Mr. Jean-Christophe Hadorn
BASE Consultants SA
8 rue du Nant
CH-1211 Geneva
SWITZERLAND
jchadorn@baseconsultants.com

SOLAR HEAT FOR INDUSTRIAL PROCESSES

Mr. Werner Weiss
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf
AUSTRIA
w.weiss@aee.at

TESTING & VALIDATION OF BUILDING ENERGY SIMULATION TOOLS

Mr. Ron Judkoff
Director, Buildings & Thermal Systems Center
National Renewable Energy Lab (NREL)
1617 Cole Boulevard
Golden, CO 80401
UNITED STATES
ron_judkoff@nrel.gov

PV/THERMAL SOLAR SYSTEMS

Mr. Henrik Sørensen
Head of Branch Office
Esbensen Consulting Engineers Ltd.
Carl Jacobsens Vej 25D
Sukkertoppen - Copenhagen
DK-2500 Valby
DENMARK
h.soerensen@esbensen.dk

SOLAR RESOURCE KNOWLEDGE MANAGEMENT

Dr. Dave Renné
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
UNITED STATES
david_renne@nrel.gov

ADVANCED HOUSING RENOVATION WITH SOLAR & CONSERVATION

Mr. Fritjof Salvesen
KanEnergi AS
Hoffsveien 13
0275 Oslo
NORWAY
fs@kanenergi.no

SOLAR ASSISTED COOLING SYSTEMS

Dr. Hans-Martin Henning
Fraunhofer Institute for Solar Energy Sytems
Department of Thermal Systems and Buildings
Heidenhofstr. 2
D-79110 Freiburg
GERMANY
hans-martin.henning@ise.fraunhofer.de

POLYMERIC MATERIALS FOR SOLAR THERMAL APPLICATIONS

Mr. Michael Köhl
Fraunhofer Institute for Solar Energy Sytems
Heidenhofstr. 2
D-79 110 Freiburg
GERMANY
michael.koehl@ise.fraunhofer.de

SHC INTERNET SITE
http://www.iea-shc.org

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