WITH AN OVERVIEW OF

Solar Assisted Air Conditioning of Buildings
IEA Solar Heating & Cooling Programme

2004 Annual Report

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The Solar Heating & Cooling Implementing Agreement

BACKGROUND

The International Energy Agency, based in Paris, was established as an intergovernmental organization in November, 1974 under the Agreement on an International Energy Program (IEP) after the oil shock of 1973/1974. The 26 Member countries of the IEA are committed to taking joint measures to meet oil supply emergencies. They also have agreed to share energy information, to co-ordinate their energy policies and to co-operate in the development of rational energy programmes.

The IEA’s policy goals of energy security, diversity within the energy sector, and environmental sustainability are addressed in part through a program of international collaboration in the research, development and demonstration of new energy technologies, under the framework of over 40 Implementing Agreements.

The Solar Heating and Cooling Implementing Agreement was one of the first collaborative R&D programs to be established within the IEA, and, since 1977, its participants have been conducting a variety of joint projects in active solar, passive solar and photo-voltaic technologies, primarily for building applications. The overall Programme is monitored by an Executive Committee consisting of one representative from each of the 19 member countries and the European Commission.

Current Tasks

A total of thirty-five Tasks (projects) have been undertaken since the beginning of the Solar Heating and Cooling Programme. The leadership and management of the individual Tasks are the responsibility of Operating Agents. The Tasks which were active in 2004 and their respective Operating Agents are:

- Task 25
  Solar Assisted Air Conditioning of Buildings
  Germany

- Task 27
  Performance of Solar Facade Components
  Germany

- Task 28/ECBCS 38
  Sustainable Solar Housing
  Switzerland

- Task 29
  Solar Crop Drying
  Canada

- Task 31
  Daylighting Buildings in the 21st Century
  Australia

- Task 32
  Advanced Storage Concepts for Solar and Low Energy Buildings
  Switzerland

- Task 33
  Solar Heat for Industrial Processes
  Austria

- Task 34/ECBCS Annex 43
  Testing and Validation of Building Energy Simulation Tools
  United States

- Task 35
  PV/Thermal Systems
  Denmark
Chairman's Report & Highlights of 2004

OVERVIEW

In 2004, the Solar Heating and Cooling (SHC) Programme made great strides in its work to promote solar thermal in the market. Activities included a workshop with solar thermal trade associations, another update of the report, Solar Heating Worldwide, presentation of the 2nd SHC Solar Award, and Task work focused on impacting the market.

SHC/Trade Association Workshop

In September, members of the SHC Programme and representatives from major solar thermal trade associations meet to discuss how they could better support each other’s work. The meeting was a success with experts from six countries and the European Solar Thermal Industry Federation (ESTIF). Two important results came from this meeting:

- Agreed upon methodology to convert installed collector area into solar thermal capacity. Solar thermal data expressed for the first time in GWth, rather than in square meters of installed collector area – shows the global installed capacity to be 70 GWth (70,000 MWth). As stated by the President of ESTIF, Ole Pilgaard, “Now the solar thermal capacity should show up in all statistics alongside the capacities of other renewable energies. And seeing that the world wide capacity of solar thermal installations exceeds even that of wind power, people will realize that our technology can contribute tremendously to reducing greenhouse gas emissions and to making the global energy supply more sustainable.”
- Prepared a Memorandum of Understanding formalizing collaboration between this Programme and signatory trade associations.

Solar Thermal Collector Market in IEA Member Countries

The updated edition of this report, Solar Heating Worldwide now includes 2001 data. Since the beginning of the 1990s, the solar thermal market has undergone a favorable development. At the end of 2001, a total of 100 million square meters of collector area were installed in the 26 recorded countries. These 26 countries represent 3.3 billion people, which is about 50% of the world’s population. The collector
area installed in these countries represents approximately 85 - 90% of the solar thermal market worldwide. And, the contribution of solar collectors to the supply of energy by the end of 2001 in the 26 recorded countries is 42 TWh (more than 151PJ). This corresponds to an oil equivalent of 6.7 billion liter and an annual avoidance of 18.2 million tons of CO2. This report can be downloaded from the SHC web site (www.iea-shc.org).

**SHC Solar Award**

The 2nd SHC Solar Award was presented to Prof. William Beckman at the World Renewable Energy Congress (WREC) Pioneer Awards ceremony in Denver, Colorado, USA this past September.

The award is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements, with links to the IEA Solar Heating and Cooling Programme, in the field of solar energy at the international level within one or more of the following sectors: technical developments; successful market activities; and information.

Professor Beckman’s accomplishments include the co-development of TRNSYS, a world renowned building energy analysis and research tool. TRNSYS has been used in IEA SHC work for over 25 years. His book, "Solar Engineering of Thermal Processes," continues to serve as a reference for experts participating in IEA SHC projects. In addition to developing tools and reference materials, Prof. Beckman has taught many SHC experts as director of the Solar Energy Laboratory at the University of Wisconsin. And, he has authored over 131 journal articles. In addition to his contributions to the IEA SHC Programme, Prof. Beckman served as President of the International Solar Energy Society and was selected as a Senior Fulbright Scholar at CSIRO in Australia. He also was a Visiting Staff member of CSTB in France.

The Programme will present the 3rd SHC Solar Award in 2005. The venue for this event is to be determined in early 2005.

**New SHC Strategic Plan**

The Executive Committee approved a new Strategic Plan for 2004-2008. The mission for the Programme for the period 2004-2008 is: To continue to be the preeminent international collaborative programme in solar heating and cooling technologies and designs.

Based on this mission, the SHC 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.

**Programme Participation**

Participation in the Programme remains strong with 19 Member countries and the European Union actively participating in its work. This year, Japan withdrew from the Programme due to a change in government priorities and funding. Japan made significant contributions to the Programme for over 25 years. It is the SHC Executive Committee’s hope that Japan will renew its commitment perhaps through industry in the near future. The Executive Committee continued to correspond with those countries invited and interested in joining the Programme: Brazil, China, Czech Republic, Egypt, Greece, South Korea, South Africa and Turkey.

**Tasks**

As for Task work, The Executive Committee approved the start of Task 35: PV/Thermal Systems and the continuation of the Task Definition Phase of the Solar Resource Knowledge Management work. The newly approved SHC Task 35: PV/Thermal Systems will be a collaborative activity with the IEA Photovoltaic Power Systems Programme, and led by the SHC Programme.

The Executive Committee also approved the completion of one project—SHC Task 25: Solar Assisted Air Conditioning of Buildings. It is with sadness that the Committee says farewell to Dr. Hans-Martin Henning.

As the SHC Programme makes visible steps in promoting solar technologies in the market, I am confident that 2005 will be another year of growth for the industry and this Programme.

Michael Rantil
TASKS

Notable achievements of the Programme’s work during 2004 are presented below. The details of these and many other accomplishments are covered in the individual Task summaries later in this report.

Task 25: Solar Assisted Air Conditioning of Buildings

The Committee approved the final management report of Task 25. This Task has played a major role in increasing the attention given to solar air conditioning techniques. Task participants initiated several new installations or were involved during their design. They also initiated or participated in several new national or international (mainly EU) projects on technology development, design issues or other accompanying measures, such as studies about energy-economic performance or dissemination work.

Task 27: Performance of Solar Facade Components

The project was completed in 2003, but the final report, “General Methodology of Accelerated Testing for Assessment of Service Life of Solar Thermal Components” was been submitted to the Secretariat of ISO/TC 59/SC 14 on service life planning. The submission was to be a contribution to the work in revising ISO 15686-1 and ISO 15686-2, and was formally made by the Swedish Standardization Committee SIS TK 209.

The SHC Task 27 input was discussed at the ISO TC59/SC14 meeting held in Toronto in early 2004. SHC Task 27 work is considered a valuable contribution to the SC14 work and will be considered in the revision of the standards, especially in a forthcoming revision of ISO 15686 - 2.

Task 28/ECBCS Annex 38: Sustainable Solar Housing

The book, Design of High Performance Housing - A Reference Book, will be published in 2005. An interesting example from this book is a cross comparison done to look for trends or commonalities in the design and construction of 20 Swiss houses that are achieving extremely low energy performance. It is interesting to note that the orientation of the house was not a significant design feature to achieve low energy levels. Houses not optimally oriented were able to offset this limitation by other energy saving features. On the other hand, compactness seems to be essential. Typically, the single family houses had an A/V ratio of 0.73 and apartment buildings the ratio was 0.49. Because space heating demand is reduced to such low levels, domestic hot water heating becomes relatively important. Not surprisingly, 3/4 of the houses in the sample had solar thermal systems for this end use.

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

Task 29: Solar Crop Drying

The Task’s coffee drying project in Costa Rica had an official opening of the plant — the largest of its kind in Central America. At the Tilaran plant, 850 square meters of Conserval’s Solarwall® panels are installed on the roof and intake fans draw in warmed air from the perforated panels to dry the coffee beans. This system is to replace the system that ran on wood. SHC Executive Committee members participated in the plans opening in November. Monitoring of the system has begun and the data collected will be analyzed in the beginning of 2005.

Task 31: Daylighting Buildings in the 21st Century

The collaboration between building owners, A/E teams and industry for the integration of daylighting responsive controls and shading devices has led to significant results in the New York Times Building Project. Dynamic façade and dimming controls have been commercially available for some years, but the barrier has been cost and reliable performance. By demonstrating and testing in a partially full-scale model of the New York Times Building on an outdoor site, it has been proven
that with collaboration, smart integrated shading and electric lighting control systems can work and are cost effective.

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

An improvement of the SHC Task 26 FSC method that compares designs of solar installations has been derived theoretically. Experts in this Task have adjusted the FSC method so that it now covers systems able to produce heat and cold from solar and eventually operating with long term storage. In 2005, the improved method will be validated against detailed simulation results.

**Task 33: Solar Heat for Industrial Processes**

State of the industry and the future potential of industrial-process solar heat were examined in 2004. The results of an Austrian study and the preliminary results of studies in Spain, Portugal and Italy show that the potential for solar low temperature heat ranges between 3% and 4% of the total heat demand of the industry. Information also was collected on industrial-process solar heat plants operating world wide. From the 49 reported plants, the majority of the projects are in the food and beverage, textile, transport and chemistry sectors with a large majority in food processes.

**Task 34/ECBCS Annex 43: Testing and Validation of Building Energy Simulation Tools**

During 2004, ASHRAE Standard 90.1, which is used for regulating energy efficiency in commercial and non-low-rise residential buildings, had an addendum published that requires use of Standard 140 for testing software used in building energy efficiency assessments. 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, distributes their Standard 140 validation results with their CDs and from their website.

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

**Task 35: PV/Thermal Systems**

The kick-off meeting to this Task is scheduled for January 2005. The objectives of this Task is to catalyze the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector. This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement.

**NEW ACTIVITIES**

**Solar Resource Knowledge Management**

The Executive Committee looks forward to the start of this Task in 2005. The objective of this Task is to exploit the emerging potential of satellite-derived solar resource information in response to the solar industry’s expressed need for improved spatial and temporal coverage, worldwide benchmarking and validation, improved reliability and access to the information, and development of customized products such as solar forecasts. The first Task Definition Workshop was held in February 2004 in Spain, and a work plan and draft Annex have been developed. The Annex is currently under review by participating countries, and the level of support from each participating country is being established. The Annex will be submitted for formal approval at the next SHC Executive Committee meeting in June 2005.

It is to be is a collaborative effort with the IEA Photovoltaic Power Systems Agreement and the IEA SolarPACES Agreement.

**Workshop**

The Programme is considering holding another trade association workshop in 2005. And, will announce the final Memorandum of Understanding, signed by the SHC Programme and solar thermal trade industries worldwide, at select events in 2005.

**EXECUTIVE COMMITTEE MEETINGS**

**2004 Meetings**

The 2004 Executive Committee held meetings in May in Helsinki, Finland (included a joint meeting with the IEA Photovoltaic Power Systems Programme) and in November in Costa Rica (included the opening of a SHC Task 29 coffee solar drying project).
2005 Meetings

The 2005 Executive Committee meetings will be held 15-17 June in Porto, Portugal (includes a joint meeting with the IEA Energy Conservation in Buildings and Community Systems Programme) and 5-7 December in Australia.

INTERNET SITE

The Solar Heating and Cooling Programme’s website continues to be updated and new pages added as needed. The site plays an important role in the dissemination of Programme and Task information. The Executive Committee continues to encourage the posting of as many Programme and Task reports as possible to the web site. In 2005, the Webmaster will finalize work on adding PDF files of the highly requested reports from completed Tasks to the web site. The address for the site is www.iea-shc.org.

COORDINATION WITH OTHER IEA IMPLEMENTING AGREEMENTS AND NON-IEA ORGANIZATIONS

The IEA Buildings Related Implementing Agreements (BRIA) is composed of the seven building-related IEA Implementing Agreements. The SHC Chairman continues to support the work of this group.


The IEA Photovoltaic Power Systems Programme worked with the SHC Programme in the development of Task 35: PV/Thermal Systems and the proposed Task on Solar Resource Management Based on Satellite Data. A joint meeting was held during the May 2004 executive Committee meeting in Finland to facilitate the continued collaborative work between the Programmes.


FEATURE ARTICLE

Every year the SHC Annual Report includes a feature article on some aspect of solar technologies for buildings. This year’s article is on what has been learned from the Programme’s work on solar-assisted air conditioning of buildings.

ACKNOWLEDGMENTS

In closing, I would like to thank the Operating Agents, participating experts, Executive Committee Members and our Advisor, Fred Morse, for working hard this year to promote our Programme and its work. I would to also thank Pamela Murphy for her work as the Programme’s Executive Secretary.
Solar Assisted Air Conditioning of Buildings – An Overview

**INTRODUCTION**

Summer air conditioning represents a growing market in building services worldwide in both commercial and residential buildings. The main reasons for the increasing energy demand for summer air-conditioning are increased thermal loads, increased living standards and occupant comfort demands as well as building architectural characteristics and trends, such as an increasing ratio of transparent to opaque surfaces in the building envelope to even the popular glass buildings.

Air conditioning includes both temperature and humidity control of indoor air. Using solar energy for air-conditioning of buildings is a very promising concept. The great advantage of solar is that the seasonal cooling loads coincide with high solar radiation availability. However, systems are complex and the involved technologies, such as thermally driven chillers, are usually not designed to be operated with solar heat.

In 1999, the Solar Heating & Cooling Programme's initiated work to make solar air-conditioning more well-known among professionals, to provide tools for system design, and to improve conditions for the market introduction of solar assisted cooling systems.

This article, based on the work of SHC Task 25, Solar Assisted Air Conditioning of Buildings, provides an overview about the technologies, describes the new developments in the field of thermally driven cooling equipment, shows some key design guidelines and explains today's market situation of solar driven air-conditioning.

**TECHNOLOGIES**

Two major types of systems exist for using solar heat for air-conditioning applications:

- open cycles for the direct treatment (cooling, dehumidification) of air, and
- closed cycles for the production of chilled water.

**Thermally Driven Water Chillers**

The dominating technology of thermally driven chillers is based on absorption. The
The basic physical process consists of at least two chemical components, one serving as the refrigerant and the other as the sorbent. The operation of these systems is well documented (e.g., in ASHRAE, 1988) and therefore is not described here.

Absorption chillers are available on the market in a wide range of capacities and designs for different applications. However, for a long time only a few systems were available in a range below 100 kW of cooling capacity. Recently, a few machines have been developed that provide small cooling capacities in the range of 20 kW and lower (see below). For air conditioning applications, mainly absorption chillers using the sorption pair water-lithium bromide (LiBr) are applied, but also ammonia-water systems are used, primarily, in applications where temperatures below 0°C are needed. The basic construction of single effect machines, in which for each unit mass of refrigerant which evaporates in the evaporator one unit mass of refrigerant has to be desorbed from the refrigerant-sorbent solution in the generator. Under normal operation conditions these machines need temperatures of the driving heat of 80-100°C and achieve a COP-value (fraction of produced cooling per unit of driving heat) of about 0.7.

In addition to single effect machines, chillers using a double-effect cycle are available. Two generators working at different temperatures are operated in series, whereby the condenser heat of the refrigerant desorbed from the first generator is used to heat the second generator. The result is a higher COP in the range of 1.1-1.2. Driving temperatures in the range of 140-160°C are typically required to drive these chillers. This type of system is only available in capacities above 100 kW.

In addition to systems using a liquid sorbent there are machines using solid sorption materials. In these cycles, a quasi-continuous operation requires that at least two compartments, which contain the sorption material, are operated in parallel. The systems available on the market use water as the refrigerant and silica gel as the sorbent. They consist basically of the two sorbent compartments, the evaporator and the condenser. While the sorbent in the first compartment is regenerated using hot water from the external heat source (e.g. the solar collector) the sorbent in the second compartment (adsorber) adsorbs the water vapour coming from the evaporator. This compartment is cooled to achieve continuous adsorption. To date, only two Japanese manufacturers produce adsorption chillers. Under typical operating conditions, with a temperature of the driving heat of about 80°C, these systems achieve a COP of about 0.6.

**FIGURE 1.** COP-curves of sorption chillers and the upper thermodynamic limit (ideal, reversible process).

Figure 1 shows the COP-characteristic of an ideal chiller (thermodynamic maximum) and characteristics of market available sorption chillers as a function of the driving temperature for typical operation conditions.

In recent years, many new developments have been achieved to commercialize water chillers with small cooling capacities. Examples of these are:

- **Water-LiBr absorption chillers**
  - EAW in Westenfeld, Germany (lowest available cooling capacity 15 kW)
  - Phönix Sonnenwärme in Berlin, Germany (10 kW)
  - University de Catalunya in Terrassa, Spain: air-cooled system (10 kW)
  - Rotartica in Spain: air cooled system with rotating absorber/generator (10 kW)

- **Ammonia water systems with mechanical solution pump**
  - Joanneum Research in Graz, Austria (10 kW, operation temperature -20°C ... 10°C)
These products are not yet well established in the market, but promise to open new market segments for solar air conditioning in small commercial buildings (e.g., offices, small hotels etc.) and even residential buildings. A very promising concept is to extend a solar combisystem (solar thermal system for hot water production and heating) to a system that also provides increased comfort during summer by using the solar collector field for air conditioning in summer.

**Open Cycles – Desiccant Cooling Systems**

While thermally driven chillers produce chilled water, which can be supplied to any type of air conditioning equipment, open cooling cycles directly produce conditioned air. Any type of thermally driven open cooling cycle is based on a combination of evaporative cooling with air dehumidification by a desiccant (i.e., a hygroscopic material). Again, either liquid or solid materials can be used. The standard cycle, which is used most often, uses rotating desiccant wheels, equipped with either silica gel or lithium-chloride as sorption material.

Systems using liquid sorption materials have several advantages, such as higher air dehumidification at the same driving temperature and the possibility of high energy storage by means of concentrated hygroscopic solutions, and therefore are close to market introduction.

In the field of open cooling cycles most new developments are focused on the application of liquid sorption due to its inherent advantages. First, it is more to cool using the sorption process. And second, the concentrated solution can be stored and provides high density, loss-free storage. Examples of new developments of open cooling cycles are:

- **Menerga in Mülheim, Germany:** new air handling unit using liquid sorption dehumidifier in combination with a standard indirect evaporative cooler
- **Technion Haifa in Israel:** small system for treatment of fresh air using liquid sorption
- **ZAE Bayern in Munich, Germany:** advanced open cooling system using liquid sorption; concentrated solution used as high energy density storage
- **Fraunhofer ISE in Freiburg, Germany:** high efficient indirectly evaporative cooled sorption dehumidifier using a air-to-air plate heat exchanger coated with zeolite

All developments employing liquid sorption use lithium chloride as sorption material.
SYSTEM DESIGN AND DESIGN GUIDELINES
Which System for Which Application?

Choosing the appropriate technology depends on many factors, such as the climate of the site, the building and its construction, and the user. A basic scheme to guide the decision is shown in Figure 2. A basic assumption is that both the indoor temperature and the humidity are to be controlled.

The starting point always is a calculation of cooling loads based on the design case. Depending on the cooling loads and the desire of the users/owner either a pure air system, a pure water system or a hybrid air/water system are possible for extracting heat and humidity out of the building. The basic technical decision is whether or not the hygienic air change is sufficient to also cover cooling loads. This will typically be the case in rooms/buildings with a high ventilation rate, such as lecture rooms. However, a supply/return air system only makes sense in a rather airtight building otherwise the leakage through the building shell will be too high.

In cases of supply/return air systems, both thermally driven technologies (i.e., desiccant systems) and thermally driven chillers are possible. In all other cases, only thermally driven chillers can be used in order to employ solar thermal energy as the driving energy source. The lowest required temperature level of chilled water is determined by the question whether air dehumidification is realized by conventional technique (i.e., cooling the air below the dew point) or whether air dehumidification is realized by a desiccant process. In the latter case, the temperature of chilled water - if needed at all - can be higher since it has to cover only sensible loads. Using desiccant techniques in extreme climates, for example, climatic...
conditions with high ambient air humidity values, requires special configurations of the desiccant cycle.

**Basic Design Guidelines**

For most thermally driven cooling equipment suitable for use in solar assisted air conditioning systems, the Coefficient of Performance (COP), that is the ratio between the produced cooling effect and the invested heat for this purpose, is noticeably below 1. This means that replacing a conventional air conditioning system, which typically uses an electrically driven vapour-compression chiller, with a solar assisted system does not necessarily imply primary energy savings. Several design restrictions affecting solar assisted air conditioning systems result from this fact:

- If a thermally driven cooling or air conditioning system with a comparatively low COP is used with a fossil-fueled heat source as the back-up, a high solar fraction is necessary in order to achieve significant primary energy savings. An appropriate design of the solar system (i.e., suitable dimensioning of the solar collector and system-integrated energy storage) is necessary for this purpose.

- Systems using thermally driven cooling equipment with a high COP lead to energy savings even at comparatively low solar contributions to the required heat for driving the system.

- In cases where a back-up system is needed either a second heat source, such as a back-up burner, to drive the thermally driven cooling equipment or a conventional chiller may be employed. The latter option may be appropriate if a large overall amount of cooling power is needed. In this case, the solar system mainly serves to reduce electric energy consumption as well as peak electricity loads.

- Solar-thermally autonomous systems that do not use any conventional heat source or back-up on the cold side may also be used. In these cases, energy savings are always achieved, but there is no guarantee of meeting the cooling loads and maintaining the indoor climate within the comfort conditions.

- In any case, the use of the solar collector field should be maximised through the exploitation of the solar heat source to match other loads such as space heating or domestic hot water production. Particularly in climates with high cooling loads during summer, the solar system also can contribute significantly to meet the heating loads during winter.

**REALIZED PLANTS**

Today, there are about 70 systems installed in Europe, with a total solar collector area of about 17,000 m² and a total capacity of about 6 MW chilling power. The majority of these systems use absorption chillers (about 60%), about 28% are desiccant cooling systems (mainly employing rotating desiccant wheels), and about 12% use adsorption chillers. The average specific collector area, defined as the collector area per kilowatt of installed cooling power, differs over a wide range, though the average range is close to 3 kW/m².

Eleven demonstration systems have been monitored and evaluated as part of SHC Task 25. An overview of the demonstra-
tion systems is given in Table 1. In general, experience gained from the installations working under real operating conditions has shown that there are frequent shortcomings in systems’ hydraulic design and controls. Furthermore, the expected energy savings that could be achieved in practice were only after detailed monitoring and subsequent optimization of the controls, and in some cases, the improvement of the hydraulic scheme. Some general monitoring results were:

- Real values about the parasitic consumptions (fans, pumps, cooling tower, water, etc.) were achieved during measurements. In almost all cases, there is an opportunity for improvements. In particular, energy consumption of the cooling tower (pump, fan) is higher than expected. But in all cases, the parasitic consumption of the solar collector system (pumps) was not dominating.
- Most systems worked reliable, however, in each case monitoring was essential in order to identify any shortcomings and problems.
- During daytime in the summer, the chillers were mainly solar driven (sometimes with a delay due to heating up of the collector circuit) in the case of high radiation availability. COP values of 0.6 or above were achieved with sufficient high driving temperatures.
- The hydraulic design of the solar collector system is crucial in order to achieve even flow through the collector field and protect the system against damage during stagnation.

**SUMMARY AND OUTLOOK**

Several thermally driven air conditioning technologies are available in markets, which enables the use of solar thermal energy for this application. Based on current technologies (i.e., market available thermally driven cooling devices and market available solar collectors) solar assisted air conditioning can lead to remarkable primary energy savings if the systems are properly designed. Pre-conditions necessary to achieve primary energy savings are a sufficient collector size and a suitable size of energy storage in the system. As part of SHC Task 25 two tools were produced—a handbook for planners and a computer design tool—to help design systems properly. Compared to the situation 5 years ago, solar cooling has made remarkable progress. Far more systems are in operation today and there are increased experiences regarding their operation. New developments in the area thermally driven cooling technology also is opening far more potential for solar assisted applications. Due to the work in SHC Task 25, a better understanding of a proper system design is now available and the technology is more well-known among professionals, such as manufacturers and planners.

Nevertheless, solar assisted air conditioning technology is just at the beginning of its way to become a standard solution. Far more experiences at the system level are necessary and a broad dissemination of the lessons learned to the target audiences is needed. Best practice solutions also need to be documented in order to serve as references for new projects. And, cost reductions have to be achieved in order to make this technology economically competitive. Here further R&D work is necessary in order to reduce costs on all levels: components, systems and the design process. With increasing energy prices, increasing shortages of existing electricity supply due to air conditioning during summer, and increasing environmental concerns regarding conventional refrigerants solar air conditioning will be a very attractive solution in the future.
The main objective of Task 25 was to improve conditions for the market introduction of solar assisted air conditioning systems in order to promote a reduction of primary energy consumption and electricity peak loads due to air conditioning of buildings. Therefore the project main aims were:

- Definition of the performance criteria for solar assisted cooling systems considering energy, economy and environmental aspects,
- Identification and further development of promising solar assisted cooling technologies,
- Optimization of the integration of solar assisted cooling systems into the building and the HVAC system focusing on an optimized primary energy saving - cost performance, and
- Creation of design tools and design guidelines for planners and HVAC engineers.

The work in Task 25 was carried out in four Subtasks.

**Subtask A: Survey of Solar Assisted Cooling** (Lead country: Mexico)

The objective of Subtask A was to provide a picture of the state-of-the-art of solar assisted cooling. This included the evaluation of projects realized in the past.

**Subtask B: Design Tools and Simulation Programs** (Lead country: Germany)

The objective of Subtask B was to develop design tools and detailed simulation models for system layout, system optimization and development of advanced control strategies of solar assisted air conditioning systems. The main result was an easy-to-handle design tool for solar assisted cooling systems dedicated to planners, manufacturers of HVAC systems and building engineers.

**Subtask C: Technology, Market Aspects and Environmental Benefits**

(Lead country: Netherlands until 2002, Austria until Task end)
The objectives of Subtask C were to provide an overview on the market availability of equipment suitable for solar assisted air conditioning and to support the development and market introduction of new and advanced systems. Design-guidelines for solar assisted air conditioning systems were developed and target groups dealing with solar assisted air conditioning were addressed by workshops and brochures in national languages.

Subtask D: Solar Assisted Cooling Demonstration Projects (Lead country: France)

Several demonstration projects were carried out and evaluated in the framework of Task 25. The objectives were to achieve practical experience with solar assisted cooling in real projects and to make data for the validation of the simulation tools available. The aim was is to study the suitability of the design and control concepts and to achieve reliable results about the overall performance of solar assisted air conditioning in practice.

Duration

The Task was initiated in June 1999 and completed in November 2004.

Participation

The following eleven countries participated in the Task:

Austria France Germany Greece
Israel Italy Japan Mexico
Netherlands Portugal Spain

TASK ACCOMPLISHMENTS

The main objective of Task 25 was to improve conditions for the market introduction of solar assisted cooling systems in order to promote a reduction of primary energy consumption and electricity peak loads due to cooling. If one compares the situation of implementation of solar air conditioning at the beginning and the end of the Task it is obvious that the technology still has a very low impact in terms of installations using solar energy among all installations of centralized air conditioning systems. On the other hand, the interest among key players— from solar collector companies and associations to innovative air conditioning companies, engineers, planners, architects, and building owners—is quite significant and definitely far higher than 5-6 years ago. It is obvious that Task 25 played a major role in increasing the attention now given to solar air conditioning techniques.

Participants of Task 25 initiated several new installations or were involved during their design. Participants also initiated or participated in several new national or international (mainly EU) projects on technology development, design issues or other accompanying measures, such as studies about energy-economic performance or dissemination work.

Results and Products

An overview of Task 25 products is shown in Table 1. These products are described in more detail in the following sections.

TABLE 1. Task 25 products.

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<thead>
<tr>
<th>Subtask</th>
<th>Products/Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Webpage on solar cooling programmes and projects</td>
</tr>
</tbody>
</table>
| B       | Component models
          | Computer design tool SOLAC and accompanying written documentation                 |
| C       | Technical report, "Ongoing research relevant for solar assisted air conditioning systems"
          | Handbook, "Solar Assisted Air Conditioning in Buildings - A Handbook for Planners" (see Figure 1)
          | Brochure, "Using the sun to create comfortable indoor conditions"               |
          | Poster series, (10 bilingual English/German, 3 bilingual English/Italian, 3 bilingual English/Portuguese, 3 bilingual English/Spanish) |
          | Guideline document, "Decision scheme for the selection of the appropriate technology using solar thermal air conditioning" |
          | Presence at 3 trade fairs and accompanying conferences                             |
          | Dissemination workshops, 6 workshops in 4 countries (some workshop still to held) |
          | Market related workshops, 5 workshops in 5 countries                              |
| D       | 11 demonstration projects: monitoring data
          | Technical report on Subtask D projects                                             |
          | Webpage on Subtask D project                                                      |
| Overall | Task 25 webpage with all documents                                                |

Subtask A Survey of Solar Assisted Cooling

Subtask A was finalized in 2001 with the production of webpage of short summary reports on solar cooling activities in the Task’s participating countries and a database of projects/systems installed in the past. The address of the webpage is http://ocuilih.cie.unam.mx/cgi-bin/main_menu.cgi and the password for entering the database is “task25.” The webpage has two partitions:

  Short national reports on activities in the field of solar
Part 2: Review of existing solar assisted cooling systems. Overview on about 25 solar cooling projects that were installed prior to the start of Task 25.

This webpage is linked to the Task 25 Subtask A page, “Database on finished and ongoing solar assisted cooling projects,” on the IEA SHC website (www.iea-shc.org).

Subtask B: Design tools and simulation programs

The main results and products of Subtask B were component models for important solar cooling system components and a computer design tool for complete systems (SOLAC = SOLar Air Conditioning design tool). An overview of the newly developed models of components is given in Table 2. All these models were implemented in the design tool, and some are also available in FORTRAN code for using in TRNSYS. All models are described in the report on the SOLAC design tool.

The main result of Subtask B is the computer design tool. With this tool many different configurations of solar assisted air conditioning systems can be designed based on an annual simulation. The tool calculates the annual energy balance and computes a complete cost break-down including annual cost. The main goal of this tool is to enable architects and planners to carry out feasibility studies in a very straightforward and user-friendly way. The user-interface of the tool is shown in Figure 2. A total of more than 500 different system combinations can be modelled by activating or switching off single components.

### TABLE 2. Overview about component models produced in Task 25.

<table>
<thead>
<tr>
<th>Component</th>
<th>Short Description</th>
<th>Source Open?</th>
<th>FORTRAN Code for TRNSYS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adsorption cooling machine</td>
<td>semi-physical steady-state models of the only two commercially available adsorption chillers (Japan)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Absorption cooling machine</td>
<td>physical steady state models for absorption chillers with mechanic solution pump and bubble pump (based on the Yazaki WFC 10)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>semi-empirical steady state model of an open cycle wet cooling tower</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Solar system</td>
<td>physical steady state collector model and detailed model of stratified hot water tanks; the solar system model also includes the radiation processor</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Desiccant wheel</td>
<td>semi-empirical steady state model of desiccant wheels using manufacturer date from three manufacturers</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Air handling unit</td>
<td>physical steady-state model of the air states in an air handling unit depending on operation mode and component performance</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Room components</td>
<td>physical steady-state models of major room components such as fan-coils and radiative ceilings</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Control strategy</td>
<td>control to decide about the activation of system components depending on actual comfort demands (temperature and humidity control)</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
The main chapters of the program documentation are:

- Introductory Remarks
- Programme Organization
- Programme Functions and Handling of Programme
- Literature
- Appendix 1: Figures, Tables
- Appendix 2: Files (Data)
- Appendix 3: Calculation Models

Subtask C: Technology, Market Aspects and Environmental Benefits

Subtask C was divided into five working packages. Work packages C1 to C3 lasted for the first three years of the Task and C4 to C5 for the last two years of the Task.

C1: Description of Hardware

In this working package, an overview was produced of the hardware components useful for solar assisted air-conditioning. The main components considered were solar collectors, thermally driven chillers, and thermally driven systems for the treatment of air (desiccant systems, open cycles). Results from this work were included in the Handbook.

A second activity was the selection of typical loads and the production of typical load files. In addition, three model buildings (office building, hotel, lecture room) and seven model climates were selected (Tropic: Merida, Mexico; Mediterranean/coastal: Palermo, Italy Athens, Greece; Mediterranean/moderate: Madrid, Spain, Perpignan, France; Central European/moderate: Freiburg, Germany; and Central European/north: Copenhagen, Denmark). Twenty-one load files were produced and then implemented in the design tool of Subtask B and used as example design descriptions in the Handbook.

C2: Development of New Cooling Technologies

In this working package, an overview of relevant R&D activities for solar assisted air conditioning were collected in the participating countries. The technical report, “Ongoing research relevant for solar assisted air conditioning systems” was then produced on the national and international R&D work on new components and systems.

C3: Comparative Description of Solar Assisted Cooling Systems

A work sheet for comparative evaluation of solar assisted air conditioning systems and their relation to energy, economy and environmental benefits was produced and included in the Handbook. Major energy related, economic and energy/economic performance figures were defined and developed to compare different systems, such as the overall annual primary energy saving or the cost of saved primary energy. An example of this approach is presented in the Handbook.

C4: Market Oriented Work

A total of 5 national workshops on both technical and market issues related to solar assisted air conditioning technology have been carried out. An overview is given in Table 3.
TABLE 3. Overview of national workshops on understanding market opportunities and further R&D needs.

<table>
<thead>
<tr>
<th>Place</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>December 16, 2003</td>
</tr>
<tr>
<td>Germany</td>
<td>September 26, 2003</td>
</tr>
<tr>
<td>Italy</td>
<td>March 2, 2003</td>
</tr>
<tr>
<td>France</td>
<td>October 21, 2003</td>
</tr>
<tr>
<td>Spain</td>
<td>October 27, 2003</td>
</tr>
</tbody>
</table>

A guideline document, "Decision scheme for the selection of the appropriate technology using solar thermal air conditioning" was produced. This scheme is designed to guide the decision for a certain technical solution which involves the use of solar thermal energy for air conditioning for a given situation, defined by climatic, building and occupation related factors.

C5: Dissemination and promotion
The following are the results of work package C5:

- A multi-colour brochure which informs interested non-professionals or semi-professionals about solar assisted air conditioning technology and status. The brochure is available as a PDF document that can be downloaded from the Task webpage on the SHC website.
- National workshops for information dissemination that were held in several countries, often in combination with other associations and/or project consortiums (e.g., projects with support from the European Commission).
- Task 25 participated in three trade fairs with posters, information materials and presentations. An overview of these activities is given in Table 4.
- Posters to inform about solar assisted air-conditioning technology and shown on different occasions. The series of posters consists of 10 bilingual posters in English/German, 3 bilingual posters in English/Italian, 3 bilingual posters in English/Portuguese, and 3 bilingual posters in English/Spanish.

Subtask D: Solar Assisted Cooling Demonstration Projects
The goal of Subtask D was to gather experiences about solar air conditioning through practical application in demonstration systems or pilot plants. Eleven demonstration projects in 6 countries were selected and detailed monitoring data collected. Although in many systems it was quite difficult to obtain long periods of reliable measurement data many valuable results were achieved. A list of the Subtask D demonstration projects is given in Table 5.

The main products of Subtask D are:

- A final technical report on Subtask D projects. Each project is described in a standardized way using form sheets. For each project at least a typical operation day is presented and for many systems also performance results for long periods (<1 year or more) are presented. For each project a detailed description of major problems and possible solutions also is outlined. The book summarises with general conclusions and a comparative assessment.
- Subtask D projects are presented on a special webpage, which will become part of the Task 25 webpage on the SHC website soon after completion of the Task.

ACTIVITIES DURING 2004
Important activities of the whole Task in the year 2004 were:

- In early 2004, the Handbook for Planners entitled “Solar Assisted Air-Conditioning in Buildings - A Handbook for Planners” was published. Several hundred copies were ordered.

TABLE 4. Trade Fairs that Task experts participated.

<table>
<thead>
<tr>
<th>Trade fair</th>
<th>Participation activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>AirConTec Trade Fair at Light &amp; Building</td>
<td>10 posters (German/English) on the stand of the Fachinstitut Gebäude-Klima (FGK), a German HVAC association. Desiccant cooling demonstration system with interactive poster; ne-day workshop; 2 presentations at accompanying “Building Performance” conference.</td>
</tr>
<tr>
<td>Trade Fair in Frankfurt, Germany; April 14-17, 2002</td>
<td></td>
</tr>
<tr>
<td>Mostra Convegno Expocomfort, HVAC Trade Fair &amp; Conference in Milano, Italy; March 2-6, 2004</td>
<td>3 posters (Italian/English) at the Italian HVAC association AICCAR stand; market oriented workshop; 2 presentations at an accompanying conference.</td>
</tr>
<tr>
<td>Climarmed conference and ExpoClima Trade Fair, Lisbon/Portugal; April 16-17, 2004</td>
<td>3 posters (Portuguese/English) at the Portuguese HVAC association APIRAC stand; 3 presentations at an accompanying conference.</td>
</tr>
</tbody>
</table>
In many countries participating in the Task, national workshops with professionals were carried out.

Task 25 was presented at two international air conditioning trade fairs and conferences (Milano, Italy and Lisbon, Portugal) with lectures and posters.

A small decision guideline on system selection was developed.

The monitoring of the Subtask D demonstration systems was completed.

A summary of Subtask research activities carried out during 2004 is presented below.

**Subtask A: Survey of Solar Assisted Cooling**
Subtask A work was completed in 2001.

**Subtask B: Design Tools and Simulation Programs**
Work on mathematical models for all key components of solar assisted air conditioning systems was completed. A complete version of the WINDOWS design tool SOLAC with user-friendly interface is available and was tested by Task participants. The tool will be available to the public via Task 25 webpage by early 2005.

**Subtask C: Technology, Market Aspects and Environmental Benefits**
The completion and dissemination of the handbook for planners was a major result of Subtask C. The creation of a tool for decision-making ("decision-tree") in an early phase of a project was finished. This tool guides selection of the most appropriate solar thermal driven cooling technology for a given building. Also a multi-coloured brochure about solar assisted air conditioning was produced.

**Subtask D: Solar assisted cooling demonstration projects**
The demonstration and monitoring of 11 plants was finalized. A technical report which summarizes all the results and documents the projects' history and learning was produced and will be published in early 2005. Demonstration project results will be available on the Task webpage.

### TABLE 5. List of Subtask D demonstration systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Site, Country</th>
<th>System Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verhuelst</td>
<td>Waalwijk, Netherlands</td>
<td>desiccant cooling with flat plate collectors; primary air for an office floor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>adsorption chiller with evacuated tube collectors; air conditioning of a laboratory</td>
</tr>
<tr>
<td>Uni-Klinik</td>
<td>Freiburg, Germany</td>
<td>absorption chillers with flat plate collectors; chilled water network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>absorption chillers with evacuated tube collectors; office cooling</td>
</tr>
<tr>
<td>BMBW</td>
<td>Berlin, Germany</td>
<td>desiccant cooling with solar air collectors; lecture room</td>
</tr>
<tr>
<td>BPA</td>
<td>Berlin, Germany</td>
<td>liquid desiccant system with flat plate collectors; offices</td>
</tr>
<tr>
<td>IHK</td>
<td>Freiburg, Germany</td>
<td>desiccant cooling with evacuated tube collectors; offices and lecture room</td>
</tr>
<tr>
<td>Technion</td>
<td>Haifa, Israel</td>
<td>desiccant cooling with air-cooled PV-facade and solar air collectors; library</td>
</tr>
<tr>
<td>Öko-Zentrum</td>
<td>Hartberg, Austria</td>
<td>absorption cooling with evacuated tube collectors; offices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>absorption cooling with evacuated tube collectors; offices</td>
</tr>
<tr>
<td>Library</td>
<td>Mataro, Spain</td>
<td>desiccant cooling with stationary CPC-collectors; office air-conditioning</td>
</tr>
<tr>
<td>DIREN</td>
<td>Guadeloupe, France</td>
<td>absorption cooling with evacuated tube collectors; offices</td>
</tr>
<tr>
<td>CSTB</td>
<td>Sophia Antipolis, France</td>
<td>absorption cooling with evacuated tube collectors; offices</td>
</tr>
<tr>
<td>INETI</td>
<td>Lisbon, Portugal</td>
<td>desiccant cooling with stationary CPC-collectors; office air-conditioning</td>
</tr>
</tbody>
</table>

### MEETINGS IN 2004

**Trade Fair Participation**
Mostra Convegno Expocomfort, HVAC Conference & Trade Fair, Milano, Italy, March 2004
CLIMAMED Conference & Trade Fair in Lisbon, Portugal, April 2004

**Tenth Expert Meeting**
April 19–20
Lisbon, Portugal

**Eleventh Expert Meeting**
October 7–8
Sophia Antipolis, France

### KEY REPORTS AND PUBLICATIONS

**Conference Papers & Presentations**


Commercially Published Report

Reports Available on the Internet
(www.iea-shc-task25.org)


Multi-colour information brochure to be published in early 2005.
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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 are 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 will focus 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 is 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 the end of 2004. Parts of Subtask B will be continued until the end of 2005.

Activities During 2004

Subtask A: Performance

PROJECT A1: General Energy Performance Methodology

In project A1 general methodologies for performance determination of solar façade components are being investigated. The integral impact of façade components on the energy related performance of buildings can be assessed with hourly simulation in principle, but simulation tools have to be adapted to comply with specific component properties. Apart from simulation on an hourly basis a simplified basis suitable for building energy performance assessment would be favourable, especially when looking to the requirements of national and international performance requirements such as the directive of the European Union on the energy performance of buildings. The four working items for the project in 2004 were:

1) Simplified methods
2) Demonstration case studies
3) Test conditions and performance indicators
4) Documentation and recommendations

Demonstration Case Studies

It was decided to use individual building and component models (e.g., single zone: PARASOL, HELIOS-WINSIM, using the reference office: TRNSYS. Results for PARASOL were sent to the participants, but more explanation and documentation is needed. The HELIOS and TRNSYS simulations are not yet complete.

Results

- Development of cooling methodology. A document in German is available (giving basic equations and definitions). The method is based on EN 832 / prEN13790. A general set of equations is shown, and nomenclature defined in order to allow for:
  - positive and negative transmission heat losses (summer/winter); and
  - inclusion of equipment in equations (losses and gain of heat in building zones)
- Simulation and simplified calculation method for reference office - sensitivity studies. A document in German is available (giving first results and summarising a presentation with comments and headers in English).
- A very simple model for DEF (only for building performance). A very simple model has been developed based on energy balance of an unheated glass space by Werner Platzer.
- Testing conditions for slat devices (MS5). The measurements of the various systems (internal, integrated and external blinds) have been completed in laboratory and outdoors. Suitable models have been defined which allow to investigate some parameters on the testing results such as divergence of the solar simulator. Using the comparison between model and experiment conclusion on favourable testing conditions can be drawn (EMPA: outdoor, ISE: indoor).
- Performance evaluation of solar shading devices. A discussion paper in German exists on a simplified way to characterise facades with shading devices in a summer and winter situation.
- Measurements of solar shadings (integrated+interior) have been completed (EMPA, LTH partly: outdoor, ISE: indoor).
PROJECT A2: Switchable Glazing

Simulation results have been reported. The results show some discrepancies in heating and cooling demand for the north and south offices in the reference office block. Some systematic trends could be noted:

- Some differences in input data were identified.
- Possible differences in how the software handles ventilation, lighting, and occupancy must be sorted out.
- Possible differences in how the software handles angle dependent optical properties must be sorted out.

In the final report, a comment on the energy consumption and embodied energy of switchable glazing will be made.

PROJECT A3: Solar Control Devices
(Hans Simmler, EMPA, CH)

General

Procedures and conditions for performance assessment of solar shading devices and their integration into building envelope assemblies or façade systems (windows, single and double envelope facades) are investigated. Models are further developed that allow for component performance calculations on a detailed and on a simplified level useful for building energy performance assessment. Based on these results, recommendations are developed for shading performance testing and calculation procedures as well as for the integration of suitable shading performance data in an enhanced performance assessment methodology for different building types.

Component measurement, modelling, validation

Various indoor/outdoor measurement data are available from Task 27 "reference" devices and former projects (exterior, integrated, and interior shading in combination with insulating glazing). Lab data, ray-tracing and view-factor calculation methods are basically in good agreement. As seen in outdoor testing non-diffuse albedo components may affect the solar gain substantially in the natural radiation environment. Data on this issue is available also from a real building investigation. Validated CFD modeling of double envelope configurations with integrated shading shows clear limitations of simplified calculation schemes of air flow and heat exchange in mechanically ventilated cavities in particular cases.

Impact on energy performance of buildings

Some simulation results are available (e.g., impact of shading and control strategy on thermal comfort in an office building, and hourly based heating-cooling energy simulation for a single zone with a physical louver type shading model in comparison with a simplified monthly based calculation). Comprehensive sensitivity analysis linking static/dynamic shading properties, control strategies, different building types etc. with major building performance indicators (e.g., TSET, direct / visual transmittance, thermal comfort, cooling-heat-lighting power) could not be undertaken because of a lack of suitable simulation tools and missing personal resources.

Standardisation recommendations

Recommendations regarding calculation of device performance can be made on the basis of existing data (e.g., comparison of ray-tracing and extended view factor methods with a standardised "flat slat" calculation). In the testing field, German work on standardisation of a calorimetric TSET test procedure and standard conditions is available.

Shading in building energy performance assessment methodology

Towards an improved consideration of shading devices in building energy performance assessment, various aspects were discussed and will be included in the final report:

- Proposal(s) for simplified but realistic performance indicators for the glazing-shading system shall be made, both for product characterisation and for use in cooling-heating energy calculation schemes.
- Minimum criteria on thermal and visual comfort shall be given and recommendations on the effectiveness of shading system vs. building type with regard to those criteria shall be made.
- Options on how shading performance data may be used quantitatively in simplified or more detailed energy performance assessment methodologies shall be shown.

Obviously these issues cannot be treated in a comprehensive way, but illustrated by qualitative considerations and demonstrated by examples.

Subtask B: Durability

PROJECT B1: Durability Assessment Methodology

Development

The project was completed in 2003, but the final report, "General Methodology of Accelerated Testing for Assessment of Service Life of Solar Thermal Components" was been submitted to the Secretariat of ISO/TC 59/SC 14 on service life planning. The submission was to be a contribution to the work in revising ISO 15686-1 and ISO 15686–2, and was formally made by the Swedish Standardization Committee SIS TK 209.

The SHC Task 27 input was discussed at the ISO TC59/SC14 meeting held in Toronto in early 2004. SHC Task 27 work is considered a valuable contribution to the SC14 work and will
be considered in the revision of the standards, especially in a forthcoming revision of ISO 15686 - 2.

**PROJECT B3: Durability Assessment of Static Solar Materials**

The general objective of project B3 is the assessment of the durability, reliability and service life of static solar materials. Materials that are studied include anti-reflective (AR) and polymeric glazing materials, reflectors, and solar façade absorbers. Work on these is performed in form of case studies. A large variety of materials representing the different categories of materials of the case studies were selected for investigations and samples of those have been distributed to the participants for testing. Presently both outdoor and indoor tests are performed with the aim of developing durability test procedures following the general methodology of project B1.

**Case Study Reflectors**

Reflectors that are studied include pure Al, Miro4, Miro27KK from Alanod, SO 790 from Alusuisse, aluminum foil protected by clear coat from Skultuna Flexible in Sweden, a thin glass mirror reflector from Naugatuck Glass and a laminated reflector provided by NREL. Anodised aluminum is used as a reference material. In outdoor exposure tests samples are exposed at different test sites with monitoring of the macro- and microclimate data and with optical characterization of exposed samples. Results from the 2-1/2 years of outdoor exposure are available.

Accelerated screening tests have been performed and reported and include high temperature/high humidity/UV tests, condensation-test with additional UV, temperature-tests with additional UV and pollutants-tests. The results of tests are presently analyzed with respect to observed damage and degradation mechanisms.

ISE had performed a preliminary principle component analysis, PCA, of reflectance spectra from ISE using also climatic data measured by ISE. During the preparation of the data-sets it turned out that before a general PCA with data from all labs could be started, all the available data has to be compiled in a way that load profiles could be generated from the outdoor climatic data as well as from the indoor test conditions. The PCA analysis will be used in the comparison of indoor and outdoor test results and would also be used for the purpose of estimating long-term degradation in performance during outdoor use from the results of the most relevant indoor tests. In parallel the conventional way of developing a procedure for service life assessment will be followed, including analysis of degradation mechanisms from spectral data and estimation of service life from the results of the most appropriate tests identified during screening testing.

**Case Study Solar Façade Absorbers**

Solar Façade Absorbers that are studied include coloured sputtered selective solar absorber coatings (INTERPANE), and thickness insensitive spectrally selective paints (NIC). As references also some electrochemically produced black chrome coated stainless steel absorber surfaces are tested. Outdoor exposure tests of solar façade absorb samples continue as an extension of the EU-Joule Sunface project and accelerated screening tests have been performed according to test procedures defined also in the EU Sunface project. Tests that have been performed are corrosion, condensation and high temperature tests. The last two mentioned tests were performed with and without artificial solar irradiation exposure of test samples. Results from outdoor exposure, monitoring of outdoor climatic data and accelerated testing are available in reports on the WIRE. Presently those data are analysed as a base for service life prediction. Additional accelerated tests also have been performed to understand better the degradation of samples observed. Today, most of the interpretation work has been completed and a final report describing the work of the case study will be prepared.

**Case Study Anti-Reflective and Polymeric Glazing Materials**

Anti-reflective materials being studied include sol-gel coated AR glass from Flabeg and from CIEMAT, etched AR glass from Sunarc. Polymeric glazing materials that are studied are a PVC glazing material (Duroglass) and a PC glazing material from Bayer (tests on this material are only performed at SP Swedish National Testing and Research Institute).

Optiwhite is used as reference. In outdoor exposure tests those glazing materials are exposed at different test sites with monitoring of the macro- and microclimate and with optical characterisation. Results from more than two years of exposure are available and reported. Initial risk analysis of potential failure modes has been performed following the general procedure of project B1. A programme for screening testing, involving high temperature/high humidity tests, condensation-tests, high temperature tests, pollutant tests and outgassing tests, has been completed and the results of the tests are now analysed.

Regarding durability analysis of the antireflective glazing materials for use in a solar collector it seems that the two most important degradation mechanisms for loss in the optical performance are soiling and in certain cases also outgassing if an inappropriate insulation materials is chosen.
PROJECT BC: Service Life Prediction Tools for Complete Systems
This project is a continuation of activities in projects B1, C2 and C3, and is aimed at adopting and comparing existing tools for service life prediction of complete solar façade components with the purpose of improving existing durability test methods for qualification. The first objective of the proposed project is to integrate a material oriented approach to service life prediction with a system-oriented approach. The second objective is to critically review the existing qualification test standards for selected solar façade components with respect to durability assessment and also in this analysis make use of existing data on service life on materials and complete solar façade components. The third objective is to improve the existing standards for qualification of durability of selected solar façade components. Presently work has been initiated related to durability of solar collectors and to durability of window/wall interfaces.

Failure modes and risk analysis related to solar collectors
INETI has prepared a draft report presenting the first steps of work in a FMEA/FMECA analysis on a low concentrating CPC solar collector. The product under study has well-known characteristics and results are available from qualification testing of the product as well as from field inspections of solar systems in which the collector has been installed.

The FMEA/FMECA analysis as described in the report, treats function of a component in a very general and qualitative way e.g. energy collection, resistance to environmental stress, etc. whereas in the IFMA, function requirements are quantitatively defined, which means also that failure is quantitatively defined. To consider resistance to environmental stress as a function as often seen in the FMEA/FMECA analysis may be misleading as this is durability and if quantitatively express this is the service life of the considered component/material.

In the FMEA/FMECA analysis you identify different failure modes, failure causes and failure effects. In an IFMA analysis you try to identify damage modes and associated degradation mechanisms that may give rise to a certain failure. The IFMA therefore is aimed mainly at identifying those degradation mechanisms, which may be the limiting for the service life of a certain material/component. The cause of failure in this case is thus the environmental stress factors or degradation factors determining the rate of degradation. The FMEA/FMECA analysis uses failure detection methods as e.g. visual inspection whereas in the material oriented approach degradation indicators are utilised that can be assessed quantitatively. It should however, be emphasised that the main purpose of the FMEA/FMECA analysis is to assess, based on a risk assessment, the importance of different correction actions for avoiding failure. The risk assessment made in the IFMA analysis is aimed to be the stating point for the set up of a program for qualification testing.

Revision of ISO standard proposal for qualification testing of solar absorber surfaces
Mr. Bo Carlsson had prepared a first draft of revised ISO proposal for qualification testing of solar absorber surfaces. The main changes made concern replacing the old method for testing the thermal stability of an absorber surface with a new method partly developed within the framework of SHC Task 27.

WORK PLANNED FOR 2005
Subtask A: Performance
This Subtask ended in 2004 and work in 2005 will focus on the completion of final reports.

Subtask B: Durability
PROJECT B3: Durability Assessment of Static Solar Materials (Bo Carlsson, SP, S)
Case Study Reflectors
The PCA analysis will be used in the comparison of indoor and outdoor test results and would also be used for the purpose of estimating long-term degradation in performance during outdoor use from the results of the most relevant indoor tests. In parallel the conventional way of developing a procedure for service life assessment will be followed, including analysis of degradation mechanisms from spectral data and estimation of service life from the results of the most appropriate tests identified during screening testing.

To obtain additional information about the degradation mechanisms and which accelerated screening tests that best reflect changes in the IR spectrum observed for outdoor exposed samples, SP Swedish National Testing and Research Institute will try to identify the most likely life limiting degradation mechanisms as well as the reaction kinetics.

Case Study Solar Façade Absorbers
Preparation of the final report for this case study will be started.

Case Study Anti-Reflective and Polymeric Glazing Materials
Work will focus on the investigation of the two most important degradation mechanisms for loss in the optical performance: soiling and outgassing of inappropriate insulation materials.
**Project BC: Service Life Prediction Tools for Complete Systems**

*Failure modes and risk analysis related to solar collectors*

Work will continue on the FMEA/FMECA analysis of collectors. An FMEA/FMECA analysis on the MARECO collector also will be performed.

A revised standard proposal to DIN for service-life-testing of absorber coatings will submitted along with a suggestion that the standard proposal shall be developed into an ISO/EN standard in accordance with the Vienna agreement.

*Critical review of existing standards and test methods for materials in solar collectors*

As a start of the activity on critical review of existing standards, the content of Annex B and Annex E of the standard EN 12975-1 (Thermal solar systems and components – Part 1: General requirements) were discussed. Annex B specifies in general terms requirements on the design of the collector and requirements on also the materials/components of the collector. The standard proposal for qualification testing of absorber surfaces is here of great importance. Regarding requirements and qualification test methods for cover plate materials, reflectors and insulation materials information given in the annex can be considerably improved. References to suitable qualification test methods are missing and it was the opinion of the meeting to make use of the outcome of SHC Task 27 to improve the content of the EN standard annex. Suitable test methods for determining the out-gassing properties of insulation materials and the different methods will be evaluated.

*Case study on window/wall interfaces*

Developing suitable test methods for assessing performance of window/wall interfaces will be performed at Fraunhofer ISE by using a double climatic chamber, one with outdoor climatic conditions and the other with indoor climatic conditions. The wall between the two chambers contains a window and thus also a window/wall interface. IR-technique is going to be used to study the effects from thermal bridges but also water penetration in the window/wall interface by the use of a special water sensitive IR-sensor.

**LINKS WITH INDUSTRY**

See the list of Task 27 national contact persons for further details.

**REPORTS PUBLISHED IN 2004**

- Workshop on "Windows in Buildings" with 75 participants was held in May in Lund, Sweden.

**REPORTS PLANNED FOR 2005**

Presentations at “Glass Processing Days” in Tampere, Finland in June. Topics will be: energy efficiency of switchable glazing in office buildings; energy performance of facades and buildings - IEA as support for the European directive?; performance assessment for solar shading devices - state of the art; and results of durability testing of antireflective glazing.

Presentations at the 10th International Conference, “Durability of Building Materials and Components.” Papers will be on: energy performance of switchable glazing – SHC Task 27; lifetime estimation of polymeric glazing materials for solar applications; and study on Durability and Service Lifetime Prediction of some Static Solar Energy Materials

**MEETINGS 2004**

**Ninth Experts Meeting**

May 16-19
Lund, Sweden

**Tenth Experts Meeting**

October 6-7
Zurich, Switzerland

**MEETINGS PLANNED FOR 2005**

**Eleventh Experts Meeting**

April 21-22
Lyon, France

In conjunction with 10th Conference on Durability of Building Materials and Components

**Twelfth Experts Meeting**

October
Date and location TBA
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Sustainable Solar Housing

TASK DESCRIPTION

The goal of this Task is to help participating countries achieve significant market penetration of sustainable solar housing by the year 2010 by providing home builders, institutional real estate investors and banks with:

- A Task web site illustrating built projects, exemplary in design, living quality, low energy demand and environmental impact.
- Brochures on Exemplary Sustainable Solar Housing as a basis for local language publications to communicate the experience from built projects and motivate planners to develop marketable designs.
- A guide: Marketable Sustainable Solar Housing: with guidelines, graphs and tables derived from building monitoring, lab testing and computer modeling.
- A Reference Book systematically compiling the experience of the experts.
- Workshops after the Task conclusion presenting the results of the Task.

Sharing the work of the Task this period are experts from 16 countries:

Austria    Canada    Italy    Norway
Australia   Czech Republic Japan    Sweden
Belgium     Finland    Netherlands Switzerland
Brazil      Germany    New Zealand  UK/Scotland

Duration

The Task was initiated in April 2000 and is planned for completion the end of April 2005.

ACTIVITIES DURING 2004

The emphasis this year was on completing full drafts of publications on marketing, exemplary houses, a reference book for sustainable solar housing in heating dominated climates and a separate reference book for cooling dominated climates.
During the year, the experts actively communicated findings from the Task at both national and international events. Particularly effective were symposia held just following Task meetings. At these symposia, the host city profited from the convergence of so many international experts, and attendance was high with participants coming from the whole country.

Poster from the symposia in Lillehammer, Norway and Aberdeen, UK – the host cities of the Task Expert Meetings in 2004.

**Subtask A: Market Strategies**

A final report on strategies to market sustainable solar housing was completed by T. Haavik of Segel Consultants, Norway with funding from the Norwegian State Housing Bank. The report, Business Opportunities in Sustainable Housing - A Marketing Guide Based on Experiences from 10 Countries, will be published on the SHC Task 28 web site in 2005. Readers are welcome to publish part or all of the report nationally. The Norwegian State Housing Bank plans to produce bound, color copies for distribution in Norway in 2005. An abbreviated version of the report was written by E. Prendergast of the Netherlands and will comprise an important section of the Task Reference Book.

One of six solar houses built on the principals of "Passivhaus" against a river dike in Sliedrecht, the Netherlands by Archidome Holland BV.

**Subtask B: Design Reference Book**

Simulations to establish optimized solutions and show the sensitivity of key parameters have been completed. Results were graphed, interpreted and written into chapters for the cold climate (all building types), temperate climate (single family and row houses). Results for mild climates (e.g., Milan) are still outstanding and expected early in 2005. Work continued on the book, Design of High Performance Housing - A Reference Book.

Learning from the trends of built, very low energy housing

An interesting example of results is from Switzerland where 20 houses achieving extremely low energy performance were cross-compared to look for trends or commonalities in design or construction. It is interesting to note that the orientation of the house was not a significant design feature to achieve low energy levels. Houses not optimally oriented were able to offset this limitation by other energy saving features. On the other hand, compactness seems to be essential. Typically, the single family houses had an A/V ratio of 0.73 and apartment buildings the ratio was 0.49. Because space heating demand is reduced to such low levels, domestic hot water heating becomes relatively important. Not surprisingly, 3/4 of the houses in the sample had solar thermal systems for this end use.

**Subtask C: Demonstration Projects**

In 2004, 22 brochures were posted on the SHC web site bringing the total to 36. To conclude this work, the brochures will be completed and be sorted into two categories: 1) houses with very low energy consumption documented with performance data and 2) good examples with less exceptional energy performance, but with important sustainable features or projects in planning/construction.

Experts and the ExCo are encouraged to use the brochures as a source for local language articles. The two sites to view the projects are:

- **IEA SHC:**
  http://www.iea-shc.org/task28/index.html
  (pulldown menu outcomes)

- **ENOVA:**
  http://www.enova.no/?itemid=2035

In a separate project, led by Harald Rostvik of Norway, an internet site on innovative components or systems for sustainable solar housing was developed which draws upon the demonstration houses of this Subtask. The site is structured after the chapter structure of the technology section of the reference book. An English version of the now operative Norwegian web site is underway (www.enova.no/?itemid=1414)
Subtask D: Demonstration Projects

The report, *Design Insights from the Analysis of 50 Sustainable Solar Houses*, will be published on the SHC web site in 2005. A German language publication drawing on the contents of this book was completed in a bi-national project and published in December 2004. The co-authors are C. Hoffmann, R. Hastings and K. Voss.

An example of publishing Task results in a local language:

Wohnbauten mit geringem Energieverbrauch – 12 Gebäude: Planung, Umsetzung und Realität (Housing with very low energy consumption 12 buildings: planning, implementation and reality).

*Sustainable Housing in Warm Climates*


Kawanda Muna House in Adelaide, Australia. An ecological, sustainable and affordable house which is self-sufficient for water and waste while using minimal electricity. Constructed from recycled materials to minimize embodied energy.

*Environmental Design Briefs*

Working together, the Task’s Subtask C, Subtask D and the Cooling Group, have produced the book, *The Environmental Design Brief* has been completed and a publisher selected. Its objective is to help designers maximize environmental benefits at an affordable house prices. It is structured in three parts:

A Review of Theory, Methods of Briefing, and Case Studies from Task 28/38 (Australia, Italy, Japan, Sweden and the UK). The book will be published in 2005.

**WORK PLANNED FOR 2005**

Work through the end of the Task focuses on the final editing and approval of the promised publications (see Table 1, below).

**LINKS WITH INDUSTRY**

Since the Task addresses the topic of housing the major “industries” include home builders, designers, consultants to designers, mortgage-banks, housing institutions and component manufacturers.

Directly participating in the Task, attending expert meetings and contributing parts of the publications are persons who, themselves are house designers, consultants and bankers. In a few cases the experts’ participation in this Task was co-funded by component manufacturers, providing this link as well.

A direct link with component manufacturers is also assured by the work on the internet directory created by Norway. It describes important features a component should have for application in high performance housing and also provides links to manufacturers or manufacturer association of a sample of components used in the Subtask C demonstration projects.

**REPORTS PUBLISHED IN 2004**

Task results were presented at the following international and national conferences:

- “EuroSun 2004” Congress in Freiburg, Germany
- “Passivhaus Conference” Krems on the Donau, Austria
- Status Seminar, ETH-Z in Switzerland

Articles appeared in the following technical journals:

- Energy and Building
- Erneuerbare Energien
- Architektur und Technik
- Spektrum Gebäude Technik
- Schweizer Baujournal
- Haus Tech
- Bauen für die Zukunft, Baublatt.
MEETINGS IN 2004

Subtask: B Workshop
LCA Workshop
January 29–30
Wallisellen, Switzerland

9th Expert Meeting
April 26–28
Lillehammer, Norway

10th Expert Meeting
October 18–19
Aberdeen, Scotland

Summer Solar Academy
Hosted by ISES with experts, lecture material and tools from Task 28 held in Freiburg, Germany from August 29 - September 4.

REPORTS PLANNED FOR 2005

Business Opportunities in Sustainable Housing - A Marketing Guide Based on Experiences from 10 Countries. Will be available on the SHC web site.


Exemplary Sustainable Solar Houses. A series of brochures that will be available on the SHC web site.

Innovative Components and Systems. Will be available on the SHC web site.

Design Insights from the Analysis of 50 Sustainable Solar Houses. Will be available on the SHC web site.

The Environmental Brief. Will be published by Spon Press Ltd.

PUBLIC SYMPOSIA PLANNED FOR 2005

Material from the Task will be presented by the experts in numerous international conferences in 2005, following are a few examples:

✦ A technical workshop in conjunction with the Joint meetings of the Executive Committees SHC und BCS (Portugal, 15. June 2005).
✦ The 15th Symposium Thermische Solarenergie (Kloster Banz (Germany, 27.-29 May 2005): Plenary lecture: ”A Time-Trip of Solar Architecture through Sustainable Solar Housing of Today”
✦ The 3rd Building Documentation Symposium "Sustainable Solar Housing" (ETH Hönggerberg, September 2005).

MEETINGS PLANNED FOR 2005

Subtask B Workshop
February 14–18
Wallisellen, Switzerland

Final Experts Meeting
April 11–12
Juan les Pins, France
SHC TASK 28/ECBCS ANNEX 38
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Task 29

Solar Crop Drying

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**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. Crop grower and processor industry associations are key partners in dissemination of the results.

After two years of bad harvests, hopes are high for a good harvest this year and the full start-up of the solar heating system installed at this new coffee drying facility near Sona in Panama.
The Core Pith drying system in India has been operating successfully for over one year. The owner is very happy with the performance. This system operates all year which enhances the economic benefits of the system.

**Duration**

The Task was initiated in January 2000 and is planned for completion in May 2006. This includes an extension to allow for monitoring a number of delayed projects.

**ACTIVITIES DURING 2004**

**Panama – Coffee Drying**

The solar system was ready for the late 2002 harvest, however, the harvest was much smaller than anticipated and some operational problems were encountered. The project was further hampered by the sad passing of one of the key members of the client team.

We were eagerly anticipating full operation of the system for the 2003/4 harvest season but once again, there was a poor harvest in the region which the drying facility serves and the owners of the plant decided not to operate the facility at all last year.

It should be noted that this drying facility was constructed in connection with an initiative of Café Duran to introduce coffee growing to an economically depressed lowland region of Panama. This is not an area which is ideal for coffee growing and the company is taking great financial risk to support this initiative. There are many variables associated with the success of the project and the solar system is only one innovation which is being tested.

During the year, the company made great strides in improving key problems in the fields, the most significant of which were the installation of an extensive irrigation system and improvements in enhancing pollination of the coffee plants. The results of these efforts seemed to have paid off as the 2004/5 harvest season looks very promising.

A Task participant visited the site in November to inspect all aspects of the solar system and help the owners take full advantage of its capabilities during this drying season.

We are expecting to have good monitoring data available after the season ends in March 2005.

**Costa Rica – Coffee Drying**

The solar air preheating system installed at the Coopeldos R.L. drying facility near Tilaran in the northern mountains of Costa Rica was finished this year. We had hoped that it would be completed in time to get some operational data during the last harvest season but some unavoidable delays prevented this.

The system was ready to begin operation with the start of the 2004/05 harvest season in late October. By mid November, the plant was operating at full capacity and one of the Task experts visited the facility to check on its performance. A number of recommendations were made to the owners to improve the performance of both the solar preheat system and the furnaces in general. The monitored data collection has begun and this will be analysed in the next few months.

An official opening of the solar system was held in conjunction with the November 2004 meeting of the Executive Committee in San Jose.

**India – Coir Pith Drying**

The solar system continues to operate well and the operators appear to be satisfied. The monitoring system at the Task site has not yet been installed. We continue to wait for the second Task project in India to be completed so that both monitoring systems can be installed in one trip.

Coir Pith is a powder found on the shells of coconuts, which after processing, is widely used as a fertilizer.

**India – Cardamon Drying**

Unfortunately, in spite of good efforts on the part of Task experts and others, it was agreed in November that we would not proceed with this project. It appears that the client
Activities Planned for 2005

The following activities are expected to be completed in 2005:

<table>
<thead>
<tr>
<th>Project</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panama – Coffee Drying</td>
<td>System monitoring for one season competed and results analyzed</td>
</tr>
<tr>
<td>Costa Rica – Coffee Drying</td>
<td>System monitoring for one season competed and results analyzed</td>
</tr>
<tr>
<td>India – Coir Pith Drying</td>
<td>Monitoring system installed System monitored and results analyzed</td>
</tr>
<tr>
<td>India – Tea Drying</td>
<td>Solar system installed System commissioned Monitoring system installed System monitored and results analyzed</td>
</tr>
<tr>
<td>China – Moyu Drying</td>
<td>Facility completed Solar system installed Monitoring system installed System monitored</td>
</tr>
<tr>
<td>Zimbabwe – Tobacco Drying</td>
<td>System report completed</td>
</tr>
</tbody>
</table>

which was supporting it. The reasons cited are difficulties in the corporate structure of the company which is operating the plant, difficulties which are not likely to be resolved in the near future.

**China – Jujube Drying**

At the time of writing this report, the project is effectively dead. A Task expert will be in China before the end of the year and will meet with representatives there to make one last effort to revive it. There has been no progress on the part of the clients for over a year. As far as we know, the pilot plant is still in operation and we may decide to monitor it but this will depend on the upcoming discussions.

**China – Moyu Drying**

This project was proposed by the Chinese government authority as a substitute for the biomass project. The proposal is to install a solar air preheat system on the new workshops of the Lianghe MoYu Taro Products Limited Company. The company is building a 2000 square metre addition to its existing plant in Yunan Province in southern China.

At the time of writing this report, Task experts are working out the technical details for the installation. Moyu is a vegetable grown in China which is very similar to a turnip.

**Zimbabwe – Tobacco Drying**

This project is effectively stalled due to the political situation in Zimbabwe. Two test systems were installed on tobacco drying silos at the facilities of the Tobacco Research Board. The systems were operated for a short period of time before the 2002 election. A principle observation during that time was that there was significant air leakage in the silos which hampered the performance of the solar systems.

The Dutch participant has agreed to prepare a report on the information gained during the time in which the systems were operating.

**United States – Various Projects**

The USA projects are not officially part of the Task, but we do intend to include reference to them in our final report. These projects include:

- Walnut drying in California
- Prune drying in California
Grain drying in New York
Wool drying in New York
Chicken manure drying in New York

LINKS WITH INDUSTRY

The Task continues to maintain excellent links with industry as summarized below:

A seminar was held in conjunction with the Executive Committee meeting in San Jose, Costa Rica. Some Task projects were highlighted at the seminar and a number of inquiries were subsequently made regarding other prospective projects in the area. The president of Conserval Engineering and the manufacturer of Solarwall® attended the seminar and have followed up on some of these leads with Costa Rican representatives.

The completion of the system in Costa Rica should further demonstrate the feasibility for using solar crop drying systems in the region. An official opening was held that attracted press and representatives from the coffee industry in Costa Rica. An official of the government organization which is responsible for the coffee industry was an official speaker at the opening.

A major international coffee industry conference is held each year in Costa Rica. A Solarwall® representative attended the trade show as part of the conference and highlighted the Coopeldos project. Many prospective leads were generated. The owners of the Panamanian coffee processing plant have indicated an interest in building a second facility which will use only dry chaff and solar as the energy sources. This has been temporarily put on hold pending the success of their current plant. The owners also have requested help in staging an official opening of their solar plant much the same as was held in Costa Rica.

The tea project in India involves a major tea producer in the country and could lead to additional projects in that industry.

REPORTS PUBLISHED IN 2004

No official reports were published in 2004.

REPORTS PLANNED FOR 2005

Work will start on the final Task report.

MEETINGS IN 2004

There were no Task expert meetings held in 2004. It is a policy of the Task to hold meetings in countries where there are active projects. The two remaining countries are India and China, but it was decided that it would be more productive to hold these meetings when the projects are completed and operating.

The Canadian team, which is responsible for most of the projects, did meet regularly throughout the year.

MEETINGS PLANNED FOR 2005

At this point, it is not clear if there will be additional meetings at the site locations.

The Canadian expert team will continue to meet as necessary to complete the active projects.
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TASK 31:

Daylighting Buildings in the 21st Century

TASK DESCRIPTION

SHC Task 31 seeks to make daylighting with controls the typical and preferred design solution for lighting buildings in the 21st century. The intent is to integrate the application of daylighting systems, shading and electric light control strategies with human acceptance and to ensure the transfer the outcomes to building design professionals, building owners, and manufacturers.

The Task focuses on commercial buildings, both new and existing, including office, retail and institutional buildings, such as schools. International Energy Agency experts from 14 countries in Europe, North America, Asia, Australia and New Zealand are now collaborating in the Task 31 work programme that emphases communication with building owners, professional designers and industry.

Through discussions with industry and subsequent changes in building design in the application of daylight, it is evident that visual comfort, health and productivity are now building priorities rather than energy savings alone. Consequently Task 31 has made a strong effort to involve industry in their research and development programme.

Symposiums have been held in Tokyo, Japan and in Torino, Italy in conjunction with experts meetings. These have been well attended with much discussion on work programme topics.

To carry out the Task 31 work programme there are four main Subtasks.

- **Subtask A: User Perspectives and Requirements** (Lead Country: Canada)
- **Subtask B: Integration and Optimisation of Daylighting Systems** (Lead Country: USA)
- **Subtask C: Daylighting Design Tools** (Lead Country: Germany)
- **Subtask D: Daylight Performance Tracking Network and Design Support** (Lead Country: France)

These Subtasks were modified in 2004 to comprise only 3-4 project areas per
Subtask due to funding difficulties of some countries. Progress in Subtasks has been made in modelling user response to lighting controls and shading devices (refer Subtask A); in collaborating with building owners, architects and engineers in the integration of daylighting responsive controls and shading devices (refer Subtask B) and in the use of algorithms and plug-ins in software (refer Subtask C).

**Duration**

SHC Task 31 was initiated in September 2001 and will be completed in September 2005.

**ACTIVITIES DURING 2004**

A detailed summary of Subtask research activities is presented below:

**Subtask A: User Perspectives and Requirements**

Web Site:
http://irc.nrc-cnrc.gc.ca/ie/light/daysim/extra/ieatask/

**Literature Survey**

The content of references in the literature survey data base has been summarized as one pagers into a short, concise document. This document together with the reference data base will be a final deliverable.

**Visual Assessment Methods**

- Visual Assessment Publication
  
  The draft of an overview of research on visual comfort has been completed. The draft is being compiled into an IEA SHC report and a submission for the Energy & Buildings special issue on daylighting in 2005.

**User Acceptance Surveys**

User acceptance surveys are now underway in Belgium office buildings (Magalia Bodart, Université Catholique de Louvain) and in several buildings with different daylighting systems in Germany (Alexander Rosemann, Technical University of Berlin). A common survey questionnaire is being currently being discussed and may be set up next year.

**Glare Investigations**

Within the European Ecco-build project Germany (Jan Wienold Fraunhofer-Institute for Solar Energy Systems, Freiburg) and Denmark (Jens Christoffersen, Danish Building and Urban Research Institute) are carrying out glare investigations for an improved glare rating system using a CCD camera. Measurements of illuminance and luminance are being carried at one minute intervals.

Data Processing Used in the Test Room Studies:
1. Conversion raw (pf) pictures to RADIANCE format
2. Consistency check: synchronisation of time and measured data
3. Picture evaluation into indices
4. Compilation of indices-in right format and order
5. Input into SPSS program
6. Correlate data with answers from occupants

Results:

In the comparison of picture calculated illuminance values versus direct measurements there was a correlation of 0.981; and existing glare formulae showed low correlation. The methodology and results will be published in the Special issue of Energy and Buildings.
User Behaviour Modelling

Lightswitch
A report on a user behaviour model called Lightswitch has been drafted as an IEA Report. The model is being integrated into the dynamic thermal simulation program ESP-R (Refer 2). It is intended that the model be integrated into daylight analysis software packages.

Lightswitch Integrated
A new 4-year NRC project is being carried out with Natural Resources Canada, and Public Works and Government Services Canada. The project will also involve students from Laval University (Architecture), McGill (Architecture), and Waterloo (Mechanical Engineering). The objective of this project is the integration of user behavioral models (such as NRC's Lightswitch model) into ESP-R; together with the development of new optical and thermal models for blinds and skylights, and collecting new field study data to validate and expand existing models.

Energy and Buildings Special Publication, 2005
Initiated by Subtask A Leader Christoph Reinhart, Elsevier Science Publishers will be publishing a special Task 31 publication in 2005 on daylighting buildings. Nineteen draft papers are being submitted for review.

Subtask B: Integration and Optimisation of Daylighting Systems

Design Guide
It has been determined that no single guide will serve all countries and all purposes. The purpose of the Design Guide is to develop a shared framework that can be customized by each country and the USA and Canada are working together to produce a "North American" version within SHC Task 31. This "NA" version is to be modified and adapted by other participant countries for motivated non expert users for architectural and engineering firms, lighting designers, consultants and informed owners. The project is to be divided into two segments:

- Version 1: Guidance to establish performance goals
Guidance to establish performance goals will be based on the adaptation of a basic approach from the existing documents “Tips for Daylighting” Daylighting Guide for Canadian Commercial Buildings and SHC Task 21 Daylighting in Buildings publication.

The basic approach in these documents will be expanded by adding:

- Benchmarked performance data (Subtask B)
– Lighting controls (Subtask B)
– User interactions (Subtask A)
– Links to new tools (Subtask C)
– Links to controls case studies

The draft is to be completed by April 2005.

Version 2: Hyperlinked, web–based version of generic guide
The Guide to implement daylighting will include decision points and links to design support tools including case studies. It will be based on Version 1 but will add in–depth reference materials in specific areas of interest to Task 31 participant countries (in their own language) and add links to the country’s specific tools, the country’s specific case studies, codes and standards. The Guide will be tested with real building projects.

The working document for this Guide will be completed by September 2005.

Version 3: Electronic version
Version III will have built in decision support tools and is to be completed after the Task has ended. It will be put on the Task 31 web site which will continue after the Task ends.

Optimized Lighting Controls
Control Design Guide (Nicolas Morel, Switzerland)
The second draft of the Control Design Guide has been prepared. A first discussion concerning the target audience of the document resulted in the document, being focused on rather technical issues of control systems, and aimed at essentially 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); not building designers (architects).

Calibration and Commissioning Guide
(Martin Butcher, Australia)
The first draft of the calibration and commissioning guide has been prepared and is out for comments from participant countries. The pre–commissioning planning and commissioning steps have been drafted. To be completed are the sensor design and placement and the commissioning of automated shades, blinds and other window treatments, and networked systems and systems with complex algorithms. There will be a final manual update.

Auto–adaptive Systems (Alex Rosemann, Germany)
The initial development of an auto adaptive system has been installed by the TU Berlin. A description of this work is to be published in the Special issue of Energy and Buildings.

Field and Laboratory Studies

Collaboration between Building Owners, A/E Teams, and Industry (LBNL)
The collaboration between building owners, A/E teams and industry for the integration of daylighting responsive controls and shading devices has been accomplished in the USA. The New York Times Building Project (LBNL) has been initiated and developed to accelerate product market transformation by the interests of motivated manufacturers and innovative owners being converged. Dynamic façade and dimming controls have been commercially available for some years but the barrier has been cost and reliable performance. By demonstrating and testing in a partially full–scale model of the New York Times Building on an outdoor site, it has been proven that with collaboration, smart integrated shading and electric lighting control systems can work and are cost effective.

Project POLITO (Anna Pellegrino and Valentina Serra, Italy)
The project POLITO which is concerned with monitoring schools has been delayed; therefore it will not be ready on time for the Task 31 report.

Project Light Cube: Laboratory experiments on user response under different illumination levels (Finland)

Descriptions of additional projects are as follows:
– New York Times mockup building–monitoring for different shading and electric lighting control systems
– Research facility in Berkeley (electrochromic glazing)–monitoring user response.

New York Times mockup building
(Eleanor Lee, Steve Selkowitz)
The project proved the performance claims of integrated systems, that the technological solution is reliable and robust and to transform the market from a niche to a commodity product by disproving myths across the entire life–cycle. Through this project, it is now understood how these technologies are specified, installed, commissioned, operated, and maintained before procurement and achieved the following:

– Direct experience with commercially–available systems
– Understanding of performance and user acceptability issues
– Confirmation of the added–value benefits for their employees and building operations
Fine-tuning of the product specs for their unique owner requirements

The logistics of how to implement the installation in the final building

Knowledge of what in-house expertise that would be needed to modify & maintain the systems

The conclusion is that smart controls, Dynamic Glazings and Integrated Lighting controls are key to achieving the desired performance. Correlation studies and a final synthesis will be added to the Field and Laboratory Report.

LBNL Research Facility (Eleanor Lee, Steve Selkowitz)
A user survey is being carried out in the LBNL testing facility to determine user acceptance of electrochromic glazings. Results are to be published in the Special issue of Energy and Buildings. The objective is to determine the physical characteristics and user response to an electrochromic window system. The method consists of the user varying the electric lighting and blinds but not the transmission, and for the user varying the window transmission and the electric lighting regarding the overall desired light level. The results to date show that the reduced luminance levels when the electrochromic windows were dimmed were correlated with lower perceptions of glare and higher levels of satisfaction and that the energy savings depended on the use of appropriate control strategies.

Project Light Cube (Jorma Lethovaara, Liisa Halonen)
Experiments have been carried out in the “Light Cube” to measure the observation ability of the eye. Before every experiment, luminances from the background and from the computer displays were measured with each illuminance level. In the second test series the objective was to study the effect of lighting situations on the measured performance and subjective assessments in different lighting situations. Daylight was used in addition to electric lighting. In the third test series measurements with daylight were carried out to investigate the effects of quantitative and qualitative factors on the lighting on office and screen based tasks. It was found that significant glare (from window luminance) began to be perceived at 2500–4000cd/m² and visual comfort decreased with increasing window luminance being poor with 1000 cd/m². Work is continuing and conclusions will be available in 2005.

Monitoring Protocol for the Assessment of Occupant Usage of Lighting and Shading Controls
An extension of the IEA SHC Task 21 measurement protocol is being carried out for monitoring studies of user behaviour in Task 31 and beyond. The working document will suggest what physical properties should be measured in long term field studies on occupant use of lighting and shading controls and analysis methods. The following is a draft of the contents showing progress:

- Section 1: Introduction—at an advanced stage
- Section 2: Underlying assumptions—at an advanced stage
- Section 3: Experimental techniques—needs further work
- Section 4: Data analysis techniques—needs further work

Subtask C: Daylighting Design Tools

User Interactions
- Tool survey
The questionnaire on user expectations of design tools has been brought into the final format of a working document.

Algorithms and Plug-Ins
- Report on Goniophotometry
A report on goniophotometry is to be available in 2005. A paper on goniophotometry will be submitted for a special issue of Energy and Buildings in 2005.

- Application of Numerical Photometer
A working document on the application of the IBP numerical goniophotometer is to be completed by the end of 2004. There is a graphical user-interface of the numerical goniophotometer, which allows it to automatically generate macros for the virtual test stand set up and diverse samples of daylighting systems. In addition it allows the transformation of the evaluated flux distributions into standard btdf data formats.

The serraglaze system is being investigated in order to have a common and standard dataset for validation of complex fenestration systems (CFS). A sample has been previously measured in the EPFL goniophotometer. The additional calculations with the EPFL and IBP numerical goniophotometers have been performed and the simulated datasets compare well. Some deviations with measured data have been identified. The exact type of serraglaze sample – whether it is embedded into layers of glazing – is to be checked again. The comparison of daylight software simulation results with scale model data have been performed.

- Plug-ins
The final working document on plug-ins for inter-program communication of different pieces of software developed in the scope of this subtask has been compiled.
Database
IBP presented the current status of the system database. The graphical representation is based on the OpenGL based Open-Inventor library. The system is being implemented using MS-Visual C++ based on COM technology allowing to plug it into other applications as well as to plug-in in other applications into the database itself. It provides a simple overview with rather qualitative information on systems and an expert mode, which allows getting a variety of detailed photometric information on the selected daylight system. Due to manufacturer license issues, some datasets have to be included in an anonymous format. The beta version of the database has been completed. The GUI will be translated into English. A report on a standard data set for validation of complex fenestration systems is being drafted.

"All sky Model"
Work on the "all sky model" has been completed including validation work with more Japanese climatic data and the development of calculation models for radiance inclusion. A draft of a final report will be edited for April 2005.

Development of Tools Catalogue
Tools catalogue
All activity on the web tool catalogue had to be stopped due to funding problems.

DELight
The software DELight has been integrated into Energy Plus and the capabilities to model calculate complex fenestration systems have been extended. IBP is to provide a program to filter the btdf. Energy plus is a new building simulation program 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. Quality calculations are not included.

Validation
Report: Test case to assess the accuracy of lighting computer programs is now being drafted (with CIE)
The completed CIE Technical Report of TC 3.33 "Test Cases to Assess the Accuracy of Lighting Computer Programs", has now become an official IEA Task 31 report and the results of the validation work are partially available on the Task 31 webpage. This online site shall be used as a future validation and benchmark site. This project has been completed.

Performance Tracking Network and Design Support Groups
Development of web server structure
A summary document has been drafted for the references in the database.

Database #2
Various fenestration systems have been compared in terms of cost: - the roof light with frame on roof, LED lighting, the sky dome, the vertical window and borrowed light. The cost of these various lighting systems has been compared over 20 year’s amortisation.

Database #3
Noteworthy buildings are being presented in terms of daylighting features that are of interest e.g. sun protection, the filtering of light, the issue of orientation, simplicity of solutions, colour of light, and cost effectiveness or low cost. The examples that have been included are: the Stechlinsee Center, Berlin, Fraunhofer, ISE, Freiburg, EDB Net Office Building, Hamm, Westfalen, ECOTEC, Solar optimized office building, Bremen, Huebner, Production Hall, Kassel-Waldau, University of Applied Science, Bonn-Rhein-Sieg, and International solar center ISZ, Berlin.

LINKS WITH INDUSTRY
Industry Involvement in Experts Meetings
Dr. Karsten Ehling of LichtVision recommended auto-
controlled blinds and electronic controls to give better results in day lit buildings and suggested inputs to Task 31 on work on user interactions and productivity to convince clients to use daylight in buildings.

There was a round table conference with owners/investors and design professionals at the Victoria University of Wellington... Invited participants from New Zealand industry were: Steve Young and Barry Andrews from Connell Wagner, David Ragg and Claire Benge from the Building Industry Authority, Armour Mitchell, Energy & Technical Services Ltd, Don Smith, DTZ New Zealand, James Fenton and Christopher Kelly, Architecture Workshop, Marc Van de Loo, Velux NZ Ltd, and David Cogan, Energy Efficiency and Conservation Authority. The general impression was that practitioners currently lacked guidance of how to implement daylighting in their designs. It is expected, that the Subtask B roadmap will be an important element to train designers. It was also evident from the discussion that only a very small fraction of building stock in NZ was daylighted and that there was the need to demonstrate the value from daylighting buildings, to create versatile tools, and to further develop cost effective technologies. The issue that architects often do not trust their simulation results were raised which makes guidance on the use of prediction tools also necessary.

Matthais Akerman of Amstein and Waltert, Engineering Company in Geneva noted that there were problems in investing in daylighting and shading controls as 30% savings in electricity consumption were required. He summarized in saying that energy savings in Switzerland are not the real incentive for new buildings in Switzerland. User comfort including related costs is the most important.

Industry involvement in the following projects is as listed:

Company
Comments
Provides
Funding
To
Kalwall Corporation
US manufacturer of translucent glazings NRC(Canada)
Structures Unlimited Inc.engineering company NRC(Canada)
BC Hydro Utility Company in British Columbia, Canada NRC
(Canada)Ledalite Canadian Lighting Control Company-in-kind
support to NRC (Canada)Smart Blind Canadian Lighting
Control Company-in-kind support to NRC
(Canada)OSRAM German manufacturer of lamps, electronic
ballasts and building management components TU Berlin
(Germany)Sage Electrochromics, Inc.US manufacturer of
electrochromic windows No direct funding – provides in-kind
support to USViracou US manufacturer of conventional
windows No direct funding – provides in-kind support to
USWausau Window and Wall Systems US manufacturer of
curtain wall systems No direct funding – provides in-kind
support to USMecho Shading Systems US manufacturer of
automated roller shades No direct funding – provides in-kind
support to US Lutron Electronics, Inc. with Vimco
(subsidiary of Lutron) US manufacturer of daylighting controls
and automated roller shades No direct funding – provides in-kind
support to US Siemens Manufacturer of daylighting
control systems No direct funding – provides in-kind support to US
The New York Times Company Building owner No direct
funding – provides in-kind support to USA Advance Electronics
US manufacturer of electronic ballasts No direct funding –
provides in-kind support to US Lite Control US manufacturer of
lighting fixtures No direct funding – provides in-kind support to
US Gensler Interiors US architectural firm No direct funding –
provides in-kind support to US Susan Brady Lighting Design US
lighting designer No direct funding – provides in-kind support to US
Flack + Kurtz US building engineering firm: electrical
engineering No direct funding – provides in-kind support to US
Southern California Edison California Utility No direct fund-
ing – provides in-kind support to US Griesser CH manufacturer
of shading devices No direct funding – provides products for
research in Italy Zumtobel German manufacturer of luminaries
and control systems No direct funding – agreed in providing
products for research in Italy 3F Filippitalian manufacturer of
luminaries No direct funding – agreed in providing products
for research in Italy Velux Foundation roof windows, etc
(Velux)funding an (already finished) EPFL (Switzerland) project
on electrochromic windows Delta Lux AB Daylight equipment
and light Fittings No direct funding – provides products for
research in Sweden

Seminars on Best Practice in Lighting in Australia

The proposed Lighting Innovation Centre - a collaborative
network consisting of the Australian Electrical and Electronic
Manufacturers’ Association, Property Council of Australia,
Institution of Engineers Australia, Royal Australian Institute of
Architects, Illuminating Engineering Society of Australia and
New Zealand, Lighting Council Australia, International
Association of Lighting Designers, Queensland University of
Technology, University of Sydney, Deakin University, Griffith
University, Queensland Government is to provide services for
the research, development, commercialisation, 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 a
demand for more sustainable quality lighting solutions and
technologies. Its initial activity has involved world class best
practices in lighting program delivered via a seminar series in Australian cities, namely, Sydney, Brisbane, Cairns, Darwin, Perth, Adelaide, Hobart and Melbourne.

In summary, the Best Practices in Lighting Seminar program aims to:

- Have the industry, as a whole, producing lighting solutions well above the energy performance levels currently set and other standards.
- Prepare industry for higher performance building energy codes and MEPS in the future and most likely increase their support.
- Produce indoor spaces more suited to the well being of the occupants.
- Deliver added asset value to buildings.
- Reduce in greenhouse gas emissions through energy efficient lighting installations.
- Establish a network of lighting related professions and professionals able to further utilise the services of the Lighting Innovation Centre for ongoing best practice lighting initiatives.

The total seminar attendance was approximately 320. The dominant professions amongst attendees were electrical engineers, facility managers, architects, and lighting designers.

Feedback was gained through attendees completing a short questionnaire. Ratings were obtained for each topic/presenter. (1 = poor to 5 = excellent) The Daylighting series was the highest rated topic. Attendees written comments on a number of positive aspects of the seminar were:

- Having daylighting and electric lighting combined in a seminar.
- Physical explanation of glazing/skylighting performance.
- Introduction of daylighting into design.
- Aspects from pre-design to facility management.
- Implications of poor daylighting considerations.
- Examples of existing buildings.
- Understanding of the importance of facilities management.
- Lack of compartmentalisation of topics.
- Emphasis on communication with FM.
- Sustainability and how it affects design.

An issue raised was a lack knowledge of “rules of thumb” that can be used when arguing the case for daylighting in the early planning (pre-design) meetings. Without basic performance figures for various “families of daylighting strategies” (light shelves, skylights, automated blinds, spectrally selective glazings) arguments for daylighting cannot be critically debated with any chance of success. What software is available and when should it be used in the design process. A current observation was that, in general professionals are not aware of the tools that are available and where in the design process to use them. They will be assisted by Task 31’s roadmap to be published in September 2005.

**REPORTS PUBLISHED IN 2004**


**REPORTS PLANNED FOR 2005**

Subtask A: User Perspectives and Requirements

- Report on the Lightswitch model
- Report on an overview of visual assessment methods
- Working document on glare investigations
- Special Edition of Energy and Buildings

Subtask B: Integration and Optimisation of Daylighting Systems

- Report on Lighting Controls Design Guide
- Report on Calibration and Commissioning Guide
- Report(s) on Field and Laboratory Studies
- Working Document on Extended Monitoring Protocol
- Working Document on Design Guide

Subtask C: Daylighting Design Tools

- Report on Goniophotometry
- Report on the “All Sky Model”
- Report on Test Cases to Assess the Accuracy of Lighting Computer Programs
- Working document on User Expectation of Design Tools
- Working Document on the Application of the IBP Numerical Goniophotometer
- Working Document on Plug-ins for inter-program Communication
Subtask D: Daylight Performance Tracking Network and Design Support

- Working Document on Summary of References
- Working Document on Benefits and Costs of Daylighting
- Working Document on Noteworthy Buildings

MEETINGS FOR 2004

Sixth Experts Meeting
March 22-26
Tokyo, Japan

Seventh Experts Meeting
September 20-24
Torino, Italy

MEETINGS PLANNED FOR 2005

Eighth Experts Meeting
April 18-21
Berkeley, California

Ninth Experts Meeting
September 19-21
Berlin, Germany (with Lux Europa)
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TASK 32:

Advanced Storage Concepts for Solar and Low Energy Buildings

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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 systems based on current compression and absorption heat pumps or new heat pumps based on the storage material itself.

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 for low energy housing. This provides both a framework and a goal to develop new technologies.

To carry out the Task 32 work programme there are four main Subtasks:

- **Subtask A: Evaluation and Dissemination** (Subtask Leader in 2004: 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; Germany to be confirmed)

Duration

The Task was initiated in July 2003 and will be completed in December 2006.
ACTIVITIES DURING 2004

Meetings

In 2004, two meetings gathered 20 experts from 8 countries plus invited persons. The main outcomes were:

- There are new Phase Change Materials that are suited to solar applications and are being tested in combsystems.
- The recent process of microencapsulation of PCM can bring new ideas for storage of solar heat or collecting heat with slurries.
- The improvement in density of storage compared to water will be however hardly higher than a factor 1.5.
- Storage based on sorption principles could bring interesting new solutions, but more for reversible heat and cold heat pumps than for long term storage. Mainly because a low grade heat source is still needed in wintertime, a new option from expert H. Kerkes might however bring a long term storage solution.
- Chemical storage is not deeply investigated in participating countries due to the lack of funding.
- Improvement in classical market standard water stores is still possible in a few directions that are being investigated both theoretically and experimentally.
- A PCM storage can improve the environmental emissions of a classical boiler by limiting the on/off cycling.
- Apart from models for advanced storage techniques, a model for a boiler in transient mode is missing in the TRNSYS library and will have to be developed.

Task Web Site (www.baseconsultants.com/iea32)

A presentation of the scope of the Task, of the participants and some official reports can be found on the site. Links to manufacturers of special storage material for solar and low energy buildings can be found. All internal reports and articles of the Task 32 (about 100 documents) are in a section of the site with restricted access to Task participants.

IEA SHC Task 26 FSC Method

An improvement of the IEA SHC Task 26 FSC method that compares designs of solar installations has been derived theoretically. FSC now covers systems able to produce heat and cold from solar and eventually operating with a long term storage. It will now be validated against detailed simulation results.


This report was originally planned for 2004. Due to external contributions and a more ambitious table of contents than anticipated in 2003, the final publishing date will be April 2005.

New Task Participants

Two new participants joined in 2004, an expert in PCM from Spain and an expert from EDF Research in France.

Newsletter

An electronic newsletter was issued in December 2004.

WORKED PLANNED FOR 2005

Task work will include the simulation of a common reference case (a low energy house placed in four climates), but with different kind of storage alternatives and experimental validation of devices, units or systems depending on each project's status and financial resources. In addition, each team in the Task will proceed with laboratory measurements on their project and development of new storage component model for TRNSYS.

A brochure describing the Task will be produced and distributed.

REPORTS PUBLISHED IN 2004

- Task 32 description of projects in a common reporting format
- Extended FSC method for cooling and or larger storage capacities. Access to this report is restricted to Task members at this time.

REPORTS PLANNED FOR 2005

- Report on Reference Conditions for the Common System

MEETINGS IN 2004

Third Experts Meeting
Combined with ECES Annex 17 meeting
June 8-10
Arvika, Sweden

Fourth Experts Meeting
December 1-3
Graz, Austria
MEETINGS PLANNED FOR 2005

Fifth Experts Meeting
May 18-20
Lleida, Spain

Sixth Experts Meeting
November 23-25
Paris, France
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TASK 33:

Solar Heat for Industrial Processes

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TASK DESCRIPTION

Around 100 million square meters of solar thermal collectors, corresponding to an installed capacity of 70 GWth, were installed by the year 2001 in the OECD countries. 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 going to carry out potential studies, it will investigate the most promising applications and indus-
trial sectors for solar heat, and it 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 to the development of design tools (based on TRNSYS simulations); other planned activities include a software tool for fast feasibility assessment, economic analyses and the design and construction of pilot plants in co-operation with industry.

Scope of the Task

The scope of the Task is on solar thermal technologies for converting 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 solar character of the 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 requiring heat to a temperature level of approximately 250°C.
- 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), and parabolic trough collectors.

To accomplish the objectives of the Task, the Participants are carrying out research and development in the framework of the following four Subtasks:

- **Subtask A: Solar Process Heat Survey and Dissemination of Task Results**
  (Lead Country: Spain)
- **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 among 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."
Duration

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

ACTIVITIES DURING 2004
Subtask A: Solar Process Heat Survey and Dissemination of Task Results

During 2004, a potential study for Austria was completed and the final report is available. The results of the Austrian study and the preliminary results of studies for Spain, Portugal and Italy show that the potential for solar low temperature heat ranges between 3% and 4% of the total heat demand of the industry.

Information also was collected on industrial-process solar heat plants operating world wide. From the 49 reported plants, the majority of the projects are in the food and beverage, textile, transport and chemistry sectors with a large majority in food processes. There are 12 plants in the food industry in fish, meat and olive processing. In the transport sector, most plants are washing installations. And, in the textile industry, most are laundry companies.

The majority of the operating plants are in countries with the most important solar industrial development. Indeed, in Austria, Greece, Spain and the USA, where there have been several plants built during the 1990s, there are more than 67% of the reported plants.

Most of the reported plants supply heat at temperature levels between 60°C and 100°C. Some plants are working at temperatures above 160°C, and there is only one project operating in the intermediate range from 100°C to 160°C. Out of the five plants working at more than 160°C there are two prototype plants and three plants for space heating and cooling with double effect absorption machines (steam production).

Following are several plants for solar process heat in industry are described:

**EL NASR, pharmaceutical chemicals facility in Egypt**
Application: production of process steam for a pharmaceutical company
Location: Cairo, Egypt
Installed capacity: 1330 kW
Collector area: 1900 m²
Collector type: parabolic trough collectors
Heat transfer medium: steam (8 bar)
Operating temperature: 173 ºC
Start of operation: 2004 (January)

**100% renewable energy for production hall and office building in Austria**
Application: heating of a production hall
Location: Bludesch, Austria
Installed capacity: 56 kW
Collector area: 80 m²
Collector type: flat-plate collector
Heat transfer medium: water-glycol
Operating temperature: 20 – 80°C
Storage: 950 litres
Start of operation: 1994

**Solar-powered air conditioning system for a road traffic control centre in Portugal**
Application: space heating and cooling with a single effect lithium-bromide 79 kW absorption cooling machine.
Location: Carcavelos (BRISA), Portugal
Installed capacity: 464 kW
Collector area: 663.3 m²
Collector type: CPC solar collectors
Heat transfer medium: water-glycol
Operating temperature: 80 – 90 ºC
Storage: 20 m³
Start of operation: 2004 (January)

Industry Workshops

In conjunction with the Task 33 Experts meeting in Brussels, Belgium an industry workshop was organized. Eleven representatives from the solar industry, the European Solar Thermal Industry Federation (ESTIF), the European Commission and the EUREC Agency participated. Another industry workshop was
organized in November in conjunction with the ISES Latin America Regional Conference in Guanajuato, Mexico.

Subtask B: Investigation of Industrial Energy Systems

The integration of solar heat into industrial production processes is a challenge to both the process engineer and the solar expert. In applying solar heat, attention must be paid to the temperature levels used in the heat supply system. Another challenge is the time-dependency of the solar energy supply and the heat demand of the processes.

Favorable conditions for solar thermal energy are mean temperatures which are as low as possible, processes that need a constant amount of energy during sunlight hours and high energy prices in the existing system. Besides these parameters, the characteristics of load curves of industrial production processes with the potential to use solar heat have been documented and analyzed with regard to peak hours and stop times and compared with the supply loads of solar thermal systems.

Based on the analyses described above, the most promising processes, applications and industrial sectors for solar heat were identified.

The expansion of existing heat integration models (PINCH technology) to solar energy and the expansion of design tools for solar heating systems to industrial processes were other main topics in 2004. The minimum energy demand of a production system and the maximum potential for heat recovery was analyzed for several industrial processes based on the PINCH theory.

In general, heat integration means the linking of hot and cold streams in a process in a thermodynamically optimal way. The pinch analysis is the most important concept in the field of process integration methodologies. Linhoff et al developed this concept into an industrial technology and the technology was later expanded into new areas such as water pinch and hydrogen pinch.

The fundamental principal behind the pinch concept is the ability to match the individual demand for a commodity with a suitable supply. The suitability of the match depends on the quality required and the quality offered. In the case of energy, the commodity is heat/energy and its quality is measured as temperature.

The pinch analysis is a structured approach to identify energy inefficiencies in industrial processes. The minimum theoretical utility requirement in the processes is calculated for overall energy use as well for specific utilities.

Subtask C: Collectors and Components

An overview of the different medium-temperature collector developments that are being investigated in connection with the Task was prepared. Concise papers which describe the collectors were written. A report based on these papers, which summarizes the information on the current state-of-the-art, will be published.

The new term ‘medium-temperature collectors’ is used to denote collectors with operating temperatures between 80°C and 250°C. The aim is to develop collectors that are suitable for applications in this temperature range within which there has been very limited experience to date. In order to give a short overview, three categories may be introduced (the involved partners are given in brackets):

- Improved flat-plate collectors: double-glazed flat-plate collectors with anti-reflection glazing (ISE, Germany).
- Stationary, low-concentration collectors: stationary CPC type collectors (INETI, Portugal and Solarfocus, Austria).
- Tracked concentrating collectors: small parabolic trough collectors (AEE INTEC and Button Energy, Austria; SOLEL, Israel; DLR and SOLITEM, Germany; CIEMAT, Spain).

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**TABLE 1. The most promising processes, applications and industrial sectors for solar heat**
All collector developments are on-going and will be continued in 2005.

Parabolic trough collector under development at AEE INTEC in Austria.

Double glazed collector with AR-glasses on an outdoor test site at Fraunhofer ISE in Germany.

Two examples of installations using medium-temperature collectors put into operation in 2004 were:

- In mid 2004, a system with a SOLITEM parabolic trough collector was put into operation. The system is installed in Dalaman, Turkey. The medium-temperature collectors supply heat for an absorption cooling machine for a dryer and for the air-conditioning system of a hotel with 700 beds.
- In December 2004, a compact sea-water desalination system was installed by Fraunhofer ISE in Spain (Gran Canaria) in which double-glazed anti-reflective flat plate collectors are used.

Collector Testing

Until the planned round-robin test starts, it makes sense to describe the medium-temperature collector testing and the activities associated with the test and qualification standards for medium-temperature collectors up to 250°C together. In the course of the work on this topic, the general approach is to base the considerations on the existing European collector testing standard EN12975. The aim is to investigate which changes or additional requirements are necessary in order to include the broad spectrum of medium-temperature collectors (improved flat-plate collectors, stationary concentrating collectors, tracked parabolic trough collectors) into the existing EN12975 standard. Most of the necessary points of discussions refer to tracked parabolic trough collectors. Based on further discussion it was decided that the following topics need further clarification:

- definition of the reference area;
- conditions for valid measurement points;
- wind requirements;
- IAM definition as in EN12975; and
- how to deal with end losses.

The present status of the Task work was published in a working document by M. Rommel, which summarizes the topic from the point of view of the low-temperature collector testing experience. The approach from the high-temperature technology point of view is described in a paper by Lüpfert, Hermann, Price, Zarza and Kistner, "Towards standard performance analysis for parabolic trough collector fields", and was presented at the SolarPACES conference in Oaxaca, Mexico in October 2004.

Realistic Medium-Temperature Component Parameters for Simulation Models

In the course of the work carried out so far, the decision was made to restrict the work to components of the solar loop and to concentrate especially on piping losses. First results of investigations on measured piping losses in testing systems installed at the testing facilities at Fraunhofer ISE and at PSA
(Plataforma Solar Almeria) revealed that the measured losses are distinctively higher than those estimated from plain well-insulated pipes. This work will be continued in 2005.

**Subtask D: System Integration and Demonstration**

TRNSYS was agreed upon as the standard simulation tool within Task 33/IV, since most partners are already using it and many solar thermal components are already available. A list of available TRNSYS models applicable for solar process heat systems and their components will be compiled, to form a basis for the identification of further development needs.

A numeric tool to assist inexperienced users in the assessment of potential applications for solar process heat can help to identify promising applications at an early stage without undue engineering analysis effort which presently creates a significant barrier for the market entry of solar process heat technologies. In 2004, a number of programs were screened, but no suitable existing program could be identified. GREE-NIUS, developed by DLR for the assessment of different renewable electricity generation technologies, was found to provide a good basis to be adapted for the purposes of Task 33/IV.

Besides the work on simulation and design tools, seven case studies have been carried out in different industry sectors and countries:

- A textile company and a dairy in Austria. Carried out by AEE INTEC and JOINTS
- Food industry (jam pasteurising), paper industry (cardboard drying), hotel (laundry and hot water preparation), food industry (slaughterhouse), all in Nicaragua. Carried out by AEE INTEC
- Parking service (hot water preheating) in Spain. Carried out by Aiguasol.

These studies indicated interesting potential in the lower temperature range, and provided good experience for the use of interim results and further development of the design guidelines.

**WORK PLANNED FOR 2005**

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

Two reports are planned for 2005. A report on the potential of solar heat for industrial processes and the most promising industrial sectors in the participating countries will be prepared in 2005. And, a second report will focus on state-of-the-art solar collector technology, system concepts and system costs in the participating countries and will review existing and projected solar process heat systems. Another main topic of Subtask A will be the organization of two workshops targeted at industries not directly involved in the Task and potential users of the Task results. These "Industry Workshops" will be organized in conjunction with the Task meetings. One will be organized in Madrid in February 2005 in conjunction with the biennial Spanish industrial trade fair for cogeneration and for HVAC technologies (GENERAl 2005). The second industry workshop will take place in October 2005 in Kassel, Germany.

The publication of the second Industry Newsletter is planned for autumn 2005.

**Subtask B: Investigation of Industrial Energy Systems**

Since the work of Subtask B must be finalized in 2005, the focus of Subtask B will be on the integration of existing heat integration models (PINCH technology) into the design procedure of solar thermal systems. The other two main topics for 2005 will be the evaluation of solar energy in comparison with other ways to save fossil fuels such as energy efficiency, heat pumps and heat integration, and the development of a shortcut "Total Cost Analysis" for solar plants for industrial applications.

**Subtask C: Collectors and Components**

The work on the development of the different medium-temperature collectors will be continued in 2005 and a first cost analysis will be carried out for the different collector technologies involved. It is also planned to include LCA (life cycle analysis) considerations, mainly to compare different medium-temperature collector technologies with each other (flat-plate, vacuum tube, parabolic trough).

A first draft of the recommendations for the performance tests of medium-temperature collectors is planned for 2005. The work on testing methods suitable for medium-temperature collectors will be continued and a round robin test for a medium-temperature collector will be started at the end of 2005.

Concerning the reliability of collectors for industrial processes, a first definition of the performance parameters for new materials in medium-temperature collectors is planned for the end of 2005. This mainly concerns the performance parame-
ters of reflectors, absorbers and insulation materials. Accelerated exposure tests on existing and new materials for medium-temperature collectors will be started.

Other work topics will focus on simulation models and on the investigation of the stagnation behavior of large medium-temperature systems. An interim report on the stagnation behavior of large systems for industrial applications will be prepared.

**Subtask D: System Integration and Demonstration**

According to the work plan, work on the "Design Guidelines" and the adaptation of the GREENIUS program is scheduled to start at a workshop in October 2005.

A main focus in Subtask D will be on a number of case studies in order to initiate first pilot projects. Further activities will be the definition of common monitoring guidelines and the acquisition of funds for the implementation of appropriate equipment in selected installations.

**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 2004**

- Austrian potential study for solar heat for industrial applications
- First Industry Newsletter

- Six papers on solar heat for industrial applications and the development of medium temperature collectors were presented at international conferences in 2004.

**REPORTS PLANNED FOR 2005**

- Report on the potential of solar heat for industrial processes and the most promising industrial sectors
- Report on the state-of-the-art of the solar collector technology, system concepts and system costs in the participating countries
- Report and design guidelines for space heating of production halls
- State of the art report on medium temperature collectors
- Second Industry Newsletter
- Subtask B report

**MEETINGS IN 2004**

**Second Experts Meeting**
March 29-30
Brussels, Belgium

**Third Experts Meeting**
October 3-5
Oaxaca, Mexico

**MEETINGS PLANNED IN 2005**

**Fourth Experts Meeting**
February 23-25
Madrid, Spain

**Fifth Experts Meeting**
October 3-8
Kassel, Germany
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Testing and Validation of Building Energy Simulation Tools

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

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 to certify software used for showing compliance with building energy standards. 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.

Scope

This Task will investigate 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 will 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**

At this time 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 in comparisons 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 and basement constructions
- BESTEST multi-zone heat transfer and shading
- BESTEST airflow, including multi-zone airflow

Within the comparative test cases, analytical verification tests for evaluating basic heat transfer and mathematic processes in building energy analysis tools will be included where possible. Analytical verification tests are comparisons with closed-form analytical solutions or with 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

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.

Regarding buildings with double-skin facades, both Fraunhofer Institute and Aalborg University have internal funding and impressive test facilities to conduct their Double-Skin Buildings research. However, Fraunhofer Institute needs supplemental funding from the ECBCS Executive Committee to take on the extra work of co-leading an IEA project. Extra responsibilities of the project leader include preparing a detailed test specification, supporting modelers in interpreting the specification, collating and reporting on results of experiments and modeling, and preparing an IEA Technical Report.

Administrative support projects are proposed to facilitate availability and distribution of IEA tool evaluation test procedures. These support projects include:
- Develop a single web site that consolidates IEA tool evaluation tests from SHC Task 12 / ECBCS Annex 21, SHC Task 22, and SHC Task 34 / ECBCS Annex 43
- Building Simulation Centre Proposal.

The Building Simulation Centre would be a proposal to create an entity dedicated to the coordination of building simulation software development activities including validation and testing. There is a need for ECBCS to support a leadership role by an appropriate Expert related to further development of the Building Simulation Centre concept within IEA 34/43.

**Duration**

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

**Participation**

During 2004 a total of 35 participants from 25 organizations in 15 countries participated in this Task. The participating countries are:

- Australia
- Czech Republic
- Japan
- Switzerland
- Belgium
- France
- Netherlands*
- United Kingdom
- Canada
- Germany
- Spain
- United States
- Denmark
- Italy
- Sweden
- *Observer
ACTIVITIES DURING 2004

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

Projects

This year was dedicated to completing planning and Subtask formation, and commencing project work. Activities during 2004 consisted of finalizing project plans, development of test specifications, acquiring empirical test data, and doing preliminary simulations of test cases.

Ground Coupled Floor Slab and Basement Comparative Tests (Leader: US/NREL)

NREL (US) revised and distributed the in-depth test specification in early June. 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 test cases compare ground models integrated with whole-building simulations to independent detailed models. There is also an analytical verification test case for checking the independent detailed models, and for checking that such models are applied properly by users. Parametric variations 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).

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; Airflow Tests including Multi-Zone Airflow led by Japan.

Non-Airflow Tests, US/NREL

During May 2004 NREL distributed updates to four in-depth test cases. The objectives of these test cases are to test models' ability to correctly keep account of interzonal heat transfer and to help define a starting point for multi-zone airflow cases. The tests include steady-state 2-zone and 3-zone configurations for comparison of whole-building simulations with simple analytical solutions. Parametric variations enable (versus previously disabled) infrared radiation exchange in both cases. Simulation results were submitted by 9 participants (submitting participant in parenthesis): CODYRUN (U. Reunion Island, France), COMFIE (Ecole des Mines de Paris, France), DOE-2.1E (ACHSL, Spain), ESP-r (U. Strathclyde, UK), HTB2 (Cardiff U., UK), SIMBAD (CSTB, France), TRNSYS-TUD (Dresden U. of Technology, Germany), TRNSYS 15 (Brno Uniervisty Czech Republic, University Liege, Belgium). Results indicated generally good agreement–see Figure 1–with disagreements noted in the results handout that was distributed by NREL to the participants on October 1, 2004.

Airflow Tests including Multi-Zone Airflow, Japan

At the November 2004 Experts' Meeting, INCT (Japan) presented a review of ECBCS Annex 23 work with testing COMIS. Some conclusions of Annex 23 were that large results differences come from modeling errors or typing errors, and including: misunderstandings of the test specification, and unclear definitions of reference heights for: buildings, zones, meteorological stations, and building orientation. One limitation of the Annex 23 work is that input specifications are only applicable to COMIS.

Shading/Daylighting/Load Interaction Empirical Tests

(Leaders: Switzerland, US/Iowa)

This project is divided into two sub-projects: EMPA Shading/Daylighting/Load Interaction led by EMPA; ERS Shading/Daylighting/Load Interaction led by ERS.

EMPA Shading/Daylighting/Load Interaction, Switzerland

During 2004 EMPA (Switzerland) improved their test cell–shown in Figure 2–by mounting an external guard zone over the wall with window for thermal characterization experiments, as suggested by NREL (US). Both overall conductance and internal capacitance experiments have been completed. Effects of thermal bridges (edges, corners, etc) were numerically modeled with TRISCO, with the TRISCO results made...
Testing and Validation

Figures and text content:

**Testing and Validation**

7 sets of simulation results were submitted: HELIOS (EMPA, Switzerland), EnergyPlus (ISU/EMPA, US/Switzerland), DOE-2.1E (ISU/EMPA, US/Switzerland), TRNSYS (TUD, Germany), COMFIE/PLEIADES (EDMP, France), ESP-r (CVUT, Cz. Rep.), SIMBAD (CSTB, France). Conclusions so far: work to date provides enough information to describe the steady-state and transient thermal characteristics of the test cell; all simulations’ zone air temperature predictions are within 3K; additional simulation iterations (e.g., for correction of input errors) may result in better agreement.

**FIGURE 2. EMPA Test Cells in Duebendorf, Switzerland.**

**ERS Shading/Daylighting/Load Interaction, US/Iowa**

The purpose of the work being done at Iowa Energy Resource Station in the United States is to create an empirical validation data set for daylighting controls. Tests were conducted to study the ability to model internal shading by roller shades and drapes for windows at south, east, and west orientations and to study the ability to model external shading by overhangs and fins applied to south windows. Equipment used includes: dimmable ballasts, fabric shades, 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. Simulation results were received from ISU/EMPA, US/Switzerland (EnergyPlus, DOE-2.1E) and TUD, Germany (TRNSYS-TUD). Other interested participants include Australia (eQUEST [DOE-2.2]) and Spain (DOE-2.1E). Example experimental and simulation results for zone electric lighting power are included in Figure 3. 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.

**FIGURE 3. ERS Shading/Daylighting Results, Zone Lighting Power.**

**Systems, Components, and Controls Empirical Tests**

(Leader: Germany/TUD)

During 2004 the project plan was more clearly defined, and preliminary work began. This work is focusing on chilled- and hot-water systems, and is separated into several sub-exercises to focus on single components tabulated below. Experimental and measurement facilities at the Iowa Energy Resource Station will be used for empirical studies.

<table>
<thead>
<tr>
<th>TEST CASE</th>
<th>SIMULATION EXERCISES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chilled water system</strong></td>
<td>Chiller (two scroll compressors)</td>
</tr>
<tr>
<td></td>
<td>Cooling coil (dry / wet regime with condensing water flow rate measurement)</td>
</tr>
<tr>
<td></td>
<td>Hydronic network (pipes, pump, valve)</td>
</tr>
<tr>
<td></td>
<td>Complete system</td>
</tr>
<tr>
<td><strong>Hot water system</strong></td>
<td>Boiler (condensing atmospheric natural gas boiler with variable firing rate)</td>
</tr>
<tr>
<td></td>
<td>Heat exchanger (terminal re-heat)</td>
</tr>
<tr>
<td></td>
<td>Hydronic network (pipes, pump, valve)</td>
</tr>
<tr>
<td></td>
<td>Complete system</td>
</tr>
</tbody>
</table>
Work accomplished during 2004 began with comparative test cases of chiller hydronic systems including tests for models of: chiller, hydronic network (piping, valves, etc.), the air/water heat exchanger (coil), and the entire system. A preliminary comparative test specification was distributed, and simulation results have been obtained for TRNSYS-TUD (TUD, Germany) and EES (U. Liege, Belgium). Air-cooled chiller model results indicate agreement for predictions of supply water temperature, but have disagreements for electric load and COP. Coil model results indicate disagreement if there are latent loads present. Disagreements were found to be caused by an input error in the EES model.

Double-Facade Empirical Tests (Leaders: Denmark/Aalborg University, Germany/Fraunhofer Institute)

During 2004 the following objective was defined for this project: 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:

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

This project is divided into two sub-projects: VERU facility tests led by Fraunhofer Institute for Building Physics (FIBP), Germany; Aalborg University (AAU), Denmark facility tests led by 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, Sweden

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; and modeling issues including airflow, thermal and daylighting simulations. The literature review found roughly 50 case studies. Their future field of interest is to study airflow within the double-skin cavity including proper width and positioning of openings, shading devices (type and position), and other design issues related to integration of double-skin facades.

Double-Skin Buildings Empirical Validation Tests, Aalborg University, Denmark

Aalborg University has experienced a 6-month construction delay on their test facility because of delays in obtaining construction permits. They have a PhD student who began work on the project in October 2004.

Double-Skin Buildings Empirical Validation Tests, FIBP, Germany

At the April 2004 Experts Meeting, the IEA 34/43 participants visited FIBP’s impressive VERU double-skin building test facility. FIBP has developed the facility to validate simplified methods for design of facades, including double facades. The work is in conjunction with the performance-based European Building Performance Directive (EPBD) and DIN V 18599 (calculation of primary energy consumption of non-residential buildings). The project is 60% funded by the German government, and has 24 industry partners providing the remainder of funding. There has been a 1/4-year delay in the project start because the industry collaborators are waiting to give signature approval until after the government gives signature approval. FIBP needs additional funding to collate/analyze IEA 34/43 participants’ simulation results and prepare an IEA report.

Building Simulation Centre Proposal (Leader: Switzerland)

The IEA Building Simulation Centre would have the following objectives:

- To provide a network for knowledge exchange and expertise for the simulation community
- To be a partner for program developers and users to improve building design in terms of energy and comfort
- To enhance the quality of both program software, and program use and application
- To promote and support the application of building simulation programs.

During 2004, the Swiss ECBCS Executive Committee member distributed a survey regarding the Simulation Centre to the IEA 34/43 Experts. Over the summer the results of the survey were compiled by Switzerland. The following survey conclusions were: financial feasibility is considered difficult; strong commitment by program developers is wanted; and the simulation community is a closed group, primarily interested in their own issues. Areas of interest include: user guidelines and checklists; documented test cases, validation procedures and data sets; national user groups, workshops and tutorial
Courses. Switzerland sent the survey to the IBPSA Board and IBPSA’s response will be forwarded to the ECBCS and SHC Executive Committees.

**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 140-2001 incorporates the IEA BESTEST suite of test cases developed under IEA SHC Task 12 and ECBCS Annex 21, which are primarily related to building thermal fabric heat transfer. During 2004, ASHRAE Standard 90.1, which is used for regulating energy efficiency in commercial and non-low-rise residential buildings, had an addendum published that requires use of Standard 140 for testing software used in building energy efficiency assessments. 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, distributes their Standard 140 validation results with their CDs and from their website.

SSPC 140 is the cognizant committee for ANSI/ASHRAE Standard 140. During 2004 ASHRAE published Addendum A to Standard 140-2001 that includes the test cases of HVAC BESTEST Volume 1, which were developed under IEA SHC Task 22 and are related to unitary space cooling mechanical equipment. Currently, ASHRAE is developing a revised version of Standard 140 (ANSI/ASHRAE Standard 140-2004) that fully integrates 140-2001 Addendum a along with the original 140-2001 material into Standard 140. Re-publication of Standard 140-2004 is imminent.

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 (normes).

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.

Communication continues with a number of CEN Technical Committees, including 89, 156, 229, which are also addressing building energy calculation methods and the development building energy analysis tool test cases. Discussions were continued on how CEN and SHC Task 34/ECBCS Annex 43 can cooperate in the development and promulgation of test cases for evaluating building energy analysis tools.

**WORK PLANNED FOR 2005**

**Ground Coupled Floor Slab and Basement Comparative Tests** (Leader: US/NREL)

Continue development of BESTEST-GC User’s Manual for ground-coupled heat transfer test cases. Conduct field trials of user’s manual using hourly (or sub-hourly) building energy simulation software programs. Perform iterations of field trials for both user’s manual and simulation software improvements. Test sequence will include:

- Steady state 3D analytical solution for rectangular slab.
- Harmonic 3D analytical solution for rectangular slab and basement, if a useable closed-form analytical solution is readily available.
- Basic heat ground heat transfer tests that cannot be solved analytically.
Solar interaction with building mass and the ground using internal gains as solar surrogate.

**Multi-Zone Heat Transfer Comparative Tests**

**Non-Airflow Test Cases** (Leader: US/NREL)

Additional non-airflow test cases were discussed at the October 2004 Experts Meeting. Based on the conclusions of that discussion, NREL plans to make the following revisions to the test specification during 2005:

- For all cases require use of constant combined surface heat transfer coefficients as if IR exchange were on, using typical values of ASHRAE, CIBSE, or CEN, etc. This will make it easier to focus on calculation issues specific to multi-zone modeling (e.g. accounting, convergence, etc.).
- Move forward with development of additional test cases beginning with a 3-zone configuration. Incrementally include (from initial steady state with conditions around the building clearly defined): varying internal gains and weather, transmitted solar radiation, internal window, shading of neighboring zone by external fin and by the building itself.

**Airflow Test Cases** (Leader: Japan)

For the near-future Japan will continue work on development of airflow test cases. Initial airflow cases will emphasize natural ventilation, buoyancy, wind driven, and temperature-difference driven flows; further cases will include interaction of airflow and thermal models. These cases will be based on the geometry of the multi-zone non-airflow cases, be simpler (potentially more diagnostic) than the previous ECBCS Annex 23 cases, and allow use of zonal, nodal, and CFD models. Later work would address the coupling of CFD airflow simulation tools.

**Both Non-Airflow and Airflow Test Cases**

- Conduct field trials 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.
- Use the results from the simulations to improve the test specifications and the simulation programs. Conduct two iterations of this process during 2005; additional iterations are expected over the course of the project.

**Shading/Daylighting/Load Interaction Empirical Tests**

(Leaders: Switzerland, US/Iowa)

- Conduct series of EMPA test cell experiments
  - Glazing only
  - Glazing with external shading screen (textile)
  - Glazing with internal shading screen (textile)
  - Glazing with external Venetian blinds (painted aluminum slats)
  - Glazing with internal mini-blinds
  - Window (Glazing with frame)
  - ERS experiments: Window with/without mini-blinds/external shading device

- Year 1
  - June, September, and December Tests
  - Internal shading with screens (A) and muslin fabric (B)
  - Dimmable lighting controls in both sets of test rooms
  - South room’s external shading with fins and overhang

- Begin Preparation for Year 2 Tests
  - Dimmable lighting controls in both sets of test rooms and automatic control of variable position mini-blinds

**Systems, Components, and Controls Empirical Tests**

(Leader: Germany/TUD)

Empirical data is planned to be collected for the chilled-water system test cases at ERS during summer 2005. Future work will include developing the tests for a hot-water system; it may be possible to perform hot-water system experiments at ERS during Winter 2004/2005. Other modelers interested in this work are Spain (EnergyPlus, DOE-2.1E), U. Brno (TRNSYS), and CVUT (ESP-r).

**Double-Facade Empirical Tests**

(Leaders: Denmark/Aalborg University, Germany/Fraunhofer Institute)

During 2005 Aalborg University (Denmark) is planning to prepare a preliminary report containing: specification of the test building, proposal for a test suite, preliminary calculations of building performance, and analysis of simulation results based on their preliminary test specification. They also plan to complete construction of their double-skin building test facility, and begin acquiring data for the empirical test cases.

Fraunhofer Institute will continue to seek supplemental funding from the ECBCS Executive Committee to take on the extra work of co-leading an IEA project. Extra responsibilities of the project leader include preparing a detailed test specification, supporting modelers in interpreting the specification, collating and reporting on results of experiments and modeling, and
preparing an IEA Technical Report. Sweden may be able to lead the VERU work if they can get funding. If a project leader for the FIBP work is found, prospective simulation modelers include: Arup, Australia; Lund U., Sweden; Brno U., Cz. Rep.; CVUT, Cz. Rep.; and maybe TUD, Germany.

**Virtual Centre Proposal (Leader: Switzerland)**

Switzerland will make a recommendation to ECBCS regarding further proposal development, and ECBCS and SHC will decide next steps. There will be no activity on this within IEA 34/43 unless it is funded and led by Switzerland (EMPA).

**Other**

Continue work outside the scope of this task related to bringing evaluation test procedures developed under IEA research into codes and standards (normes). Currently, two test procedures developed within SHC Task 22 are planned to be adapted for inclusion with ANSI/ASHRAE Standard 140:

- HVAC BESTEST Fuel-Fired Furnace Tests, by Natural Resources Canada (NRCan), Canada

During summer 2004 NRCan began the process of adapting the Fuel-Fired Furnace test cases for inclusion into Standard 140; they are currently addressing comments by members of the cognizant ASHRAE standards project committee (SSPC 140). NREL is planning to begin Standard-140 adaptation of HVAC BESTEST Volume 2 during summer 2005.

**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 (normes) 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, 5 papers by software developers related to use of tool evaluation test procedures created under SHC Task 22 were presented at the conference of the International Building Performance Simulation Association, September 2003 in Eindhoven, Netherlands. Three papers by software developers related to using simulation software test procedures developed during SHC Task 22 and SHC/ECBCS Task 12/Annex 21 were presented at the Canadian ESim conference (June 2004 in Vancouver, Canada). Additional papers by software developers related to use of SHC Task 22 and SHC/ECBCS Task 12/Annex 21 test procedures have appeared regularly at ASHRAE meetings in the US.

The results of IEA tool evaluation research are used as prenormative information in the establishment of national and international building energy codes and standards, as discussed above under codes and standards activities. The IEA BESTEST cases were used by ASHRAE to develop a standard method of test for evaluating building energy analysis programs. 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, 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.

**REPORTS PUBLISHED IN 2004**

Only internal documents.

**REPORTS PLANNED FOR 2005**

As this is the second full year for project work, no final reports are planned. Draft reports covering the following topics are expected:

- Revised ground coupled heat transfer test specification and results
- Revised multi-zone non-airflow comparative test specification and results
- Airflow comparative test specification and results
- Revised Shading/Daylighting/Load Interaction: test procedures, test cell specifications, empirical data sets, and simulation results
- Double-Skin Buildings: test procedures, test cell specifications, empirical data sets, and simulation results
MEETINGS IN 2004

Second Experts Meeting/Final Planning Meeting
April 5-7
Grosse-Hartpenning (Munich), Germany

Third Experts Meeting
October 6-8
Prague, Czech Republic

MEETINGS PLANNED FOR 2005

Fourth Experts Meeting
April 6-8
Aalborg, Denmark

Fifth Experts Meeting
September – November
Dates and location to be determined
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