

# IEA Solar Heating & Cooling Programme

## 1998 Annual Report

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

**Morse Associates, Inc.**  
1808 Corcoran Street, N.W.  
Washington, DC 20009

IEA/SHC/AR98



# Table of Contents

4	Implementing Agreement
5	Chairman's Report
9	Feature Article: The Coming of Age of Solar Air Systems
17	Task 19: Solar Air Systems
20	Task 20: Solar Energy in Building Renovation
26	Task 21: Daylight in Buildings
33	Task 22: Building Energy Analysis Tools
38	Task 23: Optimization of Solar Energy Use in Large Buildings
43	Task 24: Solar Procurement
48	Working Group: Materials in Solar Thermal Collectors
51	Address List

# The Solar Heating & Cooling Implementing Agreement

## Background

The International Energy Agency (IEA) was founded in November 1974 as an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD) to carry out a comprehensive program of energy cooperation among its 24 member countries. The European Commission also participates in the work of the IEA.

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 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 photovoltaic technologies, primarily for building applications. The overall Programme is monitored by an Executive Committee consisting of one representative from each of the 18 member countries and the European Commission.

The members are:

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

## Current Tasks

A total of twenty-four 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 1998 and their respective Operating Agents are:

Task 19  
**Solar Air Systems**  
*Switzerland*

Task 20  
**Solar Energy in Building Renovation**  
*Sweden*

Task 21  
**Daylight in Buildings**  
*Denmark*

Task 22  
**Building Energy Analysis Tools**  
*United States*

Task 23  
**Optimization of Solar Energy Use in Large Buildings**  
*Norway*

Task 24  
**Solar Procurement**  
*Sweden*

# Chairman's Report: Highlights of 1998

Mr. Lex Bosselaar  
Executive Committee Chairman  
*NOVEM, b.v., The Netherlands*

## OVERVIEW

In 1998, the Executive Committee of the Solar Heating and Cooling (SHC) Programme initiated many new activities. Two new Tasks were proposed. The first, Task 27, will focus on the performance assessment of solar building envelop components. It came to being as the result of a workshop in Washington, DC sponsored by the U.S. Department of Energy. At this workshop, experts from different fields discussed follow-on work to SHC Task 18 on advanced glazing. The second Task, Task 28, will focus on solar sustainable buildings. This continues to be an important issue and was discussed in-depth at a workshop in North Carolina, USA. This workshop was proposed by the SHC Programme and funded by the U.S. Department of Energy. It was attended by representatives from all the IEA building-related Implementing Agreements and an excellent selection of experts from R&D fields, business and government. The market orientation of the new Tasks and workshops are consistent with our new Strategic Plan for 1999-2004. The results of the ongoing Tasks are summarized below.

Participation in the Implementing Agreement continued to be strong with all 18 Member countries and the European Commission actively participating in the Programme. Two new countries, Brazil and Mexico, have expressed interest in joining the Programme. A representative from each country attended the fall Executive Committee meeting and presented an interesting overview of

the solar heating and cooling activities in their country. With the active participation of Programme members, I look forward to expanding our work in 1999 and demonstrating the tremendous potential of solar heating and cooling technologies.

Every year our annual report includes a feature article on some aspect of solar technologies for buildings. This year's article deals with solar air heating systems, a technology that is the subject of SHC Task 19. Thanks to Mr. Robert Hastings of Forschungsstelle Solararchitektur, for preparing this interesting write-up on this century old technology.

## HIGHLIGHTS OF THE TASKS AND WORKING GROUP

Notable achievements of the Programme's work during 1998 are presented below. The details of these and many other accomplishments are covered in the individual Task summaries later in this report.

### Task 19: Solar Air Systems

As this Task concluded its last full year, two documents were published: *Solar Air Systems: Exemplary Buildings*, a report on 33 case study buildings, and *Solar Air Systems: A Catalog of Products and Components*, a catalogue and guide for selecting components. In addition, a beta version PC-based tool to help planners predict the performance of a solar air system was completed.

### Task 20: Solar Energy in Building Renovation

This Task concluded in December 1998 and therefore many of its

results will be reported on in 1999. The successful application of solar technologies in existing buildings have been detailed in two new publications. *Solar Renovation Demonstration Projects* documents the experiences of designing 16 demonstration projects were documented in the report. *Catalogue of Concepts*, to be published in 1999, describes 14 concepts, and depending on the level of industry involvement some of these concepts may lead to improved products. In addition, 14 demonstration projects have been evaluated on their construction and commissioning phases as well as operational results, and the results from this study also will be published in 1999.

#### **Task 21: Daylight in Buildings**

This year was dedicated to the testing of daylighting systems and daylight responsive lighting control systems in test rooms. Experts also completed monitoring 16 case study buildings, 4 of which were also monitored for post occupancy evaluation.

#### **Task 22: Building Energy Analysis Tools**

Work on the collection and documentation of existing engineering models and the creation of a models library continued in 1998. KTH of Sweden started the operation and maintenance of Simulation Model Network (SIMONE) on its Internet site. This web site allows users to review available engineering models documented in the neutral model format.

#### **Task 23: Optimization of Solar Energy Use in Large Buildings**

Work on the development of design process guidelines suitable for the early stages of design got underway. Task experts determined that the computer program Energy 10 will be developed into a Task 23 tool and work has begun to incorporate climate data, default values and solar technologies relevant to this Task.

#### **Task 24: Solar Procurement**

This Task began in April of 1998 and the work to date has focused on the development of national buyer groups. Meetings were held with interested buyers of active solar water heating systems in various countries and study tours arranged.

#### **Working Group on Materials in Solar Thermal Collectors**

In response to the growing interest in evacuated collectors, a new project was started by Working Group experts to develop durability test methods according to the appropriate degradation factors and load profiles, taking into account the geometry of the absorbers and the application of CPC-mirrors, in particular.

#### **NEW PROJECTS**

##### **Task 25: Solar Assisted Air Conditioning of Buildings**

This Task is scheduled to begin in June 1999. The Task objective is 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 air conditioning and thereby to develop an environmentally friendly way of air conditioning of buildings. A market and technology

overview was conducted during the Task Definition Phase which showed pay-back times for solar cooling technologies similar to or better than those of solar water heaters.

#### **Task 26: Solar Combisystems**

This Task got underway in December 1998. The Task's main objectives are to contribute to the introduction of more solar combisystems (active solar space and water heating systems) on the market through the improvement in their design and performance and to develop test methods for these types of systems.

#### **Working Group on Advanced Solar Low-Energy Dwellings**

The objective of this working group is to collect and analyze the monitoring results of buildings from SHC Task 13, Advanced Solar Low Energy Buildings. Experts will compare predicted and measured performances, taking the climate and actual weather conditions into account, and analyze the reasons for deviation.

The Task Definition Phase for two new Tasks began in 1998:

#### **Task 27: Performance Assessment of Solar Building Envelope Components**

The goal of this new work is to determine accurately the solar and thermal performance of materials and components, such as advanced glazing, for use in more energy efficient sustainable buildings and systems and to promote increased confidence in the use of these products by developing appropriate methods for assessment of durability, reliability and environmental impact.

### Task 28: Solar Sustainable Houses

The objective of this proposed work is to research, design, build, monitor and promote solar sustainable houses. These houses will use, for example, no conventional heating plant, materials with minimum gray energy/emissions, and have superior comfort (heat, light and cooling).

### MANAGEMENT ACTIONS

#### Strategic Plan 1999-2004

The Programme's present Strategic Plan ended in 1998 and a new plan has been adopted by the SHC Executive Committee. The new mission statement for the Programme for the period of 1999-2004 is:

**To Facilitate an environmentally sustainable future through the greater use of solar design and technologies.**

#### Programme and Policy Actions

The IEA Governing Board approved the Implementing Agreement for another 5-year period, until December 2003.

*Information Marketing Group* began its review of the Programme's information dissemination activities and will make recommendations on a regular basis to improve how and what information is distributed as well as coordinate dissemination efforts with appropriate IEA programmes and non-IEA programmes. One of the first initiatives has been to improve the availability of Programme reports by making all reports available from the SHC Executive Secretary.

*The Software Policy Committee* contin-

ued to work on strengthening and ensuring that the policy is adhered to as new Tasks begin to develop software.

*The Executive Committee* agreed to invite 10 new countries to join the Implementing Agreement, of these 10 selected countries, 6 countries received a formal invitation to join. The other designated countries will be contacted in 1999.

#### Internet Site

The Solar Heating and Cooling Programme's world wide web site was completely revamped in 1998. The new graphical presentation and updated information on Programme Tasks, publications, the *Solar Update* newsletter, past annual reports, contact information and Internet links to other organizations should make visiting the site even more rewarding. The address for the site is <<http://www.iea-shc.org>>.

#### Future Workshops

In 1998, the Executive Committee agreed to organize several workshops for 1999.

#### Advanced Solar Thermal Storage Workshop

The workshop is planned to be held October in Germany. The objectives of the workshop are a state-of-the-art review and identification of new R&D activities. The topics will include new materials and concepts (e.g., microcapsulated PCM in building materials, sorption storage), technologies and applications (e.g., passive solar, climitization), and pilot and demonstration plants.

#### Hybrid Thermal/PV Solar Systems Workshop

The workshop is planned for the summer/spring in the Netherlands. The workshop objective is to establish the state-of-the-art in the area of hybrid PV systems. The focus of this work is to be confined to hybrid systems which combine into one collector a PV and thermal collector.

#### Solar Cities

In conjunction with the International Solar Energy Society's (ISES) work in this area, the SHC will organize a workshop in the spring in Switzerland to discuss possible Programme activities.

#### COORDINATION WITH OTHER IEA IMPLEMENTING WORKING PARTIES/AGREEMENTS AND NON-IEA ORGANIZATIONS

The Chairman of the *Renewable Energy Working Party*, Mr. Godfrey Bevan, attended the May Executive Committee meeting to present the Working Party's draft Strategic Plan. His participation in the meeting also provided an opportunity for the Executive Committee to discuss long term solar R&D needs and the development of a coordinated communication plan. And, the SHC Chairman attended the September Working Party meeting.

To follow up on the May 1997 workshop, initiated by the Solar Heating and Cooling Programme, which concluded that the IEA should undertake, within its current building-related Programmes, collaborative work in the area of sustainable (resource-efficient) buildings. A follow-up workshop was held in

September 1998 in Hilton Head, North Carolina, USA. Representatives from the *seven IEA building-related Programmes* as well as the *End Use and Renewable Energy Working Parties* oversaw the planning of this workshop. The objective of the workshop was to identify high priority collaborative work required to facilitate the transition of the building sectors of the IEA Member countries towards more sustainable buildings.

*The IEA Energy Conservation in Buildings and Community Systems Programme* and this Programme agreed to include in our respective Strategic Plans a section on collaboration with the other Programme. This agreement and the continued collaborative work in SHC Task 21/BCS Annex 29 demonstrate the importance of coordination between IEA Programmes.

The Operating Agent, Mr. Tony Schoen, from the *IEA Photovoltaic Power Systems Programme's* Task on PV in the Built Environment presented an overview of activities at the May Executive Committee meeting. The Operating Agent thanked the SHC Programme for being the "founding father" of this work to enhance the architectural quality and economic viability of PV systems in the built environment. Cooperation with the PVPS Programme is continuing with the joint organization of the workshop on hybrid thermal PV collectors.

The President of the *International Solar Energy Society*, Dr. David Mills attended the May Executive Committee meeting to discuss possi-

ble areas of cooperation between the two Programmes. Soon after this meeting, discussions were underway on developing a SHC Task on Solar Cities that would be coordinated with the activities of ISES in this area.

#### **PUBLICATIONS**

The following IEA Solar Heating and Cooling reports and related publications were printed in 1998 and are not listed elsewhere in this annual report.

*Solar Energy Activities in IEA Countries – 1997*

P. Murphy Kunz, editor, February 1998.

#### **ACKNOWLEDGMENTS**

At the May 1998 Executive Committee meeting, I was honored to be elected as the new Chairman. Doug McClenahan (Canada) was re-elected as Vice-Chairman and Conny Rolén (Sweden) was elected as the second Vice-Chairman. On behalf of the Committee, I wish to thank the previous Chairman, André De Herde (Belgium), who led the Executive Committee so capably for two years.

In closing, I would like to thank the Executive Committee members, Operating Agents, Working Group Leader and our Advisor, Fred Morse, for their work on behalf of the Programme. I would especially like to thank our Executive Secretary, Pamela Murphy Kunz, for her help as it has been crucial for me as the new Chairman. Their contribution is essential to the Programme's continued success.



# The Coming of Age of Solar Air Systems

S. Robert Hastings  
Solararchitektur  
Switzerland

## WHAT IS A SOLAR AIR SYSTEM?

A solar air system like its relative, a solar water system, consists of a collector, distribution systems, possibly storage and controls. The principle difference is that air instead of water transports the heat from the absorber in the collector to the point of use. This use may be heating a space, ventilation air or even water (via an air to water heat-exchanger). Figure 1 illustrates schematically how an unglazed solar air system can be configured to heat ventilation air.

Using air instead of water has distinct advantages, but also some limitations:

### The Advantages

- No anti-freeze chemicals are needed, and corrosion problems and leaks are not serious compared to water systems.
- Solar air collectors respond quickly as soon as the sun shines.
- They are a natural fit to mechanically ventilated buildings, and mechanical ventilation is becoming increasingly common, not only in commercial and institutional buildings, but also in very low energy residences.
- Several energy end uses can be served (i.e., space heating, ventilation air heating, water heating).
- The collector creates a warm envelope for the building even during periods of low solar radiation.
- Conventional building elements can serve as system components thereby saving costs

### The Limitations

- Potential noise problems must be

“designed out” (avoid too high air velocities).

- Electric consumption for fans must be kept minimal (stream-line air channels).
- Heat transported by air needs large volumes (plan ahead for duct passages)
- Dust and moisture in open systems must be managed (filters and condensate traps).

### The Uses

Solar air systems should be considered for any building which requires either space heating or heating of ventilation air. Common applications are space heating for residences and heating ventilation air for industrial buildings, schools, sports halls and small office buildings. It is sensible to use the hot air in summer to heat domestic hot water, thereby making use of the system all year.

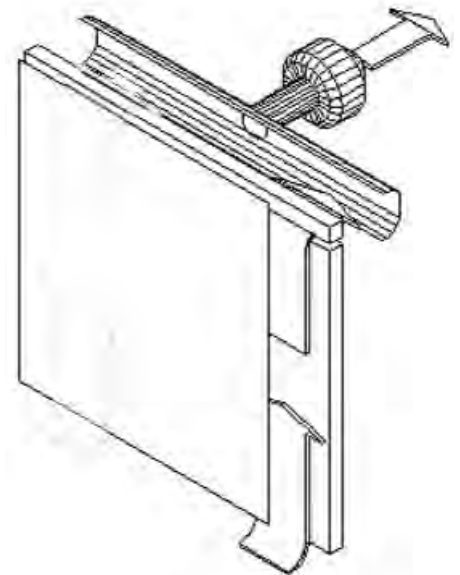


Figure 1: An open solar air system for ventilation air heating.

## THE HISTORY OF THE SOLAR AIR SYSTEM<sup>1</sup>

The first patented solar air heater was designed and built by S. Morse in 1881 and subsequently marketed in the United States in 1890.

Mounted on a south-facing wall, it was essentially a vertical sheet of black metal or slate supported inside a shallow, glass-covered box. Air was warmed by the black, sun-heated surface and would rise by natural convection. Cold air entered an opening in the lower end of the panel, and heated air exited from the top directly into the room behind. Several such solar air heaters were installed in homes in Massachusetts, but there was no further development or commercialization.

Responding to the threat of energy shortages during World War II an American, K. W. Miller, designed and patented a solar air collector with a rockbed, and G. Löff constructed and tested it. Heat storage in a rock-filled bin was evaluated in a full-size laboratory installation. In 1945 a small house in Colorado was retrofitted with a solar air heating system comprised of a collector, heat storage rock bin, air ducts and automatic controls. The system covered approximately a third of the heating demand.

One problem with solar air heating is the volume required for heat storage. M. Telkes addressed this problem in 1946 by using phase change material to store heat in a fraction of the volume of rocks. In a demonstration house in Massachusetts, heat from

vertical south-facing collectors was delivered to interior chambers containing several tons of Glaubers salt ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ) in 20-liter containers. The salt melted at temperatures of 40 to 50°C. By circulating room air past the containers, the salt would solidify, releasing its heat. However, full reversible melting and re-crystallizing of the salt apparently did not occur resulting in decreased heat storage capacity and the termination of the experiment. Today, phase change materials contain additives to overcome this problem. A second vertical solar air heater and phase-change storage system was built in the 1950s in a New Jersey building which served as a solar testing laboratory. The 60-m<sup>2</sup> collector was provided with a double glass covers, and air was circulated behind the metal absorber plate.

Approximately 10 m<sup>3</sup> of phase-change heat storage was provided. After limited testing, the system was dismantled.

A simple type of solar air heater was built into the roof of an Arizona school building in 1948. Designed by Arthur Brown, the collector was site-fabricated. Almost horizontal aluminum roof channels were covered with additional blackened aluminum sheets to form rectangular passages through which air was warmed 5 to 10 K and

forced into the building. Daytime heating was thus provided during sunny weather. In this mild climate, over 80 percent of the heating requirements were met by solar energy. Although a low-cost system, it was not adopted elsewhere.

A considerably different concept was developed for a rural house in Arizona by Donovan and Bliss. The site-built collector consisted of a single glass cover and a loosely woven black fabric absorber through which air was circulated. The heated air was conducted to a rock bin for heat storage and/or to the house rooms. Although the concept worked, the durability of the collector construction proved inadequate.

Interest in solar space heating languished in the 1950s until 1957



Figure 2: A Colorado residence with a solar air system still in service 40 years after installation.

when a U.S. window glass manufacturer funded the design, construction and evaluation of a solar air heating system for a new Colorado resi-

<sup>1</sup> Based on a contribution from George Löff, Professor Emeritus, Colorado State University.

dence. The concept also was applied in another one-story Colorado home with a flat roof, two rows of collectors at 45 degree angle, and surrounded by 1m parapet wall (see Figure 2). This home demonstrates the practicality and durability of solar air heating applications. Today, more than 40 years later, the system is still faithfully providing heat for the residence. This home has provided extensive performance data, and numerous improvements have been identified over the years.

Performance measurements after 17 years of operation showed that the heat output had declined by about one-fourth; after cleaning and refurbishing the system it once again delivered solar heat at its original level.

The continuous decline of energy prices resulted in the dormancy of solar systems until the first oil crisis in 1973. Motivated by rising fuel prices and threats of shortages, energy department officials launched research and incentive programs to revive solar energy technologies. Many projects were established, primarily in universities and their affiliated laboratories, ranging from fundamental research to full-scale system development and testing.

Almost simultaneously, commercialization began, with old and new manufacturing companies developing, producing and selling complete solar air systems. Commercial activities depended heavily on government cost sharing, usually 40 percent of the purchase price. A leader in solar space heating research and

development was Colorado State University, where four residential prototypes were provided with well-engineered active solar heating systems, two of liquid and two of the air type. In addition to government funding, heating equipment manufacturers supported extensive development work between 1973 and 1985. In subsequent years using solar air systems for cooling was also investigated. Solar heated air supplied energy to absorption refrigeration or desiccant refrigeration equipment.

installation. The number of solar collectors receiving certification by the Solar Rating and Certification Corporation increased from 12 to 34 in 1983.

In 1985, the federal subsidies that had been in place since 1975 were discontinued. In some states, tax credits and subsidies continued, but the effect of the termination of the federal subsidy was sudden and severe. Most manufacturers of solar heating systems of all types closed

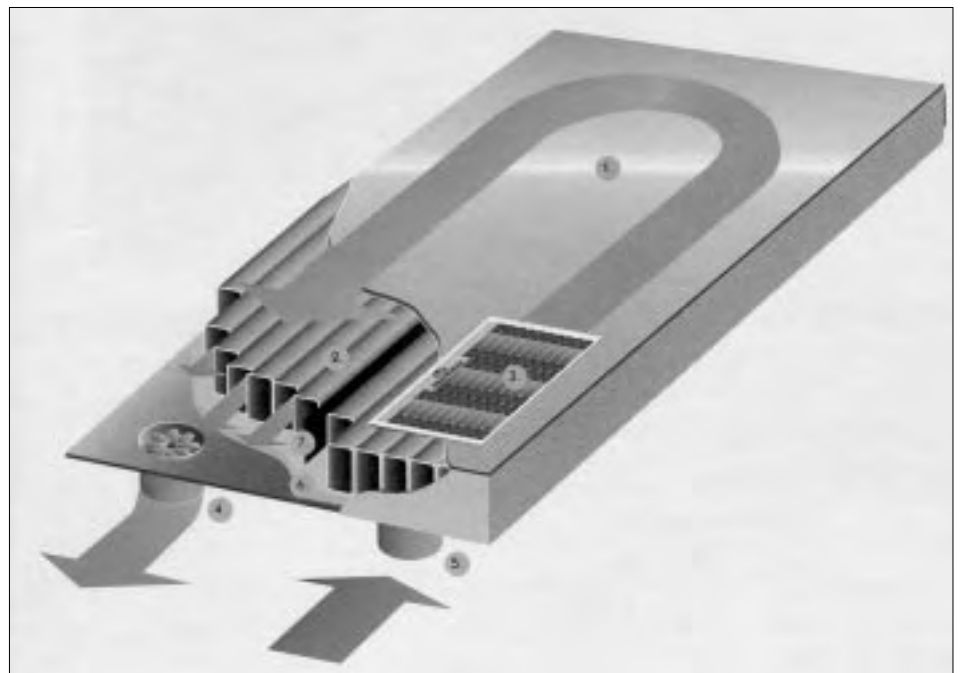


Figure 3: A high performance manufactured collector.

During this era, commercial manufacturing and sales of solar air heating systems grew in parallel with the solar water heating manufacturing industry. A 1980 survey of solar air collector manufacturers identified 85 U.S. companies offering solar collectors for commercial and residential use. Many of the companies also provided complete systems and

down their business in 1986 as the system price to the customer was too high without the 40 percent government subsidy. Manufacturing of all types of solar space heating systems virtually ceased. R&D on solar air systems also came to a halt. In contrast to the period from 1977 to 1985 when over 20 technical papers on the subject were pub-

lished in the journal, Solar Energy, only three papers were published in the following three years.

In the 1980s a slow renaissance occurred, this time in Europe. Without the backing of research institutions, architects began building solar air heated residences and schools. The buildings demonstrated very good performance and interest in this alternative way of transporting and storing solar heat grew. Systems ranged from roof or wall integrated constructions to window collectors (where a venetian blind serves as the absorber in the air gap of a double window). While many systems were architect-planned and site built, at the same time the solar air collector industry was reborn, targeting market niches. In the 1990s inexpensive package collectors came on the market to temper and dehumidify vacation cottages from Sweden to Spain. Mass produced, high performance collectors found applications in sports halls, commercial buildings and residences (see Figure 3). The greatest success was achieved with unglazed collectors to heat ventilation air for large buildings. These proved cost effective even given the falling fossil fuel prices.

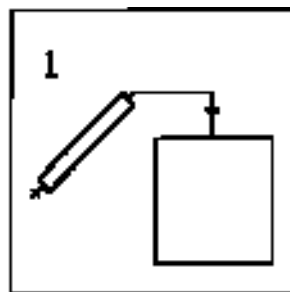
The promise of this technology gained the attention of governments as they became increasingly motivated by environmental concerns. In response to this renewed interest, the Solar Heating and Cooling Programme of the International Energy Agency (IEA SHC) agreed to hold a series of small workshops in the Netherlands, Denmark, Switzerland. The workshops provid-

ed a forum for exchanging experience and looking for ways to improve system performance. It became apparent that solar air systems showed great promise, but if the technology were to develop, help was needed. Neither the architects designing individual systems, nor the fledgling manufacturers could finance the effort needed, and so the IEA SHC Programme obtained funding from nine countries to carry out work in this area from 1992-1998. SHC Task 19 was born!

### SYSTEM VARIATIONS

Experts in SHC Task 19 began by reviewing over 30 buildings with solar air systems constructed in the 1990s. Six basic types of systems could be identified according to how heat is transported from the collector to the storage or heated space and then back. In an "open loop" collector, heated air circulates directly into and back from the occupied space. In a "closed loop" collector, air circulates through closed channels never entering the occupied space. Following is a brief description of the six system types.

#### Type 1: Solar heating of ventilation air

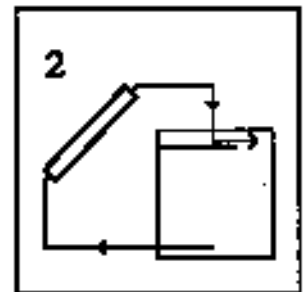


Outside air is circulated through an

unglazed or glazed collector directly into the space to be ventilated and heated. This system can achieve very high efficiencies because cool air is supplied to the collector. In the summer the collector can be vented to the outside. Appropriate applications range from keeping unoccupied vacation cottages from becoming damp and musty to ventilating large industry halls.

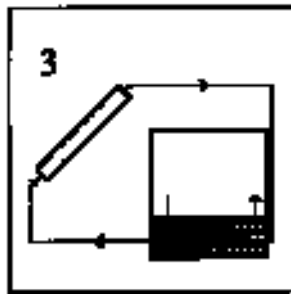
#### System Type 2: Collector/room/collector

This, so called Bara Costantini



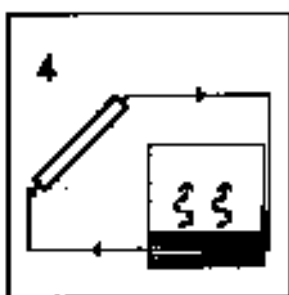
System, named after its Italian inventor, circulates room air into the collector where it is heated, rises and returns via a thermal storage ceiling back into the room, all by natural convection. The storage radiates heat after sunset. In summer the collector can be vented at the top to the outside extracting room air, which can then be replaced by cooler air from an earth register or open north-facing windows. This system has been used mostly in apartment buildings.

**Type 3: Collector-heated air circulated through cavity in the building envelop**



By circulating collector warmed air through a hollow building envelope, heat losses through the building envelope can be drastically reduced. Because the air returning to the collector from the building envelope is relatively cool, the collectors can be inexpensively constructed and still operate at a high efficiency. In summer, collector heated air can be re-directed to an air to water heat exchanger for heating domestic hot water. The system is especially appropriate for retrofitting poorly insulated apartment buildings

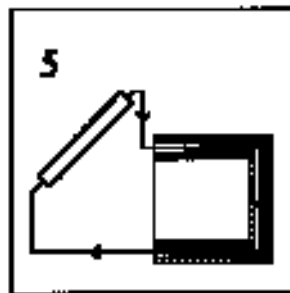
**Type 4: Closed loop collector/ storage and radiant discharge to building spaces**



In this most classical solar air system type, collector warmed air is circulated through channels in a massive floor (hypocaust) or wall (muro-caust) which then radiate the heat into the room four to six hours later.

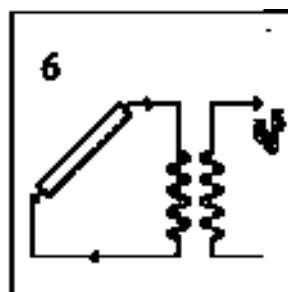
This system has the advantage of large radiating surfaces and hence provides good comfort levels. Fan-forced circulation provides the best overall system efficiency and output. Applications include all building types which can profit from low-temperature radiant heating.

**Type 5: Open single loop collector to the building spaces**



This system is similar to Type 4, but separate channels in the storage allow a controlled active discharge. Since the storage can be well insulated, it can be charged to higher temperatures and not discharged until heat is desired. Furthermore, the storage can be located remotely from the rooms to be heated. Relatively few buildings exist with this system because of its high costs.

**Type 6: Collector-heated air transferred to water via an air/water heat exchanger**



In this system, hot air from the collector passes over an air to water

heat exchanger. Because the air to water heat exchanger is typically located within the heated building envelope, antifreeze can be omitted if a frost damper is provided to prevent night back-drafts. The hot water can then be circulated to conventional radiators, radiant floors or walls, or to a domestic hot water tank. Applications where the heat must be transported over a distance are particularly suited for this system. Retrofit of existing buildings is simplified since the heating distribution systems often use water.

**APPLICATIONS**

**Single Family Houses**

Single family houses have profited the most from solar experiments. Their large ratio of exterior surface to building volume and resulting large heating demand make them a good candidate for solar air systems. In addition to flat plate collectors, sun spaces may also serve as the collector. It is critical to keep costs of fans, ducting and controls minimal. Storage is beneficial since daytime heating demand may be met with direct gains through windows. Use of the system to heat domestic hot water in the summer should always be considered, since year round use improves the payback.

**Apartment Buildings**

Apartment buildings pose an interesting combination of attributes. Their internal gains, comfort requirements and occupancy profiles are those of a residence, but their geometry is more like an office building (multi-storeyed with a small surface to volume ratio). Because heating

demand per m<sup>2</sup> floor area is often less than single family residences, a solar air system can cover a greater percentage of the heating load. And, because the building residents typically are not the owners, the operation and maintenance of a solar air system must be easy and trouble-free with a payback. A secondary function, such as being a barrier to street noise, may be of greater importance than the solar function. When kitchens and baths are mechanically exhausted, glazed balconies can admit sun-tempered air to replace the exhausted air. For mechanically ventilated corridors, lobbies and common rooms, unglazed solar air collector have proven very effective. Figure 4 shows a System Type 2 integrated in an Italian apartment building.



Figure 4: The Marostica apartments in Italy with a Type 2 solar air system.

### Schools

Schools and kindergartens are ideal buildings to demonstrate solar energy use. Modern schools often include large atria or glazed spaces for breaks and activities. Such glazed spaces also can serve as solar air

collectors when warm air is extracted from the top of the space. Window collectors can extract heat from the glazing of such south-facing classrooms, which hardly need heat when the sun shines, and deliver it to north-facing rooms. Unglazed open systems can heat ambient fresh air then deliver it to the classroom. Since heating ventilation air can account for 30 - 60 percent of the total heating demand these solar savings can be great. Combining a solar air system with a hypocaust has several benefits. In the case of kindergartens, a hypocaust can provide a warm floor, which is important since children play on the floor.

### Sports Halls

Sports halls typically have large external facades with few windows (to avoid glare for the players) and large flat roofs. These extensive opaque exterior surfaces are ideal for building-integrated solar air systems. Since occupants

playing a sport are active, hall temperatures can be low, normally about 15°C, than space with sedentary activity. Low space temperatures lead to very good solar air collector efficiencies. As important as space heating is the requirement for strong ventilation to exhaust humidity and odors. Solar heated air can serve to heat ventilation air. Finally, by means



Figure 5: The 10,000 m<sup>2</sup> unglazed solar wall of Bombardier's Canadair aircraft factory in Valcourt, Canada.

of air to water heat exchangers, solar air systems also can supply hot water for showers.

### Industry Halls

One of the best uses of a solar application is for air heating industrial buildings. These buildings often are one-story and have an expansive, often poorly insulated roof, and therefore require substantial space heating needs. In addition, heating ventilation air often consumes as much energy as the space heating demand. Solar air heaters to supply tempered fresh air have proven cost-effective even with today's low energy prices. When heating outside air, any temperature rise is useful, so the system can even function on a cloudy day (A temperature rise of 5 to 20 K over ambient is normally sufficient). If the fresh air is heated above room temperature, the solar system also contributes to space heating. Paybacks in the range of 2 - 5 years are possible from these systems. Figure 5 shows the 10,000 m<sup>2</sup> unglazed solar wall of Bombardier's Canadair aircraft factory in Valcourt,

Canada. The white part at the top of the wall is the air plenum that collects the air from the wall below. (It is white for aesthetic reasons).

### Office Buildings

In low energy office buildings more than 60 percent of the heating requirement is to temper ventilation air. But, with the increasing use of daylight and energy saving office equipment, space heating demand is again becoming an issue, particularly in peripheral offices. Ideally, a solar air system for offices should include thermal storage, since peak heating loads typically occur in the early morning. One solution is the "double facades." Here, an additional glass facade is erected 30 - 80 cm outside the insulated facade. The resulting gap can serve multiple functions: In winter the sun-tempered air in the gap can preheat fresh air for the ventilation. In summer the gap can perform as a solar chimney with the warm air rising to be exhausted out slits at the top. Shading and glare protection devices can be located in this gap, where they are protected from wind and the elements. Finally, the second glass skin can be a valuable sound barrier to street noise.

### TESTING SOLAR AIR COLLECTORS

To assess the performance of collectors an accredited in-situ test procedure and standardized test stand procedures were developed in Task 19. Measuring the performance of solar air collectors is more complex than solar water collectors due to the fact that it is difficult to measure air temperatures and air-mass flows. In addition, complex issues such as

leakage, the air flow pattern inside the collector and a low heat transfer from the absorber must be addressed.

### In-Situ Test Procedure

To assess the performance of installed collectors an on-site test procedure was developed in 1996 at the Solar Energy Laboratory in Denmark. The efficiency of solar air collectors is, unlike liquid solar collectors, strongly influenced by the actual mass flow rate inside the collector. It is therefore difficult to extrapolate the performance of larger solar air collector areas from tests of small modules on a test stand.

Air flow is determined using either a calibrated pressure drop or a calibrated air speed. Temperatures are read from calibrated temperature sensors located in a well defined grid in the ducts. Efficiency is determined through identification of the parameters within the standard efficiency equation for solar collectors.

The method was applied and tested on two large Danish solar air collectors – Havrevangen and Tjørnegade. The accuracy of the efficiency equations for the two solar air collectors using the above mentioned procedure was within the accuracy range of liquid solar collectors. Based on these experiences, guidelines have been developed to determine the meteorological conditions necessary to carry out the measurements. This method was accredited in the spring of 1998 at the Danish Technological Institute.

### Laboratory Test Procedure

Seven manufacturers from seven countries accepted the offer to have their products tested within the work of Task 19 at the Arsenal in Vienna, Austria. The products tested included well established products as well as promising prototypes. Some manufacturers used the investigations for a technical refurbishment of their products. These tests provided valuable experience on how such testing should be carried out. Figure 6 shows the Viennese test facility and Hubert Fechner, who is responsible for the testing.

For accuracy two fans, one at the inlet and one at the outlet were used. The fans had to be adjusted such, that the mean static pressure at the collector is equal atmospheric pressure. Only in this manner can the leakage rate be minimized.

The air flow pattern inside the collector is a critical issue. Working with only one collector, the air flow pattern near the inlet and outlet is often misrepresented. Air entering or exiting the collector by a duct results in the immediate areas of the absorber not being "washed" well by the air stream. The duct connections to the collector must therefore be constructed to achieve a constant air pattern from inlet to outlet. For these tests a special box was built to assure an even air-flow.

While measuring the inlet temperature is simple, measuring the outlet temperature is difficult. The air exits the collector in multiple layers of different temperatures, and therefore a

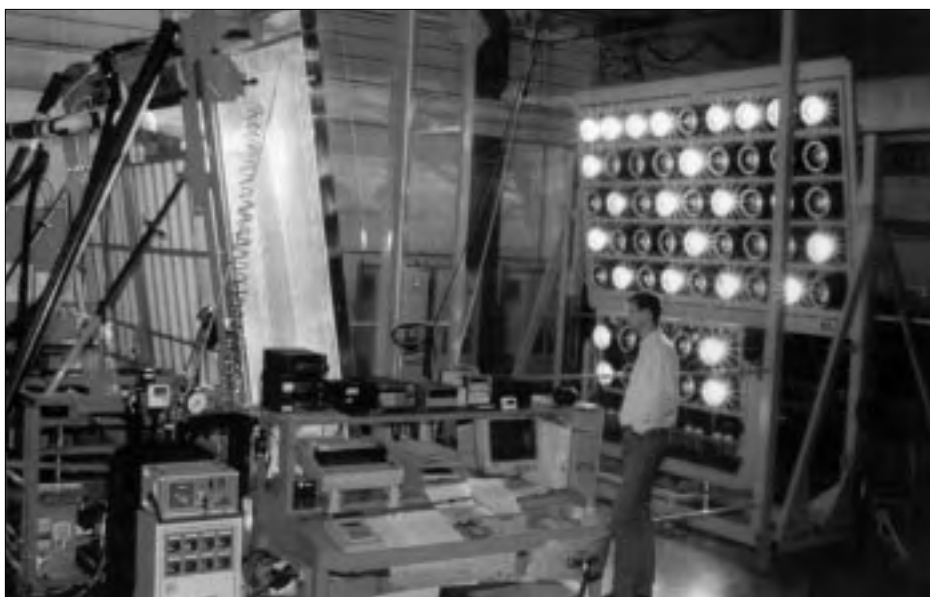


Figure 6: The indoor test stand for solar air systems at the Arsenal in Vienna.

mixing device at the outgoing duct just before the sensors and a sophisticated arrangement of temperature-sensors are necessary. To test the collectors with different air temperatures, an enclosed climatic chamber (150 m<sup>3</sup>) was used to precisely heat or cool the inlet air. Constant air temperatures between -5 and 60 °C could be delivered to the collector inlet. . By stagnation temperatures exceeding 200°C can occur, depending on absorber surface, glazing and insulation.

The simulation of wind (direction and velocity) is decisive, especially for unglazed collectors. Collectors with air flow below the absorber are not strongly affected by wind; collectors with the air flow between absorber and glazing have decreasing performance at higher wind velocities, especially if they operate at high temperatures.

## OUTLOOK

The outlook for solar air systems is particularly promising in the following market niches:

- Old buildings with decaying facades (solar air facades as a retrofit).
- Urban buildings exposed to street or air traffic noise. Solution: use double facades or atria.
- Commercial, institutional buildings and very low energy residences with mechanical ventilation (solar heating ventilation air).
- Manufacturing facilities and warehouses (low temperature, facade collectors).
- Vacation homes (natural convection or PV-powered solar air collectors for dehumidification and maintaining minimum room temperatures during vacancy).

Solar air systems have a bright future because they can serve multiple functions and use conventional building construction and components. In addition, the diversity of collector

types, storage types and modes of charging and discharging allow many creative solutions. The growth of the solar air collector industry this decade has been impressive, including: the global marketing of a Canadian unglazed collector system; the introduction of a new Norwegian type of thin-panel collector using conventional insulating glass production line capabilities; the expansion of German and Danish package systems for second homes; and the evolution of high performance modular systems for recreation facilities, commercial and institutional buildings.

Solar air systems have come of age! Growth of the industry will continue.

## References

IEA SHC Task 19: James & James Science Publishers, 35-37 William Rd. London NW1 3ER UK:

- *Solar Air Systems - Case Studies*, ISBN 1-873936-85-0.
- *Solar Air Systems: A Design Handbook*, ISBN 1-873936-86-9.
- *Solar Air Systems: A Catalog of Products*, ISBN 1 873936 84 2.

Transair ( PC Program), Transsolar, Nobelstr. 15, D 70569 Stuttgart, 1999.

M. Bosanac and S. Østergaard Jensen: *In-Situ Solar Air Collector Array Test*, ISBN 87-7756-480-4, Solar Energy Laboratory, DTI Energy, PO Box 141, DK 2630 Taastrup, Denmark, Dec. 1997.



# TASK 19: Solar Air Systems

S. Robert Hastings  
*Solararchitektur*  
Operating Agent for the Swiss  
Federal Office of Energy

## TASK DESCRIPTION

The goal of Task 19 is to facilitate the use of solar air systems for residential, institutional and industrial buildings by:

- Documenting **exemplary buildings** to inspire designers and building clients with the reliability, performance and aesthetics of building integrated systems.  
(Lead Country: Switzerland)
- Writing a **design handbook** to help engineers choose, dimension and detail a system; while assessing energy performance and non-energy issues.  
(Lead Country: Denmark)
- Developing a **computer tool** to analyze key design variables by means of TRNSYS modules of Task 19 systems and a user-friendly interface.  
(Lead Country: Germany)
- Compiling a **catalog of manufactured components** to inform designers what is available "off the shelf" for solar air systems and from where.  
(Lead Country: Norway)
- **Testing collectors** under laboratory conditions to help manufacturers optimize performance and to provide standardized data for consumers.  
(Lead Country: Austria)

## Duration

October 1993 to April 1999

## ACTIVITIES DURING 1998

The following work was completed:

- Two documents were completed:

- *Solar Air Systems: Exemplary Buildings*, a book with 33 case studies.
- *Solar Air Systems: A Catalog of Products and Components*, a catalog with a guide for selecting components and 12 product sheets.
- The Arsenal in Vienna, Austria completed testing of solar air collectors and documented a new test procedure taking into account the unique aspects of air as the heat transporter.
- A beta version of a PC-based tool to help planners predict the performance of a solar air system was distributed to all Task experts.
- The manuscript for an Engineering Handbook has been completed by the Task experts. This book will provide the planner with detailed how-to information six different system types, depending on the needs of the building, climate and budget. An example of one of these six system types is illustrated in Figure 1.

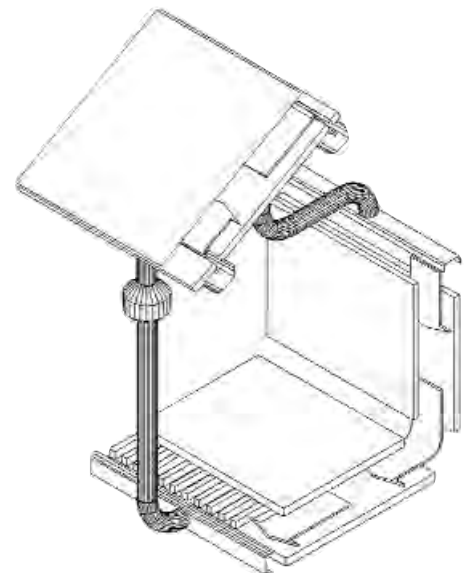


Figure 1: Solar air system Type 4, (collector to murocaust and hypocaust).

#### WORK PLANNED FOR 1999

- The Operating Agent and Subtask Leader will edit the material provided by the Task experts for the Engineering Handbook. The book will be printed and distributed in early summer.
- National Symposia will be held in the autumn to promote the publications and tools produced in Task 19.
- The Operating Agent will present the Task Final Report to the Executive Committee at the spring meeting.

#### LINKS WITH INDUSTRY

National symposia for energy planners and architects will be held by the Task experts. The following symposia and presentations are planned:

##### Austria

Seminar in Linz or Salzburg (September 1999)

##### Canada

Articles in ASHRAE Journal, possibly also a presentation at their conference.

##### Denmark

Seminar in Copenhagen (September 1999)

##### Germany

Seminar in Stuttgart, possibly also Nordrhein Westfallen (September 1999)

##### Italy

Seminars in Rome and Milan (autumn 1999)

#### Switzerland

Presentation at the CISBAT-Conference, Lausanne (September 1999)

#### United Kingdom

Part of an ETSU "New Practice Program"

#### REPORTS PUBLISHED IN 1998

*Solar Air Systems: Exemplary Buildings*, James & James Science Publishers, London (ISBN: 1 873936 85 0).

*Solar Air Systems: A Catalog of Products and Components*, James & James Science Publishers, London (ISBN 1 873936 85 0). This will be distributed free with orders for the Exemplary Buildings Book.

#### REPORTS PLANNED FOR PUBLICATION IN 1999

*Solar Air Systems: A Design Handbook*, James & James, (ISBN: 1 873936 86 9).

*Transair* (A PC tool for planning solar air systems).

#### MEETINGS IN 1998

##### Tenth Experts Meeting

April 19-22  
Sermione, Italy

##### Eleventh Experts Meeting

September 6-8  
Stavanger, Norway

##### Twelfth Experts Meeting

November 28- December 1  
Juan Les Pins, France

#### MEETINGS PLANNED FOR 1999

No Experts Meetings are planned for 1999 as the Task will conclude in April 1999.

**TASK 19 NATIONAL CONTACT PERSONS**

**Operating Agent**

Robert Hastings  
Solararchitektur  
ETH-Hönggerberg  
CH-8093 Zürich  
Switzerland

**Austria**

Hubert Fechner  
Oest. Forsch.zentrum  
Arsenal  
Faradygasse 3  
A-1030 Wien

Thomas Zelger  
Kanzlei Dr. Bruck  
Prinz-Eugen-Strasse 66  
A-1040 Wien

Sture Larsen  
Architekt  
Lindauerstr. 33  
A-6912 Hörbranz

**Canada**

John Hollick  
Solar Wall International Ltd.  
200 Wildcat Road  
CDN- Downsview ONT M3J 2N5

**Germany**

Hans Erhorn  
Heike Kluttig  
Johann Reiss  
Fraunhofer Institut für Bauphysik  
Nobelstr. 12  
D-70569 Stuttgart

Joachim Morhenne  
Ing.büro Morhenne GbR  
Schülkestr. 10  
D-42277 Wuppertal

Frank Heidt  
Fachbereich Physik & Solarenergie  
Uni. GH Siegen  
Adolf Reichweinsstr.  
D-57068 Siegen

Matthias Schuler  
Helmut Meyer  
Alexander Knirsch  
Transsolar  
Ingenieurgesch. GmbH  
Nobelstr. 15  
D-70569 Stuttgart

**Denmark**

Soren Østergaard Jensen  
Solar Energy Laboratory  
Danish Technical Institute  
Postbox 141  
DK-2630 Taastrup

Ove Mørck  
Cenergia ApS  
Sct. Jacobs Vej 4  
DK-2750 Ballerup

**Italy**

Gianni Scudo  
DPPPE  
Politecnico di Milano  
Via Bonardi 3  
I-20133 Milano

Giancarlo Rossi  
I.U.A.V. Dept. Building Construction  
Università di Venezia  
S. Croce, 191  
I-30135 Venezia

**Norway**

Harald N.Rostvik  
Sunlab/ABB  
Alexander Kiellandsq 2  
N-4009 Stavanger

**Sweden**

Torbjörn Jilar  
Dept. of Biosystems & Technology  
Swedish Univ. of Agriculture  
PO Box 30  
S-23053 Alnarp

Christer Nordström  
Ch. Nordström Arkitektkontor AB  
Asstigen 14  
S-43645 Askim

**Switzerland**

Gerhard Zweifel  
Abt. HLK  
Zentralschw. Technikum Luz.  
CH 6048 Horw

Charles Filleux  
Peter Elste  
Basler & Hofmann  
Forchstr. 395  
CH-8029 Zürich

Karel Fort  
Ing. Büro  
Weiherweg 19  
CH-8604 Volketswil

**United Kingdom**

Kevin Lomas  
Institute of Energy and Sustainable  
Development  
De Montfort University  
The Gateway  
UK-Leicester LE 1-9BH

# TASK 20: Solar Energy in Building Renovation

Prof. Arne Elmroth  
*Lund University*

Operating Agent for the Swedish  
Council for Building Research

## TASK DESCRIPTION

Task 20, Solar Energy in Building Renovation, is the first IEA SHC Task to focus specifically on the use of solar energy in existing buildings. The objective of the Task is to increase the utilization of solar energy in existing buildings by developing strategies for effectively and economically integrating widely-applicable solar designs and concepts in the renovation process. This includes compiling guidelines needed by designers and remodelers, and developing strategies to reach key players in the renovation process to obtain their support and provide them with needed information on solar opportunities.

Renovation or remodeling can be motivated by a variety of needs, including a desire to repair or replace a leaking roof, a deteriorated concrete balcony, or poor windows; increase living or work space; upgrade the building's appearance; improve indoor comfort levels; improve daylight usage; reduce utility expenses; or accommodate changes in building use. Regardless of the reason, renovation presents special challenges and opportunities for applying different solar energy strategies.

Task 20 is divided into seven Subtasks, each coordinated by a lead country:

### Subtask A: Evaluation of Existing Building Applications (Sweden)

This Subtask focused on obtaining as much relevant information as possible from existing solar renovation projects--both positive and

negative. Information was collected on the reasons for renovation, various features employed, the renovation process, and occupants' reactions. Subtask A was completed in 1995. A summary of the results were published in the journal, *Energy and Buildings* (Volume 24, 1996, pp 39-50, Elsevier, Switzerland).

### Subtask B: Development of Improved/Advanced Renovation Concepts (Belgium)

The main focus of the Subtask was to develop improved and advanced renovation concepts. A wide variety of possible systems, components, and strategies were identified and analyzed in specific renovation situations to assess their feasibility and performance. A technical report has been published. This international guide includes three parts starting with a section of tables to illustrate the applicability of different solar renovation strategies and concepts of four basic building types: houses, apartments, schools and offices. The next section presents the simulation results of the most relevant concepts which were carried out by the participating countries. The report ends with conclusions and basic market conditions for each concept, including the main characteristics of the existing products, their situation on the building market, and the financial, practical and constructive aspects. This Subtask has concluded and a technical report published.

### Subtask C: Design of Solar Renovation Projects (Denmark)

The objective of Subtask C was to demonstrate the application of



The Yellow House in Aalborg, Denmark was renovated in 1996-1997 as part of "The Aalborg Urban Ecology Project." Several solar energy concepts were used as well as advanced energy conservation measures. The solar renovations were renovation of the building facade using glass with PV-cells (33 m<sup>2</sup>) and the additions of solar air collectors for preheating ventilation air, glazed balconies and water solar collectors on the roof for domestic hot water. This project is described in reports from Task 20 Subtasks C and E.

promising solar renovation system concepts in different buildings in different climates. The Subtask activities were divided into two areas: the design of solar renovation projects and the evaluation of solar renovation projects. Subtask participants have created designs for solar renovation demonstration projects and developed monitoring procedures and reporting formats. Sixteen different solar renovation projects are described in a report, most of them are residential buildings but also include an office, a factory and a school. Several solar techniques were used: building integrated collectors, glazed balconies, solar mass walls, transparent insulation, second skin facades, daylight elements, photovoltaic systems. This Subtask has concluded and a technical report produced.

#### Subtask D: Documentation and Dissemination (Netherlands)

Under this Subtask, the results of the first phase of the Task are summarized and documented. Various information and dissemination methods are being used. The Subtask consisted of the following elements:

- Publication of four brochures presenting:
  - Solar Energy in Building Renovation (overview)
  - Solar Collectors in Building Renovation
  - Glazed Balconies in Building Renovation
  - Transparent Insulation in Building Renovation
- Participation in international symposia
- National dissemination of Task results

This Subtask has concluded and a set of four brochures published.

#### Subtask E: Evaluation of Demonstration Projects (Germany)

Subtask E comprises an evaluation of the realized solar renovation projects that were documented in Subtask C. Other projects also have been added to complete the experience. Construction and commissioning phase as well as operational results will be evaluated and reported. Results, such as energy performance, comfort, maintenance and user influence will be analyzed and documented. An economic evaluation also will be included. Non-energy aspects will get attention as well as the energy performance results. The added values of the renovated building (improved architecture, ending of facade degradation, improved thermal and visual comfort, etc.) will be an important part in the evaluation. The results will be summarized in a brochure.

#### Subtask F: Improvements of Solar Renovation Concepts and Systems (Switzerland)

The objective of this Subtask is to improve the adaptability of solar concepts and the required systems for renovation conditions. Critical aspects of solar components will be documented, with an emphasis on industrial production for improved market implementation. The results will be documented in a technical report and a catalogue of systems specifications.

#### Subtask G: Dissemination of Results (Netherlands)

The objective of this Subtask is to use existing documents to disseminate Task 20 results nationally and internationally. This Subtask also will synthesize and document information obtained from Subtasks E and F. A brochure will be produced documenting the results from Subtask E. This brochure will be linked to the other brochures that have been produced in Task 20.

#### Duration

Task 20 was initiated on August 1, 1993 and was scheduled to run until July 31, 1996. The work of Subtasks A, B, C and D were covered in this phase. A two-year extension was later approved by the Executive Committee and the Task is to until December 31, 1998. Subtasks E, F and G are covered in this phase.

#### ACTIVITIES DURING 1998

Two Experts Meetings were held in 1998. The last of these meetings was held in connection with the ISES EuroSun98 conference in Slovenia, where the Task experts presented their work in the Task, both with in overview keynote speech and detailed conference presentations.

#### Subtask C: Design of Solar Renovation Projects

The experiences of designing 16 demonstration projects were reported in the document, Solar Renovation Demonstration Projects and this report was approved and published during 1998.

#### Subtask E: Evaluation of Demonstration Projects

In Subtask E, 14 demonstration projects were selected to be evaluated,

seven of which were evaluated in Subtask C regarding the design phase. The buildings are primarily multifamily houses, but also include three schools, an office, an industry hall and a multi-functional exhibition building. Several concepts are used in these projects, such as different types of building-integrated collectors and PV-systems, transparent insulation for heating and daylighting purposes and different types of glazing and glazed balconies. An evaluation format was developed and a draft brochure, presenting the results prepared. The structure of this brochure is similar to the brochures produced in Subtask D.

#### Subtask F: Improvements of Solar Renovation Concepts and Systems

In Subtask F, a System Specification Format was developed and the first draft of the Catalogue of Concepts prepared. So far 14 concepts are described. Depending on the level of industrial involvement some ideas may lead to improved products. The Catalogue of Concepts includes two parts, an introduction and overview section with a comparative overview of the concepts, systems and components discussed, and one part with the concepts documented in a common reporting format including: concept description, modeling and simulation results and evaluation and monitoring results.

Examples of the concepts:

- Economic optimisation of combination of glazed balconies with mechanical exhaust air ventilation.
- Preheating of ventilation air by solar air collectors integrated in

glazed balcony.

- Combination of glazed balconies with different mechanical ventilation systems.
- Architectural elements for solar gain control for solar mass wall heating systems.
- Cost reduction by use of mass fabricated intermediate products for solar mass wall heating.
- Module integrated natural ventilation channel for solar gain control; combined use as thermal collector.
- Unglazed low cost facade collectors integrated in compound insulation system.
- Improved systems and components for use of daylight.

All concepts are analyzed according to development status, critical aspects, involved systems and components, required improvements, type of companies involved in development, specific cost target, application potential, additional benefits, etc.

The Catalogue of Concepts will be part of the Subtask F Technical Report, which also will include general findings of Task 20 work related to the concept, system and component levels. These general results will be summarized in the Subtask E brochure for a broader audience.

#### Subtask G: Dissemination of Results

The activities in this Subtask have been to coordinate the presentations of the Task and to prepare for the publication of the next brochure.

#### WORK PLANNED FOR 1999

The work in Task 20 was originally planned to conclude in December 1998. As there was some remaining

Table 1. Subtask E Demonstration Projects

Location	Building Type		Solar Technology						
			Solar collectors		Glazed balconies		Transparent insulation		Other
			DHW <sup>1</sup>	SH <sup>2</sup>	passive element	active ventilation	mass wall	daylight wall	
Niederurnen	CH	multifamily					■		photovoltaic
Hedingen	CH	multifamily	■				■		
Erfurt	DE	school							daylighting
Freiburg	DE	residential <sup>3</sup>	■	■			■		
Oederan	DE	multifamily	■						
Salzgitter	DE	industry hall						■	
Wurzen	DE	school					■		
Aalborg	DK	multifamily	■	■ <sup>4</sup>	■				photovoltaic
Den Haag	NL	multifamily	■		■				
Zaandam	NL	multifamily	■	■		■			
Älta	SE	multifamily	■	■					
Henan	SE	school	■	■					
Örebro	SE	multifamily	■	■					
Golden	US	exhibition							daylighting

<sup>1</sup> DHW=domestic hot water, <sup>2</sup>SH=solar assisted space heating, <sup>3</sup>actually office use, <sup>4</sup>air collector

work, the last planned Experts Meeting originally scheduled for November 1998 was postponed to the beginning of 1999. For Subtask E, the brochure will be published during 1999 and a working document including the more detailed evaluation formats will be completed.

In Subtask F, the system specifications will be reported in a technical report with a catalogue of systems specifications. One industry workshop on advanced solar renovation of balconies is planned for 1999, probably to be held in Germany. Information material for the workshop will be produced in advance

and the workshop will be documented in proceedings.

In Subtask G, the final publishing and dissemination of Task work will take place.

#### LINKS WITH INDUSTRY

For the direct work as an Expert in the Task, there is one representative from the manufacturing industry: Transparent insulation wall and glazing elements manufacturer (Ernst Schweizer AG, Switzerland). There are two representatives from engineering consulting companies in the Task (Esbensen Consulting

Engineers, Denmark and W/E, The Netherlands).

The audience for the planned workshop in Subtask F on glazed balconies, is mainly the industry.

#### REPORTS PUBLISHED IN 1998

*Solar Renovation Demonstration Projects - A Technical Report of Subtask C: Design of Solar Renovation Projects.* This report can be ordered from O. B. Jørgensen, Esbensen Consulting Engineers, Vesterbrogade 124 B, DK-1629 Copenhagen V, Denmark, Fax: +45-33 26 73 01, e-mail: o.b.joergensen@esbensen.dk

## REPORTS PLANNED FOR 1999

Subtask E, Working Document,  
Evaluation of Demonstration  
Projects

Subtask F, Technical Report,  
Improvement of Solar Renovation  
Concepts and Systems, includes  
Catalogue of Concepts and  
Proceedings from Industry  
Workshop

Subtask G, Brochure, Evaluation of  
Demonstration Projects from  
Subtask E and Managing Report

## 1998 MEETINGS

### Tenth Experts Meeting

March 30 - April 1  
Aalborg, Denmark

### Eleventh Experts Meeting

September 17-18  
Portoroz, Slovenia

## 1999 MEETING

### Twelfth Experts Meeting

February 8 - 9  
Örenäs, Sweden



**TASK 20 NATIONAL CONTACT  
PERSONS**

**Operating Agent**

Arne Elmroth  
Lund University  
Dept. of Building Physics  
P.O. Box 118  
S-221 00 Lund  
Sweden

**Operating Agent Assistant**

Elisabeth Kjellsson

**Denmark**

Olaf Bruun Jørgensen  
Esbensen Consulting Engineers  
Vesterbrogade 124 B  
DK-1620 Copenhagen V

**Germany**

Karsten Voss  
Fraunhofer Institute for Solar Energy  
Systems  
Oltmannsstrasse 5  
D-79100 Freiburg

**Netherlands**

Chiel Boonstra  
W/E  
P.O.Box 733  
NL-2800 AS Gouda

**Sweden**

Jan-Olof Dalenbäck  
Building Services Engineering  
Chalmers University of Technology  
S-412 96 Göteborg

**Switzerland**

Andreas Haller  
Ernst Schweizer AG, Metallbau  
CH-8908 Hedingen

**United States**

Robert T. Lorand  
Science Applications International  
Corp.  
MS 2-7-2  
1710 Goodridge Drive  
McLean, Virginia 22102

**Sheila J. Hayter**

National Renewable Energy  
Laboratory  
Center for Buildings & Thermal  
Systems  
1617 Cole Boulevard  
Golden, Colorado 80401-3393

# TASK 21: Daylight in Buildings

Kjeld Johnsen  
Danish Building Research Institute  
Operating Agent for the  
Danish Energy Agency

## TASK DESCRIPTION

Artificial lighting represents a major part of the overall energy consumption in non-residential buildings. However, more daylight conscious architectural solutions and the introduction of innovative daylighting systems and efficient lighting controls could displace a considerable part of this electricity consumption by utilizing the natural resources offered by daylight. Furthermore, it is generally recognized today that the design of the fenestration system and the proper use of daylight in building interiors are important factors, both for the conservation of non-renewable fuels and for the well-being of occupants.

However, a number of barriers hinder appropriate integration of daylighting aspects in the building design. One is the lack of documented, empirical evidence that daylighting can substantially improve energy efficiency and visual quality in buildings. Furthermore there is insufficient knowledge and lack of information on new fenestration technologies and lighting control systems and the ability of such systems to enhance utilization of daylight, and a lack of user friendly daylighting design tools and models for innovative daylighting systems.

Task 21 will contribute to the overcoming of the identified barriers. The Task was initiated in 1995 with the main objectives to advance daylighting technologies and to promote daylight conscious building design. Through selected Case Studies the Task will demonstrate the viability of daylighting designs under various cli-

matic conditions emphasizing system performance regarding energy savings and user acceptability.

The main deliverables from the Task will be:

- A system specific Design Guide on daylighting systems and control systems providing recommendations on systems integration and performance data on energy saving potentials.
- A set of Daylighting Design Tools that will markedly improve the designers' ability to predict the performance of daylighting systems and control strategies and to evaluate the impact of daylight integration in the overall design concept.
- A Case Studies Report, documenting measured data on daylighting performance, energy consumption and user appraisal of the environmental conditions.

The work of the Task is structured in the following four Subtasks, each coordinated by a lead countries.

### Subtask A: Performance Evaluation of Daylighting Systems (Australia)

This Subtask will provide design guidance on the performance of both innovative and conventional daylighting systems. Systems will be assessed according to energy saving potential, visual aspects and the control of solar radiation. The evaluation of systems is to be based not only on technical feasibility but also on architectural and environmental impacts.

**Subtask B: Daylight Responsive Lighting Control Systems (Netherlands)**

Energy savings from daylighting cannot be significant without an appropriate integration of window design and electrical lighting systems. The objectives of Subtask B are to evaluate the performance of existing selected daylight responsive lighting control systems (in conjunction with selected daylighting systems) in terms of their capability to control the artificial lighting in response to available daylight and in terms of user acceptance of the systems. This will assist building owners, developers, architects, and engineers to select and commission daylighting responsive systems, and to estimate the potential energy savings at an early stage of design.

**Subtask C: Daylighting Design Tools (Germany)**

The objective of Subtask C is to improve the capability, accuracy and ease-of-use of daylighting design and analysis tools for building design practitioners, covering all phases of the design process. The practitioners will be able to predict the performance of different daylighting systems and control strategies and to evaluate the impact of the integration of daylighting in the overall building energy concept by using these design tools.

**Subtask D: Case Studies (Denmark)**

Despite claims that daylighting can substantially improve visual quality and energy efficiency of buildings there is little documented empirical evidence. The main objective of Subtask D is to demonstrate the via-

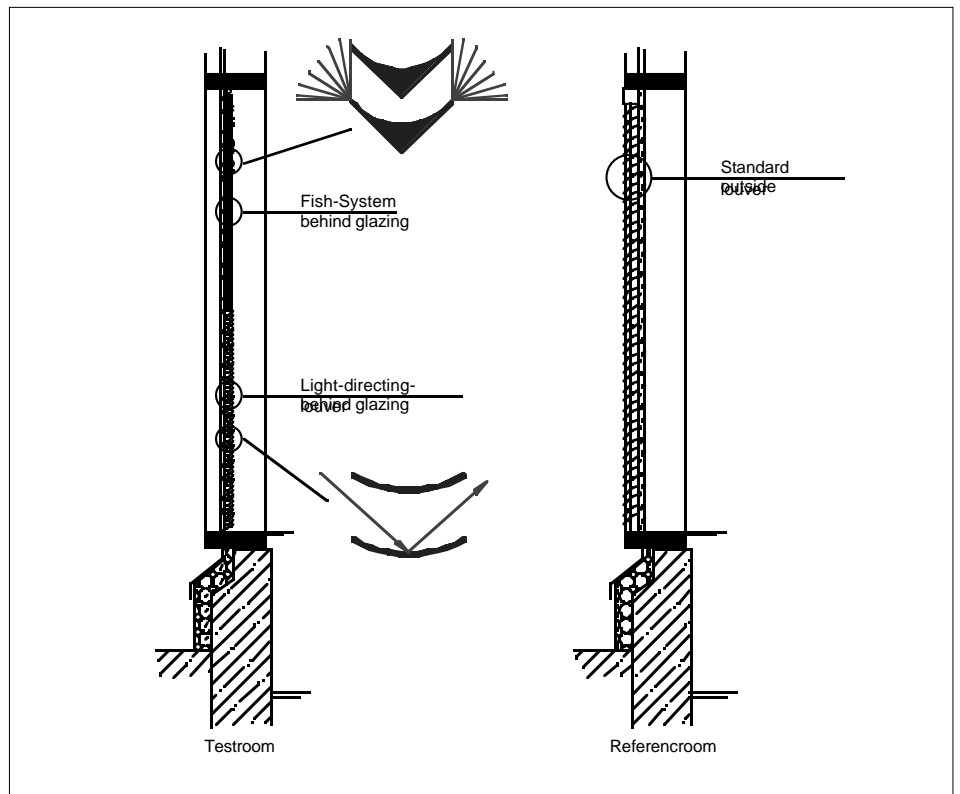


Figure 1. This daylighting system consists of two different components in the upper and lower part of the window. The upper part has a fixed light directing system, called "Fish." The lamellas are designed in a way that the outer upper quarter of the sky is transmitted to the inner upper quarter of the room and that is the ceiling. There is a theoretical transmittance of the system of 0.60 based on aluminum with 0.85 reflectance. As the system is not a sun-shading device, there is an additional roller blind in front of the "Fish," which is closed, in the sunny condition. In the lower part of the window there are moveable light directing louvers. The lamellas are rotated, so that glare can be reduced.

bility of daylighting buildings in various world climate zones as an energy saving potential in buildings while maintaining a satisfactory visual and thermal environment for occupants, and to provide real validation data to computer models.

**Duration**

The Task was initiated in September 1995 and is scheduled to be completed in December 1999.

**ACTIVITIES DURING 1998**

1998 was dedicated to the testing of

systems in the test rooms, i.e. daylighting systems and daylight responsive lighting control systems, as well as the monitoring of the Case Study Buildings. The measuring and monitoring results are essential parts of the main Task reports that will be finalized in 1999. Two experts meetings were held in 1998, one in Ottawa, Canada, and one in Berlin, Germany. An overview of the work in progress and the achievements in each of the four Subtasks of the past year is given below.

### Subtask A: Performance Evaluation of Daylighting Systems

The test room measurements on daylighting systems is going well and about 65 percent of the work has been completed. The testing includes three days of clear sky, i.e. in winter, in spring/autumn, and in summer. For a few systems the summer measurements will take place in 1999, and therefore it has been decided to extend the work till the end of 1999. Figure 1 shows one of the systems being tested in Austria. Figure 2 shows the interior of the reference room at the Danish Test Facility.

Subtask A has produced a comprehensive set of working documents of which some will be official Task 21 documents available to design practitioners and industry. The new/revised reports in 1998 were:

- Australian National Newsletter "International Daylighting 5" (USYD)
- Australian National Newsletter "International Daylighting 6" (USYD)
- Survey of architectural solutions (IBUS)
- Monitoring Protocol for Test Room Assessment of Daylighting Performance of Buildings. A revision of T21/A2-4/DK/96-11 (SBI)
- Monitoring Procedures for the assessment of Daylighting Performance of Buildings. A revision of T21/A2-3/DK/96-11 & T21/B2-1/NL/96-01 (TUD/SBI)
- Project A4: Measurement of Physical Characteristics. Descriptions of Test facilities (TUB)
- Anidolic Solar Blinds (EPFL)

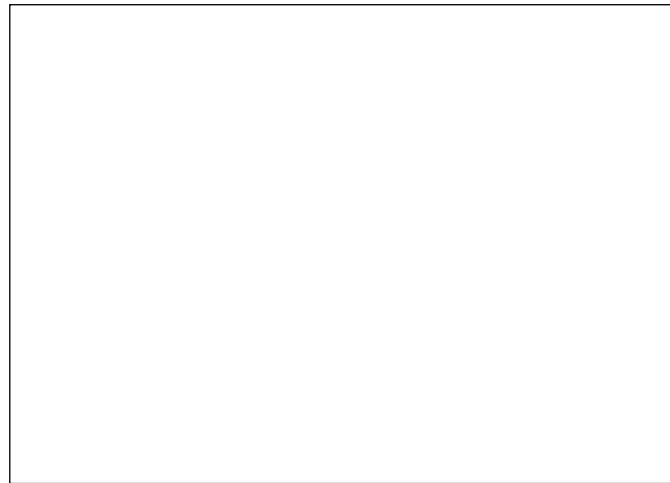


Figure 2. This reference room at the Danish Test Facility is used to evaluate the performance of daylighting systems. The measurements taken are always compared with those of an identical reference room, which has no system or has a more traditional system, e.g. Venetian blinds.

- Revised report on Scale Models (EPFL)
- Scale Model Daylighting Systems (LESO/EPFL)
- Daylighting Systems: Prismatic Panel (BAL/MKL)
- Daylighting Systems: Sun Shielding Louver (BAL/MKL)
- Daylighting Systems: 'Fish' Light Directing Louvers (BAL/MKL)
- Daylighting Systems: Light Shelf (SBI)
- Daylighting Systems: Louvers and Blind Systems (SBI)
- Matrix for Description of Daylighting systems
- Monitoring Procedure for the Assessment of Daylighting Performance of Buildings (SBI/TUD)

### Subtask B: Daylight responsive lighting control systems

The testing of daylight responsive lighting control systems is near completion. And, the first draft of the main report, *Application Guide for Daylight Responsive Lighting Control Systems*, was distributed in September. It consists of two parts, 1) a general handbook and 2) examples and performance results from practice. The report is structured in the following chapters:

#### Part 1

1. Introduction
2. General design considerations
3. Daylight control system selection
4. Prediction of energy savings and costs
5. User reactions to daylight responsive controlled lighting
6. Installation procedures
7. Maintenance
8. Quality control and post-occupancy evaluation

#### Part 2

Documentation of testing results from practice (described for a number of real buildings and test rooms according to a standard format).

The most significant reports that were distributed in Subtask B in 1998 were:

- Monitoring Procedures for the assessment of Daylighting Performance of Buildings. A revision of T21/A2-3/DK/96-11 & T21/B2-1/NL/96-01 (TUD/SBI)
- Pilot studies (ENTPE)
- Test of selected daylight responsive lighting control systems (NTNU)

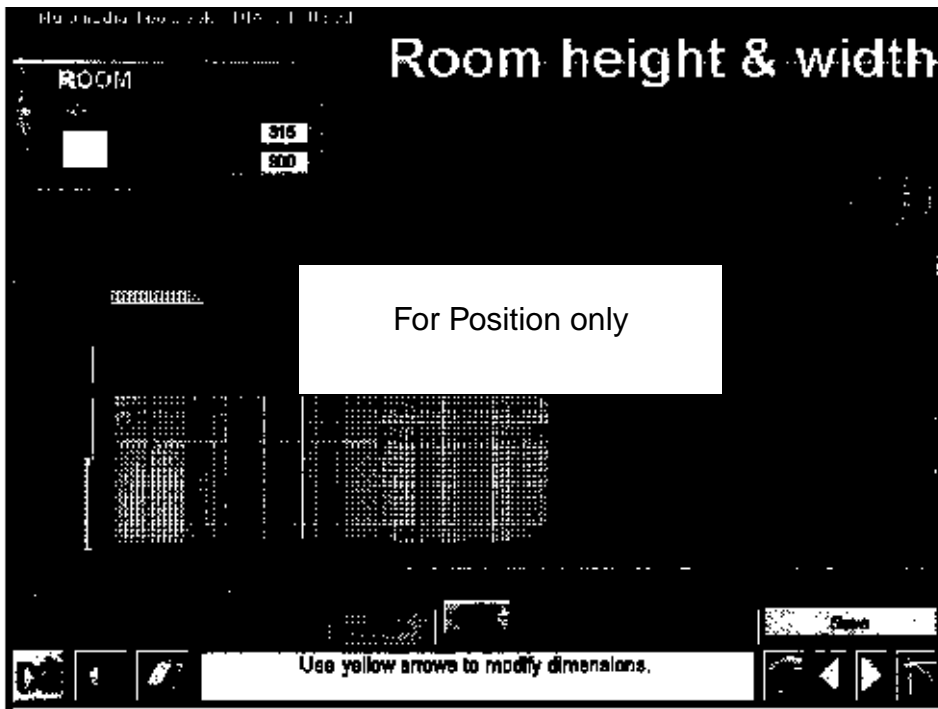


Figure 3a. Screen view of the DIAL daylight program showing the menu for the room definition.

- Test of selected daylight responsive lighting control systems (TUB)
- Economical assessment (HUT)

#### Subtask C: Daylighting design tools

Twelve institutions representing 10 IEA countries are involved in production and evaluation of daylighting design tools. The collection of daylight algorithms and the established www page has become an interesting source of information (so far for the participants only).

The work on simplified design tools has almost been completed. An English version of the simple daylighting design tool DIAL developed by EPFL is illustrated in Figures 3a and 3b.

The most significant reports of Subtask C in 1998 were:

- Data Sets for the Validation of Daylighting Computer Programs (LBNL)
- C1-Validation- Specular Atrium Model Data (BRE)
- Sky Modeling from Digital Imagery (Murdoch University)
- Applicability of Daylighting Computer Modeling in Real Case Studies: Comparison between Measured and Simulated Daylight Availability and Lighting Consumption (NRC)
- Working Document: Survey Simple Design Tools (FHG-IBP)
- Final Draft: Working Procedure and results for the atrium and adjacent office parametric study: Daylighting and Energy Consumption in an Office Adjacent to an Atrium (EMPA)

Figure 3b. Screen view of the DIAL daylight program showing the calculated daylight factors in the room.

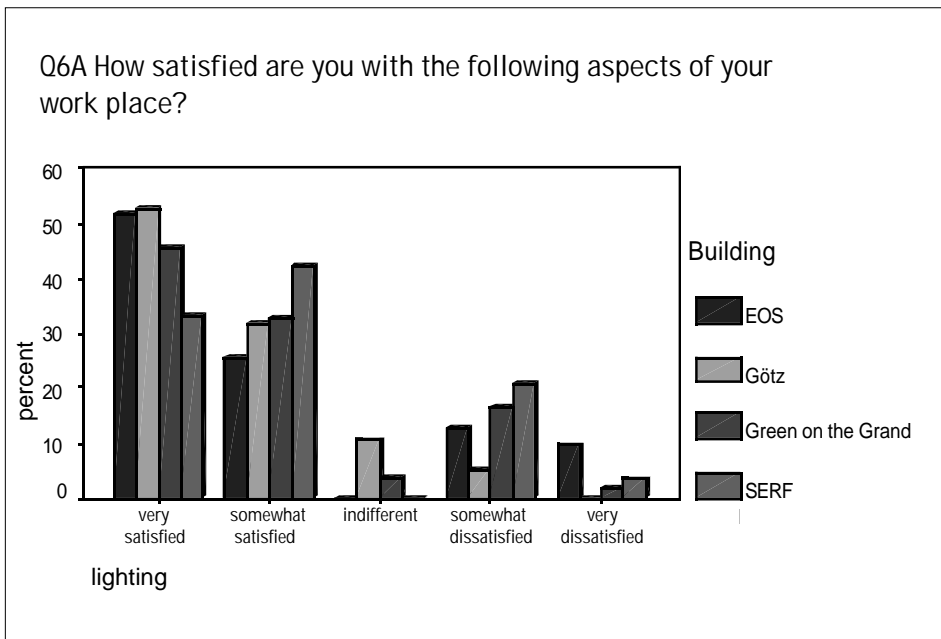


Figure 4. Example of (preliminary) results of the POE studies in some of the Case Study buildings

- Simple Design Tool for Lighting; Lighting plus Heating and Cooling Energy in an Office adjacent to the Atrium (EMPA)
- LESO-DIAL - Daylighting Design Software (EPFL/LESO)
- Simple Design Tool for Lighting plus Heating and Cooling Energy in an Office Adjacent to an Atrium - First Results (FHG-IBP)
- ADELIN 2.1 beta, Documentation on new features (FHG-IBP)
- ADELIN - An Integrated Approach to Lighting Simulation (FHG-IBP)

#### Subtask D: Case Studies

The monitoring on the 16 Case Study buildings was completed at the end of 1998. The post occupancy evaluations carried out in four of the Case Studies will be documented in a separate report of which the first draft was distributed in

September 1998. Figure 4 shows an example of some of the preliminary results of the POE studies in the Case Study buildings.

The most significant reports of Subtask D in 1998 were:

- Case Study: Oberstufen Zentrum Wirtschaft, Secondary School, Zehdenick (IBUS)
- Case Study: Nortel Research Center, Ottawa, Canada (NRC)
- Case Study: Professionals Faculties Building, University Building, Calgary (UCAL)
- Case Study: Green on the Grand, Office Building, Kitchner, Ontario, Canada (EMOD)
- Case Study: Park Ridge Primary School, Melbourne, Australia (TOA)
- POE studies in Four Case Studies of IEA Task 21 (KTH)

#### WORK PLANNED FOR 1999

Since 1999 is the last year of Task 21, the participants will be very busy in carrying out the remaining testing and monitoring before the documentation in the final reports can be produced.

#### LINKS WITH INDUSTRY

All Subtasks have significant links to industry, and in many participating countries, industry offers significant financial support for work being undertaken. Most of the daylighting systems and lighting control systems are provided by manufacturers, who naturally have an interest in the Task's testing procedures results. In Subtask B on Control Systems, major manufacturers are directly involved in the research activities and are providing excellent facilities for the testing of several systems and strategies. In Subtask C on Design Tools, the development of a common platform for integration of building design tools is partly based on the standards set by the Industry Alliance for Interoperability (IAI). Subtask D on Case Studies is led by a private engineering consultant and has strong links to a similar project under the European Community's JOULE programme. In this Subtask, building owners have made their buildings available for Task monitoring and user evaluations. In some cases, the owners have provided unoccupied spaces for direct full scale testing.

## REPORTS PLANNED FOR 1999

Some of the working documents and draft reports mentioned under the four Subtask descriptions will be finalized in official reports, available to the public. The main report and software also will be completed in 1999 while the Design Guide for Daylighting Systems, the Application Guide for Daylight Responsive Lighting Control Systems, and the Case Studies Report will be published in the first half of year 2000.

## 1998 EXPERT MEETINGS

### Sixth Experts Meeting

May 13-15

Ottawa, Canada

### Seventh Experts Meeting

October 5-8

Berlin, Germany

## 1999 EXPERT MEETINGS

### Eighth Experts Meeting

April 12-16

Innsbruck, Austria

### Ninth Experts Meeting

September 27-30

Copenhagen, Denmark

**TASK 21 NATIONAL CONTACT PERSONS \***

**Operating agent**

Kjeld Johnsen  
Danish Building Research Institute  
P.O. Box 119  
2970 Hrrsholm  
Denmark  
e-mail: [kjj@sbi.dk](mailto:kjj@sbi.dk)

**Australia**

Nancy Ruck (Lead Subtask A)  
University of Sydney  
Dept. Architecture & Design Science  
Sydney NSW 2006

**Austria**

Martin Klingler  
Ing. Bhro Martin Klingler  
Kaplanstrasse 2  
6063 Rum/Innsbruck

**Belgium**

Magali Bodart  
Université Catholique de Louvain  
Centre de Recherche en Architecture  
Place de Levant 1  
B - 1348 Louvain-la-Neuve

**Canada**

Morad Atif  
National Research Council Canada  
Building Performance Laboratory  
Ottawa  
Ontario K1A 0R6

**Denmark**

Poul E. Kristensen (Lead Subtask D)  
Danish Technological Institute  
Division of Energy  
P.O. Box 141  
DK - 2630 Taastrup

Jens Christoffersen  
Danish Building Research Institute  
P.O. Box 119  
DK - 2970 Hrrsholm

**Germany**

Heinrich Kaase  
Technische Universität Berlin  
Institut für Lichttechnik  
Einsteinufer 19  
D - 10587 Berlin

Hans Erhorn (Lead Subtask C)  
Fraunhofer Institut für Bauphysik  
Nobelstrasse 12  
D - 70569 Stuttgart

**Finland**

Lisa Halonen  
Helsinki University of Technology  
Otakaari 5A  
FIN - 02150 Espoo

**France**

Vincent Berrutto  
ENTPE/DGCB  
Rue Maurice Audin  
F - 69518 Vaulx-en-Velin, Cedex

**Italy**

Ferdinando Raponi  
ENEA, SIRE  
Casaccia  
I - 00060 S.M. di Galeria, Roma

**Netherlands**

Laurens Zonneveldt (Lead Subtask B)  
TNO-TUE Centre for Building  
Research  
P.O. Box 513  
NL - 5600 MB Eindhoven

**New Zealand**

Michael Donn  
Victoria University of Wellington  
Centre for Building Performance Lab.  
P.O. Box 600  
NZ - Wellington 1

**Norway**

Øyvind Aschehoug  
Norwegian University of Science and  
Technology, Faculty of Architecture  
N - 7034 Trondheim

**Sweden**

Staffan Hygge  
K T H, Built Environment  
P.O. Box 88  
S - 801 02 Gävle

**Switzerland**

Jean Louis Scartezzini  
University of Geneva  
LESO-PB, EPFL  
CH - 1015 Lausanne

**United Kingdom**

Paul Littlefair  
Building Research Establishment  
Lighting & Applied Vision Section  
Garston  
Watford WD2 7JR

**USA**

William L. Carroll  
Lawrence Berkeley Laboratory  
Building 90 - 3026  
Berkeley, California 94720

\*This list includes national contact persons and Subtask leaders. A total of 42 institutions participate in Task 21. For the full address list see the Programme web site at <[www.iea-shc.org](http://www.iea-shc.org)>.



# TASK 22: Building Energy Analysis Tools

Michael J. Holtz  
*Architectural Energy Corporation*  
Operating Agent for the U.S.  
Department of Energy

## TASK DESCRIPTION

The overall goal of Task 22 is to establish a sound technical basis for analyzing solar, low-energy buildings with available and emerging building energy analysis tools. This goal will be pursued by accomplishing the following objectives:

- Assess the accuracy of available building energy analysis tools in predicting the performance of widely used solar and low-energy concepts
- Collect and document engineering models of widely used solar and low-energy concepts for use in the next generation building energy analysis tools
- Assess and document the impact (value) of improved building energy analysis tools in analyzing solar, low-energy buildings, and widely disseminate research results to tool users, industry associations and government agencies

Task 22 will investigate the availability and accuracy of building energy analysis tools and engineering models to evaluate the performance of solar and low-energy buildings. The scope of the Task is limited to whole building energy analysis tools, including emerging modular type tools, and to widely used solar and low-energy design concepts. To accomplish the stated goal and objectives, the Participants will carry out research in the framework of two Subtasks:

- Subtask A: Tool Evaluation
- Subtask B: Model Documentation

Tool evaluation activities will include

analytical, comparative and empirical methods, with emphasis given to blind empirical validation using measured data from test rooms or full scale buildings. Documentation of engineering models will use existing standard reporting formats and procedures. The impact of improved building energy analysis tools will be assessed from a building owner perspective.

The audience for the results of the Task is building energy analysis tool developers. 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.

## Duration

The Task was initiated in January 1996 and is planned for completion in June 2000.

## ACTIVITIES DURING 1998

A summary of Subtask research activities completed during 1998 is presented below.

### Subtask A: Tool Evaluation

This Subtask is concerned with assessing the accuracy of available building energy analysis tools in predicting the performance of widely-used solar and low-energy concepts. Three Tool evaluation methodologies are being employed:

- 1) Analytical Tests
- 2) Comparative Tests
- 3) Empirical Validation Tests



The Energy Resource Station (ERS) test facility in Ankeny, Iowa. ERS has 4 sets of matched test rooms and a sophisticated HVAC system to create laboratory quality test data for purposes of empirical validation of building energy analysis tools.

Work accomplished during 1998 on each of these tool evaluation efforts is summarized below.

- Analytical Tests: All planned activities have been completed. The Working Document, along with a questionnaire, a recommended implementation process, and a series of one page summaries of use experience, is being readied for distribution to building energy analysis tool authors. The objective is to inform code authors of the existing analytical tests, and to obtain their views and recommendations on the importance and value of analytical tests for tool evaluation/validation.
- Comparative Tests: The HVAC BESTEST specification has been revised to address ambiguities or uncertainties identified by the participants. A second round of comparative analyses is currently underway involving five (5) tools from four countries. As a result of the first round of comparative analyses, two simulation tools have

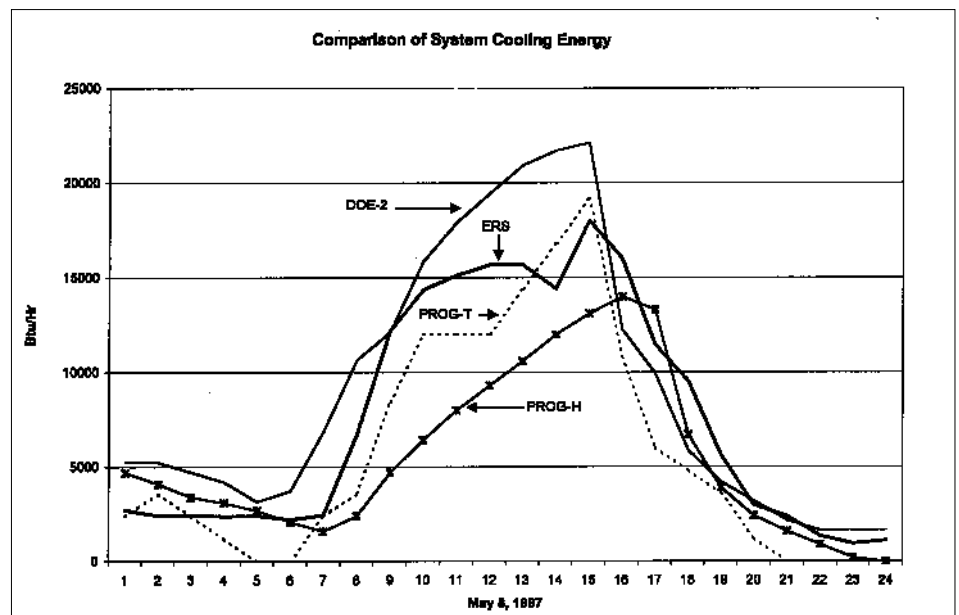
been modified to address problems or deficiencies uncovered.

A new suite of HVAC BESTEST test cases have been defined and approved by the participants. These new test cases expand and comple-

ment the existing test cases, and improve their diagnostic capability.

- Empirical Validation Tests: A final draft of the final report on the ETNA and GENEC test room empirical validation exercises has been prepared by France (EDF). It contains the final results of all Task Participants for the "non-blind" empirical validation exercise. The modeling errors found by the UK (BRE) participants have been corrected and new results generated for inclusion in the final report. The report will be approved and distributed in 1999.

The second round of analyses has been completed for the commercial empirical validation exercise using monitored data from the Iowa Energy Center's Energy Resource Station (ERS) test facility. Four tools



Preliminary results of an empirical validation exercise using Energy Resource Station test data. Results identified as 'ERS' are the measured data from the test room, while results identified as 'DOE-2', 'Prog-T' and 'Prog-H' are building energy analysis tool predictions. Results indicate a clear need to continue evaluation of building energy analysis tools, and to improve their ability to model HVAC systems more accurately.

from two countries participated in the exercise. An ERS User's Manual has been prepared which contains a detailed description of the experimental conditions and the required analysis tool output. Results clearly demonstrate the need for additional empirical validation of mechanical system modeling capabilities of building energy analysis tools. New experiments have been defined and approved by the participants. User's Manuals for each new experiment will be developed. The ERS Manager will begin modifying the ERS test rooms in preparation for conducting the experiments over the next 2-3 months. The new experiments will include a VAV system with economizer control and a fan-coil unit.

#### **Subtask B: Model Documentation**

This Subtask is concerned with the collection and documentation of existing engineering models and the creation of a models library accessible by modular tool developers. Task Participants have selected the Neutral Model Format (NMF) as the standard format for "hard" (computer-machine readable) model documentation.

KTH of Sweden is operating and maintaining the Simulation Model Network (SIMONE) on its Internet web site (<http://www/brisdata.se/NMF>). This web site allows users to review available engineering models documented in the neutral model format. These models can be downloaded for translation for use by object oriented (modular) simulation tools.

KTH has also developed an extensive library of NMF models for analyzing energy efficient, solar buildings. These models are available from SIMONE, and will be documented in a separate report now in preparation. KTH has created a building specific application of its IDA object oriented simulation environment, called ICE. ICE is now commercially available and represents a proof-of-concept of the overall concept of modular object-oriented simulation tools using universal models.

#### **WORK PLANNED FOR 1999**

At its November 1997 meeting, the Executive Committee approved an 18 month extension to expand the evaluation activities of Subtask A. The HVAC BESTEST suite of test cases will be expanded to cover more design conditions and have improved diagnostic capabilities. The commercial empirical validation exercise, which uses data from the Iowa Energy Resource Station, will conduct additional tests to obtain the data needed for the blind comparison to building analysis tool predictions. In Subtask B, a final report will be prepared summarizing the NMF models and translators developed and tested under Task 22, and the SIMONE library/web site created, operated, and maintained by KTH.

A summary of planned activities for each of the Subtasks and projects is presented below.

- Subtask A: Analytical Tests. The Working Document on Analytical Tests will be distributed to key building energy analysis tool devel-

opers for review and, hopefully, use in evaluating their tools. Their comments and suggestions will lead to a revision of the Working Document.

- Subtask A: Comparative Tests. Complete final round of analyses of first series of HVAC BESTEST cases, and summarize the results in a technical report. Prepare and distribute specification on new series of HVAC BESTEST cases. Complete at least two rounds of analyses on the new test cases, and prepare a preliminary technical report.
- Subtask A: Empirical Tests. Publish and distribute final report of ETNA and GENEC test room empirical validation exercises. Complete second round of analysis of Energy Resource Station test cases and summarize results in a technical report. Complete development, documentation, and testing of an innovative parameter estimation/identification technique for performing modeling error diagnostics.
- Subtask B: Maintain SIMONE library/web site, and NMF translators. Continue documentation of engineering models in NMF, and prepare draft final report of KTH models.

#### **REPORTS PUBLISHED IN 1998**

No official technical reports were published in 1998. However, the Working Document on Analytical Tests was distributed to the Task Participants and analysis tool authors. Also, a draft final report

was created on the ETNA and GENECE test houses. The Simulation Model Network (SIMONE) web site was created and populated with available NMF engineering models.

#### REPORTS PLANNED FOR 1999

##### Subtask A: Tool Evaluation

- HVAC BESTEST Specifications and Comparative Test Results
- Final Report on Empirical Validation Exercises – ETNA and GENECE test rooms
- Preliminary Report on Results from the Energy Resource Station Blind Empirical Validation Exercise
- Preliminary Report on Parameter Estimation/Identification Technique for Modeling Error Diagnostics

##### Subtask B: Model Documentation

- Additional Models Documented in Neutral Model Format
- SIMONE web site expanded and linked to other web sites
- Final report on all NMF models developed during Task 22

#### 1998 EXPERTS MEETINGS

##### Sixth Experts Meeting

April 6-8  
Golden, Colorado, USA

##### Seventh Experts Meeting

October 1-2  
Espoo, Finland

#### 1999 MEETINGS

##### Eighth Experts Meeting

March 17-20  
Dresden & Berlin, Germany

##### Ninth Experts Meeting

September 1998  
Location to be determined

**TASK 22 NATIONAL CONTACT  
PERSONS**

**Operating Agent**

Michael J. Holtz  
Architectural Energy Corporation  
2540 Frontier Avenue, Suite 201  
Boulder, Colorado 80301  
United States

**Finland**

Pekka Tuomaala  
VTT Building Technology  
Energy Systems Research Group  
P.O. Box 1804 (Lampomie henkuja  
3, Espoo)  
Fin-02044 VTT

Mika Vuolle  
Helsinki University of Technology  
Heating, Ventilating & Air  
Conditioning  
Otakaari 4  
Fin-02150 ESPOO

**France**

Gilles Guyon  
Electricite de France  
Les Renardieres  
Route de Sens BP1  
77250 Moret-sur-Loing

Souheil Soubra  
CSTB  
BP 209  
069064 Sophia Antipolis Codex

Elena Palomo and Gilles Lefebvre  
GISE/ENPC  
La Courtine Central II  
93167 - Noisy le Grand

**Germany**

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

Martin Behne  
KLIMASYSTEMTECHNIK  
Esdorn Jahn GmbH  
Keplerstraße 8/70  
10589 Berlin

**Spain**

Juan Travesi  
Departamento De Energias  
Renovables, CIEMAT  
Avda. Complutense, 22  
28040 Madrid

**Sweden**

Per Sahlin and Alex Bring  
Dept. Building Sciences  
KTH  
10044 Stockholm

**Switzerland**

Gerhard Zweifel and Markus  
Duerig  
Zentralschweizerisches  
Technikum Luzern  
Abt. HLK  
CH-6048 Horw

**United Kingdom**

David Bloomfield, Foroutan Parand  
and Elizabeth Silver  
Building Research Establishment  
Bucknalls Lane  
Garston  
Watford Wd2 7 JR

**United States**

Ron Judkoff and Joel Neymark  
National Renewable Energy  
Laboratory  
1617 Cole Boulevard  
Golden, Colorado 80401

Bill Beckman  
Solar Energy Laboratory  
1500 Engineering Drive  
University of Wisconsin  
Madison, Wisconsin 53706

Gregory Maxwell and Sangsoo Lee  
Mechanical Engineering Department  
Iowa State University  
2025 Black Engineering Building  
Ames, Iowa 50011

Curtis J. Klaasen  
IEC Energy Resource Station  
DMACC  
2006 S. Ankeny Boulevard  
Ankeny, Iowa 50021

# TASK 23: Optimization of Solar Energy Use in Large Buildings

Prof. Anne Grete Hestnes  
*Norwegian University of Science  
and Technology*  
Operating Agent for the Research  
Council of Norway

## TASK DESCRIPTION

### Objectives

The main objectives of Task 23 are to ensure the most appropriate use of solar energy in each specific building project for the purpose of optimizing the use of solar energy and also of promoting more use of solar energy in the building sector.

This is achieved by enabling the building designers to carry out trade-off analyses between the need for and potential use of energy conservation, daylighting, passive solar, active solar, and photovoltaic technologies in systematic design processes.

In addition, the objective of the Task is to ensure that the buildings promote sustainable development. This is done by including considerations of other resource use and of local and global environmental impact in the trade-off analyses to be carried out.

### Scope

The work primarily focuses on commercial and institutional buildings, as these types of buildings clearly need several types of systems. In particular, office buildings and educational buildings are addressed. The same issues are relevant for many other commercial and institutional buildings. However, some of these, such as for instance hospitals, require rather specialized design teams and would broaden the scope of the Task tremendously. They are therefore excluded from the Task in order to ensure concentration and focus in the work carried out.

## Means

The work in the Task is divided in four subtasks:

### A: Case stories

Subtask lead country: Denmark

### B: Design process guidelines

Subtask lead country: Switzerland

### C: Methods and tools for trade-off analysis

Subtask lead country: USA

### D: Dissemination and demonstration

Subtask lead country:  
Netherlands

Subtask A provides the knowledge base to be used in the development of guidelines, methods, and tools in Subtasks B and C, while Subtask D ensures that the results of the work are disseminated to the appropriate audiences.

## Duration

The Task entered into force on June 1, 1997 and will last five years, until June 1, 2002.

## ACTIVITIES DURING 1998

### Subtask A: Case Stories

The main objective of Subtask A is to provide the knowledge needed in the development of guidelines, methods, and tools, which will be developed in Subtasks B and C. This is done by evaluating and documenting a set of buildings designed using the "whole building approach." Both the particular processes used in the design of the buildings and the resulting building performances are evaluated.

The work in the Subtask is successfully nearing conclusion with the

This view of the south west side of the German office building in Gniebel shows the overhanging roof and thermally separated balconies which serve as permanent shading devices. Solar heat loads as well as glare is minimized by this wide overhang and the sun-path is optimized by the orientation of all openings. The atrium is sun protected by a moveable shade.



used are integral parts of the whole.

The work in the Subtask is now gaining momentum. As stated above, the objective of the Subtask is to develop guidelines for how to carry out integrated design processes rather than guidelines for how to choose between different strategies and technologies during these design processes. (The latter is the objective of Subtask C.)

production of two documents based on these studies. The final draft of the Working Document on Case Stories, which includes descriptions of a total of 20 buildings, has been completed and distributed. As the document contains valuable information, the Task participants have decided that it will be made into an IEA Technical Report. This way, it will be available to a wider audience.

The buildings in the Working Document also have been evaluated for the purpose of selecting a set of buildings to present in the Subtask D booklet: "Good examples of integrated solar design." As the purpose of the examples is to serve as a source of inspiration, it is important that they demonstrate both attractive architecture and the use of solar energy. They should be built, have good performance (low energy use, good indoor climate, satisfied users, etc.) and represent different building types and different climates. At the same time, they should also offer insight into design process issues. Using these criteria, an initial set of

five "good examples" has been selected for inclusion in the booklet.

#### Subtask B: Design Process Guidelines

The main objective of Subtask B is to develop design process guidelines suitable for the early stages of design, as the integrated design approach is particularly important in these stages. The guidelines will both deal with the make up of and the interaction between members of the design team, with the information required by the team, and with the ways of designing the building as a system, where the different low energy and solar technologies to be

This ecological primary school in Münchendorf, Austria meets high standards for indoor climate and use of nonpolluting materials. The solar technologies include a 16 m<sup>2</sup> solar collector on the gym to supply hot water for the showers and daylighting through the high share of southern windows and roof windows. The windows light transmission is 76%, total energy transmission is 60%.

#### Subtask C: Methods and Tools for Trade-off Analysis

The main objective of Subtask C is to develop methods and tools to be used by the designers when doing trade-off analyses between different low energy and solar technologies. As designers, builders, and owners optimize against a large number of criteria, such as energy use, comfort, cost, aesthetics, environmental impact, etc., it is assumed that there is a need for both a computer-based tool that can optimize against a relatively limited set of criteria and a more complex, multi-criteria decision making tool that will enable the designers to do more general and, therefore, less detailed optimizations.

The two surveys that form part of



the basis of the work in the Subtask have been completed. One describes relevant existing computer tools, the other one describes and discusses existing multi-criteria decision making methods.

Based on the survey of tools and on presentations and discussions of a few candidate tools at Experts Meetings, the Task participants have decided that the computer program Energy 10 shall be developed into a Task 23 tool. The work of incorporating climate data, default values, and solar technologies of special relevance to Task 23 in the next version of Energy 10 has started.

In parallel with this, the Subtask C working group on multi-criteria decision making methods has developed a framework for a Task 23 m.c.d.m. method, and the Task participants have selected the set of decision making criteria to include in this method.

#### **Subtask D: Dissemination and Demonstration**

The main objective of Subtask D is to disseminate the results of the Task's work to the building community. For architects and engineers designing low energy and solar buildings it is assumed that dissemination through workshops, seminars, and design competitions will be particularly effective. For builders, owners, and occupants it is assumed that demonstration buildings will be most effective.

A strategy for Task workshops has been developed, and plans for testing the strategy have been made

The Yamashi Institute of Environmental Sciences is to serve as a model for environmental conscious buildings. This Japanese building is located at the northern skirt of Mt. Fuji. The solar technologies include a combination of 170m<sup>2</sup> of PV panels and 1,060m<sup>2</sup> of solar air collectors on the roof.



(see *Work Planned for 1999*). Initial discussions on strategies for competitions and for developing demonstration buildings have also taken place. A survey of the participants' plans for demonstration buildings indicates that most of the participants are intending to build demonstration buildings, but that plans are not yet finalised. They have therefore all been encouraged to look into the concrete possibilities for such projects as finding sites, clients, and funding clearly is a long process.

#### **General**

The Task was presented at the ASES conference in the USA in June, at the Eurosun '98 conference in Slovenia in September, and at the Green Building Challenge '98 conference in Canada in October. Several of the Task 23 case story buildings also have been presented separately at the GBC '98 conference.

At the Green Building Challenge conference, it became clear that there are many similarities between Task 23 and the Green Building Challenge (GBC) and that the work in the two projects are mutually beneficial. The case study buildings in the GBC provide useful information

for Task 23, as does their work on sustainability issues. (The GBC mainly focuses on issues other than energy and on assessment tools rather than on design tools.) Several Task 23 participants also participate actively in GBC, so exchange of information is quite easy. The Operating Agent and the Canadian participant, who is also co-coordinator of the GBC, are developing plans for even closer cooperation in the future.

#### **Summary of Work to Date Subtask A:**

- A final draft of the Working Document on Case Stories has been produced and distributed.
- The case story buildings to be presented in the booklet on good examples have been selected.

#### **Subtask B:**

- The design processes used in the design of the case story buildings have been documented and evaluated.
- A survey of existing design process guidelines has been conducted.
- The elements to be included in a Task 23 design process guideline have been identified.



#### Subtask C:

- The survey of computer tools has been completed and the results have been compiled.
- The computer programs ALLSOL, TRNSYS, and Energy 10 have been presented.
- Energy-10 has been selected for further development as a Task 23 tool.
- The survey of multi-criteria decision making methods has been completed and the results have been compiled.
- The decision making criteria to be used in the methods and tools to be developed in the Task have been selected.

#### Subtask D:

- Slide sets of the case story buildings have been distributed.
- A strategy on Task 23 workshops has been developed.
- Plans for the first Task 23 workshop have been finalised.
- More concrete plans for the demonstration building projects and the design competition(s) have been developed and discussed.

#### General:

- Two experts meetings have been conducted.
- A number of group meetings have been conducted.
- A Task 23 brochure has been produced and distributed.

#### WORK PLANNED FOR 1999

In 1999, the work in Subtask A will slow down, while the work in Subtasks B and C will gain momen-

tum. Within these Subtasks, the first versions of the guidelines, methods, and tools will be produced. These will be tested in two workshops to be arranged in conjunction with the two 1999 Experts Meetings. The first will be an internal workshop for the Task participants who are architects, energy consultants and researchers. They will be given a concrete design problem to solve, using the very first versions of the Task 23 guidelines and tools. The second workshop, to be arranged in the fall, will be open to invited participants from the design community in Austria, the host country for the fall experts meeting. Both workshops are expected to give good feedback on the effectiveness of the workshop strategy as well as on the capability of the guidelines and tools.

The work in Subtask D will also gain momentum, both with the workshop activities and with the production of the booklet on good examples.

#### Summary of Work Planned

- The Working Document on Case Stories will be made into a Technical Report.
- A document presenting the design processes used in the design of the Case Story buildings in a graphical format will be produced.
- Typical national design processes used in the participating countries will be documented.
- An "idealised" design process to use in Task 23 will be developed.
- An Energy 10 library of Task 23 default values will be produced.
- The work on making Energy 10 into a Task 23 tool will continue.

- The initial framework for a Task 23 multi-criteria decision making method will be tested.
- Two Task 23 workshops will be conducted.
- Plans for demonstration buildings will be developed.
- The Task 23 Booklet on *Good Examples of Integrated Solar Design* will be produced.

#### REPORTS PUBLISHED IN 1998

*The Integration of Solar Energy Systems in Architecture: Experiences from the Work in the IEA Solar Heating and Cooling Programme*, Proceedings of EuroSun'98, Portoroz, Slovenia, 1998.

*The Optimization of Solar Energy Use in Large Buildings: IEA Task 23*, Proceedings of GBC'98, Vancouver, Canada, 1998.

#### MEETINGS IN 1998

##### Second Experts Meeting

March 2-4

Amsterdam, The Netherlands

##### Third Experts Meeting

October 22-24

Vancouver, Canada

#### MEETINGS PLANNED FOR 1999

##### Fourth Experts Meeting

March 1-3

Toledo, Spain

##### Fifth Experts Meeting

October

Vienna, Austria

**TASK 23 NATIONAL CONTACT  
PERSONS**

**Operating Agent**

Anne Grete Hestnes  
Department of Building Technology  
NTNU-Gløshaugen  
N-7034 Trondheim  
Norway

**Austria**

Susanne Geissler  
Österreichisches Ökologie-Institut  
Seidengasse 13  
A-1070 Wien

**Canada**

Nils Larsson  
Canmet Energy Technology Centre  
13/F, 580 Booth St.  
Ottawa, KIA 0E4

**Denmark**

Torben Esbensen  
Esbensen Consulting Engs.  
Møllegade 54-56  
DK-6400 Sønderborg

**Finland**

Jyri Nieminen  
VTT Building Technology  
P.O. Box 1804  
FIN-02044 VTT

**Germany**

Günter Löhnert  
SOLID.AR  
Kolonnenstrasse 26  
D-10829 Berlin

**Japan**

Mitsuhiro Udagawa  
Department of Architecture  
Kogakuin University  
1-24-2 Nishi-Shinjuku, Shinjuku-ku  
Tokyo 163-91

**Netherlands**

Bart Poel  
Damen Consultants  
Box 694  
NL-6800 AR Arnhem

**Spain**

Luis Alvarez-Ude Cotera  
A.U.I.A., c/Papa Negro 41B  
Parque Conde de Orgaz  
E-28043 Madrid

**Sweden**

Maria Wall  
Department of Building Science  
Lund University  
P.O. Box 118  
S-22100 Lund

**Switzerland**

Pierre Jaboyedoff  
SORANE SA  
Route de Châtelard 52  
CH-1018 Lausanne

**United States**

J. Douglas Balcomb  
National Renewable Energy  
Laboratory  
1617 Cole Blvd.,  
Golden, Colorado 80401

# TASK 24: Solar Procurement

Hans Westling  
Promandat AB  
Operating Agent for the Swedish  
Council for Building Research

## TASK DESCRIPTION

As a result of a number of Working Group meetings during the Project Definition Phase, a Concept Paper, Draft Annex, Work Plan and Information Plan were formulated. The decision in principle to start Task 24 was approved by the Executive Committee meeting in November 1997. After the Draft Annex ballot procedure during the first months of 1998, the Annex official start date – 1 April 1998 – was approved by the Executive Committee meeting in May 1998. Thus, the task entered into force on 1 April, 1998, and will last for five years, until 31 March, 2003.

## Objectives

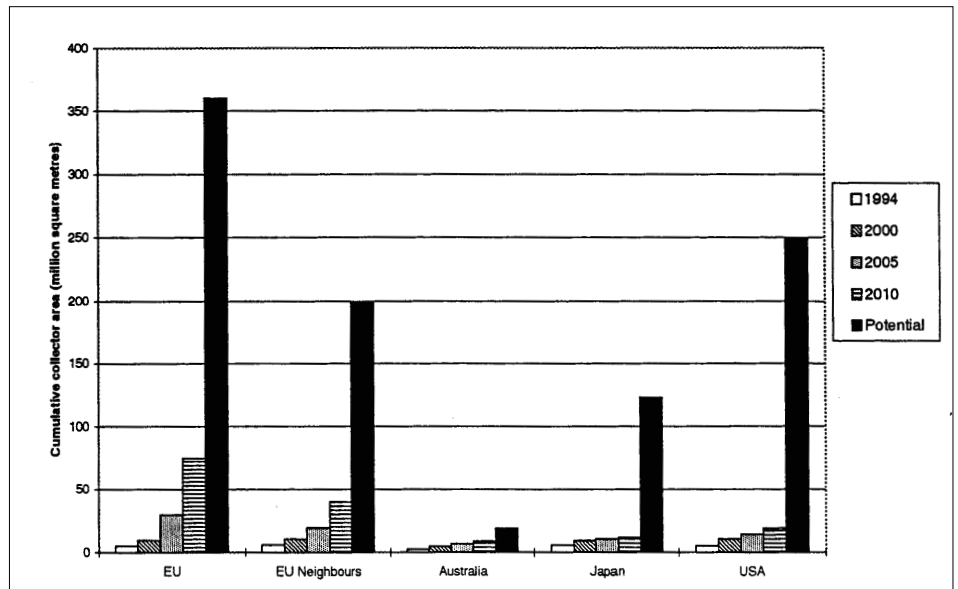
The main objective of Task 24 is to create a sustainable, enlarged market for active solar water heating systems (mainly domestic systems).

This will be done by major cost and

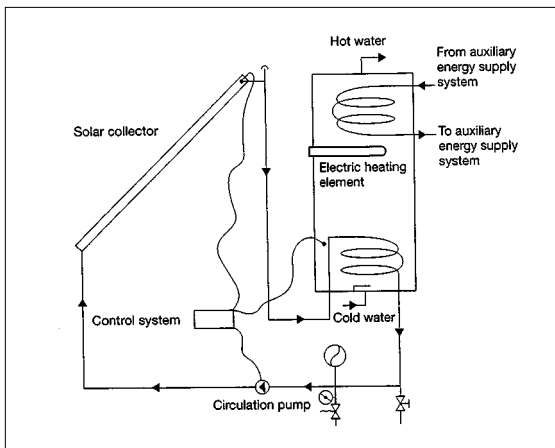
price reductions for all cost elements, including marketing and installation, as well as performance improvements and joint national and international purchasing.

## Scope

The work focuses on the identification of buyers and on forming national buyer groups. Interested buyers include electric and gas utilities, housing manufacturing companies, housing associations, developers, holiday centres, municipalities and country councils. Work on a national level aims at creating a dialogue with suppliers, such as manufacturers, installers, retailers and distributors, and at contacts with national branch organisations. The procurement activities will consist of two rounds: the first with smaller projects and a low degree of joint international collaboration, and the second with larger projects and a higher degree of collaboration.



Expected solar collector market growth and solar heating potential (based on 1m<sup>2</sup> of collector area per inhabitants).



Typical North American single family domestic solar hot water system.

chapters summarise nine "cases documenting experiences marketing renewable energy technologies in the participating countries have been prepared. The experiences from the current work with buyer groups also has been included in the first part of this book.

In the Netherlands, buyers have been found among utilities and housing associations. They have also encountered an interesting concept of working through leasing of solar collectors and systems. A technical potential also is seen in hotels.

Denmark has identified buyers among housing manufacturing companies, housing associations, holiday centres and utilities. The Swedish buyer groups include utilities, municipalities, county councils, government-owned companies, construction companies, co-operative building organisations, but also chain stores and hotels. Canada has started work on market research and has prepared a web site, as well as begun to identify buyers in electric utilities, gas utilities and builder organisations.

To raise further interest in Task 24, a web site and an information brochure on Task 24 were produced during the year. A full background report was also produced and printed in 1998.

#### WORK PLANNED FOR 1999

The procurement activities within Subtask A will continue with realization of projects and marketing. Work on the *Book of Tools* within Subtask B also will continue.

#### Means

The work in Task 24 is divided into two Subtasks, each coordinated by a lead country:

#### Subtask A: Procurement and Marketing

(The Netherlands)

#### Subtask B: Creation of Tools

(Denmark)

The objectives of Subtask A are:

- to raise interest in active solar thermal solutions
- to form buyer groups to purchase state-of-the-art and innovative systems

The objectives of Subtask B are:

- to collect, analyse and summarise experience
- to create tools to facilitate the creation of buyer groups and the realisation of projects and procurements. These tools will be included in a manual: "Book of Tools"
- to define a process for prototype testing and evaluation, using existing methods

#### Participation

Four countries have joined the Task: Canada, Denmark, the Netherlands and Sweden. Other countries are welcome to join the Task during the first year. Interested countries include Switzerland, United Kingdom and United States.

#### ACTIVITIES DURING 1998

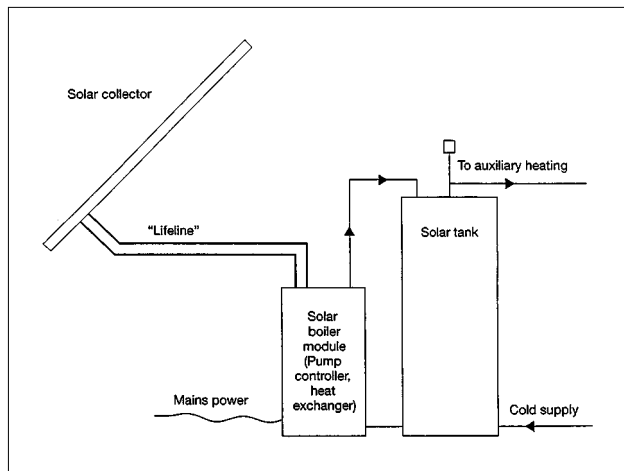
Task 24 has only been active for part of the year, and therefore work has just begun.

Work with tentative lists of participants for the national buyer groups was started during the year. Meetings with interested buyers have been held in the various countries, and study tours have been arranged.

Documents for use in supplier contacts have been prepared, for example, the memo "Supplier Involvement" drawn up by the Operating Agent and a draft model letter produced by Canada and the Netherlands.

Work of the first four chapters of the *Book of Tools* was started. These

Typical European single family domestic solar hot water system.



In Denmark, information meetings will be held with buyers, and specialists from the Netherlands will also participate. One area of interest will be the combination of solar with biomass or gas. In Sweden, the challenge will be to change from direct electricity to other solutions, including some sort of district heating. A particular change will then be combinations with solar. Canada will conduct a market research that will also be of use to the other participating countries.

The dialogue with suppliers will continue on the national level, and the National Coordinators will initiate contacts with national branch organisations. Contacts also will be made with organisations and manufacturers of similar products for renewable energy.

The image of the solar procurement project will be further worked on in order to make it clear what is offered to the buyers. An important focus will be the service as well as the whole procurement concept.

There will be special Subtask meet-

ings and meetings with interested buyers in all the participating countries. Follow-up contacts will be made with countries that have, or may express, an interest in Task 24. Efforts will be made to include some of the interested countries mentioned above, as well as Austria, with all its self-building activities, and Germany, where a large market exists.

#### REPORTS PUBLISHED IN 1998

*Opportunities for Large-Scale Purchase of Active Solar Systems* is the first official report of Task 24. It was produced in collaboration with CADDET in the United Kingdom.

*Large Scale Solar Purchasing – A Business Opportunity* is a 4-page Task 24 information brochure and was also produced in collaboration with CADDET. It has been widely distributed by the Task Experts.

Full information about Task 24 can also be found on the Task 24 Website ([www.ieatask24.org](http://www.ieatask24.org)) which was produced by Canada.

**Paper and poster presentations**  
Several papers, presentations and posters of Task 24 work were presented at various national and international conferences, such as the Sonnenforum 1998 in Germany and EuroSun '98 Congress in Slovenia.

#### REPORTS PLANNED FOR 1999

Continuation of the preparatory work on the *Book of Tools* and the publication of the first version at the end of the year. This report will be updated during the following years.

#### MEETINGS IN 1998

##### First Experts Meeting

April 6-7  
Stockholm, Sweden

##### Second Experts Meeting

September 10-11  
The Netherlands

#### MEETINGS PLANNED FOR 1999

##### Third Experts Meeting

April 20-23  
The Netherlands

(A Buyer Group Meeting is planned to take place in conjunction with this meeting.)

##### Fourth Experts Meeting

August 16-18  
Canada

## LINKS WITH INDUSTRY

The importance of a dialogue with suppliers (including manufacturers, installers, retailers and distributors) has been stressed, starting on a national level. There have been meetings and presentations of Task 24 during the autumn of 1998, including the SEAS Conference in October in Sweden, and at meetings with different representatives in The Netherlands, Denmark and Canada. An international supplier meeting also is planned in connection with the "World Sustainable Energy Trade Fair" in the Netherlands in May 1999.

**TASK 24 NATIONAL CONTACT PERSONS**

**Operating Agent**

Hans Westling  
Promandat AB  
P.O. Box 24205  
SE-104 51 Stockholm  
Sweden

**Canada**

Peter Allen  
Dalhousie University  
DalTech  
P.O. Box 1000  
Halifax, Nova Scotia, B3J 2X4

Michael Noble  
EnerWorks  
280 Cheapside Street  
London, Ontario, N6A 2A2

Gerald Van Decker  
Active Solar Energy Technologies  
Natural Resources Canada  
580 Booth Street, 13th Floor  
Ottawa, Ontario, K1A 0E4

**Denmark**

Klaus Ellehaug  
DTI, Danish Technological Institute  
Solar Energy Laboratory  
Teknologiparken  
DK-8000 Aarhus C

Torben Esbensen  
Esbensen Consultants  
Mollegade 54-56  
DK-6400 Sonderborg

Lisbet Holst  
Esbensen Consultants  
Haderslevvej 6  
DK-6200 Aabenraa

Trine Jacobsen  
DTI, Danish Technological Institute  
Solar Energy Center Denmark  
Gregersensvej, Postbox 141  
DK-2630 Taastrup

Jan Erik Nielsen  
DTI, Danish Technological Institute  
Solar Energy Laboratory  
P.O. Box 141  
DK-2630 Taastrup

**Netherlands**

Maike Fernhout  
Ecofys Research and Consultancy  
P.O. Box 8408  
NL-3503 RK Utrecht

Peter Out  
Ecofys Research and Consultancy  
P.O. Box 8408  
NL-3503 RK Utrecht

**Sweden**

Jan-Olof Dalenbäck  
Chalmers University of Technology  
Building Services Engineering  
SE-412 96 Gothenburg

Hans Isaksson  
K-Konsult Stockholm  
P.O. Box 47044  
SE-100 74 Stockholm

Bengt Ridell  
Sydkraft Konsult AB  
Carl Gustavs vag 4  
SE-205 09 Malmoe

Mats Rydehell  
KanEnergi Sweden AB  
P.O. Box 41  
SE-532 21 Skara

Heimo Zinko  
ZW Energiteknik AB  
P.O. Box 137  
SE-611 23 Nykoping

# Working Group on Materials in Solar Thermal Collectors

Michael Köhl  
Fraunhofer Institute for  
Solar Energy Systems  
Working Group Leader for  
Fraunhofer Institute

## WORKING GROUP DESCRIPTION

The Working Group was established in the autumn of 1994 as an extension of work conducted on solar collector absorbers in Subtask B of Task 10, Solar Materials R&D.

The objectives of the Working Group are:

- To develop or validate durability test procedures for solar collector materials.
- To generalize test procedures for standardization.
- To develop guidelines for solar collector design to achieve the most favorable microclimate conditions for materials.

The following areas have been identified for joint research work:

- Durability and life-time assessment of solar absorber coatings.
- Antireflecting devices for solar thermal applications.
- Methods for characterization of microclimate for materials in collectors.
- Durability aspects on the use of polymeric materials in solar collecting devices.

In each of these areas a number of well defined projects are being conducted. The activities of the Working Group were initiated in October 1994 and concluded in October 1998. The leadership of the working group was handed from Bo Carlsson (Sweden) to Michael Köhl (Germany) according to a respective agreement at the start of the work.

## ACTIVITIES DURING 1998

- A: Durability and Life-time Assessment of Solar Absorber Coatings

Project A5: Due to the growing interest in evacuated collectors, a new project was initiated to develop durability test methods according to the appropriate degradation factors and load profiles, taking into account the geometry of the absorbers and the application of CPC-mirrors, in particular.

- B: Antireflecting Devices for Solar Thermal Applications

Project B1: A cost benefit analysis for the application in solar-thermal collectors and green-houses of the materials selected was carried out.

Project B2: Accelerated tests for durability assessment of materials were started, and samples of iron-free glass and PMMA with anti-reflected surfaces as well as PVC and APEC samples for comparison were exposed for outdoor-tests.

- C: Methods for Characterization of Microclimate for Materials in Collectors

Project C1: A round robin test on test procedures for the assessment of rain tightness and air tightness of collectors was initiated in the autumn of 1995. These procedures were worked out in detail. A second Round Robin test was conducted for a selected collector in order to compare compare and validate the test procedure.



Project C2: Two different approaches for the simulation of ventilation and condensation in flat plate collectors were developed. Both the Danish model, based on an analytical physical model, and the German approach, based on numerical computational fluid dynamics, showed very good agreement with measured data. The Danish model has been refined with respect to user comfort and compatibility to MicroSoft Windows environments.

Project C4: The measurement of microclimate parameters in collectors started in June 1996 at outdoor test facilities and was finished in June 1997. Work continues on the evaluation and interpretation of the data.

#### **LINKS WITH INDUSTRY**

All participants of the Working Group work closely with solar material and solar collector manufacturers, therefore, many industry representatives participate indirectly in the work being undertaken. There are also informal links to industry via the ongoing standardization work on solar collector and solar collector materials in CEN TC 312 and in ISO TC 180. Efforts also have been made to establish a liaison with CEN 312 in the area of solar collector materials.

#### **REPORTS PUBLISHED**

A list of working documents can be obtained from the Working Group Leader on request.

#### **1998 MEETINGS**

##### **Seventh Experts Meeting**

April 22-23

Uppsala, Sweden

##### **Eighth Experts Meeting**

October 8-9, 1998

Unterwasser, Switzerland

(This meeting was held in conjunction with a task planning workshop for a follow-up Task on SHC Programme work on advanced glazings and this Working Group's results.)

#### **1999 MEETINGS**

##### **Ninth Experts Meeting**

March 21-22

Freiburg, Germany

(This meeting will be held in conjunction with a task definition workshop for Task 29.)

**WORKING GROUP NATIONAL CONTACT  
PERSONS**

**Working Group Leader**

Michael Köhl  
Fraunhofer Institute for Solar Energy  
Systems ISE  
Oltmannsstrasse 5  
D-79100 Freiburg  
Germany

**Denmark**

Svend Svendsen and Ole Holck  
Thermal Insulation Laboratory  
Technical University of Denmark  
Building 118  
DK-2800 Lyngby

**Germany**

Markus Heck  
Fraunhofer Institute for Solar Energy  
Systems ISE  
Oltmannsstrasse 5  
D-79100 Freiburg

**Netherlands**

Aart de Geus and Henk Oversloot  
Building and Construction Research  
TNO  
P.O. Box 29  
NL-2600 Delft

**Sweden**

Bo Carlsson and Kenneth Möller  
Materials Technology  
Swedish National Testing and  
Research Institute  
P.O. Box 857  
S-50115 Boras

Arne Roos  
Department of Technology  
Uppsala University  
Box 534  
S-75121 Uppsala

**Switzerland**

Ueli Frei and Stefan Brunold  
Solarenergie Prüf- und  
Forschungsstelle, Schweiz  
Postfach 14 75  
CH-8640 Rapperswil

**United States**

Gary Jorgensen  
National Renewable Energy  
Laboratory  
1617 Cole Boulevard  
Golden, Colorado 80401

# IEA Solar Heating and Cooling Address List

## Executive Committee Members

### AUSTRALIA

Prof. John Ballinger  
Solar Efficient Architecture  
P.O. Box 97  
Kangaroo Valley  
NSW 2577  
Tel: + 61/2/4465 1212  
Fax: +61/2/4465 1217  
e-mail: jiliby@shoalhaven.net.au

### AUSTRIA

Prof. Gerhard Faninger  
c/o Universität Klagenfurt, IFF  
Sterneckstraße 15  
A-9020 Klagenfurt  
Tel: +43/463/2700 721  
Fax: +43/463/2700 759  
e-mail: gerhard.faninger@uni-klu.ac.at

### BELGIUM

Prof. André De Herde  
Architecture et Climat  
Université Catholique de Louvain  
Place du Levant, 1  
B-1348 Louvain-la-Neuve  
Tel: +32/10/47 21 42  
Fax: +32/10/47 21 50  
e-mail: deherde@arch.ucl.ac.be

### CANADA

Mr. Doug McClenahan  
(*Vice-Chairman*)  
CANMET - Natural Resources  
Canada  
580 Booth Street  
Ottawa, Ontario K1A 0E4  
Tel: +1/613/996 6078  
Fax: +1/613/996 9416  
e-mail: dmcclena@nrcan.gc.ca

### DENMARK

Mr. Jens Windeleff  
Danish Energy Agency  
Amaliegade 44  
DK-1256 Copenhagen K  
Tel: +45/33/92 75 56  
Fax: +45/33/11 47 43  
e-mail: jew@ens.dk

### Alternate

Mr. Poul E. Kristensen  
Danish Technological Institute, Energy  
Gregersensvej  
P.O. Box 141  
DK-2630 Taastrup  
Tel: +45/43/50 45 84  
Fax: +45/43-50 72 22  
e-mail: poul.kristensen@dti.dk

### EUROPEAN COMMISSION

Dr. Georges Deschamps  
Commission of the European Union  
(DG-XII)  
Rue de la Loi 200  
B-1049 Brussels, BELGIUM  
Tel: +32/2/295 1445  
Fax: +32/2/299 3694  
e-mail:  
georges.deschamps@dg12.cec.be

### FINLAND

Prof. Peter D. Lund  
Helsinki University of Technology  
Department of Physics and  
Mathematics  
Rakentajanaukio 2 C  
FIN-02150 Espo0  
Tel: +358/9/451 3197 or  
+358/9/451 3218  
Fax: +358/9/451 3195  
e-mail: peter.lund@hut.fi

**FRANCE**

Mr. Yves Boileau  
French Agency for the Environment  
and Energy Management  
(ADEME)  
500 Route des Lucioles -  
Sophia Antipolis  
F-06565 Valbonne Cedex  
Tel: +33/4/93 95 79 11  
Fax: +33/4/93 95 79 87  
e-mail: yves.boileau@ademe.fr

**GERMANY**

Dr. Volkmar Lottner  
Forschungszentrum Jülich - BEO  
D-52425 Jülich  
Tel: +49/2461/61 48 79  
Fax: +49/2461/61 31 31  
e-mail: v.lottner@FZ-Juelich.de

**ITALY**

Dr. Paolo Zampetti  
Division of Systems for Energy  
Conservation  
ENEA  
Via Anguillarese 301  
I-00060 S. Maria di Galeria (Rome)  
Tel: +39/6/3048 3414  
Fax: +39/6/3048 6315  
e-mail: zampetti@casaccia.enea.it

**JAPAN**

Mr. Katsuhiko Masuda  
RNE Development Program,  
New Sunshine Program Promotion  
Headquarters  
AIST, MITI  
Chiyoda-ku Kasumigaseki 1-3-1  
Tokyo 100-8921  
Tel: +81/3/3501 9471  
Fax: +81/3/3501 9489  
e-mail: mkab1923@miti.go.jp

**NETHERLANDS**

Mr. Lex Bosselaar  
(Chairman)  
NOVEM b.v.  
P.O. Box 8242  
3503 RE Utrecht  
(Street address: Catharijnesingel 59)  
Tel: +31/30/239 34 95  
Fax: +31/30/231 64 91  
e-mail: L.Bosselaar@novem.nl

**NEW ZEALAND**

Mr. Michael Donn  
School of Architecture  
Victoria University of Wellington  
P.O. Box 600  
Wellington 1  
Tel: +64/4/802 6221  
Fax: +64/4/802 6204  
e-mail: michael.donn@vuw.ac.nz

**NORWAY**

Mr. Fritjof Salvesen  
Norwegian Research Council  
c/o KanEnergi AS  
Baerumsveien 473  
1351 Rud  
Tel: +47/67 15 38 53  
Fax: +47/67 15 02 50  
e-mail: fritjof.salvesen@kanenergi.no

**SPAIN**

Mrs. Maria Luisa Delgado  
Head of Renewable Energy  
Department  
CIEMAT  
Avda/Complutense, nN 22  
28040 Madrid  
Tel: +34-1-346-60-60  
Fax: +34-1-346-60-37  
e-mail: luisa.delgado@ciemat.es

**SWEDEN**

Mr. Conny Rolén  
(Vice-Chairman)  
Swedish Council for Bldg. Research  
Box 12866  
S-112 98 Stockholm  
Tel: +46/8/617 7369  
Fax: +46/8/653 7462  
e-mail: conny.rolen@bfr.se

**SWITZERLAND**

Mr. Urs Wolfer  
Federal Office of Energy  
Monbijoustrasse 74  
CH-3003 Berne  
Tel: +41/31/322 56 39  
Fax: +41/31/323 25 00  
e-mail: urs.wolfer@bew.admin.ch

**UNITED KINGDOM**

Dr. Peter Mallaburn  
Energy and Environmental Market  
Innovation Division  
DETR  
Floor 6/E5, Ashdown House  
123 Victoria Street  
London SW1E 6DE  
Tel: +44/171/890 6558  
Fax: +44/171/890 6619  
e-mail:  
pmallaburn@eemd.demon.co.uk

**Alternate**

Dr. Earle Perera  
BRE  
Bucknalls Lane  
Garston, Watford  
Herts WD2 7JR  
Tel: +44/1923/664486  
Fax: +44/1923/664796  
e-mail: pererae@bre.co.uk

## UNITED STATES

Ms. Mary-Margaret Jenior  
U.S. Department of Energy  
Office of Building Technology, State  
and Community Programs  
Mail Stop EE-41  
1000 Independence Ave. S.W.  
Washington, D.C. 20585-0121  
Tel: +1/202/586-2998  
Fax: +1/202/586-1628  
e-mail:  
mary-margaret.jenior@ee.doe.gov

## OPERATING AGENTS

### Task 19/Task 28 Organizer

Mr. Robert Hastings  
Solararchitektur  
ETH Honggerberg  
CH-8093 Zurich, SWITZERLAND  
Tel: +41/1/633-2988  
Fax: +41/1/633-1169  
e-mail: h Hastings@orl.arch.ethz.ch

### Task 20

Prof. Arne Elmroth  
Dept. of Building Physics  
Lund University  
Box 118  
S-221 00 Lund, SWEDEN  
Tel: +46/46/222 4645  
Fax: +46/46/222 4535  
e-mail: arne.elmroth@byggtek.lth.se

### Task 21

Mr. Kjeld Johnsen  
Danish Building Research Institute  
P.O. Box 119  
DK 2970 Høsholm  
Copenhagen, DENMARK  
Tel: +45/45/86 55 33  
Fax: +45/45/86 75 35  
e-mail: kjj@sbi.dk

### Task 22

Mr. Michael J. Holtz  
Architectural Energy Corporation  
2540 Frontier Avenue, Suite 201  
Boulder, CO 80301 USA  
Tel: +1/303/444-4149  
Fax: +1/303/444-4304  
e-mail: mholtz@archenergy.com

### Task 23

Prof. Anne Grete Hestnes  
Faculty of Architecture  
Norwegian University of Science  
and Technology  
N-7034 Trondheim, NORWAY  
Tel: +47/73/59 50 37  
Fax: +47/73/59 50 45  
e-mail:  
annegrete.hestnes@ark.ntnu.no

### Task 24

Dr. Hans Westling  
Promandat AB  
Box 24205  
S-104 51 Stockholm, SWEDEN  
Tel: +46/8/667 80 20  
Fax: +46/8/660 54 82  
e-mail: hans.westling@promandat.se

### Task 25

Dr. Hans-Martin Henning  
Fraunhofer Institute for Solar Energy  
Systems  
Oltmannsstrasse 5  
D-79100 Freiburg, GERMANY  
Tel: +49/761/4588 134  
Fax: +49/761/4588 132  
e-mail: hansm@ise.fhg.de

### Task 26

Mr. Werner Weiss  
Arbeitsgemeinschaft ERNEUERBARE  
ENERGIE (AEE)  
Feldgasse 19  
A-8200 Gleisdorf, AUSTRIA  
Tel: +43/3112/5886 17  
Fax: +43/3112/5886 18  
e-mail: w.weiss@aee.at

### Task 27 Organizer

Prof. Mick Hutchins  
School of Engineering  
Oxford Brookes University  
Gipsy Lane Campus  
Headington, Oxford OX3 OBP, U.K.  
Tel: +44/1865/48 36 04  
Fax: +44/1865/48 42 63  
e-mail: mhutchins@brookes.ac.uk

## WORKING GROUPS

### Materials For Solar Thermal Collectors/Task 27 Organizer

Mr. Michael Köhl  
Fraunhofer Institute for Solar  
Energy Sytems  
Oltmannsstr. 5  
D-79 100 Freiburg, GERMANY  
Tel: +49/761 4016682  
Fax: +49/761 4016681  
e-mail: mike@ise.fhg.de

### Advanced Solar Low-Energy Dwellings

Dr. Bjarne Saxhof  
Department of Buildings and Energy  
Building 118, DTU  
DK-2800 Lyngby, DENMARK  
Tel: +45/45 251891  
Fax: +45/45 931755  
e-mail: lfvbs@dtu.dk

**EXECUTIVE SECRETARY**

Ms. Pamela Murphy Kunz  
Morse Associates, Inc.  
1808 Corcoran Street, NW  
Washington, DC 20009, USA  
Tel: +1/202/483 2393  
Fax: +1/202/265 2248  
e-mail:  
pmurphykunz@compuserve.com

**ADVISOR**

Dr. Frederick H. Morse  
Morse Associates, Inc.  
1808 Corcoran Street, N.W.  
Washington, DC 20009, USA  
Tel: +1/202/483 2393  
Fax: +1/202/265 2248  
e-mail: fredmorse@compuserve.com

**IEA SECRETARIAT LIAISON**

Mr. Mel Kliman  
International Energy Agency  
9 rue de la Fédération  
75739 Paris Cedex 15, FRANCE  
Tel: +33/1/40 57 6785  
Fax: +33/1/40 57 6759  
e-mail: kliman@iea.org

**SHC INTERNET SITE**

<http://www.iea-shc.org>