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IEA Solar Heating & Cooling Program

1994 Annual Report

with a feature article on "Smart Windows"

Edited by

Sheila Blum

Secretary

IEA Solar Heating and Cooling Program

International Planning Associates
807 Caddington Ave.
Silver Spring, MD 20901
USA

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Background

The International Energy Agency 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 23 member countries. The European Commission also participates in the work of the Agency.

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

The Solar Heating and Cooling Implementing Agreement was one of the first collaborative R&D programs to be established within the IEA, and, since 1977, its Participants have been conducting a variety of joint projects in active solar, passive solar and photovoltaic technologies, primarily for building applications. The overall program is monitored by an Executive Committee consisting of one representative from each of the member countries. The leadership and management of the individual Tasks (projects) are the responsibility of Operating Agents.

Current Tasks

A total of twenty projects or "Tasks" have been undertaken since the beginning of the Solar Heating and Cooling Program. The Tasks which were active in 1994 and their respective Operating Agents are:

Task 12: Building Energy Analysis and Design Tools for Solar Applications - United States
Task 13: Advanced Solar Low Energy Buildings - Norway
Task 14: Advanced Active Solar Systems - Canada
Task 16: Photovoltaics in Buildings - Germany
Task 17: Measuring and Modeling Spectral Radiation - Germany
Task 18: Advanced Glazing Materials - United Kingdom
Task 19: Solar Air Systems - Switzerland
Task 20: Solar Energy in Building Renovation - Sweden
Task 21: Daylighting in Buildings - Denmark (In Project Definition Phase)

Member Countries

The twenty members of the IEA Solar Heating and Cooling Program are:

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

Dr. Bruce Godfrey
Energy Research and Development Corp.
Australia

Introduction

As the reader will be able to tell from the reports of the individual Tasks, 1994 was a productive year for the IEA Solar Heating and Cooling Program. It was also a year of endings and beginnings: Task 17 (Measuring and Modeling Spectral Radiation) completed its work with some impressive accomplishments, and we sadly said goodbye to Dr. Fritz Kasten, who served as Operating Agent of Task 9 as well as Task 17. Task 12 (Building Energy Analysis and Design Tools for Solar Applications) also concluded in 1994, and we thank Michael Holtz, another twice-blessed Operating Agent (Tasks 8 and 12), for his contributions. In addition, the final management report of Task 10 was approved.

New work initiated in 1994 included Task 21 on Daylighting and a new Working Group on Solar Collector Materials. Planning also began on another task on Building Energy Analysis Tools, which will follow up on the work of Task 12.

Each of our annual reports contains a feature article on some aspect of solar technologies for buildings. This year's article deals with "Smart Windows." Thanks to Prof. Michael Hutchins, Oxford Brookes University (UK), for preparing this interesting write-up on advanced glazings, many of which will be commonplace in the buildings of the future.

Highlights of the Tasks and Working Groups

A few notable achievements of 1994 are mentioned below. Details of these and many other accomplishments are found in the individual reports later in this document.

Task 12 - Noteworthy accomplishments include publication of the ADELINE software for daylighting design and completion of simplified models for analyzing thermal comfort and energy use in atria.

Task 13 - Eight experimental solar low energy buildings have been completed and seven are under construction; monitoring results will be of great interest.

Task 14 - Each participating country completed the conceptual design of its solar DHW "dream system," and cost/performance improvements over the base cases range from 23% to 45%.

Task 16 - The design handbook for building-integrated photovoltaics is ready for final editing and a successful architectural design competition for PV buildings was organized.

Task *17 -* A wealth of information on natural daylight is contained in the 3-volume report on broad-band visible radiation data acquisition and analysis: an overview on the activities and results in this field, a systematic documentation of the world network of daylight measuring stations, and 22 individual papers on research by experts in this area.

Task *18 - All* key glazing performance parameters required to specify the nature and quality of a glazing system were identified and defined, providing important product selection information for engineers and designers.

Task 19 - Ten case studies of exemplary solar air-heated buildings have been drafted.

Task 20 - Information on 15 existing solar renovation projects was collected and evaluated with regard to performance, occupant satisfaction, and effectiveness of the renovation to provide lessons, both positive and negative, for future renovation projects.

CSHPSS Working Group - Two documents were published on the technology of central solar heating plants: "CSHPSS Development Guide" and "Meeting the Energy Needs of Buildings in the 21st Century: What Role Can Solar Energy Play?"

New Projects

■ A Project Definition Phase meeting will be held in January 1995 in Seville to plan a new Task on Solar Energy Building Energy Analysis Tools. Work will be in the general areas of analysis tool evaluation, documentation of existing algorithms, analytical tool use case studies. The United States is likely to serve as Operating Agent.

■ Solar Collector Materials Working Group - This activity will deal with durability and lifetime assessment of solar absorber coatings, anti-reflecting devices for solar thermal applications, methods for characterizing microclimate for collector materials, and durability aspects of polymeric materials in solar collectors. Sweden is serving as lead country.

Special Workshops

■ A Workshop on Low Temperature Storage on the specific topic of "The Search for the Universal Tank" will be held February 1995 in San Diego, California. Australia is organizing the workshop.

■ A second workshop on Solar Energy for Utility Demand Side Management will be held in October 1995 in Austria. The BCS, PVPS, and Demand Side Management agreements will be invited to participate.

Management Actions

■ An evaluation process is being established for IEA SHC Tasks. Evaluations will be undertaken at three key points in a Task: Prior to initiation, mid-way in the task, and at the conclusion. A committee of Operating Agents and ExCo members has been formed to draft procedures and questionnaires for the various evaluations.

■ To increase the effectiveness of the Operating Agents' semi-annual status reports to the Executive Committee, the format for the written reports and oral presentations was revised and is being refined.

■ A review of the IEA Solar Heating and Cooling Program's Strategic Plan at the October 1994 Executive Committee meeting seemed to indicate that several recent actions taken by the Executive Committee are evidence of implementation of that Plan.

■ A committee is working on developing a software policy for the IEA SHC Program which will deal with the rights to intellectual property, distribution and licensing requirements and procedures, and other related issues.

■ At the Spring 1994 Executive Committee meeting, I was elected as the new Chairman, succeeding Fritjof Salvesen (Norway); Andre DeHerde (Belgium) and Michael Rantil (Sweden) were elected as Vice Chairmen.

ISES

The next International Solar Energy Society Congress will be held in Harare, Zimbabwe in September 1995. The SHC Program is organizing a half-day workshop in conjunction with the Harare conference for a targeted audience of technicians, architects, builders.

Coordination with Other IEA Agreements

Coordination with the IEA Energy Conservation in Building and Community Systems Agreement (BCS) continues, and, more recently, ties have been established with the new Photovoltaics Power Systems (PVPS) Agreement. To ensure the effectiveness of these interactions, a discussion paper is being prepared on when collaboration makes sense, the form it should take, and how it should be implemented.

Task 21 on Daylighting was approved as a joint Task with the BCS Agreement. It will be managed by the SHC Program. Sorting out of the implementation process is underway. The second joint meeting of the two Executive Committees will take place in October 1995.

The PVPS will undertake some new work in building-integrated PV, and the results of the work on this subject that is being carried out in SHC Task 16 will be transferred to the new PVPS Task. A joint meeting has been held between Tasks 16 and Task 5 to initiate coordination. However, there is clearly a desire within the Solar Heating and Cooling Executive Committee to maintain involvement in the important links between building-integrated PV and building design.

Publications

The following reports were published in 1994 which are not listed elsewhere in the annual report:

IEA Comparisons of Global Solar Radiation Reference Radiometers. L. Liedquist, Swedish National Testing and Research Institute, et al, June 1994. Report #IEA-SHCP-9F-4. (Task 9)

S *Using Pyranometers in Tests of Solar Energy Converters: Step-by-Step Instructions.* Bruce McArthur, Atmospheric Environment Service, Canada, et al., Oct. 1994, Report #IEA-SHCP-9F-1. (Task 9)

S *Glazing Materials for Solar and Architectural Applications.* C.M. Lampert, Lawrence Berkeley Laboratory, editor, Sept. 1994, Report # LBL 34436. (Task 10)

■ *ISOLDE - Integrated Knowledge-Based Solar Design Tool* has been completed by the ISOLDE Working Group.

Acknowledgements

In closing, I would like to thank the Operating Agents and the Working Group Leaders, our Secretary, Sheila Blum, and our Adviser, Dr. Fred Morse, for helping to make 1994 another successful year for the IEA Solar Heating and Cooling Program.

SMART WINDOWS: Recent Advances in the Development and Use of Electrochromic Glazing

Prof. Michael G. Hutchins
Solar Energy Materials Research
Laboratory School of Engineering
Oxford Brookes University, U.K.

Introduction

The ability to vary the quantity of solar radiation passing through a window in response to the needs of the internal environment has long appeared an attractive option for optimising the thermal performance of a building. The twin aims of avoiding overheating during peak periods of solar availability, hence reducing cooling demand, and employing a greater use of glazing area to enhance solar gain during the heating season could in principle be achieved by some form of reversible, variable transmittance window. One might even conceive of the possibility of developing a switchable glazing which modulates thermal emittance, in addition to its solar optical properties, to enable the window heat loss coefficient, or U-value, to be altered in situ. In addition to perceived energy and thermal comfort benefits, controlling the solar gain could enhance visual comfort by reducing glare and, undoubtedly, a window whose appearance can be varied, presents new and exciting opportunities in architectural design.

The past decade has witnessed a rapid growth in research activities in both academic and industrial laboratories in pursuit of the development of what have been termed "smart windows" (1). Many possibilities have been investigated and the potential of a wide range of chromogenic classes of materials have been assessed. In parallel with materials science R&D, design engineers have employed building energy analysis tools to simulate the performance of variable transmission windows in order to identify the most promising applications, predict energy and environmental impacts and test possible control strategies.

This paper presents a review of recent materials advances in the development of smart windows and associated studies addressing their potential use in residential and commercial buildings. The paper focuses particularly on the electrochromic window which has emerged as the most likely candidate for initial use in buildings. There is much evidence to indicate that smart windows are close to commmercialisation and will soon be available in large areas for buildings applications.

Solar Gain Control

Usable solar radiation incident at the Earth's surface comprises ultraviolet, visible and near infrared radiation essentially contained in the wavelength range 0.29 - 2.50 gm. Less than 50% of the total energy lies in the visible and about half of the solar radiation is in the near infrared waveband. The attraction of glass as a building material leads to the construction of many commercial buildings with heavily glazed facades. In many climates, this can result in excessive solar gain with consequent demands for additional air conditioning adding to the cooling load. The conventional means for reducing solar gain in such circumstances is to use tinted or coated glass. Many commercial architectural glazings achieve the attenuation of solar gain by reducing the solar transmittance across the entire range of the incident solar spectral distribution. The effect of this reduction is to boost the need for additional interior lighting and as much as 20% of the total delivered energy in commercial buildings is consumed in meeting the lighting demand. Lighting energy use also adds to the cooling load.

Excessive solar gain can be regulated through the use of passive shading, and such approaches retain the opportunity to maximise the use of solar radiation for daylighting. An ideal solution for daylighting combining with visual comfort and reducing the near infrared transmittance of an architectural glass would be to develop a glazing which allowed all visible light to enter the building while rejecting, preferably by reflection, the near infrared component of the solar radiation. Such a glazing would be characterised by high visible transmittance, T_{vis}, and low solar transmittance, T . Such optical properties are achievable in the laboratory through the use of thin film multilayer coatings, the most researched of which are those based on the oxides and nitrides of titanium (2), and are commonly termed "cold mirrors" or "cool daylighting glazings" because they reject that part of the solar spectrum which only contributes to the heating of the building.

The heating and cooling demands of buildings vary seasonally. The use of a cold mirror may assist in reducing the cooling and lighting demands during the summer periods but, at other times of the year, may also prevent the admission of valuable solar radiation required to reduce the heating demand. Thus the need is established for a glazing whose optical properties can be varied in response to the demands of the building environment. Such a window would operate in a clear state during times when heating is required and be switched to a state of lower transmittance at times when excessive solar gain causes unwanted overheating.

Chromogenic Materials

Materials whose optical properties vary in response to an external stimulus are termed "chromogenic". Most widely known are the photochromic materials which darken in response to the intensity of light incident on the material. The optical properties of thermochromic materials alter with temperature. Electrochromic materials change colour in response to an externally applied electric field.

Opportunities for the use of photochromic materials in the building facade do exist but they are limited by the restricted influence and control that the building environment can exert on such a glazing. The optical properties of photochromic fenestration would in principle be continually changing in response to availability of solar radiation and not in relation to the interior condition and needs of the building.

The optical properties of thermochromic materials alter when the material undergoes a change of phase, i.e. the transmittance is reduced when the material is heated above a critical temperature and melting or a change in crystal structure occurs. Of central importance for the use of such materials in buildings is thus the phase transition temperature. If materials can be developed with transition temperatures close to maximum desirable thermal comfort temperatures, then thermochromic materials may be successfully employed to reduce solar gain. Promising results have been obtained for thermotropic materials which undergo a reversible change between a homogeneous, transparent state at lower temperatures and a heterogeneous, scattering state at higher temperatures (3). Thermochromism in inorganic compounds such as tungsten doped vanadium dioxide has also been successful in producing films which significantly modulate the near infrared transmittance and possess transition temperatures in the range 17 - 65 °C (4).

Electrochromism is observable in many organic and inorganic compounds. Many organic electrochromic materials such as the viologens are not very stable to light and this restricts their usefulness as fenestration elements. For building applications, attention has centred on the electrochromic properties of inorganic transition metal oxides and, in particular, the properties of tungsten oxide, nickel oxide and vanadium oxide. The potential to develop dynamic glazing systems based on inorganic electrochromic metal oxides in an all solid state variable transmission device is discussed in more detail below.

Other materials which have been researched as candidates for switchable glazings include liquid crystals and suspended particle devices. Liquid crystal devices are transparent in the presence of an electric field applied across two transparent electrodes which aligns the liquid crystal molecules in the direction of the field. Continuous application of the electric field is required and this restricts the usefulness of these materials in buildings. In contrast, electrochromic materials display a memory effect, i.e. they can be switched from a clear state to a darkened state by the application of an electric field and will then remain in the darkened state when the electric field is turned off. The use of dichroic dyes in liquid crystals enables solar gain to be modulated between the clear and opaque states. Fig. 1 shows such a liquid crystal device in its clear and darkened states (5). Another alternative is the suspended particle device which employs non-spherical particles with a magnetic moment and magnetochromic modulation is possible.

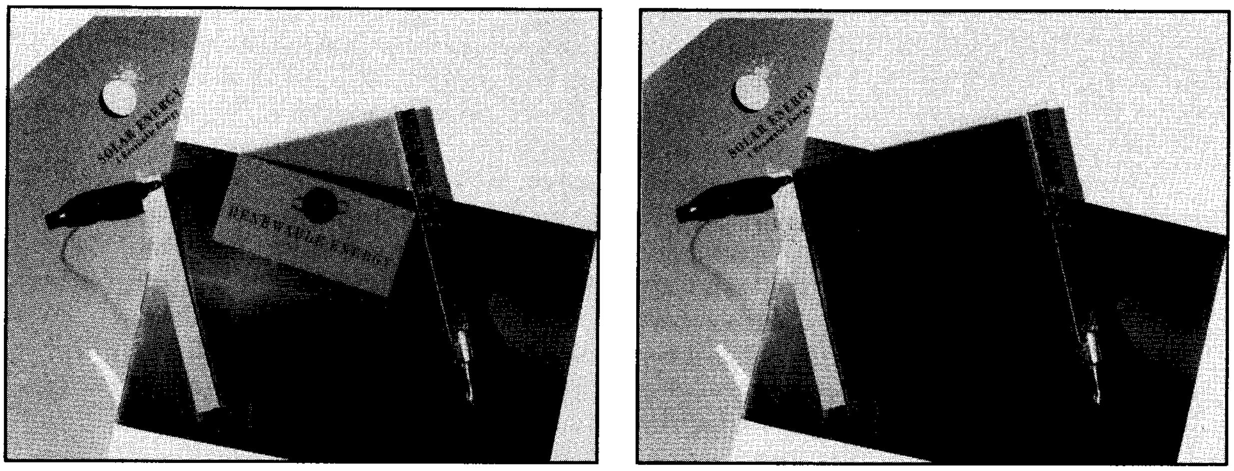

Figure 1: The clear and darkened states of a twisted nematic encapsulated liquid crystal device employing a dichroic to achieve solar gain modulation (5).

Electrochromic Smart Windows

A schematic representation of an all solid state electrochromic window is shown in Fig. 2. The device essentially consists of five thin film layers successively deposited on a transparent substrate (normally glass). Two transparent conducting thin films, commonly indium tin oxide (ITO) or fluorine-doped tin oxide (SnO_2:F) serve as the electrical contacts. The active electrochromic thin film is separated from the counter electrode, or ion storage layer, by a transparent ion conducting layer (electrolyte). In the case of tungsten oxide ($W0_3$), under the condition that it is at a negative potential with respect to the counter electrode, ions are transported from the counter electrode through the electrolyte and are inserted into the $W0_3$ lattice. The injection of ions and electrons into the lattice of the electrochromic material creates the conditions necessary for a change of colour in the presence of light. In the case of tungsten oxide a deep blue coloration is observed. The coloration itself proceeds relatively slowly because of the low ionic mobility, requiring up to one minute to become complete.

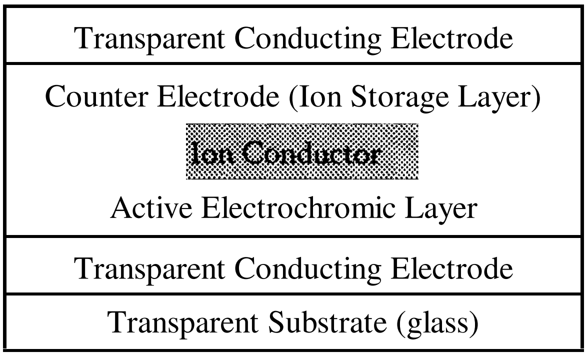

Figure 2: Schematic representation of a multi-layer thin film solid-state variable transmission electrochromic smart window.

The transmittance is hence controlled by the application of a DC electric field. A potential difference of 1-2 V across a thin film device is sufficient to cause coloration in the active electrochromic layer within the structure. The window is readily bleached to its initial clear state by reversing the applied voltage. Intermediate states of coloration are possible by adjusting the potential difference appropriately.

The positive ions may be protons (H^+) but this might require the presence of some water in the device and this is generally felt to be disadvantageous for the long term durability of the device. More commonly lithium ions (Li^+) are used and the coloration reaction is generally written in simplified form as

$$\underset{\text{Transparent}}{WO_3 + xLi^+ + xe^-} \leftrightarrow \underset{\text{Coloured}}{Li_xWO_3}$$

and the coloured state is a lithiated tungsten bronze. The coloration mechanism in the transition metal oxides is complex but great progress has been made in understanding the basic physics of these materials (6). The spectral transmittance and reflectance of a tungsten oxide coating in the bleached and coloured states are shown in Fig. 3. In the transparent state, the high near infrared reflectance is a property of the underlying ITO conducting film. In the coloured state, this behaviour is masked by absorption in the $W0_3$ layer.

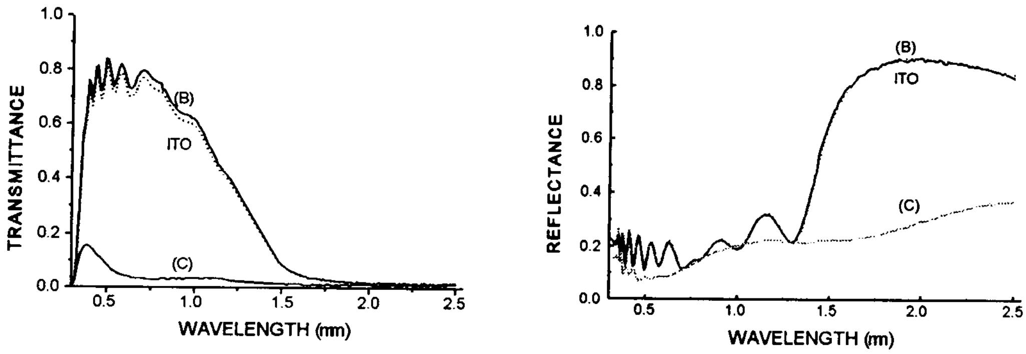

Figure 3: Transmittance and reflectance in the uv/vis/nir spectral range for a tungsten oxide film ***deposited*** *on* ***indium*** *tin oxide (ITO)* ***under proton insertion (B): bleached*** *state;* ***(C):coloured*** *state (7).*

Tungsten oxide colours cathodically, i.e. when negatively biased it colours by the insertion of positively charged ions (cations). Some other transition metal oxides, e.g. nickel oxide, colour anodically. Anodic materials darken when positive ions are extracted from the material. This phenomenon enables the concept of a complementary device to be introduced. If tungsten oxide and nickel oxide are employed together in a single device as the active electrochromic layer and the counter electrode respectively, both will colour together when the tungsten oxide is negatively biased and bleach together when the electric field is reversed. This leads to an enhancement of contrast ratio and can alter the colour of the window.

Performance Criteria and the State-of-the-Art

Target performance characteristics of an electrochromic glazing have been estimated and are shown in Table 1 (from Selkowitz and Lampert (8)).

Table 1. Desired performance characteristics of an electrochromic glazing (7).

Spectral Response	
Solar transmittance, T_s	T_s (Bleached) = 50 - 70 %
	T_s (Coloured) $\leq$10 - 20 %
Visible transmittance, T_v	T_v (Bleached) = 50 -70%
	T_v (Coloured) < 10 - 20 %
Near IR reflectance	R_{nir} (Bleached) = 10 - 20 %
	R_{nir} (Coloured) $\Rightarrow$ 70 %
Voltage Switching	1-5 V
Memory	1-24 h
Switching Speed	1-60 s
Cyclic Lifetime	>10K - 1M cycles
Lifetime	5-20 years
Operating Temperature	-30 to 70°C and 0-70°C (If protected)

The schematic electrochromic window shown in Fig. 2 cannot as yet be fully realised and the performance of state-of-the-art systems is being compromised to achieve practical devices. It has proved difficult to develop an efficient inorganic ion conductor which is transparent and can be deposited as a thin film over a large area. Practical devices employ polymeric ion conductors based on polymethymethacrylate (PMMA), polypropylene oxide (PPO) or polyethylene oxide (PEO). These compounds may have high ionic conductivity, be uv stable and have high chemical and electrochemical stabilities. In addition, they can serve as a resin to bind two halves of an electrochromic window together.

It is this latter property which strongly influences the electrochromic window design that is most likely to be made available commercially in the near future. Transparent conducting thin films are routinely manufactured in the glass industry for use in low emittance (low-e) glazing units. An electrochromic window can thus be formed by coating two pieces of low-e glass with the electrochromic thin film and the counter electrode respectively. The polymer electrolyte can then be cast in place and the device formed by bringing together its two separate halves. Such an approach has significant cost advantages in relation to the manufacture of a five layer thin film device and makes use of existing product, i.e. the low-e glazing. However, this construction doubly disadvantages the thermal performance of the smart window.

In Fig. 2, a single glass substrate is used and the final layer is a transparent conductor which confers a low emittance to the multilayer stack. The polymer sandwich device, in contrast, uses two glass substrates, reducing the solar heat gain coefficient significantly. The second glass sheet masks the low emittance property of the transparent conducting film on which the counter electrode is deposited. If an electrochromic window of this design is to be incorporated as part of a glazed unit with a low U-value, then a further low-e coating is required on a separate glazing element. This would further reduce the solar heat gain coefficient because of absorption in the low-e film and the addition of a third glass sheet.

The solar radiation that is not able to pass through the electrochromic window when it is in its darkened state must be either reflected or absorbed. Ideally, in a cooling-dominated application, the window would pass all or part of the visible radiation incident on the window and reflect the majority of the sun's near infrared radiation. Research has shown that near infrared reflectance can be partially achieved in heavily doped crystalline tungsten oxide but this work has not yet led to large area manufacture. In contrast, amorphous tungsten oxide shows no significant near infrared reflectance in its coloured state. The incident solar radiation that is not transmitted is almost perfectly absorbed. Such behaviour will cause significant heating of the window if left to stagnate in a coloured state under conditions of high irradiance. Temperature rises in the window will give rise to a radiant heat source adjacent to the room, potentially leading to thermal discomfort, and will impose additional demands on the temperature stability of the materials used in the smart window.

A further disadvantage is the colour itself. Tungsten oxide-based smart windows which are dark blue may not be visually acceptable in all potential residential and commercial markets. It is preferable to achieve a neutral or bronze coloration. Alloying of transition metal oxides can alter the chromogenic colour. The use of a complementary electrochromic material as the counter electrode, such as nickel oxide which colours together with the tungsten oxide, will affect the appearance of the coloured state. Such a device with a dark grey appearance has recently been reported (9).

The progressive darkening of a tungsten oxide-based electrochromic device employing a polymeric electrolyte is shown in Fig. 4. Figure 5 shows the spectral response of a tungsten oxide - nickel oxide complementary device employing a polymeric electrolyte in the bleached and coloured states (10).

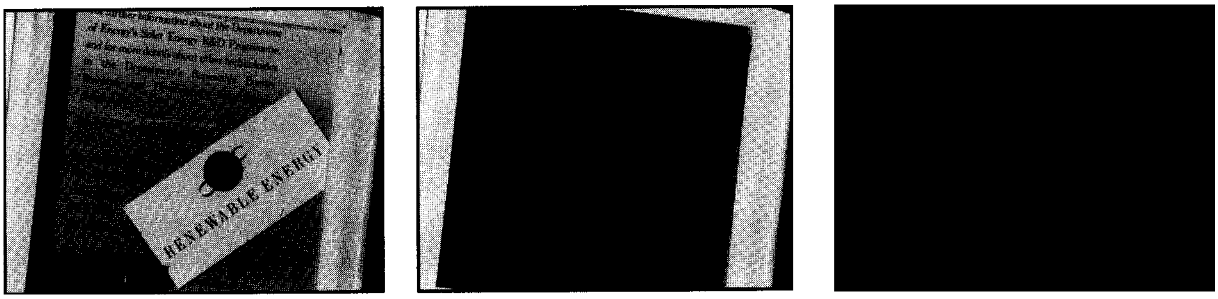

Figure 4: Progressive coloration of a ***tungsten oxide-based solid state electrochromic window employing*** *a polymeric electrolyte.*

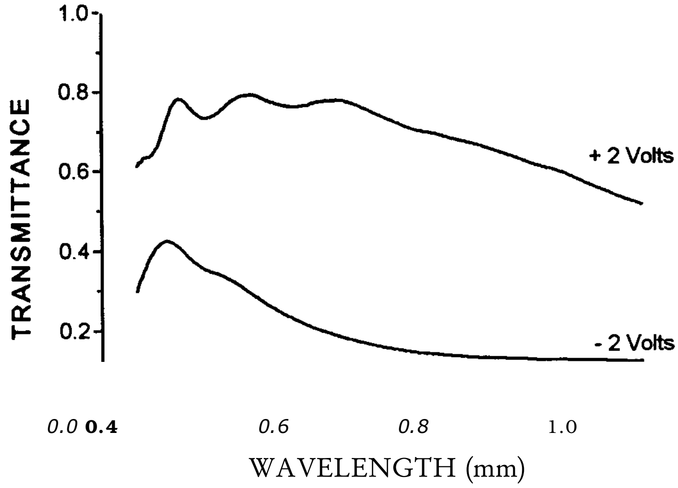

Figure 5: Spectral transmittance and reflectance of a complementary solid state electrochromic window employing tungsten oxide, nickel oxide and a polymeric electrolyte, T_{v}. (B) = 0.76; T_{v}. (C) = 0.32 (10).

Applications, Energy Benefits and Control Strategies

The lack of availability of smart windows outside of the research laboratory has meant that to-date little real experience has been gained in their use and operation in buildings. It is likely that the progress achieved by industry in realising large area electrochromic and thermochromic windows will enable demonstration projects to be set up in different climatic zones in the near future. Such projects will yield valuable information on possible control strategies to be implemented in linking the window optical properties to the building environmental conditions, provide experience on integrating the control system to the building HVAC services and contribute to the advancement of intelligent buildings.

Most studies of potential energy impacts and control strategies have involved the use of building simulation tools, and much of the detailed work has been carried out by the Windows and Daylighting Group at the Lawrence Berkeley Laboratory. This group modified the WINDOW (11) design tool to enable the optical properties of the glazing to be altered in response to different external factors, e.g. light intensity, ambient temperature etc., and provide input to the DOE2.1 building energy analysis tool. Initial studies (12) focused on evaluating the relative performances of different switchable glazings, comparing glazings which switch from transmitting to absorbing with those which switch from transmitting to reflecting, and the effects of positioning the switchable glazing element in a window. Much of the emphasis has been on cooling-dominated buildings where it is expected that a switchable glazing will help reduce cooling and lighting loads.

The performance characteristics listed in Table 2, together with additional factors which will influence the market acceptance of electrochromic windows, have been reviewed by Selkowitz et al (13, 14). The DOE2.1 model was used to calculate expected energy savings in comparison with the performance of conventional glazings. Different glazing configurations and control strategies were studied for electrochromic glazings using representative optical properties data obtained from current prototype devices and for improved devices which one may reasonably expect will be developed in the future, e.g. a low-e electrochromic device.

The study raises interesting issues regarding predictive control, the reduction of peak demand, occupant comfort and the architectural and aesthetic appeal of a dynamic coating. The results indicate that electrochromic windows can be highly effective in reducing peak electricity demand and electricity consumption in commercial buildings in southern California. Initial economic results considering annual savings, cooling equipment cost savings and electrochromic window costs have been assessed and payback periods in the range of 3.2 - 7.6 years are estimated.

The energy performance of electrochromic windows in residential buildings under a variety of state-switching control strategies has been studied for cooling-dominated climates in the USA (15,16). Several control strategies based on incident total solar radiation, space cooling load and outside air temperature were analysed and their influence on annual cooling energy and peak demand for different glazing types determined. The results show that an electrochromic material exhibiting high reflectance in the coloured state provides the best performance for all control strategies. Space load control based on the existence of a cooling load in the previous hour was found to provide the best performance for all electrochromic materials considered.

Few reliable studies have appeared which consider the switchable window in a heating-dominated climate such as Northern Europe. The Project Definition Phase of IEA SHC Task 18 crudely modelled electrochromic glazing for a Northern European climate and found limited energy benefits compared with other high performance glazings (17). The work needs refining to give a more accurate assessment of all potential benefits, i.e. energy usage, glare control, improved thermal comfort, for optimum applications of the technology.

Summary

The possibility of employing smart windows in buildings has stimulated enormous interest among architects, and investment in research and development of such materials has been very high. Electrochromic smart window technology has matured rapidly in the past decade and electrochromic windows can offer significant performance advantages in buildings. Much of the quantitative work in assessing the energy performance, developing control strategies, comparing window configurations and identifying appropriate applications has been confined to cooling-dominated climates where energy benefits appear significant.

Large-area electrochromic windows have been successfully scaled from research prototype designs, and windows are now being manufactured in small quantities in USA, Japan and Europe. Commercial availability of these windows appears imminent although their performance is not optimum. The physics and chemistry of chromogenic materials has advanced considerably, and basic research has contributed significantly to product development. Such knowledge will inevitably provide a platform from which future generations of smart windows will be developed with superior properties and performance.

The use of dynamic glazing in a building brings new problems associated with design, control, integration into the building envelope and the building services. Experience needs to be gained from demonstration projects to ensure that reliable best practice advice can be delivered. In years to come, the electrochromic window may be superseded by other dynamic glazing types, but, for the present, the time has arrived when electrochromic windows will begin to be widely employed not only as windows but as overhangs, louvers, lightshelves etc. Other applications in automobiles and aircraft are already evident. Smart windows based on electrochromic devices are destined to become an important feature of the building envelope as we enter the 21st century.

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14. Sullivan R, Lee E S, Papamichael K, Rubin M and Selkowitz S, *Effect of switching control strategies on the energy performance of electrochromic windows,* SPIE Vol. 2255, pp443-455, 1994.
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TASK 12:
BUILDING ENERGY DESIGN TOOL FOR SOLAR APPLICATIONS

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

Task Description

Solar technology for heating, cooling, and daylighting of buildings relies on durable, reliable, and cost-effective products (materials, components, and systems), and on methods for optimally designing and integrating these products in buildings to achieve significant energy savings. While other IEA Solar Heating and Cooling Program Tasks focus on technology development, Task 12 has focused on analysis and design methods (tools) to insure the optimal design and integration of existing and emerging solar heating, cooling, and daylighting technology in residential and commercial buildings. Task participants conducted collaborative research to improve the capability, accuracy, and use of building energy analysis and design tools in analyzing solar heating, cooling, and daylighting materials, components, and systems. Specifically, Task 12 was concerned with research in three Subtask areas:

(A) Model Development;
(B) Model Evaluation; and
(C) Model Use.

The first Subtask was concerned with improving the capability of analysis and design tools to analyze emerging solar heating, cooling, and daylighting technologies. It involved selection and development of appropriate algorithms for modeling of the interaction of solar energy-related materials, components and systems with the buildings in which these elements are integrated. The second Subtask involved selection of analysis and design tools and evaluation of the algorithms as to their ability to model the dynamic performance of the solar elements. Accuracy and ease-of-use are assessed and improvements recommended where appropriate. The third Subtask was concerned with improvement of the usability of analysis and design tools through preparation of common formats and procedures and by standardization of specifications for input/output, default values, and other user-related factors.

Task 12 addressed active, passive, and hybrid solar heating, cooling, and daylighting materials, components, and systems in residential and commercial (i.e., non-residential) buildings. The Task was concerned with both detailed analysis tools and simplified design tools, although greater research emphasis was placed on the detailed analysis tools.

The results of Task 12 collaborative research were new or improved algorithms for analyzing existing and emerging solar technologies, a model evaluation procedure for detailed and simplified tools, and recommendations and approaches to improving the user-friendliness of analysis and design tools in analyzing solar buildings.

The Task was initiated in September 1989, after completing a project Feasibility Phase of 12 months. The Task formally ended December 31, 1994.

Activities During 1994

During 1994, all Task 12 Project Working Groups completed their research activities and prepared their final reports. Several projects -- ADELINE Daylighting Model Development and Analysis Tool Evaluation -- will continue under the auspices of new Tasks within the IEA Solar Heating and Cooling Program.

Working group meetings were held for all projects throughout 1994.

A summary of the reports and other products prepared by the Task 12 Participants is summarized below. The reader is encouraged to contact the author to obtain copies of the reports or software.

Subtask A: Model Development

This Subtask was concerned with improving the capability of building energy analysis and design tools to evaluate new and emerging solar heating, cooling, and daylighting materials, components, and systems. Three projects were approved in this Subtask:

(1) High Performance Glazings;
(2) Daylighting Model Development; and
(3) Atrium Model Development.

■ Project A.1 - High Performance Glazings

Project Leader: United States
Participants: Denmark, Germany, Switzerland, United States

Reports and Ordering Information:

High Performance Glazings: Mr. Steve Selkowitz
An Optical Properties Database Windows and Daylighting Group
(Working Document) Lawrence Berkeley
Laboratory University of California
Building 90, Room 3111
Berkeley, California 94720

Transparent Insulation Mr. Hans Erhorn
Modeling Approaches Fraunhofer - Institute for Building
Physics
Postfach 80 04 69
D-7000 Stuttgart 80
GERMANY

Switchable Window Modeling Mr. Steve Selkowitz
(See Above)

Thermochromic Window Mr. Hans Erhorn
Modeling (See above)

Thermal and Optical Properties Mr. Steve Selkowitz
of Switchable Window Glazings (See above) (Working
Document)

Many aspects of this research topic are being addressed by Task 18, Advanced Glazing Materials.

■ Project A.2 Daylighting Model Development

Project Leader: Germany
Participants: Denmark, Germany, Switzerland, United States

The daylighting model development activities of this Working Group focused on two daylighting analysis tools: SUPERLITE and RADIANCE. An integrated suite of computer programs was created under a common user-friendly shell called ADELINE. The programs and structure of ADELINE are shown in Figure 1.

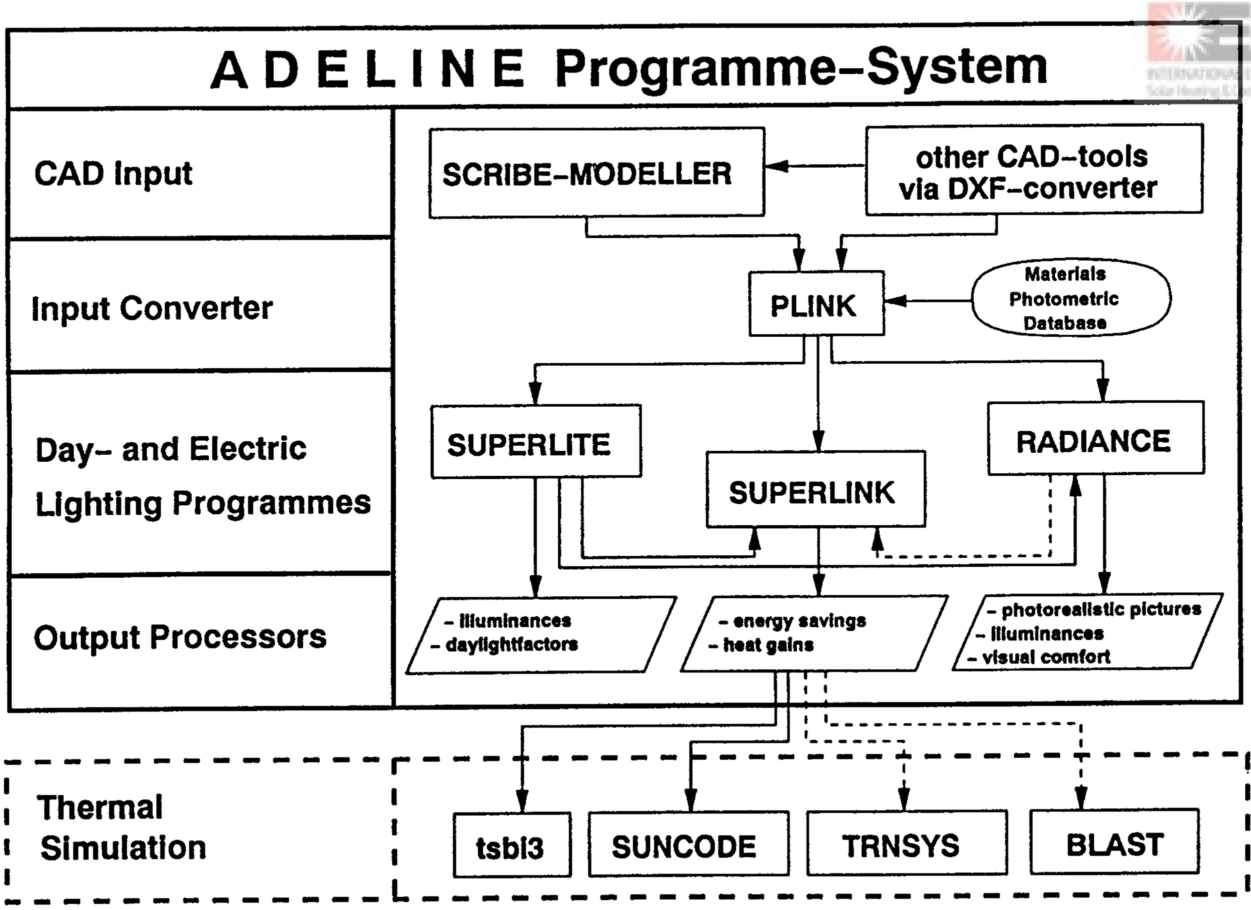


Figure 1: Elements of ADELINE

Reports/Software and Ordering Information:

ADELINE Software	Mr. Hans Erhom
Version 1.0	(See Previous Page)
Software User's Manuals and	and
Technical Documentation:	Mr. Steve Selkowitz

- ADELINE User's Manual (See Previous Page)
- SCRIBE User's Manual
- PLINK User's Manual
- SUPERLITE User's Manual
- SUPERLINK User's Manual
- SUPERLINK Technical Manual
- RADIANCE User's Manual
- RADIANCE Reference Manual

ADELINE Descriptive Brochure

The ADELINE Working Group continued further enhancement of version 1.0 with the expectation of version 2.0 being available in 1995. The ADELINE Working Group will continue its research and software development activities as a subtask within the new IEA Daylighting Task (Task 21).

■ Project A.3 Atrium Model Development

Project Leader: Norway
Participants: Denmark, Norway, Sweden, Switzerland

The Atrium Model Development Working Group was involved in the creation of a number of simplified models necessary to explicitly analyze the performance of atria. Detailed computational fluid dynamic (CFD) models were used in the development of some of the simplified models.

Report and Ordering Information:

Atrium Models for the Analysis of Thermal Comfort and Energy Use
- Chapter 1: Problem Definition
- Chapter 2: Thermal Comfort
- Chapter 3: Stratification
- Chapter 4: Surface Film Coefficients
- Chapter 5: Natural Ventilation
- Chapter 6: Radiation Exchange
- Chapter 7: Case Studies
- Chapter 8: CFD Models
- Chapter 9: Simplified Models

Ida Bryn
SINTEF
Varmeteknikk/Applied Thermodynamics
Kolbjorn Hejes V.1B
N-7034 Trondheim
NORWAY

Subtask B: Model Evaluation

This Subtask was concerned with assessing the accuracy of building energy analysis and design tools in predicting the performance of existing solar heating, cooling and daylighting materials, components and systems. Key model evaluation topics, such as cooling/overheating prediction, residential and commercial benchmark test cases, and sunspace performance prediction, were considered within the context of an overall model evaluation procedure.

Reports and Ordering Information:

Building Energy Simulation Test (BESTEST) and Diagnostic Method

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

Empirical Validation of Thermal Building Simulation Programs Using RoomData
- Volume 1: Final Report
- Volume 2: Empirical Validation
- Volume 3: Working Reports

Foroutan Parand
Building Research Test Establishment
Bucknalls Lane
Garston, Watford WD2 7JR
United Kingdom

Energy Analysis Tests for Commercial Buildings: Commercial Benchmarks (Working Document)	Prof. Timo Kalema Tampere University of Technology Thermal Engineering Division P. O. Box 527 33101 Tampere, Finland
Analytical Tests for Evaluation Building Energy Analysis Simulations (Working Document)	Mr. Peter Verstraete Vaije Universiteit Brussel Pleiniaan 2 1050 Brussels

The Building Energy Analysis Tool Evaluation Working Group may continue its activities under a new Task currently in the early stages of planning. The new Task would continue Task 12 tool evaluation research using analytical, comparative and empirical methods.

1994 Meetings

Experts Meeting (A2)	April 1994 Stuttgart, Germany
Experts Meeting (B.1)	April 5, 1994 York, England
Experts Meeting (A.3)	May 9m10, 1994 Copenhagen, Denmark
Experts Meeting (A.2)	August 24-25, 1994 Berkeley, California
Experts Meeting (A.3)	November 9m10, 1994 Paris, France

Task Participants

BELGIUM
Mr. Ric Van de Perre
Vaije Universiteit
Brussels
Pleiniaan 2
1050 Brussels

DENMARK
Mr. Kjeld Johnsen
Danish Building Research Inst.
P. O. Box 119
DK 2970 Horsholm

FINLAND
Prof. Timo Kalema
Tampere University of Technology
Thermal Engineering Division
P. O. Box 527
33101 Tampere

FRANCE
Mr. Pascal Dalicieux
Groupe Habitat de Modelisation
EDF Electricite de France
Direction des Etudes et Recherches
Les Renardieres - Route de Sens - BPI
77250 Moret-Sur-Loing

GERMANY
Mr. Hans Erhorn
Mr. Michael Szerman
Fraunhofer - Institut fur Bauphysik
Postfach 80 04 69
D-7000 Stuttgart 80

ITALY
Mr. Augusto Mazza
Politecnico di Torino
Dipartamento di Energetica
Corsa Duca degli Abruzzi 24
0129 Torino

NORWAY
Ms. Ida Bryn
SINTEF
Varmeteknikk/Applied Thermodynamics
Kolbjorn Hejes V.1B
N-7034 Trondheim

SPAIN
Mr. Servando Alvarez
Dept. Ingenieria Energetica y Fluidomecanica
Escuela Superior de Ingenieros Industriales
Avda. Reina Mercedes/SN
E41012 Sevilla

SWEDEN
Dr. Bertil Fredlund
Mr. Kurt Kallblad
Mrs. Maria Wall
Department of Building Science
University of Lund
Box 118
S-22100 Lund

SWITZERLAND
Prof. J.-L. Scartezzini
Centre Universitaire d'Etudes des Problemes de l'Energie
B.P. 81
Ch. de Conches 4
CH-1231 CONCHES - Geneva

Mr. Dominique Chuard
Sorane SA
Route du Chatelard 52
CH-1018 Lausanne

Mrs. Nicole Hopkirk
Swiss Federal Laboratories for Material Testing (EMPA)
Ueberlandstrasse 129
CH-8600 Dubendorf

Mr. Helge Hartwig
Ernst Schweizer AG
Metallbau CH-8908 Hedingen

UNITED KINGDOM
Mr. David Bloomfield
Building Research Establishment
Bucknalls Lane, Garston,
Watford, Hertsfordshire
WD2 7JR

Mr. Kevin Lomas
Leicester Polytechnic
School of the Built Environment
P.O. Box 143
Leicester LE 1 9BH

UNITED STATES
Michael J. Holtz
Architectural Energy Corp.
2540 Frontier Avenue,
Suite 201
Boulder, CO 80301

Mr. Ron Judkoff
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

Mr. Steve Selkowitz
Mr. Gregory Ward
Windows and Daylighting Group
Building 90, Room 3111
Lawrence Berkeley Laboratory
Berkeley, CA 94720

Ms. Susan Reilly
Enermodal Engineering, Inc.
1221 Preservation Park Way
Oakland, CA 94612

TASK 13:

ADVANCED SOLAR LOW ENERGY BUILDINGS

Anne Grete Hestnes
Norwegian Institute of Technology
Operating Agent for the
Royal Ministry of Petroleum and Energy, **Norway**

Task Description

The objective of this Task is to advance solar building technologies through the identification, development, and testing of new and innovative concepts which have the potential for eliminating or minimizing the use of purchased energy in residential buildings while maintaining acceptable comfort levels.

The focus of the Task is the application of passive and/or active solar technologies for space heating of single family and multi family residential buildings. The use of passive and active solar concepts for cooling, ventilation, and lighting is also addressed, as well as advanced energy conservation measures to reduce heating and cooling loads.

Since the emphasis is on innovation and long-range (after the year 2000) cost-effectiveness, the materials, components, concepts, and systems considered need not be currently feasible, economical, or on the mass market today.

In order to accomplish the foregoing objective, the Participants have undertaken work in three subtask areas:

- Subtask A: Development and evaluation of concepts (Lead country: Germany)
- Subtask B: Testing and data analysis (Lead country: Denmark)
- Subtask C: Synthesis and documentation (Lead country: Switzerland)

To facilitate the effective planning and implementation of the program of work, a feasibility phase was conducted prior to initiation of the research phase of the Task. The primary result of the feasibility phase was a detailed work plan for the research phase. The research phase began on September 1, 1989 and was scheduled to last until September 1, 1994. A 2-year extension was approved by the Executive Committee. The Task will therefore continue until September 1, 1996.

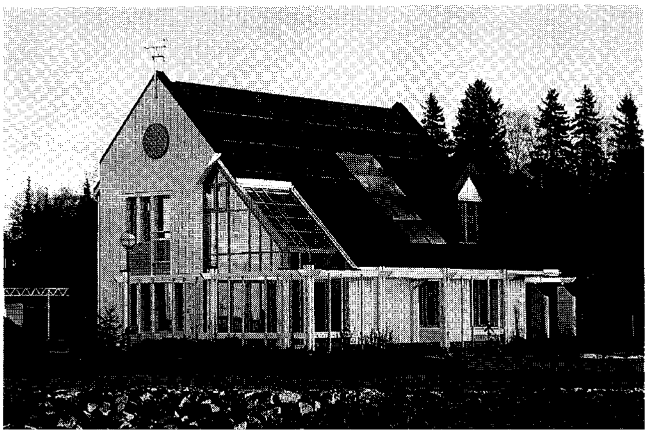
Progress During 1994

Demonstration Houses

Most activities in 1994 were related to the construction, instrumentation, and monitoring of the Task 13 experimental buildings. Eight buildings (in Belgium, Canada, Finland, Germany, Japan, Norway, and the UK) have now been completed. These are being extensively monitored, and results analyzed. Another seven buildings (in Denmark, Germany, Japan, the Netherlands, Sweden, and the USA) are under construction and will be completed in 1995.

The calculated energy consumption values for the various buildings show that the total annual consumption, for all end uses, averages only 45 kWh/m^2. Of this, auxiliary space heating comprises only 16 kWh/m^2 and electricity only 18 kWh/m^2. Most of the buildings use a number of energy conservation and solar thermal strategies to reach these very low levels. In addition, some of the buildings use grid-connected photovoltaic systems.

The buildings with the lowest consumption values are mostly buildings built in the northernmost countries participating in the Task. This is partly a result of the fact that these countries already have a strong tradition in energy conservation, with very strict building codes.



The Finnish Task 13 solar demonstration building is located at 62° latitude. This attractive house was the showpiece of the Pietarsaari Housing Fair '94 where it was visited by 160,000 persons.

The Task 13 buildings are all presented in a 50 page booklet presently being published by James & James. The booklet will be available at the beginning of 1995.

The monitoring results for the completed buildings are also promising. For instance, the Canadian house in Waterloo, which emphasizes the use of non-polluting materials, has been tested for indoor air quality. The results show that the formaldehyde and radon levels are less than 25% of Canadian standards. The monitored electricity consumption is also low; it is approximately equal to the projected values. It turns out that the monitoring equipment is the largest energy user in the house. This may actually be a problem for all the houses **in Task** 13.

Final Report

Work is at the same time progressing on the final report of the Task. The report is tentatively titled "Ways to Zero Energy Houses - The IEA Task 13 Experience". First drafts of all the chapters have been produced and discussed, and changes and additions have been suggested. A draft of the complete book will be available by the next experts meeting. The plan is not to publish the book until 1996, however, as the goal is to include monitoring results from as many building projects as possible.

Summary of Accomplishments

- The reports "Technology Simulation Sets" and "Component and System Testing " have been completed and are now approved by the Executive Committee.
- The booklet "Solar Low Energy Houses of Task 13" has been approved and is presently being published.
- Work on a catalogue of the construction details used in the Task 13 buildings has started.
- Construction of five buildings has been completed, and construction of another seven has started.
- Monitoring results from three buildings have been presented and discussed, and monitoring of five more has started.
- First drafts of all the chapters for the final report of the Task have been produced and discussed.
- Slide sets of all the experimental buildings have been distributed.

Work Planned For 1995

Most of the work in 1995 will continue to be related to the experimental buildings. A few countries will be finishing construction, while one last one, Austria, will be starting. The major activity will be related to the monitoring of the buildings, however. There will therefore be extensive discussions of monitoring results at the experts meetings.

At the same time, considerable effort will go into information dissemination. The final report will be partly finished by the end of the year, as only the last monitoring results are to be included after that time. Chapters on each of the strategies, on each of the innovative technologies, and on most of the buildings will be completed. Each chapter has an author responsible for collecting the information and for providing a draft. The drafts will afterwards be edited and compiled in the book by the Operating Agent and the Subtask C Leader.

In addition to this activity, the planning of the final Task symposium, which will take place in 1996, will begin, and the catalogue of construction details will be completed.

Summary of Work Planned

- Construction details for the experimental buildings will be compiled in a working document.

- Seven more experimental buildings will be completed and instrumented, and monitoring will begin.

- Monitoring results for the buildings already completed will be analyzed, presented, and discussed.

- The complete draft of the final report will be discussed and revised.

- The final Task symposium will be planned.

Reports Published in 1994

"Component and System Testing" (IEA Report)
"Technology Simulation Sets" (IEA Report)
"Solar Low Energy Houses of Task 13" (Booklet)

Reports to be Published in 1995

"Construction Details used in the Task 13 Buildings" (Working Document)

1994 Meetings

10th Experts Meeting	June 6-8, 1994 Sweden/Iceland

1995 Meetings

11th Experts Meeting	January 16-18, 1995 Waterloo, Belgium
12th Experts Meeting	July 3-5, 1995

Task 13 Participants

OPERATING AGENT
Anne Grete Hestnes
Faculty of Architcture
N-7034 Trondheim
NORWAY

AUSTRIA
Helmut Krapmeier
Inst.für Sinnvollen Energieeinsatz
Bahnhofstrasse 19, Postbox 51
A-6851 DORNBIRN

BELGIUM
Andre De Herde
Universite Catholique de Louvain
Place de Levant 1
B-1398 LOUVAIN-LA-NEUVE

CANADA
Stephen Carpenter
Enermodal Engineering
368 Phillip Street
WATERLOO, ONTARIO N21 5J1

DENMARK
Bjarne Saxhof
Thermal Insulation Laboratory
Building 118, DTU
DK-2800 LYNGBY

EEC
Peter Wouters
Belgian Building Research Institute
Violetstraat 21-23
B-1000 BRUSSELS

FINLAND
Jyri Nieminen
VTT, Building Technology
P.O.Box 18011
FIN-02044 VTT

GERMANY
Hans Erhorn
Fraunhofer Institut für Bauphysik
Nobelstrasse 12
D-70128 STUTTGART

ITALY
Aldo Lauritano
Dipartimento di Energietica
Viale delle Scienze
I-90128 PALERMO

JAPAN
Ken-Ichi Kimura
Department of Architecture
Waseda University
Okubo 3, Shinjuku
TOKYO 169, JAPAN

NETHERLANDS
Bart Poel
Damen Consultants
Postbox 694
NL-6800 AR ARNHEM

NORWAY
Øyvind Aschehoug
Faculty of Architecture
Norwegian Institute of Tech.
N-7034 TRONDHEIM

SWEDEN
Gudni Johannesson
Dept. of Building Tech.
KTH
S-10044 STOCKHOLM

SWITZERLAND
Robert Hastings
Solararchitektur
ETH - Hönggerberg
CH-8093 ZÜRICH

UK
John Littler
Research in Bldg. Group
University of Westminster
35 Marylebone Road
LONDON NW1 5LS, UK

USA
Doug Balcomb
NREL
1617 Cole Blvd.
GOLDEN, CO 80401

TASK 14: ADVANCED ACTIVE SOLAR ENERGY SYSTEMS

Doug Lorriman
Ballinafad Research
Operating Agent for
Natural Resources

Description

Task 14 was initiated to advance the state-of-the-art in active solar energy systems. All Task experts are working on the leading edge of system development within their own countries and bringing their expertise together within the Task to accelerate advancements in this field. Task activity includes development of computer simulation models for advanced system features, development and testing of new components and systems and design, construction and monitoring of actual operating systems.

System applications included in the Task are:

- Domestic Hot Water;
- Ventilation Air and Space Heating for Commercial Buildings;
- Large Scale Heating under 200°C.

Activities of the Task began in January, 1990. The final reports of the Domestic Hot Water and Air Systems Working Groups are expected to be completed in early 1995 and the final reports of the Large Systems Working Group and the Dynamic Testing Subtask are expected to be completed by the end of 1995.

Industry involvement has been encouraged throughout the Task and this past year has seen a continued strong interest.

Working Groups

The Goal of the Working Groups is to facilitate interaction between participants with similar projects. Participants in these Working Groups identify and address issues of common concern, exchange knowledge and experience and identify prospective collaborative activities. Working Groups have been established in the following areas:

- Domestic Hot Water Systems - Lead Country: USA
- Air Systems - Lead Country: Canada
- Large Systems - Lead rotates among Sweden, Germany, The Netherlands and Spain. Current lead is Germany.

Innovative Concepts Subtask - Lead: USA
This Subtask was established to provide a mechanism for the ongoing sharing of new ideas on active solar heating among the Task participants. Work of the Subtask helps to identify promising concepts which offer improvements in cost, performance and/or reliability. Meetings of the group typically involve informal presentation and discussion of new concepts which have been identified by the participants and could be of interest to other Task participants in their projects. A focus of effort during 1994 was identification of potential areas of new collaborative research in active solar heating systems. Recommendations will be made to the Executive Committee at the end of the Task.

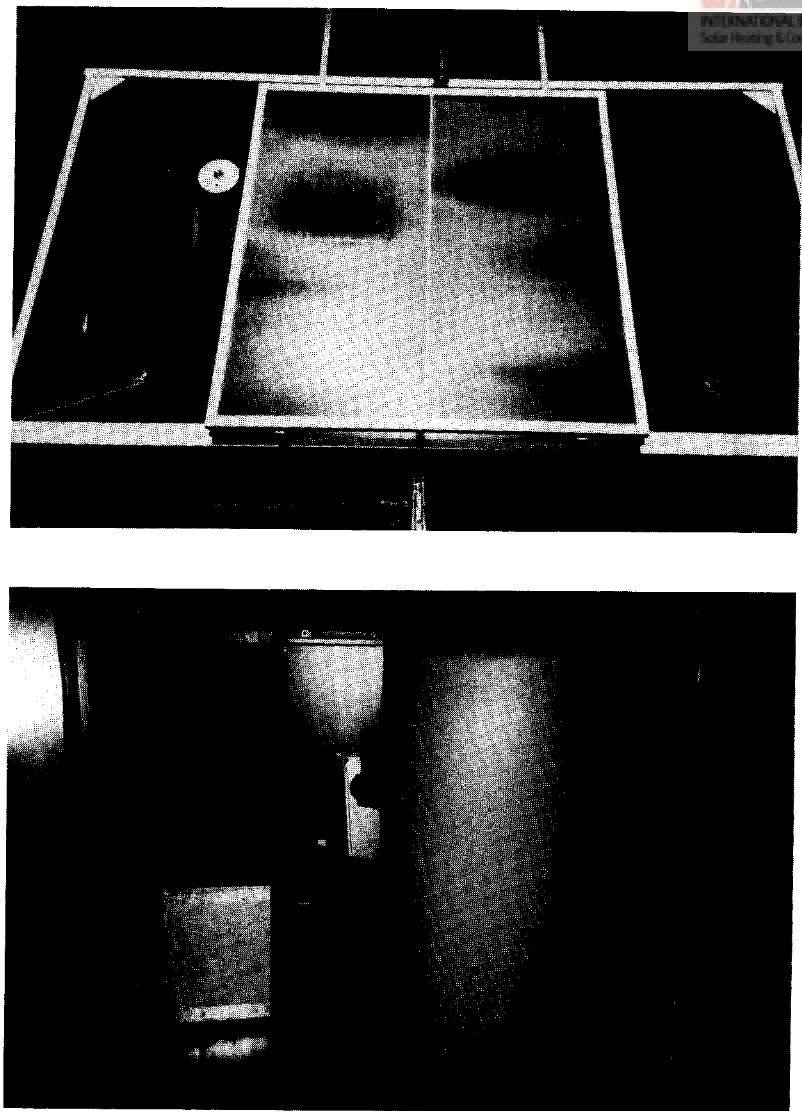
Dynamic Testing Subtask - Lead: Switzerland
This Subtask became part of Task 14 during 1992. It was established to further develop the work done by the IEA Dynamic Systems Testing Group which submitted its final report early in 1992. The general goals of the Subtask are:

- Develop short-term component test procedures.
- Develop test procedures for SDHW systems that are not covered by the existing Dynamic System Testing model.
- Perform tests to validate the procedures.
- Develop methods for rating and performance prediction of large systems.
- Evaluate the need for a user friendly modeling tool for system simulation, layout and optimization.

Progress During 1994

Two Experts Meetings were held in 1994. The technical work of the Task continued to be based in the three Working Groups. A summary of developments in each Working Group follows:

Solar DHW Systems Working Group
Work in this group concentrated on the production of the final report. A key feature of this report, which will be primarily directed at industry, is the descriptions of the



Tank and collector set up for side-by-side testing of a low-flow solar DHW system at the Canadian National Solar Test Facility .

"dream systems" developed by each country. These systems incorporate many of the innovative concepts studied during the Task, adapted as necessary to meet national market conditions. Although many technical issues were discussed and resolved during the course of the Task, it was interesting to see that when agreement was sought on the content of the final report, there were still some outstanding disagreements. One example was a fundamental difference of opinion between Danish and Dutch participants regarding the performance of different storage tank/heat exchanger configurations. The only way to satisfactorily resolve the matter was to perform side-by-side comparison testing. With the assistance of Canada, such testing was arranged and the results will be published in the final report. This activity was an excellent demonstration of the value of the collaborative process.

Participating countries include: Canada, Denmark, Germany, The Netherlands, Switzerland, Spain, USA.

Air Systems Working Group

The work of this group has been a great success. Effort has been concentrated on cost/performance improvements of a ventilation air preheat system utilizing aluminum cladding mounted on south facing walls as the collector. The innovative development has been the perforation of this cladding which makes the cladding in essence one large heat exchanger. Research on the heat transfer of the perforated panels has provided greater understanding of plate thickness, hole size, hole spacing and wind effects. Additional research has provided information on air flow distribution behind the panels and produced a computer model which be a useful design tool for designers of ventilation air solar pre-heat systems using the perforated panels.

The built projects included in the task not only conclusively demonstrated that these systems can operate at greater than 60% efficiencies but they also provided a very good opportunity to monitor and analyze design changes which were recommended based on the results of early testing and implemented during the course of the Task.

The spin-offs from the work of this group have also been impressive. Not only have perforated wall solar collector systems been designed and/or installed in a number of IEA countries, but other applications have been found as well. The German project which incorporated a perforated solar wall to preheat combustion air for a district heating plant became an official Task project during the year and will be included in the final report. The concept of using the panels for crop drying applications, mentioned in the 1993 annual report, was utilized in a project in South East Asia.

The only unfortunate development during the year was the decision by Alcan to discontinue its research program on coatings for the perforated panels. It was hoped that this work would have produced higher efficiency coatings and a greater colour selection.

Air System Projects include:

Canada -	Oakville Ford Plant
Canada -	Oshawa GM Plant

USA - NREL Chemical Storage Building
USA - NREL Test Wall *
Germany - Gottingen District Heating Plant

* This is not an official Task project but results from this installation provided useful input

Dynamic Testing Subtask

A great deal of work was done in this Subtask in preparing data and testing formats and measurement and evaluation of data. Also, as part of the collaborative work, a general data exchange on Solar Domestic Hot Water systems was started. Beyond this, perhaps one of the more important aspects of this work was evident this year as experienced gained in the work of the Sub Task helped a number of the participants provide valuable input into the development of key ISO international standards. In particular, the draft of the ISO standard for SDHW systems was reviewed and comment submitted through the appropriate channels.

The Subtask is divided into three activity areas:

■ Collector Testing - Lead: Sweden
■ Testing of SDHW System - Lead: the Netherlands
■ System Characterization by Component and Testing and System Simulation - Lead: Germany, Sweden

Industry Workshops

This important activity was continued in 1994. The purpose of these workshops is to help the Task participants appreciate the issues related to the solar industry in the participating countries and to present the work of the Task and the Task industry participants to government and industry representatives who do not otherwise have direct access to this information.

During the year, one workshop was held in Seville, Spain and was attended by a good cross section of representatives from educational institutions, local industry and the Andalusian government. A second workshop was held in Stockholm, Sweden, sponsored by the Swedish Solar Energy Association.

The willingness of our Task industry representatives to participate in these meetings, often on short notice, is greatly appreciated.

Major Accomplishments DHW Systems

■ All participating countries completed conceptual design c dream systems. Cost/performance improvements over country base cases range from 23% to 45%.

■ Dream system built and tested in Switzerland.

■ Second draft of final report completed.

Air Systems

■ Working draft of flow distribution model completed.

■ Analysis of data from NREL Chemical Storage Building indicated efficiency of 63%.

■ Modifications made to GM Oshawa system and monitoring indicates efficiency of 71%.

■ Monitoring of Gottingen system started.

TASK 16: PHOTOVOLTAICS IN BUILDINGS

Dr. Heribert Schmidt
Fraunhofer Institute for Solar Energy Systems
Operating Agent for
Forschungszentrum Jülich

Task Description

Task Objectives

Photovoltaic power supply for buildings utilizes a decentralized approach for electricity generation. It offers the possibility to match supply and demand and thus to reduce transmission losses, peak power and storage. For system optimization, all energy aspects such as lighting, heating and cooling, or hot water production have to be taken into account.

Task 16 is assessing techniques for maximizing the solar share in total energy concepts as well as optimizing the economics. Results of these findings will be incorporated into Task 16 demonstration projects which will be realized in most of the Task 16 member countries. Both residential and commercial buildings and both grid-connected and standalone buildings are included.

Subtasks and Lead Countries

■ **Subtask A: System Design and Engineering (Finland)**

In this Subtask, participants are producing working documents on existing PV-systems, components, energy-efficient electric appliances and lighting equipment, safety issues and national regulations, codes and pricing practices for electricity generation, based on responses to surveys. Recommendations and guidelines for energy concepts, utility interface issues and monitoring procedures will be made.

■ **Subtask B: Building Integration (Switzerland)**

Various methods of integrating PV modules into the building structure will be investigated and tested. The development of special modules designed for building integration will be undertaken, taking into account restrictions caused by building standards or safety requirements. The best integration methods will be demonstrated at the Task 16 Demonstration Site "Photovoltaic Building Elements" at EPFL - Lausanne, Switzerland.

■ **Subtask C: PV Demonstration Buildings (Netherlands)**

Based on the results of the preparatory work in Subtask A and B, PV buildings will be designed, constructed and monitored. It is expected that most of the Task 16 participating countries will build one or more demonstration buildings. The data from these buildings will be made available for the public.

■ **Subtask D: Technology Communication (Germany)**

Based on the information gained through Subtask A and B and the PV demonstration buildings, a design handbook for PV project planners and engineers will be compiled. To further disseminate the Task 16 results, national workshops, as well as an international symposium with published proceedings, will be organized.

Task 16 was initiated on November 1, 1990 and will conclude on October 31, 1995.

Activities During 1994

Subtask A: System Design and Engineering

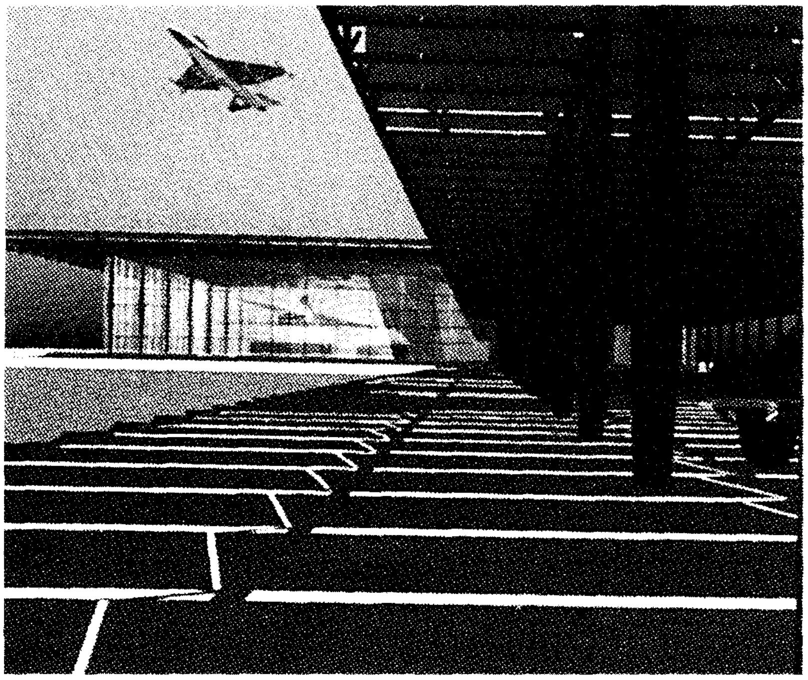
On the basis of questionnaires, information on existing PV-systems, on energy efficient electric appliances, safety issues and national regulations has been collected and discussed. This information provides important input to several chapters of the Design Handbook. Substantial efforts have been made on the testing of safety equipment (e. g. DC circuit breakers, DC switches); a working document will be prepared by the next Expert Meeting. Special "Guidelines for Commercially Available Batteries in Photovoltaic Systems" are being prepared. A working document on utility interface and islanding of grid-connected PV plants is under preparation. There is work underway on the documentation and characterization of different inverter *types.*

Subtask B: Building Integration

■ **Modelling of Irradiance Distribution**

One major item is the modelling of the irradiance distribution on building surfaces. The program RADIANCE is used to compute the irradiation distribution. An indoor illumination calculation procedure has been extended for the purposes of Task 16; several characteristic examples for the irradiation on different building structures are being investigated.

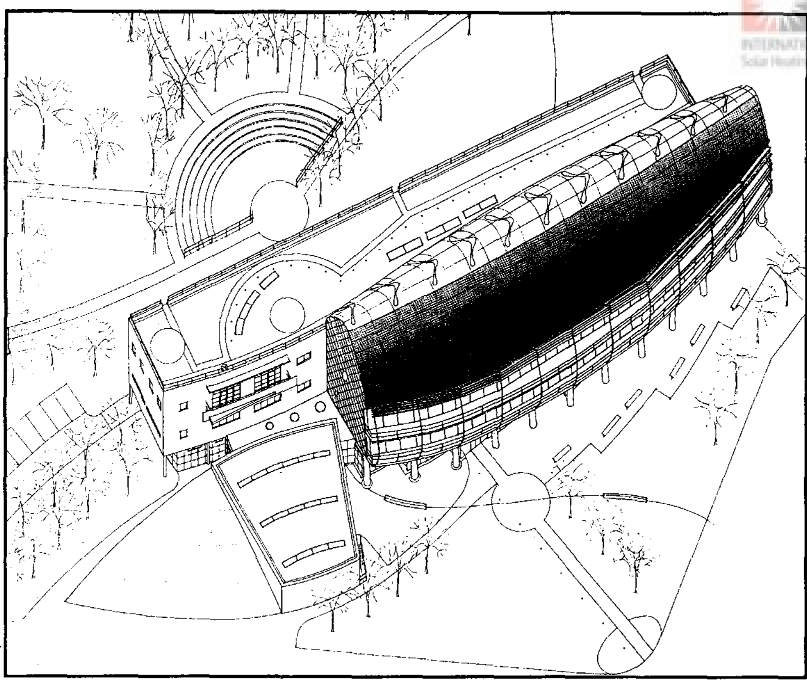
■ PV Architectural Competition



One of the prize winning entries in the IEA Architectural Ideas Competition for PV in the Built Environment was this Conference and Cultural Center designed by G. Kiss.

As part of Task 16, an International Architectural Ideas Competition was organized in 1993. The main sponsor of this event was NOVEM, the Netherlands Agency for Energy and the Environment. Administrative details were handled by Ecofys Research and Consultancy.

The objective of the competition was to generate architectural solutions to the many questions associated with the integration of PV systems into the building envelope and to familiarize the architectural community with PV and building integration issues. While technical development certainly has been important, PV systems must also be harmonious with the design of the building and aesthetically pleasing. The winners were announced at the 12th European Conference in Amsterdam in April 1994 where the winning entries were displayed.



This design by architecture student A.J. Lloyd won a second prize in the multi-story building category.

Despite the impressive number of entries, the jury unanimously agreed that no design could be considered outstanding in terms of all the criteria set: visual and aesthetic qualities, architectural appropriateness, innovation and creativity, technical viability and overall energy balance.

However, there were many submissions of high quality. In the multi-story category, an entry of "impressive overall design" was submitted by Gregory Kiss of Kiss Cathcart Anders Architects in New York for a conference center with a sawtooth roof with PV, on the south side and glass for daylight admittance on the north-facing side. A "nice example of the utilization of a well known roof construction for an additional PV function", according to the jury.

Another award in the multi-story building category went to U.K. architecture student A.J. Lloyd for a design of a "Future Bauhaus Academy of Architecture and Design." It features PV modelules incorporated into the exterior skin of the southeast-facing design studio.

These and other winning designs can be found in the book of results of the competition which was published in 1994.

■ PV Demo Site

The PV Demonstration Site for Photovoltaic Building Elements at EPFL in Lausanne, Switzerland, is still a highlight of Task 16 because several pilot installations have been realized and government delegates, architects, builders and engineers from around the world have visited the Demosite (more than five visitors a day as an average). Slides and other materials are available, and an invitation brochure was prepared and distributed. Furthermore, a Demosite Newsletter is published by the EPFL Lausanne.

As a result of the joint work in Task 16, several integration methods of PV in buildings have been described and characterized; this information will be published in a working document.

■ **Workshop**
The Task 16 - International "Workshop on Building-integrated Photovoltaics" took place September 16, 1994, in Cambridge (Boston), USA. Proceedings of this meeting will be prepared by the U.S.

Subtask C: PV Demonstration Buildings

As part of Subtask C, several countries presented monitoring results for their Task 16 PV demonstration buildings. Austria proposed a new demo building: a 13 kW PV-facade in Innsbruck, which was accepted by the participants of the last experts meeting.

The Task 16 PV demonstration buildings are indicated in Table 1.

Subtask D: Technology Communication

The first draft of the design handbook has been prepared and distributed to the participants of Task 16. At the last experts meeting, all chapters were discussed and numerous changes proposed. The design handbook is the most important outcome of Task 16, because it contains almost all major results of the different working modules.

A survey about computer programs on PV simulation has been prepared, which finally should give PV users information on which program best meets his or her needs.

Table 1: Overview of IEA Task 16 Demonstration buildings (October 1994)

Nr	Building	Location	Status A	Status B	Status C	Status D	Expected end date monitoring program
1	Photovoltaic Demo House/W.Weiss	Gleisdorf, Austria		x	x		
2	Vienna Low Energy House	Vienna, Austria		x	x		December 1995
3	13 kW-PV-facade Wild	Innsbruck, Austria		x	x		December 1995
4	Innova House	Kanata, Ontario, Canada		x		x	fall 1994
5	The Hugh MacMillian Rehabilitation Centre	Toronto, Canada		x			December 1995
6	Pietarsaari Solar House	Pietarsaari, Finland		x	x		December 1995
7	Rural Residence 'Stein'	Röhrmoos, Munich, Germany		x	x		November 1994
8	Structural Glazing PV-facade	Berlin-Kreuzberg, Germany		x	x		spring 1995
9	PV-facade for the Northumberland Building	Newcastle upon Tyne, UK	x				spring 1996
10	Energy autonomous PV-house	Woubrugge, The Netherlands		x	x		November 1994
11	Norwegian Solar Low Energy Dwelling	Hamar, Norway		x			December 1995
12	Viviendas Unifamiliares con conexion a red	Las Rosas, Madrid, Spain		x	x		summer 1995
13	Stockholm row house	Stockholm, Sweden		x	x		August 1995
14	Affoltern	Zurich, Switzerland		x		x	fall 1994
15	PV cladding on LRE Building	Lausanne, Switzerland		x			spring 1996
16	Flat roof on DMX Building	Lausanne, Switzerland		x			spring 1996
17	Energy Independent House	near San Francisco, USA		x			spring 1996

A: The building is under construction.
B: Construction is completed.
C: The PV system is being monitored.
D: The monitoring programme has been finalized.

Summary of Accomplishments

■ Ongoing development of the Task 16 Demosite at EPFL, Lausanne (several pavilions under construction and retrofit).

■ The draft of the Design Handbook is ready for final editing.

■ Collaboration has been established with the organizers of the new IEA Implementing Agreement "Photovoltaic Power Systems (PVPS)." A joint meeting between Task 5 of the

PVPS Agreement and Task 16 was held in Cambridge, USA, on September 15, 1994.

■ A "Workshop on Building-Integrated Photovoltaics" took place September 16, 1994, in Cambridge, USA. There were 20 contributions to this workshop, 9 from Task 16 experts, the others from representatives of international PV industries. About 60 people (from the US Department of Energy, industries, architects, utilities, universities) were given a good overview of the international state-of-the-art of PV in buildings.

■ A joint Seminar at the Energy Diversification Research Laboratory (EDRL) was held in Varennes, Canada. It was attended by over 30 delegates from abroad and from Canada, representing organizations actively involved in the development of building integrated PV application.

■ Ongoing industry involvement has taken place.

■ Two new PV projects were approved as Task 16 demonstration buildings. In almost all countries, monitoring of the existing demo buildings has begun.

■ A 3.5 hours special seminar on PV in buildings, organized by Steven Strong (USA), Yakinosi Kuwano (J) and Heribert Schmidt (D), was held at the "First World Conference on Photovoltaic Energy Conversion" Dec. 5-9, 1994, in Hawaii. Other presentations of Task 16 work were also made.

Work Planned for 1995

■ Based on the information collected until now, drafts of the various chapters for the design handbook for PV systems integrated into buildings will be finished and checked for content as well as for language. The final draft of the handbook will be sent to the ExCo as well as to all participants. Details of the printing (publisher, funding, number of copies) will be resolved.

■ A brochure on all demo-houses is under preparation. Details of its production (especially the funding) will be clarified by the next Experts Meeting.

■ More installations at the PV Demonstration Site at EPFL in Lausanne will be encouraged.

■ The experiments on testing of safety equipment will continue and a working document will be prepared.

■ Substantial work will be done to compile and describe the different types of integration methods for PV in buildings, and a working document will be prepared.

- Further guidelines for safety, utility interfacing, test methods for selected PV-components and monitoring will be drafted.

- The PV program checklist will be updated and should provide a quick and comprehensive overview on the availability and capabilities of the programs.

- Four participants of Task 16 are responsible for information transfer between Task 5 of the new IEA Implementing Agreement "Photovoltaic Power Systems (PVPS)" and Task 16.

- A working document on the "Workshop on Building-Integrated Photovoltaics" September 16, 1994 in Cambridge (Boston, USA) will be prepared.

Reports Published in 1994

- Technical Report "Storage Module Survey"

- Photovoltaics in the Built Environment: Results of the Architectural Ideas Competition

Reports to be Published in 1995

- Data bank for PV components - Update (internal working document)
- Market survey and test results for inverters (technical report)
- Simulation of irradiation distribution (internal working document; technical report if results sufficient)
- "Trade-Off' - Summary (internal working document)
- Computer Program Survey (technical report)
- Report on utility interface and islanding (internal working document, technical report if results sufficient)
- Report on "Potential of PV in Buildings" (internal working document)
- Brochure on all Demo-houses (technical report)
- Design Handbook (technical report)

1994 Meetings	6th Experts Meeting	April 18-20 Utrecht (NL)
	Joint IEA-PVPS Task V/ SHCP Task 16 Meeting	September 15 Boston (USA)
	Workshop on Building- integrated PV	September 16 Boston (USA)
	7th Experts Meeting	September 19-21 Montreal (CAN)
1995 Meetings	8th Experts Meeting	April 5-7 Linz (A)
	9th Expert Meeting	September I, D (?)
	Individual Subtask-Meetings	

Task 16 Participants

OPERATING AGENT
Dr. Heribert Schmidt
Frauhofer Insitute for Solar Energy Systems
Oltmannstrasse 5
D-79100 Freiburg
GERMANY

AUSTRIA
Dr. Reinihard Haas
TU Wein
Inst. für Energiewirtschaft
Gasshausstrasse 27-29
A-1041 Wein

CANADA
Jimmy Royer
SOLENER, Inc.
442 rue Laviguer
Quebec, Quebec G14 1B5

FINLAND
Kimmo Peippo
Helsinksi Univ. of Technology
Rakentajanaukio 2 C
FIN 02150 Espoo

JAPAN
Shogo Nishikawa
Tsukuba Technology R & D Institute, Kandendo Co. Ltd.
2673-169 Shimoinayoshi, Nishiyama , Chiyodamachi, Niihari-gun, Ibaraki-ken
315 Tokyo

THE NETHERLANDS
Tony Schoen
EOFYS
P.O. Box 8408
NL-3503 RK Utrecht

NORWAY
Inger Andresen
SINTEF - Architecture and Building Technology
Alfred Getz Vei 3
N-7034 Trondheim

SPAIN
Alvaro Gonzalez Menendez
CIEMAT-IER
Avda. Complutense 22
A-20840 Madrid

SWEDEN
Mats AnderssonIndustrial Microelectronics Center
Bäling
S-82077 Gnarp

SWITZERLAND
Peter Toggweiller
PMS Energie AG
Lindhofstr. 13
CH-8617 Mönchaldorf

UNITED KINGDOM
Bernard McNelis
IT Power Ltd.
The Warren - Bramshill Rd.
Eversley, Hants. RG27 OPR

UNITED STATES
Steven J. Strong
Solar Design Associates, Inc.
P.O. Box 242
Harvard, MA 01451-0242

TASK 17: MEASURING AND MODELING SPECTRAL RADIATION AFFECTING SOLAR SYSTEMS AND BUILDINGS (FINAL REPORT)

Dr. Fritz Kasten Deutscher
Wetterdienst Operating Agent
for Forschungszentrum
Jülich, Germany

Task Description

Radiation data are needed for solar resource assessment, design and evaluation of solar systems and buildings, and solar collector testing. As the performance of certain types of solar systems, building components and solar collectors depends on the spectral distribution in the ultraviolet, visible and infrared spectral range of the incoming solar radiation and on longwave thermal radiation exchange as well, a need was identified for improving the quantity and quality of spectral radiation data, both broad-band and narrow-band.

Task 17, which ran from 1 September 1991 until 31 August 1994, addressed this need by focussing research on three types of spectral radiation data:

- Narrow-band spectral radiation data for applications to solar and building materials;
- Broad-band spectral radiation data in the visible range (that is, visible light) for applications to natural illumination in buildings;
- Broad-band spectral radiation data in the infrared range (that is, long-wave radiation) for applications to the energy balance of solar systems and buildings.

The work was divided in five Subtasks, each coordinated by a lead country:

- Subtask A: Narrow-band Spectral and Broad-band Infrared Radiometry (Germany)

- Subtask C: Narrow-band Spectral Radiation Data Acquisition and Analysis (Germany) - Completed in 1992

- Subtask D: Narrow-band Spectral Radiation Modelling (USA) - Completed in 1992

- Subtask E: Broad-band Visible Radiation Data Acquisition and Analysis (USA)

- Subtask F: Broad-band Infrared Radiation Data Acquisition and Analysis (Norway)

(Subtask B was not initiated.)

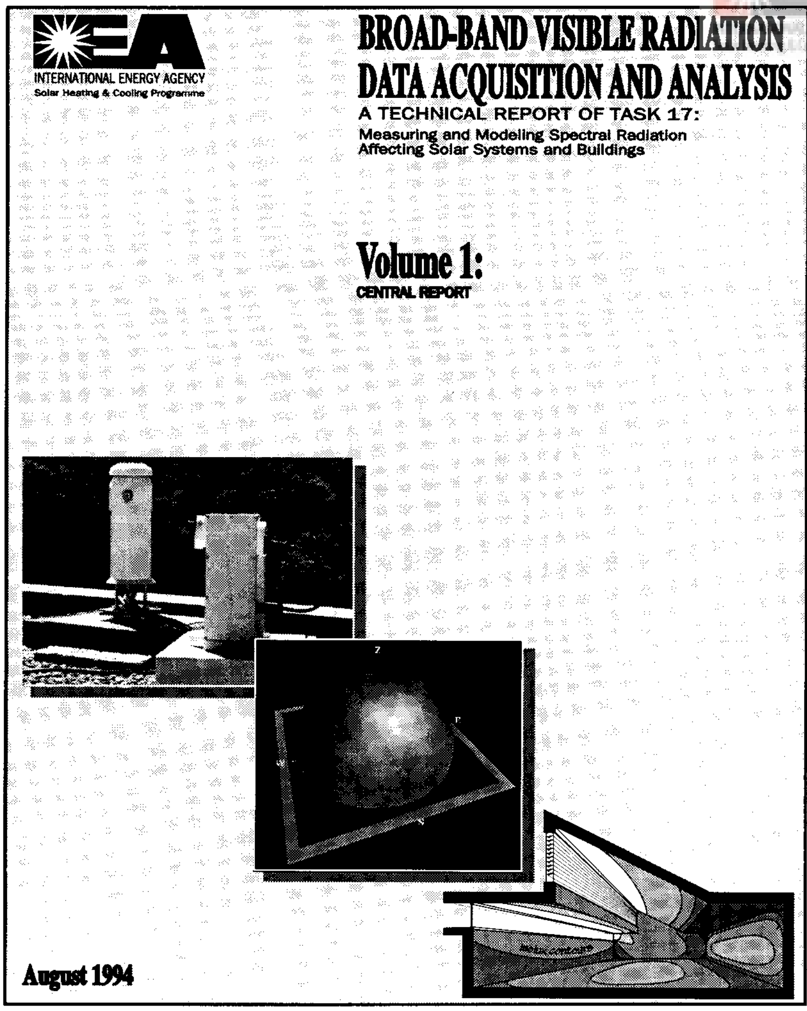
Subtask A dealt with field inter-comparisons of existing spectro-radiometers and pyrgeometers and characterized these instruments as a function of inclination, temperature, direction and spectral composition of incoming radiation, in order to specify uncertainty and predict performance.

Subtask C focussed on increasing the available amount of narrow-band spectral radiation data by measurement, evaluation and analyses of such data and associated quantities under various atmospheric conditions and climates, and the compilation and publication of such data.

In order to increase the quality of modelled spectral radiation data, experts in Subtask D compiled narrow-band spectral radiation models for arbitrary atmospheric and ground surface conditions, and improved the methods of estimating meteorological parameters needed as input to such models.

Solar illuminance and luminance data and related solar irradiance and radiance data were acquired under Subtask E, following the guidelines of the International Daylight Measuring Program (IDMP), and data analysis and model validation were conducted in order to increase the available amount of daylighting data.

To provide input needed for energy balance analysis of solar systems and buildings, the participants in Subtask F acquired and evaluated (longwave) atmospheric radiation and related data under various specified atmospheric conditions and climates, and reviewed and validated parameterizations for atmospheric radiation, relating to both horizontal and inclined surfaces.



The cover of this Task 17 report summarizes its scope. Lower right: Modern daylighting calculation tools can accurately delineate light penetration in complex interior spaces. Center: Models were developed to characterize the local light source (e.g., sky luminance distribution). Upper left: Models were validated against experimental data acquired as part of the International Daylighting Measurement Program (e.g., the two sky scanners at the University of Geneva pictured here).

Activities During 1994

Since the completion of Subtasks C and D in 1992, fourteen institutions from eight countries participated in the Task. The commitment to the Task in 1994 amounted to 60 person-months, bringing the total manpower commitment during the Task to 297.5 person-months.

The activities of the Task in 1994 focussed on preparing the final technical reports. A complete documentation of the accomplishments of the Task is contained in a series of IEA reports.

The state-of-the-art of measuring the spectral composition of global solar radiation under varying atmospheric conditions is described in a report on field intercomparisons of narrow-band spectro-radiometers. Recent improvements in the design, operation, and calibration of instruments for measuring thermal infrared radiation are presented in a report on laboratory characterizations and calibrations of longwave radiometers.

The natural variability of spectral global solar radiation as evidenced by systematic measurements and by selected models is documented in a report on narrow-band spectral radiation data acquisition, analysis and modelling which also contains recommendations for the measurement of spectral solar radiation data, a documentation of the spectral radiation data base compiled, and standardized tabular descriptions of the models.

A wealth of information on natural daylight is contained in the 3-volume report on broad-band visible radiation data acquisition and analysis. Whereas Vol. 1 gives a wide overview on the activities and results in this field, Vol. 2 presents a systematic documentation of the world network of daylight measuring stations organized within the International Daylight Measuring Program (IDMP), giving a 5-page standardized description of each of 41 stations. Vol. 3 assembles 22 "satellite reports" which were written by individual experts on the scientific and technical details of the research they had performed.

The report on review and test of parameterizations of atmospheric radiation presents a systematic, critical comparison and evaluation of the numerous algorithms proposed in the literature for computing longwave thermal radiation from standard meteorological parameters, and gives appropriate recommendations.

In addition to the five IEA reports just mentioned, three other products were generated by the Task: two data bases and one software program. The spectral solar radiation data base comprises 62,000 global solar radiation spectra acquired at Stuttgart, Germany and is described in the IEA Report no. IEA-SHCP-17C-1. The atmospheric radiation data base contains 94 years of records from 17 stations in 6 countries and is described in the working document no. IEA-SHCP-17E-1. The software is a computer program for automatic quality control (AQC) of International Daylight Measuring Program (IDMP) data.

An overall review of the activities during the entire duration of the Task, the accomplishments achieved, and the products generated under the Task, as well as a set of recommendations and conclusions, are given in the Final Task Summary Report, Document No. IEA-SHCP-17-1.

Reports Published in 1994

- Report on Field Intercomparisons of Narrow-band Spectro-radiometers. K. Dehne et al. Report # IEA-SHCP-17A-1. To be available from: Deutscher Wetterdienst, Meteorologisches Observatorium Potsdam, Telegrafenberg, D-14473 Potsdam, Germany.

- Report on Laboratory Characterizations and Calibrations of Longwave Radiometers. K. Dehne et al. Report # IEASHCP-17A-2. To be available from: Deutscher Wetterdienst, Meteorologisches Observatorium Potsdam, Telegrafenberg, D-14473 Potsdam, Germany.

- Narrow-band Spectral Radiation Data Acquisition, Analysis and Modelling. S. Nann and A. Bakenfelder. Report # IEA-SHCP- 17C- 1. Available from: Deutscher Wetterdienst, Meteorologisches Observatorium Potsdam, Telegrafenberg, D-14473 Potsdam, Germany.

- Broad-band Visible Radiation Data Acquisition and Analysis. R. Perez et al. Report # IEA-SHCP-17E. Vol. E 1: Central Report; vol. E2: Satellite Report No. 1 (World network of daylight measuring stations (International Daylight Measuring Programme)); vol. E3: Satellite Reports No. 2-7 (Data acquisition) and No. 8-23 (Data analysis). Available from: Atmospheric Sciences Research Center, The State University of New York at Albany, 100 Fuller Road, Albany, N.Y. 12205, USA.

- Review and Test of Parameterizations of Atmospheric Radiation. J.A. Olseth et al. Report # IEA-SHCP-17F-2. Available from: Det Norske Meteorologiske Institutt, P.B. 43 Blindern, N-0313 Oslo, Norway.

1994 Meetings

Fifth Task Meeting	9-11 March Saratoga, N.Y., USA

Task 17 Participants

OPERATING AGENT:
Fritz Kasten
c/o Deutscher Wetterdienst
Postfach 65 01 50
D-22361 Hamburg
GERMANY

CANADA
Bruce McArthur
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario M3H 5T4

FRANCE
Marc Fontoynont
LASH-ENTPE
Rue M. Audin
F-69120 Vaulx en Velin

Jean Oliviéri
METEO FRANCE
Centre radiométrique
F-84200 Carpentras

GERMANY
Hans Georg Beyer
Fachbereich Physik
Universität Oldenburg
Postfach 2503
D-26111 Oldenburg

Klaus Dehne
Deutscher Wetterdienst
Meteorologisches Observatorium Potsdam
Postfach 60 05 52
D-14405 Potsdam

Matthias Rommel
Fraunhofer-Institut für Solare Energiesysteme
Oltmannstr. 5
D-79100 Freiburg

NEW ZEALAND
Antoine Bittar
National Institute for Industrial Research and Development
P.O.Box 31310
Lower Hutt

NORWAY
Björn Aune
The Norwegian Meteorological Institute
P.B. 43 Blindern
N-0313 Oslo 3

Jan Asle Olseth
Arvid Skartveit
Geophysical Institute
University of Bergen
Allegt. 70
N-5007 Bergen

SWEDEN
Lars Dahlgren
Swedish Meteorological and Hydrological Institute
S-60176 Norrköping

Leif Liedquist
Swedish National Testing and Research Institute
Box 857
S-50115 Boras

SWITZERLAND
Pierre Ineichen
GPA
University of Geneva
4 chemin de Conches
CH-1231 Conches

USA
Richard Perez
Atmospheric Sciences Research Center
SUNY
1400 Washington Avenue
Albany, N.Y. 12222

TASK 18: ADVANCED GLAZINGS AND ASSOCIATED MATERIALS FOR SOLAR AND BUILDING APPLICATIONS

Prof. M.G. Hutchins
Oxford Brookes University
Operating Agent on behalf of the
United Kingdom Dept. of Trade and

Task Description

The objective of this Task is to develop the scientific, engineering and architectural basis which will support the appropriate use of advanced glazings and associated materials in buildings and other solar applications with the aim of realising significant energy and environmental benefits.

This Task builds upon work begun in Task 10, Materials Research and Testing. Comprehensive measurements of key glazing performance parameters are being made for advanced glazing materials, components and window systems. Building energy analysis tools are employed to identify appropriate applications and predict energy and environmental impacts which will derive from the use of advanced glazing products. Task 18 has a specific focus on the application and technology transfer of new materials and components with an emphasis on near-market technologies.

The Task aims to provide guidance for design engineers, building engineers and industry on the properties, use, performance and selection of advanced glazing materials. Necessary measurable parameters for specification of the thermal performance of advanced glazing materials are identified and defined, and appropriate measurement test procedures are being developed.

The work of Task 18 is organized under two subtasks. The nineteen projects included within the Subtasks A and B together with the lead country responsible for management of each project are as follows:

Subtask A: Applications Assessment and Technology Transfer (Lead Country - Australia)

A1 Applications, potentials and characteristics (Australia)
A2 Modelling (U.S.A.)
A3 Control strategies (U.S.A.)
A4 Environmental and energy impacts (Australia)
A5 Applications guidance (U.K.)

Subtask B: Case Study Projects (Lead Country - Norway)

B1 Monolithic and granular aerogels (Denmark)
B2 Geometric media (honeycombs and capillary structures) (Germany)
B3 Chromogenic glazings (U.S.A.)
B4 Low-emittance coatings (Sweden)
B5 Evacuated glazings (Australia)
B6* Advanced solar collector covers (Switzerland)
B7 Angular selective transmittance coatings (Australia)
B8 Daylighting materials and systems (Australia)
B9 Frame and edge seal technology (Norway)
B 10 Advanced glazing materials properties database and technology summaries (UK)
B 11 Investigation of the optical properties and scattering behaviour of advanced glazing materials (Sweden)
B 12 Measurement of the total energy transmittance of advanced glazing systems (Germany)
B 13 Directional optical properties measurements of advanced glazing materials (France)
B 14 Measurement of the U-value of advanced glazing systems (Netherlands)

* *This project is not **running** in Task 18.*

The Task was initiated on 1 April 1992 and will continue for five years (31 March 1997).

Review of 1994 and Work in Progress

Task 18 is engaged in activities which address all key issues relevant to the use of advanced glazing technology in buildings. The work encompasses basic materials research, window design and construction, performance definition, measurement and testing, simulation of energy benefits, environmental impacts, applications assessment and information dissemination. In 1994 the Task made excellent progress in all main areas, completing much of the planned work in good time. Participation levels have continued to be good across the whole Task. The Task has now reached its halfway point and is well placed to sustain progress towards achievement of the Task's overall objective. Some achievements of the past year are described below.

Subtask A

Advanced glazing materials promise new architectural and insulation opportunities. Windows can become net sources of useful heat, enable dynamic control of transmittance, and enhance thermal and visual comfort. Little practical experience presently exists in monitoring the use of advanced glazing, and their integration into the building envelope will require reassessment of building services needs and implementation of effective control strategies. The goals of Subtask A are to identify appropriate applications, determine the energy and environmental impacts and provide applications guidance in order to promote awareness of potential benefits and stimulate market opportunities.

■ Applications Assessment

The technical work of Project Al "Applications, potentials and characteristics" was essentially completed and final reporting is currently in preparation. A cross-referenced glossary of glazing terms has been defined and is available in both hard copy and electronic form. The glossary will be of real value to professionals working in the field of advanced glazing. The project has completed its work in identifying and defining all key glazing performance parameters required to specify the nature and quality of a glazing system. The work is of value in providing product selection information for engineers and designers and descriptive information for use in computer-based thermal performance simulation programmes. Other factors which influence the acceptance of advanced glazing products in the marketplace have been assessed and are reported in the work performed on visual amenity.

Work on simulating the energy impacts of the use of advanced glazing in different climatic zones in both residential and commercial buildings was commenced following agreement on tools to be employed and base reference conditions. Reports were written on standards for analysis and the definition of performance and on procedures for determining the energy performance of complex glazings. First simulation results are now being analysed and the work will continue in 1995.

■ **Environmental Impacts**
Australia assumed the leadership of the project on energy and environmental impact assessment. Work is now in progress to analyse a range of window life-cycle issues. This work will assist window manufacturers to anticipate and hence prevent potential problems, e.g. materials procurement, product disposal etc., from occurring. The project is examining recycling opportunities, materials abundance and the energy efficiency and environmental impacts of some thin film deposition processes used in coating window products. The work will help to establish tools and techniques for environmental quality measurement.

■ **Applications Guidance**
The UK has taken responsibility for leading the Task's work on information dissemination. Important links have been established with other relevant organisations and programmes concerned with applications guidance and the promotion of best practice. The success of the Task's work in this area is essential if the results are to be presented to the widest possible audience in forms appropriate to their needs in order to promote awareness of the potential of advanced glazing systems. Draft forms of guidance material are now in preparation and will be circulated widely for critical review in the coming year.

Subtask B

In Subtask B, each Case Study Project integrates a series of materials development and measurement activities to enable an extensive, in-depth determination and examination of materials properties and performance levels for potential use in advanced glazing systems. Each Project is undertaking measurement and characterisation work concerned with bash materials properties, e.g. optical, thermal, mechanical etc.. Where possible, measurements are being performed on large area samples of advanced glazing materials and there is particular emphasis on investigating the properties of whole windows comprising advanced glazing materials and their associated frames and sealant materials.

■ **High Performance Glazings for Thermal Insulation** Low emittance glazing is now widely available for use in double or triple glazed units, which may be filled with a low conductivity gas such as argon. Such low U-value products successfully achieve the aim of reducing heat loss through windows albeit with some reduction in incident solar gain. For the present and immediate future this technology represents an excellent solution for improving the thermal performance of the building envelope. However, there are a number of alternative materials and glazings, i.e. aerogels, transparent insulation, evacuated glazing, which have the potential to reduce heat losses still further and these opportunities are being analysed and evaluated in the Task.

Aerogels
The Task aims to produce a large area partially evacuated monolithic aerogel window with a solar heat gain coefficient (total energy transmittance) of 0.75 and U-value less than 0.5 W m ^{2} K'. The presence of short wavelength scattering of light impairs the visual appearance of aerogels and the Task has investigated the sources of this scattering and is attempting to produce improved materials which could be used as a view window. A review was completed on aerogel production methods in the member countries. The optical properties and thermal conductivity of monolithic aerogels produced in Japan, Norway and Sweden were measured. Energy saving potentials in Scandinavian climates were assessed. To date only granular aerogel materials can be made into full size windows for performance determination.

Transparent Insulation Materials (Geometric Media)
A range of different transparent insulation materials have been distributed to the participants. Angular dependent optical properties and the total energy transmittance were determined for the samples. A report assessing the durability of transparent polymers was completed. Work commenced on optimisation of TIM materials in solar collectors.

Evacuated Glazing
Following completion of the state-of-the-art review, a number of large area samples up to 1 x 1 m^2 were manufactured by the University of Sydney, Australia, and distributed for performance assessment. Figure 1 shows an evacuated glazing prototype constructed by the Sydney group. Angular dependent thermal emittance measurements were made to enable models of heat transfer in evacuated glazings to be successfully validated. Heat transfer processes and temperature gradients were investigated using thermographic imaging in the USA. A report quantifying stresses and fracture probability in evacuated glazings was completed.

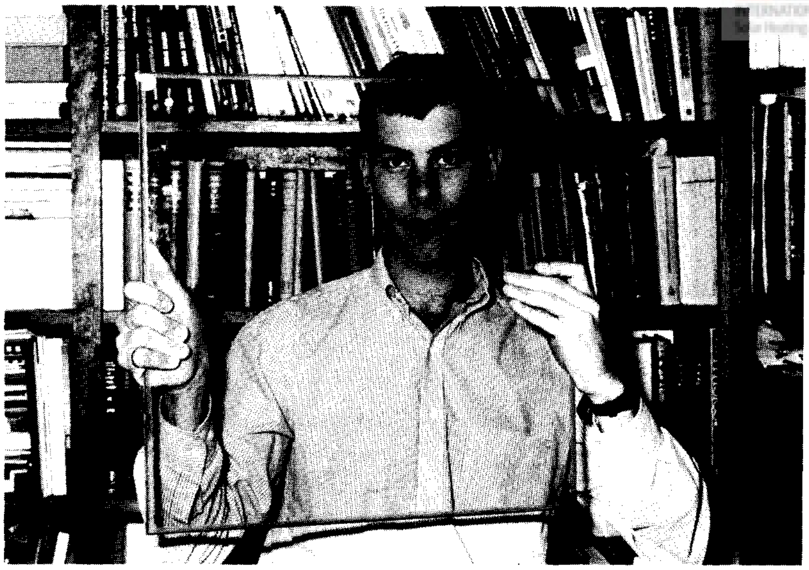


Fig. 1: Evacuated glazing prototype constructed by the University of Sydney, Australia, comprising two low-e tin oxide coated glass sheets separated by sub-millimetre dimensioned cylindrical pillars and employing a fused gas edge seal.

■ **Solar Gain Control**

Advanced glazings can be employed to filter incident radiation allowing only the visible portion of the solar spectrum to be transmitted, to reduce glare and avoid visual discomfort and to regulate solar gain dynamically using switchable, or "smart", windows. Applications include the reduction of heating and cooling demands and the effective use of daylight. Many of the candidate solar gain control glazings are sophisticated thin film coatings and the Task's research programme is establishing a basis of knowledge on the properties and potential of these glazings.

Chromogenic glazings

A state of the art review on chromogenic technologies was completed which serves as a valuable reference to work in progress throughout the world. The report contains a directory of known projects and active researchers.

The Task completed an investigation into the electrochromic properties of tungsten oxide films prepared using different techniques. The study determined the performance of tungsten oxide for both proton and lithium insertion, analysed the influence of surface microstructure and assessed the composition of the coloured and bleached state through the use of a range of surface analysis techniques.

Plans were agreed for the performance assessment of a range of all solid state variable transmission electrochromic devices and first samples were distributed. In 1995 thermochromic samples will also be distributed for analysis.

Angle Selective Transmittance Coatings
The growth of oriented columnar thin films by oblique incidence thin film processes is capable of producing coatings which exhibit anisotropic transmittance properties. The growth angle of the columns can be controlled to enable reflection of light incident at large angles whilst preserving normal viewing conditions at near-normal angles. Such coatings have potential in the reduction of glare in buildings and can be adjusted for use in a range of climates.

Angle selective transmittance films were prepared at the University of Technology, Sydney, and circulated to participating countries. The optical properties were determined for all angles of incidence. These data will be used as input to building energy analysis simulations to be performed in the USA to enable the energy performance to be assessed and compared to more conventional glazings.

Multilayer thin film low emittance coatings
Multilayer thin film designs can be used to allow only the visible art of the incident solar spectrum to be transmitted. Such coatings will reduce cooling and lighting loads in buildings. Thin film multilayers based on titanium nitride and zirconium nitride are being prepared in Sweden and the UK and their optical properties have been shown to be very encouraging.

■ **Daylighting**
Some work on the characterisation of daylighting materials and the assessment of different daylighting systems has been completed. With the decision to commence the planning phase of a new IEA SH&C Task on Daylighting, much of the Task 18 effort has been focused into ensuring effective interaction between the two Tasks. Task members have attended the daylighting planning workshops and it has been agreed that Task 18 will undertake measurements of the optical and spatial distribution properties of daylighting apertures recommended by the new Task. Work should begin in 1995.

■ **Frame and Edge Seal Technology**
The state of the art survey co-ordinated by the University of Trondheim, Norway, was completed. This report has been widely acclaimed and many inquiries have been received resulting from the work. The information in the report was supported by a number of new measurements of the thermal conductivity of many sealant and spacer materials and by surface temperature measurements on insulated glass units employing different spacer types.

Work has now commenced on producing design guidelines for frame and edge seal technology for advanced glazings. Measured U-values of Scandinavian and Canadian windows have been compared with simulated results obtained using the Canadian FRAME programme. In 1995 it is planned to build some new improved high performance frames based on the design and simulation studies.

■ Measurement of Glazing Performance

Directional** Optical **Properties and Scattering

The **accurate determination of angular** dependent solar **and** thermal optical **properties is essential** to enable the total energy gains and losses to be understood. Directional measurements have long proved difficult to perform with high accuracy and much of the Task's efforts in this area will contribute to improved measurement techniques for future application, possibly in international standards. Work has focused on improving the accuracy of measurements made with integrating spheres and on developing and validating correction methods for measured signals. This work is progressing well. Measurements have been made on a number clear and scattering glazing materials. New work has recently commenced on developing a family of algorithms for different categories of glazings to permit prediction of angular dependent optical properties from near-normal measurements. This work, when validated, will be of definite value to the glass and glazings industry and may also form the basis for future standards development.

Directional measurements have also been carried out for small samples of the low emittance coatings used in the calibration round-robin total energy transmittance measurements of large edge sealed units. These data enable calculation of the total energy transmittance to be made and comparison with the experimental work. The small sample measurements themselves constituted a round robin and the results of this interlaboratory comparison have recently been reported.

Total Energy Transmittance

Fifteen double-glazed, argon filled, low emittance (K-GLASS) windows ranging in size from 0.5 x 0.5 m^2 to 1.2 x 1.2 m^2 were constructed in the UK by Pilkington Glass Ltd and circulated to participants in 13 countries. Double glazed windows equipped with a HYPERSOL solar control glass were built in Germany by INTERPANE and circulated to the same laboratories. The calibration round robin to determine the total energy transmittance of these windows has recently been completed. A report is now in preparation which describes calorimetric and hot box methods for the measurement, the interlaboratory comparison results, test calculation exercises and an error analysis and correction methods which can be applied to account for e.g. spectral distributions in solar simulators.

With the completion of the necessary calibration experiments, work will now begin of measuring the total energy transmittance of more demanding advanced glazings, e.g. transparent insulation products, aerogels and windows with integrated louvers.

U-value Measurements

Accurate determination of U-value in highly insulating glazings is a demanding and difficult task. To prepare for future measurements on highly insulating glazings, U-values have been determined for the Pilkington and Interpane windows described above. Measurements were made with guarded hot box and guarded hot plate test facilities. Results for the opaque reference panel agree to within about 3%. Error analyses have been performed to estimate the uncertainty in the data. The test procedures have been analysed and agreement on new windows to be circulated in 1995 has been reached.

■ **Summary**

1994 was once again a successful year for Task 18. As the Task enters the second half of its Research Phase, it is well placed to make solid and substantial progress in all major areas. 1995 should see many of the results published in the open literature and the impact that the Task is having on promoting awareness of the benefits of advanced glazing technology can begin to be assessed.

Links with Industry

Task 18 has strong working links with industry, international standards organisations, the European Community JOULE programme and the US National Fenestration Ratings Council.

Industry continues to participate directly in the research activities of the Task. Industry also provides many of the prototype glazings which are being investigated. Many countries report the results arising from the work of the Task back to relevant industry and professional organisations at the national level. Some countries have formalised the links with industry through the formation of "Industry Clubs". The most developed of these are in Australia and the UK. Many workshops and seminars have been held to assist in disseminating results from the Task to the widest possible audience.

In 1995 the Task is jointly hosting a major international conference with the Canadian Ministry for Minerals and Energy Technology (CANMET) called "Window Innovations 95". The conference will be held in Toronto, 8-9 June and it is anticipated that many representatives from the North American glass and glazings industry will attend. Task 18 will present many of the results of its work through some 12 technical papers which have been accepted for presentation and publication in the conference proceedings.

Working Documents Published in 1994

A full list of Working Documents published is contained in the Task 18 Information Plan which may be obtained from the Office of the Operating Agent on request

1994 Meetings

Fourth Experts' Meeting	Jan 31 - Feb 4 Berkeley, California
Fifth Experts' Meeting	June 27 - 30 Trondheim, Norway

1995 Meetings

Sixth Experts' Meeting	Jan 10 - 12 Grenoble, France
Seventh Experts' Meeting	June 7 - 9 Toronto, Canada

Task 18 Participants

AUSTRALIA
Prof John Ballinger
(Subtask A Leader)
Univ. of New South Wales
PO Box 1
Kensington NSW 2033

CANADA
Mr Jeff Baker
Enermodal Engineering Ltd.
368 Phillip Street
Waterloo N2L 5J1, Ontario

DENMARK
Assoc Prof Svend Svendsen
Thermal Insulation Laboratory
Technical Univ. of Denmark
Building 118
DK-2800 Lyngby

FINLAND
Dr Markku Virtanen
Tech. Res. Centre of Finland
PO Box 206
FIN-02150 Espoo

FRANCE
Dr Jean-Luc Chevalier
C.S.T.B.
24 rue Joseph Fourier
F-38400 Saint-Martin d'Heres

GERMANY
Dr Werner Platzer
Fraunhofer-Institut für Solare
Energiesysteme (ISE)
Oltmannsstr 22
7800 Freiburg

ITALY
Mr Augusto Maccari
ENEA
V. Anguillarese, 301
00060 S Maria di Galeria
Rome

JAPAN
Dr Sakae Tanemura
Nat'l Industrial Research Inst.
1-1 Hirate-Cho, Kita-Ku
Nagoya 462

NETHERLANDS
Mr Aart de Geus
TNO Building and
Construction Research
PO Box 29
2600 AA Delft

NORWAY
Prof Øyvind Aschehoug
(Subtask B Leader)
Department of Architecture
Norwegian Institute of
Technology
N-7034 Trondheim

SPAIN
Sr Manuel Macias
CIEMAT-IER
Avda. Complutense, 22
28040 Madrid

SWEDEN
Dr Arne Roos
Department of Technology
University of Uppsala
PO Box 534
S 751 21 Uppsala

SWITZERLAND
Mr Robert Hastings
Forschungstelle
Solararchitektur
ETH Honggerberg
CH-8093 Zurich

UNITED KINGDOM
Prof Michael Hutchins
(Operating Agent)
Solar Energy Materials
Research Laboratory
School of Engineering
Oxford Brookes University
Gipsy Lane
Headington, Oxford OX3 0BI

USA
Mr Sam Taylor
US Department of Energy
Office Building Technology,
CE 421
Washington, Dc 20585

TASK 19:
SOLAR AIR SYSTEMS

S. Robert Hastings
ETH- Zurich
Operating Agent for the
Swiss Federal Office of

Task Description

Solar air systems can deliver space heating and tempered ventilation air while offering unique advantages. Air, unlike water, need not be protected from freezing and leaks are not hazardous. In contrast to passive systems, active air systems offer better comfort control, better heat distribution and hence fuller use of solar gains. Solar air systems are a natural fit to mechanically ventilated buildings and mechanical ventilation is increasingly common, not only in commercial and institutional buildings, but also in very low energy residences.

The economics of air systems are enhanced when they serve additional uses, such as to admit daylight, induce cooling, provide sunshading, generate electricity, or preheat domestic hot water. They may also serve non-energy needs, such as to provide a usable zone, a load bearing element, weather protection or a barrier to street noise.

Unfortunately, designers lack experience in planning, analyzing and constructing such systems. Further, documentation of built prototypes to convince building clients is scarce. The two Subtasks of Task 19 address these needs:

Subtask A: Generic Systems

- Components will be tested and documented in collaboration with industry;
- Computer algorithms will be developed to model recommended systems;
- Key design variables will be quantified through parametric studies; and
- A design handbook will be written to help engineers design solar air systems.

Subtask B: Building Applications

- Exemplary buildings with solar air systems will be monitored;

- Design reviews of new building projects will be carried out; and

- A book documenting exemplary buildings with solar air systems will be produced.

Task 19 was initiated 1 October 1993 and will continue until 30 September 1997.

Activities During 1994

First drafts of case studies have been written and were reviewed at the autumn experts meeting (lead: Italy). The buildings represent a wide cross section of solar air system types, building types and climates.

Information gathering and monitoring of projects is ongoing for the engineering handbook (lead: Denmark). A number of air system types have been classified in the Task. A new System Type 6 was defined in which outside air is circulated through a collector directly into the occupied space. Examples are the "Solar Wall" concept from Canada, a Swiss variation comprised of an air-cooled PV-facade, and the use of atria and sunspaces to pre-heat ventilation air.

Work was initiated on a catalog of manufactured components (lead: Germany). This document will help designers to locate "off-the-shelf' components, even from abroad. Too often, components are re-invented, site-assembled, or products used which are not well suited for the job. This catalog will help overcome one barrier to wider application of solar air systems.

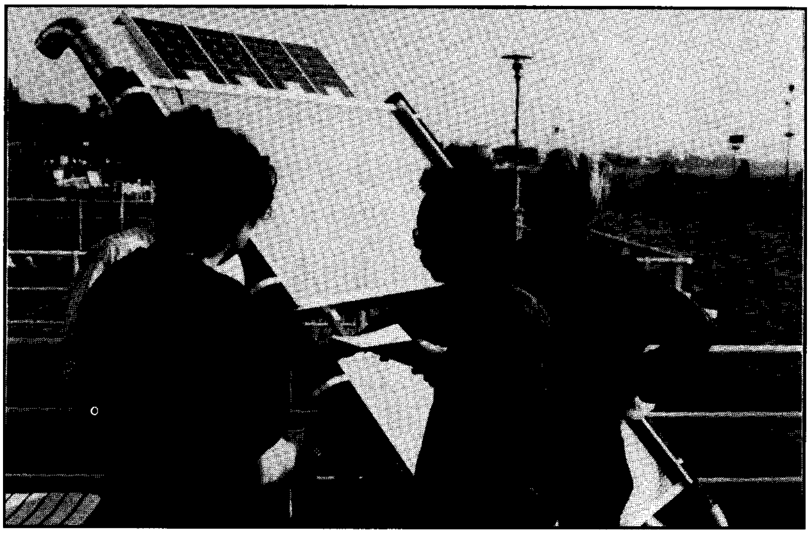
With regard to computer tools, several activities were pursued (lead: Germany):

- An algorithm was developed by the Swiss to model various types of hypocausts (hollow, massive constructions with air channels used here to transport solar heated air, provide short term storage and radiate heat into the adjacent room).

- The Italians are developing an algorithm to allow calculation of natural, rather than forced, air flow through such systems.

■ A mock-up of the **Task** 19 analysis tool for solar air systems (TRNSYS-based) was demonstrated at the spring experts meeting. The interface simplifies the use of this rather complex program so that it can readily be used by consultants.

■ Finally, a survey of existing computer-based tools was completed.



*Task 19 experts examining a Swiss solar air collector **during** the experts meeting held in Sirmione, Italy in March **1994.***

Accomplishments in 1994

■ Ten case studies of exemplary solar air heated buildings have been drafted.

■ The structure for the engineering handbook has been established and research begun.

■ The Swiss have written an algorithm for analyzing diverse types of hypocausts and the Germans have developed a simplified hand calculation procedure. These tools will be available to the Task participants to develop material for the engineering handbook.

■ A survey of the capabilities of existing, commonly used computer tools was conducted to determine their ability to analyze diverse solar air systems. As expected, there exists no readily useable, building-energy-analysis, tool for evaluating the performance of solar air systems correctly.

■ A 4-page picture brochure describing Task 19 has been prepared for the experts for distribution to interested persons in their respective countries. It explains what solar air systems are, what the goals of the Task are, and who is involved in the work.

Work Planned for 1995

■ Drafts of all the case studies are expected to be completed. Ongoing monitoring work should be completed and the data analysis begun.

■ Testing of manufactured components will commence.

■ Incomplete drafts of each chapter of the engineering handbook should be written.

■ A full draft of the catalog of manufactured components should be completed.

■ TRNSYS modules for each Task 19 system type should be completed and put to use to generate the first nomograms for the handbook.

Meetings in 1994

A workshop on hypocausts, hosted by Switzerland from 8 to 9 February, was attended by experts from Germany, Italy and Switzerland. During the first day of the workshop, architects explained how they went about designing solar air heated buildings and what they would like to see in a design/analyses tool. On the second day of the workshop, researchers presented their approach to modeling a hypocaust system, given as a homework in advance of the meeting. Model development work was then coordinated.

The **2nd Experts meeting,** hosted by Italy in Sirmione from 23 to 25 March, was attended by 20 experts from the participating countries plus an observer from the USA. The structure for the case studies and the handbook chapters were defined, a mock-up of the PC-tool interface was presented. A solar air collector system, erected on-site by a Swiss manufacturer, was demonstrated and discussed by the participants.

The **3rd Experts meeting,** hosted by Sweden in Göteburg from 3-5 October, was attended by 18 experts from Denmark, Germany, Italy, Sweden, Switzerland, an observer from Norway and the Swedish ExCo member. An American expert contributed material in absentia for the handbook, as promised. A presentation of Task 20 work was made by the Assistant Operating Agent. Prior to the meetings, a technical tour was provided. Two projects were of special interest: the Swedish case studies buildings with a roof-integrated, double wall system and a row house project with an open loop, wall collector system similar to systems in Italy.

Meetings Planned for 1995

20-21 March 1995: **Manufacturer and Testing Workshop** (Rapperswil, Switz.)
Invited manufacturers of components used in solar air systems and representatives from national testing laboratories will discuss how performance has been quantified to date. Opportunities to establish a common test procedure and then test components in the respective national laboratories will be explored. On the 2nd day, the structure, content and production schedule of the catalog of components will be determined.

21-21 March 1995: **4th Task Expert Meeting** (Rapperswil, Switzerland)
Emphasis will be on the engineering handbook. Progress on the case studies and the PC-design tool development will be checked.

June 1995: **Nomograms Workshop** (Stuttgart)
At this working meeting, the first nomograms for the engineering handbook will be generated. Representative cases will be defined and then analyzed using the new PC-design tool under the tutelage of Mathias Schuler. The nomograms are intended to provide manual estimation procedures to be described in the handbook.

September 1995: **5th Task Expert Meeting** (location to be determined)

Task 19 Participants

OPERATING AGENT:
S. Robert Hastings
Solararchitektur,
ETH-Hönggerberg
CH-8093 Zürich,
Switzerland

AUSTRIA
Manfred Bruck
Kanzlei Dr. Bruck
Garnisongasse 7
A 1090 Viena

DENMARK
Ove Morck
Cenergia APs
Sct. Jacobs Vej 4
DK 2750 Ballerup

GERMANY [1]
Frank D. Heidt
Fachbereich Physik
Universität GH Siegen
D-5900 Siegen

Matthias Schuler
Transsolar
Nobelstr. 15
D 70569 Stuttgart

Hans Erhorn
Fraunhofer Inst. für
Bauphysik
Nobelstrasse 12
D 70569 Stuttgart

ITALY
Gianni Scudo
DPPPE Politecnico di
Milano
Via Bonardi
I 20133 Milano

NORWAY
Harold Rostvik
Sunlab/ABB
Steingt. 87
N-4024 Stavanger

SWEDEN
Torbjörn Jilar
Swed. Univ. of Agriculture
Dept of Farm Buildings
S23053 Alnarp

SWITZERLAND
Charles Filleux
Basler & Hofmann
Forchstr. 395
CH 8029 Zürich

TURKEY
Melih Tan
TÜBITAK
Atatürk Bulvari Nr. 221
TY 06100 Kavaklidere
Ankara

UNITED KINGDOM [2]
Kevin Lomas
School of Built Environment
De Montfort University
UK-Lester LE1-9BH

[1] The national contact person for Germany has not yet been designated.

[2] The United Kingdom has not officially joined Task 19.

TASK 20:
SOLAR ENERGY IN
BUILDING RENOVATION

Prof. Arne Elmroth
Lund University
Operating Agent for the
Swedish Council for Building

Task Description

For solar energy technologies to have a significant impact on energy consumption in the building sector, solar strategies must be utilized in the renovation of existing buildings as well as in new buildings. Older buildings typically have higher energy use and an indoor climate that needs to be improved. Incorporating a solar energy system as a part of a renovation package is often more economically viable than is the case if the solar system is applied by itself.

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 remodellers, and also focussing on how to reach key players in the renovation process, obtain their support and provide needed information on solar opportunities.

The motivation for renovation or remodelling can be anything from a desire to repair or replace a leaking roof, a deteriorated concrete balcony, or poor windows, increase living or work space area, upgrade the building's appearance, improve. indoor comfort levels, reduce utility expenses, or to accommodate changes in building use. Regardless of the reason, renovation presents special challenges and opportunities arising from the age and condition of the building, previous construction and materials employed, building type and use. These must all be taken into consideration when selecting solar technologies and designs for this purpose.

The multi family buildings in the Ulkaer project in Denmark were renovated with roof-integrated combined air and liquid solar collectors.

The scope of the Task is the application of solar energy technologies for space and domestic water heating, cooling and lighting in existing residential and non-residential buildings. A number of the most promising concepts will be explored from the perspective of their impact on building thermal performance, visual comfort, environmental impact, and economic performance. It is also necessary to understand how decisions are made by building owners and others involved in the renovation process, how solar strategies is valued in different markets, and how to obtain the support of building contractors and other key players.

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

- Subtask A - Evaluation of Existing Building Applications (Sweden)

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

- Subtask C - Design of Solar Renovation Projects (Denmark)

- Subtask D - Documentation and Dissemination (Netherlands)

Subtask A has focused on obtaining as much relevant information as possible from existing solar renovation projects - both positive and negative. Information has been collected on the reasons for renovation, various features employed, the renovation process, and occupant reactions.

Development of improved and advanced renovation concepts is the main focus of Subtask B. A wide variety of possible systems, components, and strategies will be identified and then analyzed in specific renovation situations to assess their feasibility and performance.

In Subtask C, the participants will create designs for solar renovation projects, which may be used as demonstration projects. Monitoring procedures and reporting formats will also be developed in the Subtask. The activities in Subtask C are divided into two parts: (1) Design of solar renovation projects and (2) Evaluation of solar renovation projects.

Under Subtask D, the results of the Task will be summarized and documented. Various information dissemination methods will be employed. The Subtask consists of the following elements:

D1 - Document Solar Renovation Strategies and Lessons Learned
D2 - Arrange and Participate in International Symposia
D3 - Compile Illustrative Source Materials
D4 - National Information Dissemination

Task 20 was initiated August 1, 1993 and will run until July 31, 1996.

***Poor concrete in the balconies was the reason for renovating the multi** family **houses in Høje** Gladsaxe **in** Denmark. **The renovation** started **in** 1989 **and was completed in** 1993. Sixteen kilometers of balconies were glazed **in** this project!*

Activities During 1994

Two Experts Meeting were held in 1994. The participating countries are involved in all four Subtasks, except for Belgium and the US, which did not contribute to Subtask A.

Subtask A - Evaluation of Existing Building Applications The first activities in Subtask A have been to identify and collect information about case studies. The report now comprises an evaluation of 15 existing solar renovation projects in six countries. The reported projects involve the applications of multifamily buildings, together with one school building. The 15 case studies represent principally three major solar renovation concepts: glazed balconies & galleries, solar walls, and solar collectors. The primary reasons for undertaking the renovations were: need to repair or improve the building envelope and need to replace or improve the heating, ventilation and air conditioning system.

Most of the case studies were judged to be successful as demonstration projects. However, since most included mixed renovation activities, such as traditional wall insulation and replacement of windows in combination with one or two solar renovation concepts, it was hard to evaluate the energy savings, other benefits, and cost-effectiveness of the solar renovation concepts. This emphasizes the importance of further efforts in this field. With this report, Subtask A is completed.

Subtask B - Development of Improved/Advanced Renovation Concepts

Four documents will be the basis for an international guide that will be produced in Subtask B. In the first document "Work Area," the main principle is put together a diagram which shows how the architecture, technology and economic aspects work together in the renovation process. A double entry table is used with the strategies (heating, cooling and daylighting), the concepts and the elements on one side and the possible renovation activities on the other side.

In the second document the following issues are defined: the objectives, and the elements of resolution together with the corresponding systems. In the third document, "Tables of Resolution," the renovation activities are divided into three groups: (1) the envelope, (2) second order of activities, and (3) consequences of the two first groups.

In document number four, which is not yet completed, the results of the simulation work will be presented. The planned simulation work includes single family houses with roof windows and light core; multifamily buildings with facade windows (shading), glazed balconies, glazed facades, transparent insulation materials, light core, domestic hot water (solar collectors) and photovoltaics; offices with transparent insulation materials and photovoltaics; schools with roof windows, glazed facades, transparent insulation materials and preheat; and, finally, departments stores with roof windows and transparent insulation materials. Subtask B will conclude after completion of the international guide during 1995.

Subtask C - Design of Solar Renovation Projects

In Subtask C, the framework for a common presentation of proposals for solar renovation demonstration projects has been completed. Eleven proposals for demonstration projects have been discussed during the Experts meetings. The evaluation of the solar renovation projects will be based on the review and critique. The monitoring plan is not yet completed.

The development of a roof-integrated solar collector for producing a prefabricated module, mounted directly on the roof trusses, is also underway. This solar collector is totally integrated in the roof construction. It will soon be tested in a demonstration project, which may be included in Subtask C. The collector is being developed by a Swedish manufacturer of prefabricated houses (Derome Träteknik AB) in cooperation with Chalmers University of Technology and the Swedish absorber manufacturer Teknoterm.

Subtask D - Documentation and Dissemination

Preparation for documentation and dissemination of results has begun with developing the structure for the national dissemination and the international presentation. Planning for involvement in international symposia and congresses will be made and illustrative materials will be compiled. The planned publications are: brochures, in-depth publications on specific solar renovation concepts, subtask reports, and national research reports.

Work Planned for 1995

Subtask A

This subtask is complete and the results reported in a working document.

Subtask B

The results of the simulation work will be presented and the subtask completed after preparation of an international guide.

Subtask C
The evaluation of the solar renovation demonstration projects will continue and the pre-fabricated roof-integrated solar collector will be tested.

Subtask D
Work will continue on preparations for the national and international presentation and dissemination of results.

Reports Published in 1994

Final Draft "Evaluation of Existing Building Applications in Residential Building Blocks" (Working Document).

1994 Meetings

2nd Experts Meeting	February 21 - 23 Baden (near Zurich)
3rd Experts Meeting	Aug. 29 - Sept. 1 Copenhagen

1995 Meetings

4th Experts Meeting	March 6 - 9 Freiburg
5th Experts Meeting	September 4 -7 Sweden

Task 20 Participants

OPERATING AGENT:
Arne Elmroth
Lund University
Dept. of Building Physics
P.O.Box 118
S-221 00 Lund, SWEDEN

BELGIUM
André De Herde & Nicolas Lesens
Centre de Recherche en Architecture
Universite Catholique de Lovain
Place de Levant 1
B-1348 Lovain-La-Neuve

DENMARK
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Teknikerbyen 38
DK-2830 Virum

GERMANY
Peter O. Braun
Fraunhofer Inst. for Solar Energy Systems
Oltmannsstrasse 5
D-79100 Freiburg

NETHERLANDS
Chiel Boonstra
Woon/Energie
P.O.Box 733
NL-2800 AS Gouda

SWEDEN
Jan-Olof Dalenbäck
Chalmers University of Technology
Aschebergsgatan 55
S-411 33 Göteborg

SWITZERLAND
Andreas Haller
E.Schweizer AG, Metallbau
CH-8908 Hedingen

UNITED STATES
Robert T. Lorand
Science Applications Int. Cor
MS 2 - 7 - 2
1710 Goodridge Drive,
McLean, VA 22102

TASK 21:
DAYLIGHT IN BUILDINGS
(Proiect Definition Phase)

Kjeld Johnsen
Danish Building Research Institute Task
Organizer for the
Danish Energy Agency

Task Description

In many national and international research programs, *daylight is* being recognized as an important source for potential energy savings, due to the fact that energy for artificial lighting represents a major part of the overall energy consumption in non-domestic buildings and electric lighting often increases the cooling load of commercial and institutional buildings. Daylighting techniques and technologies have also been given high priority in the Strategic Plan of the IEA Solar Heating and Cooling Program. To begin the formation of a new Task on daylighting, an IEA Planning Workshop was held in Copenhagen in March 1994.

The main objective of the Task is to promote daylight-conscious building design with the aim of realizing energy savings and visual comfort and amenity value of the building. The following activities will be carried out to achieve the objective:

- Preparation of guidance on the integration of fenestration and daylighting systems in combination with strategies for control of electric lighting,

- Development of a set of efficient, user-friendly daylighting design tools, and

- Compilation of a report documenting pertinent case studies in buildings.

The Task will focus on daylighting of new and existing buildings having a high aggregate electricity saving potential such as offices, schools, institutional and commercial buildings. The application of daylight systems will be considered under different climates when analyzing the impact on the overall energy balance and power demand by measurements, calculations, and computer simulations. Assessment will include a careful evaluation of visual and thermal comfort and user satisfaction of the daylighting systems and control strategies examined.

A roof system designed for daylight penetration at the Trapholt Museum in Denmark. (Lighting consultant: Sophus Frandsen)

The work has been organized in the following four subtasks:

Subtask A: Performance evaluation of daylighting systems
Subtask B: Daylight responsive control of electric lighting
Subtask C: Improvement and integration of daylight design tools
Subtask D: Case study buildings

Activities During 1994

Based on the report of the IEA Daylighting workshop in Copenhagen, the IEA SH&C Executive Committee approved the initiation of a 9 months Project Definition Phase (PAP) of Task 21, starting in mid-1994.

Two meetings are planned for the PAP, the first of which was held in Rome in September 1994. The objectives of the first meeting were: to review relevant national and international activities, to identify test facilities, monitoring equipment etc., and to review the Task proposal, identify national interests, and clarify the scope.

Subtask leaders (coordinators) have been appointed to organize the work of subgroups and the finalization of the Annex.

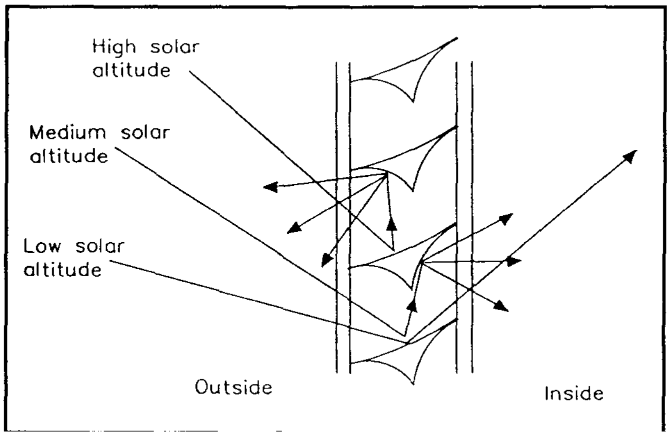
Work Proposed for Project Definition Phase in 1995

A: Daylighting Systems (Coordinator: Australia)
Identify promising systems to be tested. Classify daylight enhancement systems. Define criteria evaluation of physical performance and user acceptance. Describe test facilities and procedures.

B: Control systems (Coordinator The Netherlands) Identify promising systems and strategies to be tested. Define criteria evaluation of physical performance and user acceptance. Describe test facilities and procedures.

C: Design tools (Coordinator: Germany)
Identify available/used daylighting design tools. Define needed improvements in design tools. Identify essential differences in daylight availability in IEA countries (from Task 17).

D: Case studies (Coordinator: Denmark)
Identify Pilot Case Study. Prepare plans for pilot study. Identify potential Case Study buildings. Define monitoring and evaluation procedures.



Example of an innovative daylighting system in which mirrored louvers are set between two panes of glass. At high solar altitudes, no direct sunlight is transmitted, but at lower altitudes, light is reflected upwards into the room.

Reports Planned for 1995

- Working Report on National Daylighting Activities.
- Working Report on systems, performance criteria and test procedures

■ Working Report on daylighting design tools.

■ Working Report on Case Studies and Demonstration Buildings.

Reports Planned for Task 21

■ Technical guide for designers on integration of daylighting systems and control strategies

■ Working Report on procedures for testing and evaluation physical performance and user satisfaction with daylighting systems and control strategies

■ System of user friendly daylighting design tools

■ Booklet/guide on use of design tools

■ Report documenting case study buildings.

Cooperation With Other Daylighting Activities

Task 21 will seek close cooperation will other international activities on daylighting. The Task has been approved as a joint project with the IEA Energy Conservation in Buildings and Community Systems Agreement. Furthermore, exchange of experience and information will be organized with the EU project "Daylight Europe", started in September 1994. In addition, the work on design tools will built upon the results of the daylighting subtask in IEA Task 12, and utilize the solar radiation data generated in IEA Task 17. Needed data on glazing materials' properties will be collected from IEA Task 18. Task 21 will also establish contact with the relevant CIE Technical Committees.

Meetings in 1994

14 - 16 March 1994: IEA Daylighting Workshop in Copenhagen, Denmark Attended by 30 experts from 14 IEA countries.

26-28 September 1994: 1st planning workshop, Rome, Italy. Attended by 34 experts from 15 IEA countries (including the CEC).

Meetings Planned for 1995

6-10 March 1995: 2nd planning workshop, Morges, Switzerland. Objective: to finalize Annex Paper and Task Work Plan, based on national contributions and activities.

September/October 1995: First Task experts meeting.

Task 21 Participants (provisional as of December 1994)

OPERATING AGENT
(Task Organizer during Project Definition Phase)
Kjeld Johnsen
Danish Building Research
P.O. BOX 119,
DK - 2970 Hørsholm
DENMARK

AUSTRALIA
Nancy Ruck
University of Sydney
Dept. Arch. & Design Science
AUS - Sydney NSW 2006

AUSTRIA
Klaus Pokorny
Bartenbach Lichtlabor
Rinner Strasse 14
A - 6071 Aldrans

CANADA
James Love
Faculty of Environ. Design
The University of Calgary
2500 University Drive N.W.
Calgary Alberta T2N 1N4

DENMARK
Poul E. Kristensen
Esbensen Consulting Engineers
Teknikerbyen 38
DK - 2830 Virum

GERMANY
Hans Erhorn
Fraunhofer-Institut IBP
Nobelstr. 12
D - 70569 Stuttgart

FINLAND
Liisa Halonen
Helsinki Univ. of Tech.
Otakaari 5A
FIN - 02150 Espoo

FRANCE
Marc Fontoynont/Vincent Berrutto
ENTPE/DGCB
F - 69518 Vaulx-en-Velin

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

THE NETHERLANDS
Laurens Zonneveldt
TNO-TUE Centre for Bldg. Res.
P.O.Box 513
NL - 5600 MB Eindhoven

NORWAY
Øyvind Aschehoug
Norwegian Inst. of Technology
Faculty of Architecture
N - 7034 Trondheim

SWEDEN
Staffan Hygge
K T H/Built Environment
Box 88
S - 801 02 Gävle

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

UNITED KINGDOM
Maurice Aizlewood
Building Research Establishment
Garston, Watford WD2 7JR

UNITED STATES
William L. Carroll
Lawrence Berkeley Lab.
Building 90 - 3026
Berkeley, CA 94720

WORKING GROUP ON CENTRAL SOLAR HEATING PLANTS WITH SEASONAL

Jan-Olof Dalenbäck
Chalmers University of Technology
Working Group leader for the
Swedish Council for Building Research

Description

The main aim of the Central Solar Heating Plants with Seasonal Storage (CSHPSS) Working Group is to maintain the collaboration on large-scale solar heating which began in IEA SHC Task 7, although at a lower level. The Netherlands led the Working Group from its formation in 1992. In 199' the leadership passed to Sweden.

The objective is to provide a forum for continued knowledge transfer (international as well as national) on CSHPSS (residential heating, district hearing, process heating at moderate temperatures) and to concentrate resources--funding as well as experts.

The collaboration has taken the form of a series of workshops and preparation of a number of documents. The workshops are held annually, at a minimum, in connection with a CSHPSS demonstration project. The workshops are open to all interested IEA countries.

Activities During 1994

The "1994 Workshop on Large-Scale Solar Heating" was held in Goteborg, Sweden, August 18-20. Twenty-five participants from Austria, Denmark, Finland, Germany, the Netherlands, Sweden and Switzerland attended the meeting. The workshop consisted of a half day of national overview presentations and general discussions plus a second day with more technical presentations and discussions. The workshop revealed that at least four pilot projects were put into operation during 1994, and at least three demonstration projects will be built during 1994 to 1996. The last day of the workshop was a study tour to the Otterupgard pilot plant and the ARGON solar industry in Denmark

The working group also organized a plenary lecture and a special session on CSHPSS at the Calorstock '94 conference in Finland, August 22-24.

Reports

- Meeting the Thermal Energy Needs of Buildings in the 21st Century: What Role Can Solar Energy Play?
- CSHPSS Development Guide (To be Published).
- Proceedings of the 1994 Workshop on Large-Scale Solar Heating. (To be Published)

Activities Planned For 1995

Two workshops are planned for 1995: One will be arranged as a review of an actual demonstration project which is in the final design phase. The "1995 Workshop on CSHPSS Design" will take place in Stuttgart, Germany, March 9-11, 1995, in connection with the final design phase of the Friedrichshafen-Wiggenhausen and Hamburg-Bramfeld demonstration projects.

The second, more general workshop will be held in the early autumn for the exchange of information on the latest developments.

CSHPSS Working Group Participants

Austria
Prof. Gerhard Faninger
(See Executive Committee list)

Denmark
Karsten Duer
Technical University of Denmark
Thermal Insulation Lab.
Building 118
DK-2800 Lyngby

Finland
Prof. Peter Lund
(See Executive Committee list)

Germany
Norbert Fisch
Universität Stuttgart/ ITW
Pfaffenwaldring 6
D70550 Stuttgart (Vaihingen)

the Netherlands
Hans Buitenhuis
DWA
P.O. Box 274
NL-2410 AG Bodegraven

Sweden (Working Group Leader)
Jan-Olof Dalenbäck
Chalmers Univ. of Technology
Building Services Engineering
S-412 96 Göteborg

Switzerland
Pierre Jaboyedoff
Sorane SA
Rue de Chatelard
Lausanne

SOLAR THERMAL COLLECTOR MATERIALS WORKING GROUP

Dr. Bo Carlsson
Swedish National Testing and Research Institute
Working Group Leader for the
Swedish Council for Building Research

Description

This working group was established in 1994 as an extension of work which had been carried out on solar collector absorbers in Subtask B of Task 10 (Solar Materials R & D). Sweden has assumed leadership of the Group.

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:

- Durability and Lifetime Assessment of Solar Absorber Coatings.
- Anti-Reflecting 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.

Activities in 1994

A workshop was held in December 1994 in Switzerland to plan the program of work for the working group. Participants from eight countries attended the workshop. The purpose of the meeting was to agree on work to be performed under each of the main areas and to draft the work plans.

Activities Planned for 1995

During 1995, the following work will take place:

- Technical work plans will be prepared by the Project Leaders by February 1995.
- Work on each of the project activities will be initiated.
- The Working Group will meet again in May 1995.
- The Danish and Dutch representatives will look into obtaining funding from the EU research program "Standardization, Measurement, and Testing."

Documentation

The results of each project will be reported in the form of internal working documents and through conference papers. A summary report on the results of the entire working group will be documented in an IEA Technical report.

Meetings

December 12-13, 1994 Au, Switzerland

Participating Countries

Denmark
Finland
Germany
the Netherlands
Spain
Sweden
Switzerland
United States

EXECUTIVE COMMITTEE MEMBERS

AUSTRALIA (*Chairman*)
Dr. Bruce Godfrey
Managing Director
Energy Research and Dev. Corp.
G.P.O.Box 629
Canberra, A.C.T. 2601
Tel: 61/6/274-4844
Fax: 61/6/274-4801
e-mail: bruce@erdc.com.au

AUSTRIA
Prof. Gerhard Faninger
Austrian Research Center - Seibersdorf
c/o Universität Klagenfurt
Sterneckstraße 15
A-9020 Klagenfurt
Tel: 43/463/2700 721
Fax: 43/463/2700759

BELGIUM
(Vice-Chairman)
Prof. Andre De Herde
Centre de Recherche en Architecture
Universite Catholique de Louvain
Place du Levant 1
B-1348 Louvain-La-Neuve
Tel: 32/10/47 21 42 or 32/10/47 22 23
Fax: 32/10/47 45 44
e-mail: deherde@arch.ucl.ac.be

CANADA
Mr. Doug McClenahan
Alternative Energy Division
CANMET - Natural Resources Canada
580 Booth Street
Ottawa, Ontario K1A 0E4
Tel: 1/613/996-6078
Fax: 1/613/996-9416
e-mail: doug.mcclenahan@cc2smtp.emr.ca

DENMARK
Mr. Peter Dorph-Peterson
Danish Energy Agency
11 Landemaerket
DK-1119 Copenhagen K
Tel: 45/33/92 67 00
Fax: 45/33/11 47 43

(Alternate)
Mr. Ole Jensen
Danish Building Research Institute
Postbox 119
DK-2970 Hørsholm
Tel: 45/42-86 55 33
Fax: 45/42-86 75 35

EUROPEAN COMMISSION
Georges Deschamps
Commission of the European Union (DG-XII)
200 Rue de la Loi
B-1049 Brussels, BELGIUM
Tel: 32/2/295-5832
Fax: 32/2/296-3024

FINLAND
Prof. Peter D. Lund
Helsinki University of Technology
Department of Technical Physics
Rakentajanaukio 2
FIN-02150 Espoo
Tel: 358/0/451-3197 or 358/0/451-3218
Fax: 358/0/451-3195
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: 33/93 95 79 11
Fax: 33/93 65 31 96

GERMANY
Dr. Volkmar Lottner
Forschungszentrum Jülich - BEO
Postfach 1913
D-52425 Jülich
Tel: 49/2461/61 48 79
Fax: 49/2461/61 28 40

ITALY
Dr. Dario Malosti
ENEA
Via Anguillarese 301
I-00060 S. Maria di Galeria (Rome)
Tel: 39/6/3048-3372
Fax: 39/6/3048-6315

JAPAN
Mr. Koji Sugiue
New Sunshine Project Promotion HQ
AIST, MITI
1-3-1, Kasumigaseki
Chiyoda-ku, Tokyo
Tel: 81/3/3501-9279
Fax: 81/3/3501-7926

NETHERLANDS
Mr. Erik Lysen
NOVEM BV
P.O. Box 8242
NL-3503-RE Utrecht
Tel: 31/30/36 34 24
Fax: 31/30/31 64 91
e-mail: nlnovely@ibmmail.com

NEW ZEALAND
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: mike.donn@arch.vuw.ac.nz

NORWAY
Mr. Fritjof Salvesen
KanEnergi AS
Baerumsveien 473
1351 Rud
Tel: 47/67 13 99 84
Fax: 47/67 15 02 50

SPAIN
Dr. Manuel Macías
IER-CIEMAT
Avda Complutense 22
E-28040 Madrid
Tel: 34/1/346-6069
Fax: 34/1/346-6037

SWEDEN
Mr. Michael Rantil
(Vice-Chairman)
Swedish Council for Bldg. Research
Box 12866
S-112 98 Stockholm
Tel: 46/8/617 7308
Fax: 46/8/653 7462

SWITZERLAND
Dr. Gerhard Schriber
Federal Office of Energy
CH-3003 Berne
Tel: 41/31/322 56 58
Fax: 41/31/382 44 03

TURKEY
Dr. Melih Tan
TÜBITAK
Ataturk Bulvari No. 221
Kavaklidere
06100 Ankara
Tel: 90/312/468 5300
Fax: 90/312/427 7489

UNITED KINGDOM
Dr. Adrian Cole
Energy Technology Support
Unit
Harwell Laboratory
Oxfordshire OX11 ORA
Tel: 44/235/432 801
Fax: 44/235/432 331

UNITED STATES
Ms. Mary-Margaret Jenior
U.S. Depart. of Energy (EE-42)
Office of Bldg. Energy Research
1000 Independence Ave. S.W.
Washington, D.C. 20585
Tel: 1/202/586-2998
Fax: 1/202/586-1628

OPERATING AGENTS

TASK 12
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

TASK 13
Prof. Anne Grete Hestnes
Faculty of Architecture
Norwegian Institute of Technology
N-7034 Trondheim, NORWAY
Tel: 47/73/59 50 37
Fax: 47/73/59 50 45
e-mail: agh@due.unit.no

TASK 14
Mr. Doug Lorriman
P.O. Box 97
Ballinafad, Ontario N0B 1H0, CANADA
Tel: 1/905/873-3149
Fax: 1/905/873-2735

TASK 16
Dr. Heribert Schmidt
Systems Department
Fraunhofer Inst. for Solar Energy Systems
Oltmannstr. 5
D-79100 Freiburg, GERMANY
Tel: 49/761 4588 226 or 216
Fax: 49/761 4588 217

TASK 18
Prof. M.G. Hutchins
School of Engineering
Oxford Brookes University
Gipsy Lane Campus
Headington, Oxford OX3 0BP, U.K.
Tel: 44/865/48 36 04 or 48 36 81
Fax: 44/865/48 39 29
e-mail: mhutchins@brookes.ac.uk

TASK 19
Mr. Robert Hastings
Forschungstelle Solararchitektur
ETH Honggerberg
CH-8093 Zurich, SWITZERLAND
Tel: 41/1/633-2988
Fax: 41/1/633-1075

Task 20
Prof. Arne Elmroth
Dept. of Building Physics
Lund Institute of Technology
Box 118
S-221 00 Lund, SWEDEN
Tel: 46/46/10 46 45
Fax: 46/46/10 45 35
e-mail: arne.elmroth@bggtek.lth.se

Task 21 (Project Definition Phase)
Mr. Kjeld Johnsen
Danish Building Research Institute
P.O. Box 119
DK 2970 Hørsholm, DENMARK
Tel: 45/42/86 55 33
Fax: 45/42/86 75 35
e-mail: kjj@sbi.dk

SPECIAL PROJECTS

CSHPSS WORKING GROUP
Mr. Jan-Olof Dalenbäck
Chalmers University of Technology
Dept. of Building Services Engineering
S-412 96 Göteborg, Sweden
Tel: 46/31 772 1153
Fax: 46/31 772 1152
e-mail: hvac@vsect.chalmers.se

COLLECTOR MATERIALS WORKING GROUP
Dr. Bo Carlsson
The Swedish National Testing and Research Institute (SP)
Box 857
S-501 15 Borås, Sweden
Tel: 46/33 16 50 00
Fax: 46/33 13 55 02
e-mail: bo. carlsson@sp.se

EXECUTIVE SECRETARY

Ms. Sheila Blum
International Planning Associates
807 Caddington Avenue
Silver Spring, MD 20901
USA
Tel: 1/301/681-2826
Fax: 1/301/681-2876
e-mail: sblumipa@mcimail.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

IEA SECRETARIAT LIAISON

Mrs. Gudrun Maass
International Energy Agency
2 rue Andre Pascal
F-75775 Paris Cedex 16, FRANCE
Tel: 33/1/45-24-99-75
Fax: 33/1/45-24-94-75