SOLAR UPDATE

NEWSLETTER OF THE INTERNATIONAL ENERGY AGENCY SOLAR HEATING AND COOLING PROGRAMME • NO. 36 JUNE 2001

Solar Thermal Energy in Portugal

Based on existing technology and Portugal's significant renewable energy resources, a recent study shows that renewables could contribute 30%, with a 5% contribution from solar thermal, to the country's total energy consumption, if an equivalent investment in the RE sector was made as done for natural gas. Therefore, political decisions are needed to define an appropriate energy policy in favor of Portugal's RE sector.

Almost one century before the 1973 oil crises, the Portuguese scientist, Father Manoel Antonio Gomes, also known as Priest Himalaya because of his large stature, devoted his life to promote the use of solar energy. Over his lifetime, he invented a series of devices, such as the Sun Machine, which won the Grand Prix at the 1904 Universal Exposition in St. Louis, Missouri, USA. This Sun Machine was a solar furnace that could reach 2200ºC. His plans were to use this machine to produce potable water in desert places, to produce steam for industrial machines, to melt refractory materials and even to produce nitrated fertilizers for agriculture. Priest Himalaya was a visionary for his time. Unfortunately, after all these years and with the knowledge of the environmental problems created by fossil fuel consumption, it seems that those in Portugal that believe in the power of solar energy are, like Priest Himalaya, ahead of their time.

The reason for this is because the country relies heavily on hydroelectricity and biomass rather than solar. These two energy sources provide about 12% percentage of the country's energy, and without significantly investing in other renewable sources, Portugal will be able to achieve the EU's White Paper target for renewables of 12% by the year 2010.

Like many other countries in the late 1970s, Portugal began to recognize the importance of other renewable sources. At that time, a research group within a Testing Fuel Lab of the Ministry of Economy began to study solar collectors, and construct and test prototype flat plate collectors. In 1979, this research group then became the Renewable Energy Department of INETI. The new Department's work covered a wide range of renewable energy applications—solar thermal (active and passive technologies), photovoltaics, wind, wave and biomass. Over the past 20 years, work has continued in these areas and constitutes the majority of research work done in Portugal on renewables. In addition to this work, research on passive solar technologies is being conducted at the University of Porto (FEUP) and research on amorphous silicon solar cells at the New University of Lisbon (FCT/UNL).

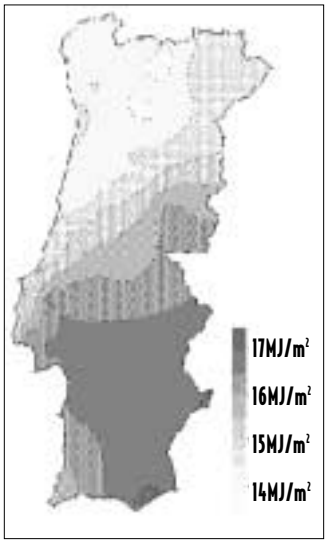

Figure 1. Daily global horizontal radiation. Source: Meteorological Institute, Lisbon

A recent study shows that the renewable energy (RE) contribution to total energy consumption could increase to approximately 30%, with a 5% contribution from solar thermal, if an equivalent investment in the RE sector was made as done for natural gas. Therefore, political decisions are needed to define an appropriate energy policy in favor of the RE sector.

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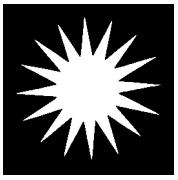
Figure 2. The passive solar house of INETI in Porto, Portugal.

1st Round of Solar Procurements Completed



Installers, dealers or manufacturers typically sell solar hot water systems directly to individual homeowners, which can mean, for many, an expensive system. To make these systems more cost competitive with their fossil fuel alternatives, the participants of SHC Task 24, Active Solar Procurement, are working to coordinate their demand and supply by creating buyer groups. By using this process, the buyers benefit because they can purchase the product they want at the lowest possible cost. And, the suppliers benefit because they can increase their sales domestically and internationally.

The first round of Task 24's active solar procurements focused on the formation of national buyer groups to purchase small domestic solar water heating systems. Since April 1998, participants from five countries—Canada, Denmark, Netherlands, Sweden and Switzerland—have collaborated to reduce the marketing, distribution and hardware costs of solar water heating systems as well as to improve their performance through the power of buyer groups. These groups have formulated performance criteria, drawn up specification documents and launched national procurements and competitions. A unique international network has been established that allows the participants to discuss and learn from each other and to prepare model tender documents. The depth of the network's work has been strengthened through workshops with invited national specialists on the procurement process.

To share task results and the lessons learned from national procurement activities with a broader audience, Task participants are relying on the Internet. The Task website, www.ieatask24.org, includes a "Business Tools" manual to assist buyer groups with the tendering process, marketing, financing, installation and quality control of solar water heating systems. The website will soon include draft "tender packages" for domestic and commercial systems as well as access to Internet buyer groups. In addition to the Task website, national websites have been set up, and in some countries the sites are being used to create national Internet buyer groups.

Procurements and Competitions

An evaluation of the first round of national projects is being prepared and will include, among other things, analysis of the strategies used when setting up buyer groups, the activities and systems used in the realization of the projects, and the responses and level of participation by the manufacturers in the procurement activities. This evaluation will be available on the Task website in the fall of 2001. The aim of the evaluation is to record and exchange information, to learn from successful and unsuccessful projects, and to aid in the planning of the second round, therefore a combination of Task projects and other solar projects will be analyzed.

National Procurement Activities

The following is a summary of some of the national procurement activities from Task 24's first round.

Canada

Two community-based organisations in Canada have initiated a procurement project. The first round tenders identified three manufacturers to supply solar systems. To date, 17 systems have been installed in Peterborough and Toronto. A second tendering was launched the end of 2000 by the utility, Peterborough GreenUp, and the NGO, Energy Action Council of Toronto (EnerACT) to install 20 systems in Peterborough and 30 systems in Toronto. These systems will be installed in 2001. Based on the success of the projects to date, it is expected that several more communities will participate in the next phase of tendering to install up to 50 systems in each community. To complement this work, a market transformation study will be undertaken, which will include a market survey, new performance and system specifications, and the assessment of peak saving electric load with solar water heating.

Denmark

A solar campaign, "Sol over Thy og Morsø", was launched by two utilities, Thy Højspaendingsvaerk and Morsø Elforsyning, in northwest Jutland. The tender documents were sent out in March 2000, and two suppliers were selected. So far, the campaign has sold about 20 systems, of which 8 are large 12 m^2 systems, and the others mainly 8 m^2 combined space-heating and hot water systems. There has been such high interest among the utilities' customers that the campaign will continue until the summer of 2001.

Contacts also have been established with several companies and organisations as potential buyer groups, such as the Danish Association of Plumbers. The goal is to install 30-40 systems per installer per year. Further contacts also will be developed with, among others, the Danish environment offices, homebuilders associations and "green" municipalities in order to establish long-term relations. Co-operation also is continuing with the housing developer, KFS-House, who will include solar systems as an option on the approximately 50 new homes they build each year.

Based on the success that Sweden and Switzerland have had with creating buyer groups using a web site, Denmark will begin a similar initiative this year. Internet-based competitions will be launched in four regions. The tender requirement will be who can offer the best 2-3 different sized systems at fixed installation prices. The tender material is being prepared and the winning systems will be described on the yet to be completed website.

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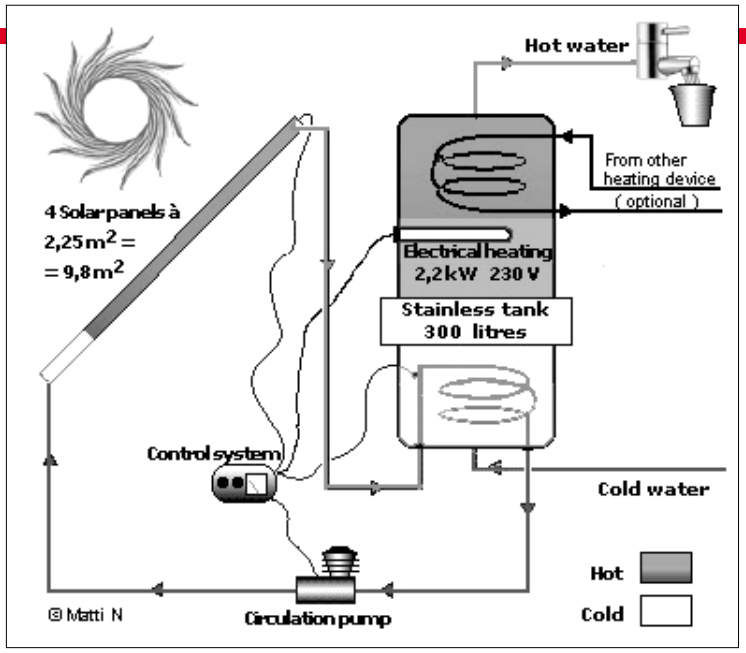
Procurements *from page 2*

The Netherlands

Several solar campaigns for systems to be installed in existing buildings as well as in new housing developments and large renovation projects have been running in the Netherlands since 1999. One of these projects was initiated in the early part of 2000. Two utilities, Essent and RENDO, in co-operation with the consulting firm Ecofys, initiated a campaign to stimulate the installation of solar water heaters in new housing developments in the provinces of Drente and Groningen. The goal was to install 1,200 solar water heaters. However, after a publicity campaign about 1,400 solar water heaters are being installed.

Another initiative was the formation of a national installation company, "Sol*ID Solar Company", which is owned by 40 installers. The company welcomes other installers to join, however, they must prove that they can provide a certain quality level of service. "Sol*ID" is the only Dutch installation company that offers solar sales and installation services on a national scale. The company plans to stay competitive by using new marketing techniques, such as a national call centre and a website. Apart from answering phone calls, the centre distributes brochures, manages direct marketing campaigns and coordinates sale and installation logistics. Another example of this new way to market solar water heaters is the Dutch ASN Bank campaign which is publishing articles in bank magazines and offering special financial arrangements.

The umbrella organization of all the Dutch housing associations and its counterparts in nine other European countries also has initiated a project called "Solhas." The aim of this project is to establish a dedicated product and marketing strategy for housing associations in Europe and to form an international buyer group of housing associations for the second round of Task 24 procurements. Already 24 housing associations have declared that they want to participate in such a buyer group.



An outline over Uponor's solar heated tap water system, 2001 "Uposun HW 300"

The Netherlands also has initiated the "Space for Solar" project for medium-sized systems. This project consists of a buyer group with 59 participating organisations, mostly housing associations and rest homes, a portfolio of more than 100 projects representing approximately 20,000 m² to be installed in the coming years. Through this project, a tender for turnkey delivered systems was issued in December 2000 and the winner of the tender was selected in May 2001.

Sweden

In Sweden, intensive work is being conducted to raise the public's interest in solar systems. This initiative has included distributing brochures, publishing articles in trade and consumer magazines, conducting promotional meetings, TV interviews and information programs. Two buyer groups have been established—one for small solar-heated domestic hot water systems (totaling 5-10,000 m²) and the other for solar collectors in larger systems (totaling 10,000 m²). Buyers were able to announce their interest in purchasing these systems on the Internet. For the small systems, more than 2,000 homeowners have sent notification of their interest.

The competition for the small systems was launched last year and a large number of entries were received. After a first evaluation, an independent testing laboratory tested eight prototypes. A spin-off effect of these tests is that in 2002 this laboratory will begin offering industry testing on a routine basis. After the eight prototypes were tested, a jury evaluated the results and a winner was announced in March 2001. The winning system, "Uposun HW 300", is a new lightweight, corrosion-free construction, made of recycled plastics (see Figure 1). The manufacturing of this system is highly automated and the low weight makes the system easy to install. Five pilot systems will be installed on homes that belong to members of the buyer group beginning in the summer of 2001.

The Swedish project for large system solar collectors was launched last year, and entries from 11 manufacturers, of which four were international companies, were received and evaluated. The minimum goal for this procurement activity is binding orders for 4,000 m². To date, interested buyers have registered orders representing 8,000 m². These orders must now be converted into binding orders before a winner(s) can be selected.

Further information about the Swedish projects is available on the website http://solupphandling.bfr.se.

Switzerland

Task participants are establishing contacts with different electricity utilities

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Portugal *from page 1*

Solar Resource Potential

The level of solar radiation in Portugal is comparable to the European Mediterranean countries, and only in the interior of North Africa can significantly higher values be found. The annual average of the solar resource is shown in Figure 1 and monthly meteorological data of Lisbon (which is close to the average in Portugal) is shown in Table 1.

Since the beginning of the 1980s, INETI has been working in the field of solar resource evaluation, and participating in European projects such as ESRA, the European Solar Radiation Atlas, as well as developing software tools such as P-Clima, a database of the most relevant parameters for RE, which provides hourly and daily meteorological synthetic series for the simulation and sizing of solar thermal active and passive systems.

Solar Market

Close to 240,000 m^2 of solar collectors are installed in Portugal, which is a small amount considering the large resource available. Solar collectors have been used in Portugal since the 1960s, but it wasn't until the end of the 1970s that a large number of solar collector factories, importers and installers entered the market. Unfortunately, many of these efforts failed due to bad system designs that led to freezing or overheating problems. The result of this initial effort created a poor image for solar technology, which coupled with the decrease in oil prices, meant that many of the factories closed and installers were out of work. By the 1990s, only three to four Portuguese factories were in operation due to the low market demand. And today, a small solar market remains despite an increasing interest in RE.

Table 1
Meteorological data for Lisbon
Lat.38.70ºN; Long. -9.18ºE; Altit.50 m
Average values over 1981 – 1990

Month	# Sunshine hours	Daily Global Horiz. Radiation (MJ/m2):
Jan	125	7,20
Feb	141	10,31
Mar	176	13,84
Apr	224	19,15
May	273	22,96
Jun	285	24,68
Jul	334	26,54
Aug	317	24,31
Sep	237	18,07
Oct	190	12,61
Nov	149	8,73
Dec	131	6,81
Annual	2581	16,27

Source: Meterological Institute, Lisbon

RD&D Activities

As noted above, the most important work on renewable energy R&D has been conducted by the Renewable Energy Department of INETI (DER/INETI). This R&D work began in the early 1980s with a set of projects on solar thermal active and passive technologies, biomass, wind and wave energy, which were developed in collaboration with universities and other research institutions.

Passive Technologies

DER/INETI and the Engineering Faculty of Porto University (FEUP) have worked collaboratively over the past 20 years on passive technologies. One of the early projects was the first Portuguese passive solar house at Porto (see Figure 2). This living laboratory is still used for research and demonstrations. Research conducted in this area has led to the country's participation in a series of European projects, such as PASSYS and PASSYSCOOL, as well as to the construction of additional passive houses.

Solar Collectors and Non-Imaging Optics

DER/INETI has indoor and outdoor solar collector testing facilities. The facilities are used to develop government- and industry-funded prototype solar collectors, conduct performance and qualification tests, and perform thermal and optical measurements on components.

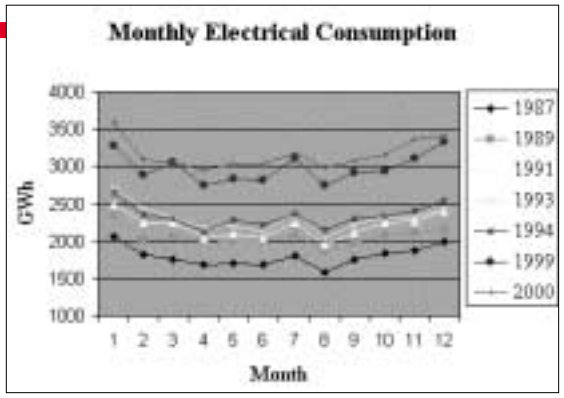

Figure 3. Monthly electricity consumption in Portugal

DER/INETI also has developed solar collectors using non-imaging optics. Applications using this technology include solar detoxification, solar cooking, domestic and industrial water pre-heating, solar desalination, and solar cooling. Second stage concentrators also have been designed and constructed using these types of optics under the framework of European projects for direct steam production and treatment of materials in a solar furnace. As a result of this work, one of the most prominent Portuguese solar collector factories, AO SOL, is producing a low concentration CPC collector that is comparable in price to the standard flat plate collector.

AO SOL also is producing a very cheap uncovered CPC collector with a glass reactor in the absorber position. This collector is a result of a UE/BRITE-EURAM research project on solar detoxification. This SOLARDETOX Project resulted in the construction of a 100 m^2 collector area demonstration system that has been in operation near Madrid since 2000. This technology is a promising answer to cleaning water during the final treatment of organo-chlorinated wastewater.

Solar Cooling

As in many other countries, energy demand in Portugal is growing due to the increased use of air conditioners. As shown in Figure 3, energy demand in

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Portugal *from page 4*

summer has been increasing steadily and could become higher than power peaks during the winter. Due to this trend and Portugal's favorable solar conditions, INETI has participated in several European projects focused on desiccant evaporative cooling (DEC) and absorption cycle technologies. Today, two DEC demonstration systems are in operation in Lisbon. One system is at INETI and another at an office building near Lisbon. The DEC system at INETI is being monitored as part of IEA SHC Task 25, Solar Assisted Cooling in Buildings. In addition to these two systems, INETI is assembling a low-power, gas/solar driven absorption machine for testing.

Actions and Promotion of Solar Technologies

At the end of the 1980s, the appeal of renewable energy technologies was renewed due in part to Chernobyl and the addition of greenhouse gases to scientific and political agendas. However, in spite of these actions, solar technologies did not get the jump-start they expected. A major reason for their mild reception was their poor credibility due to the weak performance of earlier systems. Their poor performance and/or failure was due to such factors as a lack of qualified installers, unreliable equipment, and many poorly designed systems.

Figure 4. Outdoor facility at LECS

In the 1990s actions were initiated to improve this situation. The most important actions were (1) the creation, in July 1993, of an accreditated Solar Collector Testing Laboratory (LECS) to support the solar industry in their efforts to improve their equipment (see Figure 4); (2) the participation, together with SPES (the Portuguese section of ISES) in ALTENER actions for the qualification of installers; (3) the participation in projects to promote Guarantee of Results Schemes, by monitoring installed systems and conducting follow-up either onsite or electronically; (4) the development of low cost equipment for this last purpose; (5) the development of software tools to design improved solar systems, such as SOLTERM and P-CLIMA (see Figure 5); and (6) the promotion and dissemination of information on solar thermal applications targeted to municipalities and industry (activities include expositions, seminars, short courses and pre-feasibility studies). In addition, trainee courses for designers and installer have been provided, and now INETI is participating with SPES in the European project, QUALISOL. The goal of this project is to establish a certification scheme for solar system installers.

This work is complemented by dissemination projects on pre-feasibility studies, commissioning, and short- and long-term system monitoring and evaluation. Activities with industry include promoting large solar systems to heat or preheat process water (three systems, totaling approximately 6,000m^2 of collector area, are under design). Activities with municipalities, such as Lisbon, include switching to solar energy to heat municipal swimming pools.

The Future

Portugal has conducted and supported important solar energy research, unfortunately, the market response has been somewhat weak. An effort is underway, however, to reverse this situation—national and international projects are being conducted to increase the credibility of the technology and to promote solar products in the marketplace. As for justifying the economics of solar thermal, besides the increase in international oil prices, some fiscal incentives have been initiated. For example, companies investing in solar equipment can amortize the related investment over a period of four years as part of their corporate annual income tax.

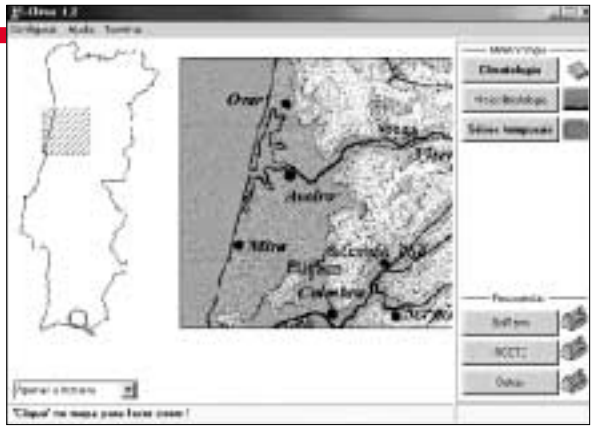


Figure 5. Entry screen of P-CLIMA

On the domestic side, more Portuguese families are becoming concerned about the environment and therefore using alternative energy sources such as solar. In addition, new legislative measures, for example a tax deduction for solar systems, and publicity campaigns are encouraging people to choose solar energy. Political actions also are changing the role of RE and solar energy. Portugal's commitments to the Kyoto Protocol and the political necessity to find appropriate measures to develop the interior of Portugal will guide the creation of an energy policy that is more favorable towards renewables, in particular, solar thermal.

Solar energy is a practical energy source for Portugal, and many hope that the country will be a leader among countries rather than wait to be passively pushed to this sunny way.✷

For more information on solar energy activities in Portugal contact the SHC Executive Committee member, João Farinha Mendes DER/INETI , phone:+351.21.7127186, Fax:+351.21.7127195, e-mail:farinha.mendes@ineti.pt

IN BRIEF

TWO SHC WORKSHOPS PLANNED FOR OCTOBER 2001

Risk of Legionnaires' Disease in Solar Water Heaters

To address concerns over the connection between Legionnaires' disease and domestic solar hot water heaters, the Solar Heating and Cooling Programme will hold a workshop 4-5 October in the Netherlands. Experts in the field of water heating and Legionnaires' disease in hot water systems are invited to attend. The goal of the workshop is to exchange information on 1) techniques (hot water systems, biological aspects, risk analysis, 2) communications (image of solar water heaters, how to inform the public), and 3) regulations (what are they and are changes needed).

For more information contact Mr. Jos Warmerdam, Ecofys, the Netherlands, e-mail: J.Warmerdam@Ecofys.nl

Compact and Long term Efficient Solar Storage

A key factor required for using solar heat for space heating is the development of compact and long-term efficient thermal energy storage to bridge the gaps between days and nights and summers and winters. To cooperatively develop a viable storage option for solar low energy houses, the Solar Heating and Cooling Programme will hold a workshop in 11 October in Rapperswill, Switzerland. Applied scientists, consultants and manufacturers are invited to explore the long-term (10 plus years) potential of solar storage options (e.g., photo-thermo-chemical and photo-bio/electro-chemical) and the short-term potential for improved density storage as well as discuss the role of international cooperation to advance the use of solar storage.

For more information contact Dr. J. van Berkel, Entry Technology, the Netherlands, e-mail: jvb@entry.demon.nl.

A storage workshop focused on solar storage materials will be held 4-5 October in Munich, Germany.

For more information contact Dr. V Lottner, Germany, e-mail: v.lottner@FZ-Juelich.de

Procurement *from page 6*

with the intention of forming buyer groups and starting procurement projects. The experiences from several municipal initiatives, for example in Zurich, Basel and Zug, are serving as a basis for this work.

One project underway is the Swiss Solar Energy Society's Internet-based "virtual" buyer group that is aimed at homeowners. The local project team consists of, among others, PR specialists, computer experts, suppliers, contractors and Swiss Task 24 representatives. Another project is "Solar roofs in the city of Zug" aimed at single-family houses and multifamily houses with less than 10 apartments. The goals are to have turnkey installations at a fixed price, to ensure professional management, and to use only certified components.

The Swiss Task 24 team also has done preparatory work on a manual for forming buyer groups and initiating a project. This manual will include instructions and checklists and be tested by current project participants. In addition, Task participants have made a special effort to convince manufacturers of the opportunities that this solar procurement initiative can have on expanding the market for solar water heating systems.

2nd Round of Procurements

The second round of procurements is now being planned and the intention is to launch these initiatives by the end of 2001. Intensive efforts will be made to prepare for the second round, which will include larger projects and increased international collaboration focused on technology specifications and evaluation principles. The Task participants agree that this second round will provide substantial added value for those involved. For example, a collaborative European project with housing associations is being coordinated by the Netherlands, and ten countries have expressed interest in the initiative. Other countries will focus on developing buyer groups and applying Internet mechanisms. In addition to the procurement activities, the Task's web-based "Business Tools" will be updated with experiences from finished projects and findings from the evaluation of the first round. ✷

For more information on this Task contact Hans Westling, Task 24 Operating Agent, e-mail: hans.westling@pro-mandat.se, fax: +46-8-660-54-82 or visit the SHC website.

NEW PUBLICATIONS

The SHC Programme has several new reports available. To order one these reports contact the SHC Executive Secretary, see back page for address. For a complete list of SHC publications visit the SHC website at www.iea-shc.org.

DAYLIGHT IN BUILDINGS

Post Occupancy Evaluation of Daylight Buildings

A method to study user reactions to indoor environment, especially daylighting, has been developed. It is based on a questionnaire that includes attitudes to daylight and windows as well as to the physical environment. This report describes how to use the questionnaire, which was first used in the EU Joule II Project Daylight Europe and then used more extensively in SHC Task 21, Daylight in Buildings.

Daylighting Design Tools

This report summarizes a survey of a cross-section of various simple daylighting design tools and their different applications. The survey included tools based on analytical solutions, tables, nomograms, diagrams, so-called protractors, simple computer tools, typological studies and scale models. Several new designs tools are included. To allow for problem sensitive selection, the report includes a table to characterize the reviewed tools.

Validation of Daylighting Computer Programs

This report summarizes the comparison of simulation results as well as comparisons with data obtained from measurements in scale models located in artificial skies for the following daylighting software—Radiance, Superlite, Genelux, Adeline and LESO-Dial.

BUILDING ENERGY ANALYSIS TOOLS

IEA Building Energy Simulation Test and Diagnostic Method for HVAC Equipment Models (HVAC BESTEST), Volume 1: Cases E101-E200

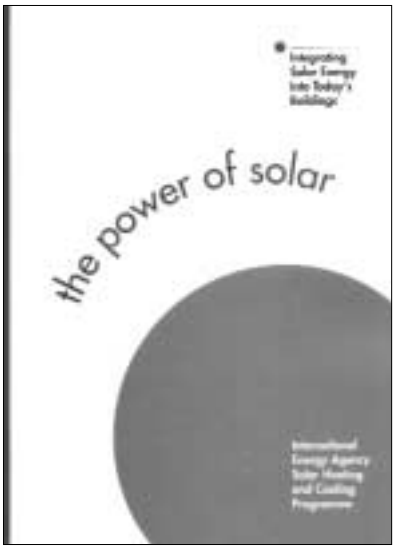
This report covers the beginning of work on mechanical equipment test cases. Part I is a user's manual on how to apply the HVAC BESTEST procedure. Part II describes the development of the analytical solutions and final analytical solution results. Part III describes the development, field testing and production of simulation data for the test procedures. Part IV presents the analytical solution and simulation program results in tables and graphs.

Models for Building Indoor Climate and Energy Simulation

This report is for readers with a basic knowledge of Neutral Model Format (NMF) and have access to the NMF source code of the models. The report provides detailed documentation and engineering justification on the individual models and an overview of the NMF library architecture.

PROGRAMME REPORTS

The Power of Solar: Integrating Solar Energy into Today's Buildings



This brochure highlights the activities and accomplishments of the IEA Solar Heating and Cooling Programme's long-term international collaboration to create solar buildings of the future.✷

MARKETPLACE $ $ $ $

The Solar Heating and Cooling Programme is not only making strides in R&D, but also impacting the building sector. This section of the newsletter highlights solar technologies which have been developed or conceptualized in a SHC Task and are now being commercially manufactured, marketed or used.

CEN Standard

The CEN standard 12976 for factory-made solar water heaters was developed based on the dynamic systems testing work of SHC Task 14, Advanced Active Solar Systems.

Low Energy House Designs Adopted by Commercial Builders

Builders are adopting many of the designs of houses built under Task 13, Advanced Solar Low Energy Houses. For example, the design of the German Ultra House built in Rottweil is being used by commercial builders throughout Germany. The solar strategies used include thermal transmittance and ventilation to minimize space heating, passive solar energy and daylighting. And, in Canada, the Waterloo Region Green Home which was designed to be energy efficient and environmentally responsible has impacted the building market in several ways—builders are incorporating its advanced house technologies, engineered wood products are becoming the floor system of choice, fiberglass windows have a growing share of the window market, and the wall-mounted water heater is available for lease from natural gas utilities.

Monitoring results of these and other Task 13 houses will be included in a 2nd edition of the book, Solar Energy Houses: Strategies, Technologies, Examples, available from James & James (Science Publishers), Ltd. later this year. ✷

IEA Solar Heating and Cooling Programme

The International Energy Agency was formed in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement a program of international energy cooperation among its member countries, including collaborative research, development and demonstration projects in new energy technologies. The 21 members of the IEA Solar Heating and Cooling Agreement have initiated a total of 29 R&D projects (known as Tasks) to advance solar technologies for buildings. The overall program is managed by an Executive Committee while the individual Tasks are led by Operating Agents.

Current Tasks and Operating Agents

Task 22: Building Energy Analysis Tools
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Task 23: Optimization of Solar Energy Use in Large Buildings
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Task 25: SolarAssisted Air Conditioning of Buildings
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Task 26: Solar Combisystems
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Task 27: Performance of Solar Facade Components
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Task 28: Solar Sustainable Housing
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Task 29: Solar Crop Drying
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Task 31: Daylighting Buildings in the 21st Century
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SOLAR UPDATE

The Newsletter of the IEA Solar Heating and Cooling Programme

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Prepared for the IEA Solar Heating and Cooling Executive Committee
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