Integrating
Solar Energy
Into Today's
Buildings

the power of solar

International
Energy Agency
Solar Heating
and Cooling
Programme

Solar energy technologies are essential components of a sustainable energy future. Energy from fossil fuels may be inexpensive and assurances may have been given of the plentiful supplies of petroleum and other fossil fuels, but these fuels are finite in nature and a major source of greenhouse gas emissions.

Governments and private industry are increasingly recognizing the need to diversify energy supplies and to develop new energy technologies that are secure, can sustain growth, and have a minimal impact on the environment. In IEA countries, a shift towards renewables is occurring due to concern over the environment, notably global climate change and the establishment of Kyoto targets. And, in many developing countries, solar and other renewables have gained prominence because they offer a competitive energy supply option to areas that are poorly served by conventional fuels.

The members of the IEA Solar Heating and Cooling Programme (SHC) are working together to meet the demands of a sustainable future by further developing solar technologies. This brochure provides highlights of some of the activities and accomplishments of this long-term international collaboration which is helping to integrate solar energy in today's buildings.

THE SHC PROGRAMME

Formed in 1974 as an autonomous body within the Organization for Economic Cooperation and Development (OECD), the International Energy Agency (IEA) carries out a program of energy cooperation, including joint research and development of new and improved energy technologies.

The Solar Heating and Cooling Programme was one of the first IEA research agreements to be established. Since 1976, its members have been collaborating to develop technologies that use the energy of the sun to heat, cool, light and power buildings.

The work of the SHC Programme is unique in that it is accomplished through the international collaborative effort of experts from the Member countries. The benefits of such an approach are numerous, namely, it accelerates the pace of technology development, promotes standardization, enhances national R&D programs, permits national specialization, and saves time and money.

The Programme is headed by an Executive Committee composed of one representative from each Member country, while the management of the individual projects is the responsibility of Operating Agents who are selected by the Executive Committee.

The Programme's work is often expanded through collaboration with other building-related IEA agreements, such as the Energy Conservation in Buildings and Community Systems Programme and the Photovoltaic Power Systems Programme.

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

If your country is a Member country then contact the Operating Agent of the specific Task you are interested in joining or the Executive Committee member from your country.

If your country is not a Member country, but interested in joining, please contact the SHC Executive Secretary (see page 7 for address), who, with the IEA Secretariat, will provide you information.

SHC*MEMBER*COUNTRIES*

The following 20 countries, as well as the European Commission are members of this agreement:

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

OPPORTUNITIES FOR SOLAR ENERGY IN THE 21ST CENTURY

Solar energy can replace fossil fuels in many applications. The best opportunities for solar technologies are in applications that require low temperature heat, such as domestic hot water heating, space heating, drying processes and swimming pool heating. Solar energy can also meet cooling needs, where the supply and demand are often well matched. At the start of the 21st century we can see that the technologies are available. Therefore, the challenge for this new century will be to continue to improve solar technologies and to expand their market share.

Many opportunities for applying solar heating and cooling technologies exist in the building sector, and as a result, this sector is a focal point of the SHC Programme. Past SHC projects have shown that solar design and technologies can provide most of a building's energy demand. And, with the addition of photovoltaics, buildings can become net energy producers. Essential to the continued success of solar technologies is the integration of solar technology in the design of the building. This is called a whole buildings perspective, which is not limited to energy use, but includes other sustainable building requirements.

The match between solar energy technologies (active, passive, daylighting and photovoltaics) and the energy needs of the building sector is excellent. Solar technologies can supply energy for all building applications—heating, cooling, hot water, light and electricity—without the harmful effects of greenhouse gas emissions created by conventional energy sources. Solar technologies also are appropriate for all building types—single-family homes, multi-family residences, office and industrial buildings, schools, hospitals, and other public buildings as well as being applicable anywhere in the world.

Benefits to Society

Why use solar energy in buildings? First, there is an enormous potential for reducing the use of purchased energy in the building sector. On average, 30-40% of the total energy consumed in OECD countries is used to provide energy for residential and non-residential buildings—for heating, cooling, ventilation, hot water, lighting and appliances. As the majority of this energy is supplied by fossil fuels—coal, oil, natural gas—and much is imported, reliance on renewable sources instead, can help to address climate change concerns. For example, solar energy technologies, in combination with improved energy efficient designs and products, can meet a significant portion of these energy needs and reduce the emission of greenhouse gases.

The advantages of solar energy are clear. As a non-polluting, safe, indigenous and renewable energy source, solar energy will be of continuously increasing importance for the buildings of the 21st century.

Benefits to Occupants

Solar technologies can create a living environment that is comfortable and daylit as well as reduce consumers' energy bills. The Programme's work on solar energy in building renovation demonstrated that by using a combination of solar and energy efficiency technologies to address renovation problems, the buildings' purchased energy use could be drastically reduced. For example, a multi-family building in Sweden was renovated using roof mounted solar collectors to fix a leaking roof. This solution not only solved the roof problem, but also reduced the hot water heating demand by 35%.

ADVANCING SOLAR BUILDING TECHNOLOGIES

The participants of the SHC Programme are investigating opportunities to achieve a sustainable built environment that relies on solar energy. As attractive as solar energy is, it must meet the same requirements as other energy sources. The technologies must be cost-effective, reliable, applicable to mainstream industry practices, and acceptable to the public.

Today, solar technologies have advanced significantly, and it is being proven worldwide that these applications can meet the needs of consumers as well as the demands of the market.

This single family home in Finland uses a 2 kWp photovoltaic system, a solar thermal collector, and a ground-coupled heat pump to reduce energy costs. The combination of these technologies has lowered the purchased energy consumption level to 27 kWh/m².

The activities of the SHC Programme have covered a broad range of solar R,D&D—performing basic research, testing hardware and materials, improving reliability and durability, developing better design tools, field-testing systems and components, and producing handbooks and manuals. Over the years, special attention has been given to sharing the Programme's results with the solar and building industries so as to improve products and designs, and to encourage greater and more effective use of solar technologies.

Some of the Programme's achievements and work-in-progress are highlighted in the following pages. More on the current projects can be found on the Programme's web site www.iea-shc.org.

Solar Low Energy Buildings

Advancing solar building technologies with the goal of reducing further or even eliminating the need for purchased energy has long been an area of Programme work. Some of the Programme's recent advances include demonstrating the impact that new and innovative solar concepts can have on energy use in residential buildings. SHC experts showed that by integrating solar and energy conservation technologies, the average total energy consumption in houses could be reduced by 75%. The average total energy consumption achieved in 14 new homes in climates as disparate as Finland and Spain was 44 kWh/m^2 per year of heated floor area versus 172 kWh/m^2 for a typical house.

The Swiss solar domestic hot water system, SOLKIT®, is a highly stratified, low-flow system. It consists of a single element collector with one opening for the inlet and outlet and a 400-liter storage tank. This system costs 30% less than the country's "typical" solar system and is commercially available.

Advanced Active Solar Energy Systems

Work in this area has focused on examining state-of-the-art systems using computer simulation models, developing and testing new components and systems, and designing, constructing and monitoring operating systems. By taking research advances out of the laboratory and to the marketplace, experts proved that cost/performance ratios could be improved. For example, six advanced solar domestic hot water systems were developed, three of which have been commercialized, of which the SOLKIT® system is one. These new systems demonstrated that cost/performance improvements of up to 50% can be achieved. Experts also developed a dynamic system test method that is now an ISO standard.

Another area impacted by work in this area is ventilation air heating. SHC experts spearheaded much of the research conducted on the innovative perforated absorber, Solarwall. In fact, the perforated absorber was a direct result of bringing together an international team of experts and industry representatives at an IEA workshop.

Photovoltaics in Buildings

Building integrated photovolatic applications have taken a giant step forward due to the Programme's collaborative work. The successful results of this work are demonstrated in 17 buildings in Europe and North America. Each of these buildings show how PV can be successfully, technically, and aesthetically integrated into a building. For example, the Ökotec3 office building in Berlin, Germany was built using integrated PV modules in its granite and glass facade. To match the reflectivity and color of the glass panels, the PV panels were made iridescent blue and mounted uniformly. These modules generate 4 kWp and the extra power generated over the weekend is sold to the local utility.

The Demosite at the École Polytechnique in Lausanne, Switzerland is an international exhibition and demonstration center for photovoltaic building elements. Since 1992 it has demonstrated the types and functions of photovoltaic elements, thus promoting building-integrated PV and stimulating demand for these new PV applications. Each pavilion shows various solutions to problems of structural integration and measures real on-site performance.

Advanced Glazing and Associated Materials for Solar Applications

Today's advanced glazings are unique in that they can transform a building envelop into a highly efficient energy system which is adaptable to different climates and users. The most recent SHC work in this area was the largest collaborative R&D project on glazings in the world.

SHC experts designed and constructed the world's first framed vacuum window—with a U-value of 0.8 W m-2 K-1 at the center and a U-value of 1.2 W m-2 K-1 overall.

Experts in this area developed guidance for design engineers, building engineers and industry on the properties, use, performance and selection of advanced glazing materials. Results from this work indicate that advanced glazings can significantly decrease the energy demand in buildings. In residential houses a saving of 25-35% on the annual heating or cooling demand can result by cutting the heat loss through the windows by 60-70%. And, in offices a savings of 30% on the annual energy demand for heating, cooling and lighting can be achieved.

Seven manufacturers from seven countries tested well-established and promising prototype solar air collectors at the Arsenal in Vienna, Austria. The test results led to technical improvements in some systems as well as the basis for a common testing procedure.

Solar Air Systems

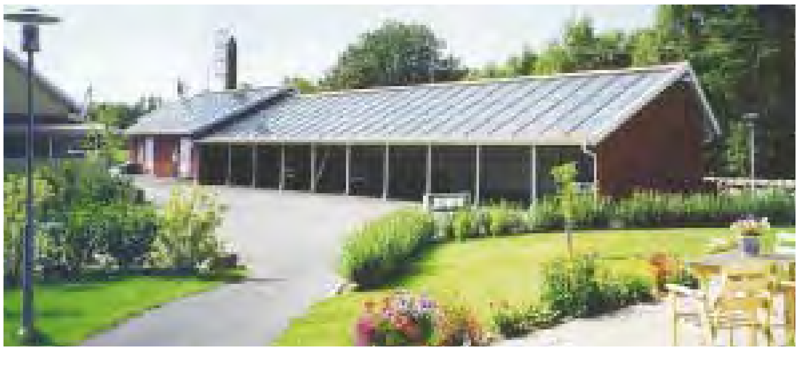
To capitalize on the potential that solar air systems could offer, SHC experts set out to give the technology a much-needed push. To begin, the experts reviewed over 30 buildings with solar air systems built in the 1990s, and based on this research, six basic systems were identified and examined in-depth.

To encourage the use of these systems, the experts have developed a set of "tools":

● A book illustrating over 30 building applications to serve as patterns for designers.
● A design handbook to help engineers choose, size and detail a system.
● The computer tool, TRANSAIR, to analyze key design variables for planning a solar air system.
● A catalogue of manufactured components to inform designers of the available "off the shelf" systems.

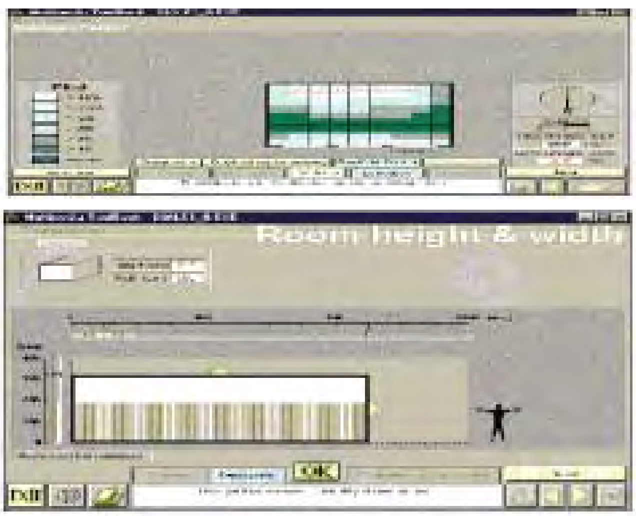
Solar Energy in Building Renovation

Existing buildings account for the majority of energy consumed in the building sector. To take advantage of the tremendous opportunities in building renovation, SHC experts have demonstrated how to effectively and economically integrate solar technologies into the building renovation process. As energy considerations often are not the motivation behind building renovation, the experts had to demonstrate how solar measures could add value to the solution of a particular renovation problem.



As a result of work in the area of solar energy in building renovation, Swedish researchers at Chalmers University of Technology and Derome AB collaborated to develop and produce prefabricated roof modules with integrated solar collectors. This pre-assembled module provides hot water and acts as a waterproofing element thus replacing the traditional roof.

For example, the Brandaris is a 14-storey building with 384 apartments in the Netherlands. It was constructed in 1968 and renovated in 1999. The renovation included the addition of a 760 m^2 solar heating system, which provides domestic hot water and some space heating. The total contribution of this system is 15% of the total energy needed. Glazed balconies also were added to some apartments to improve their appearance and preheat ventilation air.



Screen views of the LESO DIAL daylight program showing the menu for room definitions and the calculated daylight factors in the room.

Daylight in Buildings

SHC experts, in collaboration with experts from the IEA Energy Conservation in Buildings and Community Systems Programme, demonstrated how the use of daylight can considerably reduce the overall energy consumption in non-residential buildings. Work in this area focused on promoting daylight conscious building design and advancing daylighting systems.

Sixteen countries worked together to overcome the barriers that continue to hamper the widespread application of daylight in buildings—lack of enough knowledge on the performance of daylight systems and lighting controls, lack of enough appropriate daylighting design tools, and lack of enough evidence that daylight in buildings worthwhile.

Accomplishments include the testing of 15 daylight responsive control systems, the production and evaluation of daylighting design tools (e.g., DIAL and ADELINE 3.0) by 12 institutions in 10 countries, and the monitoring of daylighting performance in 15 buildings.

Building Energy Analysis Tools

The evaluation and development of energy analysis and design tools is extremely important, but costly and complex. Through international collaboration, the talents and resources of many countries have been pooled to establish a sound technical basis for analyzing solar, low-energy buildings with available and emerging building energy analysis tools.

The Energy Resource Station test facility in Ankeny, Iowa is comprised of 4 sets of matched test rooms and a sophisticated HVAC system. This equipment was used to create laboratory quality test data for the empirical validation of building energy analysis tools

To improve the accuracy of energy analysis software and to help building designers gain confidence in computer predictions, SHC experts and scientists developed BESTEST (Building Energy Simulation Test and Diagnostics Method). This procedure systematically compares whole-building energy software packages and determines the algorithms responsible for prediction differences. Due to its success, BESTEST has been expanded to cover mechanical systems, HVAC BESTEST. The tool evaluation method BESTEST, forms the basis of a new standard for energy standard compliance tool certification by ASHRAE in the United States. And, other countries are considering BESTEST as a standard method of testing building energy analysis tools for national energy codes.

LOOKING AHEAD

The 21st century will see a transition to a new energy source just as has happened in previous centuries. In the 19th century a transition occurred from wood to coal, the turn of the 20th century saw the transition from coal to oil, and the end of the century saw the rapid growth in the use of natural gas in the building sector. Which energy source will dominate as we move farther into the 21st century remains to be seen, but what is certain is that it must be a renewable source. And, the use of solar energy will surely be a major energy source, particularly in the building sector.

It is the approach of the SHC Programme is to provide building designers and industry with the solar tools necessary to meet the needs of the changing market just as the built environment must adapt to the new circumstances of the 21st century. Through innovative applications, the Programme will strive to enhance quality of life and reduce greenhouse gases emissions by taking advantage of the special opportunities that solar energy can provide.

Building on more than 20 years of experience, the IEA Solar Heating and Cooling Programme is addressing these opportunities through new activities, including projects investigating:

- Daylighting
- Optimization of solar energy use in large buildings
- Performance of solar facade components
- Solar assisted air conditioning of buildings
- Solar city
- Solar combisystems
- Solar crop drying
- Solar procurement
- Sustainable solar housing

FINDING * SHC * RESULTS *

The wealth of results generated from the 29 SHC projects is disseminated by means of:

- Handbooks, design guidelines, technical reports, computer programs, test procedures, etc.
- Programme web site.
- Programme publications—Annual Report and bi-annual newsletter.
- Presentations at national and international conferences.
- IEA workshops and symposia.
- National solar program documentation.
- Articles in energy and building trade publications.

To begin finding the information you need first start with the SHC Programme web site at http://www.iea-shc.org. On this site you will find information on current work, a complete list of Programme reports, the Program newsletter and annual report, contact information, etc.

You may also contact the SHC Executive Secretary for information: Pamela Murphy, Morse Associates Inc., 1808 Corcoran Street, NW, Washington, DC, USA, Fax:+1-202-265-2248, E-mail:pmurphy@MorseAssociatesInc.com.

IEA SOLAR HEATING AND COOLING PROJECTS AND OPERATING AGENTS

Task 1	**Performance of Solar Heating and Cooling Systems**, 1977-83 *(Denmark)*
Task 2	**National Solar R & D Programs & Projects**, 1977-84 *(Japan)*
Task 3	**Solar Collector and System Testing**, 1977-87 *(Germany and United Kingdom)*
Task 4	**Insolation Handbook and Instrumentation Package**, 1977-80 *(United States)*
Task 5	**Existing Meteorological Information for Solar Applications**, 1977-82 *(Sweden)*
Task 6	**Evacuated Tubular Collector Performance**, 1979-87 *(United States)*
Task 7	**Central Solar Heating Plants with Seasonal Storage**, 1979-89 *(Sweden)*
Task 8	**Passive Solar Low Energy Homes**, 1982-89 *(United States)*
Task 9	**Solar Radiation and Pyranometry**, 1982-91 *(Canada and Germany)*
Task 10	**Solar Materials R & D**, 1985-91 *(Japan)*
Task 11	**Passive Solar Commercial Buildings**, 1986-91 *(Switzerland)*
Task 12	**Solar Building Analysis Tools**, 1989-94 *(United States)*
Task 13	**Advanced Solar Low Energy Buildings**, 1989-94 *(Norway)*
Task 14	**Advanced Active Solar Systems**, 1990-94 *(Canada)*
Task 15	**Advanced Central Solar Heating Plants**, not initiated *(Netherlands)*
Task 16	**Photovoltaics for Buildings**, 1990-95 *(Germany)*
Task 17	**Measuring and Modeling Spectral Radiation**, 1991-94 *(Germany)*
Task 18	**Advanced Glazing Materials**, 1991-97 *(United Kingdom)*
Task 19	**Solar Air Systems**, 1993-99 *(Switzerland)*
Task 20	**Solar Energy in Building Renovation**, 1993-98
Task 21	**Daylight in Buildings**, 1995-99 *(Denmark)*
Task 22	**Building Energy Analysis Tools**, 1996-02 *(United States)*
Task 23	**Optimization of Solar Energy Use in Large Buildings**, 1997-02 *(Norway)*
Task 24	**Solar Procurement**, 1998-03 *(Sweden)*
Task 25	**Solar Assisted Air Conditioning of Buildings**, 1999-04 *(Germany)*
Task 26	**Solar Combisystems**, 1998-01 *(Austria)*
Task 27	**Performance of Solar Facade Components**, 2000-03 *(Germany)*
Task 28	**Solar Sustainable Housing**, 2000-05 *(Switzerland)*
Task 29	**Solar Crop Drying**, 2000-02 *(Canada)*
Task 30	**Solar City,** Planning Phase, 1999-2000