SUCCESS STORIES
OF THE
IEA SOLAR HEATING AND COOLING PROGRAMME

The Solar Heating and Cooling Implementing Agreement was one of the first collaborative R&D programs to be established within the IEA, and, since 1977, its participants have been conducting a variety of joint projects in active solar, passive solar and photovoltaic technologies, primarily for building applications. The overall Programme is monitored by an Executive Committee consisting of one representative from each of the 20 member countries and the European Commission. The leadership and management of the individual Tasks (projects) are the responsibility of Operating Agents. More information on the Programme's work can be found at www.iea-shc.org.

BUILDING ENERGY ANALYSIS TOOLS

Task 22 has developed IEA BESTEST, a suite of evaluation tests, which were used by ASHRAE to create a standard method of tests for evaluating building energy analysis software – ANSI / ASHRAE Standard 140. ASHRAE Standard 140-2001 will be referenced in ASHRAE Standard 90.1, a national building energy efficiency standard that is referenced in national model building energy codes. The value of this effort — prenormative research leading to standards leading to reference of these standards in building codes – relates to encouraging and promoting the widespread use of innovative energy efficiency strategies, including the use of renewable energy concepts. The SHC Programme has become the recognized source for this prenormative research on standard methods of tests for building energy software. The experts have developed an integrated, comprehensive approach to building energy analysis software evaluation, which involves analytical, comparative and empirical methods, and have developed a number of test cases within each method.

Pre-normative research continues to be relied on to provide additional test sets – HVAC equipment (A/C, radiant heating, gas furnaces), ground coupling, multi-zone, etc. – for expanding ANSI / ASHRAE Standard 140. And, tool evaluation tests are used to evaluate and debug a number of major national building energy analysis software, such as DOE-2, EnergyPlus, TRNSYS, CLIM2000, ESP, SUNREL, BUS++.

In addition, CEN and ASHRAE rely on Task 22 to provide the pre-normative research results for their use in creating standards. Close cooperation and coordination has been established, and activities include information exchanges, attendance at meetings, and Task 22 experts on CEN and ASHRAE standards committees.

OPTIMAZATION OF SOLAR ENERGY IN LARGE BUILDINGS

Five buildings were constructed using some of the guidelines, methods, and tools developed in **Task 23**. Aside from testing the Task's guidelines and tools, the buildings demonstrate the successful integration of technologies in real buildings and promote sustainable solar buildings. The Task's demonstration buildings were a community center in Denmark, a school in Canada, the German Postal Service Headquarters, and two office buildings in the Netherlands.

Danish Community Centre
The first demonstration project completed was a Community Centre for the Municipality of Kolding in Denmark. A goal of this project was to optimize the building in terms of resource use, functionality, and ecology. During the design process, the SHC Task 23 multi criteria decision making method was used to help identify the objectives, to sort out poor solutions, and to document the design. And, passive and active solar energy technologies were used in the building, together with other sustainable features.

The efficiency of this process was a positive outcome of the Integrated Design Process. And, the client considered that the resulting good indoor climate and reduced energy operating cost were a direct result of using the Integrated Design Process. Overall, the client is very satisfied, and the team members intend to use the Integrated Design Process in future projects.

Community Centre in Kolding, Denmark
(Photograph by Municipality of Kolding)

Canadian School
A school in Mayo, Yukon, Canada was built with the goal to create a building that could be used by the entire community (e.g., school, community gatherings, adult education, etc.) and meet the energy and environmental performance standards for the Canadian C-2000 Program for Advanced Buildings, all on a fixed budget. Passive solar and daylighting technologies were used in the building.

Without using the Integrated Design Process, the Department of Education would probably have implemented a "stock" building plan. After initial resistance to the high-performance approach, all the actors are satisfied with the process and there has been a groundswell of sustainability initiatives within the Yukon Territorial Government.

School in Mayo, Yukon, Canada
(*Photograph by Kobayashi + Zedda Design Group – Whitehorse*)

See the report, "The Integrated Design Process in Practice: Demonstration Projects Evaluated" for detailed information on all five of the demonstration projects.

The Impact of Integrated Design Processes on Design

The overall conclusion is that the use of the Integrated Design Process means high building performance levels, superior indoor environments, and greatly reduced operating costs, at little extra capital cost. To achieve an integrated building in terms of performance and cost, a traditional design process is in many cases ineffective. And, as the SHC Task 23 Operating Agent, Prof. Hestnes states, "Although there will always be individual designers who are able to design brilliant buildings in an individualistic way, the Integrated Design Process approach will be of significant benefit to most designers and clients who are attempting to achieve excellence in building design."

Of the 31 active participants in the Task, 15 were either owners of their own or senior members of private architecture or engineering companies. They are helping to ensure that the results of the Task are being disseminated in the design community.

Integrated Design Process Tools Available on the Web

- Introductory Booklet on the Integrated Design Process
- Integrated Design Process Guideline
- IDP Navigator Software
- Examples of Integrated Design
- Blueprint for a Kick-off Workshop
- MCDM-23 (Multi Criteria Decision Making) Method and Software

Solar procurement

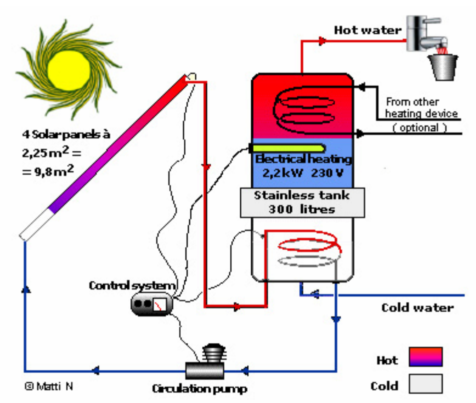
Uponor Wins Solar Procurement Competition

Fourteen systems from Sweden, Germany, Denmark and Austria entered **Task 24's** solar procurement competition for Solar Domestic Hot Water (SDHW) systems. The winner was *Uposun HW 300*, a new system with a plastic collector from Uponor AB. In addition, six other systems were given honourable mention.

The goal of this competition was to develop a solar domestic hot water system that could replace the electric hot water systems that are used in many detached houses with electric heating in Sweden. The system requirements were developed by an independent expert group and included obligatory, as well as desirable requirements. For example, the total price (including VAT, but excluding mounting) should not exceed 16,000 SKr (about 1,700 €) for an order of 1,000 systems. An independent jury evaluated the qualifying systems -- installation (including mounting time, etc.) represented 40%; price and performance 30%; environmental aspects (life cycle analysis) 10%; documentation 10%; and maintenance/length of life 10%. The system evaluations were based on prototype testing carried out by the National Swedish Testing and Research Institute (SP). In addition, the offering company had to pass an evaluation on its ability to carry out delivery and guarantees, and the winner would need to carry out an approved "real" installation of 5 systems on houses.

As a result of the competition, the average performance of marketable SDHW systems in Sweden has improved. And, to support the development of improved systems, the competition's performance test results were sent to the system designers together with detailed advice on how to improve the design, as well as performance. The majority of manufacturers have adopted the proposed improvements, and in some cases, introduced further improvements. In addition, the competition has resulted in a decreased price in the order of 20% for SDHW systems sold in the Swedish market, and lead to the establishment of SDHW system testing at SP.

The competition was initiated and financed by the Swedish Council for Building Research, which is now part of FORMAS, and LIP Stockholm (Council for the Local Investment Program in Stockholm).



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

Uposun HW 300 system

Solar assisted air conditioning of buildings

Survey of Solar Assisted Cooling

Task 25 experts have developed an operating desiccant cooling model for use at conferences and trade fairs. This model not only produces cold air, but also has an interactive poster that allows visitors to learn about the process by changing the operation conditions. This model was realized with help of many companies and the German Environmental Foundation.

Solar desiccant cooling demonstration unit with interactive poster (right) – a center of attraction at the German AirConTec trade fair in 2002.

A database on solar assisted cooling projects in 12 countries has been compiled. This webpage contains short summary reports about solar cooling activities in the participating countries and a database about projects/systems installed in the past. The address of the webpage is: http://ocuilih.cie.unam.mx/cgi-bin/main_menu.cgi and the password is task25.

Solar combisystems

A New Concept is Tested for Solar Combisystems

Integrating solar components into the façade of a building is not a new concept, however, integrating the solar thermal collectors of a solar combisystem is. Mounting the solar collectors on the side of a building instead of on the roof is a promising new opportunity for solar combisystems.

There are several features of façade-integrated collectors that have advantages over roof-integrated collectors. During the summer the angle of a façade-integrated collector helps to avoid overheating the system at stagnation when the collector loop pump is switched, which can occur due to the relatively large collector area needed in combisystems. During the winter, when heat is needed most, the irradiation in the façade at high latitudes is higher than that in a tilted surface. The collector also functions as a passive solar element, even when the collector loop is switched off, and helps to improve the insulation of a building. Due to these reasons, heat losses of the building are minimized. In addition to these contributions, there are the cost savings obtained by replacing the conventional façade with the collector.

Façade collectors are suitable for new buildings and for the renovation of old buildings as well as for homes and larger buildings. By becoming part of a building's architecture, the options for their application improves as some architects and planners are opposed to collectors being tacked on the roof of a building as they detract from the building design.

As part of SHC Task 26, Solar Combisystems, two systems with facade integrated collectors were measured by the AEE INTEC to evaluate the systems' thermal behavior. The results of these investigations have been used by two Austrian solar engineering companies for the production of façade collectors.

The test façade of one of the companies is mounted on a two-family home. The collector area is 55 m^2, the space heating storage tank is 3,570 liters with stratifiers and a 500-liter hot water tank. To optimize the overall system a new storage management concept was developed that guarantees the production of hot water outside the heating season without auxiliary energy. The second test façade is mounted on a brick wall of an office building. The collector area is 25 m^2. To measure temperature and humidity, sensors have been placed in the relevant layers of the wall construction. The first results from these tests were very positive.

Test façade with a 25 m^2 collector on an office building in St. Veit, Austria.

Also, as a result of this work, the share of solar combisystems (compared to the total solar heating systems installed) increased between 1998 and 2001 in almost all of the participating countries.

In addition, there is an official liaison with CEN TC 312. And, the Task's system test method for solar combisystems will serve as a basis for a future CEN standard.

SUSTAINABLE SOLAR HOUSING

Task 28, a joint activity with the IEA Energy Conservation in Building and Community Systems, is investigating the effectiveness of various design solutions by monitoring built projects, computer analyzing key design variables, and assessing home buyer and owner reactions. The goal is affordable, ecological housing requiring very little purchased energy.

To design a house needing almost no purchased energy is theoretically easy – the building must be so well insulated that heat losses are offset by heat produced by the occupants, appliances and sunlight through windows. Since the building should not leak cold air to the inside nor heated air to the outside, it must be airtight and hence mechanical ventilation is needed. Europe, which is leading in this area, has over 500 such housing projects.

Responding to the Market
To sell such high performance houses, as with any houses, three factors are important:
Price: The price must be within the limit of what a homebuyer can finance. Today, the price of some high performance projects is 10 % more than equivalent houses. One way to get the price down is to use more rational construction than that which is currently in local use.
Value: The value of such homes are often stated in terms of superior comfort, such as no cold walls, no downdrafts by windows, distributed fresh air (even with closed windows) and less environmental impact.
Economy: The economy can be very convincing for homebuyers because the remaining purchased heating energy is so minimal. One builder even offers his houses with 10 years of free heat.

Row houses in Nebikon, Switzerland

A Swiss Project
The first row house project in Switzerland built to the "Passivhaus-Standards" has been built and monitored in detail as part of a European project. These row houses deviate from the compact building design typical of such passive houses. The tradeoff in this design was private terraces for slightly more heat-losing wall area. Each row house has a very large glass area to the south that provides passive solar gains, extremely good insulation (U=1.1 W/m^2K), and fresh ventilation air that is first tempered by an underground duct then heated by a heat exchanger. The house is constructed of prefabricated wooden panels. And, the stairs, kitchen, and bath spaces were delivered from the factory to the building site as a single finished module. Because the project is being completed in phases, alternatives to achieve the annual energy target of 15 kWh/m^2 of net floor area can be tested at less cost and feedback from sales staff can be taken into consideration.

In this Task, data from over 50 housing projects. What is learned will be published in 2003 as a book of example projects.

Solar crop drying

Task 29 has focused on deploying developed technology in the field, not the development of new technology. Methods and procedures have varied from country to country and project to project. Therefore a consistent process has not been established. One unexpected success has been the extension of most projects from simply installing a solar system to consulting on improvements in dryer design, which will lead to much greater efficiencies in the overall process. Examples include:

- Panama coffee drying – improvements to the design of the wood burning furnace
- Zimbabwe tobacco drying – recommendations to improve the design of the drying barns
- China jujube drying – new design for the dryer to replace much outdated drying rooms
- China biomass drying – new dryer design for new process.
- India core pith drying – new method to distribute air in dryer.

Proving the Potential of Solar Crop Drying

One of the most promising applications for active solar heating worldwide is the drying of agricultural products. In a 1999 study, jointly produced by Canada and the Netherlands, the potential amount of energy that could be displaced using solar in this market was estimated to be between 657 PJ and 1530 PJ annually.

If solar crop drying offers a sound alternative to other drying methods, why is it not more extensively used? The answer to this can be attributed to three key barriers 1) a lack of awareness, 2) a lack of good technical information, and 3) a lack of good local practical experience. To tackle these barriers, the experts of SHC Task 29, *Solar Crop Drying*, are working with local companies to establish solar drying projects for a variety of crops. They also are providing technical and commercial information as well as compiling the experiences gained from the design, construction and operation of these full working demonstration systems.

The strongest market for solar drying is generally, but not always, crops that are mechanically dried at lower temperatures. Crops that are currently sun-dried are well suited to solar drying, but the financial resources to implement a solar drying system are often lacking. The processes that are used to dry crops at temperatures greater than 60° C could benefit from solar drying as a supplemental system, but the drying process must be re-organized. Therefore, this Task is concentrating on displacing fuel-fired dryers for crops that are dried at temperatures less than 60° C. The identified potential for displacing conventional energy sources in this segment of the market is estimated to be between 216 PJ and 770 PJ, but the use of solar energy is largely undeveloped. Other than open air drying, wood and conventional fossil fuels are used most extensively. And, in many countries, more expensive diesel and propane fuels are replacing wood.

At this time, five SHC Task 29 projects have been completed in Zimbabwe, Panama and India. And, projects are underway in

China, Costa Rica, India and the United States.

Zimbabwe

In Zimbabwe a Dutch team, led by Zen Solar, has worked with the Tobacco Research Board of Zimbabwe. The two solar systems are installed on drying barns located at the Board's testing facility.

The first project is a thermo siphon air system using ground mounted air collectors and a rock storage bin. The collectors, designed by Zen Solar, incorporate the required ducting and use simple technology so that they can easily be manufactured locally. An objective of the Dutch project is to find a local partner to produce the panels and market the systems in Zimbabwe. The second project is a water-based system using market-ready hydronic solar panels and a heat exchanger. In both cases, the solar system is used to preheat air going into the drying barns. Initial monitoring of the operation of these systems has been completed, and they are operating according to expectations. The monitoring also has identified opportunities to improve the design and construction of the drying barns, which should further increase the efficiency of the drying process.

Tobacco drying facility in Zimbabwe.

Panama

Two projects have been installed at a coffee drying facility near Sona, Panama at the recently established Panama Coffee Trading and Export Company.

Coffee drying facility in Panama.

Over the past three years, approximately 1,200 hectares of Robusta coffee plants have been planted and the first major harvest is expected to start in 2003. To dry the coffee beans, a solar system is being used that incorporates the Solarwall®, an air heating collector, supplied by Conserval Engineering of Canada. The Solarwall panel is profiled metal siding that is perforated with a pattern of small closely spaced slots. Air, at the rate of about 15,000 liters/second is heated as it is drawn over the surface of the panels, through the slots and behind the panels before it is ducted to the furnace. The larger system on the Sona installation uses 574 square meters of roof-mounted solar panels that preheats the furnace supply air. The furnace, which is wood fired, feeds large vertical dryers that reduce the moisture content of the coffee beans from 52% to 11%. Once this process is complete, the beans are stored in a series of silos. The second solar system is then used to further reduce the moisture content of the beans or maintain a constant moisture level, depending on what is required. This system, which uses 278 square meters of roof-mounted Solarwall panels, preheats air going to the silos at a rate of 7500 liters/second. The system was first used for the 2002 season – December to March.

Solar heating displaces about 28% of heating used by the dryers during the day. The expected payback period is about 1.5 years based on current propane costs and the price of an installed system without subsidies.

India

A project in Arskiere, Karnataka, (near Bangalore) India is an installation on a new plant built by Kaveri Argi-Care to dry core pith. Core pith is a fine granulate that is found on coconut shells. The plant washes out the sodium that is concentrated in the core pith, and then the material is pressed and dried. The finished product is marketed as Core Peat or Green Soils for use as a potting soil substitute as it absorbs about 12 times its weight in water and will hold moisture 8 times longer than standard soils. The product also floats and so is also used as oil absorbent. In this project, 438 square meters of Solarwall, installed by Conserval's Indian affiliate, Kotak Urja, was retrofitted to an existing facility. In the system, ambient air is heated by approximately 10^{o}C and ducted directly into the furnace. The moisture content of the core pith is reduced by approximately 70%. The economics of this project are particularly attractive since core pith drying is a year-round operation.

Another project is expected to proceed on a cardamom (a spice) drying facility in India. The solar system will be installed to supplement the heat for one of the drying chambers in an existing building.

China

Two projects in China are currently under construction. One is for the drying of jujubes. Jujubes are similar to dates or figs with a slightly harder skin. The Xinzheng Fengli Food Company is constructing a new building near Mengzhuang, Henan, (central China) to dry the jujubes and other products, such as garlic. The other system will be installed in Lianghe, Yunnan (southern China) on a new building constructed by the China Fuels Company to produce biomass briquettes for charcoal burners. A 50:50 mixture of crushed coal and biomass such as sawdust is mixed in slurry from which a rotating press produces the briquettes. The company needs to increase production and wants to use solar drying, since the product cannot be shipped when wet.

Costa Rica and the United States

Work also is underway to install a system at a coffee drying facility in Costa Rica and at three facilities in New York State to dry grain, chicken manure and wool.