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INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

Improving the Performance of Solar Facade Components

Participants in SHC Task 27, Performance of Solar Façade Components, have developed a general methodology for durability test procedures and service lifetime prediction (SLP) methods that is adaptable to a wide variety of advanced optical materials and components used in energy efficient solar thermal building applications.

The Basics

Solar building components must fulfill three important criteria to achieve successful and sustainable commercialization: 1) maximum performance, 2) demonstrable durability, and 3) minimum cost. This triad of requirements is shown schematically in Figure 1.

Performance is a measure of a product's ability to function in a useful or desired manner. For example, the merit of a glazing material may be characterized by its solar-weighted hemispherical transmittance or a solar energy collection system may be quantified by its overall efficiency. **Durability** is the ability to retain performance (avoid degradation) during in-service use throughout a products lifetime. Costs include the initial capital expenditure as well as cost of upkeep.

Durability assessment directly addresses all three segments of this triad. **Costs**, including life cycle costs, can be analyzed because estimates are provided for service lifetime, O&M costs, and realistic warranties. By understanding how performance parameters are affected by environmental stresses (for example using failure analysis) then improved products can be developed. And, durability is addressed by determining known causes of degradation, which can then be used to increase product longevity. For these and other reasons, the accurate assessment of durability is of paramount importance to assure an extended life of solar building products.

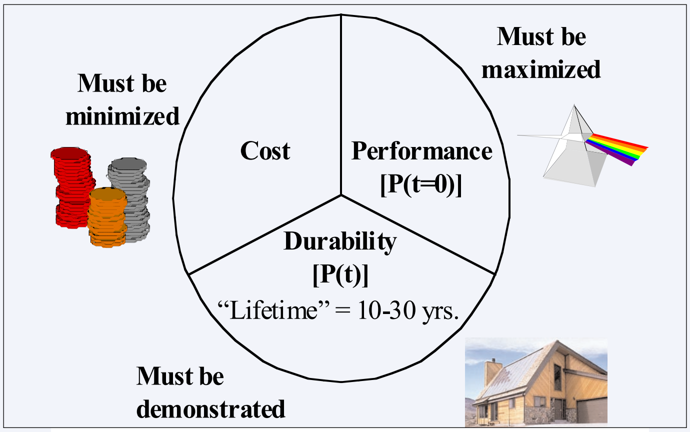

Figure 1. The product requirement triad.

Durability Assessment Methodology

Participants in SHC Task 27, *Performance of Solar Façade Components*, have developed a general methodology for durability test procedures and service lifetime prediction (SLP) methods that is adaptable to a wide variety of advanced optical materials and components used in energy efficient solar thermal building applications. This general methodology includes three steps:

1) Initial risk analysis of potential failure modes.
2) Screening testing/analysis for service life prediction and microclimate characterisation.
3) Service life prediction involving mathematical modelling and life testing.

This methodology has been used to analyze selective solar absorber surfaces and polymeric glazing materials in flat plate solar collectors. Based on the results from this earlier work, the methodology proved to be applicable to accelerated life testing. The benefits of using

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finland
Country Highlight

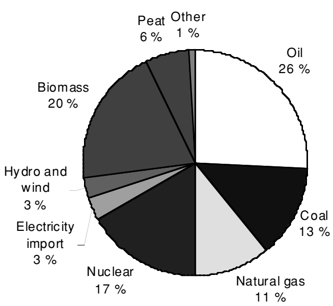


Figure 1. 2002 energy sources used in Finland.
(Source: Ministry of Trade and Industry)

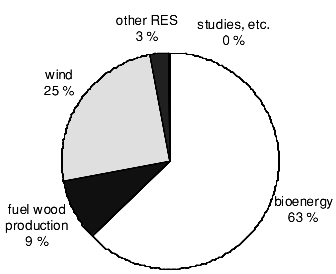


Figure 2. Market introduction expenditures of RES were 29 million euro in 2002.
(Source: Ministry of Trade and Industry)

New Hope for Solar Energy in Finland

The Finnish action plan for solar energy is a market driven initiative. Domestic markets are important to move solar energy forward, but the global market is the driving force for industries considering investments in this field.

The Status of Energy and Renewables

Finland can be considered an energy intensive country. The reason for this is due basically to three factors–a northern and cold climate, a scarcely populated country with long distances, and an energy intensive industry base. The basic industries in Finland account for about half of the entire country's energy use, which in turn has stressed a cheap energy supply and energy security in the national energy policies for several decades.

Meeting the Kyoto target, which for Finland means freezing the GHG emissions to the 1990 level, is a major challenge as the CO_2 emissions in 2002 exceeded by 16% the target level set for 2008-2012. Finland also will be the first OECD country to base its Kyoto policy on more nuclear power after a narrow decision of the Finnish Parliament in May 2002 to allow the construction of a nuclear power plant, urged by the industries after a decade long debate. Nationally, the nuclear energy issue has overshadowed the successes in renewable energy use and the new initiatives to increase its use, albeit already a high share, in the national energy supply.

As of 2002 the total primary energy use in Finland was 33.5 Mtoe (49% used by industries, 22% for heating buildings, 16% for transportation and 13% for other sectors). Imports account for 70% of all primary energy and 30% is based on domestic production.

As illustrated in Figure 1, the energy mix in Finland is spread over several energy sources and no single source dominates. Biomass has a high share (20% of all primary energy), which is due primarily to the large paper and pulp industries in the country. Finland has one of the world's largest forestry industries related to its GNP. This industry has developed a kind of energy-industry metabolism, that is, the residuals and waste wood from the forestry processes are used to produce energy. And bioenergy production can make use of this existing infrastructure, which in turn reduces the costs of bioenergy. Heating using bioenergy costs about 10-25 euro/MWh.

Another by-product from the paper and pulp industries is the high share of Combined Heat and Power (CHP), more than 30% of Finland's electricity stems from CHP.

New RES Plan 2003-2006 and Solar Road Map

Renewable energy use and policies in Finland have been dominated by bioenergy. Other renewables, such as wind and solar energy are still in their infancy, however, in the revised renewable energy plan (RES) for 2003-2006 these and other renewables are better represented.

The RES plan 2003-2006 has a goal to increase the use of renewables by 30% from 2001 to 2010 and a long-term vision of a 60-70% increase by 2025. The plan suggests new types of market deployment instruments, such as green certificates, emission trading, feed-in tariffs, etc.

Solar energy is included as one of the renewable energy sources in the new plan to be promoted both in terms of markets and technology. The national targets for solar energy by the year 2010, as stated in the government's energy policy documents are the following:

- Increase the use of solar energy in Finland by 100 GWh/yr by year 2010.
- Increase solar export business value up to 160 million euro/yr by year 2010.

To achieve the targets some 120,000 m² of solar thermal and 22 MWp photovoltaics applications will need to be installed. These goals are about 10 times the present solar utilization level in Finland.

A solar road map or so-called "Finnish action plan for solar energy" was prepared a few years ago to meet the government's goals for solar. This



Examples of Finnish solar products for global markets.

road map includes specific milestones and actions. In organizing the practical work, the government has not established a separate solar program, but instead the activities are organized mainly through a national actor network and an industry driven cooperation group.

The Finnish action plan for solar energy is a market driven initiative. Domestic markets are important to move solar energy forward in Finland, but the global market is the driving force for industries considering investments in this field. The success of the action plan will depend on how active are the market actors and stakeholders perform as industry is coordinating the activities and various government agencies are supporting them. Most of the government support is for industries and business-to-business type of investments. For example, there is no support to individual house owners to invest in solar heating, but industries or municipalities may receive a 40% investment subsidy.

Government funding for renewables is about 80 million euro per year of which 29 million euro are for market introduction. Most of this funding went to biomass, but also wind energy which is a growing sector (see figure 2). The total public expenditure for solar energy (PV and solar thermal) was about 0.2 million euro.

Strong Industrial Profile

FSI, or the Finnish Solar Industries group, was established in 2001 by strategic market actors to support the government's solar goals, to create new business in the area of solar energy, and to concentrate the joint activities on areas showing strongest added value. The FSI group now has about 25 organizations covering the whole innovation chain (research, industry, buyers, and public organizations).

In 2001, the solar export business value from Finland was about 10 million euro and in 2003 it had increased to 25 million euro. Solar has become a part of other businesses, such as steel and copper product manufacturing, heating equipment industries, and buildings companies. For example, Outokumpu Ltd. produces special oxygen free copper, which is exported to about half of all European solar collector manufacturers. LPM Ltd. is a district heating sub-station manufacturer that produces compact pump/heat exchanger packages for major European solar heating systems. Another example is Rautaruukki Ltd., which is a major steel product manufacturer. They have launched so-called energy roof products (solar air, solar water, solar PV) that are fully integrated into steel roofing—a customer may now easily choose the solar option when purchasing a roof. The solar air system is an example of a low-cost option when combined with a full roof steel collector that includes innovative heat recovery equipment.

There also are a few companies with solar as their sole business. NAPS Systems Ltd. is active in PV systems, in particular for remote applications and developing countries.

Table 1. Market potential for larger solar heating systems in Finland (GWh/yr).

Sector	w/out subsidies	with subsidies	Collector area (m²)
Small industries	0	100	290000
Service buildings	3	1050	2620000
Apartments	0.5	200	496000
Power plants	0	0	0
District heating	5	140	400000
Total	13	1490	3806000

The Domestic Solar Market

The domestic market for solar heating and photovoltaic installations is modest compared to other European countries. The yearly amount of collector installations is about 1000-2000 m^2 and 150 kWp PV systems, all of which are non-subsidized. The largest solar market segment has traditionally been PV solar home systems for recreational houses without grid connections. Over 50,000 of these systems have been sold over the years.

Another growing market is the use of solar thermal in the renovation of old oil heating systems. Five to seven companies now offer complete solar-oil system solutions. When you take into consideration that 250,000 old oil burners need to be renovated in the near future, this business represents a major potential for solar heating.

At present, the market introduction programmes for solar heating are only for municipalities and companies. One reason for this may be the rigid subsidy policy in Finland, but another reason is the desire to increase professionalism in the market introduction phase. Consequently, an energy service company (ESCO) approach is now emerging in which a solar company provides turn-key solar systems, including maintenance, and gets paid based on produced solar energy for a 10-year period. The market potential for larger solar thermal applications suitable for ESCO business models is more than 1500 GWh/yr or some 3.8 million m^2 of collectors (see Table 1). The subsidized break even cost for solar heating is about 30-35 euro/MWh.

Sustainable Housing

Several Finnish municipalities are working to promote better energy use and sustainability, including renewable energy use. Helsinki City is a good example of how a large city can lead the way. Helsinki City planned in 1996 an ecological suburb, called Ekoviikki, for 2,000 inhabitants and some 64,000 m^2 of building area with strict sustainability criteria (e.g., energy, water, health, and environment). This in turn created

Figure 4. Examples of solar energy utilization in Ekoviikki sustainable suburb in Helsinki. *(photos: Solpros)*

demand for solar energy to meet the criteria and to get building permits. As a result, several solar energy projects were realized during 2000-2003 in Ekoviikki. One being Finland's largest solar project with eight solar heating systems integrated into multi-family houses with 1250 m^2 of collectors. Other projects included an innovative integrated PV-balcony and a low energy passive solar PV house. The Ekoviikki solar projects now serve as a showcase to inspire other municipalities to use new technologies such as solar.

Sustainably built houses also are offered to private homeowners by most building companies. The data shows that compared to average heat demand, these low energy houses require 50-80% less and have negligible cost increases.

Other solar strategies include daylighting and passive solar. It is worthwhile to mention the long tradition of Finnish architects in using daylighting in building design. The world-famous architect Alvar Aalto created in the early 1930s the concept of "design with light." Aalto's school of architecture is now the prevailing school among leading architects in Finland. Passive solar also is used as it is a natural choice to take advantage of cold winters with clear skies.

The Future

Creating markets and gaining government support for solar energy has been more difficult than in other IEA countries. As a result, a smaller rate of solar energy is used in Finland. However, this has created a focused effort to overcome the true barriers (e.g., costs, widespread use of solar energy, etc.) and to find effective ways to commercialize solar energy. Finland may have a small domestic market, but Finnish solar technology has achieved a notable foothold in global markets.

In the coming decade, the domestic solar market will be developed more through private-public partnerships. As energy authorities consider solar energy to be a future possibility that deserves stronger support, they also will be working to achieve effective resource use. Overcoming the cost barrier is the main challenge ahead if the significant solar potential is to be realized in the country.

This article was contributed by Prof. Peter Lund of Helsinki University of Technology, email: peter.lund@hut.fi.

SHC SOLAR AWARD

The 2nd SHC SOLAR AWARD will be presented later this year. It is proposed to present the 2004 Award at a special ceremony at the International Conference for Renewable Energies in Bonn, Germany on 1-4 June 2004.

The award is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements, with links to the IEA Solar Heating and Cooling Programme (SHC), in the field of solar energy at the international level within one or more of the following sectors:

- Technical developments
- Successful transfer to the market
- Information

Last year's winner was Mr. Torben Esbensen of Esbensen Consultants A/S, Denmark. Mr. Esbensen was selected for his many contributions to the work of the SHC Programme and the international solar community. Since 1986, Mr. Esbensen has contributed to SHC activities in the areas of passive solar commercial buildings, solar energy in building renovation, daylighting, solar optimization in large buildings and solar procurement.

SHC Solar Award designed by sculptor Marco Goldenbeld of the Netherlands.

Thanks To…

Hans Westling, who served as the Operating Agent for Task 24, Active Solar Procurement. Dr. Westling has the distinction of running the SHC Programme's first market oriented Task. The Executive Committee thanks him for his dedicated and valuable work.

John Ballinger, the representative from Australia, who served on the Executive Committee for seven years.

Welcome To…

Colin Blair of Standards Australia International, who is the new Executive Committee representative for Australia.

Ken Guthrie of the Sustainable Energy Authority Victoria, who is the alternate Executive Committee representative for Australia.

2003 SHC publications

Many reports were published on the current work of the SHC Programme this past year. In effort to make the reports readily available, many can be downloaded as PDF documents from the SHC web site and others are available from commercial publishing houses.

Building Energy Analysis Tools

Radiant Heating and Cooling Test Cases (RADTEST)

This report documents a comparative diagnostic procedure for testing the ability of whole-building simulation programs to model the performance of radiant heating and cooling systems.

Available as a PDF document under "outcomes" at http://www.iea-shc.org/task22

Building Energy Simulation Test and Diagnostics Method for Heating, Ventilating and Air-Conditioning Equipment Models (HVAC-BESTEST): Fuel-Fired Furnace Test Suite

This report documents an analytical verification and comparative diagnostic procedure for testing the ability of whole-building simulation programs to model the performance of fuel-fired furnaces. Results from analytical/semi-analytical solutions and simulation programs that were used in field trials of the test procedure are also presented.

Available as a PDF document under "outcomes" at http://www.iea-shc.org/task22

Daylighting – HVAC Interaction for the Empirical Validation of Building Energy Analysis Tools

Two tests were conducted at the Energy Resource Station to obtain data sets for use in model validation of daylighting-HVAC interactions. Each test contains five days of data collection. The data sets include measured values of system-level and room-level parameters as well as local weather data necessary to construct weather files for use in the simulations. This report documents the experimental facility used for the empirical validation exercises, the specifications for each test, and the comparisons between simulation results and experimental results. The two simulation programs that were used for this validation exercise were DOE2.1E and TRNSYS.

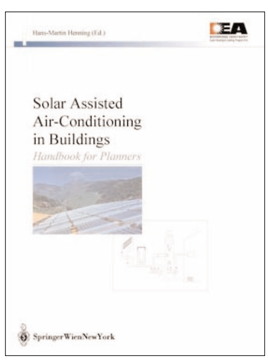
Available as a PDF document under "outcomes" at http://www.iea-shc.org/task22

Active Solar Procurement Business Tools

An online resource of tools (documents) for cooperative procurement buyer groups. The tools are designed to assist buyer groups with the tendering process, marketing, financing, installation and quality control.

Documents are available under "Business Tools" at http://www.ieatask24.org/tools.htm

Solar Assisted Air-Conditioning in Buildings



Solar Assisted Air-Conditioning in Buildings - A Handbook for Planners.

This book will help planners design a solar assisted air conditioning system. The applications covered include closed cycle and desicant cooling technologies.

Available from SpringerWienn-NewYork, EUR 40. Order form can be downloaded from http://www.iea-shc-task25.org/english/hps6/index.html *or you can contact Springer directly at* http://www.springer.at

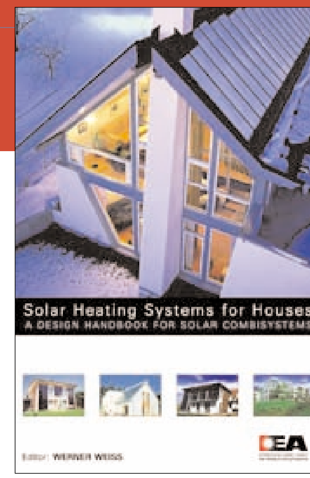
Ongoing Research Relevant for Solar Assisted Air Conditioning of Buildings

This is a technical report on national and international R&D work on new components and systems for solar cooling.

Available as a PDF document at http://www.iea-shc-task25.org

Solar Combisystems

Solar Heating Systems for Houses – A Design Handbook for Solar Combisystems



This book summarises all the results of SHC Task 26. The focus is on heat demand of buildings, different system designs and built examples, building-related aspects like space requirements of the systems and architectural integration of collector arrays, performance as well as durability and reliability of solar combisystems, and last but not least, dimensioning and testing of solar combisystems.

Available from James and James (Science Publishers) at http://www.jxj.com, *£50.00/$75.00.*

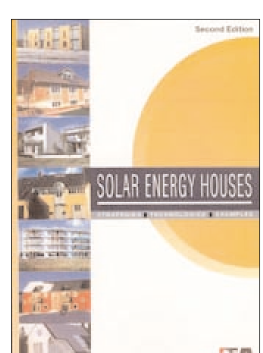
Technical Reports

A series of technical reports that document specific results and findings of SHC Task 26 in the areas of 1) Comparison of solar combisystems, architectural and reliability/durability aspects, 2) Performance tests of solar combisystems, and 3) Optimization of solar combisystems.

Available as PDF documents at http://www.iea-shc.org/outputs/task26/index.html

Solar Low Energy Buildings

Solar Energy Houses:Strategies, Technologies, Examples (2nd Edition)



This new, revised edition of Solar Energy Houses from SHC Task 13, *Advanced Solar Low Energy Buildings*, includes the monitoring results to determine the effectiveness of the techniques and strategies adopted in the project buildings.

Available from James and James (Science Publishers) at http://www.jxj.com, *£45.00/$70.00.*

solar marketplace

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

Online Daylighting Tool

The National Research Council Canada and Natural Resources Canada have developed Lightswitch Wizard (www.buildwiz.com), an online RADIANCE-based daylighting analysis tool. This tool is to be used in the early design stage to help building and lighting designers with daylighting-related design decisions in commercial buildings. It offers a comparative, reliable, and fast analysis of the amount of daylight available in peripheral private offices as well as the lighting energy performance of automated lighting controls (occupancy sensors, photocells) compared to standard on/off switches. Blinds are either manually or automatically controlled.

A user of the software does not require any previous knowledge of daylight simulation techniques as all simulation inputs are explained in the online technical background and glossary sections. Simulation results are based on pre-calculated RADIANCE simulations that are coupled with an empirical model that mimics manual lighting and blind control in single offices. A simulation should take between 20 seconds and 3 minutes to run, assuming moderate traffic on the server and a fast Internet connection.

For more information please contact Christoph Reinhart at e-mail: christoph.reinhart@nrc-cnrc.gc.ca, tel.: +1/613-993-9703.

Simple Design Tool for Combisystems

CombiSun is a PC-based design tool for architects and engineers to compare solar combisystems and properly size according to specific use requirements. The French participant in IEA SHC Task 26, Solar Combisystems, introduced the scheme FSC Procedure, which has become a powerful tool for solar combisystems. The FSC scheme has similarities with f-chart, the well-known design tool for solar water heaters. Data from SHC Task 26 was used to characterize some 10 generic systems and the characteristic functions obtained for each of these systems provided the main background information for CombiSun.

The program can be downloaded from the web site http://www.elle-kilde.dk/altener-combi/dwload.html

3-7 Year Pay-Back Period on SDHW Systems in Sweden

Uponor AB, the winner of the IEA SHC procurement competition for solar domestic hot water (SDHW) systems in Sweden has received approximately 4,000 orders for the new system Uponor HW 300. The cost of SEK 17,000-18,000 (EUR 1,850 – 1,960) including VAT and after subsidy deductions means that purchasers will see a pay-back of their investment in 3-7 years. As a result many buyers are purchasing extra panels. In addition, France, Germany, Italy and Portugal have expressed interest in this system through their Uponor subsidiary companies.

ASHRAE Standard Incorporates SHC Work

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) published Standard 140-2001 in 2001. Its relevance to the IEA SHC Programme is that Standard 140 incorporates IEA BESTEST, a suite of test cases primarily related to building thermal fabric heat transfer, developed under IEA SHC Task 12/ECBCS Annex 21. In 2003, ASHRAE Standard 90.1, which is used for regulating energy efficiency in commercial and non-low-rise residential buildings, was revised to require use of Standard 140 for testing software used in building energy efficiency assessments. This is important because it mandates formalized software evaluation using test procedures developed under IEA research activities.

The committee overseeing ASHRAE Standard 140, SSPC 140, has been given the status of a Standing Committee, this means that as new test cases become available from the SHC Programme and other sources they can be reviewed and integrated into a revised version of ASHRAE Standard 140. Recently SSPC 140 approved public review of proposed Addendum A to Standard 140 that includes the test cases of HVAC BESTEST Volume 1. These were developed under IEA SHC Task 22, Building Energy Analysis Tools, and are related to unitary space cooling mechanical equipment. Currently, SSPC 140 is responding to public review comments, and publication of Amendment A is expected during 2004.

Life Cycle Analysis of Windows and Solar Collectors

A new approach has been developed for technical experts of building envelop and thermal performance to assess the environmental performance of building products. The environmental performance project led by CSTB of France, as part of IEA SHC Task 27, *Performance of Solar Façade Components*, brought environmental specialists from several countries together to first reach a common level of knowledge and determine how to communicate and use the collected environmental data. Then with the assistance of industry representatives in the Task, they created environmental profiles for a window and a solar collector.

Results from this project include:

- **Sensitivity study on windows (SBI of Denmark, ENEA of Italy, and CSTB of France)**: Revealed that the mass of glass is the main parameter for glazing, while the frame material becomes essential when the whole window is considered. From the environmental perspective, improvements made to the glazing efficiency were more efficient than changes to the frame material. Finally, the payback time for recovering through energy savings the excess of embodied energy needed for manufacturing active glazing is less than one year.

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this methodology for accelerated life testing would be shorter development cycle times for new products and identifying improvements that could then be incorporated in products prior to market introduction.

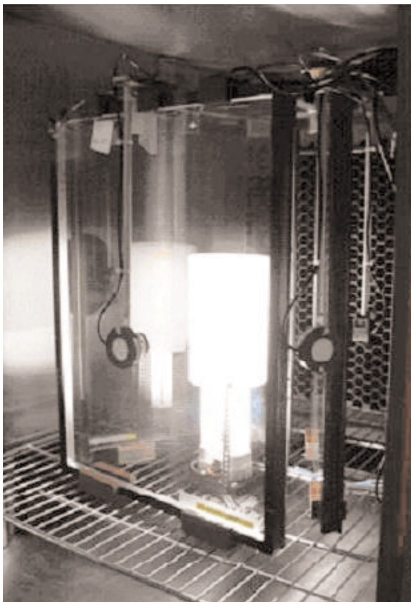

Figure 2. Advanced glazing samples mounted for testing in the climatic chamber at CSTB in Grenoble, France.

Durability Assessment of Solar Materials

The durability assessment methodology also has been used for static solar materials as a means to predict service lifetime and to generate proposals for international standards for materials used in solar thermal collectors. This project performed three case studies 1) anti-reflective and polymeric glazing materials, 2) reflectors, and 3) solar facade absorbers. The samples for the anti-reflective surfaces were kindly made available from different institutes and companies. The main difference in the samples was their production method—formation of a porous film using a sol-gel coating process or an etching process.

All the anti-reflective surfaces were investigated based on the same principle of function—a porous inorganic layer was formed on the surfaces of the glass panes to act as a so-called quarter-wave-coating. The porosity and thickness of each were adjusted to provide a maximum solar transmittance.

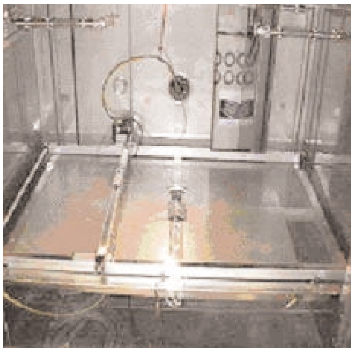

Figure 3. Double climatic chamber at Fraunhofer ISE in Freiburg, Germany.

For validation purposes, outdoor tests are being performed to monitor various kinds of climatic data during exposure to such elements as global solar irradiation, UV-radiation, temperatures, humidity, precipitation, time of wetness, wind conditions, and atmospheric corrosivity. This data will be used to predict the expected deterioration in performance over time using the degradation models developed from the results of the accelerated tests.

At this time, a number of accelerated screenings have been performed, including the simulation of possible degradation in performance under the influence of high temperature, high humidity/condensation, UV, and corrosion loads. To identify degradation mechanisms for the tested materials various analytical techniques were used. For example, fault-tree analysis was used to help better understand the observed losses in performance and associated degradation mechanisms of the different materials.

Durability Testing Facilities for Advanced Glazing

Test chambers in several countries have been modified to test the durability of advanced glazing, and a new test box for outdoor exposure was developed. These test chambers are not only important for this work, but could possibly be used for testing other solar products, such as partially transparent PV modules.

Climatic Chambers for Accelerated Ageing

Durability tests at elevated air temperatures, with or without simulated solar radiation, were made in climatic chambers at three research institutes—Fraunhofer ISE in Freiburg, Germany; CSTB in Grenoble, France; and NREL in Golden, Colorado, USA. Of specific interest in these glazing characterization tests is the measurement of the glazing transmittance. At CSTB, visible transmittance is measured online in the chamber by determining the signal ratio of luxmeters located in front of and behind the glazing, at equal distances from a light source (see Figure 2). At Fraunhofer ISE, the visible transmittance is determined spectrophotometrically off-line, or LEDs can be used to monitor the transmittance at a single wavelength on-line (see Figure 3). The approach taken at NREL is to determine the visible transmittance from off-line spectrophotometric measurements (See Figure 4).

Test Boxes for Outdoor Exposure

A test box for exposing insulated glazing units (IGU's) to natural weathering conditions was developed for use at Fraunhofer ISE and CSTB (see Figure 5). In this test box, the IGU is mounted to form the upper cover, and the interior walls are lined with highly reflective foil to simulate a box of "infinite lateral dimensions." Multiple reflections between the base of the box and the tested IGU are minimized by the base construction that consists of an anti-reflectively coated glass pane and a separate absorber, which is cooled by natural ventilation.

Air temperatures at various points within the box and the glazing surface temperatures were measured with thermocouples at CSTB and Pt100 resistance temperature probes at Fraunhofer ISE. The ratio of the luxmeter in the box to one mounted in a parallel plane (tilted at 45°, orientated to the south) was used to determine the glazing transmittance. If required, an angle-dependent function was applied to correct for the different incident angles of the sun, which was used as the light source for the luxmeter measurements. The same measurement principle is applied for the determination of the spectral transmittance, using integrating spheres connected to diode-array spectrometers. Four IGU's, each with an area of 590 mm x 895 mm, can be tested in parallel in such a test box.

Durability Assessment of Windows and Glazing

Double glazing units, windows and solar façade components, as well as their respective interfaces, constitute a wide field of innovation for energy savings and comfort improvements in buildings. Increasing the initial performance is obviously the primary objective of R&D efforts, but achieving an adequate service life also is important when considering the financial and environmental paybacks.

Assessing the durability of window systems helps to increase confidence in the selection and use of new products. An activity under SHC Task 27 is working to capitalize on the experiences of testing whole window systems. Data is being collected from Canada, Denmark, Finland, Germany, and Switzerland.

In Denmark, new test procedures were developed based on the loads approaching realistic loads. This work showed that degradation can be accelerated by increasing the number of cycles compared to outdoor exposure. Interim results from tests in Canada indicate that the size of the unit does not have a significant impact on the longevity of the edge seal. There could be many reasons for this relationship between length and failure (e.g., greater amount of crack initiation sites for glass failure, greater flexibility of the window, a result of a collapse or cyclic dishing, or more perimeter area for condensation to occur). This relationship may also be strongly influenced by the sash and frame design imparting unusual force on the glazing unit.

Failure Mode Analysis of Solar Façade Components

Within SHC Task 27, and in close cooperation with the work above, a project was led by CSTB of France on the methodological approaches for failure mode analysis of solar components. Widely used in other industrial sectors (car, airplanes), the failure mode and effect analysis (FMEA) was recently suggested as a new tool for building products, and a first FMEA experiment was performed on solar components.

FMEA is a tool that can be used to capture the knowledge of experts, practitioners and manufacturers. It is developed from the perspective of the primary (target) audience for the product and goes to the appropriate level of detail necessary to describe the relationship between the product's use and the environment. This level of detail is defined by the needs of the target audience and the ability to measure the results. A complete FMEA assesses the severity of the failure, the probability of occurrence, and the ability to detect the failure mechanism.

Sample FMEAs have been then performed for a double glazed unit of a window in the United States and France, and for a specific design of a solar collector in France. To communicate the results of the FMEA, several methods were explored, including event tree diagrams, failure tree diagrams, and event-driven graphs. Each of these methods attempts to illustrate the chain of events and the logic structures that lead to the ultimate failure of the product.

Designers, manufacturers and field maintenance personnel can then use the results. Designers will be able to use the information to improve the product quality by designing to minimize the opportunity for failure, or by devising ways to control which failure modes and mechanisms are most probable. Manufacturers will be able to use the information to create more robust manufacturing processes that eliminate specific modes of failure. And, maintenance procedures can be developed that will arrest degradation mechanisms before the product reaches ultimate failure.

Figure 4. Interior view of this climatic chamber shows the scanning radiometer for homogeneity measurements at NREL in Colorado, USA.

What Next

SHC Task 27 work on durability and service life prediction will continue for another two years. Activities will include initial failure mode analysis, FMEA, experimental accelerated testing on complete systems, and reference service life prediction through the application of the factor method. To support the work, case studies will be conducted in three or more areas–window-wall/roof interface (Denmark), IG units (United States), solar collectors (Sweden), and hopefully, chromogenic glazing units (Germany).

Figure 5. View of the test box for outdoor exposure and meteorological instruments at CSTB.

To learn more about this work visit iea-shc.org/task27.

Marketplace continued from page 6

- **Study on solar collectors (University of Palermo in Italy, CTSB of France, and an earlier study by TNO of the Netherlands**: A very detailed inventory was conducted, however due to limited data, the results were limited to energy related indicators and the upstream phases of the life cycle, such as:
  - The extra regional transports can raise from 2% to 5% the transport contribution to the global energy and CO_2 balance;
  - A copper coating may induce a 2% average increase of environmental impacts; and
  - Regarding the CO_2 balance, the installation process contribution is less than 3% while the maintenance process can reach 10%, mainly due to substituting the thermal fluid.

IEA SHC 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 20 members of the IEA Solar Heating and Cooling Agreement have initiated a total of 34 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.

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