TASK 27

Performance of Solar Facade Components

Performance, durability and sustainability of advanced windows and solar components for building envelopes

Summary, Participation and Publication List

May 2007

Operating Agent:

Michael Köhl

Fraunhofer Institute for Solar Energy Systems, 79110 Freiburg, Germany

for Projektträger Jülich, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

1 INTRODUCTION

For the purposes of this Task, solar facade components were defined as clear, translucent and solar control media for building windows and facades, dynamic glazings and solar collectors and their integration into functional facade elements. The Task identified some important components which can make a significant contribution to promoting the further development, uptake and integration of energy efficient products in the envelope of solar buildings. The work addressed specific fundamental problems and knowledge dissemination issues necessary to provide improved knowledge of solar, visual and thermal performance and to increase confidence in the selection and use of new products through increased understanding of performance, durability, reliability and environmental quality.

The Task was build on the work of Task 18, Advanced Glazing Materials, and of the Materials in Solar Thermal Collectors Working Group. The Task emphasized performance assessment methodologies to enable comparison and selection of different products, estimation of energy and indoor climate performance and required performance criteria to aid the development and integration of advanced technologies within the building envelope.

2 OBJECTIVES

The objectives of the Task were to determine the solar visual and thermal performance of materials and components, such as advanced glazing, for use in more energy efficient, comfortable, sustainable buildings, on the basis of an application oriented energy performance assessment methodology; and to promote increased confidence in the use of these products by developing and applying appropriate methods for assessment of durability, reliability and environmental impact.

3 MEANS

In order to accomplish the objectives stated, the participants have undertaken work in three subtask areas:

Subtask A: Performance

The objective of Subtask A is to further develope, structure and integrate the energy performance assessment methodology for windows and other solar building envelope components. Such a methodology will facilitate selection of components and enable comparative performance to be made. Particular emphasis will be given to the assembly and integration of high performance, novel and/or complex solar components into functional building envelope elements. Those assemblies may incorporate highly insulating glazings/frames, anti-reflecting or chromogenic switchable glazings, PV windows, solar shading devices and other daylight components. Data realised by the Subtask will be provided in consistent and harmonized forms suitable for use for product comparison and selection and in building simulation tools. This work will also enable cost benefit studies to be performed and performance criteria to be defined for the work of Subtask B. The work will directly support manufacturers in improving product characterization and specification.

Subtask Leader: Dick van Dijk, TNO, Netherlands, until December 2003

Subtask B: Durability

The objectives of this subtask are to develop a general framework for durability test procedures and service lifetime prediction (SLP) methods that are applicable to a wide variety of advanced optical materials and components used in Energy Efficient Solar Buildings applications, and to apply the appropriate durability test tools to specific materials / components to allow prediction of service lifetime and to generate proposals for international standards.

The Leader of Subtask B was Bo Carlsson until July 2005 and Kenneth Möller in the remaining time, both from SP in Boras, Sweden.

Subtask C: Sustainability

The objectives of Subtask C are investigating and identifying relevant methodologies and criteria in two of the main fields of sustainability: environmental impact assessment and service life prediction.

The Leader of Subtask C was Jean-Luc Chevalier from CSTB in Grenoble, France.

4 Participation

A total of 14 countries have participated in the Task. These were:

Belgium	Japan
Canada	Norway
Denmark	Portugal
France	Sweden
Finland	Switzerland
Germany	The Netherlands
Italy	USA

Three countries, Denmark, Japan, The Netherlands left the Task earlier than planned.
All participating countries have been very active and have participated in the work in all the Subtasks. The experts comprised both researchers from universities and research institutions, and engineers from private companies coming from 34 different institutions. The respective experts are listed in Chapter 8.

5 ACCOMPLISHMENTS

Subtask A: Performance

Project A1: Energy performance assessment methodology

The objective of a general energy performance methodology is the evaluation of the energy performance of a building envelope component, either product or development. Open is up to now the question, whether it is sufficient to characterize the properties of the component with well-defined component performance figures, for instance with heat resistance or total solar energy transmittance, or whether it is necessary to give a well-defined but illustrative view of the energy-related benefits of this components in a realistic use condition. Obviously the application and use is not a completely fixed frame. Windows and other envelope products may be used in different contexts. Nevertheless the answer can be representative for typical use. Therefore the definition of typical reference cases and conditions is a part of the work on a general EPAM in this case.

The energy related quantities to be considered in an overall energy performance cannot be restricted to an isolated performance figure e.g. heating energy requirement, but must include other indicators as well:

- energy savings heating and cooling,

- energy substitution systems,
- thermal and visual user comfort,
- air quality.

Project A2: Energy efficiency of switchable glazing in office buildings

Over the last couple of decades there has been a trend to use more glass as façade elements in large office blocks. This inevitably leads to overheating in the summer even in a northern climate, unless careful solar shading is included in the building concept. Unfortunately the easy way out is to install expensive and power consuming air-conditioning units. A better and more environmentally friendly way of reducing the over-heating problem could be to use efficient solar shading.

A new and exciting concept of solar shading is switchable windows, also called smart windows. These are windows that can switch between high and low transmittance of solar and/or visible radiation. Thus, they can adapt to varying solar irradiation conditions and maintain high interior thermal comfort, as well as reduce glare. Owing to this ability to switch, these windows have a further energy saving capacity compared to static windows.
Within Subtask A, the energy consumption of a standard reference office block has been evaluated using building simulation programs. The investigated office unit consists of two identical offices, one facing north and one facing south, both with two large windows, but not having a fully glazed facade. The results clearly indicate a large energy saving potential for switchable windows even compared to advanced static solar control windows. The simulations were carried out for three different European climates, Rome, Brussels and Stockholm. An especially interesting result was that the needed power for cooling can be reduced to almost zero in moderate to cold climates. Thus the need for power consuming air conditioning can be eliminated. This would reduce not only the energy consumption, but also the investment cost.

Project A3: Solar building components and integrated assemblies

> Case study 1: Solar shading devices

Solar shading is a special topic in building physics and design. Historically it was the first “smart” component in the building envelope in the sense that it allowed to control (solar) energy transfer from outside to the inside of the building. As known from personal experience the switching efficiency can be very high, but traditional (manual) control efficiency is sometimes low. Another speciality of the widely used slat type devices is the large anisotropy of the transmission properties with respect to the incidence angle.

The capability of blocking or letting pass solar radiation into the building makes the proper handling of a shading system rather complex, even without angle-selective properties. Solar gain may significantly reduce the heating energy demand, but may also cause glare, overheating problems and large cooling loads. Blocking radiation may reduce these problems, but strongly increase the lighting energy demand. Also, daylight and view through is appreciated by most occupants.

Solar shading thus becomes a multi-dimensional optimisation task, which is more and more important since many new office buildings have a highly glazed envelope, making the indoor climate very sensitive to solar irradiation. But for all that, knowledge about characteristics and impact of shading devices on comfort and energy performance of buildings is still on a rather simple level. For example, building simulation tools often use just a user defined shading factor or total solar energy transmittance for a glazing with activated shading device. Aims of this project were therefore to improve and validate measurement and modelling techniques for solar and thermal properties, and to get more insight regarding the performance of shading systems in buildings.

> Case Study 2: Double Envelope Facades

The double envelope façade is a wall or glazing façade, which is covered and protected with an extra glazing layer outside the normal wall structure. The extra layer outside the wall can be single glass, double glazed unit or PV-cell layer. The air gap in the structure can be ventilated and there can be solar protection or glare protection systems associated to the façade system. The motivation to build multi-functional glazed facades is, for example, architectural, aims to improve the utilisation of solar energy and daylight, improved sound insulation and ecological aspects.

The glazed multi-functional facades have a large range of different practical applications with varying performance properties. The high level of expertise is needed in design, the structures are complex, there are high risks to have problems: overheating, glare, high energy consumption, condensation, maintenance, fire safety. The design practice needs lot of information on design and selecting. The simulation and modelling is needed in component level and in building level and new tools for design are needed. The long-term performance and service life planning are not well known in practice and more study is needed. The reality is that architects and owners want to have nice-looking, glazed buildings and glazing manufacturers want to sell glass as building material. The challenge of the engineering is to develop the knowledge to improve the quality of the applications.
Thus the main objectives were:

- Determine thermal performance and improve models of double envelope facades and their integration into building envelope assemblies or façade systems
- Develop recommendations for test and calculation procedures for the integrated thermal/solar/daylighting performance of double envelope facades

> Case study 3: Performance of TI Façades

This summary is not a collection of product data but an overview of properties and performance indicators, which are relevant mainly with respect to the solar and thermal performance.

It should be emphasized that

- The main focus is given on effects of assembling and integration into the building envelope, which are often not taken into account.
- Within this case study only TI systems attached on an opaque external wall are considered.
- Thermal comfort aspects are just briefly mentioned, as well as durability issues, which were not further investigated in this case study.
- After an introduction of the building envelope assembly “TI façade”, the concept of performance indicators as defined in IEA-SHC Task 27 project A1 is summarized in short.
- Performance indicators of TI assemblies are described in more detail, and standard quantities for the characterisation of components are listed quickly. Then the calculation of solar heat gains with regard to the energy performance of buildings is summarized and demonstrated.
- Based on measurements of a “model” system in an outdoor test facility integration effects are discussed which could cause differences between the real climate performance and performance indicators determined by standard laboratory procedures (Simmler, 2001-2003). In the last section some recommendations on performance assessment of TI systems under development are given.

> Case Study 4: Daylighting elements

Efforts were made to characterize the optical performances of daylighting components in order to perform daylighting component performance analysis as well as daylighting simulation using usual daylighting software. Usual optical performance characterization involves experimental goniophotometry with the measurement of bi-directional distribution functions of reflectance and transmittance. Our aim was to characterize the response of the daylighting component to a given illumination condition also including outdoor conditions (ground, site surroundings like buildings and or vegetation). From indoor point of view, such a response of the system to outdoor illumination can be seen as a new source-like equivalent illumination condition at the interface between indoor and outdoor. This can be described by mean of virtual goniophotometry ray-tracing software, were the geometry of system is described by mean of CAD input, and the photometry by reference of either materials library or physical laws implementation. In order to avoid boundary effects, input and output covers might be necessary to restrict the illuminated area of the system.

> Case Study 5: Window-wall-interface

In this study, effects of building integration on the thermal and total solar energy transmittance of windows are investigated. Methods for characterizing the assembly of typical window products and typical wall/roof constructions will be evaluated and tested by comparative calculations on reference cases.

The thermal transmittance of the complete window-wall/roof assembly can be characterized by 1-dimensional heat transfer coefficients and linear thermal transmittances arising from the assembly. The heat transfer coefficients and linear thermal transmittances can be evaluated based on calculations with detailed 2-dimensional calculation tools and the calculated values can be checked by hot box measurements. This work presents existing methods to characterize the impact of the assembly on the heat loss and proposes a new method that simplifies the characterization. The impact of the assembly is shown for a number of typical window-wall/roof assemblies used in the participating countries.

The total solar energy transmittance (the g-value) of a window is a function of the solar incidence angle and shading effects from the surrounding environment. Shades may have significant influence on the resulting g-value. Shades arising from the integration of a window in a wall construction can be characterized and included in the resulting g-value of the window/wall assembly. The resulting g-value can in many cases be found from calculations and to some extend checked by calorimetric measurements. This work presents a method that characterizes the effect of the assembly on the total solar energy transmittance of the window.

Subtask B: Durability

Project B1: Durability assessment methodology

To achieve successful commercialisation of new advanced windows and solar façade components for buildings, the durability and reliability of these need to be demonstrated prior to installation by use of reliable and well-accepted test methods.

In Task 27 work has therefore been undertaken with the objective to develop a general methodology for durability test procedures and service lifetime prediction (SLP) methods adaptable to the wide variety of advanced optical materials and components used in energy efficient solar thermal and buildings applications.

As the result of this joint work a general methodology has been developed. The proposed methodology includes three steps:

- initial risk analysis of potential failure modes,
- screening testing/analysis for service life prediction and microclimate characterisation, and
- service life prediction involving mathematical modelling and life testing.

For another validation study performed by the Task 27 group the proposed general methodology to service life prediction was applied to PVC and PC polymeric glazing materials as collector cover in flat plate solar collectors. Previous results from IEA work are also here utilized for the analysis.

The examples on durability assessment of selective solar absorber surfaces and on polymeric glazing materials both show the great applicability of the general methodology for accelerated life testing. The usefulness and validity are also confirmed by comparing predicted results with actual measured data for samples exposed under real in-service conditions. Consequently, very abbreviated testing times at elevated stress conditions can be substituted for long-time exposures at lower stress levels in durability assessment. This will allow much shorter development cycle times for new products and will allow improvements to be identified and readily incorporated in new products prior to market introduction

Project B2: Durability and reliability assessment of switchable materials and devices (chromogenics)

The originally stated objective of this project was "to assess the durability and reliability, under service conditions, of a variety of switchable materials and devices including those containing electrochromic, gasochromic, and/or thermotropic layers. Such materials may have application for both building facades and solar thermal collector systems."

Although chromogenic materials of different types have been investigated for several decades now, prototypes of switchable windows in architectural dimensions (> 0.5 m^2) have been produced in limited quantities only within the last ten years. With the installation of such glazing in demonstration buildings becoming a reality, the task of assessing their durability and reliability has taken on new urgency.
At the same time, the need (and the feasibility) of testing complete switchable window systems is being increasingly recognised. A complete system to actively control the light and energy transmittance through a window consists not only of the glazing unit, incorporating electrochromic, gasochromic or polymer-dispersed liquid crystal materials, but also a supply unit to provide electric power or gas, and a control unit. As the systems become more mature, the supply and control units are becoming more sophisticated, so that they may be programmed to avoid conditions known to be harmful to operation, such as high voltage spikes or switching when the glazing temperature is extremely high.

When this is part of the system concept, then a complete system may perform better than its components tested individually. From the potential user's viewpoint, it is also the performance of the complete system over its lifetime which is of primary interest. Within Project B2 the joint work has reflected this shift in interest from materials and components to complete systems. The approach taken has been to adapt the general durability methodology of Project B1 to specific chromogenic requirements, define and carry out accelerated ageing tests, monitor the performance of samples in outdoor tests, and compare the results of accelerated and outdoor testing as far as this is possible with the data currently available.

Project B3: Assessment of durability and service lifetime of static solar energy materials

Task 27 started at the beginning of year 2000 with the objectives of developing and applying appropriate methods for assessment of durability, reliability and environmental impact of advanced components for solar building facades.
For the work on durability there are two main objectives. The first is to develop a general framework for durability test procedures and service lifetime prediction (SLP) methods that are applicable to a wide variety of advanced optical materials and components used in energy efficient solar thermal and buildings applications.

The second is to apply the appropriate durability test tools to specific materials/components to allow prediction of service lifetime and to generate proposals for international standards. As the result of this work, a general methodology has been developed, which is now adopted to some static solar materials.

The work was performed in three case studies on anti-reflective glazing materials, reflectors and solar facade absorbers. Anti-reflective materials that were investigated include sol-gel coated and etched AR glasses. Reflectors that were studied include aluminium alloy based mirrors; some protected by clear coatings, and glass mirror reflectors. Solar Façade Absorbers that were studied included coloured sputtered selective solar absorber coatings, absorber coatings made with sol-gel technology and thickness insensitive spectrally selective paints.

Subtask C: Sustainability

Project C1: Environmental Performance

Four major work items were completed:

- comparison of LCA studies previously performed on a wooden window,
- life cycle assessment of windows (frame + glazings),
- energy balance of windows and glazings (energy content compared to energy saved due to the use of insulating glazings),
- life cycle assessment of solar heating systems (two studies, one from France and one from Italy).

All the studies performed in project C1 of IEA task 27 show interesting results:

- Project C1 enabled to confirm some ideas about solar heating systems eco-conception.
- Project C1 confirm that for energy producing system lifetime and efficiency are more important parameters than the choice of manufacturing materials to reach better environmental performances.

For windows and glazings, an optimum between energy content increase due to new technologies and energy savings has to be determined. More precise data and refined assumptions are required to decide of the environmental relevance of a technological improvement of glazings and windows.

Project C2: Failure Mode Analysis

The main effort during the C2 project has been put on FMEA: presentation and explanation of the methodology, development of case studies on DGU's and solar collector, opportunity of a common work between CSTB and ASPEN. The resulting documents would have benefited from a wider review from all the participants, while only one or two contributors provided inputs and comments.

FMEA is known as the tool for predicting failure modes out of the confrontation of a functional diagram on one hand, and on the other hand the compilation of possible degradations.

It can be seen also as a design tool. "Andersen windows" company in USA use currently FMEA when designing new products, putting around the table the relevant experts. But how a small company, with a limited group of experts, can use FMEA? The solution could be to build up a core FMEA table for generic products, gathering the existing expertise, so that the users may start from a basic knowledge. So FMEA may appear as a knowledge management tool for design assistance. The need for service life assumption appears as an objective for several product oriented projects.

Project C3: Durability of windows

Appropriate methods for assessment of the durability of window systems help to increase confidence in the selection and use of new products.

Achieving an adequate service life is important with respect to receiving a payback in financial and environmental terms. One design attribute of interest for IG durability is the dimension. Windows of greater dimensions would have more severe thermal dilatation between spacer and glass. Since the temperature is different on the outer pane than on the inner pane, the damage experienced by outer and inner seals will be different. The difference in dilatations between the outer glass and spacer and the inner glass and spacer, result in different shear forces in the sealing. The temperature difference can be substantial. In Europe 30°C could be realistic. Deformations of the sealing in IG units as a result of elongation of the materials appear large compared to deformations from deflection of the cover caused by pressure fluctuations in the air gap. This is contrary to general judgment where the common test size is the most critical. In Denmark, development of new test procedures is based on loads approaching realistic loads. Increased number of cycles compared to outdoor exposure, accelerates the degradation. 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 although evaluation of failure in windows installed may show an increase in failure occurrence for larger size of the window especially with the failure mode condensation.

Gas fillings are used in insulating glass units to improve the thermal resistance. The quality of the gas fillings could be distrusted. For that reason existing method have been used in Finland to detect gas filling without breaking the unit and this shows permanent gas filling in normal high quality insulating glass units.

Higher loads on the edge sealant, as a result of integration of solar shading devices between the glass panes of an IG, affect the durability of the IG-units especially the edge sealant. Test results is provided from Germany for different IG units tested according to European Standard DIN EN 1279-3 and DIN EN 1279-2 and a calculation to determine the internal pressure and loads on the edge sealant for two different sizes of specimen.

6 PUBLICATIONS

Subtask A

D. van Dijk (2001)] D. van Dijk, Matrix of products and thermal and solar properties Internal report IEA Task 27 (2001).

H. Simmler, B. Binder, R. Vonbank, Wärmelasten transparenter Bauteile und Sonnenschutzsysteme, Final Report (in German), EMPA/BFE (2000).

B. Binder, EMPA report 860'065, Work Package 3 / Round robin tests as feasibility study for standardisation, EN-Project No NNE5-1999-0511 (2003).

I. Bryn, M. Smidsrød, Thermal comfort; Operative temperature in the sun, Internal report r-a1-eh-performance1 IEA Task 27 (2002).

H. Simmler, Sonnenschutz an Leichtbaufassaden: Messung und Berechnung der Solargewinne durch Glasfassaden mit Sonnenschutz, in German, Workshop „Innovative Fassaden - Planung und Umsetzung, EMPA (2004)

C.U. Brunner et al., Gebäude mit hohem Glasanteil – Behaglichkeit und Energieeffizienz (in German), Documentation SIA D0176, Swiss Society of Engineers and Architects, Zurich (2003).

.R. Wilson, R. Blessing, H. Hagenström, M.G. Hutchins, D. Dvorjetski, W.J. Platzer: The optical properties of gasochromic glazing, Conf. Proc. 4th ICCG, Braunschweig, Germany, 3rd -7th November, 2002, pp. 649-657

W.J. Platzer: Switchable Façade Technology - Energy Efficient Office Buildings with Smart Facades, Proceedings ISES Solar World Congress, Göteborg, Sweden, 2003

D. Covalet and V. Greffier: Modelling a reference office building proposed in T27 of IEA - Application to chromogenics, Task 27 report, EDF HE-14/03/006, 2003

T.R. Nielsen: Simulation results for reference office with electrochromic and gasochromic glazings, IEA Task 27 report, 2002

J. Karlsson: WinSe l- A general window selection and energy rating tool, proceedings World Renewable Energy Congress VI, Brighton, UK, 2000

Ida Bryn, Jappe Hjelseth. Double facades in dwellings – lessons learned in Klosterenga, Oslo. ISES 2003, Gothenburg.

H. Manz, Numerical Simulation of Heat Transfer by Natural Convection in Cavities of Façade Elements, Energy and Buildings, Vol. 33, 2003, 305-311

H. Manz & H. Simmler. Experimental and numerical study of a mechanically ventilated glass double envelope facade with integrated shading device. 2nd Int. Building Physics Conf., Leuven, Belgium, Sept. 2003. 8 pages.

H. Manz, A. Schaelin, H. Simmler, Airflow patterns and thermal behaviour of mechanically ventilated glass double façades, Building and Environment

Heimonen,I., Hemmilä K. Integration of windows and ventilation by smart supply air windows, Glass Processing Days Conference, June 2003, Tampere. 4 pages.

Ojanen, T.& Heimonen, I. Building integration of multi-functional glazed facades - Potential and risk assessment. Glass Processing Days Conference, June 2003, Tampere. p. 256 - 258.

Subtask B

Brunold S., Jorgensen G., and Möller K., Outdoor Exposure and Indoor Testing of PVC and PC – Summary of Results and Validation Study on Polymeric Glazing Materials; Interim report of IEA SHCP Task 27 Subtask B project B1

Marechal J. -C., Some considerations on the durability assessment methodology applied on polymeric glazing materials, Interim report of IEA SHCP Task 27, Subtask B project B1, March 2002

Palm M and Carlsson B., New Accelerated Weathering Test Including Acid Rain, , Journal of Coatings Technology, 74 (2002) 69-74

M. Köhl, M. Heck, S. Brunold, U. Frei, B. Carlsson and K. Möller, ADVANCED PROCEDURE FOR THE ASSESSMENT OF THE LIFETIME OF SOLAR ABSORBER COATINGS, Solar Energy Materials and Solar Cells, Volume 84, Issues 1-4 , October 2004, Pages 275-289

B. Carlsson, K. Möller, M. Köhl, M. Heck, S. Brunold, U. Frei, J. -C. Marechal and G. Jorgensen, The applicability of accelerated life testing for assessment of service life of solar thermal components, Solar Energy Materials and Solar Cells Volume 84/1-4, pp 255-274

Michael Köhl, Volker Kübler, Markus Heck, Optimisation of the micro-climate in solar collectors, Proceedings EuroSun 2004, Freiburg, Germany, 21.-23.6.2004, CD-ROM

Bo Carlsson, Stefan Brunold, Andreas Gombert and Markus Heck, Assessment of durability and service lifetime of some static solar energy materials , Proceedings EuroSun 2004, Freiburg, Germany, 21.-23.6.2004, CD-ROM

Gary Jorgensen, Stefan Brunold, Bo Carlsson, Markus Heck, Michael Köhl, and Kenneth Möller, DURABILITY OF POLYMERIC GLAZING MATERIALS FOR SOLAR APPLICATION, Natural and Artificial Ageing of Polymers, ISBN No. 3-9808382-5-0

Bo Carlsson, Kenneth Möller, Michael Köhl, Markus Heck, Stefan Brunold, Jean-Charles Marechal and Gary Jorgensen, Assessment of service life of solar thermal components by accelerated life testing, Natural and Artificial Ageing of Polymers, ISBN No. 3-9808382-5-0

Köhl, M.; Carlsson, B.; Jorgensen, G.; Czanderna A.W., Performance and Durability Assessment of Optical Materials for Solar Thermal Systems, ELSEVIER 2004, ISBN 0-08-044401-6

Köhl, M.; Heck, M.; Brunold, S.; Frei, U.; Carlsson, B.; Möller, K., Gebrauchsdauerabschätzung von Solarabsorbern, Tagungsband 14. Symposium Thermische Solarenergie, Bad Staffelstein

Köhl, M.; Heck, M.; Kübler, V., Prüfung und Optimierung des Mikroklimas in Solarkollektoren, Tagungsband 14. Symposium Thermische Solarenergie, Bad Staffelstein

Ole Holck; Svendsen, Svend; Brunold, Stefan; Frei, Ueli; Köhl, Michael; Heck, Markus; Oversloot, Henk, Solar collector design with respect to moisture problems, Solar Energy, 2003

Köhl, M.;Carlsson, B.; Möller,K.; Frei, U.; Brunold,S.; Advanced procedure for the assessment of the lifetime of solar absorber coatings, ISES Solar World Congress, Göteborg, 14.-19.06.03

Köhl, M.; Heck, M., Lebensdauerabschätzung bei Belastungen, die von Eigenschaften des Prüflings abhängen, Tagungsband der 32. Jahrestagung der GUS (26.-28.3.03): Umwelteinflüsse erfassen, simulieren, bewerten

B. Carlsson, K. Möller, U. Frei, S. Brunold, M. Köhl.; Comparison between predicted and actually observed in-service degradation of a nickel pigmented anodized aluminium absorber coating for solar DHW systems, Solar Energy Materials & Solar Cells 61 (2000) 223-238

Köhl, M.; IEA-SHC Task 27: Performance, Durability and Sustainability of Advanced Windows and Solar Components for Building Envelopes, North Sun, Leiden, the Netherlands, 7.-8.5.

Köhl, M.; Pre-Normative Research within IEA-SHC Task 27, Seminar Innovation and Quality in Solar- Thermal Application, INETI, Lissabon, Portugal, 19.11.2000

Michael Köhl and Markus Heck, Ulrich Frei and Stefan Brunold, Bo Carlsson and Kenneth Möller, Svend Svendssen and Ole Holck, Henk Oversloot, Gay Jorgensen, Materials in Solar Thermal Collectors;, Proceedings of EUROSUN conference 2000, 19-23 June 2000, Copenhagen

B.T. Carlsson and K. Möller, J.-Ch. Marechal, M. Köhl and M. Heck, S. Brunold, G. Jorgensen; General Methodology of Test Procedures for Assessment of Durability and Service Life, 9th DBMC Brisbane Australia, March 2002

Bo Carlsson, Durability assessment of solar energy materials based on general methodology of accelerated life testing: Introduction, Paper presented at NRC and IEA SHC Task 27 Workshop on "Recent research activities in IEA Task 27", Ottawa, 1st October 2002

B. Carlsson, K. Möller, M. Köhl, M. Heck, S. Brunold, J-C. Marechal, G. Jorgensen; The applicability of accelerated life testing for assessment of service life of solar thermal components, Proceedings ISES 2003, Gothenburg, 14-19 June, 2003 (Published also in Solar Energy Materials and Solar Cells, Vol 84/1-4 pp 255-274, 2004)

G. Jorgensen, S. Brunold, B. Carlsson, M. Heck, M. Köhl and K. Möller; Durability of polymeric glazing materials for solar applications, , Proceedings 1st European Weathering Symposium, 25-26 September 2003, Prague, Czech Republic (Published also in Natural and Artificial Ageing of Polymers, ISBN No. 3-9808382-5-0)

B. Carlsson; General methodology for service life prediction based on accelerated testing and its applicability to selective solar absorber coatings and polymeric solar collector cover materials, Proceedings IEA Task 27 Dissemination Workshop, 6 October 2003, Freiburg, Germany

K. Möller, B. Carlsson, and B-L Andersson; Determination of Corrosivity Inside and Outside Solar Thermal Collectors Using Standard Metal Coupons: A comparison between test sites in five European countries, , Paper presented at Scandinavian Corrosion Congress13 NMK, Reykavik , Iceland, 18- 20 April 2004

B.Carlsson, S. Brunold, A. Gombert, M. Heck, M. Köhl, V. Kübler, O. Holk, G. Jorgensen, B. Karlsson, M.L. Prates, K.Möller, M. Brogren, A. Roos, A. Werner, M. Zinzi, and M. Ghaleb; Study on Durability and Service Lifetime Prediction of some Static Solar Energy Materials, 10th Conference on Durability of Materials and Constructions, Lyon, April 2005

Michael Köhl, Gary Jorgensen, Stefan Brunold, Bo Carlsson, Markus Heck, Kenneth Möller; Life-time estimation of polymeric glazing materials for solar applications, 10th Conference on Durability of Materials and Constructions, Lyon, April 2005)

Bo Carlsson; A total cost accounting approach in design and evaluation of products, 10th Conference on Durability of Materials and Constructions, Lyon, April 2005)

Bo Carlsson, Stefan Brunold, Andreas Gombert, Markus Heck, Maria Hall, Michèle Ghaleb, Gary Jorgensen , Björn Karlsson, Michael Köhl, Manuel Lopes Prates, Kenneth Möller, Arne Roos, and Michele Zinzi; Assessment of service life of some passive solar thermal materials, 2nd European Weathering Symposium, Gothenburg, 13-15 June 2005)

M. Köhl, G. jorgensen, B. Carlsson, M. Heck, and K.Möller; Durability of Polymeric Glazing Materials for Solar Applications, Journal of Solar Energy, Volume 79, Issue 6, Pages 618-623, 2006

Andreas Gombert, Markus Heck, Volker Kübler, Michael Köhl, Bo Carlsson, Kenneth Möller, Stefan Brunold, Bruno Chevalier, Michele Zinci, Gary Jorgensen; Results of durability testing of antireflective glazing; (Paper presented at the Glas Processing Days, June 2005, Finland

Subtask C

F. Ardente, G. Beccali, M. Cellura, V. Lo Brano "Life Cycle Analysis of solar thermal collector (First part: Life cycle inventory), First Report of the International Energy Agency (IEA) - Task 27- Performance of Solar Facade, Subtask C- Project C1 Environmental Performance, March 2003

F. Ardente, G. Beccali, M. Cellura, V. Lo Brano: "The Environmental Product Declaration EPD with a particular application to a solar thermal collector", Ecosystems and Sustainable Development, Advanced in Ecological Sciences n°18, White-press publisher, pp.325-335.

F. Ardente, G. Beccali, M. Cellura, V. Lo Brano: "The emission saving related to the use of renewable energy sources: the case study of solar thermal collectors", Conference AIR-POLLUTION 2003, Catania 17-19 Sept. 2003.

7 TASK 27 PARTICIPANTS

Country	Institute	Name	Contact
Belgium	Université Catholique de Louvain (UCL)- Architecture et Climat Place du Levant 1 BE-1348 Louvain-la-Neuve	Magali Bodart	e-mail: bodart@arch.ucl.ac.be
Canada	National Research Council of Canad Institute Research in Construction Montreal Road M-24, CA-Ottawa, Ontario K1A OR6	Hakim Elmahdy	e-mail: hakim.elmahdy@nrc.ca
Denmark	SBI Danish Building Research Institute Dr. Neergaards Vej 15 DK-2970 Hørsholm	Hanne Krogh	
	Solar Energy Center Denmark Technical University of Denmark Department of Buildings and Energy Build. 118 DK-2800 Lyngby	Ole Holck Sven Svendson Toke-Rammer Nielson Jean I. Rosenfeld	e-mail: oh@byg.dtu.dk e-mail:ss@byg.dtu.dk e-mail: trn@byg.dtu.dk e-mail: jr@byg.dtu.dk
	VELUX A/S Maskinvej 4 DK-2860 Søborg	Jan Franson Karsten Duer Lone Moller S.	Tel: +45-39-570694 Fax: +45-39-562993 e-mail: jfr.ptt@velux.com e-mail: karsten.duer@velux.com
Finland	VTT Building Technology Building Physics and Indoor Climate Lämpömiehenkuja 3, FI-Espoo	Ismo Heimonen Tarja Häkkinnen Kari Hemmila	e-mail: ismo.heimonen@vtt.fi e-mail: trja.haekkinnen@vtt.fi e-mail: kari.hemmila@vtt.fi
France	CSTB Centre Scientifique et Technique du Batiment 24, Rue Joseph-Fourier, FR-38400 Saint-Martin d'Heres	Jean-Luc Chevalier Francois Olive Jermone Lair Jean-Charles Marechal Bruno Chavalier	e-mail: jl.chevalier@cstb.fr e-mail: jerome.lair@cstb.fr e-mail: br.chevalier@cstb.fr
	EDF - Electricité de France Division Recherche et Dévelopment Site des Renardieres FR-77818 Moret-sur-Loing	Denis Covalet Géraldine Corredera Remi Le Berre	e-mail: denis.covalet@edf.fr
	ENTPE Le Laboratoire des Sciences de l´Habitat de l´Ecole des Travaux Publics de l´Etat FR-Vaulx-en-Velin	Marc Fontoyont Richard Mitanchy	e-mail: marc.fontoynont@entpe.fr e-mail: mitanchey@entpe.fr
	Saint-Gobain Recherche B.P. 135 FR-93303 Aubervilliers	Xavier Fanton Renaud Fix Xue-Yun Lin	e-mail: marc.fontoynont@entpe.fr
Germany	FH Aachen Solar Institut Jülich Heinrich.Mussmann-Str. 5 DE-52428 Jülich	Joachim Götsche	e-mail: goettsche@fh-aachen.de

	FLABEG GmbH Entwicklung/Neue Technologien Glaserstr. 1 DE-93437 Furth i. Wald	Jens Cardinal Hartmut Wittkopf	 e-mail: hartmut.wittkopf@flabeg.com
	ift. Rosenheim Theodor-Gietl -Straße 7-9 DE-83026 Rosenheim	Norbert Sack Michael Feinberger Philip Plathner	 e-mail: feinberger@ift-rosenheim.de e-mail: plathner@ift-rosenheim.de
	Interpane E & BmbH c/o Fraunhofer ISE Heidenhofstr. 2 DE-79110 Freiburg	Helen Rose Wilson	e-mail: wilson@ise.fhg.de
	Fraunhofer ISE Heidenhofstr. 2 DE-79110 Freiburg	Andreas Gombert Michael Köhl Markus Heck Volker Kübler	Tel.: +49 761 4588 5983 Fax: +49 761 4588 9983 e-mail: agom@ise.fhg.de Tel.: +49 7961 4588 5124 Fax: +49 761 4588 9124 e-mail: mike@ise.fhg.de Tel.: +49 761 4588 5415 Fax: +49 761 4588 9415 e-mail: markus.heck@ise.fhg.de e-mail: volker.kuebler@ise.fhg.de
Italy	DEAF - Università di Palermo Viale delle Scienze IT-90128 Palermo	Giorgio Beccali Maurizio Cellura Valerio Lo Brano	 e-mail: mcellura@dream.unipa.it e-mail: lo_brano@deaf.unipa.it
	ENEA Via Martiri di Montesole 4 IT-40129 Bologna	Augusto Maccari Mario Tarantini	 e-mail: tarantin@bologna.enea.it
	ENEA Via Anguillarese 301 IT-00060 S.Maria Di Galeria, Roma	Michele Zinzi	e-mail: michele.zinzi@casaccia.enea.it
	Università degli Studi Roma Tre Via della Vasca Navale 79 IT-00146 Roma	Aldo Fanchiotti	
Japan	Asahi Glass Co. Ltd. 1150 Hazawa-cho, Kanagawa-ku JP-Yokohama 221-8755	Junichi Nagai	 :
	Nippon Sheet Glass NSG Tokyo Bldg. 2-1-7, Kaigan, Minato-ku JP-Tokyo 105-8552	Hidemi Nakai	
	Multifunctional Thin Film Group Institute for Structural and Engineering Materials National Institute of Advanced Industrial Science and Technology (AIST) 2266-98 Anagahora Shimoshidami Moriyama-ku JP-Nagoya 463-8560	Kazuki Yoshimura	
Netherlands	TNO Building and Construction Research Division Building & Systems P.O. Box 49	Henk Oversloot Dick van Dijk	

	NL-2600 AA Delft		
Norway	Erichsen & Horgen A/S P.O. Box 4464 Torshov NO-0403 Oslo	Ida Bryn Catherine Peyrouty	e-mail: ihb@erichsen-horgen.no
Portugal	Instituto de Technologias Energeticas (INETI) Department de Energias Renovavaeis Estrada do Paço do Lumiar 22 PT-1649-038 Lisboa	Manuel Lopes Prates	
Sweden	SP – Swedish National Testing and Research Institute P.O. Box 857 SE-501 15 Boras	PBo Carlson Kenneth Möller	e-mail: bo.carlsson@sp.se e-mail: kennethm@sp.se
	Vattenfall Utveckling AB SE-814 27 Älvkarleby	Björn Karlsson	e-mail: bjorn.karlsson @utveckling.vattenfall.se
	University Uppsala Department of Technology Box 534 SE-75121 Uppsala	Arne Roos Marie-Luise Persson Anna Werner	e-mail: arne.roos@angstrom.uu.se e-mail: anwe@material.uu.se
	Lund University Department of Building Science P.O. Box 118 SE-22100 Lund	Hakan Hakansson Bengt Hellström	
Switzerland	EMPA Eidgenössische Materialprüfungs- und Forschungsanstalt Überlandstr. 129 CH-8600 Dübendorf	Hans Simmler Heinrich Manz	e-mail: hans.simmler@empa.ch e-mail: heinrich.manz@empa.ch
	Institut für Solartechnik SPF Hochschule Rapperswil HSR Oberseestrasse 10 CH-8640 Rapperswil	Ueli Frei Stefan Brunold	e-mail stefan.brunold@solarenergy.ch
USA	Aspen Research Corporation	James Fairman	e-mail: JFairman@mn.rr.com
	Lawrence Berkeley National Laboratory University of California MS 2 - 300 1 Cyclotron Road US-Berkeley, CA 94720	Mike Rubin	e-mail: mdrubin@lbl.gov
	NREL - National Renewable Energy Laboratory 1617 Cole Boulevard US-Golden, CO 80401	Gary Jorgensen Roland Pitts	e-mail: gary.jorgensen@nrel.gov e-mail: roland_pitts@nrel.gov
	University of Massachusetts Centre for Energy Efficiency and Renewable Energy Engineering Lab Building 160 Governors Dr. US-Amherst, MA 01003-9265	Dragan Curcija	e-mail: curcija@ceere.org