SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 56 - Building Integrated Solar Envelope Systems for HVAC and Lighting

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Task 56 – Scope

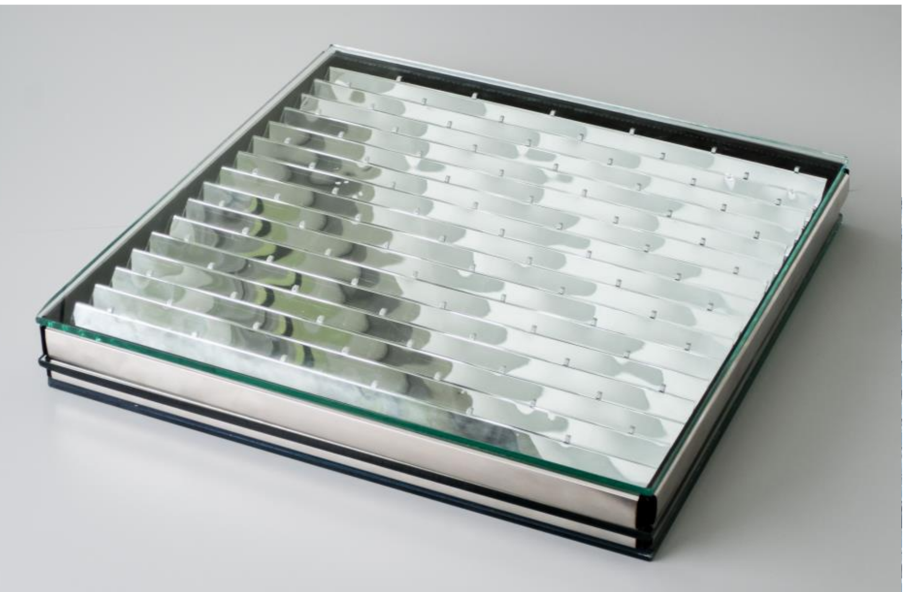
Definition and focus

- A solar integrated envelope system is a multifunctional envelope
- that uses and/or controls solar energy
- influencing thermal energy demand, thermal energy consumption and comfort of the building

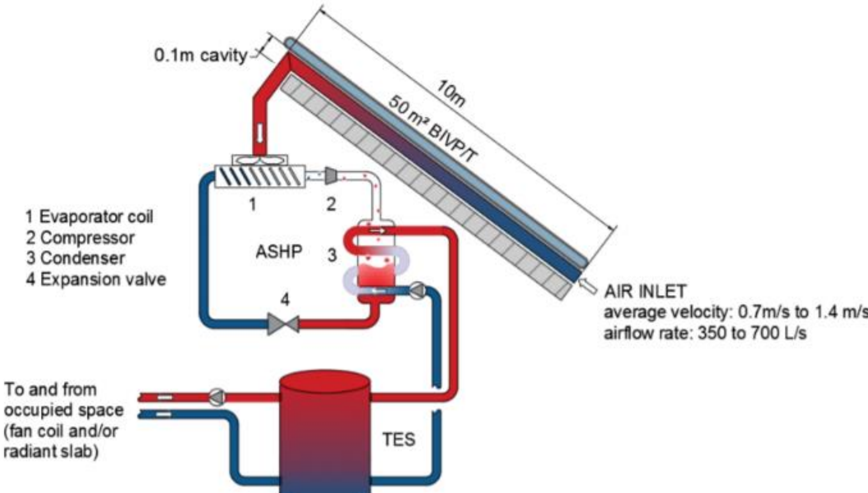
As such the Task focuses on both solar thermal and photovoltaic integrated solutions and on daylight control

Task 56 – Scope

A diversified market



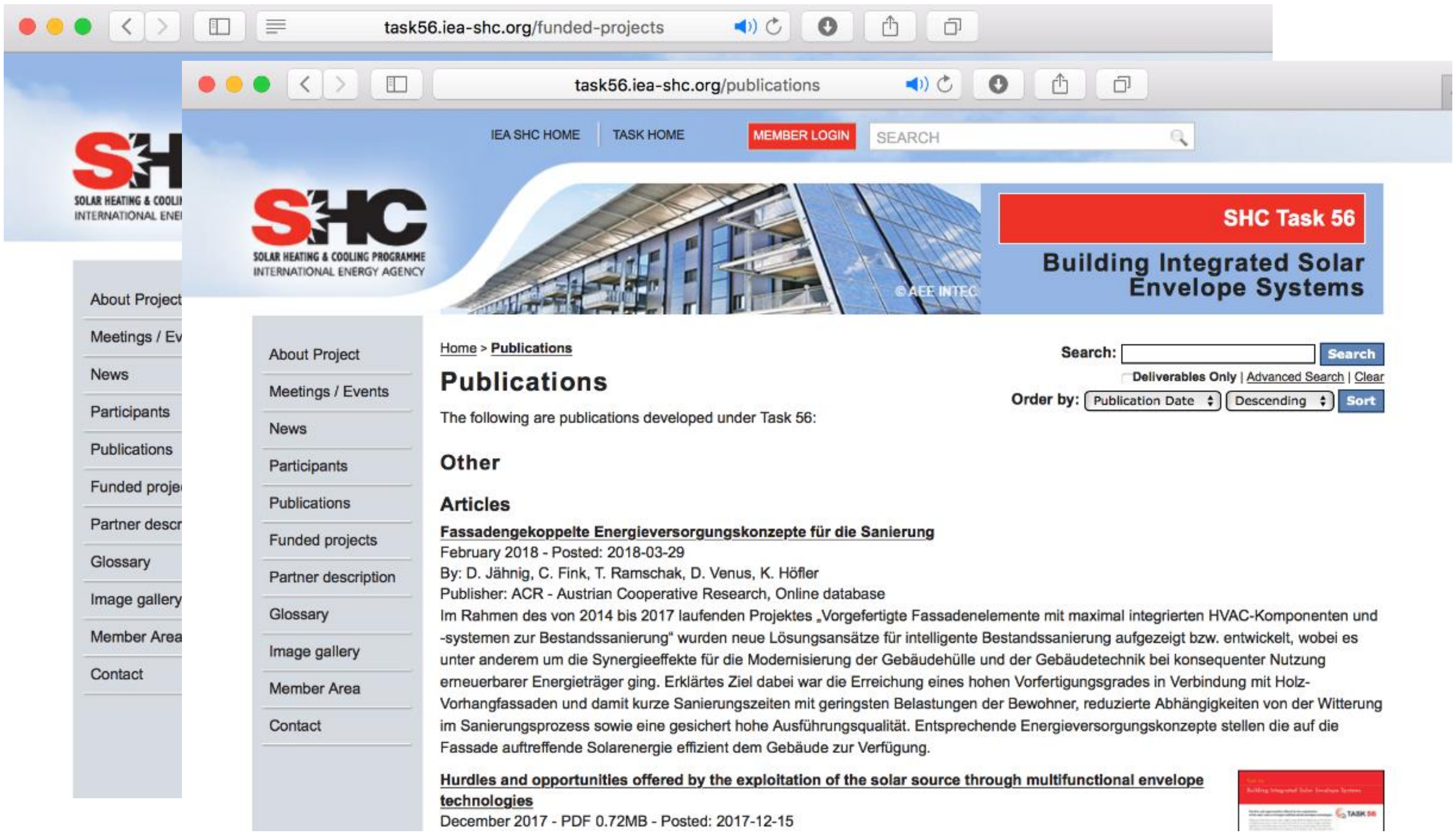
OKALUX - Source: Bartenbach



PV-T system - Source: Concordia University

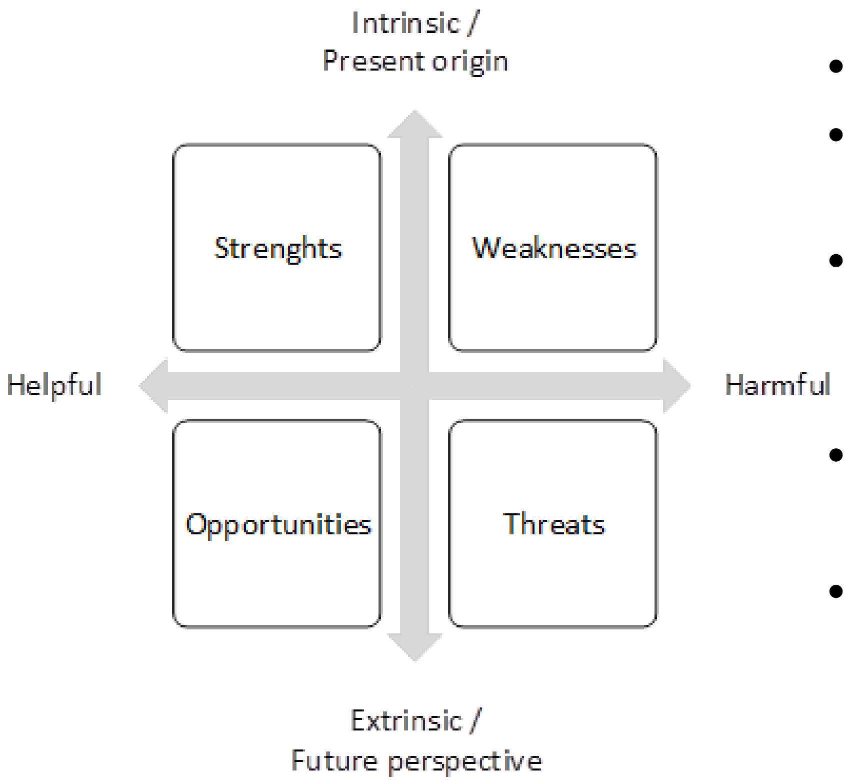
Task 56 – Activities

Website: http://task56.iea-shc.org



Task 56 – Activities

Solar envelope solutions information and SWOT analysis



- Brief concept description
- Architectural and technological integration into the façade
- Integration into the building: system and comfort
- SWOT analysis
- Lessons learned

Task 56 – Activities

Solar envelope solutions information and SWOT analysis – specific products

Source: Solarwall

Source: Aventa Solar

Task 56 – Activities

Solar envelope solutions information and SWOT analysis – specific products

Source: Cenergia a part of Kuben Management

Source: Merck

Task 56 – Activities

Building Integrated Solar Envelope Systems forms

2 SolarWall® Heating Systems

by John Hollick, SolarWall, Canada

2.1 Product description

2.1.1 Brief concept description

SolarWall Heating Systems heat air for ventilation and heating of buildings in colder climates. SolarWall consists of a perforated metal panel absorber that integrates into sun facing walls of larger buildings and connects to the heating ventilation fans. The system has been available since the 1990's and is currently the most popular technology for solar heating larger buildings using air collectors. Space heating typically represents over 50% of a building's total energy demand in cities with a heating climate such as Paris.

2.1.2 Architectural and technological integration into the façade

SolarWall is building integrated and once installed, will resemble other typical metal wall facades. The metal panels are spaced out several centimetres to create an air cavity behind it and the main wall. This air cavity is then connected to the building's ventilation fans or HVAC units. The solar panel components are assembled on site to suit the existing wall dimensions and openings such as windows and doors.

The SolarWall system is unglazed or partially glazed depending on the desired temperature rise. The unglazed wall sections offer architects the ability to select from a range of dark colours with black and dark brown being the most popular. Experience gained from thousands of installations over two decades show that the durability and aesthetics of the wall are important factors in deciding whether to proceed with a solar heating technology. The ability to work with colours and shapes appeals to the design community for many higher profile buildings. Air collectors have virtually no maintenance which is important for long term operation that typically spans several decades.

Building integration allows the solar heating system to blend in and not become an eye sore. Some clients have resorted to including logos or sun images on their walls to identify it as being a solar heating wall rather than just another wall.

2.1.3 Integration into the building: system and comfort

All projects require coordination with the designers and installers for the panels, mechanical equipment and controls to achieve complete integration into the building and its heating and ventilation and controls systems. The SolarWall systems are daytime heaters using the solar energy when available. Heat storage is not generally an option due to higher costs and the fact that most commercial, industrial, school and government buildings have minimal occupancy at night. It is necessary to have auxiliary heat in buildings. The solar heat is programmed to be the first choice followed by the auxiliary heat when solar is insufficient to meet demand. Typical overall energy savings with SolarWall are designed to be in excess of 20% to meet the EU 20% renewable energy requirement. Some buildings have reported savings over 50% and without heat storage.

Figure 2 Warehouse in Latvia

3 OKALUX OKA*SOLAR* 3D

by David Geisler-Moroder, Bartenbach GmbH, Austria, and Johannes Franz, OKALUX GmbH, Germany

3.1 Product description

3.1.1 Brief concept description

OKA*SOLAR* 3D is a sun protection and daylight management system with a three-dimensional, highly reflective sun protection grid in the cavity between the glass panes. The geometry of the sun protection grid has been optimised for roof applications. The direct solar transmission is blocked at all times, irrespective of the height of the sun. Thus, the heat gain into the interior of the building is reduced considerably. However, a large part of diffuse daylight from the northern hemisphere gets into the interior. This results in even light distribution in the interior and significantly less fluctuation in brightness than with direct sunlight.

The main louvre of the system is made of aluminium with a reflection (solar and visual) of about 95 %. The cross bars are concave in shape, so also at low solar altitude, the sunlight is always reflected to the outside. They are made of plastic with a highly reflective surface with a reflection (solar and visual) of over 80 %. The sun protection grid, which is open to the north, enables partial transparency and allows diffuse irradiation. The thin cross section of the louvres enables a transparency of the grid itself of up to 85 %, depending on the direction of sight, and a diffuse light transmission of 60-70 % in the area of transmission.

In roof applications, OKASOLAR 3D has two different functional areas:

1. Lock-out area (general direction on northern hemisphere: south):
   - thermal sun protection with g-values ≥ 7 %
   - reduced glare
2. Area of transmission (general direction on northern hemisphere: north):
   - diffused irradiation of daylight
   - partial view through

3.1.2 Architectural and technological integration into the façade

The special feature of OKA*SOLAR* 3D is that the sun protection grid is integrated into the cavity of the insulated glazing system, so there are no special requirements with regards to installation, maintenance or repair, and the entire system can be treated just like standard insulated glazing. The thickness and type of glass depend on structural and building requirements. However, for structural reasons the bending radius is to be limited to 12 m under deformation. The system can be used in a 2-pane make-up with a space between the panes of 24 mm as well as in a 3-pane make-up where the system is mounted in the outer cavity.

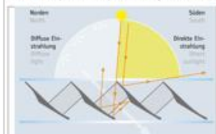


Figure 6: Functional principle of OKASOLAR 3D for installation at northern hemisphere

Figure 7: Sample of OKASOLAR 3D in a 3-pane insulating glazing unit, appearance as seen from outside

4 Summer garden

by Vickie Aagesen, Cenergia a part of Kuben Management, Denmark

4.1 Product description

4.1.1 Brief concept description

The "Summer garden" concept is a new development of the traditional winter garden. The concept will be tested and implemented in a new urban renewal housing renovation project at Gl. Jernbanevej in Valby, Copenhagen in the beginning of 2018.

The idea/concept with the "Summer garden" is that in the summertime, part of the living room along the facade will be utilised as an exterior area. This is secured by help of two different window façades, which is used in summer periods and in winter periods. The winter façade is the glass façade which is the exterior. This has a u-value of 0.9 W/(m²K). The summer façade is the inner glass façade and has a u-value of 1.3 W/(m²K). In the summer, the exterior glass façade will be opened and the inner glass façade will function as an active facade. By help of this, the "Summer garden" is introduced as a covered exterior outdoor space, where the cover also function as a horizontal solar shading system and helps the building with preventing to high indoor temperatures.

During winter, the outer façade is closed and the inner glass facade is opened. In this way, the whole space is useful as heated space area.

Figure 10 Illustration of "Summergarden" at Gl.Jernbanevej (Domus arkitekter)

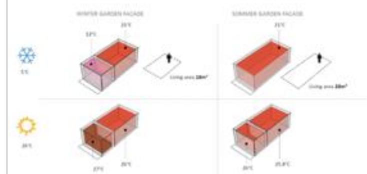


Figure 10 The winter garden vs. the summer garden concept (Illustration Cenergia)

5 Shutters

by Carolin Hubschneider, Fraunhofer IBP, Stuttgart, Germany

5.1 Product description

5.1.1 Brief concept description

Shutters are elements which dynamically solve fundamental functions of the façade: solar shading, daylight control, dynamic façade U-value, natural ventilation, and noise reduction. The shutters can be moved horizontally or vertically in front of the window. Shutters cannot be used on fully glazed façades. In their most sophisticated versions shutters can increase the façade insulation and control utilization of solar heat gain and daylight, thus reducing the energy needs for heating, electric lighting, cooling and ventilation.

5.1.2 Architectural and technological integration into the façade

An aluminium framework-based façade system is mounted directly on the outside of the window frames using an integrated, exterior placed drive system. Shutters are suitable for plane façades and can be used for both new and existing buildings and for all façade orientations. However, since the shutters need 'parking spaces' when they are open, the energy saving potentials can normally only by realized on façades with maximum 50% glazing.

5.1.3 Integration into the building: system and comfort

Shutters should be operated automatically (with manual override) to realize the potential energy savings and improvement of thermal and visual indoor climate. For this reason they have to be connected to the power supply of the building. For the control algorithm input data from several sensors of the building automatization (photo sensor, temperature sensor and presence sensor) have to be used.

Figure 13 Examples for shutters (Reference: "T50 B.6 Daylighting and electric lighting retrofit solutions - A source book of IEA SHC Task 50 (Task 50 Subtask B Report B6)", © Martine Knoop).

5.1.4 Further reading

The description of shutters is mainly adopted from "T50 B.6 Daylighting and electric lighting retrofit solutions - A source book of IEA SHC Task 50 (Task 50 Subtask B Report B6)"; Websites: http://task50.iea-shc.org/publications, https://depositonce.tu-berlin.de/handle/11303/5494

6 Blinds

by Carolin Hubschneider, Fraunhofer IBP, Stuttgart, Germany

6.1 Product description

6.1.1 Brief concept description

Blinds are solar shadings consisting of multiple horizontal or vertical slats that can be fixed or movable. They are used to control the solar incident radiation and protect against glare. Blinds are build-up of lamellas blocking and/or redirecting the direct sunshine, in function of their slope. The dimensions, colour and gloss of the lamellas determine the properties of blinds.

6.1.2 Architectural and technological integration into the façade

Blinds perform best when they are placed on the exterior of the façade. Due to their limited resistance to wind, blinds are best applied on low height buildings. Exterior blinds placed in front of windows can reduce the solar gains significantly (direct and secondary heat transfer) providing a limitation to the risk of overheating of the building (lower g value of the complex fenestration system: window + blinds). Placed at the interior of the building, they can achieve good daylight control but they do not contribute significantly to the reduction of the heat gains. The majority of redirecting blinds are designed to be installed between two panes of glass or in double skin façades to reduce exposure to dust (interior) or dirt and snow (exterior).

6.1.3 Integration into the building: system and comfort

To enable the functionality of the system, the blinds have to be connected to the power supply of the building. In modern buildings automatic control of blinds is recommended. The automatic control works with sensors (photo sensor, temperature sensor and presence sensor), that are also necessary for other components of the technical building equipment like the electric lighting. Blinds are used in a dynamic way to control daylight, provide a protection against glare and increase visual comfort.

Figure 14 Example of blinds

6.1.4 Further reading

The description of blinds is mainly adopted from "T50 B.6 Daylighting and electric lighting retrofit solutions - A source book of IEA SHC Task 50 (Task 50 Subtask B Report B6)". Websites: http://task50.iea-shc.org/publications, https://depositonce.tu-berlin.de/handle/11303/5494

13 Semi-Transparent Luminescent BIPV Windows

by James Walshe and Philippe Lemarchand, Dublin Institute of Technology, Ireland

13.1 Product description

13.1.1 Brief concept description

The integration of photovoltaics (PV's) into building facades offers the increasing possibility of making the structures in our society play a more active role in our transition towards a sustainable economy. Luminescent building integrated photovoltaic (L-BIPV) windows are solid-state and semi-transparent systems based on luminescent down-shifting (LDS) species that are combined with photovoltaic (PV) solar cells. A system combining a semi-transparent PV cell directly underneath the LDS layer forms a LDS-PV system. In the case of a luminescent solar concentrator (LSC) system, light is captured and re-emitted by the LDS species and concentrated by total internal reflection to small and highly efficient PV cells located within a window edge cell. The use of thin strip silicon within the window edge provides the advantage to lower cost of large semi-transparent photovoltaic cells that would cover the glazing surface and increase the glazing transmission as well as the overall light to power conversion efficiency of the system.

LDS materials absorb diffused and direct light within the ultraviolet region (200 nm – 400 nm) and re-radiate it to a tuned wavelength band within the 500nm-700nm light range where the PV cell can more effectively convert the energy. The capability to tune the optical characteristics of the luminescent species considered to a region of the spectrum (650 nm -700 nm) where the underlying cells responsivity is higher in conjunction with the human eyes responsivity being low would allow the semi-transparent hybrid device to provide some of the indoor lighting requirements and enhance the energy conversion from the photoluminescence. L-BIPV systems potentially can replace or be added to conventional window to produce electricity, therefore reducing the building energy consumption and carbon emission, improve indoor light and thermal comfort and provide colourful architectural designs.

The current PV market consists primarily (~80%) of first generation technology (silicon based) with a small percentage (~10%) occupied by second generation alternatives such as CdTe, CIGS or dye synthesized cells (A. A. Hossam-Eldin 2015; International-Renewable-Energy-Agency 2012). As more design-flexible and building integrating technologies (perovskite and organic based cells) become commercially viable with recent developments, the energy loss mechanisms inherent in each technology become more controllable. This aspect is represented in the differences reported in the enhancement in the power conversion efficiency of LDS devices when fitted to different generations of technology. LDS devices based on first generation, second generation (thin film) and organic PV technologies have resulted in efficiency enhancements of 0.5% - 1%, 1% -3% and 0.5% - 2% respectively (Klampaftis et al. 2009; McKenna and Evans 2017).

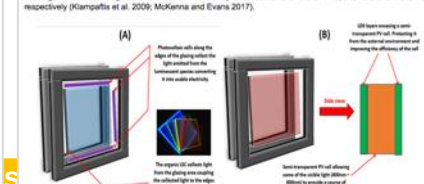


Figure 28 Two different L-BIPV design options (A) building integrated LSC window and (B) building integrated LDS-PV window

Task 56 – Activities

TASK 56

Lessons learned - Barriers

Technical barriers

- Envelopes are designed as tailor-made systems. This can make the mounting process a cumbersome and time-consuming task, with a risk for errors
- The market looks for flexible, interoperable solutions adaptable to buildings
- Air-, vapour-diffusion and fire risk are concerns

Task 56 – Activities

TASK 56

Lessons learned - Barriers

Regulatory barriers – the construction market is local

- Norms and test methods are not adequate
- Construction laws are too variegate

Planning barriers – performance unclear

- Due to the novelty, few reliable design guides or rules-of-thumb available
- Easy-to-use planning tools providing reliable information needed to planners

Task 56 – Activities

Lessons learned - Barriers

Architectural barriers – difficult to handle for architects

- Versatility in shapes, colours, textures and sizes
- Complex tendering and procurement procedures due to complex systems

Economic and social barriers – high investment, low knowledge

- High initial costs due to innovation
- Lack of knowhow by professionals
- The construction market changes slowly

Task 56 – Activities

Lessons learned - Opportunities

A market is there for technologies

Easy to manufacture, integrate and dismantle

Easy to communicate

Targeted to architects' and energy planners' needs

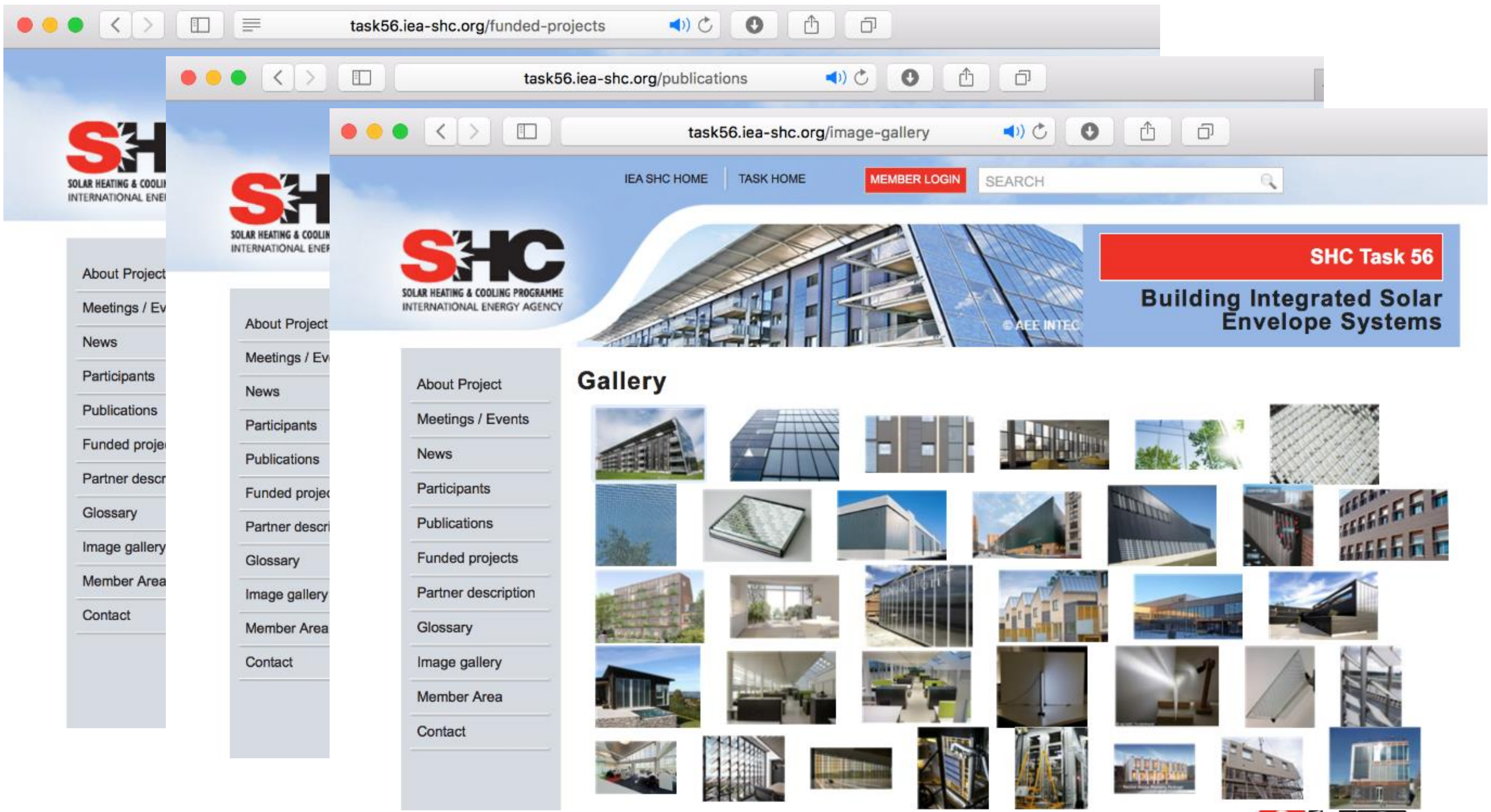
Aesthetically appealing to be accepted by the architectural community and folding around the architect needs and not vice-versa

Robust and reliable in time

Task 56 – Activities

TASK 56

Website: http://task56.iea-shc.org



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