TRANSPARENT AMORPHOUS SILICON PV-FAÇADE AS PART OF AN INTEGRATED CONCEPT FOR THE ENERGETIC REHABILITATION OF AN OFFICE BUILDING IN BARCELONA

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ABSTRACT: The present poster shows the case study of an energetic rehabilitation of a five-story staircase and the adjacent zones of an office building in the Barcelona area through an innovative transparent and colored amorphous silicon PV facade. Problems of overheating and cold due to an insufficient ventilation strategy, the lack of sun shading, and an overall deficient thermal behavior were solved as well as an innovative building design was created. An integrated design approach has been realized to explore the possibilities of BIPV within a complex building concept.
Keywords: Building Integration, Façade, PV Module.

1 INTRODUCTION

A multifunctional double-glazed facade consistent of innovative combinations of transparent PV panels and colored and printed glass elements substitutes industrial fix glazing elements. An intelligent natural ventilation strategy has been developed to cope with the special condition of the staircase as intermediate space between the air-conditioned office space and the exterior.

Thermal dynamic simulation tools were used to define the right combination of materials and ventilation concept in terms of sun shading, day lighting, electricity production, natural ventilation and architectonical quality.

2 SITUATION

SCHOTT Ibèrica SA is a glass manufacturing company situated in Sant Adria del Besos, a small community beside Barcelona, within a mixed-use residential and industrial area, approximately 500m from the seaside.

The office building, constructed in 2001 is located within the fabric site, touching one of the manufacturing halls.

It is northeast / southwest orientated with a totally glazed staircase on its southwest façade.

This staircase suffered a severe overheating problem in summer, due to the fixed, industrial glazing elements without openings and without any shading device. Poor thermal behaviour due to thermal bridges and high U-values of the glazing created discomfort also in winter with very low temperatures inside.

3 DESIGN PROCESS

In a first stage, a preliminary study was made, defining the above mentioned problems of overheating, missing sun protection, deficient natural ventilation possibilities, glare problems, thermal bridges and deficient overall thermal behaviour. (Figure 1)

Monitoring was done by use of TESTO data loggers in 6 different points of the building, recording values of air temperature and relative humidity every 30 minutes for about 40 days in July and August and 40 days in December and January.

Figure 1: Building analysis

Results showed that in some parts of the staircase temperatures of almost 50 º Celsius were reached in August, and normal air temperature of the staircase in summer could easily be 10 to 15 degrees above ambient temperature.

In winter interior temperatures in the staircase in the morning were only slightly above outside temperatures.

A second step was the study of the insulation situation of the façade, defining the amount of incident solar radiation throughout the year and the shading situation due to the adjacent building.

According to radiation data for Barcelona, there is a maximum amount of 1600 kWh/m2a inciting on a south orientated and 40º inclined plane.

Due to the verticality of the façade and the southwest orientation the incident radiation on the façade is reduced to approximately 67 % of this amount, which means around 1060 kWh/m2a.

A 3D modelling of the building with a sun study was realized for different moments of the year to define approximately the influence of shading on the façade and a possible photovoltaic installation.

As a result, a division line was defined, dividing the façade in two parts, one upper part, appropriate for a PV installation as receiving sun throughout the whole year, and one lower part, recommended to be realized without a PV installation, due to the shading caused by the adjacent building. (Figure 2)

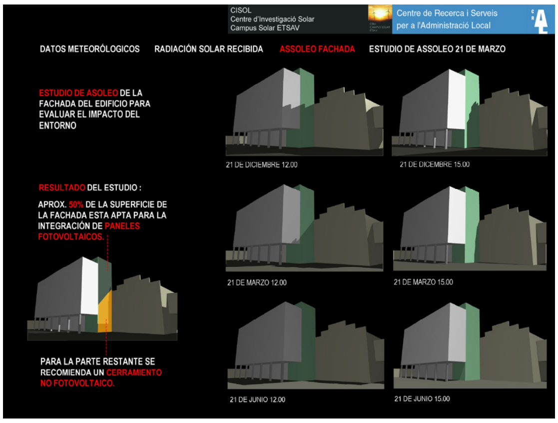

Figure 2: Sun study and evaluation of shadowing through the adjacent buildings.

In a third step this results were translated into a first design proposal with different materials in the façade. (Figure 3)

For the upper part there was recommended the use of ASI THRU semi transparent PV panels, product of RWE SCHOTT Solar, in a double glazing element, whereas for the lower part a combination of IMERA coloured glass, product of SCHOTT AG, as double glazed element with an white screen printing as additional sun protection and design element was foreseen.

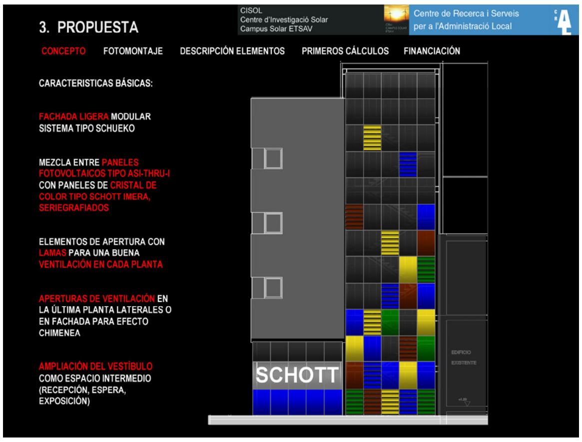

Figure 3: First design proposal for a mixed colored glass and PV facade

For natural ventilation there were proposed glass louvers in different elements of the coloured glass façade and additional ventilation openings in the upper part, to create a chimney effect within the staircase.

An additional entrance hall was proposed as a climatic buffer space between the staircase and outside.

As final step of the design process, a combination of PV panels and coloured glass sheets was proposed to explore ones more the creative potential of the companies products.

4 PROTOTYPES ASI THRU COLOR

As there was so far no experience in the combination of IMERA coloured glass with ASI THRU transparent PV panels, prototypes of different colours and glass combination have been produced, to evaluate their architectonical potential. (Figure 4)

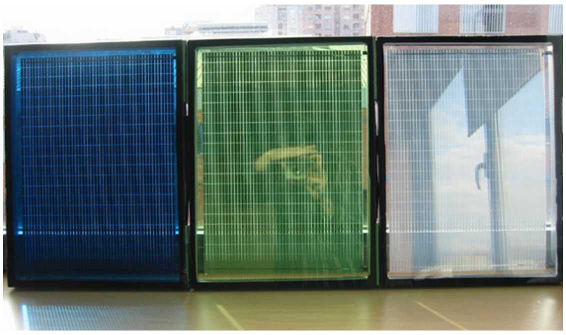

Figure 4: Prototypes of ASITHRU PV Elements with coloured IMERA glass.

The semi-transparency of ASI THRU in combination with coloured glass showed a promising effect of light and shadow as well as from inside as from outside, by the way that sun protection could be improved a little more.

Also for the IMERA double glazed elements prototypes were produced with different kinds of screen printing, finding a compromise between the sun shading properties and design aspects in terms of the play of light and shadow, opacity and transparency. (Figure 5)

Figure 5: Double-glazed IMERA element with screen-printing as sun protection and design feature.

The effect of a negative screen-printing was used, allowing to project with coloured light the printed writing on inside surfaces.

Different sizes of writings and density of printings were proved to achieve the best results in design and sun protection.

5 THERMAL DYNAMIC SIMULATION

A thermal simulation with TRNSYS was made to evaluate the effect of the proposed design on the thermal behaviour of the building and to optimize the proposed strategies in the field of sun protection and natural ventilation.

Different sizes of openings were simulated to define the requirements for sufficient natural ventilation.

The overall performance of the proposal showed to be promising. Maximum temperatures in the staircase will drop in summer to just 2-3º Celsius above the ambient temperature. (Figure 7)

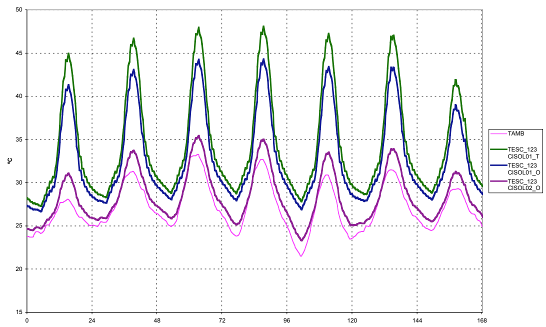

Figure 7: Simulation results for air temperature during summer reference week before and after the intervention.

In winter temperature maximums will drop also from about 26ºCelcius to about 21º Celsius, due to the improved sun protection, which limits in winter the desired direct solar gains, but the minimum temperatures will not change. (Figure 6)

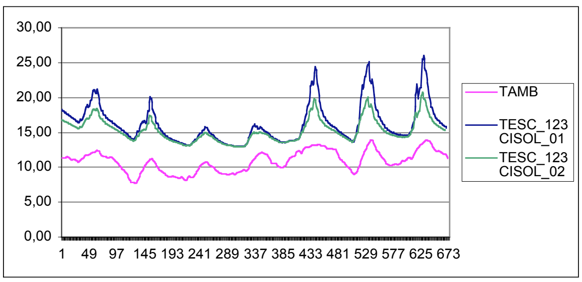

Figure 6: Simulation results of air temperature during winter reference week before and after the intervention.

The foreseen façade system showed to be a problem in terms of shadow projection on the PV panels in the upper part of the façade through its windows. Even a 15-degree opening to the outside would have caused shadow on some part of the below installed ASI THRU photovoltaic elements, causing a notable loss of productivity of the whole PV installation.

So finally the decision was made to introduce a line of windows in the upper part of the façade, which open to the inside, permitting fully opened a free ventilation opening of 1,6 m2, required minimum according to the TRYNSIS simulation results.

For visual aspects, but also as a weather protection, fixed metal louvers are used to cover these openings towards the outside, reducing only slightly the free ventilation opening.

The effect of vegetation in front of the lower openings in the façade was simulated and found as little significant.

One concern for safety reasons was the temperature that could reach the semitransparent ASI THRU PV elements as well as the screen printed coloured glass panels, as they are in direct contact with the staircase.

Simulation showed that the surface temperature of PV panels will not get higher than 48º Celsius, and the temperature of coloured glass panels would be limited to a maximum of 43º Celsius.

According to simulation results, with the new facade the overall heating and cooling demand of the office building will be reduced by 8 %, dropping from about 87 kWh/m2a to approximately 80 kWh/m2a.

6 NETWORKING

Important background for this project is the concept of a “Solar Network”, seeing research centers like CISol in the important role as connecting element between the different entities working in the field of architecture, solar energy and sustainability. (Figure 8)

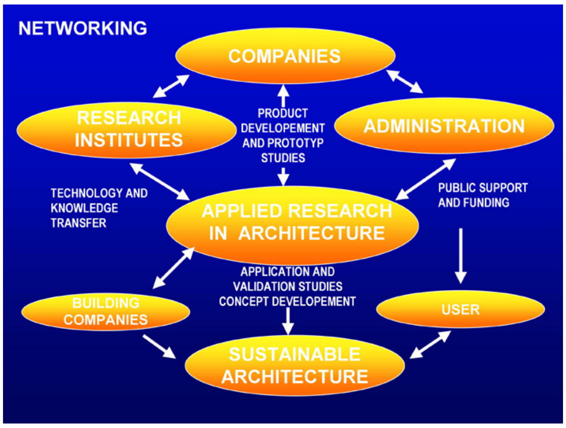

Figure 8: Network for Sustainable Architecture

7 RESULTS

The results of thermal simulations have been introduced into the project, finding an architectonically attractive solution for each parameter. (Figure 9)

The ASI THRU PV installation has a potential of 1,35 kWp, which is a rather small installation, but the project has to be understood as a prototype and as an integrated answer to a whole row of necessities.

In this sense the PV installation contributes positively in the field of daylight use, sun protection, visual relation to the exterior, thermal behaviour of staircase and building and last but not least as a corporate identity element for the company. (Figure 10)

Figure 9: Outside view of finished façade.


Figure 10: Inside view of finished façade.

8 TECHNICAL DATA

PV Instalation: 27 panels ASI THRU-2-IO-Color

Nominal unit power: 50 Wp / element

Total peak power: 1,35 kWp

Annual electrical production: 1,43 MWh/ year

Inverter: Fronius IG 15

Energy savings building: 8 MWh / year

Reduction of CO2 emissions: 5.600 kg / year

9 CONCLUSION

The presented project reflects the philosophy of the integrated design approach, which the CISol-Centre for Solar Research ETSAV, pretends to implement in the architectural education at the ETSAV of the Polytechnic University of Catalonia (UPC) but also in its work as a service and research centre.

A long-term supervision and monitoring through CISol will ensure the scientific results of this project.

PV Building Integration needs innovative products, concepts and technologies, developed in an interdisciplinary “networking” collaboration and realized within a “whole building approach”.

Only if technical and esthetical needs are met at the same time, PV will have a great future in our build environment.