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BUILDING INTEGRATED PHOTOVOLTAICS THERMAL ASPECTS

LOW ENERGY HOUSE FOR TESTING BIPV SYSTEMS

Annual Report 2010

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ABSTRACT

PV industries offering products that can be integrated as building materials represent so far a niche but promising market. At the moment only a few studies (see the references in the annual report 2009) have been carried out to assess the interaction between the PV modules and the building itself. This fact may represent a barrier not only for the PV industry, but also for the building industry that has yet to gain confidence in these new materials. The building sector must therefore possess a basic knowledge in relation to what is technologically available and how to properly employ photovoltaic integration in a building. Considering that in the near future PV will be used more and more often as a building material, the intentions of this project are to:

- Analyze building integrated PV products in order to define their **electrical and thermal characteristics**.
- Analyze the **interaction** between these materials and the building.
- **Demonstrate** what BiPV modules look like and how to integrate them into the building concept.

The real working conditions of a building-integrated PV system are generally different from those reproduced in a common outdoor test facility. For example, photovoltaic insulated glass will exhibit different electrical and thermal behavior compared to PV modules analyzed with a common outdoor test facility where ventilation, temperature, heat flux and structure are different. Consequently the photovoltaic components for building integration require a special test facility. To test BiPV modules closer to the real situation, a special stand was built on the roof of our institute with the objective of, on the one hand, analyzing new prototypes or already existing, commercialized modules and, on the other hand, showing visitors what these new photovoltaic building elements really look like and which building components can be replaced with PV.

Aims of the project

The building integration photovoltaic sector becomes more popular day after day and consequently professional interest is increasing. The photovoltaic technology is the only mean to achieve integrated delocalized electrical production. The cost of the modules is decreasing more quickly than other building elements. In this case, the photovoltaic façades will become financially interesting in the near future. For this reason, this project analyzes several PV elements used as building components in façades. For further details on the facility construction and modules technologies, see the annual report 2009.

The main goals of 2010 were the following:

- **Achievement of the outdoor test facility (see FIG.1)**
- **Beginning of the data acquisition**
- **Improvement of the test facility functioning**
- **First analysis reports after 3 and 6 months for manufacturers (confidential)**
- **Test facility tour for building professionals, PV specialists and students**
- **Presentation of the project and diffusion of the first results.**

All the objectives were reached but with a delay of three months due to the delivery behind schedule of the BiPV modules by the PV industries and bad weather conditions (snow falls) at beginning of 2010 that delayed the finalization of the facility.

FIG. 1: Outdoor facility for the testing of BiPV systems

Works carried out and results achieved

The BiPV simulator was finalized and the last modules installed, in March 2010.

Data acquisition

The data acquisition began with the simulator completion in March 2010. All electrical and thermal data are daily registered with a frequency of 1 per minute during the daylight period. The module operating electrical specification (voltage and current), the meteorological data (irradiance, outdoor temperature), the ambient temperature inside the house and the module temperature placed on the bottom of each module are registered by 24 maximum power point trackers (MPPT) specially realized by ISAAC for this project. The one-year monitoring is still ongoing.

During the first months of monitoring, some improvements were made in order to improve the working conditions of the simulator.

- The data acquisition has been improved. The modules data have been filtered in order to eliminate the very low insolation days during which the tracking of the maximum power point is not very accurate.
- The temperature homogeneity into the facility was improved by adding a ventilator and a physical barrier in front of it which diffuses the hot or cold air. This because some modules were more exposed to the air-conditioner than others. The internal glass temperature is monitored to check the temperature uniformity.
- To increase the simulator lifetime, the wood surface was covered with a waterproof paint.

Intermediate analysis reports for manufacturers

Two intermediate reports after 3 and 6 months were sent to each of the five manufacturers who collaborate within this project. The analysis reports only show the results of the PV modules provided by the producers itself. The comparison between the different technologies (without naming the manufacturer) will be shown in the final report after having monitored the installation for one year. This decision was taken in order to avoid the publication of values that don't allow a fair comparison due to the ambiguous choice of the nominal power between the different technologies. For scientific research, the Final Yield (FY) is used to compare the production of two modules having different nominal power but the same inclination and orientation (during a defined time period). The final yield is the ratio between the produced energy (E) and the nominal power (P_N) expressed in kWh/kW_P. It is noteworthy that due to its definition, the final yield strongly depends on the choice of the P_N value. The modules electrical characteristics under standard test conditions have been measured with a pulsed solar simulator (class A) before installing the modules on the test facility. The P_N value chosen for the intermediate report (that consider the initial degradation) was given by each manufactures. The P_N value will be measured again at the end of the project to quantify possible variations. When two modules with different inclination and orientation are compared, the Performance Ratio (PR) is the value that help to make the comparison. It is defined as the ratio between FY and the normalized irradiation (G/G_0) and in turn depends on the P_N given by the producer.

So far, some considerations have emerged, in particular:

- Opaque modules may be used as any building materials (paying particular attention to cables and fastening systems)
- Transparent modules: lower yield compared to standard modules, but natural light supply and reduction of summer overheating (facts that will be quantified at the end of the project)
- Insulating glazing facade with transparent modules in amorphous silicon → annealing effect
- Depending on the manufacturers and of the production line (how the transparency is obtained) different Power/m^2 values are obtained
- Standard PV laminates transformed in insulating double glazing: junction box at the edge, hermetically-sealed gap between the glass panes

Test facility tour for building professional, PV specialist and students

During 2010, many visits of the BIPV simulator were organized for planners, actors of the building sector, students, industries, associations. Considering the success of the demonstration stand, a Zoom out/Zoom in application (that was not include initially in the project) was realized in order to give the possibility to virtually visit the BiPV simulator on our website www.bipv.ch Ref. [1].

Presentations of the project and diffusion of knowledge about the concept and first results

- **25th EUPVSEC and WCPEC-5**, Valencia, Poster and paper on "Low energy house for testing BiPV systems", September 2010
- **Status Seminar**, Zurich, September 2010
- **Energy forum - solar skins**, Bressanone, Oral presentation on "Temperature and module efficiency: thermal and electrical behaviour of BIPV systems", December 2010
- **Supplemento del corriere del trentino e dell'Alto Adige**, article on "Stand di prova per elementi fotovoltaici integrati negli edifici", November 2010
- **Metallglass**, article on "Stand di prova per elementi fotovoltaici integrati negli edifici", December 2010

National and international collaborations

- Verres industriels, Moutier
  Danilo Pirotta director, Bernard Cuttat R&D engineer, Pierre Stettler sales manager
- Galvolux, Bioggio
  Marco Jelmini director
- Swiss laboratories for materials testing and research EMPA, Dübendorf
  Mark Zimmerman, Bruno Binder, Mr. Vonbank and Stephan Carl
- PV producers (confidential)

2010 Evaluation and future prospects for 2011

In 2010, our project has received a great response by planners, actors of the building sector, students, industries and associations considering that tours of the BiPV stand were regularly organized. In fact, building specialists encounter difficulties when they have to choose among different technologies in relation to the application of PV into the building and are pleased to know that our project will give more “usable” information on this subject.

Considering that the construction of the stand was delayed, the measurements at EMPA will begin in March-June, in any case they should be finished on time for the analysis report and the conclusion of the project.

The BiPV stand was more expensive compared to the estimated costs, because of the decision to give more value to demonstration by making a real house instead of having boxes behind modules.

In the final report the following considerations will be analyzed:

1) **Semi-transparent amorphous silicon modules** (single, double junction o micromorph modules) have a lower nominal power **compared to opaque modules** of the same technologies depending on how the transparency is made (during the manufacturing process). Nowadays the building standard request at least a double insulation glazing unit when the modules are manufactured with transparency characteristics in order to be used as a warm facade. In this case, the “annealing” effect (see study of our Institute), which occurs when the cells have a temperature of 40°C and more, has an important role and allows to increase the energy production during the summer period. This study will also analyze how the loss of energy production due to the transparency would be balanced by the increase of energy production in summer caused by the annealing effect. Would the application of amorphous silicon be more appropriate for ventilated facades rather than warm facades with good insulation glasses? (see Fig.2).

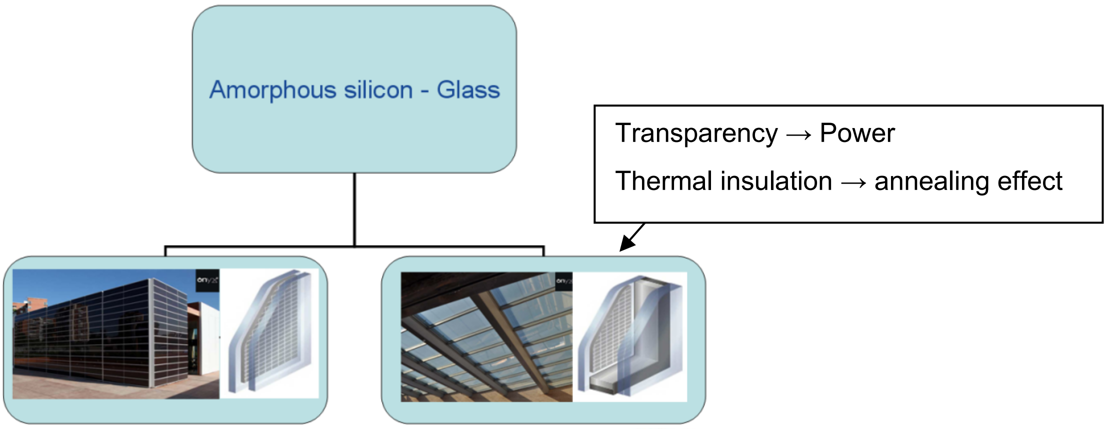

FIG. 2: The application of the amorphous silicon technologies would be more appropriate for ventilated facades rather than warm facades with good insulation glasses? (annealing effect)

2) The study will analyze if **the type of support would influence the temperature of the modules** laid on different metal roof (aluminum, zinc, steel) and membranes (black or white) and in turn also the modules production (see Fig.3).

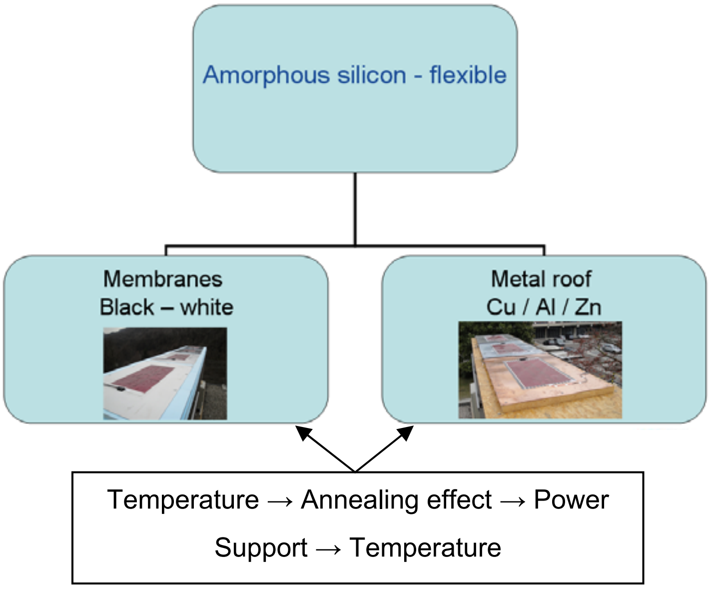

FIG. 3: The type of support would influence the temperature of the modules and in turn also the modules production by means of the annealing effect

3) In a ventilated facade, the amorphous silicon and the crystalline silicon technologies don't have an interaction with the building in terms of heat exchange and light supply. Instead in the case of a warm facade, the study will analyzed how the modules influence the building itself. **If and how semi-transparent modules would allow to reduce overheating while ensuring a certain degree of natural lighting** are aspects which will be analyzed at the end of the project with the measurements of the U and g values of the modules at EMPA (see Fig.4).

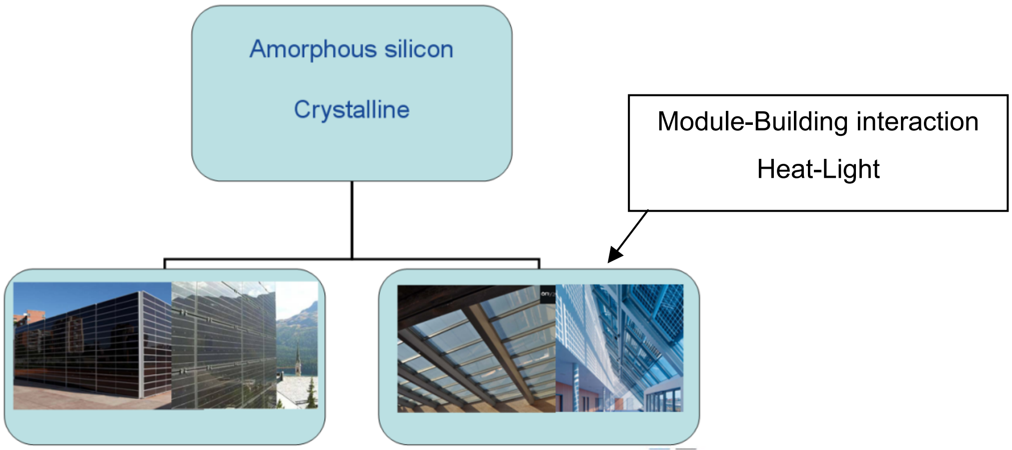

FIG. 4: Mutual module-building interaction considering heat exchange and light transmission

4) **The surface temperature of the front glass panes is hotter compared to traditional glasses**. This specific behavior will be also studied before the end of the project.

References

[1] Zoom in / zoom out application on www.bipv.ch "materials" / "BIPV simulator"