Research Project

Integration of CIS solar modules in external thermal insulation composite systems (PV-WDVS)

Summary Report

Project partner

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1 Goal of the research task

External thermal insulation composite systems are playing a leading role for the insulation of building exterior walls because of its high economic efficiency and very good physical properties. The proven technology is used since 50 years for new and existing buildings.

The Research Project combines external thermal insulation composite systems with the exploration of renewable energies by integrating photovoltaic as building component layer. The application of flexible, glassless CIS Thin Films modules allows a construction without the complex and expensive substructure used in curtain walls and ventilated façades.

Lacking a scientific basis for adhesive bonding of photovoltaic in external thermal insulation composite systems, this research project puts its focus on the testing and development of serviceable and economic façade by considering the legal, constructional, physical and creative boundary conditions.

2 Processing of the research task

The aim is to be achieved by the interdisciplinary work of research institutes, industrial partners and handcraft.

The work is done by the following steps:

- Market and patent research
- Definition of the boundary conditions
- Development of a glassless photovoltaic module
- Development and testing of PV-WDVS
- Considerations on sustainability
- Considerations on economic efficiency
- Distribution of results

3 Summary of results

Market and patent research

External thermal insulation composite systems are applied for 50 years with the main purpose of energetic modernisation of building walls. Since the 1960s more than 700 million square meters façade area is covered with this system in Germany. The further distribution is influenced by the development of new constructions, the subsequent insulation of older constructions and the restoration of existing insulation composite systems. The policy and financial framework like the law about energy saving in buildings and the state support, but also the demographic development are important conditions. Studies forecast a growing WDVS-market from ca. 40 million m^2/a to 65 million m^2/a in the year 2025.

The government's energy concept of 28 September 2010 specifies the share of the renewable energies of the electricity supply has to be 80 % in 2050. Further incentives and the establishment of technical conditions which allow for using and storing the electricity generated by photovoltaics for personal consumption will increase the part of the building integrated photovoltaic.

The analysis of the patent specifications determined during the term of the project by the Patent Information Centre Dresden shows especially glassless modules for the integration in roofs, mechanical assembly systems and the manufacturing of photovoltaic modules. Patents describing the construction which will be examined in this project are unknown.

Development and testing the PV-WDVS

The project partners decide on a pre-fabrication of the PV-WDVS building component. The high quality of the adhesion which fixes the photovoltaic module on the baseboard can only be ensured in pre-fabrication.

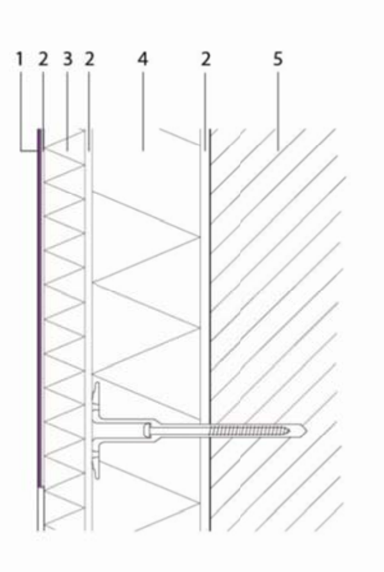

Figure 1: PV-WDVS construction

One essential part of the project was the further development of the glassless photovoltaic module under the aspect of this application. In contrast to glass, plastic films have a high permeability of water vapour and of oxygen, which damages the photovoltaic module. With barrier layers this negative properties can be reduced by means of the development and application of an ultra-high performance barrier layer.

A polyurethane foam was especially used as support plate. In addition a baseboard for plaster was applied.

Temperature measurements and hygrothermal building simulations show that the modules can reach temperatures up to 85 °C. Hygrothermal simulations also identified no critical humidity in the component layers.

Peel tests, bond strength tests between module back foil and insulation material and shear tests were carried out in the Friedrich-Siemens-Laboratorium of the TU Dresden in order to identify a suitable adhesive for fixing the glassless photovoltaic module. The adhesive has to meet especially the following requirements:

- Suitability for outdoor applications
- Temperature resistance up to 85 °C
- Moisture resistance
- Sufficient tensile strength
- Suitability for plane bonding
- Adhesion on module and baseboard
- Tension-equalizing sealing of different materials

Especially elastic 2-component adhesives were investigated.

The Guidelines for European technical approvals of external thermal insulation composite systems, the ETAG 004 and 017, specifiy that „the minimum bond strength to the insulation product should be at least equal to 0.08 N/mm^2 or failure occurs in the insulation product instead”.

The tests were carried out with different adhesives and plastic films, different temperatures and after ageing. The experimental set-up is based on DIN EN 1607. All tests were successfully passed. In order to determine the bond strength between module and adhesive the tests also were carried out without a baseboard. The failure mode was cohesive within the module film. (See Figure 4)

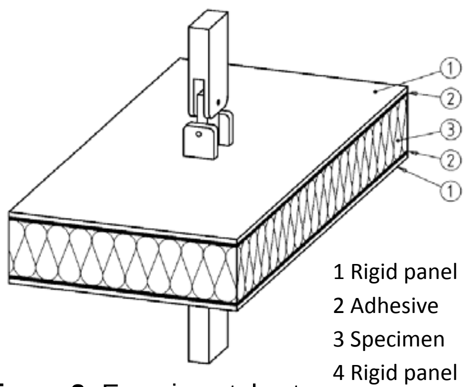

Figure 2: Experimental set-up

The thermal expansion of the photovoltaic module causes shear forces in the adhesive and the material bellow. With shear tests the effect of thermal expansion can be simulated.


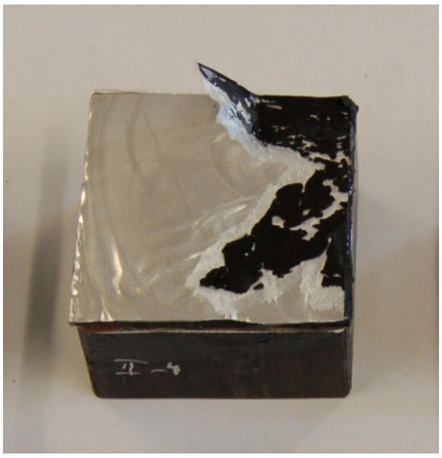

Figure 3 and 4: Specimen after testing

The hygrothermal behaviour of the specimens shown in figure 5 has been tested at the Sto AG. In 200 heat-rain cycles the rig is subjected to following phases: heating up to 70°C/85°C for 2 hours and then spraying for 2 hours.

The components which were fixed with the proposed adhesive have passed the test sucessfully.

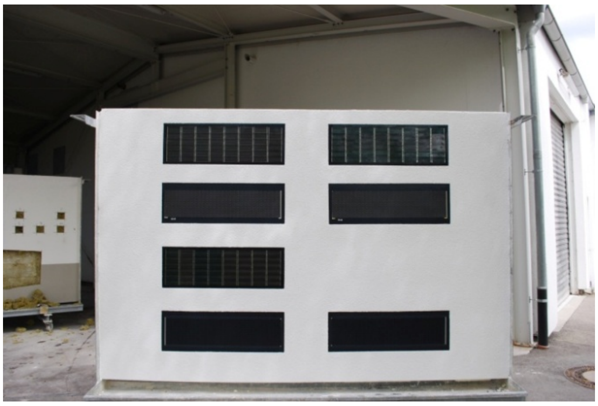

Figure 5 und 6: Variation of several build-ups (Sto AG) und test apparatus

Visualisation

The impression can be altered by means of module size, the module arrangement and variation of the distances between the modules. Each module size is theoretically available dependent on the number of cells.

The colour impression of the façade is able to be changed with coloured modules edges or coloured finishing plaster.

The figure shows the visualisation of photovoltaic modules integrated in the façade of an one-family house.

Figure 7: Visualisation (Sto AG, TUD)

Sustainability

Life cycle assessment (LCA) describes energy and material flows in all stages of the life. For the photovoltaic module a separately LCA can be done. However, the energy saving by insulation material depends on the existing energy state of the building. Therefore, a separate consideration of the photovoltaic and insulation was made. One criterion is the Energy Payback Time (EPBT). The EPBT of CIS production varies between 1 and 3 years. External thermal insulation composite systems are known for very short EPBT. In case of the subsequent insulation of existing buildings the EPBT is often less than one year.

Economic efficiency

The economic efficiency of the photovoltaic depends on the investment and operation costs in combination with the gain of the solar system. The gain of the photovoltaic system is determined by the location such as the weather conditions, the orientation, the installation situation which has an impact on the temperature development in the module, and the system quality with its optimal design and installation. The options of financing, state fundings, the share of personal consumption and the electricity price trend have also an influence on the economic efficiency. Calculations show that the solar system will have amortized within 10 years.

Dissemination of results

The project and the results were disseminated in conferences and papers. A prototype has been exhibited at the fairs Deubau 2012 and bautec 2012.