TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Bauingenieurwesen Institute of Building Construction

RESEARCH PROJECT

Examination of an insulated panel with integrated photovoltaic for the application in transom-mullion facade systems (insulated PV-panel)

SUMMARY REPORT

Date: 31.08.13

Partner: Manz CIGS Technology GmbH

MBM Metallbau Dresden GmbH

TU Dresden – Institut für Baukonstruktion

Project Manager: Prof. Dr.-Ing. Bernhard Weller, TU Dresden

Project Engineer: Dipl.-Ing. Jasmin Fischer, TU Dresden

The research project was funded by Forschungsinitiative Zukunft Bau of the Federal Ministry of Transport, Building and Urban Development.

Reference Number: AZ: II 3-F20-11-1-115 / SWD-10.08.18.7-12.18

The responsibility for the content of this report is solely with the author.

Adresse:
TU Dresden
Fakultät Bauingenieurwesen
Institut für Baukonstruktion
01062 Dresden

Telefon: 0351 463 3484
Fax: 0351 463 35039
Besucher: Beyer-Bau, Zimmer 202
E-Mail: bauko@mailbox.tu-dresden.de
http://www.bauko.bau.tu-dresden.de

Prüfstelle nach LBO
SAC23

1 PURPOSE

Photovoltaic modules in facades are often used as opaque cladding elements in ventilated facades or integrated in insulated glass units (IGU) for curtail walls. The opaque elements (blind panels) are hardly considered for the installation of pv-modules but show a great potential for such an application.

Insulated panels are the main opaque elements for railings and balustrades or for cladding of the front side of slabs in transom-mullion-constructions respectively. The research project has the focus on the innovative development and improvement of these panels as an energy generating facade element by integrating a pv-module in the cover sheet.

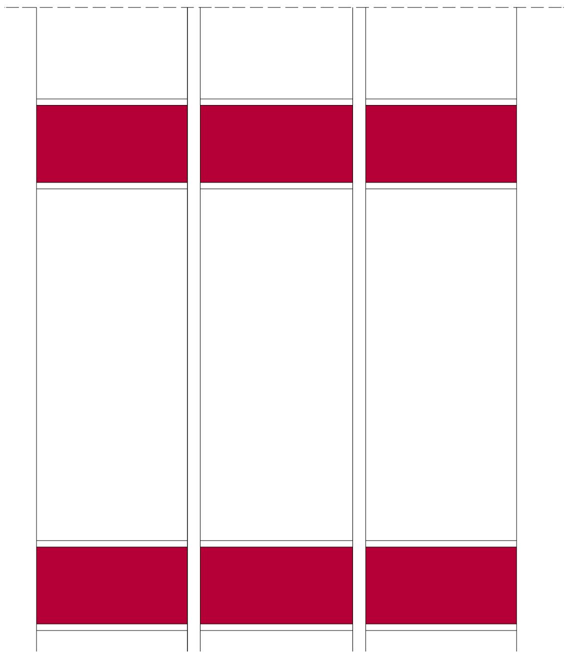

Figure 1 sketch transom-mullion-facade with coloured panels

2 SUBJECT OF THE RESEARCH PROJECT

The element to be developed requires knowledge form the fields of architecture, building construction and photovoltaic and, therefore, an interdisciplinary research approach. The project is worked by the leading research partner, the Institute of building construction of Technische Universität Dresden, and the industrial partners Manz CIGS Technology GmbH and MBM Metallbau Dresden GmbH.

Figure 2 shows the working plan.

							2012						2013					
					Juli	Aug.	Sept.	Okt.	Nov.	Dez.	Jan.	Febr.	März	April	Mai	Juni	Juli	Aug.
Paket	**Bearbeitungsinhalt**	**MBM**	**TUD**	**Manz**														
0	**Koordination**		**1,5**															
1	**Marktrecherche und Patentrecherche**	**0,5**	**0,5**	**0,5**														
2	**Ermittlung der Anforderungen**	**0,5**	**2,0**	**0,5**														
2.1	Definition architektonischer Kriterien																	
2.2	Definition baukonstruktiver Kriterien																	
2.3	Definition bauphysikalischer und elektrotechn. Kriterien																	
3	**Entwicklung und Herstellung PV-Paneele und Prüfstand**	**3,5**	**2,0**	**2,0**														
3.1	Entwicklung und Herstellung PV-Prototypen																	
3.2	Entwicklung Prüfstand																	
A	**1. Zwischenbericht**		**1,0**															
4	**Prüfungen**		**7,5**															
4.1	Materialverträglichkeitsprüfungen																	
4.2	Bestrahlungsprüfungen indoor/Temperaturmessung/elektr. Vermessung																	
5	**Simulationen Temperaturentwicklung**		**2,0**															
6	**Abschlussbericht**	**1,0**	**2,5**	**1,0**														
	Personenmonate	**5,5**	**19,0**	**4**														

Figure 2 working plan

2.1 INSULATED PANEL

Glazing or prefabricated insulated panels usually serve as infill elements in transom-mullion-facade systems. These panels consist of insulation at the inside, a rear covering for instance made of aluminium and a front cover made of coloured, enamelled safety glass for example. The replacement of the front cover by pv-modules is matter of research within this project.

Two types of fixing are investigated in detail:

- The standard fixing with all side support by means of clamping and
- Adhesive fixing with mechanical protective fixing (Structural Glazing – SG).

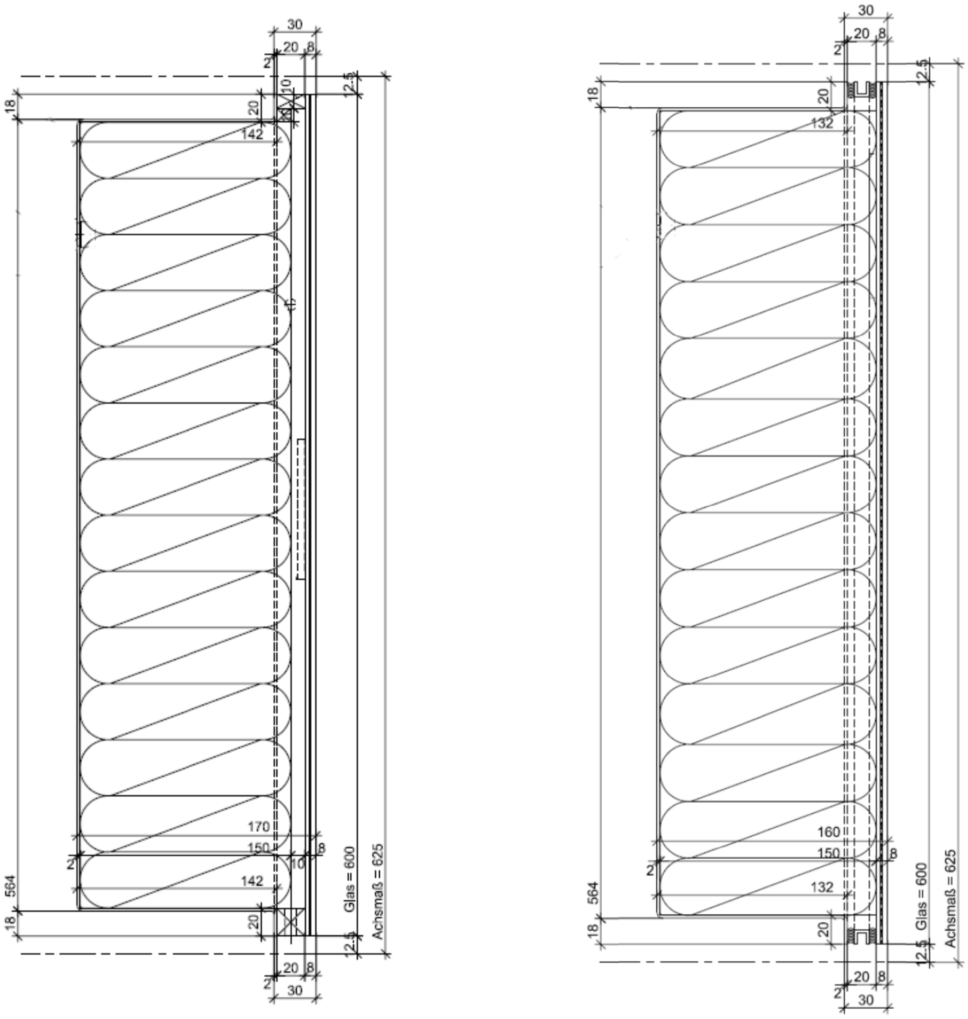

Figure 3 vertical section of the panel for standard fixing (left) and SG-facade (right)

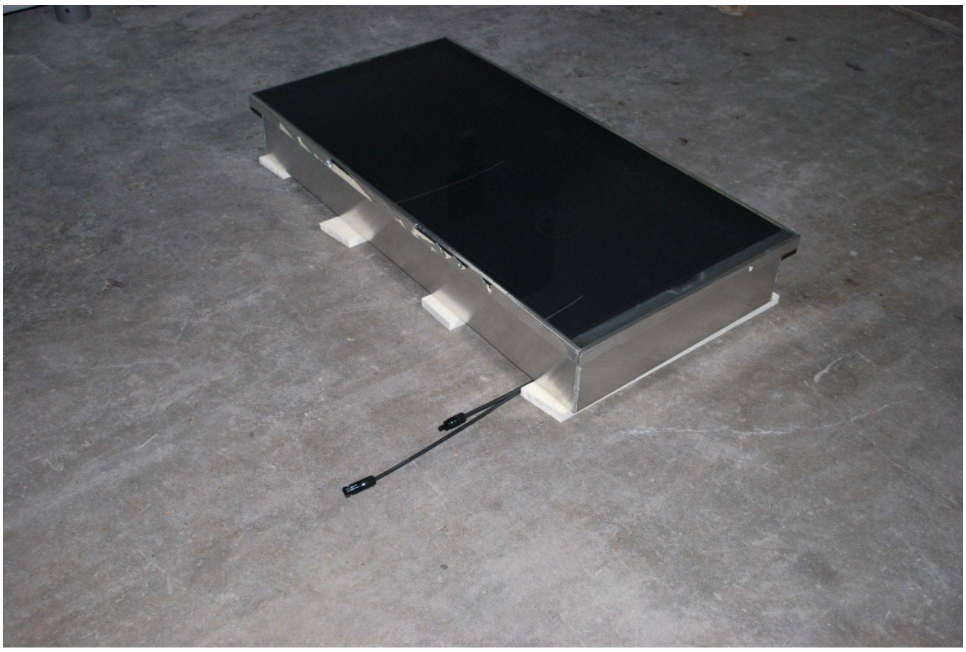

Figure 4 pv-panel for standard fixing

2.2 TESTS FOR MATERIAL COMPATIBILITY

The behaviour in case of direct contact or potential emission of addities between the laminate foil (pv-module) and the adhesives used will be investigated by means of material compatibility tests. A one-component Polyurethane adhesive of the manufacturer Fa. Henkel (test series B) is used as fixing of the concealed edge band in the standard fixing system. In SG-facades two types of silicone adhesives are used: for the structural use a two-component silicone-rubber (test series A) and as sealant one-component silicone sealing compound (test series C). All adhesives used were tested in terms of material compatiblity.

The test is done according the ift-rule DI-02/1: Verwendbarkeit von Dichtstoffen, Teil 2 Prüfung von Materialien in Kontakt mit der Kante von Verbund- und Verbundsicherheitsglas.

After 7, 14 and 21 weeks the visual alterations were evaluated. The size or diameter respectively of bubbles, the number of them, the penetration depth, the staining and delamination were checked. The following figures show the specimens after the tests.

Figure 5 specimen A after 21 weeks

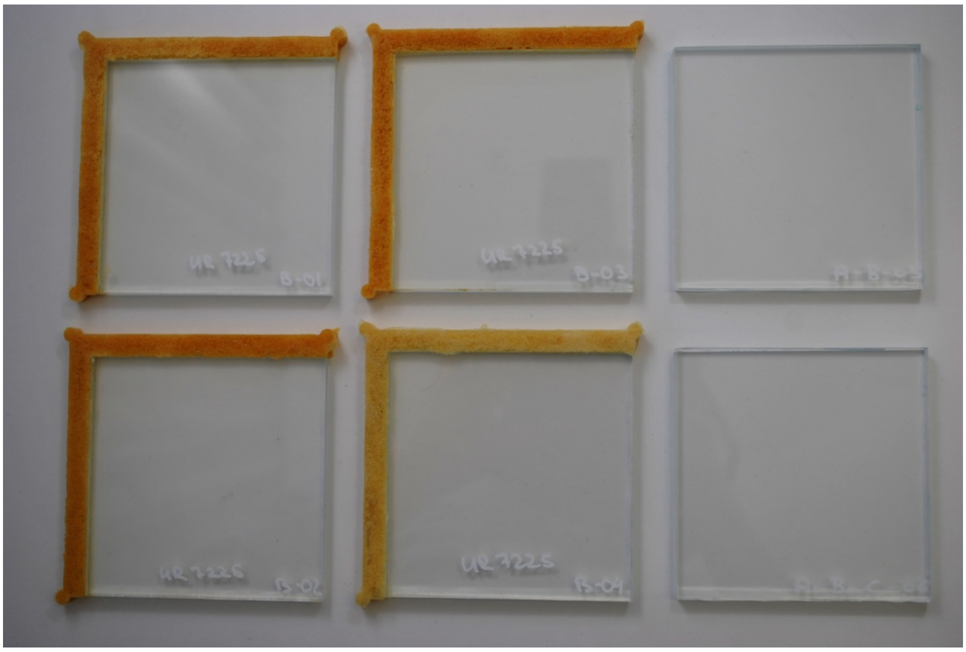

Figure 6 specimen B after 21 weeks

Figure 7 specimen C after 21 weeks

There are no alterations which have an impact on the proposed usage.

2.3 RADIATION TEST

The cell temperature influences the energy performance of pv-modules significantly. Therefore, it was an essential research challenge to determine how rear insulation affects the temperature development and the efficiency of the pv-modules.

Lamps with solar like spectra were available as radiation source. The radiation intensity was regulated by the distance between the lamps and the pv-module. At a distance of 50 cm the radiation was approximately 900 W/m^2, measured with a Pyranometer in the middle of the module. The equivalent radiation for the reference spectrum, that is the sun spectrum, amounted then to 250 W/m^2.

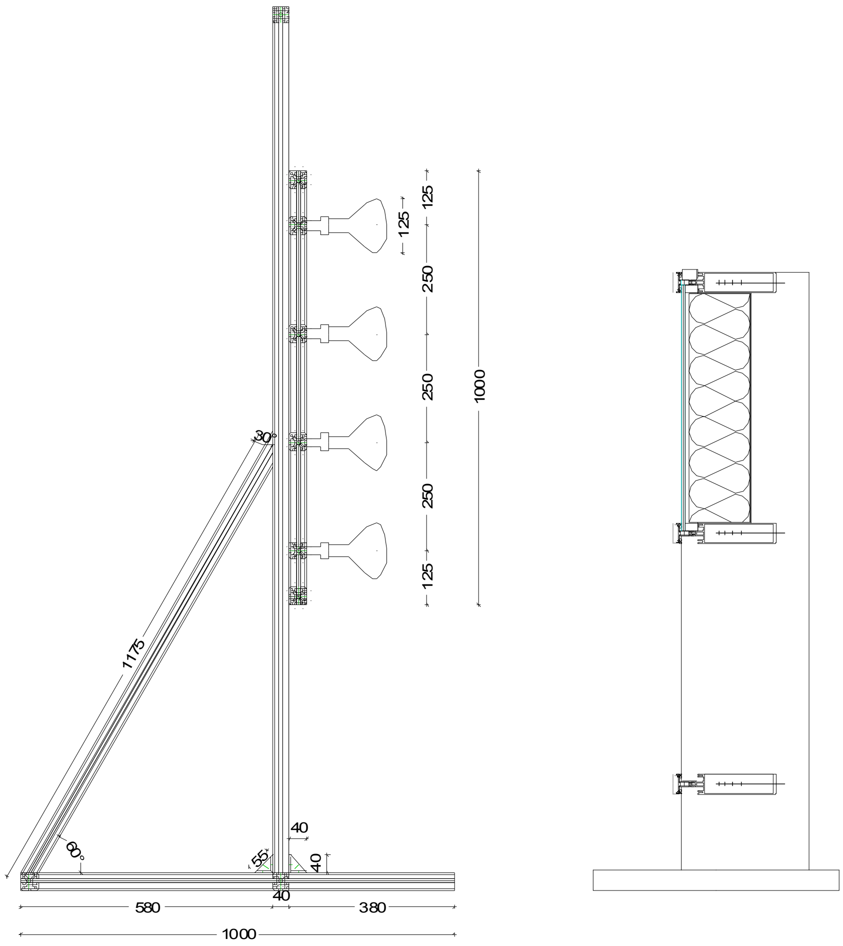

Figure 8 test set-up with radiation unit and panel rig

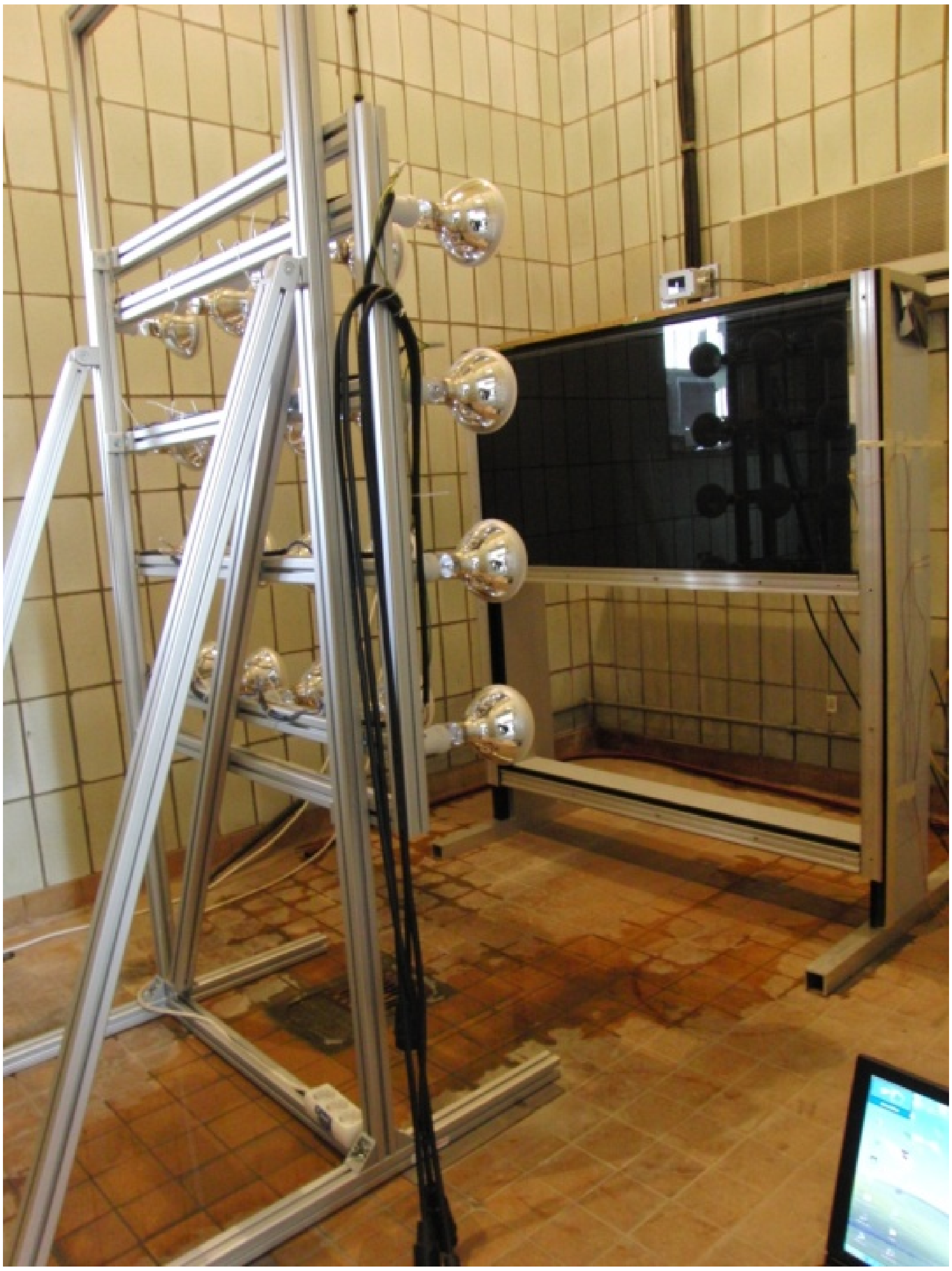

Figure 9 test set-up with radiation unit and panel rig with pv-module PV-S-1

Thermo elements of the type T were used as temperature sensors. An important criterion was the little thickness of this thermo couples. The maximum thickness is fixed by the thickness of the interlayer foil of the pv-module due to the embedment of these couples between the foil and the cell layer.

An electronic load was connected for determining the power and efficiency of the pv-modules.

The testing procedure is equal for the non-insulated reference modules and the insulated pv-panels. The experiment was started with a distance of 50 cm of the radiation unit. At a temperature of approximately 75 °C in the cell layer the lamps were switched off. After the cool down of the system to ambient temperature the test was continued with a distance of 30 cm of the radiator. After reaching a temperature of 50 °C in the cell layer the distance was reduced to 10 cm and the test was continued without cool down until reaching the final temperature of 75 °C.

It has to be mentioned that the temperatures might differ under real climatic conditions due to the fact of the given internal conditions with less heat transfer.

The following figure shows the measured temperatures as comparison between the reference module PV-S-1 and the pv-panel-S-1 in the cell layer.

The temperature at location Mz2, that is in the cell layer in the middle of the module, increased in the reference specimen at a distance of 50 cm linearly up to a temperature of 50 °C. Subsequently it was increasing asymptotically to a limit value. The mandatory temperature for stopping the test was reached after 2680 s.

The stopping temperature was even reached after 1450 s in the pv-panel. The temperature increased with a similar slope like the reference module. While the temperature of the reference module is aspiring asymptotically a limit value, this effect is not discovered at the pv-panels.

At a distance of 30 cm and 10 cm respectively the influence of the radiation prevails significantly so that the temperature development of the reference module and the pv-panel within the interesting temperature range is almost identical.

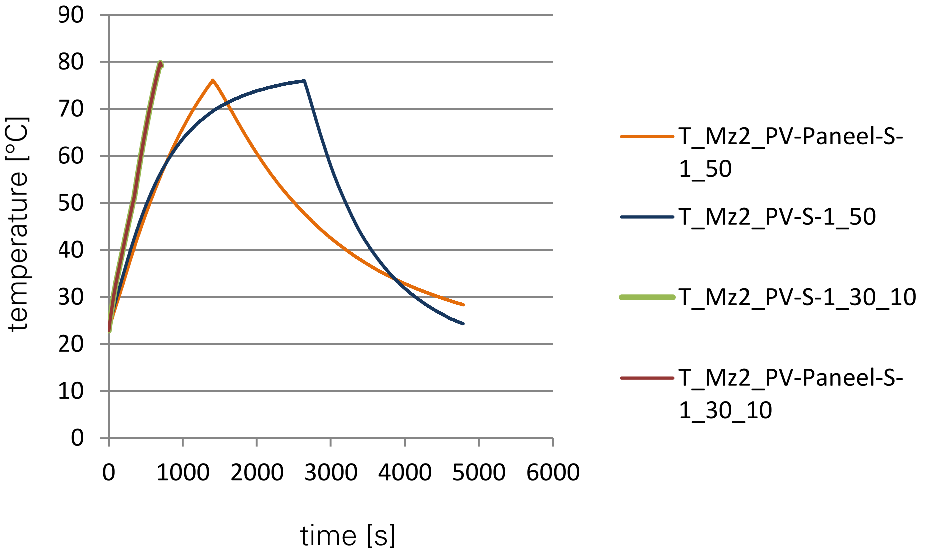

Figure 10 measured temperatures as comparison between PV-S-1 and pv-panel-S-1

The following figure shows the measured temperature at cell layer and the measured pv-output in MPP for pv-panel-S-1, pv-panel-S-2 and pv-panel-WG-1.

The evaluation yield for the black modules a mean temperature coefficient of approximately 0.4 %/K, under the condition that the values are referred to the first measured result at approximately 27 °C.

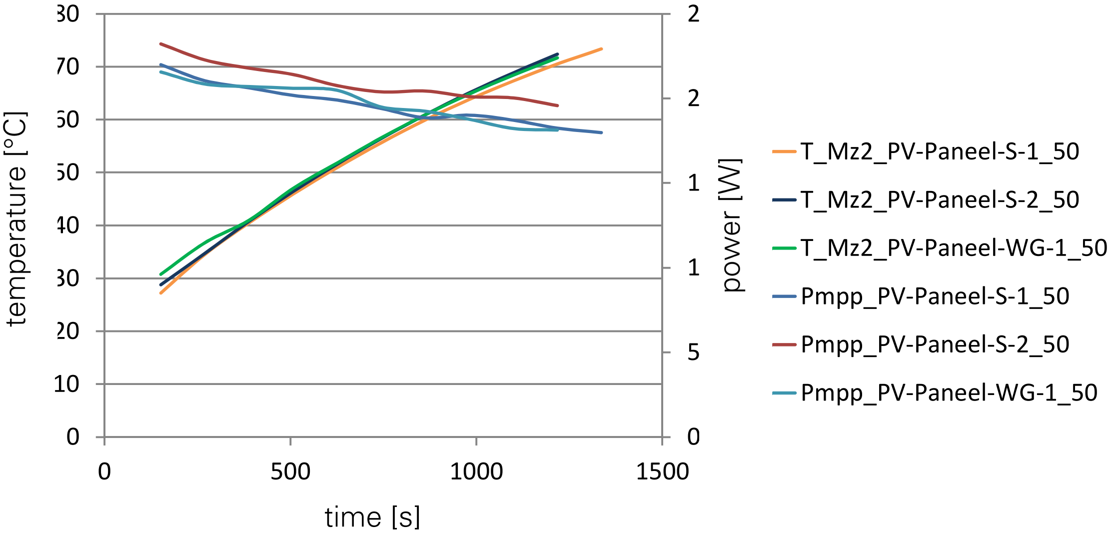

Figure 11 influence of temperature on the pv-performance

3 SUMMARY OF THE RESULTS

Two different construction types for panels with pv-modules as front cover were investigated within the frame of the research project, especially under the aspect of construction, building physics and electronic.

Material compatibility tests showed the general possibility of use of the proposed adhesives with the other plastic materials involved.

Radiation tests proved the influence of the temperature on the efficiency of the pv-modules as well as the impact of the rear insulation compared to ventilated facade systems.

Simulations with realistic climatic conditions – reference Munich – showed that there might be 20 K higher temperatures in the panel with rear insulation. The maximum reachable temperature is less than 75 °C.

A simulation of the possible energy output shows that the influence of the rear insulation is negligible pertaining to the annual gain in spite of the partly remarkably higher module temperatures of the pv-panel. The reason is that the maximum temperatures are quite seldom related to the whole length of a year.

To monitor and evaluate the system under real climate conditions the surveillance of black and coloured modules is proposed after completion of the current research project.

4 KEY DATA

Short title	Insulated PV-Panel
Partner	Institute for Building Construction, Technische Universität Dresden Manz CIGS Technology GmbH MBM Metallbau Dresden GmbH
Overall Cost	181,600 Euro
Portion by Funding	121,000 Euro
Duration	14 Months