SOLAR-FAÇADE (OPV) AS CORPORATE DESIGN – STUDENTS DESIGN CONCEPTS FOR THE ZAE BUILDING IN ERLANGEN

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ABSTRACT: In the field of building integrated photovoltaics (BIPV), thin-film PV modules or films with organic solar cells (OPV) in particular also represent new solutions, especially when it comes to requirements for flexible module sizes and geometries. These potentials have not yet been exploited enough for further developments.
In the context of a course with master students of the Faculty of Architecture of the Nuremburg Tech in the summer semester 2018, a solar façade was planned for this innovative technology at the former ZAE office and research building in Erlangen as a beacon project and research object, which provides sun and glare protection for the interior and functions as a visible sign of advanced energy research. This eye-catcher is intended to demonstrate how a fully functional yet aesthetically pleasing construction can be realised.
The projects show interesting solutions from the viewpoint of architects and give an indication of the technical requirements for pv modules as construction material. They demonstrate the realization of consistently functional and aesthetically appealing constructions for a striking sign of advanced energy research.
Keywords: OPV, printed PV, BIPV, PV façades, solar architecture

1 OPV FAÇADE FOR A BUILDING OF ZAE

Organic photovoltaic modules and printing processes for their manufacture in a roll-to-roll process are being developed by the former Bavarian Center for Applied Energy Research (ZAE Bayern). [1]

In the context of a course with master students of the Faculty of Architecture of the Nuremberg Tech in the summer semester 2018 [2], a solar façade was planned for this innovative technology at the front section of the ZAE in Erlangen (Fig. 3), which on the one hand provides sun and glare protection for the interior, and on the other hand functions as a visible sign of advanced energy research. This eyecatcher should demonstrate how a fully functional and yet aesthetically pleasing construction can be realized (with simple means).

Fig 1: ZAE Bayern, office and research building (2011), Architekturbüro Fischer + Partner (Photo: Tobias Stubhan)

The ZAE building is located at the western entrance to the southern campus of the Friedrich-Alexander-University of Erlangen-Nuremberg. The L-shaped structure is three-storeyed and oriented to the northeast/southwest. The building forms the access area. Due to clearance areas and the entrance to the underground car park, the two-storey front section tapers in the northwest and is indented in the southeast. On the ground floor there is a meeting room and on the upper floor a lounge.

2 THE PROJECTS

A number of differences can be identified in the constructional design as well as in the façade structures. [3] Essential parameters are:

- Structure
- Position to the building and façade area
- Supporting material
- Module design

With regard to the overall structural appearance, a simplified distinction can be made between band-like and planar/point-like solutions, which are designed to be flat or spatial. In terms of design, systems with flat or curved supports/primary and secondary beams or rope net and frame structures with secondary support structure can be found.

In most projects, a plastic foil is used as a carrier material in which the OPV modules are encapsulated and thus additionally protected from the weather. Some solutions use rope nets or membranes in addition to rod-shaped steel profiles. In the module design, there are also strip and planar/point-like solutions that sound out the design potential of the OPV. In all projects, the aim was to make it as easy as possible to exchange the OPV modules with regard to the façade construction as a research object and test facility.

2.1 Linear façade structures

Within the band-like concepts, Moritz Bachmann and Sven Vorliczky position the OPV façade in the area of the mullion and framed glazing façade. The solar foils are vertically mounted over the two storeys in the south- and the northeast. The substructure of square hollow profiles, which follows the structure of the existing façade, is fixed to the façade mullions at certain points. Based on the motif "rays of light from different points of the compass", different high and low points are distributed over the surface, which move the solar foils against each other in the area of the mullions. This results in different expansions for a view from the inside, which nevertheless provide sufficient sun protection. Integrated, opening frames allow access to the windows. (Fig. 2)

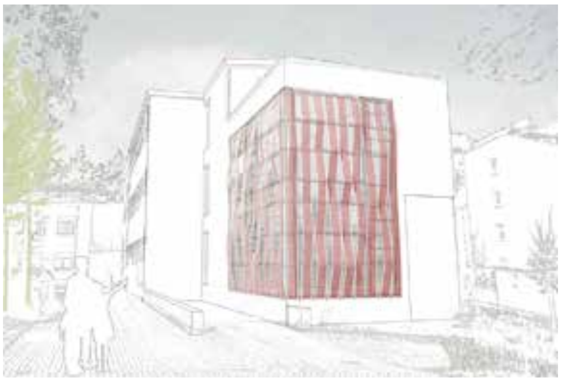

Fig. 2: Moritz Bachmann / Sven Vorliczky, rendering

In contrast, Daniel Huuck and Alexis Lode move away their construction "Beyond" from the façade level. In doing so, they refer to the edges of the building and create the largest possible PV generator area. From the base point, the sheets are stretched over spacers (Fig. 3) in the plane of the parapet up to the edge beam of the roofing to also indicate the performance of the solar foils over the length. At end points, the sheets can be rotated 90° out of the plane. This allows partial tracking of the OPV modules and creates different viewing angles. To simplify the rotation, the paths are grouped in 5 areas. The partial roofing opens up additional possibilities of perception of the OPV in the overhead area.

Fig. 3: Daniel Huuck / Alexis Lode, model 1:50

Benedikt Buchmüller and Quirin Stammler extend the framework over two floors and beyond the alignment of the building. The length is determined by the shading of the north-east façade and that the external effect is increased, as the façade is thus also perceptible from the north. In addition, an "inviting gesture" to the main entrance is created and the access to the underground car park is separated from the pedestrian access. The tracks of the solar foils are fixed at the height of the floor ceiling and can be rotated by 45° in both directions by means of two movable holding points. (Fig. 4)

Fig. 4: Benedikt Buchmüller / Quirin Stammler, rendering

In the "Square" concept by Peter Simon and Benedikt Zarschizky, the primary construction forms a square frame that ends at the height of the attic of the three-storey main building. An orthogonal cable net is stretched between the edge beams, to which the OPV modules are fixed in vertical stripes. Different square surfaces are generated with colour variations, which create a nuanced internal division. (Fig. 5)

Fig. 5: Peter Simon / Benedikt Zarschizky, rendering

Marjhonelly Concepcion and Nicole Polster chose a different approach. They lay the solar films as horizontal strips around the three façades of the front section. Their "copper coil" concept refers to the ZAE Bayern logo. Horizontal sliding shutters, also fitted with OPVs, can be installed in front of the glazing on both floors to adjust the use of daylight and visibility as required. To stabilise the sheets, they are held in position field by field by springs on tensioning ropes. (Fig. 6).

Fig. 6: Marjhonelly Concepcion / Nicole Polster, rendering

2.2 Planar / point-like façade structures

The "squameus" concept by Julia Credé and Astrid Pümmerlein was inspired by the roofing of a terrace at the AA School of Architecture in London. Two curved girders are placed at an angle in front of the south-west façade and run across the flat roof terrace. Folded plastic foils with integrated OPV modules are attached to the diamond-shaped stainless steel cable net stretched between them. The OPV modules are arranged closer and closer to the roof. (Fig. 7)

Fig. 7: Julia Credé / Astrid Pümmerlein, model 1:50

The reference for Gözde Gürbüzler and Lisa Stapf is another realized project. The façades of the extension of the King Fahad National Library in Riyadh (2014) form a spatial zone of curtain-type, three-dimensionally shaped fibreglass membranes, equally elegant construction and efficient sun protection. For the ZAE building, this approach is varied in such a way that the membrane façade to the south-east is formed at a lesser depth, while to the north-east the aim is to create a three-dimensional spatial effect. The OPV modules are placed in horizontal strips on the sun sails, which are clearly spaced in the field of vision in terms of density. (Fig. 8)

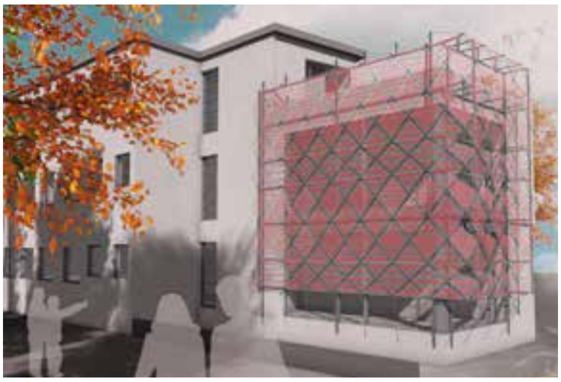

Fig. 8: Gözde Gürbüzler / Astrid Pümmerlein, rendering

Antonia Bader, Stefanie Matthäi and Dominic Weinstein present the post and beam construction with vertical steel tubes in a half façade grid, on which triangular frames are arranged offset to each other and rotated by 45° from the plane, which also creates a spatially attractive effect. (Fig. 9) Robert Braun and Theresa Ketisch also position the OPV screen directly on the existing front section, but lay the frame construction with a square grid completely over the two façade areas. Three different sizes of the OPV modules, which are suspended over the diagonal, are a response to the different requirements in the façade zones.

Fig. 9: Antonia Bader / Stefanie Matthäi / Dominic Weinstein, rendering

Fig. 10: Tessa Distler / Merve Tufan, rendering

Tessa Distler and Merve Tufan in turn divide their construction, which is put in front to the south-east façade as a three-storey structure, into nine almost square sections. The horizontal cables of the hexagonal netting in front of it are also covered with hexagonal foils, each with three diamond-shaped OPV modules. (Fig. 10)

Leaf-like structures show the projects of Lisa Prokein and Lisa Schreiber as well as Giulia Rudloff and Katarina Sokac. In the former, a fine net of vertical steel profiles is attached to the supporting structure, on which folded solar foils in six different sizes are alternately fixed, which additionally creates a shimmering appearance through variation in the arrangement. (Fig. 11)

In their "Plug-in Leaf" concept, Rudloff and Sokac stretch steel cables between the wall of the underground car park exit and a beam which rests on brackets at parapet height on the eastern corner of the front section. Three differently abstracted formats (based on leaves of oak, Norway maple (Fig. 12), hornbeam) are attached to

Fig. 11: Lisa Prokein / Lisa Schreiber, model 1:50

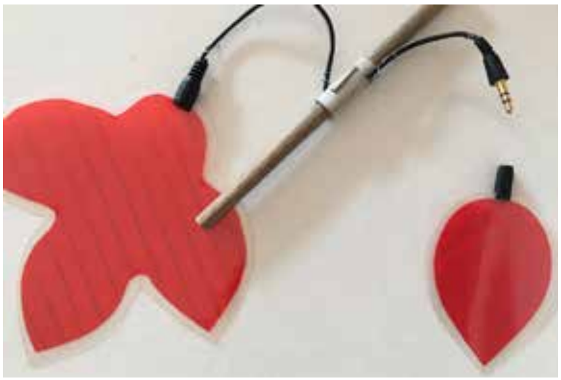

Fig. 12: Giulia Rudloff / Katarina Sokac, model 1:2

these by means of thin, slightly bent metal tubing, which also includes the cable duct. In addition to the rotation of the surface between the base and the top of the construction, a very small but "natural" solution is created in the interplay of light and shadow, with advantages when replacing the modules.

Free forms, which are placed between the heterogeneous parts of the building, are chosen by two teams. Simone Baiz and Josefine Raab stretch a cable net construction over the south-east and north-east façades, in the meshes of which square modules of varying density are inserted. (Fig. 13)

In contrast, Kevin Beierlein and Fabian Holzer place a supporting structure with repeatedly spatially curved edge beams in front of the two façades of the head building. A plastic film is streched between them, curved in the same and opposite directions, as a carrier material for diamond-shaped OPV modules. (Fig. 14)

3 (INTERIM) CONCLUSION

Considering the search for quality standards and competent decision-makers in the field of building-integrated photovoltaics (BIPV), architects – and planners – are primarily called upon to develop new solutions. This still means that the profession has to deal much more with the "progress in technology and science for an integral, future-oriented and resource-saving building" (Helmut C. Schulitz) [5].

With regard to Generation Y or Z, it is not only in the face of student strikes for the climate said, that "concern for the environment is politicized" and "sustainability is modern".[6] Therefore, students play an important role tointerest architects in the multifunctional and design potential of photovoltaics. Even if topics such as BIPV

Fig. 13: Simone Baiz / Josefine Raab, model 1:50

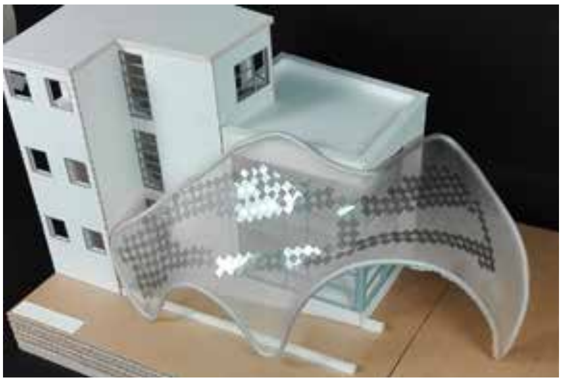

Fig. 14: Kevin Beierlein / Fabian Holzer, model 1:50

continue to receive little attention in the curricula of architecture faculties, seminars such as "OPV Façade for the ZAE Building in Erlangen" show how curiosity and creativity can be successfully activated. [7]

In the end, the concepts developed did not always meet the requirement of planning a solar façade as a lighthouse project and research object with simple means, but in the occupation with interesting references and their adaptation, the designs, which also include in-depth structural engineering, show consistently functional and aesthetically appealing solutions for a striking sign of advanced energy research.

Students teams

Moritz Bachmann, Sven Vorliczky / Antonia Bader, Stefanie Matthäi, Dominic Weinstein / Simone Baiz, Josefine Raab / Kevin Beierlein, Fabian Holzer / Robert Braun, Theresa Ketisch / Benedikt Buchmüller, Quirin Stammler / Marjhonelly Concepcion, Nicole Polster / Julia Credé, Astrid Pümmerlein / Tessa Distler, Merve Tufan / Gözde Gürbüzler, Lisa Stapf / Daniel Huuck, Alexis Lode / Lisa Prokein, Lisa Schreiber / Giulia Rudloff, Katarina Sokac / Peter Simon, Benedikt Zarschizky

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[3] Meanwhile Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (HI ERN). http://www.hi-ern.de/hi-ern/EN/home.html <07.08.2020>

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