Innovative German Approaches in BIPV

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Introduction

Architects', project developers' and clients' attitudes toward building integrated photovoltaics (BIPV) have changed considerably in the last nine years. There has been a dramatic development towards building integrated photovoltaic applications in Germany especially since the German government decided to apply BIPV on most of the new governmental buildings in the newborn German capital Berlin.

BIPV has given up its meaning as only being an ecological symbol. It has become a very sophisticated and prestige-building matter. In the nearest future BIPV will be looked at like marble, high-grade steel and sophisticated glass-facades. Clients, like banks, assurance companies, tourist enterprises as well as public institutions and residential's owners have begun to understand that applying BIPV means following the mainstream of modernity, ensuing the latest architectural developments, combining ecological consciousness with the demand for ambitious Hi-Tech solutions. BIPV is helping clients to build up their corporate identity and showing they have recognized the mood of the times.

Building integrated photovoltaic systems must be distinguished from ordinary photovoltaic systems. Whereas ordinary photovoltaic systems only serve the aim of producing power by converting sunshine, BIPV systems follow the idea of using much more advantages of these Hi-Tech photovoltaic systems.

BIPV systems can be placed on top of roofs, either as tracking or non-tracking systems, they can also replace a complete building' roof cover and become the building's fifth facade. BIPV roof systems improve the optical appearance of a building's top as a mounting assembly or as fully integrated roof systems. Both, roof and facade integrated BIPV systems are focusing on the multifunction of PV facade elements in the building envelope adding a design flair but also meet all requirements demanded from a conventional facade, like heat-insulation, weather-protection, sound-insulation, fire-protection and aesthetics. Semitransparent modules create very nice lighting patterns inside and give people a very pleasant atmosphere to live in.

What shall not be overlooked but emphasized again is the fact that using BIPV architecture is an image-building factor for companies and public institutions. Many German BIPV users have shown how successful their buildings can be marketed as part of their company's corporate identity.

The following article will have the reader become familiar with some sophisticated and innovative German approaches in BIPV.

Office of the Federal President, Berlin

Fig. 1: *Bird's eye view onto the Office of the Federal President*

One of the most prominent examples of BIPV in Berlin is the system on top of the Federal President's office with a nominal power of 44 kWp. This system started its operation on November 23rd 1998 and is an example of a perfect roof integration. The new construction of the office is 83 meters long, 41 meters wide and 15 meters high. Its upper surface area is dark, polished granite.

The blueprint of the new office was determined by its solitary position to the neighboring Bellevue Palace and the surrounding Park. In regards to this ensemble the surface of the roof plays an important role, because the building can only by means of this roof surface area be experienced as a whole. In conformity with this the surface has been dealt with in the sense of an overall integration of the facade to the building.

The architects' intention was to extend the visual line of the square windows on the roof by having small steel beams run perpendicular to the modules. Following this guideline 144 individually curved modules were produced, perfectly fitted to the roof as elliptic shape. The modules interfaces at the edges of the attica and the maintenance corridor take on the elliptical form. The have the same optical appearance as the other modules, are, however, only in part electrically in operation. Each of these modules had to be designed and manufactured individually. In addition, the challenge of optimizing the connecting concept while limited system losses due to the shadow from the beams and the attic around the roof, was successfully met.

Paul-Löbe-Haus

Fig. 2: *Bird's eye and detail view onto the Paul-Löbe-Haus*

In the course of the German government's move from Bonn to Berlin approx. 20 BIPV systems have been installed so far. The biggest system among them, the Federal Lower House of Parliament, is the so called Paul-Löbe-Haus. This building houses offices of the federal elected officials as well as the meeting halls of the Federal Lower Parliament Commitee. In many respects this project stands out against other BIPV systems as an outraging example of BIPV.

This PV system represents an outstanding example of photovoltaics: it is the world's largest thin-layer system (123 kWp) integrated into a building made of amorphous silicon, the world's largest system made of semitransparent PV modules in form of roof lamellas, and one of the largest directed shadow voltaic systems in existence. It started its operation in January 2001.

The central hall runs the length of the entire building complex. This hall is covered by a 5.500 m^2 saw-tooth glass roof. 6,048 semitransparent PV lamellas were installed above this class roof. The lamellas serve as active element of the covering of the building as well as producing power and the control of the light and heating conditions within. Facing south, they are directed toward the sun by a single axle.

The PV lamellas are integrated into the screen-form metal construction above the glass roof. The unique thin-layer switching system within the individual lamellas was made necessary by the shadows of the metal construction and the shadows produced by the positioning of the modules beneath one another. Shading occurs often because of the architecturally required sinking of the lamellas within the metal screens. This put serious demands on the module layout and on the system technology. The lamellas were built from three raw modules of amorphous silicone, which are embedded in a glass-on-glass laminate. The semitransparency (10% transparency) is achieved by a fine screen of laser lines.

Jakob-Kaiser-Haus

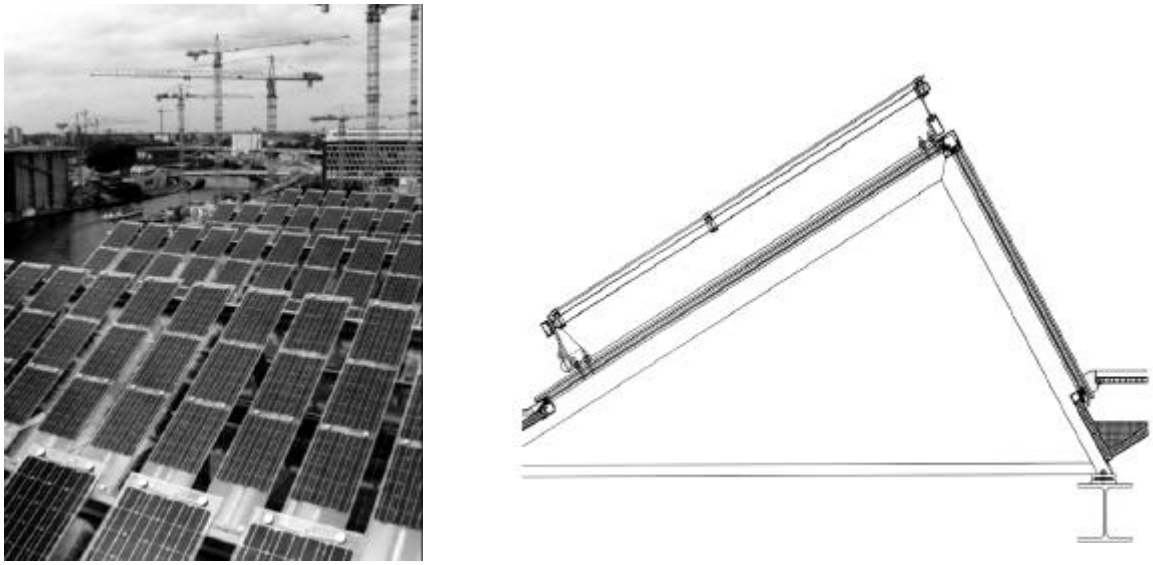

Fig. 3: *Bird's eye view onto the Jakob-Kaise-Haus and construction scheme*

As a visitor to Berlin you should not miss taking a sightseeing tour through Berlin on one of the tourist boats on the river Spree. You will pass the German Reichstag und have a look at the the Jakob-Kaiser-Haus where at its top a very Hi-Tech BIPV-system has been placed.

The Jakob-Kaiser-Haus is located in the immediate vicinity of the Reichstag and will house the federal office of representatives after start of operation. The total capacity of the system is 45 kWp of which 28.1 kW directed on a single axle. The photovoltaic installation consists of two separate components which were erected on two different sections of the building.

Section 1 of the installation was realized above a glass saw-tooth roof. The photovoltaic lamellas afford shade in addition to their primary function of providing energy. In order to achieve an optimal yield from the installation and to ensure the use of the sun screen for every position of the sun, the lamellas are directed to the sun on a single axle. This increases the output and enhances the structure's visual aesthetics. The photovoltaic lamellas determine the essential character of the roof space and the visual atmosphere of the building's interior.

Section 2 of the installation was installed on a pergola above a green roof garden. The 140 modules are composed of partially transparent construction. High-efficiency monocrystalline solar cells are used, which guarantee maximum yield of solar energy.

Fig. 4: *Bird's eye and detail view onto the Paul-Löbe-Haus*

New construction of the Forum for Tradition and Vision of AUDI Corp. in Ingolstadt

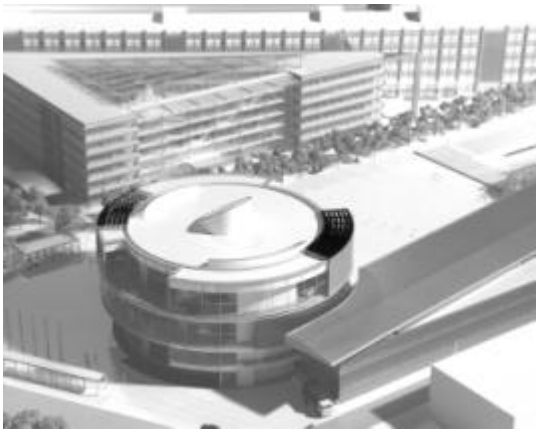

Fig. 5: *Model of the building and view onto the realized module integration*

The automobile industry has discovered Hi-Tech BIPV as an image-building factor in the field of marketing. Here, the German manufacturer AUDI plays a pioneer's role.

The AUDI Corporation in Ingolstadt planned a representative four-storey, circular building on their plant property in accordance with the guidelines for new and renovated construction. Several areas of the site are designed for exhibition space and will be used for special displays and presentations.

The circular steel frame construction is completely glazed and enclosed by a free standing tie-beam glass facade. A sunshade being planned is designed to shade the floor plan from direct sunlight.

The protective shield of perforated plate construction covers approximately one quarter of the circular facade, and is made mobile by means of a guide rail and is automatically directed according to the position of the sun. The load bearing construction extending beyond the roofline was fashioned so that a laminate photovoltaic installation could be integrated within the mobile circular segment.

The special 112 glass-on-glass modules (10,8 Kwp) are suspended in the specially enclosed chassis within the stationary, radial metal construction. The operation started in fall 2000.

Since the complete system can be viewed from below at certain times of the day with its two individual mobile carriages, the realization of the module-integrated construction was given special consideration in order to make it compatible with the total architectural concept.

Clinical Molecular Biological Research Centre, Erlangen

Fig. 6: *Façade of the Clinical Molecular Biological Research Centre with two BIPV solutions*

At the western facade of the Innovation Center for Environmental Technology in Erlangen, Bavaria, first photovoltaic modules have been integrated into shading columns with optimal sun exposure. The gray colored cells match the architectural design of the building facade. This existing photovoltaic facility of the Clinical Molecular Biological Research Centre in was expanded with a shadow voltaic installation in the south facade.

Altogether, 140 custom glass-on-glass modules were arranged in 14 linear string segments optimally positioned for light exposure in front of the fire escape. The partially transparent, point-mounted PV modules are laminated onto the supporting plate glass by means of a grid-point screen form so that the light absorption also affords the most effective shading for the office interior.

The installation is composed of three system segments, each of which, shading the upper part of each of the three floors, offers an open view from the offices. The glass lamellas are freestanding without the interference of torsion bars, and are supported on cast aluminium consoles in fitting colours. The solar modules are driven by 15 linear drive motors dependent on external light and which are continually directed on a single axle towards the position of the sun. In this way, an optimum incidence of daylight, sunshade and photovoltaic energy production are achieved. Being opposite the rigid structures of the facade, the efficiency of the warmth yielded is increased dramatically along with the solar power output.

The entire installation is composed of 5 SOLON inverters in the interior of the building, precisely accompanied by the comprehensive measuring technology of the University of Erlangen.

Service Pavilion, Resort Island Steinhuder Lake

Fig. 7: *Bird's eye view and illustration of constructive use of pv panels*

The field of tourism seems to have the biggest potentials for future applications in the field of BIPV. A German private developer built a tourist service center, replacing the roof-cover with PV modules. The unique architectural solution draws the attention of thousands of tourists every month.

The service pavilion and boat dock with integrated loading station for solar catamarans on the resort island in the Steinhuder Lake are supplied with regenerative energy which conserves power.

Altogether 110 solar modules (16 kWp), which are integrated into the roof, along with a coleseed block-heating power station, deliver ecological power to the buildings.

To cover any possible higher than normal energy use as well as to deal with excess solar power, the building is connected to the public utility system.

The warm water requirements for showering and in the Bistro kitchen were met by three vacuum pipe collectors as well as the radiant heat from the block heating power station (power-warmth-coupling). The energy concept was designed by SOLON Corporation working as general contractor.

The integration of the solar technology into the architecturally arresting wooden construction has lent the building special optical interest. The photovoltaic elements comprise a total of 155m^2 which replace the previous covering. Daylight is allowed into the interior of the building through the PV elements due to their transparency, so that the artificial lighting can be drastically reduced.

The architects received the "Next L.A. Design Award" for the design of the service pavilion.

Conclusion

It might have become clear that the photovoltaic technology has still potentials which are from being exhausted. Architects are called upon to come up with new ideas and challenges for the photovoltaic industry which is awaiting their proposals.

Abstract

The article gives prove that German architects', project developers' and clients' attitudes toward building integrated photovoltaics (BIPV) have changed considerably. BIPV-systems on new German government's buildings are presented in that article. Clients, like banks, assurance companies, tourist enterprises as well as public institutions and residential's owners have begun to understand that applying BIPV means following the mainstream of modernity, ensuing the latest architectural developments, combining ecological consciousness with the demand for ambitious Hi-Tech solutions. BIPV not only subtitute or complement traditional building material like steel, glass, wood and stone. BIPV is also helping clients to build up their corporate identity and showing they have recognized the mood of the times. The article concludes with an innovative BIPV application: a tourist resort with a grid-independent supply potential, an appeal and a challenge to the tropical and ecological targeted architecture.

Keywords

Photovolatics

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Solar Applications (SOLON AG)

Architecture

Tourism

Facades

Curtain walls