

All-rounder PV - Strategies for Building Integration and Multifunctional Use of Photovoltaic

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ABSTRACT: The results of the described research give an introduction to the design and implementation planning of building integrated Photovoltaic and the potentials for their multifunctional use. Photovoltaic can't only generate electricity out of light. Additional functions, which can be covered by photovoltaic systems, are for instance shading, electromagnetic energy conversion, electromagnetic shielding effectiveness, design, heating, climatisation, sound insulation, security, heat insulation, weather protection and screening form view. Regarding the cost effectiveness of Photovoltaic installations these functions may play an important role. Therefore they should be considered and used consciously during the planning of installations. It is important to include the cost savings, which can be generated by the multifunctional use of photovoltaic components, e.g. by shading or weather protection, in the calculation of profitability. The integration of Photovoltaic in buildings should be considered as early as possible in the design process, desirably already during the preliminary draft. This is facilitating positive interactions between the specific building design and the efficient photovoltaic use of solar energy, including for instance also the use of preferably large south-orientated building surfaces which are not shaded by building components or buildings. An integrated planning process facilitates the development of optimal solutions regarding the design, the function and the profits of buildings with integrated photovoltaic generators. The requirements for the integration of Photovoltaic in the building design affect particularly the subject areas "appropriate surfaces in facades and roofs", "integrated design with Photovoltaic and available components" as well as "building types and structural boundary conditions".

Keywords: building-integration, component, design, multifunctional, photovoltaic

1. INTRODUCTION

At first glance, photovoltaic systems have the function to dissipate daylight - especially the high-energy direct solar radiation - in electric energy. This is true for photovoltaic-systems on open-land as well as for systems which are integrated in the building envelope – in façades, roofs and additional components. [1]

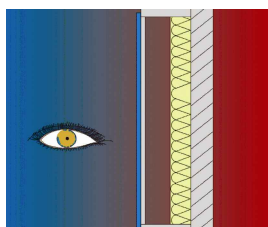
Multi-performance for additional use is based on the physical properties of the PV-component “module”. Especially components, which are used for the substitution of common assembly parts, do include such multi-functionality. Such PV-components can be differentiated in bending-resistant (e.g. glass/glass- and glass/film- modules) as well as flexible parts (film-modules). At present, the assembly of PV-constructions in building envelopes is mostly carried out comparable with common components of so called glass architecture, with screwed, jammed or bonded splices on substructures, which are fixed on parts of the building, e.g. columns, slabs, outside walls, balconies or roofs. [2]

The subsequent mentioned functions of photovoltaic components are not always considered during the planning of building-integrated photovoltaic constructions. But they play, or can play, a significant role concerning the profitability of such constructions, if they would be used accordingly. Their applications and functions are depending on specific basic conditions, which can be assigned to specific building types. Besides the generation of electrical energy photovoltaic can achieve the following functions:

- Blinds
- Climatisation and efficiency
- Design
- Electro-magnetic energy conversion
- Electro-magnetic shielding effectiveness
- Heating
- Security
- Shading and light direction
- Sound insulation
- Thermal insulation
- Weather protection

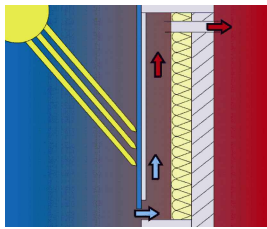
2. MULTIFUNCTIONAL PHOTOVOLTAIC

2.1. Blinds



The appearance of PV-modules with semitransparent amorphous cells is dark and reflective from the outside but lucent from indoor during the day. Therefore they present one-sided blinds. Glass modules (outside). The transparency depends on the size and the distance of the chosen single photovoltaic cells to each other. Opaque PV-modules screen the components behind completely from view.

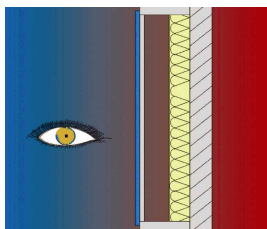
2.2 Climatisation and efficiency



The absorbed radiant heat of rear-ventilated PV-modules in facades and roofs can be utilized as thermal energy. At the same time an electric efficiency increase of the PV-modules occurs, caused by the cooling effect of the rear ventilation, so that it is possible to achieve energy balance, if the systems are expert designed and elaborated. That is, one could get a warm and pouring airflow free of charge, in case of an optimized rear-ventilation in spring and in transitional seasons

respectively. The thermal energy can be used for the heating of indoors. In summer the airflow would reduce the thermal load of the outer skin.

2.3 Design



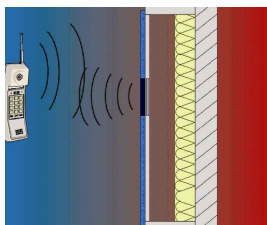
Photovoltaic cells and modules are important design elements. They should be used in a sensible way and be integrated

in the building design, based on architectonic considerations in all applications, as components as well as for the primarily use as electric generators. According to the specific architectonic concepts and desired optical effects, PV-components should be considered during early building design phases. The look of PV-modules is dependent on the cell type (amorphous or crystalline), the cell structure (opaque or semi-transparent), the transparent cover (glass or plastics) and where appropriate a frame. Modules with amorphous as well as crystalline cells are available in many different designs and colors.



Illustration 1: Photovoltaic facade of a University building in Germany (left) [FHS Siblik] and a redeveloped residential building in Germany (right) [Rheinznink].

2.4 Electro-magnetic energy conversion



Specially designed PV-modules can be used for electro-magnetic energy conversion. These can be used e.g. for sending and receiving high-frequency signals for mobile phone communication. Solar planar antennas have been developed first in Germany in 1999 and were

presented internationally in first pilot projects. Such building-integrated solar planar antennas can function as so called repeater-antennas in aesthetically challenging areas with poor reception (e.g. dead-spots in areas of multi-story buildings).

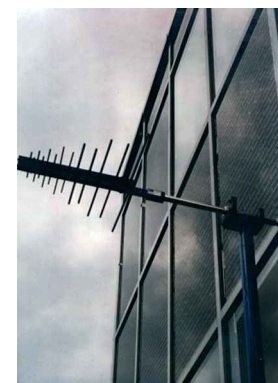
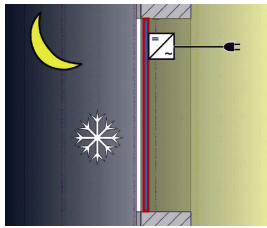


Illustration 2: Solar planar antenna: Design of a telecommunication route between a field-gauging-station and planar antenna in the area of a buildings attic. [ISET]

2.5 Heating



In general, the application of roof lights in inside courtyards requires also the application of heating devices near the glazed areas in the ceiling, to avoid the circulation of cold air and the generation of condensed water on the insides of the glazing. This effect

should be avoided by the utilization of new insulated glass (e.g. triple glazing) with low thermal transmission coefficient. Thereby it is always required to scatter the direct sunlight to enhance the illumination of the indoors underneath and to avoid their overheating during hot seasons. Low cost solutions are based on the application of transparent coatings of paint.

If those skylights are substituted by special semi transparent PV-modules, they can produce electricity with solar radiation and shadow indoors underneath during the day. During the night and during cold outside temperatures they can avoid the circulation of cold air and the generation of condensed water on the insides of the roof lights, by feeding-in of reverse current in the PV-components and the resulting heating of the glass component.

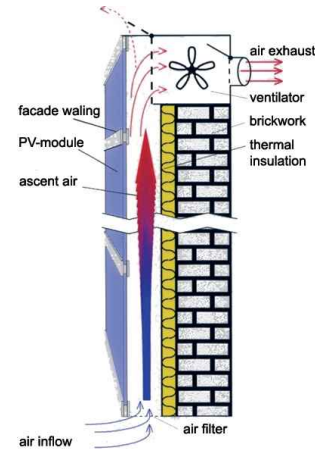
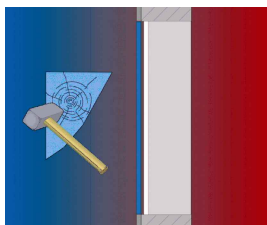


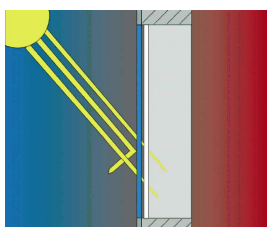
Illustration 3: Schematic Diagram of a rear ventilated PV-Façade. Investigations on a test-façade reconfirm a balanced energy balance between the generation of photovoltaic current and the increase of efficiency by simultaneous cooling of the rear side of photovoltaic components. The product is warm pouring air, which can be used for climate control [1]. [ISET]

2.6 Security



PV-modules can incur the function of laminated safety glass due to the laminated assembly of toughened glass and foils. Additionally the electrical network of the photovoltaic modules can be used as an electric loop for a burglary safeguard.

2.7 Shading and light directing systems



In transparent glazing (single, double or triple glazing) PV-cells adopt the function of shading elements. The degree of shading can be decided by the different arrangement of cells in the module, or by the use of more or less transparent cells (crystalline or

amorphous). Thereby, the degree of transmittance is arbitrary, e.g. between 10 and 90 %.

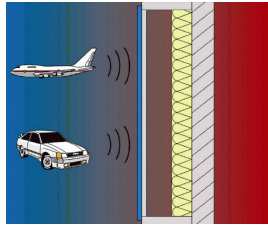
PV-modules in outside shading devices (e.g. light shelves, reflective blinds or prismatic components) adopt the function of shading for glazed building apertures, facades and roof



Illustration 4: PV-shed-roof: Photovoltaic shading (90%) with 10 % light entry by semitransparent amorphous pv-modules, which are integrated in the south orientated double-glazed shed-roof areas in the lounge of the local court in Kassel, Germany. [ISET]

surfaces. Additionally they can adopt certain light directing and redirecting functions to supply indoors with diffuse and reflected solar radiation.

2.8 Sound Insulation

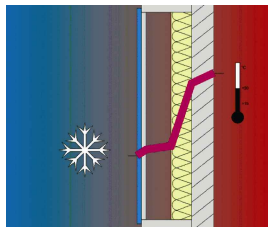


Photovoltaic components in facades, windows and roofs contribute to the sound insulation, due to the laminated assembly and the good sound absorbing properties. The multi-layered sandwich body of common photovoltaic components can reach a sound reduction index of up to 25 dB.



Illustration 5: Sound insulating wall with PV-modules at a motorway. [Kohlhauer GmbH]

2.9 Thermal Insulation



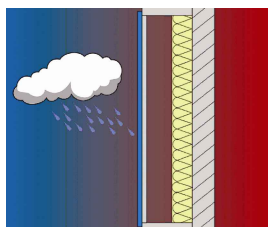
Insulation glass with integrated PV-cells, e.g. in windows, glass-facades and roofs, contributes to the heat insulation of buildings. These components meet all civil engineering requirements (like components with conventional insulation glass), and additionally they produce electricity.

PV-modules contribute to the heat insulation of buildings in extensive rear ventilated assemblies, in front of exterior walls and on roofs, as well as in rear ventilated facades as façade siding. "Intelligent" rear ventilated curtain type PV-facades use the air volume for thermal insulation (non ventilated state) or heat removal (ventilated state), using appropriate measurement and control technology.



Illustration 6: Roof integrated skylight out of insulation glass components with semitransparent amorphous PV-cells in a showroom in Germany. [Glaswerke Arnold]

2.10 Weather Protection



Photovoltaic components as water and wind-tight outer skin adopt the weather protection of roofs and facades. In rear ventilated roof and wall sidings the PV-components adopt the weather protection of the thermal insulation. Their assembly is equivalent to common glass components.

3. BUILDING INTEGRATION OF PHOTOVOLTAIC COMPONENTS

The building integration of photovoltaic should be considered as early as possible during the design process of a building, desirably already during the preliminary draft phase. This facilitates the use of positive interactions between the specific building shape and the efficient photovoltaic use of the solar energy and includes the use of preferably big, south-orientated

building surfaces, which are not shadowed by building parts or other buildings. However, an integration of photovoltaic is in most cases also possible and explicitly desired, if these criteria's can't be completely met. A basic condition therefor is an interdisciplinary cooperation of architects and specialist consultants for systems- and building services engineering and producers of photovoltaic components, preferably at an early stage.

An integrated planning process facilitates the development of optimal solutions regarding the design, function and the earnings of buildings with integrated photovoltaic generators. The requirements for the integration of photovoltaic in the building design of existing buildings as well as new constructions can be assigned to the subject areas: adequate areas in facades and roofs, integrated design of photovoltaic, as well as building types and structural basic conditions.

3.1 Economical Aspects

Economical aspects of building integrated photovoltaic installations include the costs for building and service as well as the profits, which can be achieved with the photovoltaic installations. Additionally financing and amortization influence the cost effectiveness of photovoltaic installations.

4. CONCLUSION:

In the past the main focus for the development of photovoltaic was initially on wafer-, module- and system-technology. Today it becomes more and more apparent that the skin of buildings provides ideal surfaces for the conversion of solar radiation in electric energy by photovoltaic. This particularly applies to the big available areas. The outcome of this is the need of a structural integration. Such an integration of new technology in buildings is one of the most exciting tasks for planning and designing architects. The integration requires the knowledge of specific criteria of these technologies, the technical, economical and structural as well as the artistic and formal. It is obvious that these criteria have to be considered already during the first design steps. Everything, which would be introduced later would lead to technical worse solutions and would cost more money. Already in the design phase two scopes of duties have to be bridged, the design of the photovoltaic installation and the design of the building, in which the photovoltaic installation has to assume an important function. Important therefor are components and systems, which have multifunctional properties and can be used as photovoltaic installations as well as components.

5. REFERENCES:

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