PV-Carport Systems as an Application for Thin Film Modules

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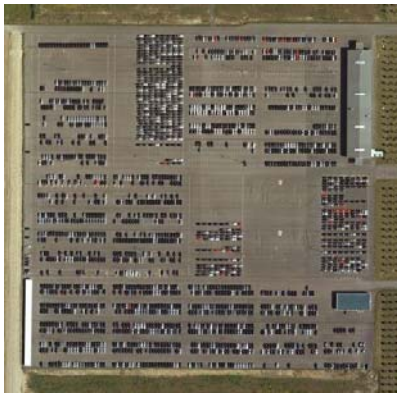
1. Introduction

In view of the tendency towards electric mobility, the expansion of the application range of photovoltaic plants to carports seems to be a future-oriented step. Also regarding the current decision criteria for the realization of photovoltaic projects that are mainly focused on the yields that can be gained by feeding in solar energy into the power grid, carports are getting more and more important in Germany, because the compensation for electricity fed into the grid for solar plants on roofs is also granted for carports if certain requirements specified in the Renewable Energy Law are fulfilled. An essential requirement for that is that the carports can also provide shelter for cars without being equipped with solar modules. This requires a water-leading roof cladding underneath the module layer. As a further precondition, the building site must be specified as a residential or business area. In case of companies and shopping centers it has to be made sure that the number of carports correlates to the actual need for parking spaces in order to avoid any allegation that the specific project could be mainly intended for the generation of solar power. This matter should be sorted out with the local energy supply company within the framework of the project planning. Besides house owners, the owners of big parking lots are also a potential target group for solar carports.


Single carport


Car delivery warehouse

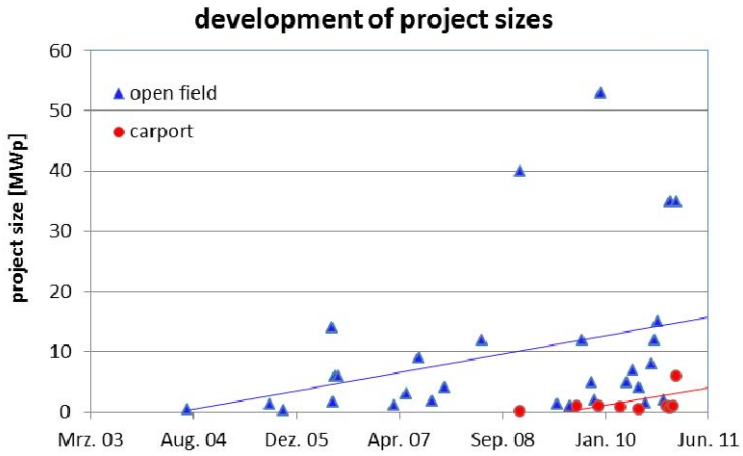

Special project on a parking deck

Picture 1: Product category for carport projects

Picture 1 shows the application cases of single carports and carports on big parking lots using the example of a distributing warehouse for new vehicles. Moreover, special projects on existing buildings are feasible, like in this case on the fifth deck of a parking house close to the exhibition grounds in Frankfurt.

Compared to typical open area plants, the mounting racks of carport plants have significantly bigger dimensions. Moreover, the utilization as a parking space for motor vehicles requires a defined clearance profile which means that there must be a bigger minimum distance to the ground. The inclination of the modules and the alignment of the carports are largely determined by individual aesthetic requirements and the layout of the parking lot. Low module inclinations and unfavorable alignments make the utilization of thin-film modules almost inevitable. Modifications of the support distances for the sake of cost reduction are only conditionally possible, as the dimensions of the parking spaces or a multiple of these dimensions (depending on the number of carports) have to be maintained. The disadvantages resulting from building law and geometric constraints and the potential extra costs resulting from the size of the mounting units have to be made up for by the compensation for electricity fed into the power grid, so that comparably attractive yields can be gained.

Picture 2 (Source: Schletter Solar Mounting GmbH) shows a selection of open area and carport projects for which the author of this report carried out the planning of the supporting structures. Even though open area plants started with plant sizes of less than 1 MWp in 2003, projects kept getting bigger in the following years. The regression line clearly highlights this tendency. The first carport projects were realized in 2008. Also here, an obvious tendency towards ever bigger projects can be observed. In the fourth quarter of 2010, a carport plant with a total performance of 6.0 MWp was set up in Italy. The trend line showing the sizes of carport projects in picture 2 is almost parallel to the regression line of open area projects, which suggests that the developments of the project sizes are comparable. Carport plants as a project category started only 5 years later. But as carport projects mainly depend on the parking lot areas that are available for carport installations, it is to be expected that the curve will flatten earlier. Realistically, a project size range from 0.5 to 10.0 MWp can be expected.



Picture 2: Development of open area and carport projects

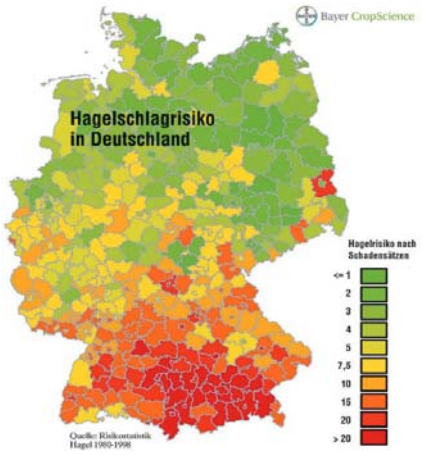
2. Intention for carport projects

Besides the generation of solar power, solar carports bring about a considerable additional value for the owner of the parking lot:

- Rain/snow protection
- Sun protection
- Hail protection (Picture 4)
- A basis for electric mobility

Experiences gained on the basis of already existing carport projects prove that people prefer carports on hot summer days with strong solar irradiation as well as on rainy or snowy days, even if the utilization of these carports goes along with longer distances to walk. In these cases, aspects of convenience lead to a high level of acceptance. Using the example of distributing warehouses of car manufacturers or parking spaces of car dealers, hail protection has to be pointed out as a decisive criterion, as it can bring about considerable reductions of insurance rates.
These are decision criteria that can justify the installation of carports even if only low yields from the generation of solar energy can be gained in certain circumstances. For retail shops, convenient parking spaces definitely can have a turnover-increasing effect, especially in view of the fact that the generation of solar energy improves the public image of a company. Picture 3 shows an electric vehicle at a charging pillar to give an idea of electric mobility in the future. The availability of opportunities to recharge electric cars (possibly for free) while shopping or working could be a decisive plus for the acquisition of customers or staff members.

Picture 3: Charging pillar for electric vehicles



Picture 4: Hail risk chart

3. General technical requirements

In the current market situation, carports may actually have a certain deterrent effect on potential builders due to the technical complexity of both the support structure and the execution of construction works. With exception of single carports and double carports on private ground, generally a construction licensing procedure is required. Depending on the project size, the simplified approval procedure can be chosen. Within the framework of the approval procedure, structural analyses of the carports and the foundation according to the current technical rules and standards have to be submitted, which have to be checked by an inspection engineer in many federal states of the Federal Republic of Germany. Regarding the technical rules and standards, the DIN 1055 for loads resulting from the self-weight of the construction, wind and snow has to be pointed out. A special requirement for carports that has to be mentioned is the verification against vehicle impact. Picture 5 exemplarily shows the utilization of pre-cast reinforced concrete components as a protection against vehicle impact.

Picture 5: Concrete foundation as a vehicle impact protection

Picture 6: Precast concrete part connection detail

Picture 7: Carports with an inclination of 25°

Picture 8: Carport with an inclination of 10°

In contrast to most solar plants on roofs of industrial buildings, aesthetic requirements have to be considered when carport plants are installed, and the fulfillment of these aesthetic requirements is even more important than yield parameters. Picture 7 shows two solar carports at the sides of an industrial hall with inclinations of 25°. It is quite remarkable that the height of the front edges of the carports is exactly on the same level as the roof top of the two-story building. In the example shown, the design is visually attractive, as the inclination of the carports corresponds both to the facade plant and to the roof plant. The photograph on picture 8 shows a view of a carport with a roof inclination of 10°. This design is visually balanced and can also be installed in residential areas or on parking lots with several rows behind one another.

4. System optimization

The mounting of the system including foundation is an essential aspect of the economic success of a solar carport plant. Compared to open are plants, the height of the load-bearing system is a clear disadvantage. Thus, a mounting progress that is at least comparable to the mounting progress with open area plants can only be achieved with pre-assembled system components and accordant lifting platforms and lifting devices. However, mounting takes almost twice as long. The pictures 9 and 10 show the installation of solar carports with surface foundations that are usually applied in the construction of buildings. When this technique is applied, the risk of lifting off or keeling over must be compensated by concrete weights. At the same time, the divergence in the foundation plane has to be limited within the framework of the normative regulations. This results in rather big dimensions of foundation elements that only are feasible when new parking lots are built. The paving operations shown on picture 9 give an idea of the foundation dimensions. Basically, this kind of foundation equals an inclusion of the parking lot.

Picture 9: Surface foundation (existing substructure)

Picture 10: Surface foundation (new foundation)

When micro-piles are used for foundation, profiled hollow piles are driven into the ground and grouting mortar is injected with a defined pressure through the drill bit. By this pressure, the grouting mortar is driven into the hollow spaces. As soon as the mortar has hardened, the concrete body will have a very uneven surface that will anchor in the soil like a root. Depending on the local soil conditions, the forces from the carport can be transmitted with anchoring depths ranging from 2 to 6 meters. Picture 11 shows the installation of a micro-pile using an accordant machine. In picture 12, a readily installed micro-pile after installation is shown.

Picture: 11 Installation of micro-piles

Picture 12: Suitable pile

After the insertion of the micro-piles that reach out about 60 cm over top ground surface, a pre-cast concrete unit is inserted and monolithically fastened by grouting. Already after one day, rack mounting operations can be started, as there are only little loads impacting on the rack at this stage and the mortar has a sufficient tightness. As the unavoidable interferences into the existing parking lot only have a very limited extent, micro-pile solutions are especially advantageous for this kind of application.

5. Design examples

The Park@Sol carport system by the Schletter solar mounting company GmbH described above has been installed in photovoltaic plants with a total performance of 20 MWp in the last years. In the following, some selected projects are portrayed and described. In picture 13, a 1 MWp carport plant close to the Lausitzring (speedway) is shown. In this pilot project, parking spaces for spectators were equipped with carports.

Picture 13: Carport plant with a performance of 1 MWp close to the Lausitzring

Picture 14 shows a kWp carport plant on the top deck of a 5-storey parking house close to the Frankfurt exhibition center. The essential characteristic of this project is that the carports had to be fastened to existing building structures. For this purpose, core drillings through the concrete layer into the supporting steel structure were carried out. According to the micro-pile principle, the pre-cast concrete parts were fastened using shear studs and grouting mortar. Picture 19 gives a first impression of our biggest carport project carried out so far – the carport plant in Piadena, Italy.

Picture 14: 0.8 MWp on a parking deck in Frankfurt

Picture 15: 6 MWp in Piadena Italy

6. Summary

In this essay, building law and building practice-related arguments as well as the expectations regarding future market developments are shown and analyzed, and these arguments back up the assumption that solar carport plants could become a new project category for large-scale projects. The increasing tendency towards electric mobility, the additional convenience of sheltered parking spaces and the image gain by the use of renewable energies open up a new prospect for solar carport projects that gives reason to expect considerably increasing demand in this project category.