

Case Study

Stainless Steel Tilted Solar Roof:
German Nautical Museum,
Stralsund



Project concept

The German Nautical Museum has an extensive collection of items relating to fishing and nautical research. The Nautineum, a branch of the Museum in Stralsund, was constructed so that large objects in the collection, including ships, could be exhibited.

The project brief called for an exhibition hall with an unconventional shape. The brief specified that sustainable materials should be used during both the construction and use of the building.

The concept of sustainable architecture suggested the integration of an energy-gaining system. The architects decided to integrate photovoltaic modules as multifunctional units into the stainless steel roof as a demonstration of the technology. The roof was tilted 45° to the south to maximise use of the available sunlight (see Figure 1).

Construction of the timber hall was completed in 2001. The tilted stainless steel roof, including the integrated photovoltaic array, is the main visual feature of the building (see Figure 1).

Stainless steel and the photovoltaic array

The photovoltaic array has a peak performance of 1.7 kW_P output power and is connected to the local electricity grid. The compound units of the photovoltaic system are stainless steel elements, partly laminated with flexible modules of triple-junction amorphous silicon solar cells. This building demonstrates the excellent construction and aesthetic possibilities for building-integrated photovoltaic systems in conjunction with stainless steel.

The combination of different functions in one compound unit is a proven method of economical building construction. It is also an important feature of architectural design. In other projects, solar energy devices are added as separate elements to roofs or facades. A better and more efficient method is to integrate the solar energy elements into roofs and facades as multifunctional compound units, as demonstrated in this building.

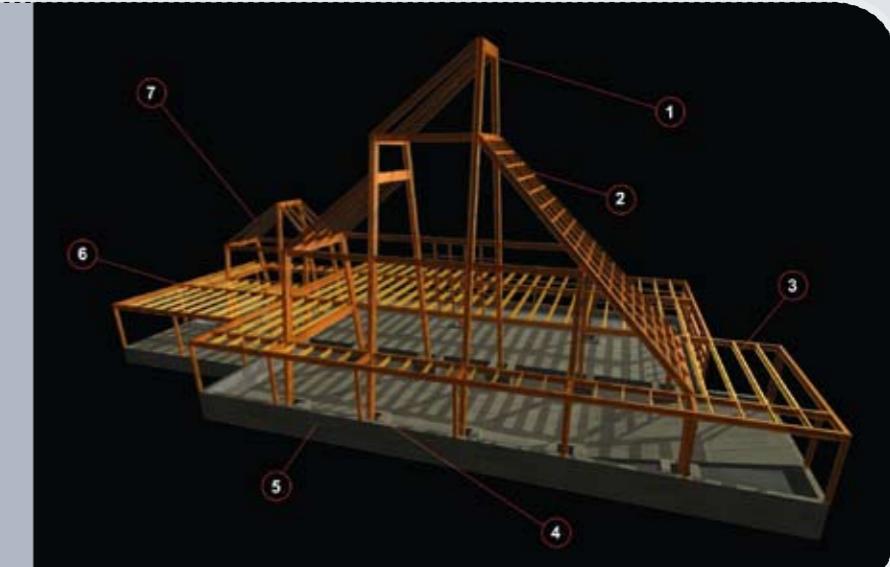
The advantage of integrating photovoltaic modules is that the compound system can be applied in the usual way, equally for both active and non-active photovoltaic elements. This includes all constructive conditions and connections to other parts of the building. The roof can be finished before the electrical system inside the building is completed.



FIGURE 1: The tilted stainless steel roof of the German Nautical Museum in Stralsund with integrated photovoltaic modules

FIGURE 2: Bearing structure of the Nautineum exhibition hall

- 1 Frame construction
- 2 Filler construction
- 3 System of timber beams
- 4 Foundation slab
- 5 Hole footing
- 6 System of timber beams
- 7 Frame construction



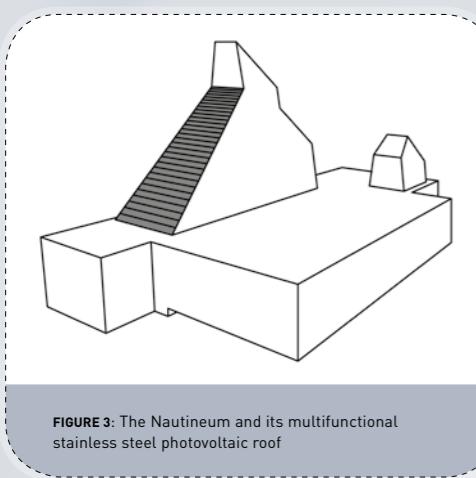


FIGURE 3: The Nautineum and its multifunctional stainless steel photovoltaic roof

Roofing concept and integration of the photovoltaic array

Natural ventilation is used in the exhibition hall and the space is not heated during winter. This meant a simple design could be applied to the facades and the tilted roof. The construction of the roof comprises particle board with bituminous sheeting. Multifunctional stainless steel photovoltaic compound elements are incorporated on the outside. The facades are made of larch boards on lathing, particle board elements and an inner particle board.

Multifunctional roofing elements are designed for constructive, functional and aesthetic integration. Flexible photovoltaic modules (about 40 per 400 cm) are added to 0.6 mm stainless steel roofing elements in a hot bonding process in the factory. It is possible to assemble the pre-fabricated elements on site using standard fastening devices. A tight roof can be produced in a very short time.

Cables for electrical connections are passed through holes in the stainless steel elements which are hidden under the photovoltaic modules. The adhesive also acts as a sealant so the hole does not impair the water tightness of the element, especially as this process is carried out in a controlled workshop environment. The connections can be finished in weather-protected conditions inside the building.

Because of the mechanical properties of stainless steel, the panels are just 0.6 mm thick. The weight of the photovoltaic roofing elements is low, virtually the same as that of roofing elements without a photovoltaic function. The low weight is advantageous for the design of the supporting structure.



FIGURE 4: Detailed view of the stainless steel tilted roof in Stralsund. Active photovoltaic sections (centre) can easily be combined with non-active ones (right and left).

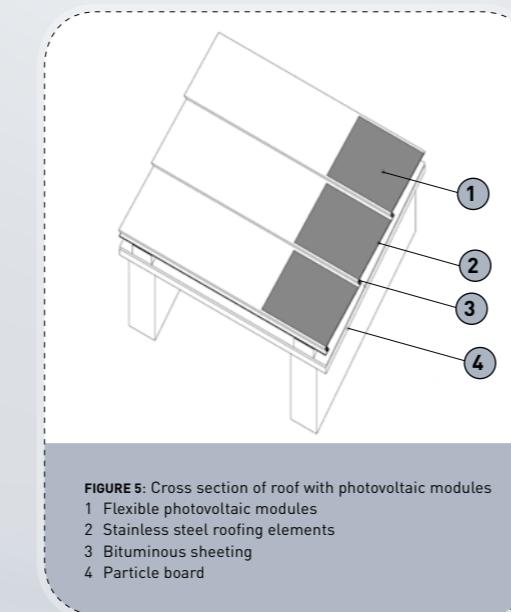


FIGURE 5: Cross section of roof with photovoltaic modules
1 Flexible photovoltaic modules
2 Stainless steel roofing elements
3 Bituminous sheeting
4 Particle board

Sustainability: materials and operation

Sustainability was an important consideration when selecting the building materials for the Nautineum. The load-bearing structure is a timber skeleton construction (see Figure 2). Columns and horizontal framework beams are arranged in the same plane and are connected by welded steel plates. Horizontal reinforcement of the structure is achieved by steel elements. Walls are made of timber panels while the outer layer of the facade is finished with larch boards. Larch is a type of conifer which is produced nearby.

Multifunctional stainless steel photovoltaic compound units may be single-leaf or sandwich elements. They consist of several layers, each of which has a different function (for example, heat protection and vapour barrier). In both cases the exterior is laminated entirely or partly with flexible photovoltaic modules. The module covers and protects the point where the cable enters the interior.

Multifunctional compound units, in this case including weather protection and photovoltaic energy gain, can be integrated into the roof in a very simple way. It is possible to make the entire roof an active photovoltaic surface, or to combine active sections with non-active ones. Besides its construction and aesthetic properties, stainless steel offers the advantage of excellent durability, especially in a marine atmosphere.

The combination of stainless steel roofing elements with integrated amorphous silicon photovoltaic modules allows a large variety of designs. For example, the roof can consist of sandwich elements in a horizontal arrangement, single leaf elements arranged ridge to eave, or sandwich elements arranged ridge to eave. It is also feasible to construct facades with almost the same multifunctional units.

As the exhibition hall is not heated in winter, the demand for energy is low. The main energy requirements are electricity for lighting, equipment and some other functions. The electricity is provided from the local grid. However, the building also feeds electricity into the grid from the photovoltaic demonstration array integrated in the tilted roof which is oriented to the south. Grid-connected photovoltaic systems are very popular in Germany. It is compulsory for the grid operators to buy excess electricity from the owner of the solar panels at a fixed price. Return on investment is ensured for the building owner.



FIGURE 6: Multifunctional photovoltaic roofing elements at the assembly stage

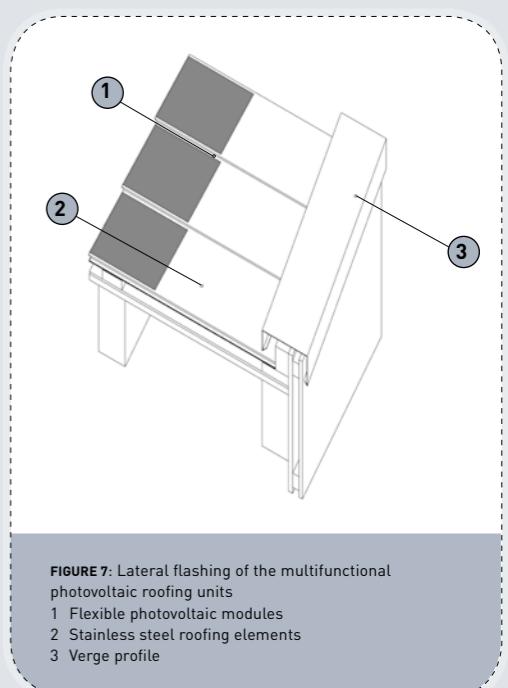


FIGURE 7: Lateral flashing of the multifunctional photovoltaic roofing units
1 Flexible photovoltaic modules
2 Stainless steel roofing elements
3 Verge profile

The photovoltaic modules are glued onto the stainless steel roofing elements in a hot bonding process at the factory. They are made in a roll-to-roll vacuum deposition process on a continuous strip of stainless steel. Together they form multifunctional roofing elements, which combine weather protection and energy production.

Blue, green and red light in the visible spectrum is absorbed by different layers of the cell. The different layers are only sensitive to a limited light-frequency range. The combination of three layers enhances the overall efficiency of the cells, especially at low levels of sunshine and in diffuse light.

Each module consists of 12 cells. The cells have a flexible stainless substrate that is 120 µm thick. The combined thickness of the three photovoltaic layers applied to the stainless steel is only 1 µm (see Figure 8).

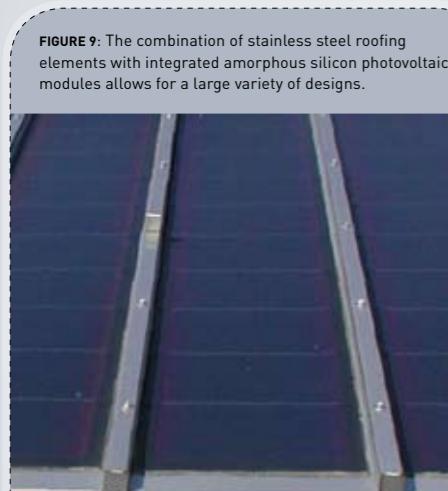


FIGURE 9: The combination of stainless steel roofing elements with integrated amorphous silicon photovoltaic modules allows for a large variety of designs.

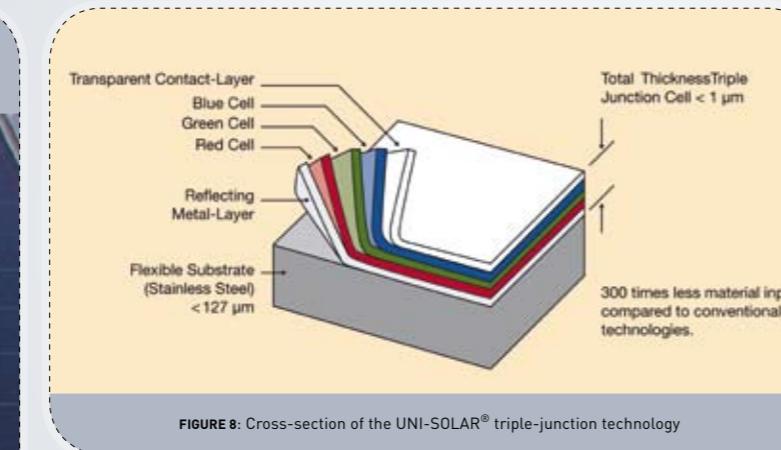


FIGURE 8: Cross-section of the UNI-SOLAR® triple-junction technology



Conclusion

Multifunctional stainless steel roofing elements combined with amorphous silicon photovoltaic modules are pioneering developments for sustainable and energy-conscious architecture. The technique can be applied to both roofs and facades, in residential buildings and in commercial or public buildings. The Nautineum building shows the excellent constructive and aesthetic possibilities for the realisation of building-integrated photovoltaic systems in connection with stainless steel.

Project data

LOCATION	Kleiner Dänholm, 18439 Stralsund, Germany
CLIENT	Deutsches Meeresmuseum, Museum für Meereskunde und Fischerei, 18439 Stralsund, Germany
ARCHITECT	AIC Mittelbach Architekten- und Ingenieur-Contor, 184335 Stralsund, Germany
ENGINEERS	BLS Energieplan GmbH, 17489 Greifswald, Germany Braeuer, Ingenieurbüro für Tragwerksplanung, 18435 Stralsund, Germany
MULTIFUNCTIONAL ROOFING ELEMENTS	United Solar Ovonic LLC, Auburn Hills, MI 48326, USA United Solar Ovonic Europe GmbH, 60487 Frankfurt/Main, Germany
TEXT	ThyssenKrupp Hoesch Bausysteme, 46047 Oberhausen, Germany
PHOTOS AND DRAWINGS	hwp – hullmann, willkomm & partner, 22767 Hamburg, Germany
	Figures 1 and 4: BLS Energieplan
	Figure 2: AIC Mittelbach
	Figures 3, 5 and 7: hwp – hullmann, willkomm & partner
	Figure 6: Hoesch Contecna
	Figure 8: United Solar Ovonic
	Figure 9 (top and bottom left): Hoesch Contecna
	Figure 9 (bottom right): Thyssen Solartec

