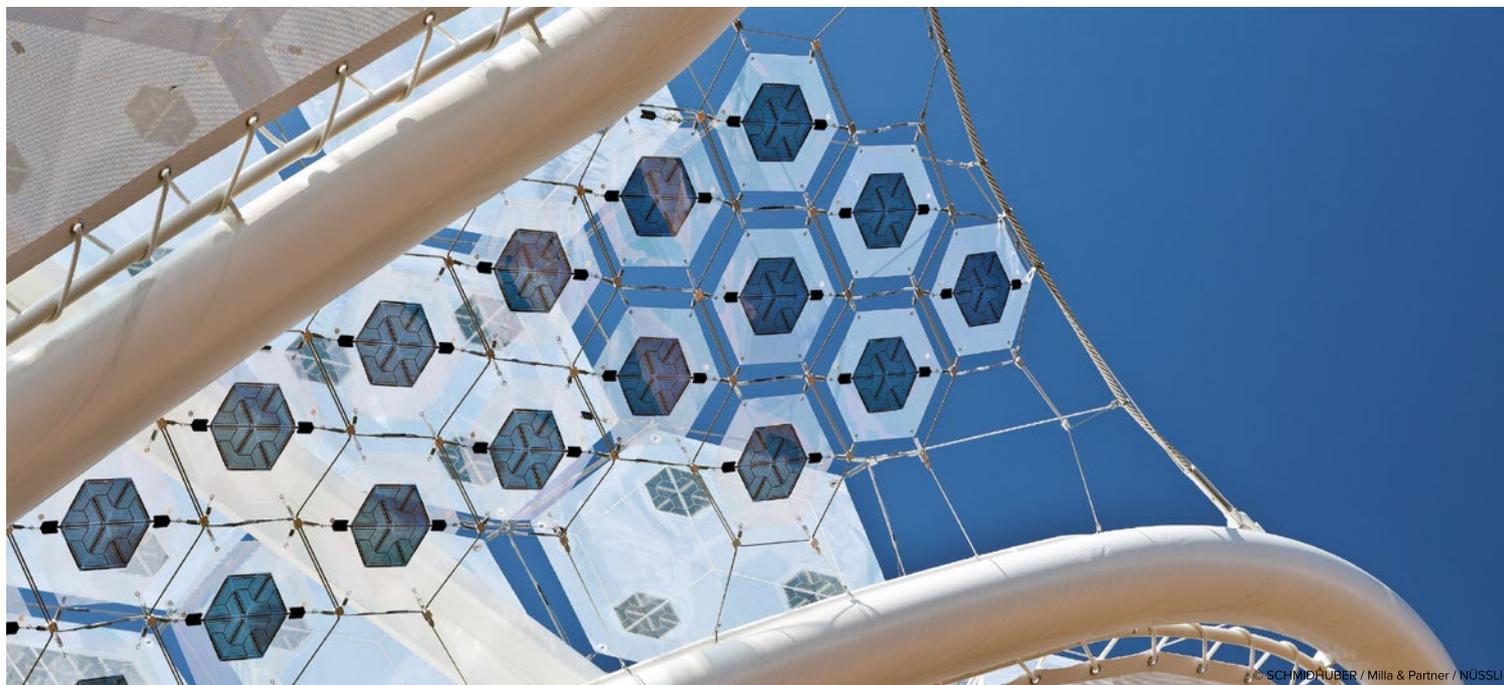


ORGANIC PHOTOVOLTAIC TECHNOLOGY AT THE GERMAN PAVILION

Delicate, Beautiful and Productive

Photovoltaic steel nets could soon be a feature in cities around the world



It sounds like science fiction: a feather-light solar generator hangs above a public space, its light, swaying form casting a pattern of shadows like leaves on a tree. But it's real: individual solar cells are suspended from a net of steel cables, generating electricity at the same time as casting shade on the space below and protecting it from the elements. And it's eye-catching, too.

This giant leap in solar technology uses flexible organic photovoltaic (OPV) modules on an extremely lightweight structural rig. Designers have the freedom to finally escape from the roof and walls of a structure and bring solar facilities into a three-dimensional space, with all the possibilities that come with it.

Visually Attractive



"You can use this technology to build solar generators on a parking garage, a bridge or a stretch of highway," says Lennert Wiechell. "This makes the structure more attractive at the same time as generating electricity." Wiechell is Managing Partner at the Munich design agency Schmidhuber, and is the lead architect for the German Pavilion at this year's EXPO 2015, which will be in Milan from May to October. His agency is responsible for the spatial concept and architecture as well as general planning.

A Wide Range of Possible Installations

Photovoltaic steel nets are incredibly flexible, and can be attached to the outside of buildings or in public spaces in a wide range of different ways. Covering a train station, square or courtyard or even a large open space – the possibilities are endless.

As well as generating electricity, the installation does not hinder the free use of the space beneath – quite the contrary. Depending on the details of construction, the solar roof can offer shade from the sun or protection from wind or other elements. And because of the lightweight construction and light, transparent and flexible solar cells, this net can cover an extremely large area.

Planning and Installation

When planning a photovoltaic steel net, it is vital to consider all the forces that will act on the structure: as well as wind, snowfall in winter must be considered. EXPO Architect Lennert Wiechell explains the main considerations in the design and construction of the Solar Trees: "We needed to take into account all of the forces that would act on the trees, and then design them in such a way that the shape of each tree acted in harmony with all the forces acting upon it. The largest impact on this project was certainly the wind."

This factor was important for the design of the steel trunk and branches of the tree – the solar modules were less affected by the wind. "Our structural engineers used special software to simulate how the membrane would behave under the influence of different forces," says Wiechell. "As the EXPO only runs for the warm summer months, we could ignore certain forces. For example, we didn't have to take snowfall into consideration."

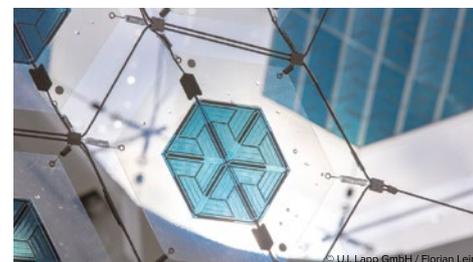
Building the Steel Net

The components for the steel net to support the solar cells are all made by specialist suppliers, sometimes made to measure. The net is suspended from masts or anchor points on pre-existing structures. First, a surrounding frame construction is attached – this can be made out of steel beams or steel cable with a diameter of 6 to 16 mm. Then, the steel net is mounted to the frame. The net can be designed with openings of different shapes and sizes: square, rectangular, triangular – even hexagonal, as in the current EXPO construction.

Special net clamps were developed to attach the solar cells to the net. In the EXPO project, each cable in the steel net has a diameter of 4mm, but for different projects the cables can be anything from 1.5 to 4 mm in diameter. In some areas of the net, the cables were doubled for structural reasons.

Mounting the Solar Cells

Each corner of the solar cell has a reinforced eye to attach a clip or a binding. At the EXPO pavilion, coil springs are used to connect each module to the net. As the OPV modules are mounted after the net has already been installed, the springs offer extra tolerance to make mounting the modules easier.

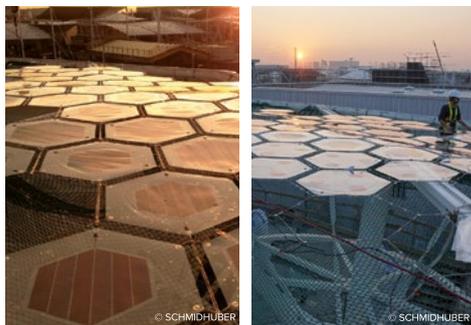


The first time this technology was used was in 2012, in an advertising tower for the energy provider Mainova in Frankfurt. Nine OPV modules were attached with clamps to vertical steel cables. For such applications, the modules need to withstand all different kinds of weather conditions, including UV radiation, wind, ice and snow. The modules also need to be kept under tensile stress, otherwise they could flap uncontrollably in the wind and rip at the corners. Furthermore, tolerance limits with regards to construction and installation must be met and cabling complimentary to the modules must be effectively integrated (Solartension GmbH, Stuttgart).

Lightning-Quick Installation

When it comes to installation, photovoltaic steel nets have another advantage: as shown with the EXPO project. "The installation was incredibly quick," says Lennart Wiechell. "The nets were pre-fabricated to the correct size and on the building site they just had to be spread out. We used cherry pickers to lift them up and attach them to the frame. Then the solar modules could be connected using the spring clamps." It was more practical to mount the net first and then the solar modules rather than fit the modules into the net and then fit the complete assembly to the frame.

OPV is Perfect for Lightweight Net



OPV cells are laminated between two sheets of transparent plastic, and are extremely light – ideal for mounting in a delicate net construction such as this. Unlike with traditional solar cell technology, the photoelectric element in OPV cells is made of a sheet of synthetic carbon compounds. This sheet is made in a machine press, and it offers excellent performance particularly in low-light or indirect light conditions. This means that the system can still generate electricity even if it is not perfectly oriented towards the prevailing light source.

OPV has remained a niche technology, as it cannot match the output of traditional, crystal photoelectric cells. The system performs with an energy conversion efficiency of four to five percent, although in laboratory conditions this can be as high as ten percent.

There is still conflicting information about the life span of OPV installations, and the lamination process is seen as a major challenge. The experts at Belectric OPV are not worried about this. "The solar cells in the Mainova installation are already four years old, and we haven't seen any degradation," says Hermann Issa. "Our own tests project a life span of at least ten years, and the laminated modules have performed well in the IEC aging tests performed by the TÜV standards organization."

Confident Manufacturers

At present, there are very few producers in this market. The most experienced is Belectric OPV GmbH, based in Nuremberg, who took over technology and core personnel from the US firm Konarka in 2012. Belectric produced the cells for the Milan project, and belongs to the Belectric Group, one of the leading producers of photoelectric technology in the world.

Director Business Development Marketing & Sales Hermann Issa expects his products to make their long-awaited breakthrough soon. "The EXPO project is vital for us, as it shows the international architecture industry our product's potential and flexibility in design and installation," says Issa. "In the coming years, we need to lift photovoltaic technology out of the dangerous dead end of financial derivatives. We need to make sure that the focus is on the energetic side of the product. The main theme for us as producers of photoelectric cells is going to be responding to the demands of decentralized energy generation, and looking at the energy efficiency of buildings and other structures."

These developments mean that integrative product solutions are becoming more and more important. "Developing a market for architectural applications is entirely dependant on allowing creative characteristics to emerge and then translating them into a structure." The German pavilion in Milan shows that these projects do not need to be driven purely by financial considerations, but that a photovoltaic system can be integrated into a structural net as a sun shade and a key element of an architectural design.

Beyond Demonstration Projects

One of the biggest challenges has long been finding fully approved projects. According to Hermann Issa, this is no longer a problem. Most of the projects so far have been for temporary installations – the "Solar Gate Roof" at the Frankfurt Motor Show 2011 was only in place for two weeks, for example. The EXPO Pavilion in Milan will also be disassembled at the end of the World Fair, although three of the five Solar Trees will find other homes afterwards.

Temporary installations can be useful in the beginning, to raise awareness of the new technology. "Particularly at sports or music events, this kind of structure will be possible in the future," says Lennart Wiechell. "It could offer visitors the chance to charge their smartphones, for example." The OPV modules can even be assembled to overlap like the scales on a reptile's skin, to offer shelter from the elements.

Less is Often More

At the moment, it is difficult to calculate the costs of a photovoltaic steel net installation, as the few projects that have been undertaken so far are mainly demonstration constructions. Similar considerations apply to OPV cells as well, with price being strongly dependent on the design used and the type of installation. However, if using OPV up to 30% more electricity per kWp than in a classic solar cell installation can be harvested.

Without a doubt, OPV projects have real business potential. "Steel rope systems are minimalist in terms of material consumption. Accordingly, if used as a mounting system they complement the light-weight OPV modules perfectly," according to Vito Gualazzini from Carl Stahl Architecture, partner of the OPV technology consortium and responsible for the steel rope net. "Approaching the market with a light-weight and aesthetical superior PV system holds potential for the future, and differs substantial from today's solutions."

Author: Martin Frey

„Fields of Ideas“ – the German Pavilion at the Expo 2015



"Feeding the Planet, Energy for Life" is the theme for Expo 2015. The German pavilion clearly orients itself to this leit-motif – under the "Fields of Ideas" motto. Germany reveals itself as a vibrant, fertile "landscape" filled with ideas on future human nutrition. The pavilion vividly illustrates just how important dealing respectfully with nature is to our ongoing food supply, while inviting visitors to take action themselves.

Visitors can discover the "Fields of Ideas" along two different routes. They can either stroll along the pavilion's freely accessible upper level, which invites them to relax and enjoy. Or they can explore the exhibition inside the pavilion, which addresses such topics as the sources of nutrition, through to food production and consumption in the urban world.

The central design element of the pavilion are expressive membrane-covered shelters in the shape of sprouting plants: the "Idea Seedlings." Their construction and bionic design vocabulary are inspired by nature. The Idea Seedlings link the interior and exterior spaces, a blend of architecture and exhibition, and at the same time provide shade for visitors in the hot Italian summer.

By integrating cutting-edge organic photovoltaic (OPV) technology, the seedlings become Solar Trees. The German Pavilion is the first large international architecture project to use these innovative new products. In contrast with a project using conventional solar modules, the German Pavilion architects had the opportunity to do more than just incorporate existing technology. They had free rein to design the flexible, OPV membrane modules to match their own creative ideas, and to integrate them into the overall design of the pavilion.

Overall responsibility German Federal Ministry of Economics and Energy, Bonn
Management company Messe Frankfurt Exhibition GmbH
Design, planning, realization German Pavilion Expo Milano 2015 Consortium
Spatial concept, architecture, general planning SCHMIDHUBER, Munich
Content concept, exhibition, media Milia & Partner Stuttgart
Project management and construction Nüssli (Deutschland) GmbH, Roth
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Constructing the OPV modules system, integration and installation BELECTRIC OPV, Nürnberg
Steel net construction and installation Carl Stahl GmbH, Sulßen
Energy storage and building connection Hager SE, Blieskastel
Electrical connectors U.I. Lapp GmbH, Stuttgart
Polymer semiconductors Merck KGaA, Frankfurt
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