Solar cells as part of the house façades of the future

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Markus Babin (left) og Sune Thorsteinsson in front of a solar panel test facility at DTU Risø Campus. Credit: Thomas Steen Sørensen

Solar panels with different colors can be integrated in the façades of buildings and become an aesthetically exciting part of the architecture. The Technical University of Denmark (DTU) is collaborating with façade contractor HSHansen to document the effect of different-colored photovoltaic elements.

Most people probably know solar panels as shiny black glass plates laid on top of a roof. Efficient, but perhaps not the prettiest solution when the house is to be supplied with sustainable energy. And, yes—this is necessary. Since 2020, according to an EU Directive, it must be ensured for all new buildings that they have virtually zero carbon emissions, and the energy they consume must come from renewable sources located close to or in the house itself.

Here, solar cells are an obvious solution because they provide a high energy yield and have also become reasonably priced. The price has fallen by approx. 90% over the past 10 years. Therefore, it makes sense also to work with the appearance and location of the panels. For example, it pays to give them different colors, even if it reduces the efficiency to varying degrees, and—in terms of location—it is important to utilize as many surfaces as possible to produce the demanded renewable energy.

All this is now being studied further in the UnitSun project, in which researchers from DTU participate together with the consulting company MG Solar and façade contractor HSHansen.

A visible expression of the project is a small pavilion that has been erected on the field at the northern end of DTU Risø Campus. The original walls of the house towards the south, east and west have been removed and replaced by façade elements with solar panels in different colors. And inside, it is full of wires and measuring equipment, which—over the next year—will provide a solid data basis for assessing how much energy you can get out of the panels depending on color and location.

"How do you achieve the best compromise between aesthetics, power generation, and price? This is the task we're trying to solve for HSHansen," says project manager Sune Thorsteinsson, who is working

on the case together with special consultant Peter Behrensdorff Poulsen and Ph.D. student Markus Babin.

"We need to give a reliable estimate of what façade elements with solar cells will mean for the energy of the house, so that it will become as easy to choose them as any other façade material."

Warm colors generate the least energy

The reason why solar cells are usually black is that black absorbs all light and therefore provides the cell with the highest possible amount of photon energy which can be converted into electricity. When solar cells are colored, this may result in a decrease in the efficiency of the cells, and the efficiency loss is difficult to predict without detailed measurements. There are various technical solutions for coloring of solar cells, with some being more efficient than others. Typically, the most effective solutions tend to change in color shade, depending on the angle from which you look at them.

At the demonstration house, the south side is covered with the normal black cells. Here, experiments are made with the distance from the solar cells to the insulation. To the west, there is a white photovoltaic element, which has been shown to lose about 50% energy relative to the black element. There are also different colored panels—including one in brick red—which may be required for building projects in certain areas. They lose 20-30% energy, while a deeper red means that the cells generate 40% less energy. But even though the colored solar panels are less efficient, the energy production is still expected to be able to offset the additional costs, especially because the entire façade element replaces a conventional element and even generates earnings.

Solar panels produced on site

DTU has long been working with solar cells, in recent years also those that are placed behind a transparent colored film according to a method developed by Danish Solar Energy Ltd. And, in 2019, the possibilities of developing new photovoltaic solutions were further strengthened with the inauguration of a laboratory in which researchers can build and test solar modules of all types and sizes.

The test house with the many different solar cell elements is thus homemade all the way through. And the data generated in the house itself is supplemented by data from an advanced measuring system built by Ph.D. student Markus Babin. Here—using a laser light source—you can test the solar cells at all angles and get figures on both the importance of the colors to the effect and amount of glare, which a very annoying known side effect of conventional photovoltaic solutions.

In addition to the colors, experiments are also being made with different textures—such as sandblasted glass—and surfaces, where the silver-colored bands that conduct the current away have been covered.

HSHansen hopes to be able to offer built-in solar cell modules in its prefabricated façade elements before long, so that architects and clients can both achieve an energy gain and have a new aesthetic element to play with.

"With DTU's help, we expect to establish a catalog of the possibilities, their effect, and their cost. Our façade elements are already often designed with surfaces of opaque glass, which can create special visual effects. And here it would, for example, be obvious instead to insert a solar cell window, which can even produce energy," says Pernille Brændstrup Kjær, Head of Department at HSHansen.

"With the UnitSun project, we're aiming for solar panels to become a standard supplement to our façade elements, which architects will love."

Provided by Technical University of Denmark