▶ The technology used to make white modules was developed at Swiss research center CSEM. In 2014, the first prototype was presented, and now production is set to begin.

What's white and produces electricity?

Solar modules, as white as a white-washed wall – a dream for any architect. An initial project is planned for this year.

Text: Anne Kreutzmann

Highlights

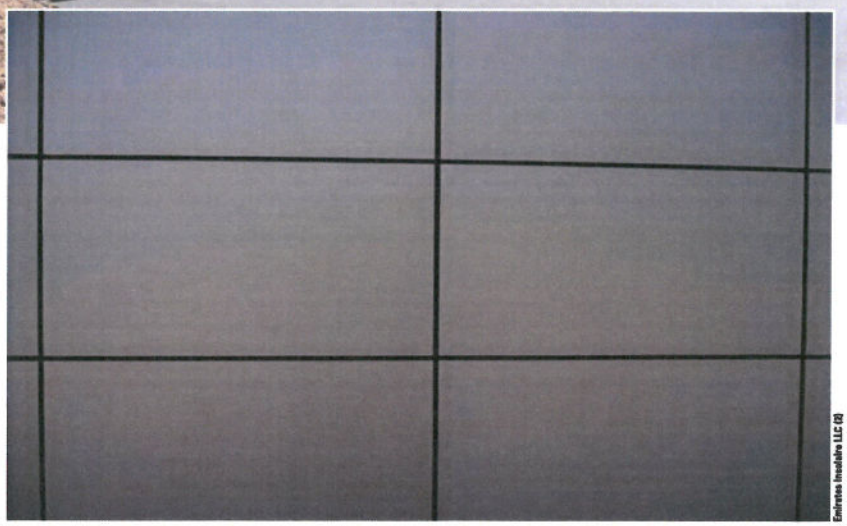
- Back in 2014, Swiss research center CSEM presented solar modules that hide their electrical insides from view.
- The modules are crystalline silicon and use a special film between the solar cells and the cover glass that reflects the visible part of sunlight. The infrared part, however, passes through the film and is used to produce electricity.
- Belgian PV specialist Issol SA is the first company to offer the white PV systems on the market.

Architects love white. Whether you're thinking of Mies van der Rohe's Farnsworth House in Plano, Illinois, in the US, the Casa son Vida by Sebastian Knorr in Palma de Mallorca, the National Museum of Brasilia by Oscar Niemeyer, Le Corbusier's Villa Savoye in Poissy close to Paris or the »Isbjerget« housing complex from architecture firm Cebra in Aarhus, Denmark, they have one thing in common: they're all completely white. Le Corbusier even supposedly said, »By law, all buildings should be white.« And that quote can be found on Belgian PV company Issol SA's website. And there's a good reason for that: the company, which has specialized in building-integrated PV (BIPV) is the first vendor to offer white solar modules on the market – and the modules appear to have paper behind the cover glass or even plasterboard.

Laurent Quittre, the CEO at Issol, is able to amaze even the most experienced PV experts with his product: »Ask PV specialists if white solar technology is possible. The majority will say no.« After all, generations of scientists have been working on making solar modules as dark as possible – ensuring that all of the available light is absorbed and not reflected. Quittre says, »They argue that it cannot be done because light would be reflected, a contradiction to their obsession to make efficient solar panels.« But Issol is taking care of architects' dreams: »At Issol, we care for architects and we demonstrate that it is possible while guaranteeing high efficiency.«

The trick is actually quite simple: only the visible part of the light is reflected by Issol's white modules; to be exact, the wavelength range between around 350 and 700 nm. The infrared range above 700 nm, which is what solar cells use to produce the majority of their electricity, is able to pass through. So Quittre is quite right in saying that white modules can be produced, though the »high efficiency« he is referring to is just 11 to 12 percent. Compared to regular crystalline silicon modules, which achieve efficiencies of 16 to 20 percent or more, the results are rather weak.

However, white modules don't warm up as much as their standard counterparts: the Swiss Center for Electronics and Microtechnology (CSEM), which developed the technology in collaboration with Ecole Polytechnique Fédérale de Lausanne (EPFL), estimates that temperatures are 20 to 30 °C lower. And that has a positive effect on the yield. Moreover,



Emirates Insolaire LLC (2)

▲▶ Grey instead of white: This is a solar façade, too. The technology used to create grey modules was also developed at the CSEM, but it differs greatly from the method used to produce white modules. Essentially, it involves using a colored coating on the cover glass. This school building in Leysin, Switzerland, is covered in solar modules from Emirates Insolaire.

white facades and roofs enable the inside of the building to stay cool: »Several US cities have started to paint roofs white for the same reason,« states CSEM. And the researchers are hoping that white solar modules will offer a superb alternative.

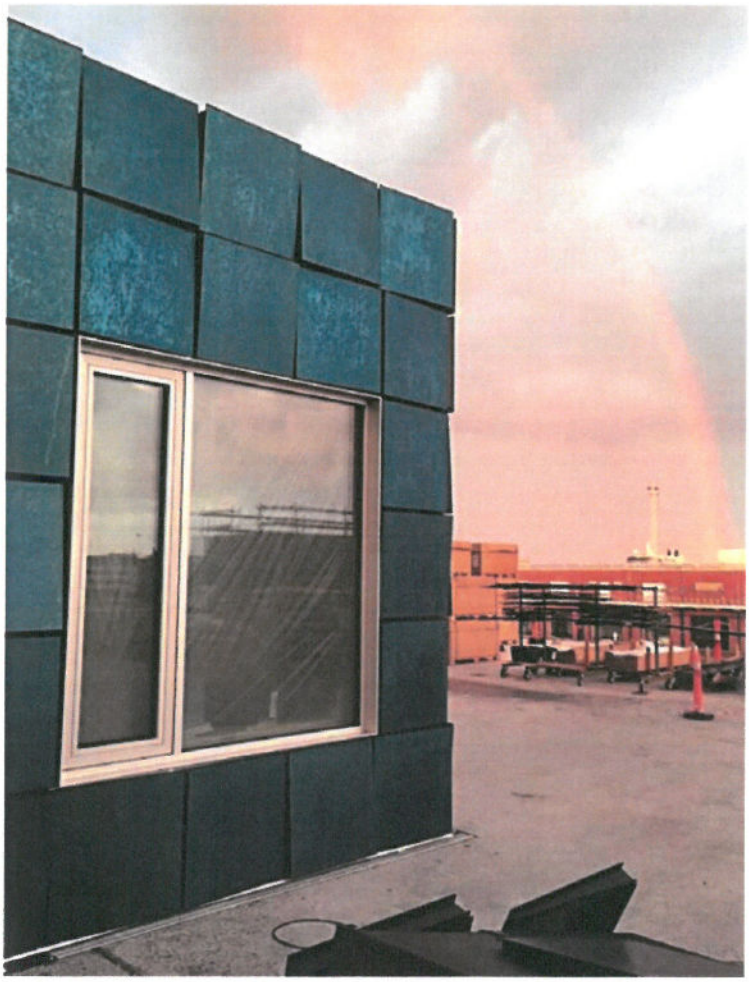
Easily integrated into standard production

The reflection is achieved by putting a special film in place, which is then laminated between the solar cells and the cover glass. The film, which is around 0.12 mm thick, is dual-coated. The first coating creates the optical filter, while the second coating allows for the reflected light to be diffused so that the module doesn't end up acting as a mirror. The film is produced by Swiss company Solaxess SA, which was founded in 2015 and which also holds the patent for the product. The solar cells themselves remain unaltered. Solaxess is also working with other module manufacturers beside Issol, including SI Module GmbH from Freiburg, Germany, which has already carried out a diverse series of tests. When we went to print, it remained unclear when or even whether SI Module

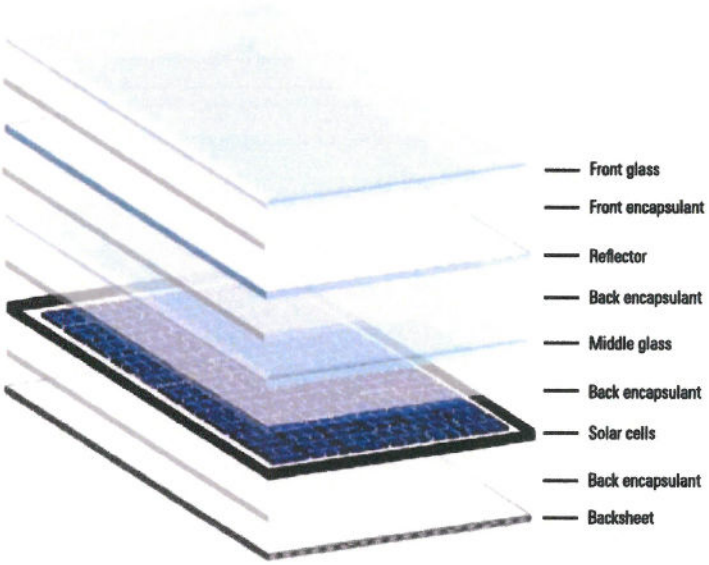
CSEM Centre Suisse d'Électronique et de Microtechnique (2)

▲ Broad color palette: The technology developed at CSEM can also be used to produce colored solar modules - as shown by Christophe Ballif and Laure-Emmanuelle Perret-Aebi

Emirates Insolaire LLC (4)



Structure of white solar modules

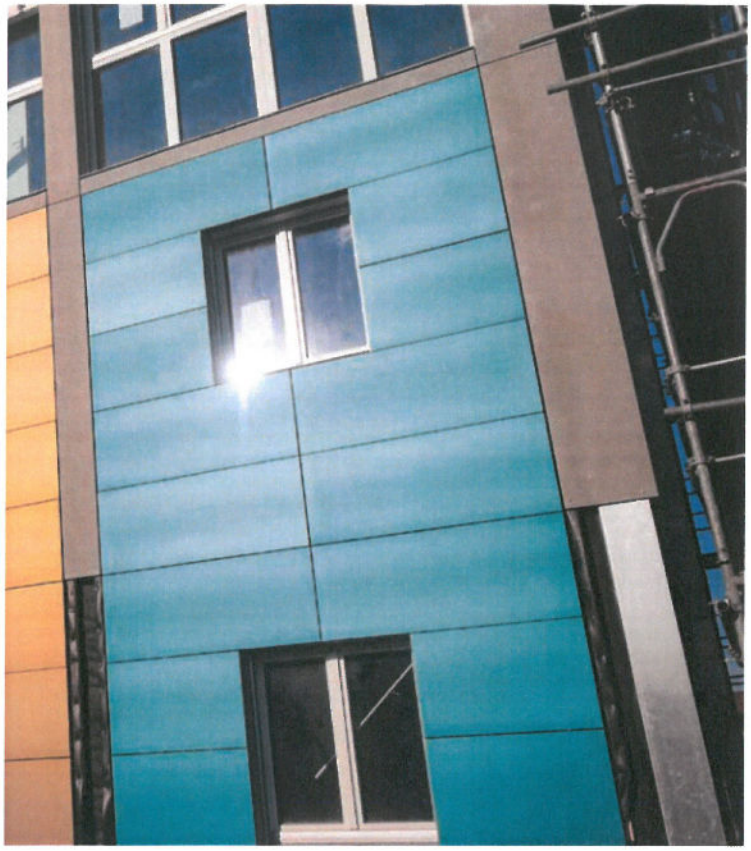


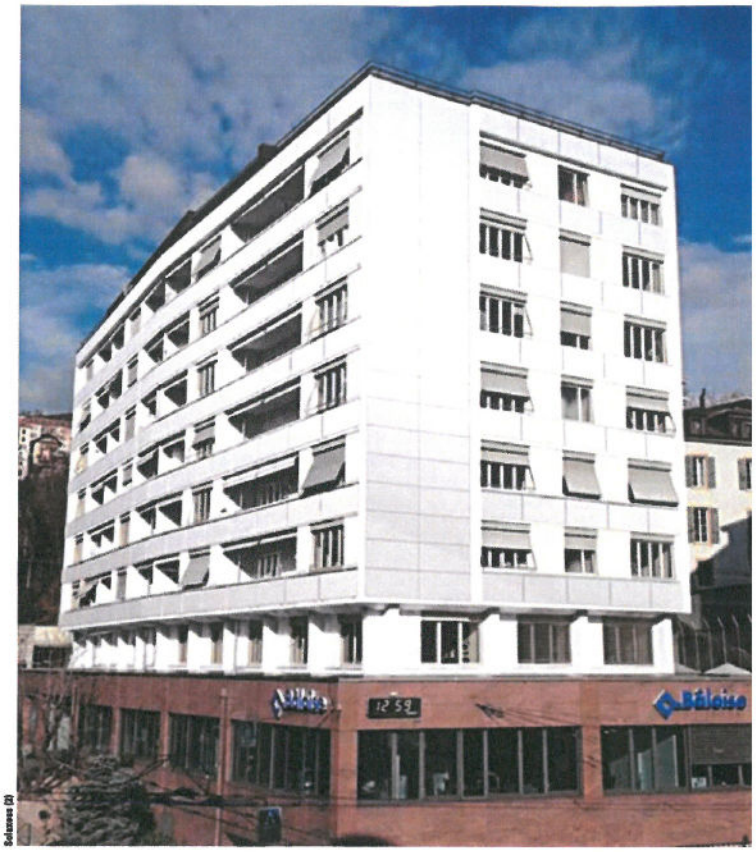
◂ In Copenhagen, one of the world's largest BIPV systems is currently being built during the construction of the new campus of the Copenhagen International School. When completed, around 13,000 green solar modules from Emirates Insolaire will cover half of the building complex's energy needs. The opening is planned for January 2017.

▲ Office building in Basel, Switzerland, using colored modules made by Emirates Insolaire: The BIPV system has a power of 25 kW and is meant to deliver 16,000 kWh of power per year.

▲ Solaxess recommends that module manufacturers encapsulate the reflective film between two panes of glass. The solar cells would then be below the second layer of glass and are protected by a backsheet on the rear. The cover glass could also be replaced with an ETFE film.

▲▸ This is what white solar facades could look like: Even though no white PV systems are installed yet, Issol is expecting to realize its first project this year. And maybe it'll look something like this photo montage.





would be bringing white solar modules onto the market. And apparently, Solaxess is fielding more requests. According to the company, the technology can be integrated into any standard module production line.

The degree of efficiency losses depend on the cell technology being used: »The newer the cell technology, the lower the losses are,« explains Andreas Schöni, the head of sales at Solaxess: »Heterojunction cells or PERC technology are best suited.« Tests have shown that the short-circuit current of white modules using regular multicrystalline solar cells is around 48 percent lower, while heterojunction cells (such as the HIT cells from Panasonic) display just 45 percent lower values. When looking at module efficiency, Schöni estimates losses of 35 percent, meaning that white modules have a third less yield. However, that's »still more than a façade without solar modules,« says Schöni. The white modules from Issol are rated at 90 W per m².

Colored modules from Dubai

Furthermore, Solaxess is not the only company marketing products to manufacture white and colored solar modules developed by CSEM. Back in 2013, Dubai-based Emirates Insolaire LLC was founded – a joint venture between Dubai Investments PJSC and Switzerland-based SwissInso Inc. While Solaxess has been focusing on technology using reflective films, Emirates Insolaire obtained the license for CSEM's earlier work. That involves using color-coated glass, which Emirates Insolaire is now calling Kromatix.

While that makes white modules impossible, this technology allows more light to reach the cells beneath, meaning that losses are much lower. According to Rafic Hanbali from Emirates Insolaire, losses amount to between just 2 (grey modules) and 7 percent (red). The first projects have already been completed – and the most spectacular is probably a PV façade installed last year on a coal silo in Basel, Switzerland. The installation was even awarded the Swiss Solar Prize in 2015. The modules used were green, gold, blue and grey and have 25 kW of power; the system is expected to produce 16 MWh per year. Furthermore, the company is currently installing a grey solar façade on a school in Leysin, Switzerland, and a green façade at the new campus of Copenhagen International School (CIS).

Only slightly more expensive than usual

Neither Emirates Insolaire nor Issol were able to provide list prices of their unusual PV systems. Both companies emphasize that the modules cannot be considered standard goods, and that customer requirements are implemented – and those clients are usually architects. Both technologies can be used regardless of the solar cell technology being implemented, though the quality has an impact on the price, of course. Even thin-film modules can be used. The product guarantee is 25 to 30 years.

Emirates Insolaire has provided a guide for the extra costs associated with using the colored-glass Kromatix products, coming in at €80 ($89) per m². »Naturally, price depends on the required panel type and size, and on quantity. Consider an average of €150 per m². Kromatix PV colored glass costs between €320 and €350 installed, turnkey, including PV glass or panels, cables, inverters, mounting structure and labor,« says Hanbali, stressing that these prices are only slightly higher than those charged for facades without PV. Depending on the cell technology, 1 m² of Kromatix has a power rating of 150 to 160 W. The projects realized in the last 2 years highlight that the minimal additional costs don't deter architects or their clients in any way.

Solaxess' Schöni has similar expectations for his company's technology: »Based on our estimates and pilot projects, we are able to say that the technology is well placed for market acceptance in terms of pricing.« Schöni won't provide any more information, and simply refers the question to its business partners, saying, »We don't make the modules after all.«

But neither SI Module nor Issol will provide actual prices; they are all about gaining more experience at the moment. Unlike the technology introduced by Emirates Insolaire, no IEC certification is in place for the modules as yet. But that is set to change very soon: »By the end of the year, everything should be in place,« says Schöni.

Further information
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