Photo: RDC Fine Homes

Featured at the 2010 Olympic and Paralympic Winter Games in Vancouver, this 2,200-square-foot home sports a six-kilowatt system of monocrystalline silicon Just Roof modules from Suntech Power.

A marriage of beauty and function

BIPV: A growing number of PV manufacturers are offering modules designed to blend into roofs and building facades in North America. Competition will be particularly fierce for the precious real estate on the residential rooftops.

The idea of solar modules that can blend into buildings like chameleons promises to unlock new installation spaces, inspire eco-friendly architectural designs and create a new market for solar electric equipment manufacturers. The idea has been around for decades, but the building-integrated PV (BIPV) market remains tiny even today primarily because of technology, pricing and public policy. The BIPV market emerging in the United States will contain different dynamics than in Europe because the U.S. lacks a national feed-in tariff or other incentives designed to encourage these installations.

In North America, there are some fancy building-integrated PV projects on high-rise commercial and residential structures that illustrate novel uses of solar cells in building facades and walkways. While these projects are attention-grabbing, they don't make up the volumes needed to cultivate a booming market for BIPV products.

New single or multi-family housing development projects, particularly those in states with strong solar incentives, are the new frontier for BIPV manufacturers and their customers. California and Arizona, for example, are emerging as potentially big BIPV markets because of their historically strong home sales and generous rebate programs. Industry analysts are also counting on the Canadian province of Ontario as a potential stronghold for BIPV deployment, even though the Ontario program doesn't have BIPV carved out. "BIPV provides the aesthetics. Builders are more concerned about the aesthet-

ics – price isn't as important when ensuring that their homes look a certain way and makes a good first impression to home buyers," says Tom Harvey, Director of Sales and Marketing at SunRun, a solar energy service company in San Francisco.

The growth will depend largely on a close collaboration between the PV and building industries. Builders and roofers, of course, will want data showing that BIPV systems will perform well and last for decades. But what they also need assurance that any integration of BIPV equipment into building facades or materials won't compromise the integrity of the buildings and lead to expensive warranties and lawsuits. Architects have expressed a strong interest in using solar modules, but they also have a host of other technology options to choose from to design buildings with lower carbon footprints. Although the American Institute of Architects doesn't endorse technologies, it is promoting the use of software and other tools to streamline the process of selecting and designing emerging eco-friendly features into projects. One such approach is the use of Green BIM (building information modeling), a simulation software that can be used not just for designing buildings but also for determining how well new technologies will perform once they are up and running. "Architects like the flexibility, aesthetics and the lack of wind-load of BIPV. They like the integration concept," says Jean-Noël Poirier, Vice President of Marketing and Business Development at Global Solar Energy. "We need to educate the market, and it takes time."

There isn't one definition of BIPV. Generally, BIPV systems are considered equipment that is integrated into building materials and may offer functions other than electricity generation, such as insulation from weather elements. Modules that lie flat on flat roofs and require no racks, on the other hand, don't meet the definition, though that hasn't stopped manufacturers from using the term BIPV in marketing materials. Although crystalline silicon solar modules are dominating the market, BIPV technology options have expanded significantly in 2010 when several American makers of copper-indium-gallium-selenide thin films unveiled flexible modules that use plastic instead of glass to protect the solar cells. Not coincidentally, polymer film maker 3M also recently launched a new plastic film that offers strong protection against moisture, a huge threat to the performance and durability of CIGS cells.

BIPV technology menu

Up until now, BIPV systems have largely been fabricated using rigid, glass-covered crystalline silicon modules. Some of the showcase projects, such as the high-rise residential projects in New York City developed by altPower, required customized modules with cells from manufacturers such as SunPower and General Electric. The growth of the rooftop residential and commercial markets in certain regions of the country has prompted some module makers to design standardized products that can fit snugly into space reserved for shingles and tiles. Suntech Power, for one, is producing multicrystalline silicon tiles branded SolarBlend, which is sold through Eagle Roofing Products based in California. SunPower also offers a competing product called the SunTile, which makes use of monocrystalline silicon cells.

Both Suntech and SunPower still use glass to package their cells, and the tiles are meant to sink into the roof to take place of the normal concrete tiles, even though their dark blue or black

colors don't match many of the common tile colors. SolarBlend comes with frames that run one of the three colors that are most commonly found on tiles (grey, terracotta and brown). The colored frames help to camouflage the dark blue solar cells somewhat, especially for homeowners looking up from their yard, says Jay Banister, National Solar and Marketing Manager for Eagle Roofing and Eagle Solar. A polycarbonate frame that requires no grounding, which simplifies the installation process, Banister says. To install SolarBlend, roofers lay down thin wooden strips whose depth provides room for running wires underneath the solar modules. The modules are then screwed onto the wooden strips.

On the thin film front, United Solar Ovonic is viewed as a veteran in BIPV business. The Michigan company launched solar shingles back in the 1990s, but discontinued after losing the UL listing as the shingles no longer met the national electric code. The shingles required drilling many holes on the roof for the wires, making them cumbersome to install.

Uni-Solar recently launched a new generation of shingles and showed them off at Solar Power International in Los Angeles in October, though company representatives weren't willing to reveal how the wiring would work. The shingles use the same triple-junction amorphous-silicon cells found in Uni-Solar's core product – laminates that can lay flat on the roof without racks. This time around, the shingles are supposed to be outfitted with thinner wires and connectors. The design should also only require roof penetration in one spot, where the wiring will run through to be connected to the meter, says Stan Kosierowski, vice president of NJR Clean Energy Ventures, which is launching a pilot program to install two Uni-Solar products, including the shingles, on 30 homes in New Jersey. The shingles won't be available until next year. The shingles would be nailed to the roof deck in the same way that shingles are installed, says Wendy Ventura, a Uni-Solar spokesperson.

The low efficiency of Uni-Solar's modules, around seven percent, has always been a trade-off for buyers who value its light-weight, flexible designs. It's facing a growing number of competitors offering glass-less modules with higher efficiencies. Several U.S. makers of copper-indium-gallium-selenide modules, such as

Photo: 3M

3M recently launched its Ultra Barrier Solar Film, which is able to replace glass as the protective cover.

Global Solar Energy, SoloPower and Ascent Solar Technologies – unveiled their flexible products this year that can achieve more than ten percent efficiency.

The CIGS module makers have either obtained certifications or are in the process of doing so. These companies envision seeing their laminates applied onto the roofs, particularly on commercial buildings, but whether the modules will be used as true BIPV products remains to be seen. Global Solar's cells will go into Dow Solar's shingles for residential construction, and Dow plans to start shipping next year.

Perhaps not uncoincidentally, Minnesota-based 3M also recently unveiled a fluoropolymer film designed to replace glass as the front cover for CIGS, cadmium-telluride and organic thin films. Until now, CIGS module makers have largely relied on glass as the protective layer because it is cheap, durable and waterproof. Plastic covering is used for more novelty products such as solar chargers that aren't going to be exposed to the weather elements continuously for decades. 3M has figured out a way to achieve a water vapor transmission rate of $5x10^{-4}$ grams per square-meter per day. That means only 0.0005 grams of water can move through the plastic film. The rate is hundreds of times better than competing Teflon films from DuPont, which is working on a film that it hopes will get to the level of 10^{-5} grams per square-meter per day. "Having a good moisture barrier is a key challenge. With amorphous-silicon you can get away with lower moisture permeation rate because

amorphous-silicon isn't as moisture sensitive. CIGS is the hardest one to protect", says Dan Doble, Group Leader of the Fraunhofer Center of Sustainable Energy Systems.

Module makers could use lamination machines already available on the market for applying the 3M film. Or they could invest in equipment that could do roll-to-roll lamination. 3M is in the pilot production of the film and expects to enter mass production by the end of 2011, says Derek DeScioli, Business Development Manager for 3M's renewable energy division. Some conventional module makers also envision seeing selling their equipment into the BIPV market. Sulfurcell of Germany, for example, hopes to see the use of its CIS or CIGS modules, sandwiched in glass, built into a building facade or cover the roof of a home. The company has done projects in Germany and France to show how its modules can fit the overall design of a structure.

"Hotels could be a big market. They are rebuilt every five to ten years because of re-branding or they are being bought by another chain," says Boris von Bormann, Sulfurcell's Director of Sales for North America. He adds, "BIPV also is ideal for pre-fab houses." Pre-fabricated homes – which are built in factories and assembled onsite – can also make an attractive market, von Bormann says. The move towards designing more sustainable homes has sparked an interest in marrying the efficiency of prefabricated homes in factories with designs that make the homes more energy efficient. This is one way to reduce the carbon footprint of homes during and after their construction.

Given that the BIPV market is small and even smaller in North America compared to Europe, the solar industry needs to educate architects, builders and other potential customers the benefits of integrating solar into buildings, as von Bormann says. Sulfurcell is looking for partners to create a design guide that can explain the different BIPV technology choices, energy savings and costs, and other common issues asked by those interested in BIPV.

Initial BIPV market

As emerging products, BIPV systems and the cost of installing them won't be cheap. The installations have to fit snugly into the space previously occupied by shingles or tiles, for example, and that requires not just an efficient use of space but also special training for roofers. The equipment and installation costs can run 0.40 to 0.90 U.S. dollars per watt (DC) higher than conventional PV systems, as Banister says. Government incentives will play a big role for BIPV adoption, of course. Regions with strong rebates programs and feed-in tariffs already in place, such as California, New Jersey and Ontario in Canada, are markets most likely to see more BIPV installations. The city of Los Angeles, which has its own utility, offers an extra 0.02 U.S. dollars per kilowatt-hour for BIPV systems.

A big selling point of BIPV system is its ability to blend in with the roof. Some homeowners and community associations – which can pass rules dictating the use of building materials – have objected to conventional PV systems because they stand out. BIPV manufactures and installers expect to see a quicker adoption in new home constructions, where builders can offer solar as an option and design the homes to more easily accommodate modules and related equipment. Build-

Photo: Eagle Solar and Century Roof and Solar

This house features the Eagle Solar Roof with SolarBlend, a system of polycrystalline silicon tiles from Suntech Power.

ers are also more likely to offer BIPV in order to appeal to buyers who want a less obtrusive system.

"We went with (Uni-Solar) to test the thin films and try to test how big the market is," says Kosierowski. The NJR Cleantech Energy Ventures is starting a pilot program to install Uni-Solar's shingles and laminates on 30 homes in New Jersey. The company will lease the installations, which will average three kilowatt in size, to homeowners for 26 dollars per month. California also has a regulation that will require home builders to offer solar as a standard option to buyers starting on January 1, 2011. This rule applies to single-family home projects with at least 50 homes each. Options are features and designs that buyers can choose to add, for additional costs, to the homes they want to buy. They typically make the selections before the homes are built. Up until now, many home builders preferred to offer options that might generate more profits for them, such as granite kitchen counters and hardwood floor. Builders of luxury homes might be more inclined to install PV systems at their own expenses or pass on the costs to buyers. Solar electric systems are expensive, so buyers of more modest homes might prefer to spend their extra money on better appliances or large kitchen cabinets. By making solar a standard option, however, it will at least remind home buyers that they have an opportunity to generate their own clean energy.

A change in Californian regulation earlier this year also has prompted home builders to consider offering solar. In 2007, the state launched the New Solar Homes Partnership (NSHP), which offers rebates to builders for new homes that can be more energy efficient than required by the state's building standards. To get the rebates, builders have to show that each new home will use at least 15 percent less electricity, and they can qualify for more incentives if they can achieve greater efficiencies. To qualify, builders will have to pay for the PV systems and installations themselves or convince home buyers to pay for them up front.

The change in the program allows leases and power-purchase agreements, which could make adding solar more attractive to home buyers. SunRun, a residential solar financing company, has teamed up with Toll Brothers to offer a service plan for buyers of a new, 90-home community in Southern California. San Francisco-based SunRun will own and maintain the PV systems, at around 2.5 kilowatts in size, and charge homeowners a flat 42 dollars per month for 20 years. The PV systems offered include solar shingles by Suntech.

"They don't have to come up with 10 to 15,000 dollars out of their own pockets to put solar on their homes. You will see a wider adoption," says Bill Scott, senior vice president of solar solutions at PetersenDean Roofing and Solar Systems, a roof installation company that also designs and installs PV systems. PetersenDean is working with SunRun on the Toll Brothers project.

How much demand will come from new-home market will also depend on how well the economy has recovered from the financial and housing market crash that led to high foreclosure rates. Single-family new home construction has increased slowly in 2010 compared with last year, the worst year since the Federal Government began collecting data in 1959.

Beauty vs. power output

BIPV systems generally offer aesthetic appeal at the expense of electricity production – the production could be five to 15 percent less per year, says Scott. Without space to air, the performance of crystalline silicon modules can diminish, Harvey says. Thin film modules also have lower efficiencies than crystalline silicon modules.

How much power a PV system can produce matters more when it's owned by a service provider that owns the system and sells the electricity to homeowners. The building integrated designs, though a good selling point, may lose their competitive edge as new system designs give conventional PV systems lower profiles while they perch on the rooftop. "We are trying to find a happy middle ground where builders are happy with the aesthetics with a system that costs less to install and produce more power during the course of the year," Scott says.

As manufacturers improve their cell efficiencies and BIPV designs, they can carve out a significant market. The market is still in its infancy and offers much room for innovation. The winning combination will offer visually pleasing looks that also give a nice payback. As businesses and consumers become more educated about the benefit of solar energy, they also will be willing to consider options beyond traditional PV systems. ◆

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