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The next eight years in building-integrated photovoltaics (BIPV)

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ABSTRACT

The solar industry suddenly finds itself in an altered business climate in which construction markets seem permanently damaged and government subsidies are under challenge. This paper outlines how BIPV provides a strategy for expanding the market for PV and creating value-added products in a radically changed political, economic and financial environment.

Introduction

NanoMarkets' latest analysis [1] suggests that building-integrated photovoltaics (BIPV) presents some important opportunities in what we consider will continue to be a challenging business climate for the solar industry for years to come.

- Despite the occasional encouraging monthly statistic, we think it is unlikely that the construction boom (which was fuelled by public policy mistakes in many developed nations) will happen again in the foreseeable future. But without a rapidly growing construction industry, the solar business is robbed of part of an important addressable market on which it has counted for many years.

- We also think that the governmental subsidies on which the solar industry has relied for a couple of decades are likely to experience declining political support. This trend may be counteracted to some extent by both policy makers and electorates who favour 'green energy' over nuclear energy in the light of the Japanese nuclear disasters. However, it is unlikely that this factor will be sufficient to keep some of the most important subsidies in place for solar. And anyone who believes that the solar industry can do well in the absence of subsidies should take a look at the recent history of the Spanish solar industry.

These issues should not be treated lightly. Inevitably they are factors that produce slower growth for the solar industry compared to what that growth might once have been. Moreover, in a market climate in which slow economic growth is endemic, one should expect choices to be made in favour of options with low initial cost. Such an environment cannot be good for the solar industry, which intrinsically is all about high upfront costs, followed by low operating costs.

A new business case for solar is needed

What all this adds up to is this: the traditional business case for solar has been badly mauled in today's business environment. If we are not to go backwards in time to the 1980s, when the solar industry existed primarily to serve the needs of a small circle of enthusiasts, something radically new is required. More specifically, what is needed here is a new kind of solar – one that provides a transformed price/performance offering to the marketplace. This 'new kind' of solar could emerge in different ways:

	2011	2015	2018
Tiles and floating panels	691.9	2,015.5	6,628.1
Flexible BIPV products	153.8	1,071.3	4,339.2
Glass	1,171.6	4,357.5	12,668.8
Total	2,017.3	7,444.3	23,636.1

Table 1. Summary of BIPV markets (US$ million).

- The most obvious perhaps would be through entirely new technology. For example, one can easily imagine micro- or nano-concentrators or some entirely new absorber material based on quantum dots or metamaterials, say, ramping up conversion efficiencies (and ultimately making significant reductions in $/W) to a point where photovoltaics would be much more competitive with other sources of electrical power. Such developments may be highly likely in the long term. But the operative words here are 'long term.' And one might add to any description of such technologies the word 'risky.'

- NanoMarkets believes that BIPV offers a route to an entirely new way of thinking about solar costs and also to teasing out new addressable markets, even in difficult times. As this paper explains, BIPV represents a technology that can spread the costs of PV across multiple functionalities, thereby reducing the need for subsidies. And BIPV also seems to imply the potential for an entirely new aesthetic – one that will be market expanding for the solar firms that adopt it. However, taking the BIPV road is not without its risks too, nor is it an entirely immediate prospect. But it is less risky and nearer term than any strategy that involves a fundamental shift in the materials used for solar panels.

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As Table 1 shows, we believe that the aggregate revenues from BIPV will be quite large; these revenues will be established in part by taking custom away from traditional solar business, but also by tapping into new markets that are difficult to reach using conventional solar panels.

BIPV: aesthetics and opportunities

Throughout the several decades of the existence of solar, its aesthetic has been one that might reasonably be said to be propagandistic or 'in your face', to the extent, that is, that solar energy had an aesthetic at all. In its earliest days, purchasers of solar power systems typically did not care that much about how the solar panels on their roofs looked; the point was to be part of a movement. To the extent that there was an aesthetic it was a political one.

Of course, this kind of aesthetic does not come close to being universally acceptable; the markets to which it can appeal are inherently small. Large roof- or wall-

Source: RELAB

Figure 1. The Visionaire, a high-rise residential tower in the Battery Park City area of south-western Manhattan, shows how aesthetics can be easily addressed in BIPV installations.

mounted solar panels are not generally considered aesthetically pleasing any more than satellite dishes are; at best, people get used to seeing these installations as they become more common.

In some cases conventional PV installations can even run foul of local building ordinances. To put it in blunter terms, not only are significant segments of the building owner/building manager market not being turned on to using photovoltaics as a way of providing electricity to the buildings they control, but they are also quite definitely being put off the whole idea. This is not something the solar industry can afford to let happen at a time when its political support and markets are both under strain.

The first-generation BIPV products – building-attached PV (BAPV), as they are sometimes called – went some way towards addressing the issues mentioned above. BAPV could, for example, be installed flush with roofs and was therefore less objectionable. Second-generation BIPV products take this trend to a dramatic new level:

- By integrating PV absorber layers and electrodes into roofing, siding and glass, second-generation BIPV products become something entirely new, or at least they create a major strategic shift. That is, the old-style PV industry produced something called a 'solar panel.' Under the second-generation product paradigm, the solar industry is merging into the building product business, while at the same time preserving the best performance characteristics of solar panels. More specifically, second-generation BIPV products are generally made to provide 10–14% PV efficiency, while also meeting all the codes and standards of traditional high-end building products.

- BIPV in its second-generation form is just another kind of roofing product – it is no longer a radical form of energy system. This is a good thing from the perspective of marketability: PV industry insiders often have a hard time understanding how novel PV systems seem to most building owners and managers. We believe a shift of this kind will open up many new markets for PV.

- Second-generation BIPV also brings a new familiarity to the purchasing of PV panels; with this kind of BIPV, buying a panel could become just another option in the purchasing of roofing or siding, for example. Moreover, the latest BIPV products are designed to be delivered through standard building industry supply chains and installed by the usual building industry professionals. These new BIPV products, we expect, will start 'bootstrapping' themselves into the market as ease of installation and attractive functionality trigger ever more demand.

- The final goal is that BIPV will be seen as part of the standard portfolio of high-end 'green' building products used by architects and builders.

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As we have already noted, we think that this 'normalization' of PV is certain to open up new markets for BIPV. However, one should not underestimate the difficulties in such a transformation.

Getting BIPV panels accepted by the roofing and siding industries will be a challenging business development issue in particular. It may mean even taking some steps backwards before we can move forwards. Thus, for example, Ascent Solar has demonstrated a flexible laminate product called WaveSol Light. This product is claimed to be 8–9% efficient, and claims improved aesthetics on curved building surfaces. However, Ascent has retreated from the BIPV markets. Instead, the company is focusing on niche markets such as the military and defence; off-grid charging solutions in developing countries; power for portable electronics; and custom and standard products for rooftop integration on buses, heavy goods vehicles and trains. It is only once these markets are established that Ascent will return to the BIPV sector.

And the aesthetic questions at the beginning of this section also raise issues:

- It is one thing to use second-generation BIPV concepts to cover up the PV; it is quite another to use BIPV to actually enhance the aesthetics of the building. Some of the earliest examples of BIPV have emphasized aesthetics quite explicitly, but they have done so only by employing architects. Architecture is a lot more than simply going for the lowest-cost building. That is why using an architect rather than simply a builder/draughtsman is almost always the most expensive option in constructing a building. Bringing a specifically BIPV aesthetic to moderate-budget buildings – where BIPV aesthetic is defined as something that shows off the PV in a beautiful way – is an issue that has barely been talked about yet. However, in the long run, creating a BIPV aesthetic is not just a challenge, but also another part of making PV fit into a post-subsidy world.

- Crystalline silicon still provides the highest PV conversion efficiency and – with clever understanding of optics, mechanics and industrial engineering – can be incorporated into new second-generation BIPV products. Pythagoras Solar is noteworthy for using arrays of prisms to hide crystalline silicon cells on their sides in double-pane insulated glass units (IGU) that appear almost completely transparent when looking straight at them.

- Thin-film PV-based BIPV glass is another approach to creating a new PV aesthetic using the BIPV concept. These panels replace the squareish silicon cell space pattern with tighter, more precise pinstripe or other patterns and eliminate the tabbing that spans the spaces between cells. Uniform thin-film semi-transparent and opaque panels also exist for side-wall spandrels, shade screens and canopies.

The bottom line here is that second-generation BIPV holds open the possibility of expanding the market for PV by normalizing it as part of the building products market. That being so, it enables designers to come up with something quite new: a BIPV aesthetic that follows its own rules and goes well beyond just hiding ugly silicon panels!

	Advantages	Disadvantages
Crystalline silicon		
Rigid BIPV	Cells fit well into tile-shaped packages Suitable for flush mounting Cell appearance can be attractive	Cell appearance can be considered unattractive Limited sizes and shapes of cells Silver tabbing usually required
Flexible BIPV	Would offer a classic PV appearance if it could be made affordably in volume	Standard cells too rigid and fragile for flexible BIPV Ultra-thin silicon only shown in labs with no commercial product plans known
'Transparent' BIPV	Custom shapes can be handled with attractive cell layouts Cell appearance can be attractive	Cell misalignment produces irregular reflections, and tabbing may look unattractive Even use of prism/mirrors limits off-axis transparency
Thin-film/organic-based PV		
Rigid BIPV	Clean, uniform appearance Suitable for flush mounting	More or larger panels required for same power
Flexible BIPV	Clean, uniform appearance Curved installations possible Versatile for use on many surfaces	Additional framing needed for some installations Versatility can lead to some undesirable installations
'Transparent' BIPV	Clean, factory precision appearance Some may produce transparent BIPV glass with no visible pattern	Very low efficiency limits economic appeal Custom/irregular panel shapes may have unattractive patterns or be impossible

Table 2. Aesthetic advantages and disadvantages of BIPV.

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This new aesthetic has yet to be fully defined, although as a practical issue the degree to which factors other than cost matter is highly dependent on the particular building, the particular architect, etc. Architects, we believe, might help promote BIPV as an aspect of 'green/LEED' building design. But as the BIPV market evolves, the content of some future BIPV aesthetic will become clearer. What is relatively clear at the present time are the dimensions in terms of which such an aesthetic will be defined. These are shown in Table 2, which also illustrates some of the aesthetics-related advantages and disadvantages of crystalline silicon thin-film and organic-based BIPV.

BIPV and its new economics

Also of critical importance to the future of BIPV is the fact that BIPV products exhibit an economics which is fundamentally different from that of standard PV products. With regular PV we are looking at a large upfront cost – high enough that, outside of a few small market niches, PV makes little sense without government subsidies. With BIPV the cost of the PV is added to the cost of a roofing shingle, a sheet of wall cladding or even a window. But at the same time, the functionality is increased: the product is now a roofing tile and a PV panel.

In much the same way that an integrated fax/copier offers good economics for both fax and copying functionalities, because it shares a common electronic and electrical infrastructure, a BIPV product becomes a good deal because the PV functionality and the building product share a common substrate. Quite how good a deal is ultimately technology dependent, because we expect the level of integration, and therefore improvements in BIPV economics, to increase over time:

- Today we are probably talking about a PV laminate on an otherwise fairly conventional roofing product.
- Another new approach to BIPV is the manufacture of BIPV tiles that interlace with conventional high-end roofing tiles. This approach has been used for a few years with crystalline silicon PV, but only to a small extent with thin-film PV. Now, however, there is increasing development of interlacing products with slightly different approaches. New CIGS-based flexible roofing products such as Dow Chemical Company's shingle product make additional markets more accessible to PV and BIPV firms.

In the future we are talking about something closer to a more monolithic type of integration, with the integration being created at the layer of the materials themselves. What this might mean is the introduction of some kind of composite material that could genuinely be claimed to be both a PV absorber layer and an attractive and highly functional roofing material.

Nothing like this exists yet, but when it does, it would present the possibility of a BIPV roofing product that would cost only slightly more than the equivalent roofing product without PV functionality. This could be a very attractive offering, potentially reducing the cost of PV panels by orders of magnitude.

Of course, while the adoption of a BIPV strategy improves the economics of BIPV, it does not eliminate the inverter or other peripherals from the cost equation. But our belief is that the integration aspect of BIPV will still be sufficient to lower costs not just to a point where the addressable markets for PV would expand significantly, but also to the point where PV could become inexpensive enough to exist without government subsidies. So BIPV could be a key technology strategy for the survival of the PV industry in a world in which economic growth will be severely curtailed for the next few years.

"The possibility of a three-year ROI for grid-connected BIPV is certainly possible with government incentives and grid electricity costs greater than US$0.20/kW."

A large cost breakthrough still lies in the future for BIPV, although many second-generation BIPV products can already offer payback periods of seven to ten years without incentives, which at current low interest rates may be acceptable in some markets. And, of course, in most markets in which it competes at the moment, BIPV can

Source: Romag

Figure 2. Romag's BIPV installation in the London Borough of Hackney, UK, covers the glazed roof of the local Council's 'Customer First Centre.'

still tap into government subsidies. In a few places there are even incentives specifically aimed at BIPV, based on the idea that BIPV (as opposed to regular PV) may have added value from a communitarian as well as an individual point of view.

Given the benefits of BIPV and various potential market scenarios, NanoMarkets sees several thresholds for BIPV payback time consideration, specifically three, five, ten and twenty years. The possibility of a three-year ROI for grid-connected BIPV is certainly possible with government incentives and grid electricity costs greater than US$0.20/kW. Even a 20-year ROI, while probably not of interest to most residential and commercial owners, could be acceptable for schools or other government buildings (see Table 3).

The BIPV approach is easiest to justify when the conventional building materials

BIPV ROI (years)	Residential	Commercial	Government	Off-Grid/Special
3	Strong	Strong	Strong	Strong
5	Some	Strong	Strong	Strong
10	Some	Some	Strong	Strong
20	None	None	Some	Some

Table 3. Level of interest in BIPV for end-user segments as determined by ROI term.

that BIPV is designed to match or replace are high-end, high-cost ones. If the building material costs are already comparable to, or higher than, the cost of PV by itself, there is much more ability to absorb a significant part of the PV cost into the cost of the building materials used or replaced. This situation already exists for some expensive building materials such as certain architectural glass and high-end roofing slate. Declining PV prices will also eventually allow significant portions of PV costs to be absorbed by mid-range and lower-end building materials, enhancing BIPV's market position in those categories.

BIPV has some big backers

Just a few years ago, BIPV meant little more than using completely conventional panels and hiding them with architectural features. Currently, a lot of what passes for BIPV is actually flush-mounted panels and little more. Still, there is reason to hope that a next generation of BIPV products is emerging in which: 1) fully integrated BIPV products will come from a factory with the PV devices already incorporated; and/or 2) building materials do not function well without the PV devices, or vice versa.

When this happens, the distinction between the architectural and building material costs of a BIPV product and the PV costs is much fuzzier. BIPV suppliers can then more easily maximize the perceived value of the architectural aspects of their BIPV products, leaving a smaller portion of the BIPV costs to be assigned as PV system costs and increasing their opportunity to improve profitability. In this environment, it becomes far less clear that subsidies will be needed to keep the solar business in business, as it were.

No doubt we are still a long way off from achieving such goals, but there are signs of progress. It is particularly encouraging, we think, that BIPV is being treated seriously enough that large companies are getting into this business. The participation of such companies would, it seems, be essential for the development of BIPV for at least two reasons:

- First, in today's financial climate, strategic investment by a large multinational may be the best hope for an innovative start-up to secure funding for its BIPV business.
- Second, an alliance between such a BIPV start-up and a larger firm seems to be essential in order to provide access to a sophisticated marketing channel for the smaller company. It is clear that not all marketing channels are created equal, and we think that BIPV firms which can build alliances that get them into the conventional professional building materials and do-it-yourself supply chains will be substantially advantaged.

We have already mentioned Dow as a major firm that already sees opportunities in the BIPV space. Dow is constructing a facility in Michigan capable of producing up to 200MW of its BIPV shingles by 2015. But there are other big firms entering the BIPV market too. For example, both Tata Steel and Pilkington Glass (now part of Japan's NSG group) are collaborating with Dyesol to develop DSC technology for BIPV applications. The collaboration with Pilkington Glass covers commercial architectural canopies, side walls and shade structures. Tata Steel is looking at the potential for DSC-based BIPV-on-steel roofing, with plans for a multi-million square-metre pilot line being discussed.

There are also, of course, many medium-sized firms in this BIPV space that we expect to thrive. And what all of the firms in the BIPV business appear to share are strategies focused on creating value-added products that effectively distinguish them in the marketplace from the sector of the PV industry that specializes in plain vanilla and rapidly commoditizing solar panels of the kind that Chinese companies have proved so good at supplying.

Conclusion

While the underlying technology of BIPV products that are likely to appear on the market is just the same as for the ones that have been touted by the PV industry for (more or less) the past decade, the BIPV perspective on product strategy is the only one that seems to us to offer a relatively short-term fix to a market environment in which subsidies may eventually become a thing of the past and in which the potential for price wars is frighteningly real. In addition, the arrival of genuinely integrated BIPV products will also lead to a new architectural aesthetic for them, which could, when translated into business strategy terms, mean the opening-up of entirely new markets for PV in the not too distant future.

Reference

[1] NanoMarkets 2011, "Building integrated photovoltaics markets, 2011" [available online at http://www.nanomarkets.net/index.php/market_reports/report/building_integrated_photovoltaics_markets_2011].

About the Author

Lawrence Gasman co-founded NanoMarkets, where he is currently principal analyst and his consulting clients include both multinationals and start-ups. Lawrence was educated at the London School of Economics and London Business School; his latest book is on the commercialization of nanotechnology.

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