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Building-Integrated Photovoltaic Markets 2009 and Beyond

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Executive Summary

E.1 PV's Place in the Building Materials Market

Installing photovoltaics on buildings has long been considered. This is only natural because buildings account for 40 percent or more of electricity consumption worldwide, the timing of peak PV power production correlates fairly well with that of building electricity usage, and distributed generation of electricity is less taxing to the power grid than the currently dominant system of centralized generation.

As the installation of PV systems on buildings has taken hold in some markets, the PV system has become considered one among several building systems, and like any new kind of building system it has been—and continues to be—undergoing an evolution as the best implementations are developed. Part of this evolution is taking advantage of the fact that many portions of building skin—the conventional building materials that make up the exterior of a building—receive daily exposure to the same sunlight that the PV system uses for power generation.

Since PV power itself is produced by surface-covering materials, the natural extension of this part of building-installed PV evolution is to cover the surfaces of—or integrate—the building skin with PV-generating materials. The BIPV products that do this best combine the properties and functions of conventional building materials with those of PV modules, eliminating the need for the conventional materials where these BIPV products are installed. They also yield the benefits of improved appearance and architecture since the PV system is visibly and structurally integrated into the building surfaces and materials, rather than being mounted on racks that do not integrate with the building structure.

Trends in architecture, construction, and the motivations of building owners are important considerations when integrating photovoltaics with building skin materials. Increasingly, businesses, architects, and homeowners want buildings that are aesthetic in appearance, modest or light in energy consumption, and sustainable. And this is reasonable: reducing energy consumption keeps the cost of ownership down, and can even compensate in many cases for higher construction costs to achieve lower sustainment costs.

Other factors in BIPV's favor include growing implementation of renewable energy portfolio standards, which provide further incentives for PV on buildings: the utilities need them to boost their solar percentages. This may help to trigger other incentives, but it also produces something of a baseline to predict the extent of PV conversion. That is, if fewer solar installations are installed than are necessary to meet renewable portfolio standards and solar carve-outs, one can reasonably expect additional incentives to be generated to help boost participation.

Not everything is positive, of course. In the past year, up-front cost of construction projects such as BIPV ones has taken center stage as the current recession and financial mess have shortened the investment horizon, and the required payback time, for all construction projects, including, and perhaps especially, PV and BIPV projects. Financing for these projects is difficult to obtain, and a greater rate of return on the projects is required to make them move forward.

Notwithstanding the slow construction and credit markets, the combination of policy incentives and trends in architectural style produces a need for aesthetic integration of PV cells into the buildings that use them. Even though the appearance of solar panels on homes and other buildings has become more mainstream in some markets, there is still a large segment of the population that is interested in the benefits of solar power for their homes or other buildings, but is averse to anything resembling a power plant. Put another way, the early adopters of a technology such as PV power are not as concerned with other issues including cost and appearance, while subsequent waves of adopters get more and more concerned with these issues. Currently, we are at a point in adoption where, in many cases, well-done BIPV can make the difference for a large proportion of potentially impending users because they are very concerned with the appearance of the systems on their buildings.

Because they are an option and are designed to appeal to customers who are highly concerned about building appearance, BIPV products can be expected to remain at the high end of the construction materials market even as costs come down. Currently, based on their cost, they belong there—and perhaps beyond the high end—anyway, but the fact is that customers selecting building materials based mainly on cost are also likely to select a PV system for their buildings mainly on cost, with appearance secondary.

That is not to say that mid-range and even low-end product types should be ignored. Although it is a long way off, it is likely that certain BIPV materials may eventually cost less than the combination of similar building materials and add-on PV panels. Then, even the cost-centered adopters will have enough options that their secondary concern for appearance will make more of an impact.

E.1.1 Types of BIPV Materials

While there are an increasing number of BIPV products on the market, they generally fall into three categories based on their manufacture and potential applications. Rigid, opaque BIPV products are suitable for roofs and walls—opaque surfaces of buildings—either as tile-type structures that replace conventional rigid materials like tiles and shakes or as larger modules that can be assembled to replace an entire wall or roof surface. These products benefit from standardization; for instance, the dimensions of commonly-used roofing tiles are well-known and BIPV tiles can be made to fit seamlessly. As there is with other standardized rigid building materials—bricks, blocks, etc.—there is considerable flexibility in the areas that can be covered by these tiles simply by laying them together.

Flexible opaque products cover the same building surfaces—the opaque ones—as the rigid products just mentioned. These can be products such as shingles or metal roofing sheets with embedded PV laminates, or simply the laminates themselves, to be adhesively bonded to conventional building materials. These products benefit from their flexibility—matching with various conventional building skin materials that are also flexible—and, especially in the case of the separate laminates, their versatility. Adhesive-backed flexible PV laminates can be adhered to any number of conventional building material products—even on a construction site—to form a large variety of BIPV composites with only a single PV product.

Semitransparent products, generally glazed between two or more sheets of glass, serve all of the building material applications where light transmission is required—windows, skylights, partial shading devices, architectural glass, etc. These products benefit from glazing technology, making it easy to glaze discrete cells—such as c-Si PV cells—with custom dimensions and spacing, as well as from the relatively high cost of the conventional architectural glass materials they often replace. The addition of PV functionality to architectural glass increases glass cost by a smaller percentage than such an addition does to many other building materials.

E.1.2 BIPV for Residential vs. Commercial Buildings

There are many options as far as where BIPV materials can be applied, and the range of these choices is one of the areas where residential and commercial BIPV differ. For the purposes of this report, we separate commercial and residential buildings mainly by their size and the type of owner or other decision maker who would determine whether to install PV systems and what type. Aside from buildings that are clearly solely used for commercial purposes, the commercial category thus contains large, multi-family apartment buildings and multi-use buildings.

Commercial buildings, as we have defined them, include the large prestigious buildings that showcase BIPV technology as part of their overall architecture and are designed to impress, but also include more mundane buildings such as office buildings, schools, and government buildings. These buildings are larger than residential ones and thus individually offer larger paychecks to the BIPV material suppliers, integrators, and installers as well as savings to the end user due to significant economies of scale when standard products and systems are used.

Commercial buildings typically have flat roofs, which can limit the choice of BIPV materials options and can also make rooftop BIPV installation less advantageous relative to standard rooftop PV installations because in many cases either type of system can be installed without being visible from the ground, largely eliminating the aesthetic benefit of a BIPV system. Taller than residential buildings in most cases, commercial buildings also offer more wall area for BIPV installations and in fact many commercial buildings—especially high-rise buildings—have more sun-exposed façade area than they do rooftop area. They also generally use more glass and in more functions than the windows and skylights that are typically the only glass on many residential buildings. Commercial buildings may have entire wall façades made of glass, rather than just the windows, and may have additional glass structures such as curtain walls and atria. This makes commercial buildings by far the larger market for BIPV glass, especially since these non-window structures typically do not need to be completely transparent.

Residential buildings, as we have defined them, are mostly single-family and small multi-family homes. By virtue of their smaller size, installation of BIPV on individual homes is generally a more costly proposition because there is little opportunity for economies of scale. However, especially in the construction of new housing developments these economies of scale can be realized by outfitting several homes with standardized BIPV systems at the same time. In addition, the design and installation of a BIPV system can be more rapid for a residential building because of its smaller size and because the project decisions can be much simpler; often only a single decision maker—typically the homeowner—is involved.

As far as sun exposure goes, residential buildings are typically dominated by their rooftop exposure, and residential rooftops are more often sloped and visible from ground level. This makes the rooftop the logical location for residential BIPV installations, and in fact there is little market currently for residential BIPV wall products. The ground-level visibility makes the choice of rooftop BIPV, rather than conventional rooftop PV, more noticeable and have more of an impact on building aesthetics, and capitalizes on one of BIPV's chief benefits, better aesthetics. Sloped rooftops are the target of most BIPV roofing products; BIPV roofing tiles are the single type of standardized product that has seen the greatest growth in terms of product offerings in the last few years.

The smaller proportion of sun-exposed wall area and glass makes BIPV cladding and BIPV glass a smaller prospect for residential markets. Options for residential BIPV glass installations are mainly restricted to skylights; the wide views that often go along with sustained sun exposure on windows are also features that add value to homes and homeowners are not likely to want to detract from those views by using the type of semitransparent glass that is typically the result of the integration of PV with glass. However, it is common to shade sunlight from entering windows—typically using interior curtains and blinds—to reduce warm-weather cooling loads and to reduce interior glare and—in some cases—improve interior comfort and aesthetics. This raises the potential for new residential building features that shade sunlight from entering residential windows while generating PV electricity.

What this means for the commercial vs. the residential BIPV markets is the following:

- Larger size makes installation of BIPV systems on commercial buildings generally more economical than installation on residential buildings.
- BIPV wall products are more often suitable for commercial buildings than for residential ones because of the larger wall area and the more frequent use of conventional architectural glass, which need not be completely transparent, for commercial walls and other vertical structures.
- Because of the higher proportion of glass use, commercial BIPV projects are a much larger market for BIPV glass than are residential ones. Residential BIPV glass consists mainly of skylights because of the importance of transparency in residential windows.
- Residential buildings use BIPV roofing products almost exclusively among BIPV product types because they have a high proportion of roof space and it is typically sloped and visible from the ground, making roof aesthetics more important than they are for many commercial buildings.

E.1.3 BIPV for New Construction vs. Retrofits

It is widely agreed—including by NanoMarkets—that new construction offers the best opportunities for BIPV installations. This is because BIPV system can be planned and designed more effectively and with fewer constraints, as building components don't need to be installed twice—once with conventional materials and again with BIPV materials—and because new construction is often done more than one building at a time, offering opportunities for economies of scale. New commercial buildings and new housing developments are generally the best projects for installing BIPV, both for reduced cost and for effective design.

But new commercial building projects and new housing development projects are rather hard to come by in the current economy. Even as recovery begins, the construction market is likely to remain down as lenders remain cautious and wary of contributing to another "bubble." So the reality is that there are likely to be many more opportunities for retrofits over the next several years than there will be for new construction.

Retrofits can be done effectively. For residential installations, reroofing offers an opportunity to perform the retrofit with minimal waste of conventional building materials. Residential roofs are generally designed to last for 30 years or more, so over three years as much as 10 percent of the addressable market could be addressed simply through reroofing.

Without reroofing, the most cost-effective residential retrofits will be installation of the flush-mounted panels—designed to be minimally disruptive of building lines and architecture—that we consider to be BIPV products for the purposes of this report. These panels do not require removal of functional roofing and are also less costly than the fully-integrated products that replace roofing materials.

If the existing roof happens to consist of tiles or other units that some BIPV products are designed to emulate, an aesthetic and well-integrated BIPV installation may be easily achievable by replacing a portion of the roofing tiles with BIPV tiles. Again, this is more cost effective than a complete reroof, but involves the loss of some functional building materials.

Commercial retrofits using BIPV products can be more involved, especially if the roof is avoided because BIPV products would not be visible. There are BIPV products designed for membrane roofing, but they sacrifice much of their aesthetic value because they are not visible from the ground. In fact, in cases where a large, flat roof is available and invisible from the ground, it would often make sense to begin the retrofit by covering the flat roof first, considering both membrane roof BIPV products and conventional, low-profile modules on the flat roof.

If additional power is desired after retrofitting the roof, BIPV cladding tiles can be mounted over existing cladding cost effectively. But for architectural impact similar to that of a new building, entire new features can be added to buildings in order to incorporate BIPV. A semitransparent canopy above a courtyard or entrance area can be an impressive new feature, as can a curtain wall in front of an existing wall. Some architects have gone as far as to build a complete additional building skin—incorporating BIPV—around the old one.

E.1.4 Geographies for BIPV

In ordinary economic times, after considering the incentives in the different geographies, it would generally make sense to pursue BIPV installations in the more affluent geographies. Because of its current greater cost, BIPV is an option that may have a long payback time—or may never produce a complete payback—if only the monetary value is considered. An affluent customer base is more likely to have the ability to pay extra for the less tangible benefits that BIPV provides.

As we point out throughout the report, these are not ordinary economic times. With today's poor construction market, the regional construction markets have become the most important geographical consideration for BIPV, aside from policy incentives. That means countries that are likely to see the earliest growth in construction should be high on the list of BIPV market prospects. The developing world has in general had a more volatile economy than the developed world, suggesting that there may be some boom-like activity there before the developed world gets back to consistent economic growth. With the added impetus of rapid population growth, new construction is likely to grow at a reasonable pace in the next few years in the developing world, even if construction markets continue to slump in the largest world economies. In a market like India, with rapid long-term growth, a growing population, and emerging PV targets that are very ambitious, significant BIPV growth seems like a good bet in the next few years.

Not just in India, but throughout the world, PV—and BIPV—incentive policy is still very important in determining the best opportunities for BIPV growth. Europe, China, and California all have strong PV policy incentives that seem likely to stay in place for the next several years. In the European market and in the U.S., there are a range of different policies but a high level of interest among the individual countries or states in boosting PV markets. As the policy blender spins in those jurisdictions, some effective policies are likely to stick in some places.

There has also been a recent trend toward incentivizing BIPV above and beyond the incentives for PV in general. This has been seen so far in France and China but is likely to spread further. The places with favorable policy incentives will continue to see the best PV growth, and in those places the prospects for BIPV will be best where there is either a mature PV market (Germany, Spain, Japan, California) or BIPV-specific policy incentives (China, France). It should be noted, though, that where construction markets are lagging, the BIPV markets are likely to be tilted toward retrofits.

E.2 Economics and BIPV

The goal of BIPV is to be competitive with—actually superior to—the combination of conventional building materials and the installation of conventional PV panels. Competitiveness and superiority are measured not only in terms of cost but also in architectural terms including building appearance and functionality.

BIPV can do more than simply follow on the heels of conventional PV. This exciting new collection of technologies can help to revitalize a sagging PV market by attracting interest from a new set of potential adopters. Many decision makers who would never consider conventional PV systems for their buildings—because of concerns about the typically unsightly appearance, perceptions that a prominent system makes a political statement, or for other reasons—may now consider BIPV systems because they make an architectural statement—and an aesthetic one—rather than an environmental or political one.

Here we examine some of the issues that play into the assessment of BIPV markets.

E.2.1 PV vs. Conventional Energy

It is universal—or almost so—that for BIPV to be advantageous, PV itself must also be advantageous. Without the benefits of PV power, BIPV becomes an overpriced set of conventional building materials rather than an integrated power generating system. For BIPV to gain a foothold in a market, the PV power to be generated must be understood and recognized as a financial benefit. The race for grid parity helps to illustrate that.

In the absence of incentives, which create an artificial grid parity or even grid superiority, grid electricity prices and the intensity of daily sunlight are the chief factors influencing the achievement of grid parity. There is a wide range of electricity prices throughout the world, and they are already having some impact independent of policy. Japan has some of the highest, and it was able to maintain a somewhat robust PV market even in the absence of policy incentives for a couple years. Hawaii also has very high electricity prices; the impact on solar energy there has been mainly on solar hot water, though. New Jersey's second-place showing in U.S. PV installations is not entirely due to the state's incentive policies, which are subject to annual approval, but also because grid electricity prices are fairly high in the state.

So policy-neutral grid parity will be achieved first in those markets where grid electricity is most expensive. But insolation plays a role, too. Besides traveling from regions of high electricity cost to those of low electricity cost, grid parity will also begin nearer to the equator, and in the sunnier areas ahead of the cloudy ones; this is simply because of the power produced daily from the PV modules.

With the cost of PV power on a long-term downward trend and grid electricity prices generally increasing over the long term, there is naturally speculation about when PV power will be "cheaper" than grid power, or better-than-grid parity. This condition might be called "grid superiority". We should point out that NanoMarkets does not expect any kind of significant, sustained long-term "grid superiority" in the absence of policy incentives; if and when grid parity is achieved we expect it to stick as PV prices slow their descent and grid electricity reverses its climb.

This sustained grid parity situation will not be due to any kind of malicious market manipulation—although there are certain to be conspiracy theorists who espouse this view—but simply due to market forces. Increased demand for low-cost PV installations would boost PV prices while reduced peak power loads—the most costly on the margin—combined with a huge, already paid-for infrastructure will cause grid power prices to drop in order to retain business. The boost in PV prices has already been witnessed in the recent past: as Spain and Germany produced huge demand for PV modules—through policy-induced, artificial "grid superiority"—PV module prices have risen in response.

It should be noted that the long-term decline in PV costs will be driven in large part by increasing volumes and economies of scale. This is even truer for TFPV, which can benefit from the use of larger or longer substrates, than it is for c-Si PV, which is a wafer process such that capacity expansions are more a matter of duplicating equipment. While PV prices, especially c-Si PV cells, are down in the current economy, that is largely a result of oversupply rather than cost reduction. Sustained low PV demand will eventually impact supply and slow the decline of prices. Conversely, if PV does pick up significantly in demand, the long-term price trend—after a brief increase due to consumption of inventories—will resume its rapid downward motion.

E.2.2 BIPV vs. Conventional PV

As we point out in the main body of the report, BIPV is currently significantly more costly than either conventional PV panels, the conventional building materials they replace, or the combination of both. Currently the value in BIPV is primarily driven by its aesthetics rather than by any savings in cost. This is not expected to always be the case, though, as BIPV is a newer technology than PV itself and has many opportunities for cost reduction.

One such opportunity is associated with the growing proportion of TFPV being used in BIPV materials, especially the flexible ones but also BIPV glass. TFPV itself is fairly new and going through a cost reduction phase of its own. As TFPV trims costs, the savings will be carried through to BIPV products that use it. Flexible BIPV materials stand to benefit to a greater extent than BIPV glass because a greater proportion of their cost is the TFPV cells contained within. Architectural glass is more expensive relative to the TFPV portion (minus the substrate).

Other opportunities for cost reduction exist, and in the long term the cost of BIPV products will trend toward the combined cost of the PV cells contained within and the building materials used to construct the BIPV product. As any new technology matures, the materials tend to make up a greater and greater proportion of the cost as equipment, labor, and other costs are reduced relative to volume. BIPV products seem like natural devices to follow this trend.

There are, of course, the aesthetic and architectural factors that influence BIPV adoption. These are important considerations in the decision to go BIPV versus conventional PV and, although they work strongly in favor of choosing BIPV, their impact is reduced somewhat in this environment. With the difficulty of obtaining financing and the short-term investment focus, the bottom line is just too important to give appearance too much leeway in the decision. This cost-centric focus will most likely ease somewhat as the economy begins to improve and as the businesses and individuals that choose to adopt PV or BIPV systems begin to take a longer view on investment decisions.

Where BIPV will be favored more clearly is in new construction. However, new construction is not a very big part of the addressable market at this point. Even as economic growth begins to return, NanoMarkets believes that the housing and construction markets will lag behind. Thus for the next few years we expect only a small number of new construction projects, but a high proportion of them will be built with BIPV systems. The rest of the BIPV market will be in retrofits, which will be more common but less likely to implement BIPV. An important key to finding opportunities in BIPV will be to seek out the markets that are likely to have higher rates of new construction.

E.2.3 Incentives and Policy

Policy, too, will impact BIPV, both as distinct from conventional PV and along with it. The standard policy toolkit of the various subsidies on the devices, net-metering, and feed-in tariffs are typically measured in terms of power—peak watts or kilowatt hours—and thus do not distinguish between BIPV and conventional PV. In fact, these policies can even provide a relative disincentive for BIPV since the reward is only on the power from the system; the additional cost of BIPV products—beyond the cells within them and the conventional building materials they replace—are still paid in full by the purchaser.

Some PV policies reward building-mounted PV systems at a different rate than ground-mounted systems. We do not distinguish this type of policy from the most general policies because BIPV does not generally compete with ground-mounted systems. The relevant choice is almost always between a BIPV installation and a non-integrated, building-mounted installation. But there has been an interesting trend in some places toward subsidizing—or otherwise rewarding—BIPV to a greater extent than conventional PV. France and China stand out with this kind of policy. France's feed-in tariff is at a higher rate for BIPV-generated electricity than for conventional PV electricity. China's approach is to subsidize fully-integrated BIPV products at a higher rate than conventional PV products.

E.3 Opportunities for Building Materials Firms

The number one BIPV-related opportunity for building materials firms—if they have not already done so—is to partner with PV manufacturers to develop innovative BIPV products. This has already been going on for a few years; most of the fully-integrated products already available are either roofing tiles and slates, larger tiles that link together to form whole roofs or facades, or semitransparent glass products. There have also been some building materials firms that are working on flexible or laminated products based on United Solar Ovonic's Uni-Solar laminate; more of these laminates are likely to become available from different PV manufacturers over the next several years, and some of them are likely to be higher in conversion efficiency.

There is also plenty of opportunity to innovate with standardized products. For instance, while there are several BIPV materials—including tiles and semitransparent glass sheets—available for cladding of commercial buildings, the residential siding market appears rather sparsely populated. Development of innovative residential siding or cladding BIPV materials could help fill a niche that would benefit from more product types. Roofing markets already appear to be more equitable; there are all manner of roofing products for both residential and commercial applications. However, windows appear to be another niche where residential applications are underserved.

BIPV glass is widely produced—especially now that its production provides a market for excess c-Si PV cells—but it is almost always targeted for commercial buildings or for structures like curtain walls that are rarely if ever used on residential buildings. Residential PV glass is almost exclusively limited to skylight-type products. The development of smaller residential BIPV windows, especially in standard sizes to match conventional residential windows, could fill another niche that could grow substantially. We would like to point out that these examples are merely suggestions and there are likely many more niches that can be well-served by new innovative products.

E.4 Opportunities for PV Panel Firms

An important opportunity for thin-film and organic/DSC PV firms is to bring new flexible BIPV products to market as soon as possible. This is certainly not a revelation to anyone in the TFPV business, but there may be only a limited time for some of these products to be profitable. CIGS PV has been slow to produce its first flexible BIPV products—largely because of encapsulation issues—but when they do, the efficiency will almost certainly be substantially higher than that of the Uni-Solar laminates that currently dominate the market. The faster the flexible CIGS BIPV products get onto the market, the faster they will begin to move toward dominance.

This opportunity exists both for CIGS PV manufacturers and for other TFPV manufacturers. While a few CIGS PV firms appear to be very close to releasing flexible BIPV products, we have seen this before from CIGS. There is certainly the possibility of significant delays which would open a window for greater market capture by new flexible products made with OPV, DSC, or TF Si companies including market leader United Solar Ovonic.

Also for TFPV firms, the semitransparent glass market offers substantial opportunities. Here the potential advantages are greatest for CIGS PV and OPV because of the nature of their products. An additional consideration is that BIPV glass would encapsulate the cells adequately and minimize concern for air or water intrusion.

For CIGS PV, we see a simple opportunity for more BIPV glass production. Würth Solar is already producing this type of product, but we believe the market can sustain greater volumes. The BIPV glass market is currently dominated by glazed c-Si and a-Si modules, but CIGS PV can offer an improvement over either of those technologies. CIGS BIPV glass could provide the same clean, pinstriped—or other design—pattern that is common in a-Si BIPV glass, but do so with a conversion efficiency closer to that of the glazed c-Si PV products. Taken another way, CIGS PV can produce glass that is more attractive than c-Si BIPV glass yet more efficient than a-Si BIPV glass.

For OPV, the glass opportunity is to eliminate the visible pattern altogether, and produce BIPV glass that is uniformly tinted. OPV can already produce cells that are 50 percent transparent; visually eliminating the untinted gaps between them could yield a compelling product. Currently, BIPV glass is not used where an undistorted view through a window is needed or wanted because of the embedded cells or the thin-film pattern. Uniformly tinted BIPV glass would open this market niche to PV power generation.

We see another opportunity for OPV in terms of its cost. If the cost reductions that are hoped for actually materialize, OPV could be uniquely positioned to produce BIPV products—probably laminates—that are disposable, or at least cheap enough to replace more frequently than conventional building materials.

E.5 Opportunities for Systems Integrators

The current economy and poor construction market have resulted in fewer opportunities to install BIPV where it is most cost-effective, on new construction. NanoMarkets does not expect this situation to change any time soon, and it will make sense for many systems integrators to focus to a high degree on BIPV retrofits. By doing so, these firms will be well positioned to capture a larger portion of the BIPV installation market during the lull in construction. If—as NanoMarkets predicts—economic recovery begins well ahead of a recovery in the construction industry, this will continue to be a good position well into the future.

For those systems integrators that prefer to seek new construction BIPV markets, the best opportunity is to seek out markets where construction growth is more likely. Our prediction is that emerging countries will see the quickest return of new construction growth because of their volatile economies and their rapidly growing populations. NanoMarkets believes that the best opportunities for rapid BIPV growth while the worldwide economy is still stagnating are in India and China. India has little BIPV now but has recently been making grand plans for huge PV growth over the next decade. Combined with its huge and growing population—boosting the likelihood of significant levels of new construction—a rapidly growing BIPV market is at least as likely in India as anywhere else in the world. China shares some of these characteristics and already has a substantial PV base—including BIPV—not to mention BIPV-favorable policy incentives.

There are also some specific, smaller opportunities for systems integrators. Since the worldwide economic crisis began—pinching demand for PV installations while also contributing to ending the silicon shortage—there has been excess capacity for—and inventory of—c-Si PV cells. Module makers—including many new entrants—have capitalized on this situation by buying those excess cells and glazing some of them to produce innovative semitransparent c-Si PV modules, for architectural glass applications. These are often customizable and there appears to be an ample supply of them. The opportunity here is to use these products in BIPV projects while they are available. Either a correction in c-Si cell supply or increased PV demand would quickly limit the availability of the cheap c-Si PV cells they are made from.

Another opportunity is actually to steer some clients away from BIPV. On commercial retrofits, a flat roof is often invisible from the ground and BIPV installations on such roofs would lose much of their aesthetic appeal. As clients seek to retrofit their commercial buildings with sleek BIPV wall products, it would likely be of benefit to them to focus on retrofitting the roof—probably with low-profile, relatively inexpensive, non-BIPV panels, still invisible from the ground—before diving into expensive BIPV facades and curtain walls. The power generated on such mundane roof installations is real, and there is still the option to either retrofit the walls with BIPV as well or to add a less costly, non-PV architectural feature.

E.6 Opportunities for Construction Firms

As is the case for systems integrators, BIPV retrofit markets represent a lucrative opportunity for construction firms in this economy and construction market. Focusing exclusively on new construction markets will likely yield few projects for quite some time without moving to India or China (which are also opportunities). One option for retrofits that may be more cost-effective than most is to concentrate on reroofing markets. Even without much of a new construction market, roofs still have limited lifetimes and need periodic replacement. Installing BIPV products on residential roofs—and commercial roofs in the cases where it makes sense—can share some of the benefits of new construction BIPV installations while not requiring an actual new building.

Also related to retrofit markets—but applicable to some new construction markets as well—is the opportunity to capitalize on a trend that has emerged in the last few years: BIPV modules and laminates that are applied to conventional building materials onsite. These are some of the most cost-effective BIPV products in part because installation is fairly simple. Expertise in this area can allow clients to use these products in their projects without a dedicated installer.

The case is similar for BIPV architectural glass. As has been mentioned above, this type of BIPV product is easily available now, but that may not be the case for much longer. Expertise with the installation of this type of product can also yield installation opportunities. But perhaps the bigger opportunity is to gain in-house expertise on actually glazing the modules onsite. Producing these semitransparent modules onsite can make custom dimensions easier to achieve and confirm.

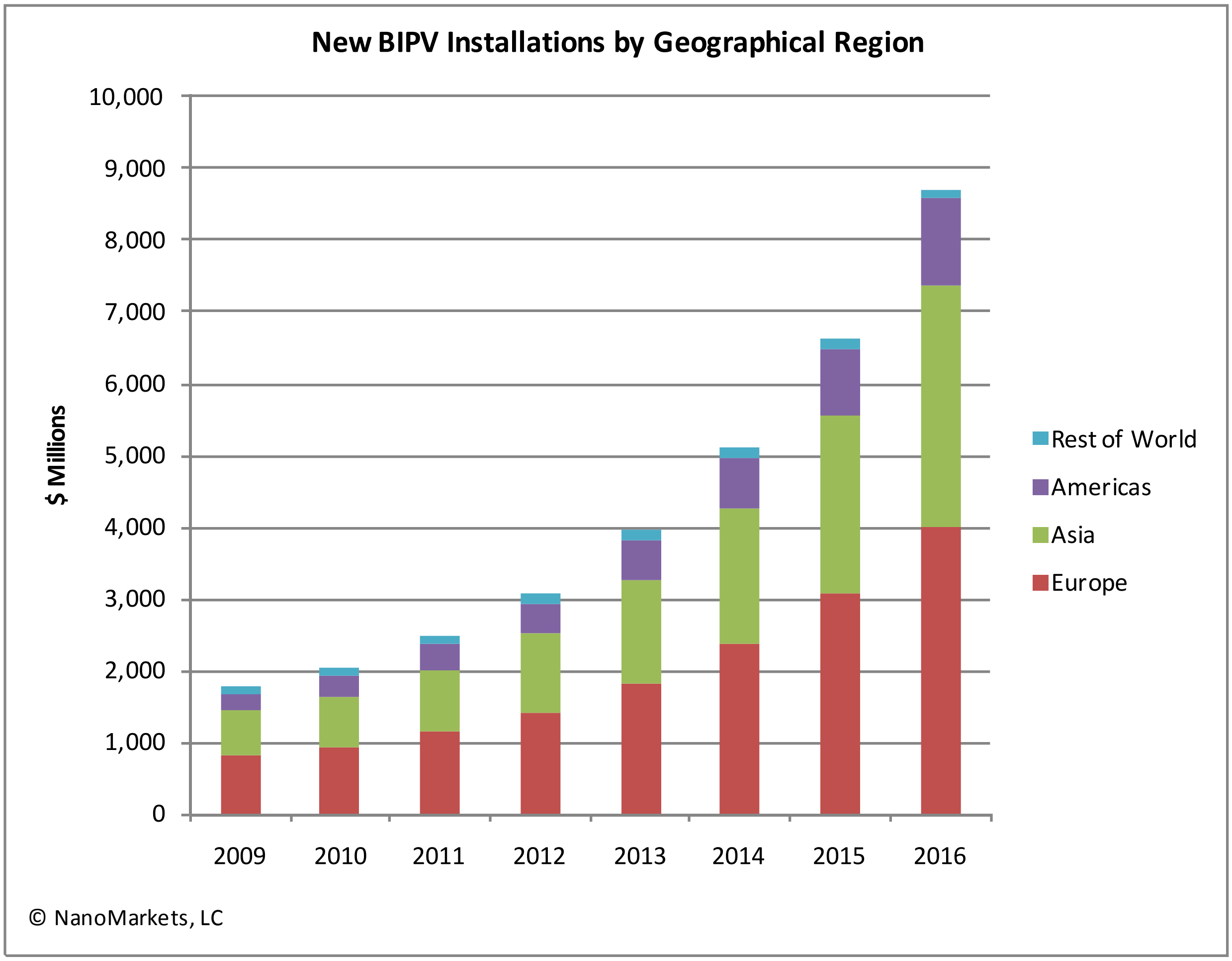
Finally, we see an opportunity for economies of scale in installing higher volumes of particular BIPV products. One way to achieve higher volumes may be to standardize the BIPV products that are used across several projects. This works for BIPV installations on subdivision-level new construction projects, and it may also yield savings on isolated construction or retrofit projects.

E.7 Summary of Eight-Year Forecasts of BIPV Materials

Worldwide BIPV Revenues: Exhibit E-1 summarizes our BIPV revenue forecasts by region.

Exhibit E-1
BIPV Installations by Geographical Region ($ Millions)

	2009	2010	2011	2012	2013	2014	2015	2016
Worldwide BIPV Revenues								
Europe								
Asia								
Americas								
Rest of World								

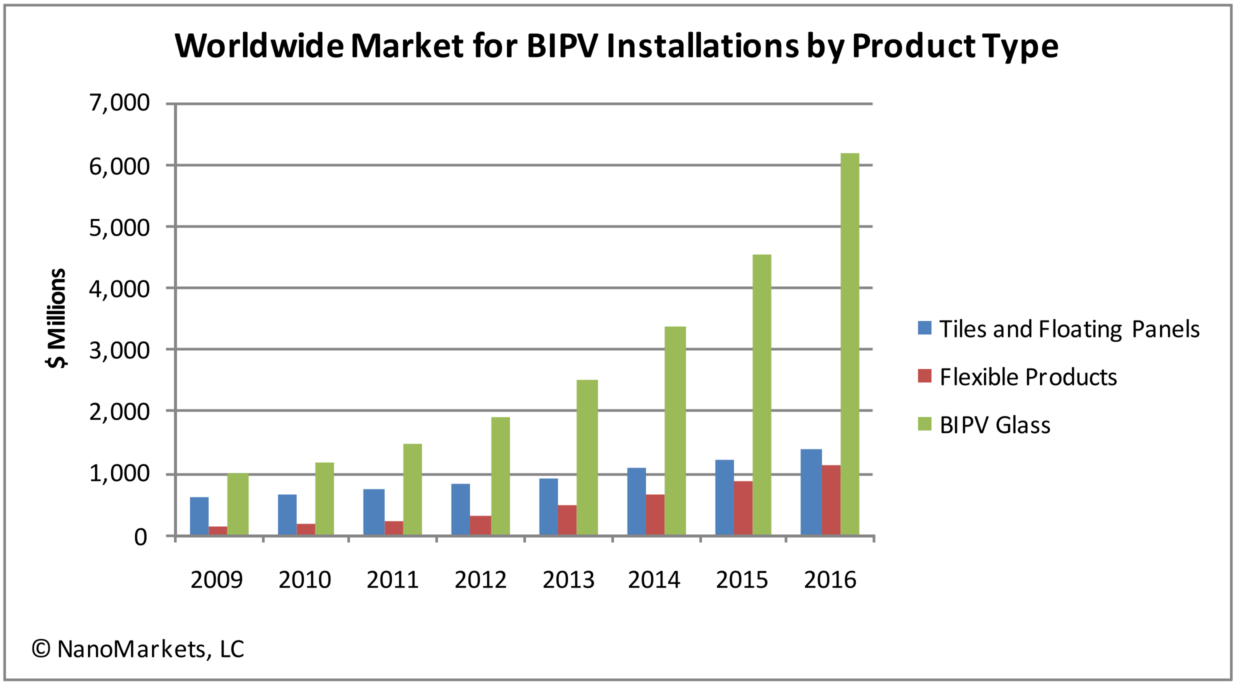


BIPV Price per Watt: Exhibit E-2 summarizes our forecasts for pricing of BIPV products by product type.

Exhibit E-2 BIPV Pricing by Product Type								
	2009	2010	2011	2012	2013	2014	2015	2016
Average BIPV Cost per Watt ($)								
By Product Type								
Tiles and Floating Panels								
Fully Integrated Tiles								
Flush Floating Panels								
Flexible Products								
Flexible Integrated								
Flexible Laminates								
BIPV Glass								

BIPV Product Types: Exhibit E-3 summarizes our forecasts of BIPV revenues by product type.

Exhibit E-3 BIPV Revenues by Product Type								
	2009	2010	2011	2012	2013	2014	2015	2016
Tiles and Floating Panels ($ Millions)								
Of which:								
Fully Integrated Tiles								
Flush Floating Panels								
Flexible Products ($ Millions)								
Of which:								
Flexible Integrated								
Flexible Laminates								
BIPV Glass ($ Millions)								



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