Solar Energy Expands, Escapes the Power Grid

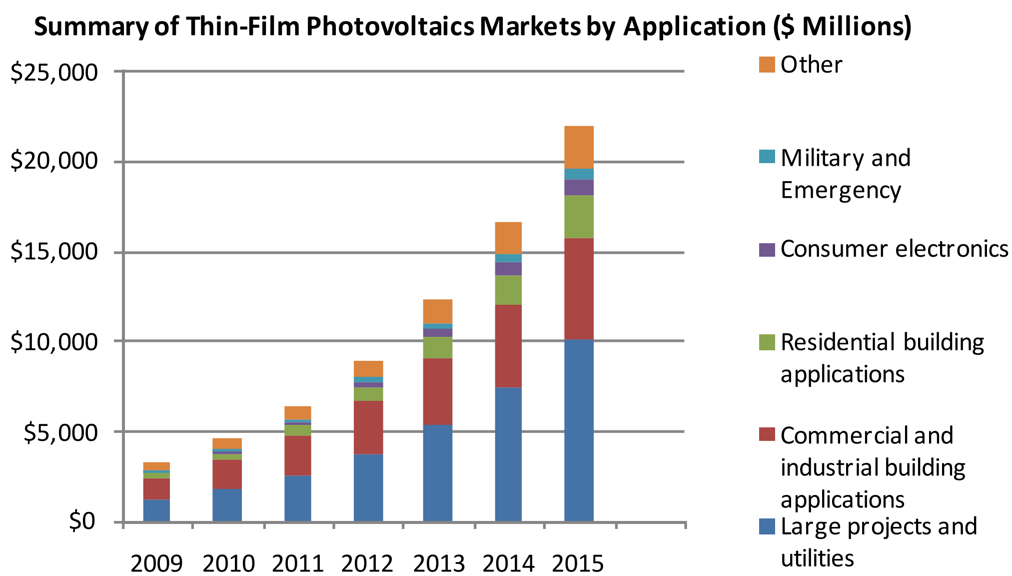
This article is based off the NanoMarkets report [Thin Film Photovoltaics, 2008 and Beyond]

Solar power has come a long way since its origins as a niche technology for satellites, finding its way into a wide range of large and small power generation applications. This range of applications is what makes photovoltaics unique among alternative energy technologies, most of which can only succeed by incorporating themselves into the existing power infrastructure. Biofuel-fired generators and concentrated solar thermal power are most efficient in large, centralized generation facilities. Wind resources tend to be most abundant in remote locations. All three depend on transmission lines to deliver power to customers, and incur the efficiency losses imposed by those lines.

Solar energy, in contrast, is inherently decentralized. Though the available solar radiation varies by location, a large solar field is no more efficient than a rooftop panel using the same PV technology. Placing solar panels near the point of electricity consumption reduces transmission losses and boosts net efficiency. Decentralized facilities also give both large and small users some measure of control over their own power supply. For large customers in particular, the price stability that solar panels provide can be more important than the absolute cost. Moreover, decentralized solar generation competes against retail electricity sales through the grid, an easier target than the wholesale prices paid by utilities.

Thin films for building integration

The decentralized nature of solar power has enabled the emergence of building-integrated photovoltaics (BIPV) as an important market niche. NanoMarkets expects installations on residential, commercial, and industrial buildings to account for more than half the thin film photovoltaic market in 2008. (See Table 1.)



Source: NanoMarkets, LC (*Thin Film Photovoltaics, 2008 and Beyond*, July 2008)

BIPV has received an additional boost from the emergence of several important alternatives to conventional silicon wafer-based solar cells. As the name implies, BIPV units strive to look and behave as part of the building. In some cases, a conventional panel is integrated by means of special trim and low profile mounting hardware. Though these designs make solar panels more attractive, wafer-based panels are still limited by their weight, rigid bulk, and cost. Thin film-based cells, in contrast, can replace conventional building materials with active PV equivalents. For example, United Solar Ovonic offers adhesive silicon-on-metal laminates, which can replace conventional metal roofing. Companies like Schott Solar and Kaneka deposit thin film silicon on glass for use in atriums, skylights, and other architectural glass applications. The light transmission of the glass varies depending on the amount of area covered by silicon. A south-facing atrium (in the Northern hemisphere) might use high silicon coverage to reduce glare while simultaneously maximizing the amount of power generated. A north-facing window receives less direct solar radiation and might employ reduced silicon coverage to let more light into the building. These options can make BIPV part of a “green” building design strategy, managing the available sunlight to optimize heating, cooling, and lighting, as well as power generation.

Compared to standalone solar fields, BIPV installations require no land beyond the building’s footprint. While wafer-based panels require special mounting hardware, active building materials do not. Thus, balance of system costs can be lower for these installations. At the same time, BIPV purchasers evaluate their investments using different criteria than utilities. A utility company will compare the costs and benefits of a solar field against other types of generating capacity. It may be willing to incur a relatively large initial cost—investing in high performance panels, for instance—in order to maximize long term output. For a building owner, in contrast, the power output of the installation may be less important than its appearance, initial cost, or compatibility with the overall building design. Panels that are “inferior” from a performance standpoint may still serve these auxiliary goals.

Central generation still the big PV gorilla

Though BIPV is a large and growing opportunity for thin film photovoltaics, central generation remains the largest sector of the overall PV market. Large sites generate more than 20 MW of electricity, a substantial sale for any solar cell supplier. NanoMarkets expects that wafer-based solar panels will continue to dominate this sector. For large installations, land, wiring, and even mechanical supports account for as much as half of the total cost. All of these costs increase as panel efficiency drops, offsetting the savings obtained by using less expensive thin film technology. The thin film technologies that have been the most successful in the large-scale generation sector are also among the most efficient: hybrid wafer-based thin film cells, concentrator-based GaAs cells, and CdTe panels.

Large installations are the most likely terrestrial application for concentrating photovoltaic (CPV) cells. These cells use lenses to focus light from a large area onto a small semiconductor surface. Though the high efficiency multi-junction GaAs-based cells used in this type of solar power are expensive, concentration ratios of 500X or more mean that only small amounts of semiconductor are required. To further improve efficiency, CPV systems use motorized tracking to follow the sun across the sky, and active cooling to dissipate excess heat. These components add complexity and ongoing system maintenance costs, and their energy consumption reduces the overall site efficiency. While a utility might find CPV maintenance costs pleasantly low compared to other generating plants, homeowners and commercial building owners tend to shy away from these systems.

While concentrating PV systems are inherently suited to large installations, the success of CdTe in this sector appears to be a product of First Solar's business strategy. To a large extent, First Solar is the CdTe market, and First Solar is focusing on large installations. Not only do large sites represent the largest market opportunity, but they may also be the most able to handle the cradle-to-grave life cycle management that CdTe panels require. As part of its life cycle management program, First Solar requires module owners to register their installation, and pays all packaging and transportation costs for modules submitted for recycling. Placing a large number of panels at a single site reduces the per-panel tracking and management cost for both First Solar and its customers.

Because balance of system costs are so important, large installations also derive more benefit from incremental efficiency improvements, such as Sanyo's "heterojunction with intrinsic thin layer" (HIT) technology. HIT cells are wafer-based, but use thin film technology to deposit high quality silicon on both the front and back sides of the wafer. Thus, they have two active surfaces, capturing reflected and ambient light with the back side of the cell in addition to direct illumination of the front side.

Flexible thin films go off grid

While both wafer-based and thin film technologies compete to serve fixed installations, thin film technologies are poised to dominate the market for portable solar generation. Portable wafer-based panels exist, but their bulk has confined them to such highly specialized applications as powering electronics for Arctic and Himalayan expeditions. Thin film technology promises to reduce both cost and bulk substantially, opening up a wide range of new markets.

The cost model for portable solar cells is somewhat more forgiving than for fixed installations. From a foldable sheet powering a business traveler's laptop to a military tent with embedded solar panels, portable generators are used in situations where grid power is inconvenient or unavailable. Competitors include generators, batteries, and eventually portable fuel cells, all of which are far more expensive than grid power. Logistics planners find generators especially problematic, as the fuel to power them must be transported across potentially hostile terrain.

For this reason, the U.S. military has been an enthusiastic investor in such technologies as CIGS deposition on flexible substrates. Currently available products include PowerFilm's solar field shelters and Global Solar's personal scale chargers. Such investments are likely to continue regardless of oil prices, greenhouse gas reduction incentives, or other drivers of the civilian solar market.

Portable solar panels will attract other customers as they become more capable and less expensive. From disaster relief to music festivals, large-scale, temporary gatherings create tent cities with as much potential panel area as many fixed installations. On the consumer side, portable electronic devices are proliferating in regions where grid power is unreliable or nonexistent. For example, micro-business owners in remote villages transport lead-acid batteries to the nearest grid-connected town for charging, then sell the electricity to their neighbors. Affordable solar chargers could streamline such small-scale mini-grids.

Though the applications discussed in this article can all be served by thin film photovoltaic technologies, there is no single solution for all markets. Cost, efficiency, and portability all affect the value of a panel, and each customer will weigh these factors differently. Thin film PV's greatest strength is its ability to match specific products to these needs.

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