The Integrated PV Learning Curve

By Kelly Jon Andereck
March 8, 2001

PV technology has come a long way in the last several years, but many architects and designers are discovering that we still have a long way to go and a lot more to learn.

Siemens 4 x 4-inch solar cells laminated with clear low-e. Design by Adrian Smith, SOM Chicago.

Within the past several years - and even just the past several months - much has changed in the energy marketplace. California is now in jeopardy of losing the battle between growth and power supply, and their situation could soon spread throughout the US. Adding more fuel to the fire, wholesale electricity providers responding to the demand have increased the price of electrons, making an alarming situation even worse for California's powerful economy. As the Federal Energy Regulatory Commission and California Governor Gray Davis debate the issues that beset them, distributed energy, energy efficiency and alternative power sources - including photovoltaics (PVs) - become more viable than ever.

Meanwhile, the growth of the PV market has begun to outpace the cost of the product, allowing the industry to begin transforming the marketplace. Today's PV systems produce electricity - and more of it - at a fraction of the cost of early PVs. While early PV modules converted only about 1%-2% of sunlight energy into electric energy, today's PV devices generally reach a 10%-20% conversion. Additionally, advances in PV technology are making it increasingly easier to fully integrate PV systems into a building's structure in an aesthetically pleasing design.

Many of today's architects and design firms, along with creative and forward-thinking clients and community leaders, have begun steadfastly pursuing PV energy solutions in various projects throughout the US and Canada, as well as in the more progressive architectural communities of Europe and the Far East, where three progressive solar suppliers - BP Solar, Sharp and Siemens Solar - all have production facilities. Skidmore, Owings & Merrill, LLP (SOM), an architectural firm headquartered in Chicago, is among those firms helping to drive the demand for PV installations. The company believes that we, as architects and designers, hold the keys to sustainable development. For that reason, we've dedicated ourselves to pushing the design envelope using PV and other sustainable technologies, and to sharing what we've learned with other firms so that, together, we can push these technologies forward. But if there's one thing we've learned through our experiences, it's this: No matter how far we've come in terms of solar technology, there's still a long way to go and a lot more to learn.

Education is Key

SOM has been involved in the design and development of over 17 projects incorporating PV systems. Through these projects, one of the main lessons we've learned is that while a focus on design is important to promote aesthetic and mechanical issues, educating the general contractor and the glazing and electrical subcontractors, as well as the client, is crucial to ensure the successfu use of PVs.

Educating the Contractor

Educating the contractor is important because a well-educated contractor will be comfortable enough with the technology to help keep the installation process within the client's budget. For example, if the glaziers understand that PV glazing materials are virtually identical to the glass products they deal with as a standard course of business, the result can be dramatic reductions in labor. Rather than hiring PV specialists for installation, glaziers can become confident enough to handle the installation themselves, resulting in bottom-line cost reductions for the client.

One example of this chain of events occurred in the Whitehall Ferry Terminal in New York, NY - a building that incorporates 60 kW of integrated PV (designed by Schwartz Architects of New York and manufactured by Atlantis Energy). W & W Glass, the contractor installing all of the project glass, will set the PV glazing elements, and 5 Star Electric will wire the inverters and terminations in conjunction with the electrical work on the entire project. No PV specialists are required in the design or installation because W & W Glass understands enough about PVs to install the project.

In another example, SOM was uncertain how the electrical union, International Brotherhood of Electrical Workers (IBEW), would handle the prospect of wiring a pre-assembled BIPV curtainwall in a new world headquarters building for a client in Chicago. Rather than take a chance on creating problems with the union, SOM began working with Atlantis Energy and Siemens to involve the union in the project at the design stage. This will help prevent any surprises - and thus extra costs - at the installation stage.

"It can be extremely difficult to coordinate the installation of PVs among the industry, architects and contractors. Often the most fundamental component of servicing the client requesting PV applications is educating the construction team," said Steve Coonen, vice president of Atlantis Energy, Inc., a solar supplier and consultant in Sacramento, CA.

Educating the Client

Of course, the project won't even get to the construction team if the client doesn't approve the use of the technology, so the design team often has to educate or re-educate the client as well. This factor came into play in SOM's design of the Chicago headquarters building. Among other sustainable building features, the new facility will incorporate a 2'-4" x 8'-0" spandrel of integrated photovoltaics over the length of the multi-story building's south, east and west facades instead of the base building solution of fritted spandrel. The PVs will control daylight and produce approximately 72 pkW of energy on the southern exposure of the building alone. (The other facades will produce the same power per square foot but less kWh annually due to site conditions.)

When presenting the PV concept to the client, we used the EPA's "Global Warming" website (www.epa.gov/globalwarming) to simplify the power production into terms readily understandable to all stakeholders, from the board of directors to the construction manager. For example, the website illustrated that the 72 pkW of PV capacity would enable the client to reduce carbon dioxide emissions equal to the emissions expended driving approximately 309,500 miles in an average passenger car. We also took the time to explain how the power generated from the PV system could be used to help power the company's computers and other plug loads. After we answered all questions related to equivalent savings (both in site power consumption and emission savings), we presented the client with case studies to substantiate the information.

Case studies of successful applications are often beneficial in discussing renewable options with the client. Such projects can easily be found in Europe and the Far East, where electricity is at a premium and renewable energy sources are in high demand. However, an increasing number of projects are also beginning to incorporate PVs in the US and Canada. Each successful PV installation provides a springboard for another successful installation by helping clients buy into the idea of PV systems, thereby generating more success stories and increasing market acceptance. In many cases it is also necessary to educate the client on the basic workings of photovoltaics and the benefits of fully integrated PVs over design solutions that are added too late in the process or as an afterthought.

Additionally, design teams proficient in PV and other sustainable design technologies can help their clients understand how the use of such technologies can be a key marketing tool by helping promote their company as environmental leaders. The client can only benefit from the clear win/win of advertising environmental issues, particularly where photovoltaics are concerned.

Communication is often the key to the education process. "Find out what your clients' 'green goals' are and help them achieve those goals," said Tom Kerwin, Associate Partner at SOM Chicago. "Some clients view their projects through the bottom line costs. In this case, the design team needs

to present environmental initiatives with a focus on the return on investment. In other cases, the client is interested in the green marketing or PR value. Finally, there are the clients who want to give something back to their respective clients. These clients often focus on the indoor and outdoor environments for their employees, guests, etc., and are less intrigued with image. As project managers, we need to be aware of the fact that all of this can be provided if green conversation is routine."

Architects and designers that take the time to educate their clients will usually find a very willing audience. "Green initiatives, including PVs, have moved from the back burner to the forefront of design not only because of SOM, but because our clients desire to learn and implement some or all recommendations," said Kerwin. This mindset is being exemplified in SOM's projects around the world. In our initial meetings with designers, clients often push discussions toward in-progress environmental measures and incentives. Increasingly, clients are requesting that the focus on their projects be green with tangible results. Because of the clients' excitement about PV technology, and SOM's willingness to educate everyone involved, some projects will not only incorporate cutting-edge integrated PV systems, but will also become showcases for community residents and visitors to learn about PV and other sustainable technologies.

Manipulating Costs

Generally, electricity prices for PV range from 12-20 cents per kilowatt-hour (¢/kWh). These prices are expected to decrease to below 6¢/kWh over the next decade as market share for PVs increases. But while the price of solar power has dropped drastically, first cost estimates can still be overwhelming for many clients. Architects and designers should be willing to bring up the topic of renewables early and work closely with their clients to show them the payback and find "first-cost-reduction" strategies.

SOM's environmental team has developed economic tools to aid in the financial assessment of integrated PVs. For instance, using Microsoft® Excel, we have developed a series of spreadsheets that enable us to track the economic performance of the capital investment. We then use this data to present the client with a year-by-year assessment of their investment based on IRS codes and the client's tax bracket. Life cycle cost analyses, energy and net annual costs are also included in the spreadsheet.

In addition to these tools, SOM uses other commercially available programs in our initial PV assessments, such as DOE2.1E (a building energy simulation tool developed with the Lawrence Berkeley National Laboratories) and Desktop Radiance (a ray-tracing software program developed by Lawrence Berkeley National Laboratories with the U.S. Department Of Energy and others). These tools quantify daylighting levels and overall energy performance. We then present the resulting analyses to the client along with available incentives and the resulting payback. For smaller scale projects, we use Atlantis Energy's "Clean Power Estimator" web site at www.clean-power.com/atlantis to aid the designer in estimating power, cost and payback.

Specific PV projects in targeted geographic areas are now capable of demonstrating relative cost-effectiveness when sold into the wholesale electrical supply market as the cleanest source of green power. For instance, Green Mountain Energy Co. in Vermont offers electricity made from renewable sources. Another example is Washington, DC-based Environmental Resource Trust, Inc. (ERT), which has established the Clean Power Program to increase the sale of renewable energy in the electric power market.

Additional economic justification can be achieved by offsetting local power supply as a component of energy efficiency and demand side management practices. States like New York, Illinois and California have programs in place to provide funding; such programs bring integrated PV systems into an economic structure, allowing the power generated from the PVs to offset the first costs of the PV system.

A number of Federal incentives are also available. For instance, the "Modified Accelerated Cost Recovery System," US Code Citation: 26 USC, Sec. 168 of the Internal Revenue Code, allows a client to reduce the capital investment of PV from around 20 to 25 years to 6 years or less based on a five-year depreciation schedule.* In addition to a reduction in payback, the "Energy, Reforestation Credit," Section 48 of the IRS Code, can allow the client to reduce the premium cost by 10%. When combined with other Federal programs, such as the "Million Solar Roofs Initiative" (enabling businesses and communities to install solar systems on one million rooftops across the United States by 2010) and others, this credit can enable first costs to be significantly reduced.

The payback is there, and incentives exist - architects and designers simply need to be willing to spend the extra time to find this information and share it with others. Whenever possible, the architectural team should urge the client to seek council from a certified public accountant and

validate the integrated system by enlisting the aid of the Department of Energy (DOE) to verify total system cost.

The Importance of Industry Partnerships

While solar technologies have come a long way, a lot of opportunity for advancement still exists. In many cases, off-the-shelf technology may not be the optimal solution for a particular design, and a more custom solution has to be developed. SOM has discovered firsthand that many industry suppliers are more than willing to partner with architects and designers to develop solutions that meet their design needs.

For instance, we have teamed with Siemens Solar and BP Solar to introduce photovoltaics in the spandrel portion of a typical curtainwall, and to design with various cells and distances between cell edges to provide optimal shading coefficients and peak power production. Working with Atlantis Energy, we have found a limitless source of design inspiration from the integration of shading, renewable power sources and aesthetics. Although power production is not at peak performance in this type of design, it is fully incorporated into the building's exterior envelope, providing true integration. SOM designers have also teamed with suppliers to integrate the technology into catwalks, street lighting, and as latticed shading devices over large parking areas.

SOM is also working with PowerLight to design rooftop solutions using PowerGuard®-a pre-engineered, lightweight (4.5 lb/sf) roof tile system that rapidly installs via tongue-and-groove interconnections and without roof penetrations. In addition to clean solar electricity, the tiles also provide R-10 insulation and roof life extension properties. This type of system allows the design team to integrate PVs into the base building design or as an alternative design option with little installation costs compared to curtainwall integration or shading devices. "Although PowerGuard can be easily installed on existing rooftops, strong industry partnerships in the design stage allow the value of PowerGuard's roof insulation and life extension properties to be maximized," says Mark Bronez, PowerLight's sales director for major accounts.

In other cases, SOM is working with suppliers to pursue curtainwalls that use monocrystaline silicon solar cells as both shading and power. This design solution becomes more fully integrated into the construction than other, off-the-shelf technologies in the market.

In the San Francisco Bay Area, SOM's San Francisco office has teamed with Pacific Gas and Electric and other industry leaders to implement a western façade design scheme on a four-story, 332,000-square-foot, second-phase office building on the campus of a large programming company. The western façade's prolonged exposure to the sun has provided an opportunity to integrate photovoltaic monocrystaline silicon cells into the entire curtainwall except for a 2'-6" view area. Along with a low-e laminate, which adheres the PV to the glass, the curtainwall is designed to allow plenty of light into the perimeter spaces, reduce glare and provide a 70-80% visible transmittance. SOM is working with state officials to secure funding for the project through a Public Interest Energy Research (PIER) Innovation Grant, and is also working with industry suppliers to develop the required PV technology.

Throughout this process of learning and perfecting integrated-PV design, SOM's environmental team has found that any original economic analysis is usually rendered useless when the developer or construction manager and subcontractors review submittal drawings. Based on their lack of experience with PV systems, they may double, triple or even quadruple the original cost estimates. To resolve this issue, SOM has been working with Atlantis Energy, Viracon, Siemens, Flour City and others to study the fundamental steps in the process of designing an integrated curtainwall. SOM will use proven design tools to quantify design choices while working closely with industry leaders to develop a design that houses low-voltage DC electrical outside of the building in the outermost mullion detailing - all with the intent to push the envelope of integrated photovoltaic curtainwalls. It is clear that this type of design involvement is tantamount to the success of the integrated curtainwall.

"Photovoltaic technology needs to be integrated into the entire construction process, from design through commissioning, to achieve optimum cost reductions and technology acceptance," says Steve Coonen of Atlantis Energy.

Bringing PVs into the Mainstream

With a renewed focus on renewable energy resources, integrated PVs are quickly becoming a mainstream technology. But for the architects and designers looking to incorporate PVs into their projects, the process will still be far from trouble-free. We must learn as much as we can about the technology so that we can, in turn, educate our clients and contractors. We must be willing to

research ways to bring the first costs of PVs into the client's budget. And we must be willing to partner with suppliers and other industry leaders to drive further development of PV technology.

Ultimately, it is our responsibility as architects and designers to move this technology forward. In the words of Peter Ellis, Design Partner at SOM Chicago: "For the longest time, architects have struggled for dynamic architecture - not static. By promoting the use of renewable elements like photovoltaics, we can create buildings that change with the environment and are 'living, breathing organisms.'"

Links

Atlantis Energy >>
BP Solar >>
Desktop Radiance >>
DOE2.1E >>
Environmental Resources Trust Inc. >>
Flour City >>
Green Mountain Energy Co. >>
PowerLight >>
Sharp >>
Siemens Solar >>
SOM >>
Viracon >>