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Highlights of Sandia's Photovoltaics Program

Sandia National Laboratories

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THE FLORIDA PHOTOVOLTAIC BUILDINGS PROGRAM

Sandia National Laboratories leads the Systems effort within the Department of Energy's National Photovoltaics Program, where one of our commitments is to develop high quality, reliable, affordable photovoltaic (PV) systems associated with and integrated into residential and commercial buildings. Sandia's partnership with the Florida Solar Energy Center (FSEC) is a focal point for this goal.

The partnership has been long and successful. The U.S. Department of Energy (DOE) established the Southeast Residential Experiment Station (SERES) at the Florida Solar Energy Center nearly two decades ago as part of their overall National effort in PV. (A counterpart is the Southwest Technology Development Institute located on the campus of New Mexico State University).

The Florida PV Buildings Program is a state model for the widespread commercialization of grid-tied, rooftop PV systems. Started in 1999, the program is the primary focus for Sandia's Southeast Regional Experiment Station contract with the Florida Solar Energy Center. The implementation of this program is a key element of Sandia's systems effort and DOE's National PV Program addressing issues of system cost, performance, maintenance, reliability, installer training, product certification, utility interconnection, and owner satisfaction, as well as a number of other concerns that affect customer acceptance and value of grid-tied PV. To emphasize Sandia's commitment to the Florida PV Buildings Program, Hal Post of the Photovoltaic Systems Assistance Center has been on a one-year assignment at the Florida Solar Energy Center (since November), to help implement the program and to oversee Sandia's support for the effort. Much has been learned. In this issue of the Quarterly, we highlight the program's status, observations, and lessons learned.

This issue has been prepared by Mary Freen of the Florida Solar Energy Center.

Introduction

The Florida Photovoltaic (PV) Buildings Program is in its second year of growth and expansion, well on its way to establishing a sustainable market for grid-tied PV systems throughout the state. Not only is it building a strong infrastructure for the PV market in Florida, it is serving as a successful commercialization model for other states. Its future looks bright, and the program goal of 20,000 rooftop installations by 2010, well within reach.

The thrust of the program is to identify and match high value applications with potential end users, and to reduce or eliminate all major barriers to commercialization. It complements the federal government's Million Solar Roofs Initiative (MSRI), which calls for one million solar installations in the U.S. by 2010.

The program is based on the following premises:

- A PV system can provide a significant portion (if not all) of the energy requirements of Florida homes, a major benefit.
- PV technology has the potential to make a significant contribution to electric power production in Florida and the U.S. in the twenty-first century.
- Emphasis is being placed on identifying potential end users of PV technology and delineating high-value applications for each end user, especially for the grid-tied market.
- The development of a sustainable market for grid-tied PV building applications requires that PV systems become more affordable.
- It is important to meet or exceed customer and end user expectations for PV building applications. This requires consistent success in implementing a large number of solar projects.
- The value of PV applications must be readily apparent to potential end users. This requires information and statistically-significant data based on actual experiences.
- For broad acceptance by the building community, new building-integrated products that are attractive and easily assimilated into the building construction process must be developed.
- Widespread markets for grid-tied PV systems will develop most rapidly when the technology is accepted and embraced by the electric utility industry.
- Customers should be able to choose PV or other renewable energy technologies to meet a portion of their energy needs.

To realize the successful commercialization of PV, the programs' authors included the following key elements:

- Create effective partnerships.
- Generate sufficient revenue and financial resources to support and subsidize applications.
- Overcome major barriers to commercialization.
- Develop a diversity of high-value applications for potential end-user groups.
- Ensure and improve the quality of installed systems.
- Provide sufficient information and data for business planning and decision making.
- Share information, accelerate learning, and improve products and services.

Key elements of the Florida PV Buildings Program.

This program is a collaboration among the Florida Energy Office of the Department of Community Affairs (FEO/DCA), the U.S. Department of Energy through Sandia National Laboratories, the photovoltaic industry, the Florida Solar Energy Center, and nine end-user groups. These end-user groups include municipal utilities, commercial building owners and operators, government agencies, school and church organizations, manufactured building corporations, roofing companies, builders and developers, and homeowners.

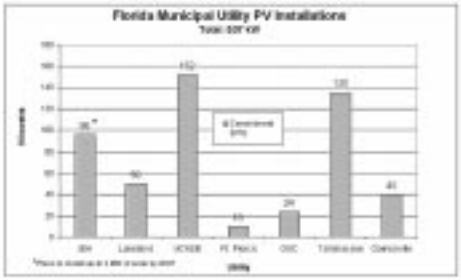
Creating Effective Partnerships

All of the program's participants play key roles, providing the technical, financial, management and organization resources needed for the plan's success.

One partnership vital to the program's early success is that of the Florida Municipal Electric Association (FMEA) and its participating utilities. Through the SunSmart Community Partnership (see sidebar), FMEA serves as the focal point for communication among its member utilities and works with them to help market green pricing programs. To date, seven municipal utilities have become partners, committed to PV projects involving more than 100 systems (over 500 kW). And the list of partners is growing; utilities in Leesburg, Ocala and Key West have recently expressed interest in joining.

Each of the municipal utilities brings a significant contribution to the overall success of the Florida PV Buildings Program. JEA (formerly Jacksonville Electric Authority) has committed to increasing its renewable energy capacity to 7.5 percent of all generation by 2014. This is the largest commitment to renewable energy in the state. Up to 2 MW of PV will be installed by 2007 to meet this goal. In addition to its Solar for Schools project (see sidebar), JEA has installed two PV systems on its own property and repaired an existing PV system at one of its older facilities. JEA is using its own funds along with $100,000 in buy-down funds from FSEC. It will pursue a green pricing program within the next few years and already has net metering and interconnection requirements in place.

The Utilities Commission of New Smyrna Beach (UCNSB) was one of the first municipal utilities to commit to a large-scale solar project: 150 kW of PV on at least 60 public and private buildings over the next four years. UCNSB has allocated $645,278 to the project, with the difference being paid for through green pricing and $100,000 in buy-down funds from FSEC. Through their Renewable Rooftops program, customers may opt to pay a public building contribution (a $5 or $10 premium on their monthly bills), or choose private ownership (purchase a PV system for $1.82 per Watt – the lowest price in the country). All of the systems will be net metered, and UCNSB offers free installation and service of the system as well as low-interest financing over five years. UCNSB has installed about 8 kW of PV and expects to complete another 23 kW of installations by the end of this year.



So far, seven municipal utilities in Florida have made commitments to install more than 500 kW of grid-connected PV over the next few years, and several more utilities are expected to get on board in the near future.

Lakeland Electric has been a long-standing supporter of solar energy and recently completed the installation of 17 PV systems on portable classrooms as part of a joint effort with UPVG, Florida Solar Energy Research and Education Foundation (FlaSEREF), and FSEC. Already they have been able to significantly reduce their installation costs. After completing FSEC's training course and performing multiple installations of the same configuration, they installed their last ten systems for under $1 per Watt (installation labor cost only).

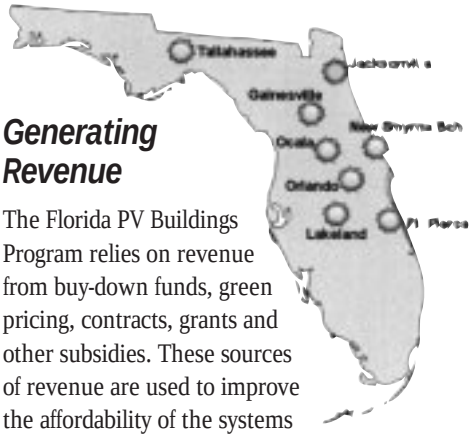
The Utilities Commission of New Smyrna Beach installed and will maintain this customer-owned residential system.

Orlando Utilities Commission (OUC) recently made a commitment to install five PV systems (4 kW each) on five Orange County public high schools. OUC will purchase, install, and maintain the systems, and will credit the electricity produced from the PV systems to each of the participating schools.

Ft. Pierce recently announced plans to install a 10-kW PV system on a Manatee Education Center, and Gainesville Regional Utility (GRU) will install ten 4-kW PV systems on covered walkways at local middle schools. Construction is expected to begin by the end of the year.

The City of Tallahassee recently announced plans to partner with a local commercial facility to install a 125-kW PV system. The system will be partially financed by both partners, as well as $25,000 in buy-down funds from FSEC. In addition to this project, Tallahassee is set to break ground on a 10-kW PV system to be installed on a local aquatic center, scheduled for completion by August 2000.

In related activities, the Legal Environmental Assistance Foundation (LEAF) is working with all the investor-owned utilities, the Florida Public Service Commission, FMEA and community groups to get them to make greater investments in renewable technologies, including photovoltaics. These efforts are complementary to the goals of the Florida Photovoltaic Buildings Program and should lead to many more system installations.



Generating Revenue

The Florida PV Buildings Program relies on revenue from buy-down funds, green pricing, contracts, grants and other subsidies. These sources of revenue are used to improve the affordability of the systems until the market sustains itself.

The FEO/DCA provided $525,000 in buy-down funds, which have been put to excellent advantage. For every dollar the state invested, four dollars have been raised by the partners. Such powerful leveraging has worked well to kick start the program. On top of the funds allocated for commitments made to date, allocations may soon be made for additional PV projects pending with municipal utilities in Tallahassee, Gainesville, and Orlando.

Contracts, grants and other subsidies include long-term, low-interest financing, Utility Photovoltaic Group (UPVG) TEAM-UP awards, and a host of funded activities from the Florida Energy Office. For example, Lakeland received a UPVG TEAM-UP award to install PV systems on 17 portable classrooms in Polk County, and has a research grant from FEO/DCA to administer the only program in the country that actually meters and sells solar heated water to its customers.

How State Funds are Distributed

The FEO buy-down funds are distributed through rebates and contract awards. Rebates can be made for individual PV system installations up to $10,500, and for commercial system installations (minimum 6-kW system), up to $25,000. Contract awards are made in response to proposals and "letters of interest."

Two changes have been implemented since the program began to improve and expand it. Initially, a maximum of $7/W was allowed for the installed system price. This requirement proved to be too restrictive.

Similarly, contracts were awarded to winning proposals submitted in response to a request for proposals, but this method left some hopeful participants at a disadvantage. Organizations were passed over that wanted to participate but did not have the necessary resources or experience to prepare a competitive proposal. Now awards are based on "letters of interest." This approach allows FSEC to provide assistance in project development that it was prohibited from offering when it acted as administrator in the proposal award process.

Rebates have generated a lot of interest with homeowners and PV system installers, but processing rebates has been slow. Before rebates can be processed, PV system installations must meet the following requirements: (1) they must undergo design review and approval; (2) only modules with FSEC-approved ratings may be used; (3) the installer must be a licensed solar or electrical contractor, and must pass an authorization exam; and (4) installed systems must comply with all applicable codes and pass acceptance tests.

Another reason for the slow response to the rebate program is that Florida lacks a standard utility interconnection agreement. FSEC has prepared a position paper for creating a standard interconnection agreement that addresses three main interconnection issues: standards and codes, insurance, and metering and billing. Although most of Florida's municipal utilities have adopted many or at least some of the standards set forth in this paper, across the board acceptance of the entire position is yet to come. In addition, the Florida Public Service Commission, which regulates the four investor-owned utilities in the State, has not finished the process of adopting new and more appropriate interconnection requirements.

Ensuring Quality

While technical and policy requirements may slow the rebate process, they help ensure the quality of installations and are a vital component of the program. Other program accomplishments are helping ensure quality as well.

SunSmart Community Partnerships

The SunSmart Community Partnerships Program is an ambitious, immensely practical idea. The goal of this program is to bolster municipal utilities' efforts to develop sustainable green energy programs. Member utilities share ideas and resources, which allows them to learn from each other and save time, effort and money. They each play an active role in designing the program's structure and meet every other month to share information, attend both technical and marketing workshops and collaborate on specific program details. SunSmart partners include the Florida Solar Energy Center, FEO/DCA, the Florida Municipal Power Association (FMPA), the Florida Municipal Electric Association (FMEA) and its member utilities, and various members of local communities. The program provides the following services:

Consumer education primers. These materials can be used to educate utility customers prior to offering a green program.

Grassroots marketing support. LEAF works with local grassroots organizations and utilities to hold promotional events. This method saves each utility marketing dollars and leads to more community acceptance and ownership of the program.

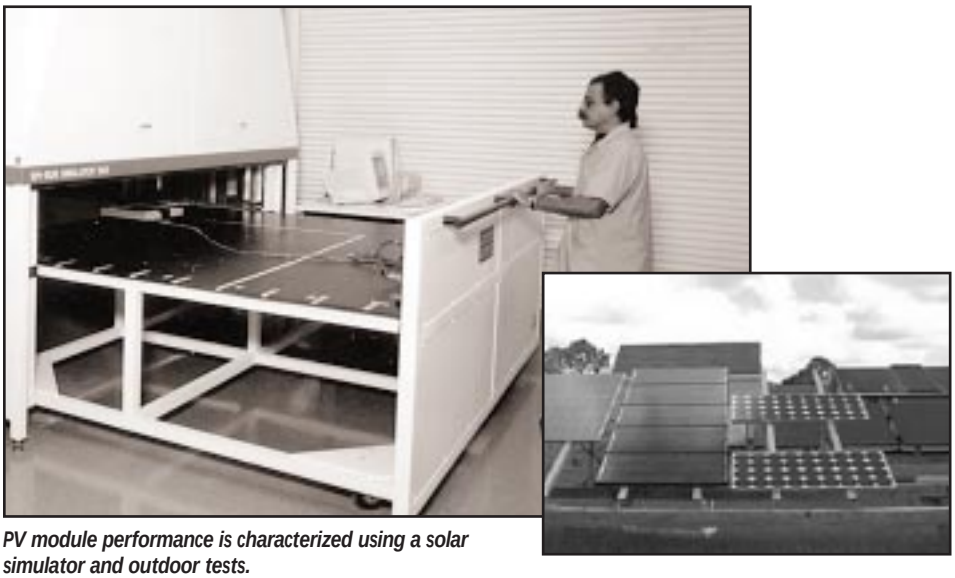
Standard marketing materials. These materials may be customized for each utility's needs, saving on expenses such as designing logos, developing and maintaining a website, etc.

Corporate partnerships. This package is being developed to provide template documents and sample techniques for approaching large corporate customers and key accounts. FMEA will assist by actively recruiting corporate partners.

School curricula. Utilities that pursue green programs involving local schools can provide curriculum materials and teacher training to those schools through the SunSmart program.

Equipment purchases. FMPA acts as a central purchasing agent to procure PV hardware, data acquisition equipment and solar thermal systems, saving member utilities time and money.

Project development assistance. FSEC and FMEA can help each utility create a project implementation plan.



PV module performance is characterized using a solar simulator and outdoor tests.

The requirement that systems undergo a design review creates an incentive for suppliers to provide better documentation of their products, which often has been inadequate in the past. Poor documentation of designs invariably leads to problems over time. The Siemens earthsafe™ systems were the first to be reviewed and approved by FSEC. Others are now under review.

Eight installers' training programs have been offered to date, with authorization of more than 50 installers. Although significant progress has been made in terms of course materials and hardware, FSEC is still improving these programs in terms of content, organization, delivery and audience participation. The required authorization examination recognizes that grid-tied PV applications are new to most solar and electrical contractors, and is an attempt to help ensure compliance with all relevant articles of the National Electrical Code.

The requirement that modules be tested and rated arose because of discrepancies between manufacturers' ratings and actual measured performance. In some cases, these discrepancies lead to poor designs and customer dissatisfaction. An important component of the Florida PV Buildings Program is module rating. Module ratings, based on FSEC testing, have been validated using round robin testing of the same groups of modules by Sandia National Laboratories and the National Renewable Energy Laboratory (NREL). Module test results are being made more available and associated procedures and databases are being improved.

FSEC also requires that installed systems pass acceptance testing before buy-down funds are awarded. This requirement helps ensure that the installed system is consistent with the design specifications, the systems and components are functioning properly, electric power output is consistent with predictions, and the system installation complies with local codes.

FSEC plans to combine acceptance testing with on-site instruction for code officials. Acceptance testing is especially important because, as yet, many code officials are unfamiliar with PV applications, and the acceptance tests give an added degree of assurance that the installation is code compliant.

FSEC has also developed technical specifications for procuring PV systems, including checklists and an easily applied template. They have developed checklists for site surveys and analyses, and for testing, evaluating and troubleshooting existing installations.

Overcoming Barriers

Interconnection

The single greatest barrier to the development of a market for customer-owned, grid-tied PV systems is that of interconnection requirements. Application experiments across Florida are providing a significant body of data, that will help alleviate concerns about the technical, insurance, metering and billing issues that often stall PV system interconnections.

Important technical issues have been addressed with recent changes to the IEEE 929 (an interconnection standard for ensuring compatibility between the PV system and the utility). The response of Florida utility companies to the IEEE 929 has been overwhelmingly favorable.

At the national level, UL 1741 and the 1999 National Electrical Code have established standards for safety of grid-tied PV inverters. With these safety standards in place, the application experiments are expected to demonstrate that redundant protection equipment to isolate the PV system when the grid is down is not necessary. The experiments also will prove the low risk of injury with utility-interactive photovoltaic

Hands-on training takes attendees through the complete installation process.

systems, thus eliminating the need for excessive liability insurance and associated premiums.

Affordability

Price represent another major barrier to the development of a viable PV market. Application experiments are pointing to ways of reducing non-module related costs of rooftop systems, which often account for about 50 percent of the installed system cost (with installation labor being a major contributor). Installation training courses have helped reduce costs significantly (as well as helping ensure the quality of installations). After completing installation training and performing multiple installations of the same configuration this past year, the City of Lakeland saw their installation labor costs fall to $1 per Watt.

Applications experiments are also demonstrating other ways to reduce costs:

- Many of Florida's municipal utilities are opting to own residential rooftop PV systems, which precludes the need for a homeowner to pay any high first costs.
- Through SunSmart, FMPA makes bulk purchases of items such as PV hardware, data acquisition equipment and solar thermal systems for member utilities. Direct sales of multiple systems from photovoltaic manufacturers should help to bring costs down. For PV systems, FSEC has developed a standard procurement specification that can be used by any participating utility.
- The standardizing and packaging of PV systems should help to bring installed prices down. There still is room for significant improvements in the packaging of systems.
- Several experiments involve the installation of systems on metal and tile roofs. Because metal and tile roofs have lifetimes equal to or longer than photovoltaic arrays, eliminating the need to remove an array for reroofing may significantly decrease the system life-cycle cost.

Mobility

For many home buyers, mobility is a very good reason not to buy a rooftop PV system, especially if it is uncertain that a PV system will increase the selling price of a home. This is not a serious barrier for utilities, commercial building owners, government agencies, and school and church organizations. It is expected that the program will make inroads with these user groups. Already seven utilities have made commitments to install PV systems on schools and other public buildings across Florida.

Fear

Fear that system performance will not meet expectations and fear of component failures and system malfunction have been valid. But as a barrier, fear is perhaps the most readily overcome. Performance and reliability are functions of quality, which is dependent on site selection, system design, component hardware, and competency of installers. As quality is controlled and improved, and as documented results verify that performance does meet expectations, this fear will be eliminated for all end-user groups. Application experiments are providing real experience with typical failures, resulting in solutions and effective ways of handling problems. Technical support services are helping ensure the quality of systems and installations. Training, in particular, is leading to greater understanding and the growth of the PV industry infrastructure, including highly experienced professional installers.

Inertia

Reluctance to change is part of human nature and often slows the adoption of new technology. Most people hesitate when faced with change; in reality, it means accepting the risk of the unknown. Surveys show that many homeowners like the idea of getting a portion of their electricity from renewable resources, but may be reluctant to incur this risk. Municipal utilities are helping homeowners and other end users overcome this reluctance by taking responsibility for much of the uncertainty; for example, by agreeing to own, service, and maintain the PV system for the customer.

SunSmart, too, is bringing about change through its promotional efforts – offering consumer education primers, grassroots marketing support at the local level, and standard (boilerplate) marketing materials that can be customized for each utility's and local community's needs.

Solar in Schools

A shining offshoot of the Florida PV Buildings Program is a new core of school programs designed to bring solar energy into the classroom. Through SunSmart and the Florida PV Buildings Program, municipal utilities are energizing Florida's schools with photovoltaics.

JEA (Jacksonville) is currently completing PV system installations on 19 high schools in Duval County. And this past year, Lakeland installed 17 PV systems on portable classrooms in west central Florida. The Utilities Commission of New Smyrna Beach (UCNSB) completed a PV installation at Coronado Elementary School this past year and will soon offer its customers a green energy program that consists of a public buildings green pricing component. Over the coming year, Gainesville Regional Utility will install ten 4-kW PV systems on covered walkways at local middle schools, and Orlando Utilities Commission (OUC) plans five PV installations in Orange County.

Not only will the PV systems generate electricity for the buildings' occupants, they will serve as educational tools, enhancing the systems' value as electrical power producers. The schools will receive curriculum materials, teacher handbooks and teacher training. Students will gain real world experience with photovoltaics and other energy-related topics.

Science curricula are available for two age groups: one for Kindergarten through 8th grade and another for high school. For the Florida PV Buildings Program, this represents an added benefit to their goal of creating a viable PV industry. But for the state, as a whole, it means a new generation of more knowledgeable energy consumers.

Please note, any school can download energy science curricula materials from FSEC's website. Several units are available for students from 4th grade through high school at www.fsec.ucf.edu/Ed/Teachers/.

The SunSmart' program provides a number of important services to facilitate municipal utilities' efforts to develop green energy programs.

Solar Access

Lack of solar access represents a significant barrier to PV applications, but again, one that is relatively easy to overcome through good design review, and proper site selection and survey. Training courses and workshops have been developed specifically for system designers and installers, which will lead to a more knowledgeable body of professionals to support and strengthen Florida's PV industry.

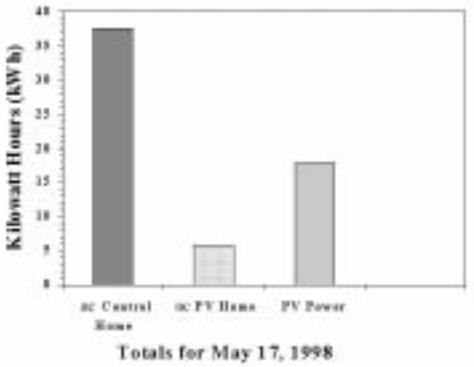
Conducting Application Experiments for Targeted End-User Groups

The majority of application experiments conducted thus far have involved utility-owned, distributed generation and should be useful in generating statistically significant data for business planning purposes. In most of these application experiments, the utilities own, operate and maintain PV systems on schools. These projects are especially appealing because the schools are given solar and renewable energy curricula as well as teacher training.

Several experiments involving flexible photovoltaic laminates bonded to metal roofing are underway and should provide useful information on performance, aesthetic appeal, and alternative approaches to bonding.

Of the nine targeted end-user groups, municipal utilities have shown the greatest interest in participating in the Florida program thus far. Because photovoltaic technology and grid-tied applications are new to many of them, project development and technical assistance have been especially beneficial in eliciting their participation. The present commitment from utilities in Florida is for 3.8 MW, over half of which is from municipal utilities. These commitments are expected to increase dramatically in the near future.

One particularly noteworthy application experiment appears to be a potential high-value application for homeowners, commercial building owners and operators, and builders and developers. This application combines a rooftop photovoltaic (PV) system, super energy-efficient building design, and peak load reduction strategy. It is producing excellent data and has benefited both the municipal utility and the builder.



A super energy-efficient PV home in Lakeland, Florida. On the bar graph, the control home represents a typical Florida home, and used 37.5 kWh on a sunny day in May. On the same day, the energy-efficient PV home used only 5.8 kWh (84% less than the control) and sent net power back to the utility. The solar array produced 17.9 kWh, almost three times what was used.

Providing Information and Data for Business Planning

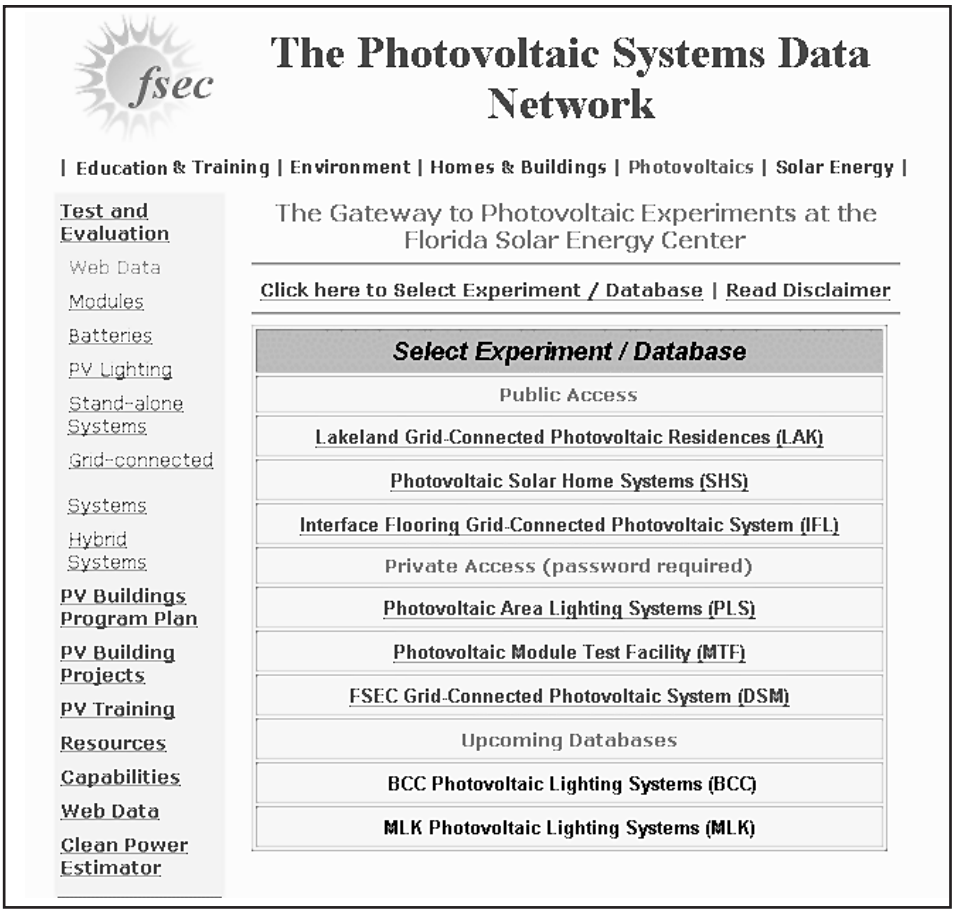
A significant body of performance data must be collected over time to accurately show the economic value and benefits of PV building systems. Every application experiment in the Florida PV Buildings Program undergoes some level of monitoring, with the most common level being the monitoring of energy output of the inverter in kilowatt-hours. The information is collected on a monthly basis with an ordinary utility watt-hour meter, or in some cases, with the recording capability of some of the new inverter designs. In addition to simple metering of inverter output in kilowatt-hours, FSEC uses two, more sophisticated levels of monitoring, one designed to meet the primary needs of utilities and one designed to meet the needs of the research and design communities.

Utility-level monitoring yields time-of-day electric power production and solar irradiance data, and is useful in evaluating the overall impact of distributed generation and its impact on meeting peak demand. In most cases, utilities are more interested in power production versus time, especially during the peak demand period, than in kWh production.

Homeowners and other end users without time-of-day electricity pricing are usually only interested in energy production and the associated savings, and are not particularly interested in power production versus time.

Reliability data allows FSEC researchers to evaluate system performance and to identify and communicate problems to manufacturers, system integrators and installers. Researchers at FSEC also compile statistical data on component reliability, such as percentages of specific problems, failures, availability and the like. This data will lead to improved component and system reliability and longer system lifetimes.

In addition to measuring performance and reliability, FSEC is developing qualified databases documenting the costs of buying, installing, interconnecting, operating and maintaining the system. All non-proprietary data is available on FSEC's website at www.logger.fsec.ucf.edu/pvdata/.



The Photovoltaic Systems Data Network contains information on performance and reliability as well as systems cost.

Cost-benefit analyses, based on the combination of real performance and reliability data collected over a sufficient period of time, will allow business planners, investors and consumers to assess true value and make informed decisions.

Sharing Information and Improving Products and Services

It is important to learn quickly from both successes and failures so the former can be replicated and the latter avoided. Modern telecommunications, especially the Internet, are being employed to make information as readily accessible as possible and accelerate the learning process.

The solar and renewable energy curricula, teaching materials, and teacher training activities used in Florida have been well received by the educational community and efforts in these directions are being expanded.

The creation of an advisory committee to provide guidance on the implementation of the Florida Photovoltaic Buildings Program has been recommended by the national laboratories but has not yet been established.

The Photovoltaic Systems Data Network has proven to be extremely useful to both the research community and the user sector. It is continuously being updated.

Plans call for an annual review of the Florida Photovoltaic Buildings Program for all Florida stakeholders, the U.S. Department of Energy and regional offices, the national laboratories, other states and interested parties.

Top Ten Lessons Learned

Many important lessons have been learned over the past two years. Here are some of the most significant:

- An FSEC-recommended design, combining a rooftop PV system and super energy-efficient building features, demonstrated an 84 percent reduction in cooling load under controlled conditions. The PV system produced three times the cooling load under sunny skies.
- The Florida Municipal Electric Association (FMEA) and participating utilities have been largely responsible for the program's early success. Through SunSmart, FMEA has been the focal point for communication among its member utilities, and for enlisting cooperation in marketing green pricing programs.
- State funds, from the FEO/DCA, were leveraged to great success. For every dollar the state invested, four dollars were raised by the partners.
- Two original criteria, a system installation price cap and formal proposals, were too restrictive and dropped from the program.
- The greatest barriers to the development of a market for customer-owned, grid-tied PV Systems are the uncertainties that affect costs and benefits. Beyond the basic prices for the system hardware, the utility, interconnection issues, which include insurance, utility metering, pricing and billing, and safety are among the most important.
- Training and experience are crucial in reducing installation costs.
- Requirements for system design review and approval have led to greatly improved design documentation by suppliers. Documentation is especially important for grid-connected PV systems.
- Acceptance testing has provided some assurance that a system is built to specifications and works as expected. FSEC plans to combine acceptance testing with on-site instruction for code officials.
- FSEC proposed nine applications experiments to various end users. Systems for schools, owned by the utility with the utility providing O&M, have been the most widely accepted.
- The solar and renewable energy curricula, teaching materials, and teacher training activities have been well received by the educational community and will be expanded.

Teachers learn about new science units designed to develop students' awareness of the potential of alternative energy sources.

This PV system was recently installed by municipal utility JEA at First Coast High School in Jacksonville. *Photo courtesy of JEA.*

Conclusions

The architects of the Florida PV Buildings Program want to emphasize that its thrust is to establish value based on data and real experience and to reduce or eliminate all major barriers to commercialization. For scenarios where value and benefits are clearly established and when price reduction goals are achieved, real markets will follow.

Significant achievements have already been realized:

Florida utilities and other stakeholders have made major commitments to the program. The state will see 3.8 MW of grid-tied systems on line by 2007, with over half of that coming from municipal utilities.

Strong partnerships and an effective communication network have been established among Florida utilities, the PV industry and other organizations.

'Solar in schools' programs across the state will educate a new generation to the science of photovoltaics and other energy resources, as PV systems on school buildings generate a portion of their electricity.

Over $300,000 has been committed through the Florida PV Buildings Program to buy down the cost of over 100 grid-tied PV building systems, and these funds have been leveraged by a factor of four-to-one.

Interconnection requirements that address legitimate concerns of both utilities and PV system owners and operators have been recommended to Florida utilities and the Public Service Commission.

Eight PV system installation training courses and examinations have been offered, and over fifty installers have been authorized to participate in the Florida buy-down program.

A PV systems data network has been developed and system performance data for a variety of applications is readily available on FSEC's website.

The Florida PV Buildings Program provides the National PV Program with outstanding opportunities. Perhaps the most important and visible bonus is the value of lessons learned applied to other parts of the PV Program. This effort complements not only the Million Solar Roofs Initiative, but BIPV, TEAM-UP, and other DOE programs. As such, the Florida Buildings Program at FSEC is a model for technology application, and worthy of replication elsewhere.

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Sandia creates and distributes a variety of publications on photovoltaic systems and their applications. For a list of these documents, please contact the Photovoltaic Systems Assistance Center:

through e-mail: *pvsac@sandia.gov*
by phone: *505-844-3698*
by FAX: *505-844-6541*

by mail: *Photovoltaic Systems Assistance Center*
MS 0753
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185-0753

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Sandia National Laboratories
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