

**Solar
Electric Power
Association**

Solar Power Solutions Showcase Projects Final Report

**Prepared by the
Solar Electric Power Association
Washington, DC**

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Solar Power Solutions Showcase Project Final Report

Executive Summary

The Solar Power Solutions (SPS) program was designed by the Solar Electric Power Association (SEPA), with support from the U.S. Department of Energy (DOE), to address the barriers to the commercialization of photovoltaic (PV) technologies. SEPA conducted a market analysis, held stakeholder brainstorming sessions, and examined other PV commercialization efforts to determine how to best address the barriers inhibiting PV technologies from becoming mainstream. These efforts resulted in a blueprint document, entitled *Solar Power Solutions: A Business Case for Capturing Total Value (Business Case)*¹, and the funding of two PV showcase demonstration projects illustrating the characteristics necessary to overcome the commercialization barriers.

SEPA and its subcontractors, Global Environment and Technology Foundation (GETF) and Technology Transition Corporation (TTC), researched the current market conditions and barriers. Federal and State incentives and commercialization efforts were examined, and key components from the various programs were used to structure the showcase project component of the SPS initiative. Two brainstorming sessions were held to collect the perspectives of all PV stakeholders. Once this information had been compiled, SEPA developed the *Business Case* report indicating a number of “critical success factors” needed to achieve the goal of the commercialization of PV.

Based on the critical success factors identified in the *Business Case*, SEPA designed a request for proposals (RFP) for one or more showcase projects. Two projects, one lead by the City of Tucson and the other by the Detroit Shoreway Community Development Organization (DSCDO), were each selected to receive funding of \$75,000 through a competitive process lead by an independent evaluation committee. Both were unique, replicable projects that incorporated the installation of one or more PV systems, training, education and outreach, and the development of the local PV infrastructure into a larger, sustainable PV program.

The City of Tucson partnered with Tucson Electric Power to install two 17 kW PV systems at the Hayden/Udall water treatment facility in Tucson, AZ. The two systems provide electricity for a considerable amount of the building’s load, and are part of an effort to provide secure power to critical services. Venture Catalyst, a Tucson based environmental consulting group, was contracted to help develop educational and promotional materials for distribution to other municipalities; and to conduct training for PV installers.

The Cleveland EcoVillage, an environmentally sound townhouse development lead by DSCDO, partnered with AstroPower to incorporate PV into the design of new homes. Four townhouses were equipped with PV systems ranging from 2 kW to 3 kW, making them near zero energy homes. This project also offered education and outreach programs to teach the community about solar power as well as training sessions for PV installers. In addition to the funding from the

¹ *Solar Power Solutions: A Business Case for Capturing Total Value* is available on the SEPA website at www.SolarElectricPower.org.

SPS program, the Cleveland EcoVillage project also received support from the U.S. Department of Energy, the U.S. Environmental Protection Agency, and a number of other national and local government agencies and organizations.

These showcase projects have demonstrated the needed linkage of the critical factors of a successful program, such as: targeting the building market; effective outreach vehicles; local incentives; capturing the total value; infrastructure development; easy grid interconnection; integration with energy efficiency; and, most importantly, easy replication. When these items are combined on a large scale, PV will be able to reach the needed market penetration levels for commercialization and large-scale manufacturing. The showcase projects illustrate just two approaches to these critical success factors. There are a number of ways to address them, as were shown in the diversity of the spectrum of proposals submitted for this funding. Alternative approaches must continue to be explored to fully develop an array of successful community business models.

Introduction

The Solar Power Solutions (SPS) initiative was undertaken by SEPA in the fall of 2001 to determine the best approach to addressing the commercialization of PV. This DOE funded effort began with researching the past, present, and future PV markets, as well as examining previous commercialization efforts, such as SEPA's TEAM-UP program.

SEPA issued the *Solar Power Solutions: Business Case for Capturing Total Value (Business Case)* early in 2002. This report detailed the findings SEPA's research, and identified several "critical success factors" necessary for the commercialization of PV. This report was followed by a request for proposals for one or more PV projects that captured the critical success factors.

Two projects were selected to receive funding, a partnership between Tucson Electric Power and the City of Tucson, and a project lead by the Detroit Shoreway Community Development Organization (DSCDO). The Tucson project installed two 17 kW PV systems (all ratings in this report are at AC PVUSA test conditions) at the Hayden/Udall water treatment facility, located in Tucson, AZ, and also incorporated education and training into a larger PV program. The DSCDO project installed four PV systems with sizes ranging from 2 kW – 3 kW at a new townhouse development, the Cleveland EcoVillage, located in Cleveland, OH.

Both showcase projects were completed in the fall of 2002, and successfully demonstrated the critical success factors as identified in the *Business Case*.

Solar Power Solutions: A Business Case for Capturing Total Value

The *Business Case* report examined the value, U.S. markets, and other Federal initiatives to advance the commercialization of PV. With that information the *Business Case* developed a strategic analysis of the current state of the solar industry highlighting the economic, business and environmental characteristics of PV systems.

SEPA conducted two focus sessions with representatives from the energy service, PV, homebuilder, and related industries. These sessions gathered information on current market demand, manufacturing, and finance conditions; and sought stakeholder input on potential new deployment opportunities. Additionally, the sessions examined public or private policies for the future of PV, particularly in areas of market development, financing, and incentives. Both sessions were well attended, and the resulting comments and suggestions provided valuable guidance for the *Business Case* report.

The information documented in the *Business Case* provided the groundwork for the RFP for the Solar Power Solutions Showcase projects.

The RPF Process

The two showcase projects were selected on a competitive basis. SEPA developed an RFP containing critical characteristics, as identified in the *Business Case*, which the proposed projects should include.

All projects were required to meet the following 12 Threshold Requirements, any proposals that did not meet these requirements were rejected.

1. The applicant must demonstrate how the SEPA funds from this solicitation would be used to make their project a showcase project by increasing the effectiveness of the critical market acceleration elements.
2. The applicant must demonstrate that the critical element(s) identified in item #1 above are not sufficiently covered by funding sources previously secured (non-SEPA funds) for this project.
3. The applicant must provide evidence that the project is already under development, with site selection complete, project partners identified or committed, and at least some of the equipment purchased/ordered. Systems already installed may be used as long as they were completed after January 2002 and the applicant clearly identifies that the SEPA funding significantly increases the market acceleration value of the project.
4. The applicant must have prior experience successfully deploying, operating, and/or maintaining PV projects.
5. The applicant must agree to identify and document all the “values” and results (including customer, developer, utility and community values, in new creative settings, beyond energy output, load displaced, etc.) of their project via the following:
 - ◆ One page monthly progress reports
 - ◆ One article on the showcase project in the SEPA *Record* publication
 - ◆ A formal project presentation at the SEPA 2002 UPEX Conference
 - ◆ A short report to be distributed to DOE, SEPA members and others
6. There must be a clear and documented process for measuring the success of the project (this could include public recognition, public actions, financing closed, and/or other metrics that indicate market success). It is expected that applicants will include in the proposal a description of the metrics and measurement tools to be utilized to determine success.
7. Projects must comply with the technical specifications for installed PV systems (Attachment D).
8. The SPS program requires that new U.S. manufactured PV equipment must be installed as part of the showcase project. However, the funding from this solicitation may be used for any project needs. All PV modules, inverters, and major electrical equipment must be new and manufactured in the United States.

(A variance to this manufactured in the U.S. requirement may be requested by the proposer, with supporting justification including sufficient information to explain why the variance is needed, and that the use of a non-U.S. product will significantly enhance the showcase project and will strengthen the Solar Power Solutions Program. A request for a variance, if approved by SEPA, may then be forwarded by SEPA to the DOE Contracting Officer for consideration and approval.)

9. The proposal and signed funding agreement must be received before the response deadline, adhere to the Response Format, and contain all of the information requested.
10. The proposal may request a maximum of \$150,000 of SEPA funds.
11. An applicant's cost-share of at least fifty (50) percent (non-federal source funds) is required. Normal DOE mandated financial record keeping is also required.
12. The project PV System(s) must be operational by September 30, 2002.

In addition to the Threshold Requirements, the RFP included the following Preferred Characteristics that were used to rank the proposals during the evaluation process.

- Addresses the fast growing, efficiently served, PV market segments of commercial buildings, new residential, and public buildings;
- Includes effective public outreach and education to stimulate public and market interest and purchase decisions;
- Effectively utilizes state, local and other public funds committed to energy efficiency, renewable energy, and solar energy;
- Captures and highlights all the "values" of PV that customers and the public recognize, beyond energy and capacity benefits;
- Offers or takes advantage of long-term financing mechanisms;
- Strengthens or establishes the local PV infrastructure, which includes sales, installation, maintenance, repair, training and certification;
- Demonstrates by example easy grid interconnection and siting approvals consistent with all local codes and rules;
- Assists customers in the integration of energy efficiency and on-site PV generation, such as achieving zero energy buildings;
- Demonstrates long term project and business model sustainability and is replicable by others.

The Evaluation Process

SEPA established an independent evaluation committee consisting of members of the PV industry, utility industry, and other PV stakeholders. See Attachment A for the list of Evaluation Committee members. SEPA staff participated in the evaluation discussions; however they did not vote. The evaluation committee and SEPA staff were required to sign disclosure statements (Attachment B) ensuring that they had no ties to the businesses that submitted proposals, and that all information submitted would be kept confidential.

Eight proposals were submitted, and all met the Threshold Requirements. These proposals were distributed to the evaluation committee for review. The evaluation committee then held a conference call to discuss and rank the proposals according to the following criteria:

1. The degree to which the proposed project plan efficiently and effectively utilizes the SPS funding to develop the original project into a showcase project. **30 points**
2. The proposed project plan, including the feasibility of the plan and its approach to addressing the critical market acceleration elements; project size (number of installations, installed capacity); its ability to be replicable and sustainable. **30 points**
3. Capability of the team to design, install and operate photovoltaic systems and to address/conduct the critical market acceleration elements (with emphasis on the communication aspects of the public outreach and education) as described in the proposal and Statement of Work for the venture. **20 points**
4. Clarity of the proposal and a realistic budget and schedule that allows for PV project completion by September 30, 2002. **20 points**

Each proposal was evaluated for non-price factors before the funding request and budget is considered. Proposals were ranked overall according to this total set of proposal evaluation criteria.

SEPA provided evaluation forms, Attachment C, to be used in the scoring of the proposals. Through this competitive process, the evaluation committee selected the proposals submitted by Tucson Electric Power and the Detroit Shoreway Community Development Organization.

Tucson Electric Power and the City of Tucson – Hayden Udall Water Treatment Facility

The Hayden/Udall Water Treatment Facility PV Project was conceived by the City of Tucson as a mid-scale PV showcase project to make effective use of funding designated for the purpose of developing renewable energy resources for the City. The City of Tucson's "1% for Solar" program uses city funds released by a 1% electric rate reduction by Tucson Electric Power (TEP) for the purpose of constructing City owned PV systems. Based on experience with the cost and performance data from similar systems and with the funding from the "1% for Solar" program, the City originally planned to install a single 17 kW system at the Hayden/Udall Water Treatment facility in 2002 and a subsequent 17 kW system in 2003 or 2004. With the SPS funding award TEP and the City of Tucson were able to accelerate the schedule and install two 17 kW systems by September 2002.

To ensure successful operation, and to minimize total system costs Tucson Electric Power provided design and performance information for three existing 17 kW systems in operation at their facilities in Arizona. These designs laid the groundwork for the final system design, and allowed the City to quickly and easily finalize the plans for the Hayden Udall systems. In addition to providing system designs, TEP also supplied the two 20 kW inverters and accepted the role of project manager to facilitate an expedited installation by Tucson based sister company, Global Solar.

As part of the SPS program, the Hayden/Udall project conducted an education and outreach program through Venture Catalyst Co.; a Tucson based renewable energy consultant. Outreach activities included:

- Design and development of a campaign name and logo: “Power for Critical Resources.”
- Design and production of a campaign briefing pack, emphasizing the benefits of replicating the project, including technical and financial resources.
- Identification of key target market and priority candidates for maximizing awareness and applications of the solar investment strategy.
- Implementation of an outreach plan to conduct interviews by phone, email and primarily, in person (very important)
- A review of interview responses and identification of key obstacles and opportunities for the proposed solar investment strategy.



The City of Tucson’s Vice Mayor, Carol W. West, dedicates the Hayden/Udall PV systems during a ceremony held September 20, 2002.

Critical Success Factors

The Tucson project was selected as a SPS showcase project for the way the critical success factors, identified in both the *Business Case* and the SPS RFP, were addressed.

Addresses the fast growing, efficiently served PV market segments of commercial, new residential and public buildings:

The Hayden/Udall Project takes advantage of the unused land surrounding the water treatment facility, and makes use of the existing perimeter security and equipment control telemetry for data collection and status indication. The Hayden/Udall Project offers a low cost, cookie cutter approach to commercialize medium size, ground mounted photovoltaic systems for municipal

facility energy support, a potentially fast growing, efficiently served market opportunity for public facility solar electrification.

Includes effective public outreach and education to stimulate public and market interest and purchase decisions:

The City of Tucson and the associated Tucson-Pima County Metropolitan Energy Commission are pioneers in the development of model water and building energy codes in the United States.

They have also maintained an effective educational program for renewable energy and energy and water efficiency/conservation.



The two 17 kW Hayden/Udall PV systems, located in Tucson, Arizona.

Through the Greater Tucson Coalition for Solar, the partnership developed educational outreach efforts including: installation training programs; outreach to other municipalities; and outreach to institutional facility managers interested in adopting the City of Tucson's model. The Greater Tucson Coalition for Solar has incorporated the installation of the Hayden/Udall PV systems into its educational programs and is posting the system output on the City's website: www.ci.tucson.az.us. Additionally, the City has provided educational exhibits at the other City facilities that feature PV systems.

Effectively uses state, local, and other public funds committed to energy efficiency, renewable energy and solar energy:

The City has dedicated the savings from TEP's 1% reduction in electric rates to the installation of new PV systems. This five year program, "1% for Solar", provides annual funding of about \$160,000 for installation of PV systems and other solar energy utilization devices. The 1% for Solar program was designed to create growth in the solar industry in Tucson. The following benefits are expected from the program:

- The creation of high value, high tech jobs in Tucson.
- Reduced dependence on imported primary fuels for generation.
- Reduction of emissions from the generation of electricity.
- The positioning of Tucson as the Solar Capital of the United States.
- Appropriately exploit the excellent solar resource available in Tucson.
- Increase integration of PV systems into the development of buildings and other facilities.
- Expand the level of solar expertise and knowledge in the community.

The annual investment of the \$160,000 is estimated to provide savings of \$3,500 in annual utility bills and over \$2,000 in economic development and educational benefits. This program has already significantly increased the amount of City-owned PV systems and promises additional installations and educational outreach if awarded the SEPA grant.

Captures and highlights all the “values” of PV that customers and the public recognize, beyond energy and capacity benefits:

PV generation is valued by the public for its ability to provide clean electricity at the point of use with minimal environmental impact. The Hayden/Udall Project combines the values derived from PV with those realized from the treatment of water, another product valued by consumers for its purity. As noted above, security of the water supply is of vital importance to any community. The use of PV to provide additional energy security for municipal water supplies is a new value created by the application of distributed PV generation.

Strengthens or establishes the local PV infrastructure, which includes sales, installation, maintenance, repair, training and certification:

The Hayden/Udall Project was constructed and will be maintained by local workers and TEP personnel, as is the case with the existing Tucson-based TEP PV systems. This local employment and involvement will encourage the continuation of local PV training programs offered by the Greater Tucson Coalition for Solar. Global Solar, the TEP installation partner, is located in Tucson and employs a significant number of local personnel for installation and manufacture of PV. The installation of Hayden/Udall systems strengthens the local PV infrastructure by providing additional experience to existing PV installers, and offering training opportunities to new installers.

Demonstrates by example easy grid interconnection and siting approvals consistent with all local codes and rules.

TEP has established interconnection requirements for PV systems that meet the SEPA recommendations for interconnection, this allowed the Hayden/Udall Project to benefit from simplified interconnection. The system protection features of the Xantrex 20208 inverter combined with the visible AC disconnect meet the TEP interconnection requirements for a PV system of this size. Although the Hayden/Udall system is not expected to generate excess electricity beyond the demand of the facility, TEP does offer a net metering option for its customers.

The system was designed by an Arizona Registered Electrical Engineer, permitted through the City of Tucson’s Development Services Department, and meets all local building codes necessary to obtain the required permits. Additionally, the Hayden/Udall system faced extremely rigorous scrutiny during the permitting process because it was a City project.

Assists customers in the integration of energy efficiency and on-site generation, such as achieving zero energy buildings

This project utilizes land that otherwise has little use and makes use of existing fencing, electrical support and communications equipment. During daylight hours it provides a significant portion of the water treatment facility’s electricity load. Additionally, the project provides energy supply security for a critical municipal infrastructure.

Demonstrates long term project and business model sustainability and is replicable by others

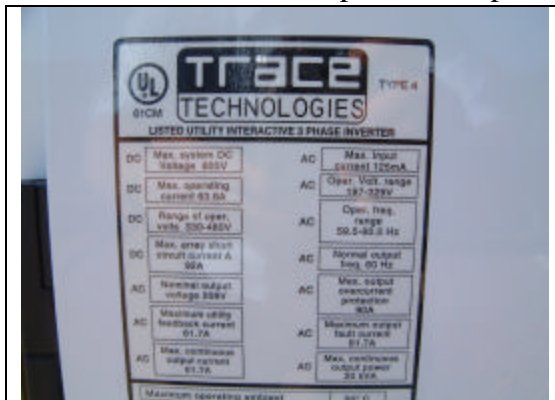
This project is potentially applicable to other municipal water facilities throughout the United States. Its cookie cutter approach allows for the Hayden/Udall system design to be easily replicated and installed with minimal modifications. The system requires a relatively small

amount of land, is modular and has a relatively low installation cost. Similar systems have a demonstrated history of reliable operation producing energy savings in the range of thousands of dollars per year. These savings can be applied to new PV projects to develop a sustainable solar program.

Technical Information

The SPS funding award stipulated detailed technical requirements for PV systems installation ensure that the systems meet a high standard of safety and performance (Attachment D).

The major components of the system are two Xantrex 20208 DC to AC maximum power point tracking inverters, 144 ASE America 300/DG50 PV modules, two 25 kVA 208 to 480 volt step up transformers and associated AC and DC disconnects, junction boxes, fuses, blocking diodes, conduit and wire. The PV modules are supported on simple legs designed by TEP to withstand winds of more than 75 mph, and are pinned to the ground with steel stakes.



The Xantrex, formerly Trace Technologies, 20208 DC to AC maximum power point tracking inverter used for one of the Hayden/Udall PV systems.

From the standpoint of the Owner/Designer, the availability of a proven configuration of photovoltaic panels feeding a particular inverter was invaluable. TEP laid the groundwork by investing the staff time and funding and dedicating the real-estate to install, observe, and analyze nearly 2 MW of experimental systems.

In addition to strict technical guidelines, the funding award required that system performance be monitored for a minimum of one year (Attachment E). Performance data is gathered from the systems at one second intervals by an NRG 9300 Cellogger modified to accept the KYZ contact of the 208 volt

AC revenue meters. Data logged includes:

- AC Power in watts for Hayden/Udall Unit #1
- AC Power in watts for Hayden/Udall Unit #2
- Solar insolation in watts per square meter
- Ambient air temperature in degrees F.
- Wind speed in MPH
- Wind direction in degrees.

Data is averaged over a 5-minute interval and collected daily via cell phone. The daily data is processed to produce an Excel spreadsheet with graphs, as shown in Figure 1, for performance analysis. Comparison of the data from the Hayden/Udall PV system with the data from the TEP sister units in Tucson indicates an improvement of about 250 watts per unit at peak power, given the same input conditions. As the other, similar, TEP PV system has a PVUSA test condition AC rating of 33.416 watts, it is estimated that the total for the two Hayden/Udall PVUSA systems rating is 34.0 kW. Data will be gathered monthly by TEP and sent to SEPA and City of Tucson through the end of September 2003.

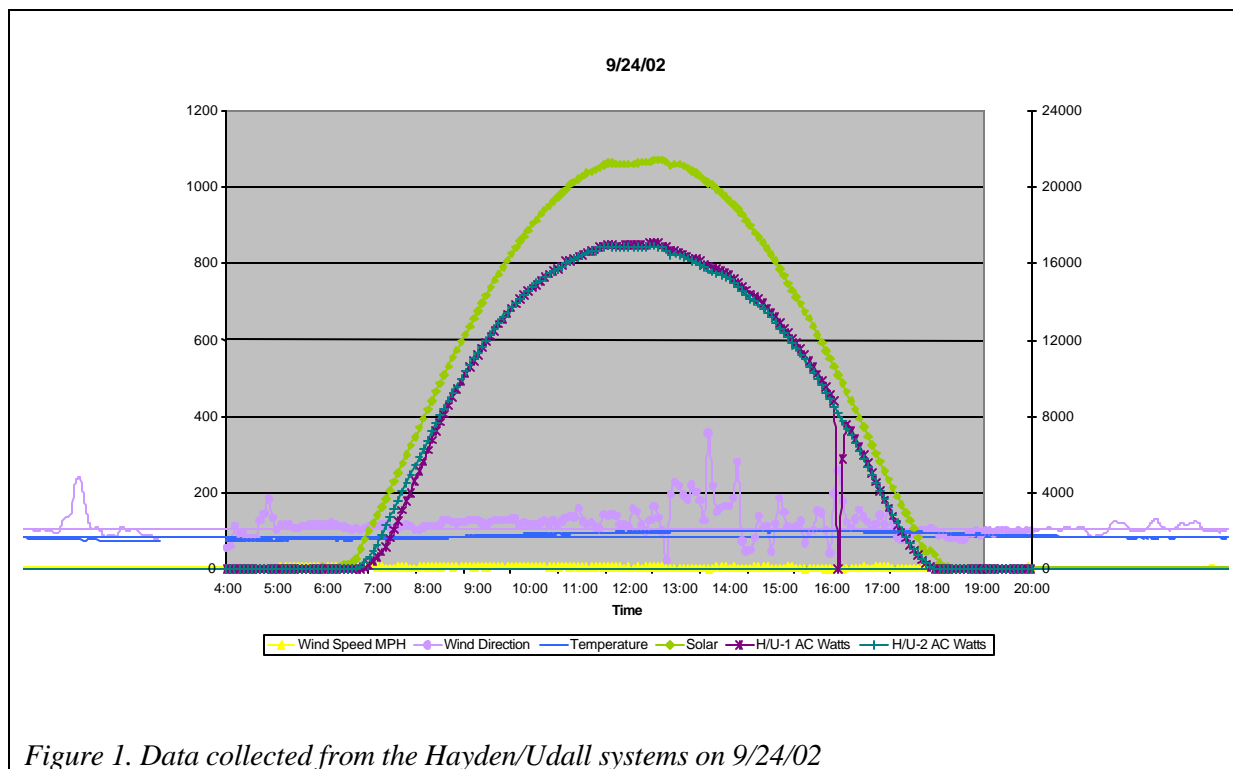


Figure 1. Data collected from the Hayden/Udall systems on 9/24/02

TEP is responsible to provide all labor for routine and breakdown maintenance of the PV systems through the year 2012. The City will provide a periodic inspection and provide for site vegetation control and will be responsible for any material costs incurred to keep the systems operating correctly.

Based on two years of operating experience with the three other TEP 17 kW systems, the only costs to date have been for weed control. Reliability has been greater than 99%, with rare – once or twice a year – inverter trips of the Springerville, AZ site system in cold weather due to cloud enhancement. Barring inverter failures after the two-year warranty period, operating costs are expected to be less than 0.1 cents per kWh, or \$72 per year.

Lessons Learned

A strong working relationship must be established between the peers of any partnership for the project to be successful. TEP and the City established this type of relationship early in the development of the initial Hayden/Udall project plan allowing the partners to work together to meet the strict deadlines required by the SPS funding. It is important that all members of the partnership team be involved in the grant application development process to ensure that all members understand clearly what is expected of them during the project implementation.

Having a full scale operating model to use in the design process and especially during the permitting process was very beneficial. The use of historic operating data was valuable to show inspectors how the systems would operate, the ranges of operating voltages and currents

expected given the temperature extremes of Arizona. Actual operating experience is often more valuable than the specification sheets provided by the PV manufacturers.

Scheduling equipment delivery and labor was simplified by using a contractor with installation experience of 1000 kW of PV in Arizona, and a proven system design and materials. The City of Tucson Water Department was a very interested and cooperative host site, and their cooperation and participation was beneficial to making this a successful project. Additionally, the Arizona Corporation Commission Environmental Portfolio Standard was very helpful in establishing an incentive for TEP to facilitate with customer sited PV projects. This value can not be underestimated.

The foresight of The Greater Tucson Coalition for Solar and the leadership of the Tucson City Council in setting aside the benefit of a 1% electric rate decrease for development of solar energy generation systems was an essential element in providing the funding needed to implement this project. Continued support for solar projects in general and this project in particular from the top down was essential in completing the necessary contracts in a timely manner. To ensure that the project was completed on time it was necessary to involve all stakeholders, such as the City Mayor and Council, early in the process.

Building permits were far more expensive than anticipated. Permit costs for PV systems should not be based on the initial cost of the system, but should be based on the benefit to the owner.

Despite the high up-front cost of PV compared to traditional electricity generation, the City of Tucson and TEP are dedicated to developing a sustainable solar program that demonstrates the range of benefits provided by PV.



Another view of the two systems located at the Hayden/Udall water treatment facility.

Detroit Shoreway Community Development Organization – Cleveland Eco Village

The Cleveland EcoVillage project received funding from the SPS program to install PV systems on the garage shared by four new town homes. These homes were initially planned to only incorporate energy efficient and green building technologies, however the SPS funding allowed the developer to include a PV feature.



The Cleveland EcoVillage groundbreaking ceremony was held May 2, 2002 with the Cleveland mayor, SEPA staff, and other dignitaries in attendance.

Groundbreaking at the site occurred May 2, 2002. The Cleveland mayor, SEPA staff, and others attended the ceremony. Some delays were caused in the proposed project because of a slump in the Cleveland housing market; however the PV systems were installed by the September 30 deadline and operational in early October 2002. Three of the homes were equipped with 3 kW PV systems, and one home featured a 2 kW PV system.

The Cleveland EcoVillage is a national demonstration project with the goal of developing a model urban village that will realize the potential of urban life in the most ecological way possible. The

EcoVillage planning area centers on the W. 65th Street Rapid Transit Station and surrounding neighborhood on the west side of Cleveland. It is an ethnically diverse community with residents with low to moderate incomes. Development opportunities include the Rapid Station, adjacent commercial strip, nearby Zone Recreation Center and church campuses, and vacant lots for infill housing.

Many organizations partnered to make the Cleveland EcoVillage project successful. The leading partners were the Detroit Shoreway Community Development Organization, and a nationally-recognized environmental planning organization, EcoCity Cleveland. In addition to these main partners, the project involves the Greater Cleveland RTA, private developers, the City of Cleveland, Building America, Department of Energy (DOE), the Foundation for Environmental Education (FEE), block clubs, other neighborhood development organizations and other environmental organizations, such as the Green Building Coalition.



The first four homes of the ten-home Cleveland EcoVillage development.

Critical Success Factors

The SPS RFP defined a number of critical success factors that each showcase project should address in order to further the goals of solar energy commercialization. Cleveland EcoVillage thoroughly incorporated these critical success factors into their project, even beyond the portion of the project funded by SPS.

Addresses the fast growing, efficiently served, PV market segments of commercial buildings, new residential, and public buildings

This project addresses the market for affordable new housing in an urban environment. As older cities, such as Cleveland, are redeveloped it is vital that the regeneration take into account ecological design, energy efficiency, and long-term sustainability. The EcoVillage project is a model for other neighborhoods in Cleveland and throughout the U.S. This project involves major development organizations in the Cleveland area, as well as state agencies that can replicate the success of this project in other new development projects in Ohio and elsewhere in the U.S.

Includes effective public outreach and education to stimulate public and market interest and purchase decisions.

The project has been funded with \$92,000 from the Cleveland and Gund Foundations to conduct public meetings, technical workshops, charrettes, monitoring, and other types of outreach. The project has been and will continue to be highly publicized through the Building America Program, as a recipient of a Sustainable Development Challenge Grant from the U.S. Environmental Protection Agency, through coverage of the project's development through the *EcoCity Cleveland Journal* and invitations to speak both locally and nationally on lessons learned through the Cleveland EcoVillage. EcoCity Cleveland has worked with reporters from the *Plain Dealer*, *Inside Business Magazine*, *Northern Ohio Live* and others to help generate positive media coverage of the EcoVillage, the town home development and the significance of ecological design in the region.

Effectively utilizes state, local and other public funds committed to energy efficiency, renewable energy, and solar energy.

The Cleveland EcoVillage has received funding from the US EPA, the US DOE, and the Cleveland and Gund Foundations specifically to promote the use of energy efficiency and renewable energy in the Cleveland EcoVillage. The Cleveland Green Building Coalition, EcoCity Cleveland, and DSCDO have committed \$32,000 of in-kind funding to promote ecological design, including energy efficiency and renewable energy. Funding has also been secured from the Wean Foundation, the City of Cleveland Housing Trust Fund, and Community Development Block Grants to offset some of the costs of advanced design and construction of the energy-efficient town homes.

Captures and highlights all the "values" of PV that customers and the public recognize, beyond energy and capacity benefits.

The concept of the Cleveland EcoVillage is one of sustainability and ecology. Much of the project's focus is on the environmental benefits of green building and the economic benefits of lower energy consumption. Measurable outcomes will be immediate and produce considerable financial and environmental savings to the homeowner over many years. The goal of the demonstration materials is to show how alternative energy sources and innovative design create significant financial and environmental savings to homeowners.

Additional outcomes include green building standard measurements, documentation and evaluation through a pilot-project with the Leadership in Energy & Environmental Design (LEED Standards). Local and national developers, architects, builders and community members

will understand and be owners of the latest green building technology. The project team will show individuals how to construct projects incorporating green materials and pushing the market to incorporate green building standards as the norm rather than the exception.

Offers or takes advantage of long-term financing mechanisms.

The owners will finance the town homes, including the PV system, with long-term mortgage financing.

Strengthens or establishes the local PV infrastructure, which includes sales, installation, maintenance, repair, training and certification.

Part of the outreach effort includes workshops for building industry professionals. These workshops are ongoing, and offer an opportunity to build local PV infrastructure in the design-build community. In addition, AstroPower is providing sales and installation training to project participants on-site. Currently, the project partners are also studying changes in Cleveland building codes to facilitate green building including the incorporation of PV.

Demonstrates by example easy grid interconnection and siting approvals consistent with all local codes and rules.

AstroPower assisted the project developer in permitting and grid-interconnection through preparation of appropriate document submission packages. AstroPower has also worked closely with local building code and utility officials to navigate the permitting and interconnection processes, as they have done in numerous new residential construction projects on the East and West Coasts in the context of their residential solar power system business.

Assists customers in the integration of energy efficiency and on-site PV generation, such as achieving zero energy buildings.

Its participation in Building America requires that the EcoVillage town homes achieve greater than 30% of the efficiency outlined in the 1995 Model Energy Code. With the PV systems funded by the SPS program, the homes approach the Zero Energy Home target. Additionally, the energy efficient designs should reduce the cost for heating to as little as \$300 annually. Water saving devices to collect storm water run-off will be used for shared community space and gardens as well as certain places in the home. Building performance will be tested and documented throughout the building commissioning.

Demonstrates long term project and business model sustainability and is replicable by others.

By demonstrating successful deployment of PV technology and its impact on home operating costs, this project will provide a model for low-income urban housing that can be replicated both by the project participants and others in future projects.

Technical Information

Three of the 3 kW systems, and one 2 kW system, featuring AstroPower's SunLine-20 and SunLine-32 PV systems, were installed on the roofs of the townhouses' garages. The AstroPower SunLine™ product line is designed to install quickly and offer years of trouble-free performance.

Features of AstroPower's SunLine system design that facilitate quick installation, ensure safety, and improve reliability include:

- Solar modules with pre-installed quick connects
- Complete rooftop mounting system engineered to 125 mph wind loading
- Pre-engineered panel wiring boxes
- Inverter enclosure with disconnects and protection devices pre-wired
- System performance monitor that shows system energy production and home energy consumption (AstroPower's SunChoice™ Meter)
- Equipment that meets applicable national standards
- Design meets requirements of NEC 690 and IEEE 1374-1998
- Components which comply with industry standards, including IEEE 1262-1995 and UL 1703 (modules), IEEE 929, UL 1741, and IEEE 519 (PCS)
- Conductors are listed for operation up to 600 volts and are temperature to 90°C in wet locations. Conductors and over current protection devices are properly sized
- Individually fused module source circuits.

The PV arrays consist of 20 (SunLine-20) or 32 (SunLine-32) AstroPower AP-120 single crystal silicon PV modules, which require approximately 10 square feet of roof space per module to install.

Features of the AP-120 module include:

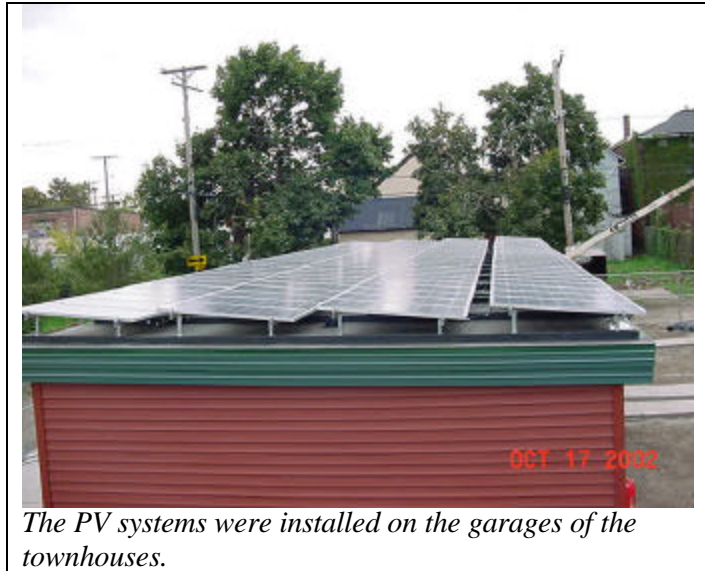
- 120 W rated DC output
- Pre-assembled Multi-Contact quick connectors for ease of installation
- Bypass diodes in each junction box
- Listing under UL standard 1703
- A standard 20-year performance warranty

The inverters used are SMA SunnyBoy

1800 and 2500 grid-interactive, sine wave inverters (1@2500 for the SL-20, 2@1800 for the SL-32). Features include:

- Proven track record in the field
- 93-94% efficiency
- Maximum power point tracking
- Compliant with UL standards 1741, IEEE 929-2000, FCC Part 15, 1999 NEC, article 690, and IEE 519 and ANSI C84.1, where applicable.
- Five-year warranty
- Weather-proof enclosure with ground fault protection and inverter display installed;

AstroPower's roof mounting system is designed to mount flush on a roof with attachment to the roof joists (or sleepers). This system allows for superior strength characteristics by attaching to the roof joists, minimizes roof penetrations (one per foot), and is suitable for a variety of roof



surfaces. The modules mount onto the rack one at a time and connect to each other easily to facilitate fast installations. The roof-mount system is manufactured exclusively for AstroPower by Professional Solar Products, of California. The system is engineered to withstand 125 MPH wind loading, and contains no ferrous parts.

Each SunLine system includes AstroPower’s SunChoice Meter. This meter indicates the instantaneous power (kW_{AC}) and cumulative energy (kWh_{AC}) production of the solar power system as well as the instantaneous power and cumulative energy consumption of the entire home.

Each AstroPower SunLine-32 system includes the components described in Figure 2, in the amounts indicated.

Quantity each system	Item	Description
32	AP-120	AstroPower single crystal silicon 120 $W_{DC Peak}$ PV modules with quick connectors
2	SMA SB1800U	High efficiency utility tie inverter with maximum power point tracking, 1.8 kVA nominal output, includes GFP and inverter display.
8	AM-6-B	AstroMount aluminum module mounting kit, each holds four AP-120 modules
4	LSB	AstroPower panel interconnection box, attaches to mounting rail, with pigtail connectors to mate with module string terminal connectors
1	SC M2	SunChoice system performance meter

Figure 2. Components included in AstroPower’s Sunline-32 system.

Each AstroPower SunLine-20 system includes the components described in the Figure 3, in the amounts indicated.

Quantity each system	Item	Description
20	AP-120	AstroPower single crystal silicon 120 $W_{DC Peak}$ PV modules with quick connectors
1	SMA SB2500U	High efficiency utility tie inverter with maximum power point tracking, 2.5 kVA nominal output, includes GFP and inverter display.
5	AM-6-B	AstroMount aluminum module mounting kit, each holds four AP-120 modules
2	LSB	AstroPower panel interconnection box, attaches to mounting rail, with pigtail connectors to mate with module string terminal connectors
1	SC M2	SunChoice system performance meter

Figure3. Components included in AstroPower’s Sunline-20 system.

Lessons Learned

The addition of PV to the first four homes in the Cleveland EcoVillage development generated a great deal of interest both locally and nationally. The Cleveland EcoVillage has used the installation of PV systems to demonstrate to other developers, architects, and businesses the

benefits and challenges of installing solar. With the addition of PV to the homes, the project has received an increased amount of media attention, evidenced through the planned articles in Properties Magazine, a publication that has serviced the community for 58 years. The project will be featured on their cover as well as the feature story. Builders Exchange-The Magazine and Ohio's largest newspaper, The Cleveland Plain Dealer art Critic Steve Litt are both working on articles on the Cleveland EcoVillage.

The project is drawing international attention as well. A developer out of Toronto that builds over 3000 units annually recently visited the site and may incorporate many of the same energy efficient and green building strategies into future developments.

The demand for new homes in Cleveland has decreased, resulting in construction delays of the EcoVillage development. Because of these delays, the original plan, which called for 10 homes featuring relatively small PV systems, was modified. The revised plan resulted in four homes receiving larger PV systems. This change did have the benefit of bringing the four homes close to the zero net energy goal.

Most of the challenges were easily overcome by cooperation between the contractor, architect, and all other parties. Communication was critical because many of those involved were located out of state.

The SPS project is only the first step in a larger plan to bring solar to Ohio. DSCDO and AstroPower are continuing to petition the State of Ohio to provide funding for additional PV installations on the townhomes, and, to date, the State has shown enthusiasm for supporting these efforts.

As a State of Ohio's Governor's Energy Smart Community award recipient, the Cleveland EcoVillage project is committed to working with others to have 50kWdc of solar installed by 2004. Additionally, DSCDO is working with the Green Building Coalition (GBC) to promote photovoltaic systems in future residential and commercial projects. GBC is also using the EcoVillage townhomes as a template to showcase PV applications.

A workshop on the basics of solar is planned for late January with Green Energy Ohio, EcoCity Cleveland, Green Building Coalition and the City of Cleveland to discuss existing PV efforts and to promote future solar projects. Other training programs are being planned.

Solar Power Solutions Showcase Program Conclusions

Through innovative partnerships and applications, the two SPS showcase projects demonstrate PV applications and programs that can easily be adapted by others to further accelerate the commercialization of PV. The success of both showcase projects illustrates that PV is a viable technology that, when all the benefits are quantified, and incentives utilized, can be cost effective. In order to achieve the commercialization of PV, the critical success factors identified in the *Business Case* must be addressed. A holistic approach is necessary for a sustainable PV market.

Photovoltaic technology and products continue to improve. The PV industry is developing building integrated photovoltaic (BIPV) technologies that offer improved aesthetics and provide added value such as insulation and/or roofing credit. Inverter reliability, which has consistently been the biggest weakness in PV system performance, has improved and selection has expanded as new companies enter the market, and existing companies offer a wider range of products. As utilities and municipalities develop solar programs PV becomes more accessible to the average consumer. By offering PV as an option for the homes in the Cleveland EcoVillage the DSCDO has simplified the process for homeowners and allows the cost of the PV system to be incorporated into the mortgage.

While many utilities are taking the lead locally, the government at all levels has a role in the development of PV markets. Recently most of the activity has been at the state level, providing incentives for the purchase of PV and legislation to provide guidelines for the use of PV. Federal policies should support State efforts, but also set national guidelines and standards.

Utilities are critical stakeholders in the efforts to achieve market penetration of PV, and they can benefit in many ways. Utilities benefit from PV as a distributed resource; the peak output from PV often coincides with the utility's peak demand. As customers become more environmentally aware, the demand for "green" energy is increasing, and a solar component in the mix is important to customers as utilities meet that demand. TEP and the City of Tucson have recognized the benefits of PV to themselves and their customers. In part because of their partnership, Tucson is on its way to becoming the "solar city" of the southwest. Utility cooperation is necessary for simple grid connection of PV systems, and utility acceptance of PV is critical for market development. Additionally, utilities often have the capital necessary to secure long term purchasing or financing agreements with PV suppliers and installers. These long term commitments are necessary for stabilizing the growth in PV demand.

For PV to reach larger market penetration levels, the distribution and service (installation and maintenance) network must be better developed. There must be trained, qualified people locally who can sell, install and maintain PV systems. An important component of this is the availability of regional training and certification for installers.

Electricity consumers often have little or no knowledge of PV and its values. The PV industry must undertake a marketing effort to educate consumers on the value proposition of PV, and why PV may be the best energy option regardless of price. This type of effort is critical to create a sustainable demand for PV.

Financing mechanisms must be readily available to PV consumers. The upfront cost of PV is prohibitively high for most people, and some method of long-term financing is almost always necessary. This will require educating financial institutions on PV technology so that they understand the values and risks involved. By incorporating the PV system into a new home, the cost can be included in the home's mortgage, making financing easier for the homeowner.

When all of these items are combined on a large scale, PV will reach greater market penetration. The showcase projects illustrate just two approaches to the critical success factors, although there are a number of ways to address them, as were shown in the diversity of the proposals submitted

for this funding. More showcase examples will provide added value to communities and utilities that are considering the best business cases for solar electric power.

Attachment A: Solar Power Solutions Proposal Evaluation Committee

Committee Members:

Voting

Chuck Linderman

Christy Herig

Glen Hamer

Committee Chair and SEPA Board Representative

NREL

SEIA

Non-Voting

Steve Hester

Hank Habicht

SEPA/TTC

SEPA/GETF

**Attachment B: Solar Power Solutions Evaluation Committee,
Voting and Non-Voting Members Disclosure Forms**

Solar Power Solutions Evaluation Committee Disclosure Form

Voting Member

Whereas, the Solar Power Solutions (SPS) Evaluation Committee will review and score all proposals that are in technical compliance with the requirements of the Solar Electric Power Association (SEPA) Request for Proposals, dated February 22, 2002.

Whereas, the Evaluation Committee is acting on the behalf of the SEPA and the U.S. Department of Energy under cooperative agreement # DE-FC36-01GO11063 in selecting appropriate projects to receive funding, the Evaluation Committee understands and recognizes the importance of acting with knowledge and understanding of the goals of the SEPA and the U.S. DOE;

Whereas, as a member of the Evaluation Committee, I agree to properly execute the duties and obligations of the Evaluation Committee and to advance the purposes of the Committee through the following resolution:

“I _____ hereby declare that as of _____
2002,

- 1) I am not associated — including, without limitation, as a shareholder, director, officer, trustee, partner, employee, agent, contractor, vendor, purchaser, consultant, or otherwise — with any person or company which has submitted a proposal to the SEPA in response to the SPS RFP, dated February 22, 2002 or which has agreed to take part in a Solar Power Solutions project team with any such person or company (“Participant”).
- 2) I have no current understanding or expectation to become associated with or be compensated by a Participant.
- 3) I agree that, if I discover the existence of, or initiate an association (including receiving any form of compensation) with a Participant, I shall immediately inform the Evaluation Committee Chairman, and shall abide by his/her decision as to whether my continued participation in the SPS evaluation process is appropriate.
- 4) During the term of my duties as a member of the Evaluation Committee and for one (1) year thereafter, I shall not seek or accept an association with, or receive compensation from, any Participant or winning project proposer or team, including, without limitation, as a bidder on any solicitation for products or services resulting from a proposal awarded funding under the SPS RFP except where that association is not related in any way to activities involving or affecting the application of photovoltaic systems.
- 5) During the term of my duties as a member of the Evaluation Committee and for one (1) year thereafter, I will not use information learned during the evaluation process for any purpose other than the evaluation itself, except where expressly authorized by SEPA or otherwise required by law.

6) I agree that, as a member of the Solar Power Solutions Evaluation Committee, I shall execute my duties with due care, diligence and in a fair and impartial manner.

_____ Printed Name

_____ ,2002
Signature Date

Solar Power Solutions Evaluation Committee Disclosure Form

Non-Voting Member

Whereas, the Solar Power Solutions (SPS) Evaluation Committee will review and score all proposals that are in technical compliance with the requirements of the Solar Electric Power Association (SEPA) Request for Proposals, dated February 22, 2002.

Whereas, the Evaluation Committee is acting on the behalf of the SEPA and the U.S. Department of Energy under cooperative agreement # DE-FC36-01GO11063 in selecting appropriate projects to receive funding, the Evaluation Committee understands and recognizes the importance of acting with knowledge and understanding of the goals of the SEPA and the U.S. DOE;

Whereas, as a non-voting advisory member of the Evaluation Committee, I agree to properly execute the duties and obligations of advising the Evaluation Committee and to advance the purposes of the Committee through the following resolution:

- 1) I agree to disclose in writing to the Evaluation Committee Chairman any associations — including, without limitation, a shareholder, director, officer, trustee, partner, employee, agent, contractor, vendor, purchaser, consultant, or otherwise — with any person or company which has submitted a proposal to the SEPA in response to the SPS RFP, dated February 22, 2002 or which has agreed to take part in a Solar Power Solutions project team with any such person or company (“Participant”).
- 2) I agree that, if I discover the existence of, or initiate an association (including receiving any form of compensation) with a Participant, I shall immediately inform the Evaluation Committee Chairman, and shall abide by his/her decision as to whether my continued participation in the SPS evaluation process is appropriate.
- 3) During the term of my duties as a member of the Evaluation Committee and for one (1) year thereafter, I will not disclose or use information learned during the evaluation process for any purpose other than the evaluation itself, except where expressly authorized by SEPA or otherwise required by law.
- 4) I agree that, as a non-voting advisory member of the Solar Power Solutions Evaluation Committee, I shall execute my duties with due care, diligence and in a fair and impartial manner.

_____ Printed Name

_____, 2002
Signature

Attachment C: Solar Power Solutions Proposal Evaluation Forms

THRESHOLD REQUIREMENTS									
Project	Demonstrate that SPS funds will be used to make the project a showcase project	Demonstrates that the critical element(s) are not sufficiently covered by other funding sources	Evidence that the project is under development	Prior experience successfully deploying, operating, and/or maintaining PV projects.	Applicant agrees to identify and document all "values" and results of their project as described in the RFP	Clear and documented process for measuring the success of the project	Projects must comply with the technical specifications for installed PV systems	All PV modules, inverters, and major electrical equipment must be new and manufactured in the United States	The proposal and signed funding agreement were received before the response deadline, adhere to the Response Format, and contain all of the information requested in Section 3
EcoVillage Cleveland									
Green Mountain Solar Projects									
Hayden/Udall Water Treatment Facility Solar Integration Project									
JEA Clean and Green Power Program									
PowerLight - Santa Rita Jail									
PV Market Acceleration with Tradable Renewable Energy Credits (TREC)s									
SMUD - Non-Penetration Flat Roof Mounting									
SMUD - PV Patio Structures									

CRITICAL ELEMENTS									
	Addresses the fast growing, efficiently served, PV market segments of commercial buildings, new residential, and public buildings;	Includes effective public outreach and education to stimulate public and market interest and purchase decisions;	Effectively utilizes state, local and other public funds committed to energy efficiency, renewable energy, and solar energy;	Captures and highlights all the "values" of PV that customers and the public recognize, beyond energy and capacity benefits;	Offers or takes advantage of long-term financing mechanisms;	Strengthens or establishes the local PV infrastructure, which includes sales, installation, maintenance, repair, training and certification;	Demonstrates by example easy grid interconnection and siting approvals consistent with all local codes and rules;	Assists customers in the integration of energy efficiency and on-site PV generation, such as achieving zero energy buildings;	Demonstrates long term project and business model sustainability and is replicable by others.
EcoVillage Cleveland									
Green Mountain Solar Projects									
Hayden/Udall Water Treatment Facility Solar Integration Project									
JEA Clean and Green Power Program									
PowerLight - Santa Rita Jail									
PV Market Acceleration with Tradable Renewable Energy Credits (TREC's)									
SMUD - Non-Penetration Flat Roof Mounting									
SMUD - PV Patio Structures									

Attachment D: Technical Performance Specifications

1.0 TECHNICAL SPECIFICATIONS

1.1 System Rating Criteria ($kW_{AC,PTC}$). The PV system and modules shall utilize a modified set of PVUSA Test Conditions (PTC, Ref. 1998 PVUSA Progress Report) as the primary rating of power. The PV system rating shall be in kilowatts (kW) AC (Alternating Current) at PTC (PVUSA Test Conditions). See Section 3 for a description of the rating conditions and the SPS modification, and also see Section 6.4 for the rating methodology.

2.0 CODES & STANDARDS

The PV system hardware and services shall conform to the applicable codes and standards, and shall have passed the listing and qualification tests, listed below. (Dates of latest known version shown, the most recent version should be used.)

- **National Electrical Code – NFPA 1999**
- National Electrical Safety Code – ANSI C2-1999
- Occupational Safety and Health Administration (OSHA) Directives
- Applicable regional Building Codes, such as UBC – Uniform Building Code
- All outdoor enclosures shall be minimum NEMA 3, or equivalent rating.
- ANSI/IEEE 519 1992 Guide for Harmonic Control and Reactive Compensation of Static Power Controllers
- Photovoltaic Module Qualification Tests:
 - **IEEE 1262 “Recommended Practice for Qualifications of Photovoltaic Modules”**
 - **(Optional)** PowerMark certification for PV modules.
 - IEEE Standard 928-1986, Recommended Criteria for Terrestrial Photovoltaic Power Systems (PV system performance criteria)
 - **IEEE 929-2000, Recommended Practice for Utility Interface of Photovoltaic (PV) Systems ,**
 - **Underwriters Laboratories 1741-2001 (UL Standard for Inverters and Charge Controllers)**
 - Underwriters Laboratories 1703 (UL Standard for Listing Photovoltaic Modules)
 - Certification of PV Equipment: All PV modules, inverters, and electrical components shall be required to be listed or recognized by an appropriate and recognized United States Safety Laboratory (for example: UL, ETL, etc.).
 - ANSI/ASCE 7-88 – Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

- FCC Regulations Electromagnetic Interference (EMI) Part 15, Section B, 1998
- Local and State Codes and Standards

3.0 SYSTEM POWER

The PV energy conversion systems shall be rated at an AC power output rating at modified PVUSA Test Conditions (PTC)*. This modification of PVUSA Test Conditions (PTC) is defined as follows:

Modified PVUSA Test Conditions for Flat-Plate Systems : 1,000 W/m² Global Plane of Array (POA) irradiance, 20°C ambient air temperature and 1 m/s wind *speed (measured at an appropriate location)*. The modification to the rating conditions shall be the measured height of the wind speed. PVUSA test conditions require wind speed to be monitored at 10 meters, whereas the SPS modification to these PVUSA rating conditions only requires that the wind speed be monitored at a location nearby the PV array to be representative of the prevailing wind conditions

The system rating methodology is described in Section 6.0, Acceptance Tests. The PV components and the system shall be designed to safely operate at continuous output, under a wide range of temperature and irradiance conditions characteristic of the specific site.

4.0 DC ELECTRICAL

The PV system installation shall comply with the National Electric Code (NEC). PV system grounding should follow the requirements of the NEC.

5.0 AC ELECTRICAL POWER SYSTEM (POWER CONDITIONING UNIT(PCU), TRANSFORMER, ETC.)

Prior to shipping the PCU or any of its component parts to the installation site(s), operability shall be demonstrated. At a minimum, and in addition to the trip point testing of UL 1741, the PCU shall be tested to demonstrate that all controls, protective functions, and instrumentation perform as designed and that the PCU has the functional capability to be connected to a utility grid.

Factory testing shall include a burn-in test. For this test, the PCU shall be operated at full rated power output for one continuous eight (8) hour period. This test shall be performed at an elevated temperature (site maximum temperatures) on a statistically significant sample for residential and small commercial units, and on each 20 kWAC or larger systems. If full power testing is not possible at the testing facility, each of the bridges, or power segments, may be tested independently at rated capacity for eight (8) hours. These tests shall be performed on a statistically significant sample lot of the units procured.

All wiring shall be new, copper, and, if possible, continuous for each wiring run; splices are allowed only where essential and in appropriate junction boxes. Insulation shall have identifying labels or markings on both ends.

6.0 ACCEPTANCE TESTS

This section of the specification provides a recommended practice for grid-connected photovoltaic systems to determine that the system is functionally operative and meets the design and performance requirements. The tests will verify that the system, as installed, is safe for personnel as well as equipment, and establish or verify system power rating.

Test methods and procedures shall be utilized on all PV systems to determine actual post-construction operational, performance, and safety characteristics. The test results can be used to compare system

performance and operation with the specifications, predicted performance, and applicable codes and standards.

The tests described are suitable for system acceptance purposes and can be performed at any time thereafter to evaluate system performance.

6.1 Scope

The tests described in this document apply to small (less than 20 kW) residential or commercial concentrator and flat-plate grid connected PV systems.

The equipment, material, and components shall be tested in accordance with the applicable standards, requirements, and guides.

6.2 Acceptance Test Plan

6.2.1 Visual Inspections. Make sure all disconnect switches are off.

6.2.1. A. PV Modules and Module Wiring. Verify that all connectors are properly mated, module cables are properly secured to module frame, no debris on module surface, no physical damage to module frames or laminates, and ground wire and lug are securely attached to module frame.

6.2.1. B. Source Circuit Junction Boxes. Verify that all connectors are secured, field wiring terminations are tight, field wiring is properly polarity-marked with colored tape or jacket color, ground wire is securely attached, labels are in place, and all covers are secured.

6.2.1.C. DC and AC Disconnect Switches. Verify field wiring terminations are tight, field wiring is properly polarity-marked with colored tape or jacket color, conduit connections are tight and bushings used (if applicable), ground wire is securely attached, labels are in place, and all covers are secured.

6.2.1.D. Inverter(s). Verify field wiring is routed properly, field wiring terminations are tight, field wiring is properly polarity-marked with colored tape or jacket color, conduit connections are tight and bushings used (if applicable), ground wire is securely attached to inverter, labels are in place, and all covers are secured.

6.2.1.E. Wires, Cables, and Buses. Electrical cables and wires should be tested for continuity (or megger tested, if appropriate).

6.2.2. Electrical Check-Out. Make sure all disconnect switches are off.

6.2.2. A. Source Circuit Junction Boxes. Check that the polarity and magnitude of the open-circuit dc voltage of source circuit inputs are correct (refer to specific system documentation).

6.2.2. B. DC Disconnect Switch. Verify polarity and open-circuit DC voltage magnitude of PV input to switch are correct (refer to specific documentation).

6.2.2. C. Inverter. Verify polarity and AC voltage magnitude of utility connection to inverter are correct (refer to specific documentation).

6.2.2. D. Grounds. Verify System and Equipment grounds according to NEC.

6.2.3. System Turn-On

6.2.3. A. Apply AC power to inverter (close circuit breaker and/or AC disconnect switch).

6.2.3. B. Apply dc power to inverter (close dc disconnect switch).

6.2.3. C. Operation should begin after appropriate delay and the inverter should come on-line.

6.2.3. D. Confirm that operating voltages and output power (as indicated on the inverter display, if available) are within expected range (refer to specific documentation).

6.2.4. System Operation

6.2.4.A. With the system operating, verify that system AC output ceases when the DC disconnect switch is shut off.

6.2.4.B. With the system operating, verify that system AC output ceases when the AC disconnect switch is shut off.

6.3 Initial Start-Up

The test shall demonstrate proper functional operation of control and protective features under normal and abnormal conditions. The majority of these tests are related to the PCU since most of the system operation and control is assumed to be performed here. In some cases, one or more of these features will be handled by devices external to the PCU.

6.3.1. PCU Operational Tests

- Local Operation and Controls
- Loss of Utility (Run-on Test)
- Loss of DC
- Array Ground Fault (if possible)

6.4 System Rating (Optional, the rating procedure requires additional data instrumentation)

System performance shall be monitored (if possible) to collect data for the system rating. The AC system shall be rated at modified PVUSA Test Conditions (PTC) which are defined as follows: 20°C ambient temperature, 1 m/s wind speed, and 1,000 W/m² global plane-of-array irradiance for flat plates, or 850 W/m² direct normal irradiance for concentrators.

The data collection period shall consist of at least thirty (30) days with a cumulative total of at least 10 kWh/m² above 850 W/m² of global plane-of-array irradiance (or 850 W/m² of direct normal for concentrators). If the site selected for the PV installation does not have adequate irradiance during the rating period, the rating should be delayed until these conditions are met.

The System Rating shall be based on a regression analysis of quality-checked data using only 500 W/m² or greater irradiance. The following parameters shall be measured and recorded over the 30-day period:

- Plane-of-Array Irradiance
- Ambient Temperature
- Wind Speed
- AC System Power Output (measured at the point of interface)

The measured data shall be used in the following equation and a regression analysis performed to determine the coefficients:

$$S = Irr * A + Irr^2 * B + Irr * Tamb * C + Irr * WS * D$$

where: S = system output power, kWac; Irr = irradiance, W/m²; Tamb = ambient air temperature; WS=wind speed; A, B, C, D = regression coefficients.

7.0 OPERATIONS AND MAINTENANCE MANUAL

An O&M manual is suggested to be obtained from the system supplier as part of the Technical Performance Specification (Annex GCA-B) Section 2.2.5.

OPTIONAL SUGGESTED SPECIFICATIONS

This section contains additional design criteria, codes, standards, specifications, and policies that are **suggested** as an option for successful utility PV purchase specifications.

- **Independent Safety Review.** A program for an Independent Safety review shall be conducted. The review shall be conducted by an independent entity (laboratory, consultant, or other with recognized credentials in the areas of electrical equipment design and safety. The scope of the review shall include the PV system design, its installation and operation.
- **Field Wet Resistance Test.** A field wet resistance test (FWRT) may be conducted on the installed PV array. Due to the large labor costs of conducting FWRT tests on large systems (>100 kW), the Recipient may elect to randomly select sections to test rather than the entire array. If significant failures occur, the entire array can then be tested. See PVUSA test procedures for details to conduct the field wet resistance test.

Attachment E: Data Monitoring Requirements

The objective of requiring data collection systems for PV Systems is the need to collect and report performance and operational information that accurately indicate performance and provide basis for value analysis. These are key requirements for decision makers.

In order to ensure a common data base for all the SPS applications and also allow easy comparison to TEAM-UP systems, the Recipient shall use a Data Collection System or Data Acquisition System (DAS) utilizing a Campbell Scientific Data logger (or equivalent). A portion of the data system instrumentation and transducers could be part of the PC system inverter (Power Conditioning Unit, PCU) if appropriately specified in the system or inverter procurement.

Each application of PV may require various levels of data collection. It is expected that the data systems will fall into three categories. One version will monitor typical numbers (for example, 1 in 10) of residential PV installations. Another version will be required with commercial/industrial applications that also will need to monitor some of the load functions. A third type would be required for grid-support and distributed generation to monitor the nontraditional (if possible) benefits of PV in the applications.

The required DAS shall consist of a Campbell Scientific Data Logger or equivalent, terminal strips for input and output signal wires, a dial-up modem, a power supply, and an outdoor rated enclosure (as necessary); and the Recipient must provide a telephone connection.

1.0 DATA MONITORING SYSTEM CONTROL AND SIGNAL REQUIREMENTS

Below is a general description of the control and signal points required. All signals shall be compatible with the Campbell Scientific CR 10 or CR 21X data logger (or equivalent). All instruments shall have a maximum signal plus common mode within 0-5 Volts (CR21X), "2.5 Volts (CR10). Signal Conditioning may be used to limit common mode voltage as long as the required five percent (5%) accuracy is maintained. All analog instrumentation (other than thermocouples or RTD) shall provide a linear response.

1.1 AC Power (Analog)

Overall AC system output power is required to be monitored, but additional options may be appropriate, such as monitoring the real and reactive energy output (pulse output kWh metering) and voltage and current for the AC side. The type of application should determine what measurements are appropriate.

1.2 Ambient Temperature

The data system shall interface with a type T thermocouple or RTD as the device used to measure ambient temperature.

1.3 Wind Speed

An anemometer shall be installed in an appropriate location near the array.

1.4 Irradiance (Analog)

A pyranometer (or pyrliometer for concentrator systems) shall be mounted on the array structure and in the array plane. Optionally, shadow band instrument may be used to measure horizontal and diffuse irradiance data, if desired.

1.5 Benefits Measurements

It is the intent of the SPS program to identify the traditional and “nontraditional” benefits of the PV system to the customer and the utility. For a commercial roof-mounted system, information related to the building’s load and shape should be monitored by the DAS to provide valuable insight into the extra benefits of a commercial or industrial installation. For grid-support PV and for large aggregation of residential PV installations, the collection of utility feeder load, load shape, and/or transformer load data by the DAS is desirable. The use of existing utility or customer data collection (for example, existing load bank data for the substation transformer) to obtain these data is encouraged.

2.0 DAS HARDWARE REQUIREMENTS

The Recipient shall procure and install a Data Acquisition System (DAS) consisting of a Campbell Scientific Data Logger (or equivalent), terminal strip for input and output signal wires, a dial-up modem, a power supply, an outdoor-rated enclosure (if necessary), and a telephone connection.

A central data collection plan for collection of the DAS from each of the SPS PV system installations is being implemented. Therefore, the Recipient shall allow access to PV System Hardware for purposes of data monitoring and may be required to permit expanded data monitoring. The data logger software required shall be provided by SEPA.

2.1 Unless AC power is directly accessible, the data system shall be stand-alone PV powered. The data system shall have adequate battery backup for site conditions to allow the operation of all sensors during utility outages. The accuracy of the data system shall be at least five percent (5%).

2.2 The minimum channels and the parameters measured are described in Section 1.0.

The specific components, other than the data logger unit, are not stipulated in this Annex and are open to design as long as the accuracy requirement are met. A channel map identifying the connections of the data logger channels shall be provided by SEPA, along with the software for the data logger, prior to installation of the data system.

3.0 DATA COLLECTION SOFTWARE

The software to perform the data collection on the Campbell Data Logger will be provided by SEPA. This software will identify the channel allocations for the various parameters measured.

4.0 DATA REPORTING

Requirements for the quarterly, monthly exception, and other Venture reporting are covered in other sections. With the capabilities of the DAS system it is expected that additional performance and operation data may be available. At a minimum, it is expected that a representative assessment and performance plot showing average and peak conditions for the system and any performance anomalies be included in the SPS quarterly/monthly exceptions reports and other reporting requirements.