SAND Number 2006-1508 P

NativeSUN: A Model for Sustainable Solar Electric Systems on Indian Lands

Debby Tewa and Connie Brooks
Sandia National Laboratories[1]
Albuquerque, New Mexico

Abstract

This paper describes the tenets of sustainable photovoltaic systems and how these tenets have worked to help create long-lived solar electric systems on Hopi lands. Specifically, we describe NativeSUN, a historically Hopi-owned photovoltaics company, and its history of installing photovoltaic (PV) systems in Indian Country. We believe the components of sustainability described in this paper will serve as a model for other Native American business plans for solar electrification or to institutions seeking sustainability in developing countries or rural communities everywhere. One company, in an isolated community without a technological base, created a legacy of end-users who fully understand how to operate and maintain their solar systems. We believe this is due in large part to the numerous aspects of NativeSUN's business operation that mirror the tenets of sustainability we have identified.

Introduction

For millennia, Native American ancestors have harnessed the sun through passive architectural design both to minimize the sun's power to keep their homes cool and

[1] Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

maximize the sun's power to help heat their homes. Today, many Native Americans living far from electrical grid-power still benefit from the sun through the use of photovoltaics, or solar electricity. Photovoltaics (PV) is a renewable energy technology that allows rural Native Americans to develop a sustainable livelihood. Sustainable development can be described as, "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs."[2] There are several tenets of sustainability, and without incorporation of each of these tenets, a rural PV system in itself may never become a sustainable system. Unfortunately, part of the legacy of solar electrification over the past quarter century has been identified with abandoned, abused, or misused systems and misunderstood systems operations because they were not installed with sustainability in mind. Largely due to the fact that NativeSUN practices all of the tenets of sustainability, their system installations have had a monumental success rate and continue to be vital components of the Hopi people's cultural ways and ancient values as they blend with modern technology.

Sustainability

As designers and installers of PV systems everywhere know, system sustainability is key to the success of any PV system. But on Native lands it may be even more important because of the close match between Native Americans' cultural values and the inherent sustainability a modern PV system can afford when properly integrated.

We believe that PV system installations must incorporate all of the following components of sustainability in order to become and remain successful:

[2] Bent, Orr, and Randall Baker. Energy: Science, Policy, and the Pursuit of Sustainability. Washington·Covelo·London: Island Press, 2002.

- ☐ There must be a need for solar electrification; that need must fit with and blend with cultural values.
- ☐ The infrastructure for delivering PV systems must be in place, including supply, installation, service, maintenance, and financing.
- ☐ A customer must be "vested" in his or her system. He or she must be committed to maintaining the PV system. PV systems will be long-lived and successful only if there is a match between customers' ability to pay and the system's cost, including maintenance. Options as to size, aesthetics, and siting must be available.
- ☐ There must be a "champion" supplying the system. Without the passion of an individual or institution committed to providing the follow-up with customers, systems will likely fail.
- ☐ Consumer education is key: There must be full disclosure of non-technical information presented in a way that consumers can best learn it.
- ☐ Expectations must be realistic. Customers must realize that solar electricity is not the same as grid electricity.

Systems that incorporate all of these conditions will find a perfect synergy with Native Americans' cultural values. Sustainable PV systems will be the result.

Hopi Culture

Sustainability has always been a value to the Hopi, who have continually occupied their ancestral homelands since 500 AD. Currently 1.6 million acres of Hopi

Reservation land located in northeastern Arizona, is home to fewer than 12,000 enrolled tribal members. The Hopi survive in a harsh, arid landscape on the high desert, with annual precipitation averaging only 8-12 inches. Yet the Hopi have adapted through remarkably efficient dry-farming techniques. They produce corn, beans, and squash. Several natural springs nestle below the mesa, but no year-round water streams exist. The Hopi people depend heavily on ancient ceremonies to bring moisture in the form of rain and snow clouds to sustain them.

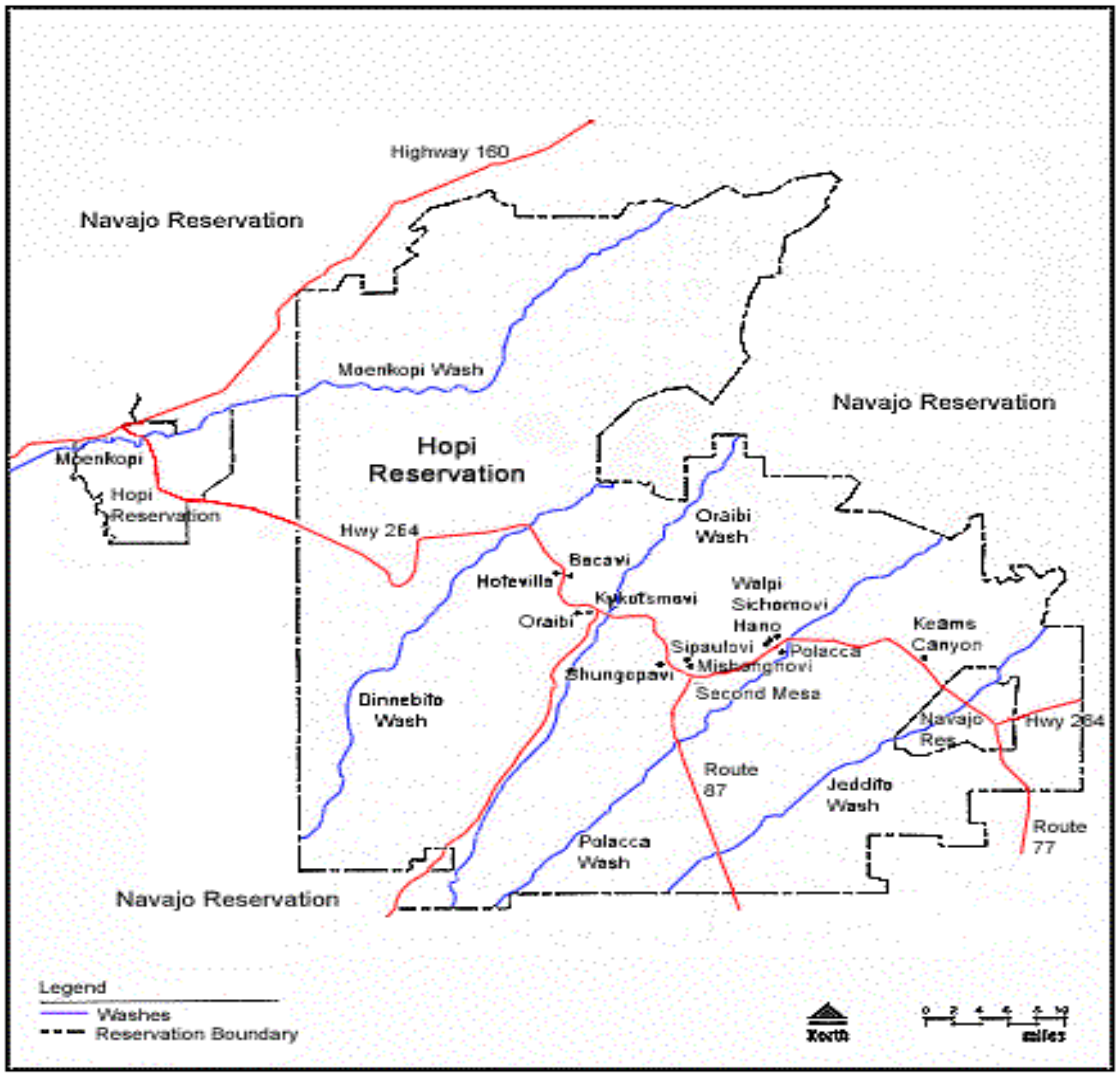

Figure 1. Map of the Hopi Reservation.[3]

With the continuous adaptation to modernization, the Hopi continue to practice their ancient rituals while embracing modern technology to enhance their way of life in a sustainable manner. Hopi elders view this balance between the old and new as essential to the survival of the Hopi culture. Solar electricity is one of those modern technologies that has found a successful transition on the Hopi Reservation.

The NativeSUN Model

One successful grassroots PV business is NativeSUN, located at Kykotsmovi on the Hopi Reservation in Northeastern Arizona. Begun in 1985, its goal was to provide PV power to remote locations in Indian Country for those who did not have access to the electric grid, or who chose not to draw power from the grid. NativeSUN began as a non-profit organization under the Hopi Foundation. It offered financial resources through a revolving loan program and trained local people to install and maintain solar electric systems on their off-grid homes. After more than 20 years' operation, NativeSUN's emphasis continues to be educating customers on the operation and maintenance of their PV systems. From its inception, NativeSUN sought to capture a niche market where solar electrification could make a huge difference in people's lives. Aware that the electrical grid was going to become available on Hopi lands, they chose to concentrate first on the Hopi Reservation; later they branched out to serve other Native American communities.

[3] Map of the Hopi Reservation, http://www.hopi.nsn.us/visitors.asp

The Hopi Foundation's market research team identified some 2500 people in the Hopi villages and an additional 35,000 people on the adjacent Navajo Reservation living without electricity.[4] Their objective was to bridge the electrical divide with a stand-alone system and decentralized solar-generated electricity where it was a good fit with people's cultural values and belief systems.

As grid power was introduced to the Hopi Reservation, eight villages chose to allow the power lines, but not without conflict among residents. Often traditional elders objected for religious, economic, or aesthetic reasons. Many villagers believed the electrical grid's attendant poles and lines infringed on village rights-of-way. When all of the discussions were consummated, four villages refused grid power altogether, creating a market for NativeSUN's solar electric program for providing off-grid electrical systems. Even this process, however, was not without difficulty. Some people suspected the solar panels of 'taking away from the sun.' Always from a Hopi viewpoint, the staff of NativeSUN was responsive and educated the Hopis in these four villages with great patience and cultural sensitivity. Still, according to NativeSUN's own web site, "overcoming these fears took many years [but] sentiments have diminished."[5]

NativeSUN emphasized educating their customers on the operation and maintenance of the whole system: the photovoltaic array and the balance of system, consisting of an inverter, batteries, cables, safety and monitoring equipment, and solar panel mounting racks. In NativeSUN's successful model, education meant the transfer of technology in easy to understand terms – and in the Hopi language – to maximize a customer's understanding of the operation of the system and their role in maintaining that

[4] *Hopi Indian Solar Electric Enterprise Proposal*, 1989
[5] http://www.nativesun.biz/background.html

PV system. We will now discuss each of the tenets of sustainability as they apply to the NativeSUN model.

A Legitimate Need. The absence of grid power in four of the twelve traditional villages and one other community made solar electricity a relevant technology that is both culturally sensitive and environmentally acceptable. Harnessing the sun's rays to produce electricity does not disrupt the village way of life because PV systems emit neither noise nor harmful emissions. Photovoltaic systems lessen fire danger by allowing compact fluorescent lights to replace propane lanterns. Elders or the disabled can move about their homes safely at night with the light provided by PV. Children no longer have to strain their eyes when doing their homework. And, as mentioned earlier, the solar electric systems were a good fit with the Hopi's cultural values.

Investing in an individual power generation system can be rewarding to the customer because it allows them to be self-reliant. Satisfaction is realized when customers fully understand the fundamentals of solar power, such as minimizing over-usage and budgeting energy loads.

The Hopi Reservation historically experiences frequent brown-outs and black-outs (when electrical power is unavailable due to weather, aging equipment, inadequate end-of-line power, or other incidents). These outages can sometimes be several hours in duration. Owning a solar electric system during such electrical outages can add yet another level of self-sufficiency. On Hopi lands there was definitely a need that could be met with a culturally sensitive applied technology.

Infrastructure. The two factors, unelectrified homes and the abundance of sunshine in Arizona, were conducive to the business NativeSUN envisioned, but they

required funds to get their business off the ground. The Hopi Foundation obtained grants from private foundations and state funds. One of many highlights of the solar program was personal delivery of a check for $150,000 by then Governor Rose Mofford. The Navajo-Hopi Observer wrote:

> The $150,000 contract, from the Arizona Energy Office of the Department of Commerce, will allow for the start-up of the Solar Electric enterprise. This will include the building of a demonstration facility; advance training for Hopi solar technicians, and program management for the first year. [6]

The start-up funds and grants received from private foundations provided the money for the organization to produce a detailed business plan. The funding also helped in training staff, finding a site for a demonstration building, establishing a financing mechanism, and marketing products and services.

A second – and vital – part of financing had to do with identifying a funding channel for individual loans to consumers who wanted to purchase solar electric systems. Initially, NativeSUN asked customers to pay in full before installing the solar electric systems. Due to the high cost of PV equipment, a revolving loan was established internally to speed up delivery. The revolving loan program was not a foreign concept; most people already paid monthly payments on automobiles, modular homes, or furniture. Once a customer was approved, he or she was required to come up with 10 percent of the value of the loan. The revolving loan managed by NativeSUN and, later, by banks and consumer unions, was a worthwhile experiment. The experience taught NativeSUN the criticality of financing costly hardware in Indian Country in order to assist a customer. The funding mechanism was worthwhile, even essential. But because the organization was small, spending time with delinquent customers became too great a

[6] "Hopi gains $150,000 solar pact with state," The Navajo-Hopi Observer, July 25, 1990, page A4.

burden. A delinquency meant having to repossess a system and resell the used equipment. The delinquency rate averaged 10 percent, and recovering a system was cumbersome and costly since the remote locations meant driving long distances.

Customer Vesting. Five newly hired technicians took an intensive two-week PV course from Appropriate Technology Associates (now operating as Solar Energy International) in Carbondale, Colorado. The technicians returned to the Hopi Reservation to install five model solar electric systems in the Third Mesa villages of Hotevilla, Oraibi, and near the First Mesa village of Tewa. Hopi-speaking installers translated the information about the array and the balance-of-system to the Hopi speaking customers. They explained operation and maintenance in detail to help the customer use the batteries efficiently. The system's user passed on the information to curious visitors. This word-of-mouth advertising benefited the business. Many people recognized the convenience of flicking on a switch for lights that replaced kerosene lanterns. They saw the potential of using the system for their various needs, including sewing machines, small power tools, vacuum cleaners, microwaves, and televisions.

Figure 4. **The 240 watt model unit deployed in Hotevilla, Arizona, is owned and operated by a former NativeSUN employee. It is sufficient for a small direct current (DC) television, a radio, and two 22 watt DC fluorescent circular lights.**

Education. After financing was achieved, NativeSUN electricians visited the site to make a thorough assessment and possibly prepare the site, informing the customer of the process that would take place when the system was ready to be installed. The educational process was key, and NativeSUN used a variety of almost home-spun methodologies for the successful transmission of information to the new consumers.

One example used was the analogy of water to help customers visualize the system. Native people everywhere who live without a nearby source of water learn the value of conservation. NativeSUN asked the consumers to imagine the batteries holding water for storage. The panels receive the sun's rays and turn them into electrons (again, picture water) in the storage tank between 9:00 a.m. – 3:00 p.m., the duration of the solar window. Since loads varied, NativeSUN used examples of 15 watt compact fluorescent light bulbs versus a 60 watt incandescent light bulb to make the customer aware of load consumption and energy efficiency.

In the early stages of development, NativeSUN realized that both the company and the consumer had to work together to create this win-win situation. NativeSUN focused on explaining the delicate balance of operating and maintaining a PV system to a customer from the first day of installation.

Supplier "Champions". NativeSUN's mission is to provide an alternative: living with an environmentally safe technology. Since some villages and remote areas lacked the infrastructure, NativeSUN offered alternatives to allow for modern conveniences. The success of NativeSUN's office, which served as a demonstration project, and the solar powered homes of three NativeSUN staff members

rippled out to potential customers through testimonials. People shared information about what works, and how it works.

Using some of the initial grant funds, NativeSUN's office building was retrofitted with a 900 watt photovoltaic array on passive tracking mount and BOS, 500-watt wind turbine, Solatube® tubular skylights, direct current (DC) water pumping system with a 300 gallon cistern, composting toilet, and a DC powered evaporative coolers. All of these components worked together to show consumers that NativeSUN was living the example of sustainable solar systems.

Figure 5. NativeSUN Office in Kykotsmovi, Arizona

Initial funding was also used to purchase a small trailer-mounted PV system that was loaned to a potential customer for a week. The utilization of 'solar on wheels' proved to be an effective educational tool. People who took advantage of the 'solar on wheels,' a tangible display of what was possible, became interested in purchasing a system. Within a month of using the free electricity from the 300-watt unit, a customer would take a full tour of NativeSUN, looking at the demonstration models installed there. Finally, they sat down with a representative to discuss their needs: load

size, hardware, and price. This full-disclosure approach proved an integral part of the success of the systems.

Figure 6. Solar on Wheels

The week-long stay of the 'solar on wheels' usually led the customers into the NativeSUN office, most often committing to a loan averaging $5000-6000. The "average" system included four modules, the balance-of-system, and installation labor.

Aside from the "average" system, other options were offered to consumers. NativeSUN's deployment of PV systems varied in output from 35 watts to 1.8 kW. Some modules were mounted on a fixed or passive tracking rack. In addition to the photovoltaic array, NativeSUN also installed small wind-powered turbines. The turbines would produce 300-500 watts if the wind resource was greater than 8 mph. The hybrid system worked well for many customers who had relatively large daily load consumption.

Expectations. The language barrier is not a large obstacle to overcome if the supplier explanations and educational training pay special attention to a customer's

ability to comprehend a complex technology. NativeSUN's staff was expert at this, and the rewards were in-kind.

One Hopi elderly woman understood her PV system not as "electricity" but as a "battery." She made the distinction between grid power as "electricity" and solar electricity as a "battery." She understood the function of the solar panels, concluding the solar panels need heat to generate electricity. She interpreted this to mean long daylight hours during the summer months would bring more energy into her batteries. Although solar panels are much more efficient when the temperature is cool, the example above is indicative of NativeSUN's transfer of technology in non-technical language. Because of this, a 60-year-old woman has been able to maintain her battery bank for an astounding twelve years. It is essential to put the technical material into terms a layman can truly understand. Early on, consumers at NativeSUN were taught not to expect more than their PV systems were designed to provide. Again, education was key. But personal experience played a part in expectations, too. Elders who had lived most of their lives without a modern electric grid were highly successful owners, as were those whose deliberate choice was to live without grid power.

Partnerships

Southwest Technology Development Institute at New Mexico State University and the Photovoltaic Design Assistance Center at Sandia National Laboratories partnered with NativeSUN to evaluate the design, installation, and reliability of the five model PV systems first offered in 1989. The evaluation team noted both successes and areas that needed improvement in NativeSUN's first steps into the photovoltaic business. The team

found that the systems were properly sized and wired and that good quality components were used. They also found that the battery boxes were well built, easy to open, vented, and well insulated. Suggestions for improving the dc disconnect boxes and upgrading grounding and wiring practices were offered. Perhaps the most meaningful suggestion offered by the evaluation team was to offer a maintenance and operation manual to customers. This suggestion was incorporated. Operations and maintenance continue to be crucial to the sustainability of the PV systems.

Communicating a Successful Model

In 2001 Sandia National Laboratories published *The Solar Way: Photovoltaics on Indian Lands*. The publication documented solar electricity being used by tribes through the United States, but NativeSUN benefited from a feature layout in the book, which helped publicize the work that the company was doing with PV. As a result of NativeSUN's business practices being highlighted (along with successful systems experience across Indian Country) other tribes have benefited by networking with the Hopi PV company. *The Solar Way* focused on sustainable systems and how they are a cultural fit with tribal values.

NativeSUN's experiences have been highlighted in numerous other printed matter, in addition to radio and (recently) a television documentary. Debby Tewa, former director of NativeSUN, has frequently been featured in a variety of media as well (see Appendix).

Lessons Learned

In addition to emphasizing that installing sustainable systems is critical to their success, NativeSUN former director, Debby Tewa, would stress that patience is required when doing business in Indian Country. Not every professional skill that would be desirable was present in one place. It took time to establish rapport with customers and become adept at knowing their needs, their budget, and their skills that could be utilized in maintenance of PV systems. Patience is also key when explaining renewable energy technology to non-technical people, wherever they may be. A vital component is emphasizing the operation and maintenance of the hardware to create sustainable systems and a lesson that too often is omitted when systems are simply installed and left to an untrained end-user. Therefore, knowing the limitations of a PV system must be emphasized to a customer from the onset, reducing unwarranted maintenance costs. Lastly, financing of the system is a very important part of business development in Indian Country. A revolving loan or establishing a partnership with conventional banks allows a customer to afford the high cost of the array and balance of system by paying on a monthly basis, as opposed to the up-front cost that can be in the thousands of dollars.

Conclusions

NativeSUN, a historically Hopi photovoltaics company, has been offering solar electric systems to Native American customers for many years. Their systems have overwhelmingly been shown to be sustainable systems. We believe this has occurred because NativeSUN practices the several tenets of sustainability outlined in this paper. Those components of sustainability include the following: a good match between

customers' needs and availability and price of systems; an infrastructure in place; a sound way to educate consumers about systems loads and simple maintenance procedures; and the realization by customers that solar electricity can enrich their off-grid lives, but that it cannot be considered the same as grid electricity.

Acknowledgements by Debby Tewa, Co-Author

I am fortunate to have participated in the U.S. Department of Energy's Tribal Energy Program internship. While I had worked with photovoltaic systems for several years, including the experience documented in this paper while at NativeSUN, the internship complemented by prior work 'in the trenches,' and has been a gratifying experience. I have learned a lot about governmental processes and the government-to-government relationship that exists. Working with tribes as they move forward with their own renewable energy technology development is exciting and rewarding. The DOE's Tribal Energy Program, under the leadership of Sandra Begay-Campbell, continues to expand my knowledge of energy policy and practical application, and has made possible the opportunity to continue to work with tribal energy issues even though I am no longer an intern with the program. Many thanks to both Sandra and Connie Brooks for their continued support of my educational pursuits and occupational endeavors.

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Appendix

The list below captures Debby Tewa's work with both NativeSUN and Sandia National Laboratories.

- ☐ "Hopi Power: One of Their Own Gives the Gift of Electricity to Her Native American Tribe," by Ted O'Callahan, Seed Magazine.com, 2006.
- ☐ "Empower Your Customers to Perform Their Own PV Maintenance," EC & M Magazine, 2006.
- ☐ "Light-bringer Debby Tewa Provides Expert Advice about Photovoltaic Units to People on Indian Reservations," by Chris Burroughs, Sandia Lab News, 2005.
- ☐ "Solar Power Lights Homes on Indian Reservation," New Mexico Business Journal, 2005.
- ☐ "Solar Self-Reliance," by Winona LaDuke, Mother Earth News Magazine, 2004.
- ☐ "Powering Native American Lands," by Craig Cox, Solar Today Magazine, American Solar Energy Society, 2002.
- ☐ *The Solar Way: Photovoltaics on Indian Lands*, Sandia National Laboratories, 2001.
- ☐ "Solar Energy on Hopi," by Patty Talahongva, Native Peoples Magazine, 2000.
- ☐ *All My Relations*, by Winona LaDuke, South End Press, 1999.
- ☐ "Amazon Women," by Laurie Stone, Home Power Magazine, 1998.
- ☐ "Honey, We Bought the Company: Livelyhood on a Hopi Reservation in Arizona," aired on PBS, September 1998.
- ☐ *Renewables Are Ready: People Creating Renewable Energy Solutions*, by Nancy Cole and P. J. Skerrett, Chelsea Green Publishing, 1995.