PHOTOVOLTAIC TECHNICAL ASSISTANCE TO THE NAVAJO TRIBAL UTILITY AUTHORITY

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ABSTRACT

Since 1999, the Navajo Tribal Utility Authority (NTUA) has been operating a large off-grid PV program to provide electrical power to its remote customers. Since that time, NTUA has purchased 200 stand-alone Photovoltaic (PV) power systems for installation at remote homes throughout the Navajo Nation. Each system consists of a 640 W PV array, 876 Ah battery, 2.4 kVA inverter, battery charge controller, and associated electronics mounted on a self-contained steel skid. Engineers from Sandia National Laboratories (SNL) and Southwest Technology Development Institute (SWTDI) have been assisting NTUA in all facets of this wide-scale program including: system design evaluation; installer and customer support training; field test and evaluation; performance monitoring; and development of maintenance schedules and procedures and maintenance record forms. This paper presents the experiences of the SNL/SWTDI team and the lessons learned in this ambitious, off-grid PV program.

1. BACKGROUND

The Navajo Nation is the largest tribe in the United States covering over 26,000 square miles. The tribe reaches into the states of New Mexico, Arizona and Utah. The terrain is varied and diverse encompassing flat lands and hills, desert and forested areas. It was reported by the Energy Information Administration in May of 2000, that approximately 35% or more of the housing units on the Navajo Reservation lack electricity. This equates to between 10,000 and 30,000 families living without electricity. In an effort to remedy this situation, The Navajo Nation has installed more photovoltaic remote home installations than any other Native American tribe. Small scale, all dc systems were installed during the early 1990's, which have been followed by larger, inverter-equipped systems in the last two years. At present, there are 200 of the larger ac power system. All systems were installed and are maintained by the NTUA. Customers are charged a fee for service under a lease purchase agreement. While NTUA leases the systems, trained NTUA electricians provide all system maintenance. Under the terms of the lease, customers own their PV systems after 15 years.

2. SNL AND SWTDI ASSISTANCE TO NTUA

Sandia National Laboratories along with the Southwest Technology Development Institute have been assisting and supporting the PV program of the Navajo Tribal Utility Authority for over two years. This assistance has comprised a variety of tasks needed to provide NTUA with the capability to continue to grow this program, the nation's largest off-grid residential PV deployment, in a way that is technically and economically self sustaining. Key tasks in this support program have been design evaluation; field and acceptance testing; installation and maintenance training for electricians; outreach and education material development

for customer support; performance monitoring; and development of maintenance procedures and schedules.

2.1 System design evaluation

SNL and SWTDI have worked with NTUA to evaluate the design for the installed systems. To this end, a complete system was installed at Sandia for testing. The system was operated for several months with various loads to simulate real-life, residential conditions.

System performance data were recorded throughout this period. Analysis of the data followed during which a positive working relationship was established with the system integrator. This overall collaboration among vendor, customer, and lab was a success for all parties involved. The vendor received valuable feedback on the performance of the system and suggestions for minor design changes that would improve reliability, and the customer got a well-developed knowledge of the different operating modes of the equipment as well as operational strategies for obtaining maximum system performance.

2.2 Field test and evaluation

The SNL/SWTDI team assisted NTUA with early field assessments performed 90 days after installation of the first five systems. These tests revealed a few common, minor problems which were addressed in later installations. These problems can be categorized as either problems related to improper installation, or improper operation and included improved settings for inverter controls. The problems associated with installation which were identified and addressed resulted in proper watering of the batteries, proper torque on battery cable connections, proper setting of inverter controls, and proper grounding. Operational problems were also addressed through education of the homeowners. These issues included blown fuses and over-use of the system by the homeowners (resulting in excessively discharged batteries).

After installation of all systems, the SNL/SWTDI team supported NTUA electricians with periodic field testing and troubleshooting of systems that were under-performing or otherwise problematic. With each field test, new techniques were learned by the electricians, including identifying low water cells in the battery bank and proper orientation of the PV array.

2.3 Installer and customer support training

SNL and SWTDI staff along with representatives from the systems integrator provided training to NTUA electricians, engineers, technicians, and customer service representatives. Training was needed because the NTUA experience with PV and dc systems in general was minimal. The electricians, engineers, and technicians were provided with an introduction to PV systems, their components, and principles of operation. They were provided extensive training on installation issues and on system test and troubleshooting techniques. Maintenance procedures were covered at length, as was overall safety. Both classroom and field training were provided.

Customer support issues were also addressed. Customer support personnel are the first point of contact for PV systems users at NTUA. The customer service representatives were given basic information about PV system fundamentals, how to help customers recognize system problems, and how to best operate their PV systems. In addition, the need for energy efficiency was stressed and alternatives for reducing customer loads were covered.

2.4 Performance monitoring

A low-cost, reliable data acquisition system (DAS) was developed by SWTDI to support this project. The DAS has 4 input channels, is dc powered, and uses less than 1 W. Ten DASs were installed on fielded systems. Half were installed on customer systems with light household loads and the other half were installed on customer systems with large

loads. The DASs provide up to 6 months of non-volatile data storage.

Analysis of DAS data has shown that the basic system performance meets the vendor's specifications when the systems are used properly. The data also give an indication of how component life (such as batteries) will be affected by overuse of the system.

2.5 Development of maintenance schedules and procedures

Early on, the SNL/SWTDI team helped NTUA develop maintenance schedules and procedures to properly operate their PV systems. The systems were designed so that general maintenance (watering the batteries and seasonal adjustment of the array) would not be needed more than twice a year. During the first year of operation, some systems required more maintenance visits due to component failures, misuse and overuse of the systems. It was recognized that customer training was needed to help the system users get the most reliable service from their PV systems. Customer outreach materials were developed for NTUA and a customer interactive workshop on PV was held.

2.6 Maintenance record forms

SNL and SWTDI staff helped NTUA create a maintenance form for NTUA field staff. The form was based on previous field experience with similar PV systems. NTUA staff contributed to the evolution of this form as they gained more experience with fielded PV systems. This form is useful for NTUA technical staff to identify reoccurring problems with the PV systems and to insure better reliability.

3 PROGRAM IMPACT

NTUA now owns and maintains 200 off-grid residential PV systems. Maintenance charges are built into the monthly payment plan. The program has been financially successful for NTUA and is self-sustaining. In the Fall of 2001, their success at running this program, convinced the Rural Utility Service (RUS) to award them a $4.8 million loan to expand this service with the first loan for PV procurement in RUS' history.

4. CONCLUSION

In the early 1990's, NTUA decided that PV was a cost effective way to bring electric service to its remote customers. Early on, it gained experience with small dc lighting systems. In the last two years, NTUA moved forward with larger, residential ac power systems. Training and technical support from Sandia National Laboratories and Southwest Technology Development Institute has helped NTUA prepare for the technical and institutional challenges of running this large, off-grid PV program.

The Navajo Tribal Utility Authority now operates and maintains the nation's largest off-grid, residential PV program in a way that is technically and economically sustainable. As this program doubles in size in the next year, NTUA electricians, customer support personnel, and engineers have the training and experience to continue this success--the result of a successful collaboration among the PV system vendor, the utility, PV users, and national laboratories.

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