Lifecycle Cost Assessment of Fielded Photovoltaic Systems

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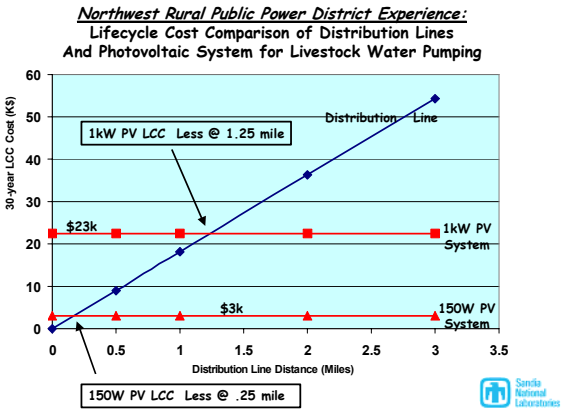
Abstract

Actual operation and maintenance (O&M) cost information from fielded photovoltaic (PV) systems provides critical input to business plans necessary to develop and expand market opportunities. Performance information on PV systems is available but little information exists on O&M and lifecycle costs (LCC), component reliability and system lifetime. This project is focused on capturing qualified field information from existing systems and analyzing these data to answer questions on reliability, LCC, and lifetime for a variety of PV applications. A key activity in this effort is developing the partnerships with those who have the systems and who maintain complete records of field operation. A reliability database has been developed through this effort to serve as a tool to collect this O&M information and to facilitate analyses of the data. A number of partnerships are currently in place to provide O&M data for several PV applications.

1. Current Status

Five PV applications are currently supported by the reliability database. These include lighting, water pumping, off-grid residential, small grid-tied, and utility-scale grid-tied systems. Active partnerships exist to provide field information for these applications.

The partnership with Northwest Rural Public Power District is the longest of the ongoing cooperative efforts. Their oldest PV water pumping systems were installed in 1990 and their O&M cost experience has been continually tracked since installation. The average annual O&M cost for these systems is about 4% of their initial system cost over the past 12 years. In the nearby figure, this O&M cost was used as input to the calculation of lifecycle costs. The plot of LCC versus distribution line distance shows that PV systems are a financially attractive option when compared to extending distribution lines. The small PV water pumping systems (150W) have lower LCC when the distribution line is greater than 0.25 mile. The larger PV systems (1000W) have lower LCC when the distribution

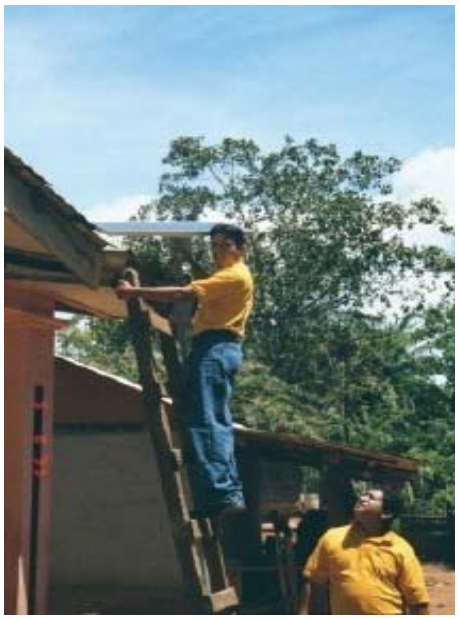


line is greater than approximately 1.25 miles. Northwest Rural Public Power District is using these results to expand their business plans for leasing PV water pumping systems to their customers.

Work is in progress with Arizona Public Service (Phoenix) on small off-grid residential PV/ propane generator hybrid systems. These 62 systems range in size from 500W to 2.5kW to provide daily energies of 2 to10 kWh. Analyses of quarterly scheduled maintenance records show that quarterly O&M costs have stabilized at 0.6% of initial capital cost over the six years of field operation. Unscheduled maintenance costs are currently being analyzed to develop LCC for these systems.

Soluz is fielding small PV lighting systems for rural applications in developing countries. At present, for example, Soluz is serving some 2,000 customers in Honduras, the majority on a rental or fee-for-service basis with systems ranging from 20 to 100W. Sandia has helped Soluz to implement the Sandia-developed PV

reliability database, solardb, on a pilot basis. The database is now helping the local operation, Soluz Honduras, to monitor almost 1,000 rental systems similar to that shown in the photo. This work is currently focused on tracking and managing system service needs and analyzing



component failure mechanisms from the maintenance records. Initial inspection of the service records by Sandia and Soluz indicate some component selection changes (i.e., battery connectors) will substantially reduce maintenance costs. Work is underway to capture O&M costs resulting from these failures.

Tucson Electric Power (TEP) currently has 18 utility-scale grid-tied PV systems installed, each approximately 130kW, totaling nearly 2.8MWdc in the Springerville area of east central Arizona. These systems include a-Si (BP Solar), CdTe (First Solar), and x-Si (RWE Schott, formerly ASE Americas) collectors and identical 150kW inverters (Xantrex) that are tied to a transmission line that carries the power back to Tucson as an integral part of TEP's contribution to the Arizona Portfolio Standard. An additional 8 systems totaling more than a 1MWdc will be installed in the spring of 2003. The first systems were installed in 2001 with future yearly installations expected to total 1 MW until a total of 10 MW is reached. These systems are now in their third year of operation. Preliminary results indicate that annual O&M costs are less than 0.4% of the systems' initial capital costs. The continuing O&M experience from these systems will be a valuable contribution to the PV community as these large systems continue to gain in market prominence.

The Florida PV Buildings Program is a source of small grid-tied systems field experience. As part of this program, the Jacksonville Electric Association in Jacksonville, Fl has installed 22, nearly identical 4kW grid-tied systems on schools in their service territory. Maintenance events have been captured and are currently being studied to develop an O&M experience database for these systems.

2. Plans

Analyses of additional PV applications such as large-scale water pumping (i.e., 50 hp and larger) and small facility hybrids (i.e., 1-5kW) are in various stages of development.

The Center for Irrigation Technology (CIT) located at the University of California, Fresno Campus is considering a broad effort to support PV power water pumping systems in California. The energy crisis in California has brought long-term costs to the farming/ranching community that may provide an opportunity for PV powered systems. There are about 92,000 agricultural pumps in California drawing almost 12,000 GWh/yr. With costs of $.09-.18/kWh for conventional grid-supplied energy, 50 hp and larger systems may become competitive on a site specific basis. An early partnership with CIT for this application will provide important cost information to support the development of this market. A strategy planning session as well as a PV workshop is planned for CIT staff in April 2003.

The Bureau of Land Management has been an active partner with Sandia since 1994 installing PV systems for a variety of applications including water pumping, lighting, off-grid facility power, as well as grid-tied visitor centers. The off-grid hybrid systems in the size range of 1 to 5kW serve maintenance facilities and visitor contact stations at a number of locations across the west where a PV hybrid system in the energy option of choice. These systems are the focus of our collaborative efforts with the BLM to capture O&M information. The O&M information from these systems, when combined with the experience from the Arizona Public Service systems, will provide a more comprehensive evaluation of LCC for assessing PV for off-grid sites.

Additional partners are being sought to add to the database of applications already underway to provide statistical significance to the existing analyses and to provide a sufficiently large sample for calculating failure rates for individual components

3. Summary

Progress has been made in determining the lifecycle costs of PV systems for various applications. A number of cooperative partnerships are in progress with others in various stages of planning.

Maintenance information has been collected and analyzed for livestock water pumping systems, off-grid residential hybrids, small lighting, and grid-tied systems. Results to date show that the average annual maintenance for water pumping systems is about 4% of initial system cost. For small off-grid residential systems, the scheduled quarterly maintenance indicates the maintenance costs stabilize at about 0.6% of the initial capital cost. For small lighting systems that are fielded in developing countries, inspection of the maintenance records from the database indicate some component selection changes (i.e., battery connectors) will substantially reduce maintenance costs. Initial results from a large database of utility-scale grid-tied systems indicate that O&M costs are less than 0.4% of installed capital cost.

Understanding O&M and the impact on LCC is critical to developing the business case for PV applications. This work will continue to add data to the existing applications and develop partners for additional applications. Providing feedback to the PV community, both system users and industry, is an absolute requirement to further the development of PV as an acceptable energy option

4. Acknowledgement

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