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Abstract: India is the world's second most populous country, quickly approaching one billion persons. Although it has a well-developed electricity grid, many of the people have little or no access to electricity and all of the benefits associated with it. There are areas that are isolated from the grid and will not be connected for many years, if ever. One such area is the Sundarbans located in the delta region of the two great rivers, the Ganges and Brahmaputra, partially in India and partially in Bangladesh. It is estimated that 1.5 million people live in this area, crisscrossed by many islands and rivers, who have only marginal supplies of electricity generated primarily from diesel generators and batteries. Working with the regional non-governmental organization (NGO), the Ramakrishna Mission, and the West Bengal Renewable Energy Development Agency, the governments of India and the United States initiated a rural electrification initiative to demonstrate the economic and technical feasibility of photovoltaics to provide limited supplies of electricity for such applications as solar home lighting systems (SHS), water pumping, vaccine refrigeration, communications, and economic development activities. This paper details initial results from approximately 30 kilowatts of PV systems installed in the area, including socio-economic impacts and technical performance.
Key Words: Stand-alone PV Systems - 1: Developing Countries - 2: Sustainable - 3

1.0 INTRODUCTION

With some two billion people worldwide without access to electricity, the developed countries are challenged to deploy their technologies to meet this large need. The many attributes of photovoltaics (PV) make it ideal in many respects to confront the challenge. The availability of even as few as 20-50 watts of power can have major impacts on the lives of villagers living in isolated communities. PV has already been demonstrated to be technically feasible; the challenge is more economic. Can the end users afford to spend their limited disposable income on PV systems at the expense of not having other needs met? Many can, but the reality is that subsidies may be required, and in many cases, outright gifting may be the reality. Thus, governments will be faced with difficult choices amongst their funding priorities.

The U.S. Department of Energy (DOE) with its National Renewable Energy Laboratory (NREL), agreed in 1993 to cooperate on a 50-50 cost shared initiative with India's Ministry of Non-Conventional Energy Sources (MNES). This demonstration was to demonstrate the economic viability and sustainability of PV systems to provide the basic needs of villagers in the isolated region of southern West Bengal known as the Sundarbans [1].

1.1 The Sundarbans

The vast swampy delta of the two great rivers, Brahmaputra and Ganges, extends over areas comprising mangrove forests, swamps, forests, and islands, all interwoven in a network of small rivers and streams that flow into the Bay of Bengal. The area is about 10,000 square kilometers, renowned for its abundant wildlife including the royal Bengal tiger. Transportation into the area and between its countless villages is by boat and on the land areas by foot or bicycle rickshaw.

Snake bites represent one of the largest contributors to death in the area, primarily because refrigeration for snake bite serum is not available. Home lighting is provided by candles, kerosene lights, dry-cell batteries, and rechargeable car batteries. Battery recharging is difficult because of the distances that batteries must be transported to be recharged and the unpredictable quality of the available charging service.

The Sundarbans is served by the Ramakrishna Mission (RKM), which provides education, agriculture, training, and medical services. The RKM is a well-respected humanitarian organization principally known for their slum-relief activities in the Calcutta area.

1.2 The Ramakrishna Mission

Ramakrishna Mission Ashrama, Narendrapur, is a branch center of the Ramakrishna Mission headquartered at Belur Math, Howrah, West Bengal. Through its integrated development wing, the Ramakrishna Mission Lokasiksha Parishad, this Ashrama is actively engaged in various rural and urban development programs. Its training wing offers several development programs such as literacy, child and mother care, integrated rural development, agriculture programs, intensive sanitation programs, environmental restoration, participatory forest management, employment and entrepreneurship, and most recently, renewable energy systems. The Mission's work is carried out at the village level through a number of youth clubs that are coordinated and monitored by local cluster organizations. Today, the Ramakrishna Mission Lokasiksha Parishad is working with about 40 affiliated cluster organizations, with 1500 youth clubs spread over 4000 villages in 12 districts of West Bengal.

The renewable energy programs are an important part of the Lokasiksha Parishad. The RKM was recommended as the working NGO to implement the

cooperative program between India's Ministry of Non-Conventional Energy Sources and the DOE's National Renewable Energy Laboratory. The Mission has been responsible to identify the beneficiaries of the PV systems, provide trained personnel to install and maintain the systems, collect the loan repayments, and work with other funding organizations to expand the program.

2.0 THE U.S.-INDIA SUSTAINABLE ENERGY PROGRAM

High-level meetings were held in 1994 between MNES's Minister Krishna Kumar and DOE's Secretary Hazel O'Leary. An agreement was reached to implement a 50-50 cost-shared program to supply PV energy systems to eight villages in the Sundarbans region of West Bengal. A number of participants were identified with various responsibilities for the project. The organizational structure is shown in Figure 1.

The Sustainable Rural Economic Development Ramakrishna Mission PV Initiative was conceived as a small-scale demonstration project that would show the economic viability of photovoltaic systems in the Sundarbans region of West Bengal. The viability was to be predicated on the systems being economical without substantial subsidies, and eventually, without any subsidy at all. The operation and maintenance of the systems was to be the responsibility of the chosen NGO [2].

2.1 Project Responsibilities

NREL was assigned the responsibility to manage the U.S. side of the cooperative agreement. PV hardware was procured under a competitive solicitation. Modules and charge controllers were delivered dockside to Calcutta, where MNES had contracted with Exide Industries to receive the materials and deliver them to the Sundarbans under the auspices of the West Bengal Renewable energy Development Agency (WBREDA). System hardware provided by the Indian side was joined and installed by Exide and WBREDA. The trained Mission installers carried out much of the system installation and worked with the end-users to educate them in the correct use of their new power systems.

2.2 Project Financing

The Government of India (GOI) provides about a 40% subsidy to qualified beneficiaries (the unit costs Rs. 14,000 for which the GOI provides Rs. 6,000). The remaining 60% (Rs. 8,000) was either in the form of cash or through low-interest loans of Rs. 4,500 repayable over an extended period of time (a down payment of Rs. 3,500 was required at the time of system delivery). Typically the Mission has limited the loan period to less than 3 years, which they have found to be a more effective period to achieve total repayment. The experience to date is that they have achieved in excess of 95% repayment rates due largely to the prior establishment by the Mission of good borrowing and banking habits in the communities. Most of the villages that have taken part in the program have already established village-level banking.

The Indian Renewable Energy Development Agency (IREDA) is charged with the responsibility of dispersing World Bank funds for qualified renewable

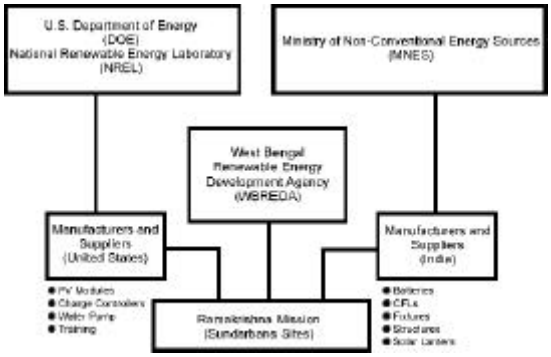

Figure 1. Project Organization

energy projects. To aggregate larger numbers of systems sales, a leasing arrangement has been established that removes all subsidies while allowing end-users access to low-interest money to purchase solar home lighting systems. IREDA has contracted with a private organization to purchase the solar systems and to lease them to the end-users. The organization treats this arrangement strictly as a business deal. They buy the PV systems directly from a dealer and receive 85% of the purchase price from IREDA as a low-interest loan (2.5% over 10 years). The company is then eligible to receive the full depreciation and tax benefits available from the Government of India. They then lease the equipment to the Rural Energy Service Company (RESCO). RESCO then provides the systems to the end-users with a repayment schedule of 1 or 2 years. This arrangement has been approved for a trial of 3000 SHS. If successful, the approach could be replicated to much larger projects.

2.3 Project Details

The Sundarbans region was chosen for its remoteness and the reality that the electrical grid will be long time coming, if ever. The seven villages chosen to receive the PV systems were provided 300 home lighting systems (one VLX-53 Solarex polycrystalline silicon module and one SunSaver 6LVD charge controller per each home lighting system) that furnish 50 watts dc for 2-9- watt compact fluorescent lamps (CFLs) and one electrical outlet of about 30 watts for a black-and-white television or other appliance; 15 street lights; electrification for a clinic, the training center, and a youth club; and two battery-charging stations of 4 kW each, capable of charging 10-100-amp-hour car batteries from complete discharge to full charge within one day at full sunlight.

A typical installation in Figure 2 shows the PV module mounted on the thatched roof. The addition of about four hours of light each night allows the young students to study at home at night, allows additional productivity such as found at the weaving center, and provides health care at the local clinic where the vaccine refrigerator makes snake bite serum available. The street lights will be deployed in the village gathering places.

3.0 EXPERIENCE AND LESSONS LEARNED

NREL has contracted with the Tata Energy Research Institute (TERI) to perform a before-and-after impact study in the region. The study will include both

Figure 2. Solar home lighting system mounted on home owner's thatched roof

social and economic impacts. It is hoped that the experiences in the Sundarbans can be replicated in other regions of the world experiencing a similar lack of access to electricity.

3.1 Technical Issues

In addition to the 300 home lighting systems, lighting has been installed at youth cubs in Katakhali, Satjlia, and Shantigachi. The clinic at Satyanarayan is completed, but the vaccine refrigerator still remains to be delivered by WBREDA. The weaving center at Pakhiralya is also completed, with the Gosaba Rupayan Lighting system remaining to be installed.

One minor problem with the home lighting systems has been the flush mounting of the PV modules on the thatched roofs. This hinders air circulation behind the panels which prevents cooling that would improve the performance. Flush mounting also leaves the panels tilted at the pitch of the roof, of about 40 degrees. The slight penalty by not having the panels at an optimum 30 degrees is minor. Because the panels are facing south, they catch the cooling breezes from that direction.

The battery-charging stations have not been installed because the locations have not been settled on. The RKM plans to charge 15 rupees per charge initially. Once everything is operational, they plan to increase the fee to 25 to 30 rupees. The RKM has provided the following information for charging a 60-amp-hour battery 3 times per month. The battery, with an expected lifetime of two years, costs of 3500 rupees, or about 150 rupees per month. A battery charge is estimated at 30 rupees, or 90 rupees per month. The boat trip required to transport the battery to the charging station is 20 rupees or 60 rupees per month. This totals 300 rupees per month.

3.2 Customer Satisfaction and Infrastructure Development

During a recent visit to the region, it was clear that customer satisfaction was high. No systems have hit their low voltage discharge, indicating that the batteries are operating at a high state of charge (SOC). This was confirmed by taking specific gravity measurements, all of which were at or above 80% SOC. This indicates that the PV systems are underutilized. Most home owners do not have a televison and are only powering 2 or 3 9-watt CFLs for 3 to 4 hours per night. Those with TV (14 watt) will operate it 2 to 3 hours per night. Thus, the 50-watt systems are more than adequate to provide additional power beyond this.

The RKM is very committed to PV for SHS. Since the NREL systems have been installed, more than 1100 systems have been sold and installed in the region. Up to now, the RKM has focused their attention on four districts, South 24 Parjanas, Modnapur, Bankura, and Gosaba. A senior PV technician is responsible for each district. Under him are four or more village-level technicians who work on solar energy systems, taking care of installation, maintenance, and inspections. The RKM plans to expand into three other districts, Burdwan, Hoogly, and Birbhum. The have selected 10 new technicians who will undergo training in basic electronics with a PV emphasis. All electronic students at the Mission get solar in their courses.

In other areas of the Sundarbans, the RKM has begun to sell PV systems through shopkeepers. The Mission does not install or maintain these systems, but does send a technician out to inspect the installation once it is completed. The shopkeeper performs any follow-on service. The shopkeeper gets a 600-rupee commission on the sale for making the contact and setting it up. Shopkeepers are responsible for approximately 10% of the follow-on sales. Another indication of the success of their infrastructure is the attention to record keeping. The NREL systems are inspected once a month, and the technician fills out an inspection report. Each homeowner is provided a simple homeowners's guide for his system.

Homeowners were asked what they used for lighting before PV. The majority used hurricane lamps that use kerosene. Their fuel charges were 60 to 80 rupees per month. This provided two lamps for 4 hours per night.

Figure 3. Where there was once darkness, there is now light.

4.0 Retrospective

This collaborative project has successfully brought the benefits of electricity to a region formerly with little or no electrical power. Figure 3 is a powerful picture showing mother and child enjoying quality light for the first time. PV system sales are now continuing without government subsidy. Evaluations are ongoing to determine

the economics of PV and the real benefits to the end-users. From this information a definitive statement can be made as to how sustainable these projects can be. The Ramakrishna Mission continues to interact with other funding agencies to expand the electrification effort to other areas in their sphere of influence. Their efforts have led to one of the largest and most successful rural electrification efforts in Asia [3].

5.0 Conclusions

The impact of the initiative will only be known after the passage of time. Very clearly, the major influence will be on the young. Figure 4 shows a young man in the village studying under PV-powered light. Before, he would most likely have used candles or kerosene-fueled lanterns. The project will be sustained by the number of trained personnel, shown receiving their initial training in Figure 5, responsible for maintaining the systems. The quality of health care in the region will be improved with PV power for lighting and vaccine refrigeration (Figure 6 illustrates the involvement of the locals in installing the PV modules on the clinic roof). The project will continue to be monitored, and lessons learned will be applied to similar projects, both in this region and in other countries around the world.

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References.

[1] J.L. Stone and H. S. Ulal, "PV Opportunities in India," 13th NREL Photovoltaics Program Review, Lakewood, CO 1995, pp. 275-280, *AIP Conference Proceedings 353*.

[2] J.L. Stone and H.S. Ullal, "The Ramakrishna Mission PV Project — a Cooperation between India and the United States," NREL/SNL Photovoltaics Program Review, Proceedings of the 14th Conference—A Joint Meeting, Lakewood, CO, 1966, pp. 521-527, *AIP Conference Proceedings 394*.

[3] J. L. Stone, H. S. Ullal, and E.V.R. Sastry, "The Indo-U.S. Cooperative Photovoltaic Project," 26th IEEE Photovoltaics Specialists Conference, Sept.30-Oct.3, 1997, Anaheim, CA, pp. 1273-1275.

Figure 4. Where there is light there will be knowledge— a student studies under light powered by photovoltaics

Figure 5. Hands-on training offered to RKM personnel

Figure 6. Installing PV modules on the village clinic