APPLYING SOLAR ENERGY TO EXTEND DISTANCE EDUCATION TO REMOTE COMMUNITIES IN MEXICO AND CENTRAL AMERICA

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ABSTRACT

In collaboration with various state and federal government educational organizations in Mexico and Central America, Sandia National Laboratories and its partners are helping to extend existing distance education networks into rural off-grid communities through the proper utilization of renewable energy technologies. This paper describes the education networks that are in place, the institutions that have built them, and the technical obstacles they have encountered reaching rural off-grid schools. It describes a working relationship between these organizations and a team of renewable energy experts to resolve the problems of delivering reliable electric power in order to extend the educational network.

1. INTRODUCTION

Thousands of rural communities in Latin America are isolated and unelectrified and often lack the basic infrastructure to provide the level of education that is received by school children in urban areas. It is important to bridge this gap so that rural student populations living outside of electricity grid services can have the same opportunities as other students. An enhanced quality of education forms a foundation for increased productivity leading to higher standards of living.

Renewable energy technologies can be used to bring services, such as distance education and computer internet access, to rural isolated communities, where the application of such technologies is appropriate and suitable. The high costs associated with fuel purchases, transportation of fuel, and engine maintenance, coupled with difficult-to-quantify environmental costs, make renewable energy an attractive alternative to conventional fuel-burning motor generators.

Several programs in Mexico and Central America are using renewable energy to bring quality distance education programs to their rural populations. The Mexican Secretariat of Public Education is recognized for its distance learning programs that are based on satellite broadcast. Recently the Ministries of Education in Guatemala and Honduras pursued distance education programs on a pilot level patterned after Mexico's programs and materials. They are also using Mexico's satellite network for coverage. Most of the schools in the programs are located on the electrical grid, but there is an increasing desire to extend the educational network to off-grid areas.

An ingredient often lacking in many programs is a clear understanding of what renewable energy technologies are, what equipment is available and how it can best be used to meet their energy needs. The technical expertise required to implement projects that incorporate the use of renewable energy is often overlooked. In-country partners need knowledge, experience and engineering expertise to install and operate long-lived, high-quality systems.

Sandia National Laboratories and their partners provide technical assistance in the appropriate and sustainable use of renewable energy technologies. The U.S. Department of Energy (USDOE) and the U.S. Agency for International Development (USAID) are sponsors of this work. Technical assistance comes in the form of training, workshops, technical specifications, guidelines, demonstrations and assessments. Institutions involved in large-scale projects that use renewable energy are prime benefactors of the Sandia programs. Distance learning development programs, such as those of the Ministries of Education in Guatemala and Honduras, Mexico's Secretariat of Public Education, and the Latin American Institute of Educational Communication, are such large-scale efforts. Sandia works with these institutions where an emphasis is placed on building local infrastructure to support the installation, maintenance and operation of the renewable energy systems.

2. DISTANCE EDUCATION NETWORK

Mexico's Secretariat of Public Education (SEP) has been recognized internationally for the success of its Distance Education Program (PROED), whose general objectives are to:

- Broaden coverage and improve school-based learning;
- Contribute to greater equity by offering distance learning comprised of open educational programs and services;
- Support the preparation and placement of teachers;
- Improve the competitiveness of the labor force; and
- Promote a culture of life-long education.

PROED is managed by the Office of Educational Television (DGTVE) within SEP and uses a satellite-based system (EDUSAT) with continent-wide coverage that reaches thousands of participating schools. DGTVE maintains the infrastructure necessary to produce and distribute top-quality curricular materials and programming, to train teachers, and to operate and maintain the satellite system network, including the reception and audiovisual equipment at each school.

The EDUSAT system reaches 30,000 reception points in Mexico. These include general and technical high schools, grammar schools, teacher centers, and university groups. The network covers both urban and rural areas. The *Telesecundaria* Program is the heart of EDUSAT, and it has a little more than half of the network's reception points. The program enhances the educational experience of students in the seventh through ninth grades. This program has been in operation for over 30 years and has a set curriculum.

A typical one-room *Telesecundaria* school in Mexico has a satellite signal receiver and parabolic antenna, a large screen television, and on occasion a videocassette recorder. Each hour each grade receives 15 minutes of lessons from the satellite televised system. In multi-room schools each classroom has its own dedicated television and satellite receiver.

Fig. 1: A solar photovoltaic-powered one-room *Telesecundaria* school in Quintana Roo, Mexico.

EDUSAT has a presence in Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua), where there are over 500 schools receiving distance education programming from the Mexican-based network. Distance education activities using EDUSAT outside Mexico are coordinated by the Latin American Institute of Educational Communication (ILCE), a nongovernmental organization located in Mexico, which mainly deals with Latin American and Caribbean countries.

Most of the distance education schools in Central America are located in Guatemala and Honduras where each country is piloting its own distance education programs, which combine video-based and classroom materials for children in various grade levels. Using educational materials provided by the Mexican government, the Guatemalan *Telesecundaria* program brings distance education to children in almost 400 schools. In Honduras, the *Telebásica* program is being tested in 37 schools. The respective ministries of education conduct the programs. Educational materials are downloaded from the EDUSAT network at a central location and distributed to the schools via videotape. Thus, during this initial stage of the program each *Telesecundaria* and *Telebásica* school does not have a satellite antenna or receiver, only televisions and videocassette recorders.

Fig. 2: Students watch PV-powered educational programming in La Concha, Guatemala.

Nearly 98 percent of the distance education schools in Mexico are connected to the electric grid. In Guatemala and Honduras the distance education programs have been limited to only grid-connected schools until recently. In rural off-grid areas the communities have been responsible for providing their own source of power in order to have the opportunity to benefit from distance education. Often, the communities have found it difficult to obtain a cost-effective, reliable source of electricity to meet their school's energy requirements.

3. ENERGY ISSUES AND COLLABORATION

Hundreds of schools located in rural off-grid regions in Mexico have been using either conventional fossil fuel burning generators or renewable energy technologies to provide the necessary power for their distance education reception equipment. Unfortunately their experiences have not been entirely positive. Diesel- or gasoline-powered generators experience voltage fluctuations that damage the schools' sensitive electronic appliances, exhibit a fair amount of noise and foul odors, have a significant amount of downtime, and are subject to high fuel, maintenance, and transportation costs.

Renewable energy technologies, such as solar photovoltaic (PV) systems, are currently installed in more than 400 off-grid schools in Mexico. However, many of the PV systems in use have been poorly designed and installed, thus operating inefficiently. Thus, both the fuel-powered and the solar-powered options have been problematic, depriving schools of hours of service, and in turn, the children of their education.

Recognizing the need to have a reliable energy source to extend the distance education network to unelectrified communities, SEP's DGTVE enlisted the technical support of a Sandia-led team. The main emphasis is on the proper and appropriate use of PV technologies, targeting both new system installations and improving the quality of existing systems at schools. In a joint collaboration effort to extend the network, DGTVE and Sandia are working together in the following areas:

- Assessing previously installed systems to gain information on the status of each system, identifying faults, obtaining profiles of the daily usage and loading, maintenance routine, etc.;
- Defining technical specifications, system configurations and sizing;
- Recommending energy efficient appliances and operational habits;
- Training workshops covering the selection, design, procurement, installation, operation, and maintenance of PV or other renewable energy systems that are, or will be, used in rural schools;
- Building local capacity to install, operate, and maintain systems;
- Developing guidance and instructional material aimed at system users, technicians, and decision makers;
- Monitoring installed systems (field and model arrangements) to identify and resolve potential problems; and
- Analyzing system performance to feed back to industry to help improve system quality and reliability.

4. JOINT ACTIVITIES AND FINDINGS

Collaborative activities began in November 2000 with a 3-day workshop on applying photovoltaic energy systems to meet rural distance education school requirements. More than 25 SEP EDUSAT technicians from 9 Mexican states attended the workshop, which consisted of classroom training and technology demonstrations. The participants were from states with the greatest need for off-grid energy systems to power school educational equipment. The workshop was held at ILCE in Mexico City, thus allowing many ILCE managers to participate in the sessions.

The best outcome of the workshop was the fact that the participants returned to their home states with new ideas and confidence in the use of PV technology. This inspiration has influenced the purchase and installation of new PV systems for additional schools and for those with problematic diesel generators. New state programs have been initiated to extend the distance education network into off-grid areas and to rehabilitate many existing systems that were either performing poorly or simply not working altogether.

Previously installed PV systems in rural schools in the states of Chihuahua, Durango, and Quintana Roo were visited and evaluated by a joint collaboration team. The most important assessment was done in Durango, since this state had the largest number of PV-powered *Telesecundaria* schools in Mexico.

Fig. 3: A collection of power system components on a bench at one side of a *Telesecundaria* classroom in Durango. The box in the middle is actually a homemade inverter.

In each assessment the plan was not only to investigate the system hardware, but to understand in detail the use of the equipment by the schools on a day-by-day basis. At each site information was collected by:

- Interviewing teachers, students, and parents to better understand their perceptions and experiences with the PV powered educational system and how they interact (operate and maintain) with the system; and
- Evaluating the PV power and educational reception equipment in detail, identifying characteristics of the design, components, installation, power profiles, and the current state of health.

It was critical to evaluate existing PV power systems and their actual use at the distance learning reception points (schools). The field assessments provided the information that the collaboration is now using to:

- Rehabilitate existing systems to optimal performance;
- Design new systems that align properly with the application and avoid common pitfalls and errors;
- Educate users on proper operation and maintenance;
- Identify faulty components on the market; and
- Develop model systems or design blocks.

Two common observations for most of the systems visited were that: (1) each system is unique in its design, installation, components, and usage; and (2) most problems leading to failure or under-performance are easily resolvable. The uniqueness of each system signifies that each community has its own usage requirements and each has been responsible for its own system procurement and installation. This conforms with past policy, but has led to a hodgepodge of system designs and performance levels. System deficiencies are mainly due to the selection of low quality components and inexperienced system designers and installers. The communities would benefit from a uniform PV-system block design and/or a central system of information dissemination, a need which is currently being addressed.

Most PV systems tend to suffer from simple resolvable problems such as:

- Under-sizing of battery cables, thus limiting battery recharge;
- Improper orientation and location of the panels;
- Incorrect type of batteries used for the application; and
- Lack of end-user knowledge on proper operation and maintenance, and on limitations of the system.

Over-sizing of systems can be a costly mistake. It was found in one case involving 11 identical PV systems that the vendor sized to account for the use of an old AC water pump for the school bathroom. The pump was not used often, since the water was pumped to a large holding tank on the roof of the building. The schools could have reduced their costs substantially by replacing the old AC pump with a DC pump and then purchasing a smaller-sized PV system (fewer panels, less battery storage, and smaller inverter).

Fig. 4: A well-organized layout of power system components in a newly installed PV-powered *Telesecundaria* in Quintana Roo.

In Central America the activities have mainly been focusing on demonstration projects in rural areas, where PV technology is applied to support the distance learning equipment at the schools. Several pilot projects have been implemented in Laguna del Rincón in Honduras with participation from Enersol Associates and ADESOL. In Guatemala projects have been implemented in the La Concha village in the Suchitepéquez region with Fundación Solar and FUNRURAL. Several more demonstration projects are planned in 2002 in these two countries.

5. POSITIVE COLLABORATION EFFECTS

The collaboration has produced results that indicate that the efforts are leading to the shared goal of extending distance education networks into rural off-grid communities. The key to reaching this goal has been to increase the level of confidence of the education partners to use renewable energy technology, particularly photovoltaic systems. Confidence is gained by people believing that the technology can be a reliable source of electricity for the application. Compared to other energy options, such as motor generators and line extension, PV technology has proven itself to sometimes be the best choice economically for isolated areas.

The first immediate results were a direct consequence of the November 2000 workshop (mentioned in the previous section). SEP technicians returned to their home states equipped with sufficient knowledge to determine why previously installed systems were not functioning well. Simple resolvable issues were confronted first, such as replacing small-gauge battery cables, reorienting PV modules, trimming trees that partially shaded them, and adding appropriate grounding when required. In the state of Quintana Roo roughly a dozen identical new PV systems were purchased and installed at new *Telesecundaria* schools. The workshop provided substantial information to enable the procurement. In this case the state public education office was responsible for the purchase, as opposed to the individual communities.

In terms of large-scale programs, the office of the Chihuahua State Secretariat of Public Education (SEP) has approved a budget to procure and install 54 new PV-powered distance education schools in the year 2002. Some of the PV systems will replace existing systems that have been faltering. A select number of schools will receive larger PV systems to power several computers as well as the satellite receivers and televisions. In the state of San Luis Potosí the SEP office is considering rehabilitation of at least 55 under-performing PV systems at EDUSAT schools. Querétaro is the state where the work reported here can be expected to have the greatest potential impact. The state plans to install 188 PV-powered distance education systems. Installations will occur at 60 primary schools in indigenous regions; 120 in other off-grid primaries; and 8 in middle (*Telesecundaria*) schools.

6. SUMMARY

Public education agencies in Mexico and Central America had, in some measure, lost confidence in the use of renewable energy sources and technologies – thus diminishing the willingness to repair or replace existing systems and/or to purchase new systems for additional rural off-grid schools. However, with appropriate knowledge and institutional capacity, the majority of the problems are simple and resolvable. The technical assistance provided by Sandia National Laboratories and its partners has been helping to restore confidence and to ensure successful applications of these technologies.

The collaboration described here appears to genuinely improve the functionality of education networks in Mexico and Central America. The goal to extend the networks successfully to rural off-grid communities is definitely obtainable. It will be teaming on the part of renewable energy experts and the agile response of the public education organizations in Mexico and Central America that will satisfy this goal.

7. ACKNOWLEDGMENTS

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