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Mexican Renewable Energy Development: Creating New Markets

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ABSTRACT

Sandia National Laboratories (SNL) began work in Mexico in 1991 for the U.S Department of Energy (DOE) to explore and strengthen opportunities for the renewable energy in Mexico. By 1992, the Mexico office of the U.S. Agency for International Development (USAID) joined DOE in the on-going program. Mexico Program goals are in promoting environmentally sound economic and social development in Mexico through renewables. Since the inception of the program, more than 230 kilowatts of renewable energy systems has been installed in Mexico and has formed the foundation for much replication. Mexico represents an attractive market for the renewable energy industry, because more than 5 million Mexicans in 88,000 villages do not have access to grid-supplied electricity, and more than 100,000 rural communities are in need of potable water. In addition, at least 600,000 ranches need water for livestock and/or irrigation. If these requirements were supplied by a reasonable mix of grid extension and renewable-energy systems, these markets for renewables would total more than a billion dollars. This paper reviews how SNL has helped develop these new renewable energy markets in Mexico.

PROGRAM FOCUS AND STRUCTURE

The goals of the SNL Mexico Renewable Energy Program are to promote use of renewable energy systems, enhance economic and social development in Mexico, create new business opportunities for the renewables industry, and offset greenhouse gas emissions. The original concept was, and still is, focused on rural, off-grid, productive-use renewable energy applications, particularly photovoltaics and small wind, with some interest in solar thermal systems. Productive-use applications are those that provide an economic or social benefit to the user of the technology, such as water pumping for agricultural use or lighting for an ecotourism facility. Because of the income they provide, productive-use applications provide a built-in means for paying for a renewable energy system. The focus on productive uses distinguishes the Mexico Program from most other international efforts to introduce renewable energy technologies.

The Mexico Program approach focuses on six tenets:

- Partnerships
- Capacity Building
- Technical Assistance
- Pilot Project Implementation
- Replication
- Monitoring Progress and Results

Partnerships

Many partnerships have been formed through this program to address the diverse cultural, technical, social, and institutional issues that SNL has faced in working to meet program goals. A multi-institutional implementation team has been formed. Key team members of the SNL team include the Southwest Technology Development Institute at New Mexico State University (SWTDI-NMSU), Winrock International, Centro de Investigación de Energía - Universidad Autónoma de México (CIE-UNAM), Asociación Nacional de Energía Solar (ANES), Enersol Associates, Ecoturismo & Nuevas Tecnologías, and the National Renewable Energy Laboratory (NREL). The combination of these and other organizations brings a diverse set of talents to the program.

Program development activities have been closely coordinated with Mexican partner organizations at both the state and federal levels, as well as with U.S. and Mexican industries. The most significant in-country partnership has been with the Federal Trust for Shared Risk (FIRCO - Fideicomiso de Riesgo Compartido), which is an agricultural development organization under the Secretariat of Agriculture, and has offices in each of the 32 Mexican states.

In 1993, amidst a four-year drought in Chihuahua, SNL in cooperation with the SWTDI began working with the State Directorate of Rural Development (SDR - Secreataria de Desarrollo Rural (formerly DGDR)) for widespread dissemination of solar energy technologies in Chihuahua. DGDR organized a dozen governmental, university, and NGO entities into the Chihuahua Renewable Energy Working Group. The Chihuahua program has gained international recognition as a successful and high impact model for widespread renewables project implementation, with over 200 project installations.

SNL also maintains strong collaborative ties with the Comisión Nacional de Ahorro Energetico (CONAE), the Comisión Nacional de Electricidad (CFE), and the Fundación Mexicana de Desarollo Rural A.C. (FMDR). In collaboration with Conservation International, The Nature Conservancy, the World Wildlife Fund, and their Mexican partner NGOs, the Mexico Program has provided training and assistance to increase the NGOs' capacity to evaluate energy options, considering their relative feasibility compared to conventional options. SNL is also partnering with the U.S. and Mexican renewable energy industries. The program has helped improve local system quality and reduce barriers to commercialization, either of new products or in new or under-developed markets. Data collected from project activities assists the renewables industry in the development of new systems technologies or in the improvement of existing technologies.

Capacity Building

Sandia's Mexico team has made great efforts to assist partners in building the capacity necessary to independently evaluate and develop projects by offering formal training workshops that often include hands-on installation experience, focused field activities, and in-depth reviews of suppliers' quotes for proposed systems. More than 1,700 people have been trained in various aspects of implementing renewable energy projects, including technical design, installation and acceptance tests, and related issues such as proposal writing and development of financing programs and policies. Engineers, technicians, suppliers, and decision-makers from more than 100 institutions in 15 Mexican states have received this training and have utilized their resulting capabilities to develop program activities and projects in these states.

Technical Assistance

SNL provides technical assistance to program partners in a variety of forms. Working with partners, SNL has assisted the development of technical specifications for installed systems, and has also worked with local suppliers to assure that they understand what is required to meet these specifications. NREL has conducted extensive studies of solar and wind resources in Mexico, and has developed resource maps of the country and specific regions. These maps are valuable tools for partner organizations and systems suppliers as they work to determine the most feasible regions for renewable energy technologies. These and other forms of technical assistance are provided as part of the capacity building process, and assist program partners in making informed decisions about the appropriate use of renewable energy technologies.

The importance of including the U.S. and Mexican industries in all aspects of the program cannot be overstressed. On a local level, sustainability and growth of markets can only be assured if there exists a strong supply infrastructure, and if installed systems function reliably over time. Therefore, Sandia works closely with local suppliers to help them strengthen their ability to deliver high-quality systems at reasonable costs to end-users. As part of this process, the Mexico Program works to facilitate the formation of partnerships between U.S. and Mexican suppliers. To date, more than 40 Mexican and U.S. companies have participated in the program, through attendance and presentations at training courses, installation of pilot systems, and the development of their own training programs. Several U.S./Mexican supplier partnerships have been formed, resulting in greater customer satisfaction and strong, growing local markets for photovoltaic systems (see Case Study on Water Pumping).

Pilot Project Implementation

After fielding 345 pilot projects, SNL and its partners are building the foundations of growing, sustainable markets. Local suppliers have a better technical understanding of the integration of photovoltaic systems and have learned that with adequate planning, little cost is required to maintain installed systems. As a result of this and an increased demand, prices to end users have been declining in areas where the program is well established.

Figure 1. Typical program installation: PV water pumper in Rancho Jeromin, Aldama, Chihuahua.

The Mexico Program has also initiated new technological developments in the renewable energy sector. One example of a significant new development is a pilot hybrid (PV/diesel) ice-making system in the state of Chihuahua installed in March 1999. The integrated hybrid energy supply component is a new product under development from SunWize

Technologies, Inc. Project costs are being shared by Sunwize, the New York State Research and Development Authority, the State of Chihuahua, and SNL. The Chihuahua icemaker system fabricates 100 Kilograms per day of ice for a fishing cooperative. SWTDI-NMSU is monitoring its continual performance through satellite communications.

The Mexico Program is also collaborating with the utility industry. In partnership with CFE and Arizona Public Service, the program installed this past June the world's largest wind/solar village hybrid system (118 kWp) in San Juanico, Baja California Sur.

PROGRAM RESULTS

Since 1995 the Mexico Program has resulted in the direct installation of over 350 systems (150 for water pumping) of more than 230 kWp in twelve Mexican States providing power directly for more than 10,000 rural Mexicans. The geographic distribution of project types is shown in Figure 2. These systems were chosen to have high visibility and high impact, for instance they are being used in communal ranches, villages, and bio-diversity reserves where many people will see them.

Figure 2. Geographic Distribution of SNL Mexico Program Installations

Figure 3 shows the cumulative capacity of projects installed for each fiscal year that the program has been in existence. The trend in the graph shows that the rate of implementation has been increasing steadily over the years, and is based primarily on increased familiarity with photovoltaic and other technologies on the part of partners, local suppliers, and end users.

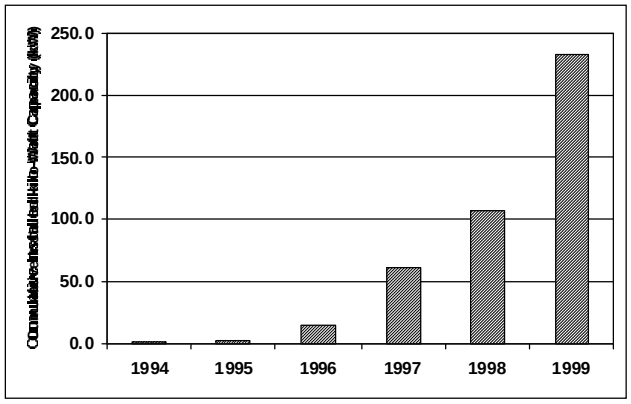

Figure 3. Cumulative kW for SNL Mexico Program Installations

All of these renewable energy systems were installed through partnerships with in-country organizations and help to meet the various needs of these partners. Applications include water pumping for livestock and communities; facilities power for research stations, ranger stations, and ecotourism hotels; and communications systems. Figure 4 shows the distribution of applications and technologies as applied to installations through the program. As can be seen in Figure 4, there has been an equal number of solar and wind energy kilowatts directly installed under the Mexico Program.

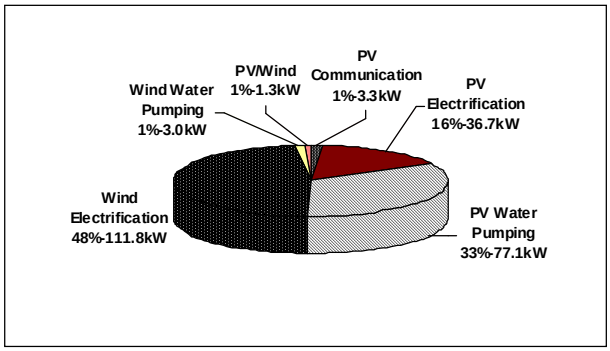

Figure 4. Distribution of Installations by Solar and Wind Energy for SNL Mexico Program.

The Mexico Program has helped the Mexican renewables industry expand. These growth trends and increasing competition have also had an important effect of lowering overall installed system costs, while quality levels have improved substantially. For instance, installed costs of PV water pumping systems have decreased dramatically as vendors and program administrators gain experience with technologies; this despite the fact that PV module prices have not fallen over the same time frame. Some good examples are in Chihuahua and Baja California Sur, shown in Figure 5,

which demonstrates how overall installed system prices have decreased as competition has heated up in those states. Note that these costs include all system hardware (pumps, conductors, etc.), as well as labor and taxes. Many of these same vendors also have expanded their service territories to other states, further contributing to increased competition and decreasing system costs nationwide.

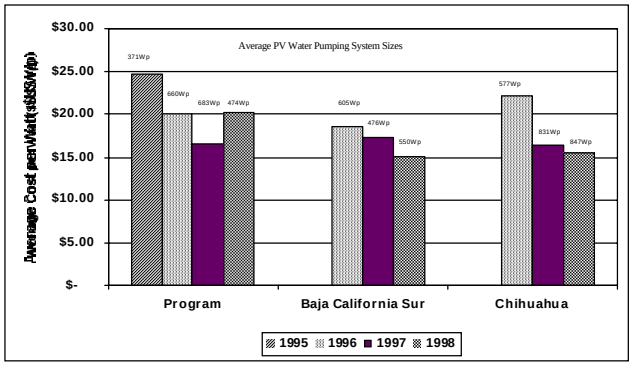

Figure 5. Cost Reduction Trends for PV Water Pumping Systems (first 120 systems)

PROGRAM REPLICATION

The Mexico Program has also been able to successfully leverage Mexican national development programs such as the Alliance for the Countryside (Alianza para el Campo). This six-year program cost-shares 50 percent of agricultural improvement costs with participating farmers and ranchers, such as for water pumping systems. Both FIRCO and SDR have obtained buy-in for this important development program to qualify renewable energy technologies in agricultural applications such as PV water pumping. Under this activity, SNL provides technical assistance and training to FIRCO engineers and technicians, who work with end users to develop projects. FIRCO activities have branched out beyond original program funded States, such as in Baja California Norte where 46 PV water pumping systems outside of SNL program funds. Currently, there are an additional 100 Alianza PV water pumping projects currently in the project pipeline across Mexico.

Mexican industry has seen significant replication from the Mexico Program. For instance, vendors in Sonora and Chihuahua have seen a huge growth in water pumping installations since the program began, having now installed about double the amount installations outside of the program than from those funded from within the program. These vendors directly attribute the opening of this market in Sonora and Chihuahua directly to Mexico Program activities. Another good example of outside replication, is in Chiapas, where neighboring communities to SNL pilot projects in protected areas have requested technical assistance and installed more than 13 kWp of PV systems.

Project replication, or growing sustainable markets, is the program's ultimate measure of success or failure, and can occur in a number of ways. As partner institutions gain familiarity with the use of renewable energy technologies, they begin to implement new projects on their own. This generally occurs within a specific region first and then spreads to new regions. Through these activities, other related institutions become familiar with the merits of renewables and initiate projects as well. For example, in Chiapas, the success of projects that were installed with partner conservation organizations led to nearby municipal governments electing to use community funds to purchase photovoltaic systems for their constituents' houses. The potential for this type of replication can be huge, given that budgets for development organizations can be in the millions, even billions of dollars. Private-sector spin-off replication occurs as a result of successful pilot projects. For replication to be substantial, several factors must be adequately addressed: the local population must know the technology and what it can provide; quality products and services must be available locally; and the ability to pay for the technology must exist. For the latter reason, access to applicable financing mechanisms is key.

Perhaps the greatest example of program success to date is a proposal that FIRCO is developing for the World Bank and the Global Environment Facility, through which FIRCO intends to dramatically increase the rate of project implementation achieved in partnership with Sandia. FIRCO is working with SNL in developing a US$15 million program that will result in thousands of photovoltaic and wind systems installed nationwide over the next five years.

MONITORING

One important feature of the Mexico Program that differentiates it from most renewables development programs to date is that there is a genuine commitment to project follow-up and monitoring. Monitoring activities were designed into the program at its inception, and focus on several issues, including the technical, social, economic, and environmental impacts of the appropriate use of the technologies and applications. The majority of monitoring data comes from interviews with partner agencies, suppliers, and end users, and from visits to specific sample sites. For some complex or novel systems, performance

monitoring equipment is installed and analytical reports are developed.

The Mexico Program provides a large test bed of a variety of projects and technologies for long-term evaluation. For this program, an extensive database is being maintained at SWTDI-NMSU, and all applicable project and program information is being collected from field personnel. Maintaining this database allows program personnel to conduct analyses and make necessary adjustments along the way. As the program continues its transition from direct implementation of pilot projects to further replication and institutionalization of partner organizations, these monitoring efforts will continually grow in importance.

Information obtained and analyzed to date indicates that rigid adherence to technical specifications and maintenance guarantees is leading to systems that are performing well in the field and to customers who are satisfied with their systems. For the approximately 150 photovoltaic water-pumping systems that have been installed through the program, follow-up studies indicate that 23 unscheduled and 8 scheduled maintenance actions have been performed. Equally as important as the low percentage of failures that these numbers indicate is the fact that the maintenance is indeed being conducted. Figure 6 shows some results regarding customer satisfaction of some of the owners of program water pumping systems (27 were interviewed).

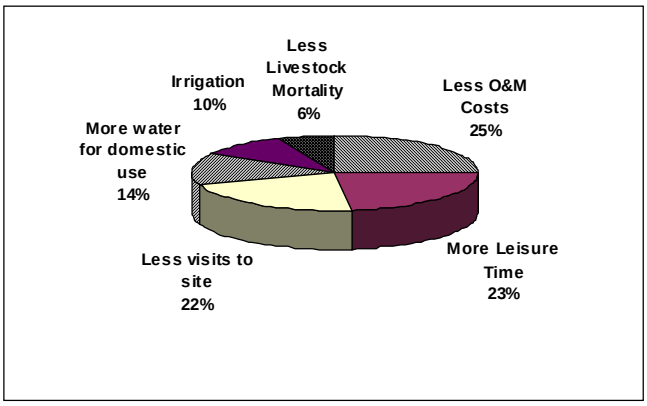

Figure 6. End-user perceptions in Mexico about the value of a PV water pumping system.

LESSONS LEARNED

Implementing the Mexico Program has provided a wealth of information about what works and what doesn't. The key lessons learned are as follows:

Develop Solid Partnerships: A program such as this one depends for its success on working with in-country organizations and with industry, in this case, on both sides of the border. In addition, the program team itself, which is composed of members from different organizations, must function well together. It is important to choose partners carefully.

Conduct Strategic Planning: Strategic planning with collaborating partners helps to create realistic goals makes renewables part their established programs. The program must be focused to make the most of available resources, in other words, do one thing well. Planning should include sufficient promotional activities to accelerate acceptance, including training. The development of a comprehensive program from the project identification stage to acceptance testing and operation are key themes that local developers must learn to dominate, yet keep program development as simple and straightforward as possible. In general, many more options for partnering and tapping into opportunities exist than resources can support; therefore, focus, limit, and succeed in a few locations, than expand. Government-funded programs generally impose a one-year cycle on which to base planning and budgeting. The Mexico Program has greatly benefited from multi-year funding, mainly because the results of a such as this one tend to be realized after several years' of diligent effort.

Use Grass-Roots Development Approach: An integrated and grass-roots development approach across a critical mass of different agency types provides a strong base for dissemination and replication. A local and capable champion greatly facilitates local renewables development. If a program is going to succeed and have any lasting effects, the work has to be done from a development perspective first.

Create Sustainable Markets: Investments in cost share of pilot projects greatly facilitate renewable technology acceptance and create a sense of local ownership. As project volume increases, system costs are reduced due to increased competition. Renewables must be cost accessible to rural people, either through cost-sharing or financing. End-user financing at an affordable level similar to what conventional energy expenditures lowers out-of-pocket initial capital expenditures and expands renewable markets. Pilot projects should be used as a tool, not an end. Pilot projects should be installed to

establish growing and sustainable markets, not to be able to point to the number of installations accomplished during the project. Their primary value is as tools for training and building the capacity of implementing organizations, business, and the user community.

Focus on Capacity Building: In-depth training is critical in developing the interest and knowledge required to understand and successfully apply renewables technologies. Technical assistance and training are a continual process best served up in an incremental fashion over time. It is important not only to train project developers, but also local industry (supply side). Local suppliers are generally very eager to receive training. System suppliers also need to come back and check (and fix if needed) installations; the best classroom is the "field." Success depends largely on the technical capacity of local technicians and administrators who continue development efforts and must assure the overall quality of future systems long after the outside "experts" leave. Greater technical capacity of suppliers leads to greater consumer confidence and less work on the part of the consumer and partner organizations in terms of assuring quality projects.

Evaluate Results: Monitoring and follow-up are key to understanding the true results for any renewable energy development program. Measuring replication and impacts requires a concerted effort and significant resources. Adequate resources must be allocated to ensure monitoring of replication if the true impact of a renewables development program is to be known. It's important not to parachute renewable energy technologies into a rural region, but to establish a solid local industry base that can follow-up on installed projects maintenance needs.

FUTURE DIRECTIONS

Given the special relationship and proximity between Mexico and the United States, SNL with USAID and DOE have a long-term commitment to assisting with Mexico renewable energy development. Existing partnerships will continue to be strengthened while new partnerships initiated. Mexico Program activities are continually expanding from the first dozen states to the remaining two dozen Mexican states. SNL activities and collaborations are also expanding to include new applications such as centralized hybrids, dairy milking, electric fences, and solar thermal applications (e.g., hot water and potable water).

There are several issues to be addressed as the SNL team continues to work with its Mexican partners on the broader acceptance of renewable energy technologies in Mexico. One of the most critical areas still needing attention is facilitation of financing mechanisms for renewable energy systems through banks or non-government organizations. The first pilot credit fund in Mexico for renewable energy ever was created in Chihuahua in August 1999, and an additional fund is now being created in Baja California Sur. These loan funds offer up to US$10,000 credit and are available to farmers, ranchers, and homeowners interested in using solar and wind energy systems.

Additional program monitoring is desirable, in particular, data regarding renewable energy business development, as is data on spin-off replications (market growth), analysis of customer satisfaction, and information on the effect renewable energy systems are having on local economic development via the productive-use applications. Increasing the renewable energy industry's involvement in the program is another area needing attention. FIRCO's US$15 million replication program with the World Bank is to be initiated next year, and will results in thousands of more program installations over the next five years,

The Mexico Program is recognized as one of the most successful renewable energy development programs in the world. SNL is working with its partners to assess and demonstrate the applicability and expansion of the this successful program model in other international settings, such as in Central and South America.

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