NICARAGUAN RENEWABLE ENERGY FOR RURAL ZONES PROGRAM INITIATIVE

Debora Ley
Sandia National Laboratories
P.O. Box 5800, MS-0703
Albuquerque, New Mexico
87185-0703
dley@sandia.gov

Herminia Martínez
Elieneth Lara
Comisión Nacional de Energía
Apartado Postal CJ-159
Managua, Nicaragua
erural@cne.gob.ni

Robert Foster
Luis Estrada
College of Engineering
New Mexico State University
MSC 3 SOLAR, PO Box 30001
Las Cruces, New Mexico
88003-8001
rfoster@nmsu.edu

ABSTRACT

The Nicaraguan National Energy Commission (CNE) with the World Bank (WB) is implementing a large-scale solar and micro-hydro rural energy initiative called the Renewable Energy for Rural Zones Program (PERZA – Proyecto de Electrificación Rural para Zonas Aisladas). The main project objective of the PERZA is to provide basic electricity services and associated social and economic benefits in selected rural areas of Nicaragua. In Nicaragua, rural electrification was largely absent during the long civil war years, so that today nearly 80 percent of the rural population is without electricity. The major impediments to off-grid electrification in Nicaragua include the high cost of providing access to remote sites, dispersed populations, difficult terrain, limited budgets, as well as the generally low income and low power demand of the rural population. This paper discusses the initial implementation of PERZA including the installation of solar electric battery charging stations.

1. BACKGROUND

The Project for Rural Electrification of Isolated Zones (Proyecto de Electrificación Rural para Zonas Aisladas – PERZA) is preceded by two phases. The first one is an initiative of The World Bank to visit Nicaragua in June 2000. During this trip, the Government of Nicaragua and the Comisión Nacional de Energía (CNE) presented a portfolio of projects for a rural electrification program to be executed in the Atlantic Regions of the country. In a second mission of The World Bank to Nicaragua, the municipalities of Chontales, Boaco, and Nueva Guinea were visited. The result was the signature of a Support Memoir between CNE and the head of The World Bank mission, that established the preparatory activities to begin an evaluation of the different institutional models within the electricity supply of the rural sector, specially isolated systems. These are financed through a Private Fund for Infrastructure (Fondo Privado de Infraestructura - PPIAF) and The World Bank. The second phase begins with the preparation of what is now called the PERZA. For this, multiple preparation studies were done, among them, market surveys, site evaluations, and identification of productive uses. Once the preparatory studies were finalized, the PERZA was negotiated and finally approved and signed on May 27, 2003 and became effective on November 28 of the same year. The total amount for these two phases was of US$ 1,296,400.00. Preparatory studies were conducted and actual project installations began in 2005.

2. INTRODUCTION

Nicaragua is one of the countries with the lowest electricity coverage in Latin America. Approximately 81 percent of its rural population does not have access to electricity. CNE is developing a rural electrification strategy with the goal of increasing the coverage index. Though such strategy has

been focused on grid extension and isolated power plants, CNE has been redesigning this strategy. PERZA is being used to pilot some new sustainable delivery mechanisms and a variety of decentralized energy systems that are based on renewable energy technologies (RET). These systems will supply electricity to more than 16,000 homes, public centers, and, as a consequence, will allow productive use applications and new opportunities to expand businesses or create new microenterprises. The PERZA will design a component called Enterprise Development Services (Servicios de Desarrollo Empresarial - SDEs) that will be adequate for each one of the selected sites and where remote populations will have feasible access to microcredits, through a microfinance component.

The redesign of the national strategy for rural electrification and its replication, will have as an objective the improvement of the conditions and quality of life of the rural population living in remote areas. The environmental objective will be to reduce greenhouse gas emissions through the elimination of obstacles associated with politics, information, institutional capacity and financing that will help with the dissemination and development of an international market for renewable energy technologies.

Photovoltaics (PV) is a promising alternatives for providing energy to rural areas in Nicaragua, either through individual PV home lighting systems (PVLS) or centralized PV battery charging stations (PVBCS). Both approaches charge batteries through charge controllers. Typical appliances powered by one battery per household are a few energy-efficient light bulbs, a radio, and perhaps a black and white TV. The main difference is that the batteries are charged centrally in the BCS (and then transported by the users). For PVLS, each household has its own small PV module, battery, and charge controller. The advantages of PVBCS are potential economies of scale in management and battery charging, as well as the potential to adopt payment schedules to local needs. The main advantages of PVLS are the increased convenience and the household charge controllers which avoid deep discharging and increase battery lifetime over PVBCS.

For this program, The World Bank is supporting the Government of Nicaragua with a financing of US$12.0 million through an IDA credit US$ 4.0 million grant through the Global Environment Facility (GEF). The Government of Nicaragua is leveraging with US$2.23 million, and the private sector is contributing approximately US$ 4.46 million that will consolidate the redesign and implementation of the national rural electrification strategy, developing an innovative off-grid public/private electricity supply mechanism in various pilot sites.

Willingness to Pay demand studies in Nicaragua have found consumer payment levels vary by region from about US$5 to US$13 per month. This can help serve as a basis for initial planning base for micro-credit institutions. Nicaraguan rural users should pay full operating and maintenance costs. Their monthly fee can also help recover some of the initial investment. Users can pay an initial connection fee, to assure ownership from the outset. Investment subsidies from the Government are useful to improve profitability for private service providers in low-income areas.

3. OBJECTIVE

The objective of the PERZA is to improve the quality of life of the Nicaraguan population that is located in remote areas through the sustainable provision of electric energy services and the associated social and economic benefits. The project will pilot new sustainable mechanisms for the construction of a variety of decentralized energy systems that are based on renewable energy technologies, for the electrification of areas that are isolated from the grid.

The location of the Projects will be in poverty areas where there are development possibilities according to the National Development Plan, established by the Government of Nicaragua by taking into account the needs expressed by the communities, mainly rural, in terms of access to energy.

4. PROJECT COMPONENTS

4.1 Rural Electrification and Renewable Energy Policy

The objective of the policy initiative is to establish a legal and regulatory framework that will allow the sustainability of rural electrification projects, converting the National Electric Industry Development Fund (Fondo de Desarrollo de la Industria Eléctrica Nacional - FODIEN) into a mechanism whose transparency and operations will contribute to expand the coverage of electric energy services. It also has the purpose to promote the active participation of the private sector, and of the different organization forms of the civil society.

As part of this initiative, several studies are being carried out to better understand tariffs and subsidies for concession and rural zones; determine policies for prices and subsidies; and in part to help set up a policy framework for the application of solar energy and other renewable technologies. The purpose of these studies is to strengthen policies for the application of renewables for the country. The expected results are:

- Adoption of a national strategy for rural electrification by CNE, which will integrate solutions for off-grid locations

and will reflect the diversity between the Atlantic and Pacific regions of the country.

- Improvement of the National Electric Industry Development Fund (FODIEN), for rural electrification; completion of the regulatory and legal framework for rural electrification (for on-grid and off-grid extension projects); and the explicit integration of the off-grid solutions in the National Strategy for rural electrification.
- The application of an effective scheme for rural electrification subsidies, including off-grid electrification and use of solar energy.
- Capacity building of CNE and Nicaragua's regulatory entity (Nicaragua's Energy Institute – INE, Instituto Nicaragüense de Energía) to implement and supervise the rural electrification strategy.
- Reduce market barriers for renewable energy technologies through the replication of mechanisms used in pilot projects and lessons learned in these experiences, as well as through changes in the current procedures adopted by the Government during the design of the rural electrification strategy.
- Application of the lessons learned in the integration of the microfinancing component of the off-grid rural electrification national strategy.

4.2 Solar Electrification:

PHASE I SITES

FRANCIA SIRPI, BUTKU, SAGNILAYA and ILBARA PV BATTERY CHARGING STATIONS

These indigenous Miskito communities are located in the North Atlantic Autonomous Region (RAAN) of Nicaragua north of Puerto Cabezas in the Waspam area. The project has financed 7 photovoltaic battery charging stations that provide energy for approximately 300 homes that represent about three quarters of the total population of these communities.

These battery charging stations were installed in November 2005 in locations selected by the communities so as to facilitate access by the population. Each home has a complete 'kit' that includes a battery, two fluorescent lamps, and a voltage regulator. All of the PV systems and kits have similar design and construction.

This project is subsidized entirely by the Government of Nicaragua, due to the extreme poverty conditions of the Miskito indigenous communities. The users pay a small fee, calculated based on their payment capacity, to recharge their batteries.

CNE supported the management during the initial operation of the project to ensure training and capacity building activities in the communities and make sure they can take care of the service. This includes hiring a local NGO to operate, supervise and monitor the battery charging stations under the supervision of CNE. The installations were done by a private company: ConsEnergy.

A typical PV battery charging station in the community of Francia Sirpi is comprised of a 2400 Watt PV array with three subarrays that can charge up to 24 lead acid batteries at the same time. Shell SQ80 80 Wp PV modules are used. The complete system is composed of three PV 800 Wp substations with its own individual Stecca PL2085 controller that is capable of charging 8 PV batteries per station simultaneously. The intelligent control unit in which the adjustment, operation, and display functions are carried out by a microprocessor, serve as the brains of the battery charging station. The batteries are charged as quickly and efficiently as possible, in the order of priority according to when they are connected. In addition a MPP-tracking system enables optimum use to be made of the energy available even if not all battery stations are fully utilized. No energy is wasted even if all 8 stations per subarray are not occupied.

Fig. 1. One of the three PV battery charging stations (NW system) at Francia Sirpi.

Approximately 150 residential household lighting packages have been installed in the Francia Sirpi community. Residents have been provided a PV lighting household kit to with two or three 15 Watt fluorescent lamps. The lighting kit installed on each house has a small 6A Morningstar SHS-6 charge controller used as a low voltage disconnect for the 12V 105 Ah maintenance free AGM battery. No photovoltaic modules are installed on the individual homes. Instead, when the battery is low on energy it is disconnected from the home lighting system and taken to the charging station site to be recharged. When it is fully charged the

battery is then brought back to the house and is reconnected back to the home lighting system.

Fig. 2. Battery charging at Francia Sirpi with Stecca controller capable of charging 8 batteries simultaneously.

A data acquisition system (DAS) was installed with CNE by New Mexico State University (NMSU) on one of the PVBCS systems in the community of Francia Sirpi in October, 2005. The DAS monitors the input and output voltages of the charged and discharged batteries, as well as overall performance of the PV array. Both irradiance and temperature are also measured. Parameters are measured every five seconds and averaged every hour. Data on system performance and end-user operation is now being gathered by CNE and analyzed. This will better help to understand how users operate their systems and how the batteries are being used and to what extent they are being deep-discharged.

Fig. 3. CNE engineer inspecting the charge controller used as a LVD for a household lighting system in Francia Sirpi.

Fig. 4. Home kit with deep-cycle battery safeguarded in a battery box against the most curious PV system clients.

The main concern for PVBCS is that if the users overly deep-discharge their batteries (e.g., bypass the LVD), then their lifetimes could be prematurely cut short. NMSU designed and provided technical assistance for the installation of the DAS.

Additional PV battery charging stations were installed in the smaller Miskito Indian communities of Butku, Sagnilaya, Auas Tigni, and Ilbara. They are similar in design, construction, and utilization as the systems installed in Francia Sirpi.

Fig. 5. Sangnilaya Miskito Indian village 2.4 kWp PV battery charging station in the Waspam can charge 24 batteries at a time.

4.3 Hydro Electrification

EL AYOTE PROJECT:

The project is under development and is located in the South Atlantic Autonomous Region (Región Autónoma del Atlántico Sur – RAAS), 90 km. North of Juigalpa and 170 km. away from Managua, in the limits of the municipalities of Santo Domingo and El Ayote.

The Project will finance the development of a 5 MW hydroelectric system 17 km. away from El Ayote in a site called Tapalwas. The concept is to develop a concession for a capacity of 700 kW.

The community currently has a diesel engine, one of the isolated systems of ENEL, which provides basic energy services for approximately 8 hours per day. It also represents a loss to ENEL due to the high administration costs because of the distance and the cost of fuel. The number of homes that will use the energy from the mini-grid distribution system will be expanded to approximately 1,500 homes.

According to the pre-feasibility study of El Ayote, the total investment cost is of US$2.4 Million. The Government, through the WB loan funds, will provide approximately 30% subsidy to the investment. This was calculated to ensure the economic feasibility of the project and to avoid an excessive tariff that the population is unable to pay. Another 30% will come from the private operator and the remaining 40% will be a debt assumed by the same operator.

EL CUA BOCAY PROJECT:

The project will finance the construction of a 900 kW hydroelectric system with two 450 kW units. This project will facilitate the interconnection to the national grid to sell the exceeding energy and to connect the existing plant of San José de Bocay to the off-grid project of El Bote.

The system will allow 2,300 homes to have electricity. The estimated cost of this sub-project is US$2.2 Million with 22% from the private operator, 55% debt and the remaining 23% as a subsidy of the Government of Nicaragua.

The operation of this project will be responsibility of the Benjamín Linder cooperative, who has the concession for the distribution of the 900 kW El Bote self-supply project.

PHASE II SITES

CNE, in parallel with the implementation of PERZA, is implementing a project called Productive Uses of Small Scale Hydroenergy (Usos Productivos de la Hidroelectricidad en Pequeña Escala - PCH) in collaboration with the United Nations Development Program. Both projects use GEF funds for technical assistance and for their preparation. Under the frame of collaboration among both projects, it was defined that PERZA would use part of its funds to finance the implementation of two or three hydroelectric sites of the PCH project. Two initial sites are El Tortuguero and San Juan del Norte. Other projects are still being analyzed.

EL TORTUGUERO PROJECT:

El Tortuguero is located in the South Atlantic Autonomous Region, 530 km. away from Managua and approximately 6 to 7 hours away by canoe up the rivers of Kukarawala and Kurinwas, through the lagoons to rivers of Kukra and Escondido, and up to the community of Rama. The municipality of El Tortuguero has a population of 11,232 persons. Approximately 2,000 people live in the center of the town. Energy will be provided to the center of the town through the construction of an isolated hydroelectric plant. The technology to be used still needs to be defined and will be done once the feasibility study and the economic analysis are completed.

SAN JUAN DEL NORTE PROJECT:

This project is located in the Department of Río San Juan, Municipality of San Juan del Norte. Main income sources are tourism and fishing.

Their current energy source is a diesel genset from the isolated system of ENEL. The system provides energy for approximately 8 hours and has numerous technical failures that interrupt the service, causing serious damage mainly to

the fishing industry that depends on ice to maintain its products. This site has a nice hotel that houses tourists and those who practice sport fishing, mainly from Costa Rica. The project will benefit 250 homes and will promote productive uses that are currently abandoned or aren't promoted due to the lack of a reliable energy supply. Taking into consideration the geographic location, wind resource measurements are underway to determine feasibility for a wind hybrid system. Otherwise, the site will consider a solar hybrid system.

LA UNION PROJECT:

The sub-project of La Unión is located in the Municipality of Nueva Guinea within the South Atlantic Autonomous Region (RAAS), specifically in the district of Nueva Guinea, located 26 km. south-east of El Verdún.

The dispersed homes will have solar energy. The energy supply to the community will be provided through a 23 km. grid extension from El Verdún. The cost of this project is of approximately US$ 450,000. This project will have a concessionary that will distribute the energy. The project will benefit 250 homes and will increase the development of productive use activities, mainly fishing.

4.4 Enterprise Development Services (EDS):

Besides the energy supply through the use of renewable energy, the PERZA is developing activities that can bring additional development benefits to the communities, through Enterprise Development Services. This component looks at the productive use applications and other opportunities to expand existing businesses or create new enterprises as a result of rural electrification. Likewise, the program provides assistance to micro and small enterprises in the pilot sites through training and capacity building in business and marketing. Due to the new development of rural EDS, the Project provides a small subsidy to participants to help cover expenses for training courses.

4.5 Microfinancing

This project component provides financing to all the homes and microenterprises in the PERZA pilot regions that benefit from electricity. The financing allows the connection to a mini-grid, financing for solar photovoltaic systems, and other energy systems introduced.

As a complement, the Project provides credit to the microenterprises that have a productive use of the energy. This credit is offered in the project sites by certified and selected Nicaraguan microfinancing entities that are responsible for the recuperation of loans.

4.6 Social Promotion

This component supports the activities of the other components through the social promotion of the PERZA program. The goal is to maintain and increase community participation in each of the project sites through training to the local population in the topics of electrification, energy savings, O&M, and other energy related themes.

5. TRAINING AND CAPACITY BUILDING

An important component of the PERZA program is training, both for the PV and microfinance organizations. Several important training workshops have been conducted for the PV industry, installers, and users. In May, 2004 a training course was held for the Nicaraguan PV industry (6 companies) on how to design system to meet the Nicaraguan Electrical Code. Article 690 is similar to that of the U.S. NEC. All PV systems installed under PERZA are designed to meet the Code. This training was conducted by NMSU and Sandia National Laboratories.

A workshop for two dozen PV system installers, both new and old, was conducted in October, 2005 by NMSU with CNE aimed at vendors and independent installers operating in the communities where CNE has projects. Training focused on PV system basics and installation. Participants learned how to evaluate solar resource, determine energy demand, size and design systems, install, and conduct PV system testing. The five day workshop incorporated a mix of both classroom and hands-on sessions.

Fig. 6. PV systems installer training by CNE with NMSU in Juigalpa, Nicaragua - October, 2005.

6. CONCLUSIONS AND SUMMARY

An important objective of the PERZA project is to promote participation of the private sector in the provision and

financing of electricity and accompanying services in rural areas. CNE is implementing the PERZA program to further strengthen the Nicaraguan solar energy industry by promoting commercial dissemination of PV systems through a dealer approach offering financing for rural users. The PERZA project essentially represents a "supply push" rather than a "demand pull" for off-grid PV applications. Off-grid rural energy services can be designed to be franchised and supplied through standardized distribution chains.

PV is a promising alternative for providing energy to non-electrified rural areas, either through individual PV home lighting systems (PVLS) or centralized PV battery charging stations (PVBCS). Both approaches charge batteries through charge controllers. Typical appliances powered by one battery per household are a few energy-efficient light bulbs, a radio, and perhaps a black and white TV. The main difference is that the batteries are charged centrally in the BCS (and then transported to the users). For PVLS, each household has its own small PV module, battery, and charge controller. The advantages of PVBCS are potential economies of scale in management and battery charging, as well as the potential to adopt payment schedules to local needs. The main advantages of PVLS are the increased convenience and the household charge controllers, which avoid deep discharging and increase battery lifetime over PVBCS.

In Nicaragua, the government does not regulate off-grid electrification. Likewise, there are no guidelines on service quality for off-grid connections. Most consumers are not familiar PV technology and should be protected through product and installation codes and standards, after service sales, and warranties. As in many Latin American countries, there is already a national electrical code adopted by Nicaragua that is based on the U.S. National Electrical Code. Article 690 of this code legally applies in Nicaragua, which provides basic design and installation guidelines for PV systems. CNE working with NMSU and Sandia, has now developed and applied PV technical specifications that meet electrical code requirements, as well as service standards.

PERZA is adopting widespread financing for PV systems as part of its overall rural development program. When considering the establishment of a financing program for PV, it is important to take into account the affordability of financing to both rural people and local business. Financing must be designed for profitability, and aim at establishing sustainable business models. The capabilities and commitment of PV businesses, as well as credit worthiness of customers, must be evaluated. It is important to understand both the market and the level of competition that already exists and what consumer choices are.

PERZA has installed seven PV battery charging stations in northeastern Nicaragua in the Waspam for 300 homes. Likewise, they are installing hundreds of individual household lighting systems in 2006. Plans are to solar electrify over 3,000 homes with micro-financed PV systems by the end of the initial project phase.

7. ACKNOWLEDGMENTS

This project is possible through funding from the World Bank and GEF. Technical assistance provided by NMSU and Sandia was possible with funding from USAID, DOE, and the GEF/World Bank. Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the U.S. Department of Energy under contract DE-AC04-94AL85000.