BEST PRACTICES IN SUSTAINABLE RURAL ENERGY DEVELOPMENT: FIVE INTERNATIONAL CASE STUDIES

PROJECT: RURAL ELECTRIFICATION

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About The Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development, and client confidential environmental consulting services. Its mandate is to develop and promote policies and practices that lead to environmental protection, resource conservation, and environmentally sound and sustainable energy and resource management. The mission of the Pembina Institute is to implement holistic and practical solutions for a sustainable world. Incorporated in 1985, the Institute's head office is in Drayton Valley, Alberta with offices in Ottawa, Calgary, Edmonton, and Vancouver, with research associates in other locations across Canada.

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Preface

The OLADE / University of Calgary Energy and Environment Project is a five-year project developed jointly by OLADE and The Board of Governors of the University of Calgary, and funded by the Canadian "Executing Agency" for the Canadian International Development Agency ("CIDA"). The goal of the Project is to enhance policy making of OLADE member countries in the areas of rural energy, energy markets, gender issues, indigenous issues and climate change.

The Rural Energy Initiative offers stakeholders the opportunity to consider how innovative approaches and best practices in rural energy development can be adapted to meet their needs, and then trialed through the implementation of the rural energy pilot projects. As a key aim of the pilot projects is to support the replication of similar projects within the LAC region, the lessons learned from the international case studies profiled within this report should provide insights into whether, and if so, how rural communities have applied similar strategies.

The key output of the Rural Energy Initiative is a series of strategy and policy recommendations, based on the outcomes of rural energy pilot projects as well as experiences outside of the LAC region that will facilitate appropriate rural energy development within LAC countries. To this end, this paper provides a series of five "best practice" case studies from outside of the LAC region that illustrate a selection of planning strategies, financing mechanisms, and community ownership and management structures that have been successfully used to meet rural communities' energy needs.

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Introduction: Linking Energy and Rural Development

Access to clean reliable energy is one of the keys to creating sustainable livelihoods in rural communities. Sustainable energy resources and technologies can:

- ◊ Provide amenities such as light, heat, motive power, and fertilizers
- ◊ Decrease the outflow of financial resources to pay for fuels and electricity
- ◊ Offer a source of income
- ◊ Create opportunities for new businesses, especially for women
- ◊ Improve health, and air and water quality
- ◊ Reduce vulnerability to climate change and other disasters

At the 2002 World Summit on Sustainable Development (WSSD), the Plan of Implementation called for action at all levels to:

- ◊ Substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply, and ensuring that energy policies are supportive of developing countries' efforts to eradicate poverty.
- ◊ Improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources, sufficient to achieve the Millennium Development Goals, including the goal of halving the proportion of people in poverty by 2015.

These goals were reiterated at the International Renewable Energy conference in Bonn in June 2004.

Providing access to clean energy at the community level is a challenging task. Clean energy technologies tend to have a higher first cost than traditional energy sources such as wood burning fires and kerosene lamps. There is a lack of the skills needed at the local level to manufacture, install and maintain clean energy products. Local infrastructures to manage and finance new enterprises supplying clean energy services do not exist in many places.

On the other hand many communities already have the community spirit, micro-finance services, and community-based organizations and NGOs that can be used to establish an infrastructure to provide clean energy services. This report describes five case studies in Africa and Asia where rural energy programs have been successfully established in rural communities. These projects have not only met locally defined energy needs and provided income generation, in many cases they have also improved women's access to resources, resulting in improved status and capacity. The five projects are as follows:

1) Char Montez, Bangladesh – A micro-enterprise owned and operated by women to manufacture and sell battery-operated lamps.

2) Mbuiri Village, Kenya – A micro-hydro development to provide power to local enterprises

3) Maphephetheni Development Program – A community enterprise to install solar home systems and provide micro-finance

4) Sri Lanka Energy Services Development Project – A national community financing program for solar home systems
5) Sagardeep Island, India – A community owned solar PV mini-grid providing power to island residents

Together these projects identify the key features of a successful community energy project. Each of the following case studies examines the enabling features, the community structures, the financing models used, and other key aspects of the project that contributed to its success. Based on an assessment of these features, some general conclusions are drawn which can be used to help in the design of community energy projects in the LAC region.

Case Studies

Case Study 1: Char Montez, Bangladesh

Micro-Enterprise to Manufacture and Sell Battery-operated Lamps

0) Community Profile

The community of Char Montaz is located on one of several remote islands in the south of Bangladesh, surrounded by the sea of Bengal. These islands are remote and are not served by grid electricity. The main sources of income for the communities in the area are agriculture and fishing.

Biomass is the most predominant form of energy, used primarily for cooking needs within the home. Kerosene lighting is also common (open flame or hurricane lamp); 95% of indoor lighting is provided in this manner. Indoor air pollution from cooking and lighting fuel sources is a health concern, and open flames from the kerosene *kupis* are a fire hazard. Grid electricity is not likely to be provided in the area for another 15-20 years, despite a government objective of universal electrification by 2020.

There are significant cultural barriers affecting the relative status of women and men in the area. Women are traditionally barred from visiting or working in pubic markets, or even working in the formal sector of the economy. As a result, most rural women are poorly educated and spend the majority of their time in the home or completing agricultural labour. Micro credit organizations serving the needs of women have a long history in the area, however.

1) Project Context

The project "Opportunity for women in Renewable Energy Technology (RET) Utilization in Bangladesh" began in 1999. The project set out to establish a sustainable, private micro-enterprise owned and operated by women to deliver energy services.

The micro-enterprise is co-operatively owned by the workers who manufacture, market and sell DC battery operated energy efficient fluorescent lamps and operate diesel charging stations. Local women were selected for training in areas such as manufacturing, sales, quality control and business administration. These women become government certified to operate a cooperative business and to manufacture lamps.

The enterprise is now expanding to provide micro-credit services to those buying lamps, and solar photovoltaic charging systems.

The project aimed to address poverty and gender inequity in the area by improving the working conditions of women (in the home) through electrical lighting. Further, the project aimed to provide training, meaningful employment and income for women from non-traditional sectors. Lighting and micro-grid services would provide improved indoor air quality and lighting, improved security for households and businesses, enhanced productivity (particularly for income generating activities), and increased income (as much as 30%).

As a broader goal, the project aimed to improve the status of women in society by removing barriers that prevent them from participating in the formal economy.

There are 20,000 households in the target area of the micro enterprise, including some on the mainland.

The Energy Sector Management Assistance Progamme (ESMAP)[1] initiated the project following consultations with communities and NGOs in the region. The consultations revealed that electric lighting was a priority need. ESMAP provided base funding for the project which was then implemented by Prokaushali Sangsad Limited (PSL), an engineering firm based in Dhaka. Several local NGOs were involved in the project as well.

Phase I began in 1999 in a space rented from a local NGO. Hiring, training, production and sales of lamps were completed.

Phase II was launched in 2002 and aimed to expand the credit schemes, scale-up production to meet demand beyond the islands in the region and diversify services to include Solar Home Systems (SHS). The project established a plan that will lead to financial sustainability by the end of 2004, at which point PSL had planned to withdraw completely.

2) Energy Needs

Before the project commenced, surveys of women in the area were completed by women staff consultants from PSL. The surveys concluded that electric lighting was a high priority for the local women. It was also determined that 95% of households use kerosene for lighting.

Women who purchased the lamps are now able to extend the hours when they generate income (example: extended hours for tailoring business – particularly beneficial during festival times), as well as benefit from reduced indoor air pollution. In some cases, lamps are being shared with husbands who can then operate stalls at night markets for extended hours, further contributing to household income (power is only currently provided to the market four hours each night). Household income was found to increase with electric lighting, and lighting was found to be a deciding factor in whether people opened a home-based business.

3) Enabling Factors for Implementation

[1] ESMAP is a joint program of the World Bank and the United Nations Development Programme (UNDP).

One of the key enabling factors was that local NGOs were already established in the communities, and were able to provide support for the project. Even though local NGO projects were focused on health, sanitation and education, and the NGOs had little energy experience, their skills in micro-credit and their familiarity with the community were crucial support to the project.

PSL conducted the initial surveys and facilitated training/consultation. Women were interviewed by women staff of PSL and eventually selected for participation with input from local NGOs. These women were trained to operate a government certified business cooperative, as well as the manufacturing of the lamps. The project intent was to support 'progressive improvement of women's lives, economically, socially and environmentally.' Women were hired for all aspects of the operation. Most had no employment experience in the formal economy although many had experience with micro credit through other NGOs.

The Government of Bangladesh has a goal of universal electrification by 2020, which is an important enabling measure to this project, even though the Government itself was not directly involved in this project.

4) Barriers to Implementation

Some of the challenges encountered during implementation were as follows:

- There was an initial resistance to the project from conservative local elite because women would be breaking social/religious norms by working in a public space, outside of the household.
- There was a need for policy guidelines and institutional frameworks for improving access to energy as a means to promote economic development.
- Rural energy was not a mainstream activity for NGOs so they were hesitant about offering micro credit for energy equipment.
- The cost of the batteries and/or the location of battery charging stations was an obstacle, as those residing more than 2km from a charging station were inconvenienced by the travel distance.

The strategies to address these barriers are described below.

- PSL spoke with local NGOs and community members about the benefits of the project; the NGOs were excited about potential employment opportunities.
- To encourage participation of all stakeholders, community meetings were held with women, local market committees, schoolteachers, local elite and NGOs during preparation of the implementation plan.
- Women were encouraged to invite their husbands to monthly meetings. The husbands of project members even offered assistance to the working team, especially in marketing and sales (This has been found to increase women's confidence and build interest in the project among the men. As a result, some social and cultural discrimination experienced by women has been removed).

5) Financing Mechanism

The micro-enterprise was established to manufacture and sell battery-operated energy efficient lamps to the community. To date, these have mostly been cash sales, but the enterprise is being extended to provide lamps on credit, and to operate solar recharging stations.

Core funding for the project was provided by ESMAP. This covered PSL consulting services for surveys, worker training, and enterprise management during Phase I. It is hoped that the project will become self-sustaining in Phase II.

- Phase I (1999-2004): direct cash sales of the lamps and batteries. Lack of credit hinders sales. The co-operative using its own money offered limited credit sales to those customers known to the women managing the project – loans all repaid (in bi-weekly installments).
- Phase II (2004-): Co-investing in more charging stations on other islands. Use of solar PV panels for recharging – enterprise becomes an Electricity Service Company (ESCO) that rents out solar panels in response to demand.

6) Energy Technology

The enterprises decided to initially manufacture small battery operated lamps and energy efficient lights. These would be coupled with rechargeable batteries (currently recharging stations are operated with diesel generators, but recharging could foreseeably be done by solar PV in Phase II).

The technology was selected so that the cost would be low enough to be affordable to residents, and be simple enough to be manufactured locally.

The women were trained to identify electronic components and tools, assemble the printed circuit board (including soldering), and to conduct quality control and testing operations.

7) Ownership and Management Structure

The enterprise is owned as a cooperative business by the women working for the enterprise. All decision-making is democratic (voted by the workers).

8) Project Sustainability

For the women directly involved in the project, the project builds capacity and skill, as well as providing employment. Further, the project produces an item that is socially and environmentally beneficial to the buyers. With increased availability of lighting, customers are able to improve both their education and income due to improved lighting conditions.

Phase II of the project expands the scope of the project to ensure that economic viability is maintained, as well as striving to implement renewable solar technologies.

9) Project Replication

PSL aims to use the approach in other areas of Bangladesh and is consulting in Ghana for a similar project to empower women through energy service delivery.

Lessons learned are being incorporated into the IDA/GEF funded “Rural and Renewable Electrification Project” [2].

[2] This project is aimed at removing barriers to off-grid electrification through incremental-cost subsidies of installations, capacity building, regulatory/policy development, information, and financing mechanisms. The technical assistance component is expected to focus on capacity building of various stakeholders to facilitate market development and assist in preparation of a policy and regulatory framework for off-grid renewable energy. The investment component is expected to focus on supporting a remote community investment fund to facilitate the formation of capital for community based renewable energy initiatives, including micro-hydro and micro wind power projects and support private sector as well as village-based implementation of off-grid renewable energy activities.

10) **Lessons Learned**

The key lesson learned from this project is that energy services can be provided to communities by local enterprises on a self sustaining basis, provided that core funding is available for training and establishment of the enterprise during the first few years. Other key factors include:

- The energy needs surveys of local women undertaken by women staff members of NGOs and consultants before the project commenced were an important factor in the success of the project.
- If women own and operate energy enterprises, the quality of life, income, and status of women are improved.
- It is important that there is some experience in the community with micro-credit and that NGOs are working in the community on the provision of other services (not necessarily energy).
- It is important to start with simple low cost energy products, moving on to more complex products such as solar PV chargers as the enterprise gains experience and cash flow. A financing mechanism such as micro credit is an important component of selling more complex products.
- Cooperative ownership of the enterprise by the women working for it ensured democratic operation and a level of interest to maintain the enterprise.

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Renewable Energy Information Network summary and photographs: www.lged-rein.org/solar/solar_sre_charmontaz.htm

Global Village Energy partnership summary and photographs: www.gvep.org/content/general/detail/7942

Case Study 2: Mbuiri Village, Kenya

Micro Hydro for Community Enterprises

1) Community Profile

Ninety-six percent (96%) of rural Kenyans lack access to grid electricity. In the area of Mbuiri, energy costs amount to one third (1/3) of family expenses.

Mbuiri is a small village 200 km north of the capital city of Kenya, Nairobi near the Tangu River. There is no electricity service in the community. The village is about 12 km away from the nearest town.

There are about 300 households in the village, with a total population of nearly 1800. Females account for 56% of the population, children under 10 account for nearly 23%. The regional district has a population of 5400, covering 43 sq.km. The Meru people form the majority of the population, although several other tribes live in the region.

The predominant construction material for homes is mud, followed by wood and stone. The roofs of the homes are iron sheets.

Typical climate patterns include a heavy rainy season from September to December, and another shorter and lighter rainy season between March and May. Otherwise, the area is hot year-round (average temperatures above 30 degrees Celsius).

The soil is red and has poor water retention characteristics. The vegetation is typically low although there are scattered indigenous trees.

Nearly eight percent (7.8%) of the population has no formal education. Ninety percent (90%) are considered literate in English (although reading and writing ability is better than oral). Less than 12% of males and females have completed secondary education. There are several primary schools and one secondary school in the village. There is also a community centre and two under-serviced health centers (these clinics lack basic amenities such as clean water, refrigeration, and essential drugs). Most service requirements must be directed to the nearest town – 12km away – at the expense of the patient.

The main occupation in the village is agriculture, in which the labour is dominated by women. Farming provides subsistence as well as produce to be sold at the market. The market lacks sanitation, clean water and electricity. The major cash crop is tobacco, with 86% of households cultivating at least some, and multinational corporations are active in the area promoting this crop.

There is no access to micro-credit for the villagers, as most have no collateral to offer. Ninety five percent (95%) of villagers have no monetary savings; savings are in the form of livestock to be sold in case of emergency.

Although none of the homes have electrical supply, most have some electrical appliances (radios, televisions) that are run on rechargeable batteries. A very few homes have solar photovoltaic home systems. The predominant sources of energy are wood fuel for cooking and curing tobacco, and kerosene for lighting. Diesel fuel is used to run the grain mill in the village.

There is a scarcity of clean water in the village; most residents use water directly from the Tungu River and it is not often boiled because of the fuel requirement. On average, women spend 4.5 hours per day retrieving water. There is no water pump in the village. Attempts have been made in the past to divert water from upstream to the community to facilitate irrigation and cultivation, but financial and organizational problems hindered further development. Water quality decreases even further during the rainy seasons due to sedimentation caused by flooding.

Health problems in the community include malaria, typhoid, cholera and HIV/AIDS. Except for the latter, which is still not widespread, incidences are seasonal (increased incidence in rainy season).

Two large tobacco multinationals operate in the area; other private enterprises include kiosks, shops and private clinics.

2) Project Context

The project involved diverting flow from the Tungu River though a micro-hydro plant that provides electricity for an Enterprise Centre – a new building housing local enterprises. A local organization – the Tungu-Kabiri Community Micro Hydropower Project - was formed to own and operate the micro-hydro scheme. Shares in the project were issued to local residents in return for cash or labour. Power users in the Centre pay for the power used at rates set by the organization.

The objective was to improve livelihoods, and to provide communities with energy for commercial activities. At present, the energy is distributed only to the Enterprise Centre as power is only allowed to be distributed to households by the Kenya Power Light Corporation – the national utility.

The project also sought to remove the policy, technical and institutional barriers limiting development of renewable energy for poor, off-grid areas.

Implementation was undertaken by the Ministry of Energy (Dept. of Renewable Energy) and the Intermediate Technology Development Group (ITDG-East Africa), with funding support from UNDP-GEF. The project was part of a *national project* to assess the potential of micro-hydro power. The village of Mbuiru was selected from a list of candidate project sites based on predetermined characteristics. Core funding was provided from the UNDP-GEF Small Grants Programme.

Extensive support was provided by the community during the consultation process. Local laborers donated one day per week to the construction of the facility.

3) Energy Needs

The community was selected from over 20 candidate sites. The community has no electricity service; income generation is highly dependant on seasonal activities such as agriculture.

The community was consulted following the selection of the site (this prevented disappointment for communities not selected for development). However, the community determined what the hydropower would be used for. The majority of the women preferred to have water pumped and purified, while the men wanted to utilize the electricity for micro enterprises. The latter scheme was adopted with the goal to expanding capacity and providing clean drinking water from the diverted water as a ‘phase II’ project (this has yet to be completed).

The hydropower facility provides power to a community center where several small enterprises have been established (the Enterprise Centre). Enterprises currently operating with hydropower include a barbershop, beauty salon, welding shop, a battery charging station, a cell phone charging station and a video-show shop.

Secondary uses for the hydropower include electric powered grain milling and tobacco curing, which will reduce the amount of time required for collecting fuelwood and the amount of money spent buying diesel fuel. Other uses of the power include a health facility, homes, social hall and community development building.

4) Enabling Factors for Implementation

There are limited vocational skills in the community; there is some relevant capacity in the areas of masonry and carpentry, and there is a local vocational school.

Social groups (women, youth) are present in the community. There is some international NGO presence. There are several church groups in the area that sponsor some schools and provide bursaries to needy students. Farm Africa is an international NGO operating in the area that supports livestock production projects through women’s groups.

5) Barriers to Implementation

The Power Act of 1997 allows for independent power producers to supply electricity to the grid but does not provide for decentralized energy. There are no incentive programs for rural off-grid schemes.

Furthermore, government legislation prevents private distribution of power to households; the Power Act stipulates that only the Kenya Power and Lighting Company (KPLC) is authorized to distribute power.

There are no set standards for micro hydropower at this time (only for larger hydropower development). The Power Act does allow independent producers to supply electricity to the grid. There are no national policies encouraging or enabling local communities to develop renewable power.

The national Land Act has been implemented slowly. By 2002, land adjudication had not yet reached the area, so villagers did not have legal ownership of the land they cultivate and live on The Water Act controls use of water from the Tungu River.

Despite the legislative barriers, financial barriers are the most significant in the community. ITDG worked with the community to form the commercial enterprise (Tungu-Kabiri Community Micro Hydropower Project). This group, composed of some 200 members, contributed free labour and financial resources in exchange for part ownership of the enterprise (a maximum share value was established). Financial challenges still exist: the group is having trouble raising capital to invest in water pumping and purification facilities.

The project involved the government ministries from the beginning, giving them a stake in the project. This helped to remove the policy barriers. The community acquired one acre of land from the government for the micro-enterprise center. The government has now initiated a process with the Kenya Bureau of Standards to establish a code of best practice for the small hydro sector, including standards related to transmission poles, wires, accessories and installation.

The lack of technical skills within the community was also addressed throughout the project. The community is now able, through training and direct involvement, to construct, maintain and repair the system, as well as manage and operate a power scheme.

At the national level, the project stimulated interest in capacity building for the manufacture of small hydro facilities. A training workshop was facilitated, and there is now in-country capacity to build system components (turbines, penstocks, load controllers, etc) as well as conduct feasibility studies. Spin-off from the project has led to the construction of two pico-hydro facilities (less than 5 kW) in the country.

6) Financing Mechanism

The community raised funds to acquire land, donated materials and labour to the project, and paid cash for required licenses and shipping of materials to the community.

Two hundred (200) community members bought US$50 shares of the micro enterprise. ITDG continues to provide advice to the enterprise regarding implementation of tariffs for the use of power and rent for the use of stalls in the micro-enterprise center. The community has complete ownership of the facility.

ITDG secured funding from UNDP-GEF Small Grants Programme (US$63,700) and other donors, as well as providing technical expertise. Government support was also provided (both technical and other assistance) by the Ministries of Energy, Land, Water, as well as the Social Service Department and the local government authority.

7) Energy Technology

Water from the Tungu River is diverted at an upstream point into a canal constructed with local labour. The 250-meter canal provides areas for desilting. At the end of the canal, the water is directed down a penstock to the turbine. The penstock length and head height are 20m and 13.5m respectively.

The facility is rated at 18 kW; it therefore produces 18kW mechanical power or 14 kWe. Flow rate in canal is 200 l/s with an effective 180 l/s running a T12 cross-flow turbine.

8) Ownership and Management Structure

The community group (Tungu-Kabiri Community Micro Hydropower Project) owns and operates the facility. Approximately 200 community members are shareholders, contributing free labour and financial resources in exchange for part ownership of the enterprise (a maximum share value was established). Key features of the ownership structure are:

- Community owned and operated – thus improved likelihood that there will be timely maintenance.
- Improved economic opportunities for community members.
- Community enterprise establishes use of power, thereby acting as developing agency as well.
- Women are involved in management, and thereby have stronger influence in community development.

9) Project Sustainability

Core funding was needed to establish the local community enterprise managing the micro-hydro, undertake local surveys and training, and build the micro-hydro facility. The income from sale of power to micro-enterprises covers the cost of maintenance and management, and therefore the project is now sustainable and could expand the activities receiving power. The income will not, however, cover the core capital and set up costs.

Local labour and resources were required to construct the facility and acquire land for waterway and powerhouse, and is used on an ongoing basis for operation and maintenance. As locals have developed these skills, there is a sustainable knowledge base developing in the community. The Kenyan government is promoting the small hydro industry in the country to build capacity and decrease reliance on foreign experts for energy projects.

10) Project Replication

Two pico-hydro facilities have been constructed in other communities. Capacity for manufacturing and feasibility has been established in the country.

The financial resources of the communities are not enough, alone, to develop micro-hydro power schemes. Outside funding is still required.

Establishing links with credit organizations will improve (or provide) access to credit facilities, improving likelihood of securing capital for small enterprise start-up.

11) Lessons Learned

This project responded to the energy service needs identified by the community – water purification and power for community enterprises. It is unfortunate that the energy needs identified by men in the community (power for enterprises) were given priority over those identified by women (clean water), and the project still has not met women's needs. This is quite often the case in energy projects[3]. It is important to design community energy projects to ensure women's needs are identified and met.

Other key features of the project include:

- Establishing a community based organization to own and operate the facility, including both cash and sweat equity shares. This organizational structure establishes the uses for the generated power, thereby acting as a development agency as well. Women are involved in management, and thereby have stronger influence in community development.
- Having a local development NGO like ITDG to provide expertise and training during the first few years of the project.
- Core financing for the project in the form of a grant. Such a project can sustain itself once built, but cannot finance its capital and set up costs.

10) References

Intermediate Technology Development Group – East Africa. Project Overview and photographs available online at http://www.itdg.org/?id=micro_hydro

Mbuiri Micro Hydro Project Kenya: A sustainable livelihoods case study. February 2002. Intermediate Technology Development Group & Intermediate Technology Consultants. Available online at

[3] Biogas generators can be constructed with latrines that would greatly improve the quality of life for women, but in many cases, this part of the project is never built.

http://www.itcltd.com/docs/final%20version%20casestudy%20kenya%20mar02hjm.pdf

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Case Study 3: Maphephetheni Development Programme, Kwazulu, Natal Province, South Africa.

Solar home systems, school and clinic electrification system, water pumping and biogas. Ongoing as of January 2004.

1) Community Profile

Maphephetheni is a small village located in a hilly region of rural South Africa known as the Valley of a Thousand Hills approximately 80 km from Durban. It has small settlements dispersed over the area and has a higher than average rainfall compared to the rest of South Africa.

There is a traditional chief who presides over the area with a local community representative council. There are some 16,000 people spread across 2,000 homesteads.

Economic activity in the area consists primarily of subsistence agriculture, informal economic activities and small enterprises.

The primary sources of energy for cooking and heating are biomass, paraffin and liquid petroleum gas (LPG). Candles and paraffin are mostly used for lighting. Grid electricity is supplied to the clinic, high schools and administration office.

2) Project Context

The solar home system (SHS) pilot component featured in this case study was part of a larger energy services development project in the area. The development project in the area also included the following initiatives:

- A solar/LPG hybrid system was installed at Myeka high school providing up to 3 kW.
- Biogas system for Myeka high school. Gas piped to classrooms for cooking and to a 2.5 kW generator used for lighting and other power needs.
- Domestic Biogas. A constant pressure digestor system was installed in a residence with local labour. Gases produced from manure are used for cooking. The waste is used as fertilizer.
- Health clinic PV electrification. Solar PV used for lighting and security. Hot water is provided with solar water heater.

Other initiatives and projects include solar crop drying, small hydro, battery charging, compressed earth blocks, solar and new cooking technologies, and rainwater harvesting.

The project began with a pilot installation of a SHS in 1996; nearly 50 units have been installed since then. SHS are sold to local residents with loan financing available over a three or four year term. In addition to these units, solar PV power systems have been installed at schools in the area – mostly donated by SHS manufacturers and suppliers.

Solar Electric Light Fund (SELF) – an international solar energy development specialist group based in Washington, USA - initiated the project by contracting services to Solar Engineering Services (SES). SES and SELF determined that Maphephetheni was an ideal location to begin this project because there was a spirit of cooperation among the local administration.

SES approached key players in the community seeking support for the project, initiated awareness-building program, and developed a local organizational structure to select an Energy Committee, based upon local customs. The Energy Committee consisted of a project manager, 2 sales persons, 4 installers, and the KwaZulu Financing and Investment Corp (KFC). SES also set up the community capacity building program. Decisions regarding financing options for the SHS were made in consultation directly with the community. The Energy Committee handles installation, sales and maintenance.

A small community based organization was set up to market the SHS and also provide assistance for the processing of loans. Local installers are responsible for installations. SES trains local installers, procures systems and assists with quality monitoring, project management and preparation of marketing materials. In general, it was found that women were more successful at sales and were generally more reliable and delivered 'neater' installations.

The South African Government provided core start up grants to cover project management and project demonstration. Loan guarantees were provide by US Department of Energy.

3) Energy Needs

While there was no formal energy needs assessment carried out in the area, SELF identified several reasons why SHS would be most appropriate to meet local needs:

- Areas serviced by the grid in the village of Maphephetheni are subject to high energy prices.
- Homesteads are generally quite dispersed.
- The area is mountainous and extension of grid service is not expected for more than 5 years.

It was found that the SHS had a larger development impact on women than men, mainly because women used the technology for lighting, radio and reading, while men used the technology for leisure (watching football on television).

Overall, the renewable technology initiatives have impacted women more significantly because their labour requirements have been reduced. In particular, the use of domestic biogas systems has significantly reduced women's labour required for collecting fuelwood and decreased deforestation rates, has improved indoor air quality in homes decreasing associated health problems, improved management of animal and human wastes and improved water quality.

4) Enabling Factors for Implementation

Three key factors made the project a success:

- Cooperative spirit among the community leadership which allowed the formation of an Energy Committee/management structure to operate the SHS enterprise
- SES and SELF contributed technical and organizational experience in the community and provided support to the community.
- Funding from the South African Government and loan guarantees from the US Department of Energy were crucial in enabling project start-up.

The project also promoted several renewable technologies as a group and it was found that overhead costs for training, travel, supervision and marketing were reduced as a result.

5) Barriers to Implementation

Initially, residents had trouble obtaining loan financing, as procedures for residents interested in purchasing SHS were not fully developed.

SES needed to develop a market for SHS.

At the start there was a general lack of skilled personnel in the area able to install, maintain and market SHS. However, through capacity building by SELF and SES, there are now enough qualified people in the community to install and repair the majority of systems.

Out of 50 SHS installed during the pilot project 19 were removed due to failure to make payments. A three to six month leeway was provided, but there was still a high default rate.

6) Financing Mechanism

The participants in the project financing are as follows:

- The Solar Electric Light Fund (SELF) was the programme initiator, provided a portion of project management funding as well as experience and expertise.
- Solar Engineering Services (SES) assisted with quality monitoring, preparation of marketing materials, and project management and provided training for installation technicians under contract to SELF.

- The South Africa Department of Minerals and Energy (DME) provided partial contribution to project management costs and financial support for project demonstration.
- To finance the SHS, KwaZulu Financing and Investment Corporation (KFC) provided community loan financing to buyers over 3 to 4 years at commercial interest rates. The US Department of Energy provides guarantees for this loan funding.
- Various private companies donated most of the equipment for the Myeka high school project, and Valley Trust provided funding for the upgrading of the Embuyeni Clinic, including PV electricity and hot water.
- A small community based co-operative took responsibility for marketing SHS, purchasing SHS directly from the supplier, and also providing assistance for the processing of loans.

The SHS were imported and sold to households for between R 2500 and R 3000[4] at a repayment rate of R57 to R82 per month depending on local currency fluctuation. As mentioned above some members of the community experienced difficulties in meeting their monthly repayment obligations, and have had their SHS removed.

The SHS were guaranteed for the period of the loan (replacement is subject to payments being up-to-date). The maintenance was completed by the local installer.

7) Energy Technology

The SHS package consisted of:

- a 50 to 55Wp solar module,
- 3 compact fluorescent lights of 9W,
- a 105Ah battery,
- battery cover,
- charge controller fitted with 12 volt DC Monochrome TV or 12 V DC radio connection point.

The majority of SHS were single module systems (a few used double modules). A 50Wp SHS provides enough electricity to power 3 lights for 5 hours each, and a black and white TV set. The battery's storage capacity can provide sufficient power for 3 days under totally overcast weather conditions. The photovoltaic panel transforms sunlight into Direct Current (DC) which is stored in a 12V battery. A battery controller is connected between the solar panel and the battery to ensure that the battery is neither overcharged nor over-discharged**.**

8) Ownership and Management Structure

A community-based organization was set up to market the SHS and also to provide assistance for the processing of loans. Local men and women were trained by SES to

[4] In 1998 the Rand fluctuated between US$.16 and US$.21

install the SHS. In addition SES procured systems and assisted with quality monitoring, project management and preparation of marketing materials.

A representative of SES was the project manager. The Energy Committee met regularly with the Chief, the Maphephetheni Development committee, representatives from the high school, KFC and Valley Trust (a local NGO working on health/social issues). Also present are representatives from nearby universities with related programs.

The SHS are owned by the end user – either home or school or clinic. It was found that there was no theft of panels from home systems because these were directly owned by the users. There were significant problems with theft of solar panels from the high school and clinic, although this has now been reduced because the school has purchased the panels.

9) Project Sustainability

Because SHS are quite expensive and current loan periods are only 3 or 4 years, many residents will not be able to afford the systems. This has been illustrated by the large number of loan defaults. The project will not reach all community members unless the loan period is extended or some form of rental or lease financing is introduced. Some form of continuing loan guarantees will also be needed to reduce the risk for local lenders.

The project has, however, set up a workable community structure with trained women and men installers and managers, which as long as there are buyers, will provide reliable and on-going service. Because solar technologies have been applied for school and clinics as well as homes, those trained for installation and maintenance can be utilized for more projects, increasing the value derived for their training.

10) Project Replication

The South Africa DME is currently implementing a national non-grid electrification programme in three provinces that will adapt some of the models used in this project.

A South African electricity provider has established a non-grid service company that is exploring the possibility of expanding this project.

11) Lessons Learned

The project illustrates that a community owned and operated SHS supply and loan structure can effectively provide rural off grid communities with needed lighting services.

An existing spirit of community cooperation is needed to provide community input and help set up and manage the process (for example through an Energy Committee). There is also a need for outside technical and managerial expertise for capacity building (SELF and SES), and a lending agency willing to provide loan services (KFC). In many cases, these loans will require guarantees by outside sources to reduce risk for the local agencies (US DOE).

Some source of grant financing is needed to provide the outside expertise and pay for the set up and initial management of the community organization.

Other interesting features include the finding that overhead costs for training, travel, supervision and marketing were reduced by combining several different components. Those trained for installation and maintenance of solar technologies can be utilized for more projects - school and clinics as well as homes, increasing the value derived for their training.

It was also found that women were more successful at sales and were generally more reliable and delivered ‘neater’ installations, meaning that SHS projects can provide income as well as quality of life for rural women.

There have been quite a large number of loan defaults on the project resulting in repossession of SHS. This is mainly because SHS are quite expensive and current loan periods are only 3 or 4 years. A SHS project will not reach all community members unless loan periods of 5 or more years are provided, or some form of rental or lease financing is introduced.

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Case Study 4: Sri Lanka Energy Services Delivery Project

Dissemination of Solar Home Systems (SHS)

1) Community Profile

Rural Sri Lankan communities are typical of rural communities in developing countries; there is no widespread electrification and most residents derive income from agriculture or other local industries (such as fishing). Only 30% of the entire population of Sri Lanka is served by grid electricity.

Attempts at distributed solar home systems (SHS) in the 1970's were ultimately unsustainable due to the high cost of technology. In 1989, the government owned People's Bank attempted microfinance SHS but had little success due mainly to lack of interest of the urban banks at dealing with small rural customers.

Constraints typical in rural areas of developing countries persist in Sri Lanka: dispersed markets and the high cost of business in remote areas; relatively expensive energy systems compared to income; and a banking system that is focused on the urban market.

2) Project Context

The Energy Services Delivery (ESD) project was set up in 1997 to finance renewable energy implementation in Sri Lanka. Core funding to design and build capacity for the ESD was from the World Bank's Asia Alternative Energy Unit, and the Sri Lankan Government.

One of the major components of the ESD was a national solar home system promotion and implementation program. This was a promotional campaign to raise awareness of solar technologies. Other components include community micro hydro mini-grids, pilot wind farms and national capacity building.

The SHS program involved several stakeholders and service providers at various levels.
Other players included the SHS dealers and participating credit and micro finance institutions (MFIs). The size and scope of these organizations vary, some are local and national and other are subsidiaries of international corporations. Financing for the SHS was provided through a loan from the World Bank that was distributed through the financial institutions and a grant provided by the Global Environment Facility (GEF) to subsidize the cost of each system. The grant reflected their environmental value of SHS over competing fossil fuel alternatives.

Of the four approved dealers/developers operating in Sri Lanka, the two largest are foreign companies.

The Development Finance Corp of Ceylon (DFCC) provided a monitoring program to ensure that all systems were in fact installed, that they were installed properly and that they were functioning to specifications.

The Sri Lankan government has linked its rural electrification program to the market based SHS program, thus lending credibility to the private sector and increasing consumer acceptance. The government has also acted to promote it through legislation. It has modified standards twice, each time allowing smaller systems, better suited to consumer demand and solar insolation in the country.

The project supported the creation of a Solar Industry Association (SIA), whose members include dealers and micro finance institutions. The SIA communicates with the project, the World Bank, the government, and the national utility board on matters affecting its members. Currently, the SIA is addressing training and accreditation issues.

One of the key partnerships in the national program was that established with Sarvodaya Shramadana Society, one of the largest NGO's in Sri Lanka with an extensive network of rural contacts. SHS financing is provided through SEEDS, the NGO's finance arm, while its technical division Rural Technical Services (RTS) fulfills the role of SHS dealer. The distribution process is as follows:

- Photovoltaic supplier introduces customer to SEEDS.
- SEEDS completes a credit appraisal; customer signs credit agreement if accepted.
- SEEDS pays the supplier and is responsible for repayment from customer. The supplier receives 20% up-front.
- The supplier installs the system and forwards "Customer Acceptance Certificate" to SEEDS.
- SEEDS pays the balance of the loan to the supplier. The dealer provides technical support.

3) Energy Needs

The project was initiated at the national level to meet community energy needs that had been identified in previous surveys and assessments and to test local financing methods for renewable energy systems.

4) Enabling Factors for Implementation

The most successful partnership in this national program has been the one established with SEEDS, offering installation and financing as a package deal.

The GEF subsidies made the systems available to a larger number of residents.

Quality assurance through the Development Finance Corp of Ceylon ensured that all installed systems are installed properly and that they are functioning to specifications.

Having a variety of accredited SHS suppliers is kept prices competitive and ensures product innovation.

Because Sri Lanka has an extensive history and network for micro financing, the financing models were more easily utilized.

Finally, government support for the program provided the background legislation and product standards needed, and helped to build consumer awareness of SHS and a Solar Industry Association. Linking this market based SHS program to rural electrification objectives is also important – as it lends credibility to the technology and increases consumer acceptance. Warranties are provided for all systems, and there is a national body that performs verification. Furthermore, there is access to an extensive network of technicians for servicing.

5) Barriers to Implementation

As shown in section 6), consumer financing has been the most challenging component of the SHS program. Although three basic financing schemes were tried, only one was successful. On the other hand, offering three financing models provided the flexibility needed early in the program, demonstrating which financing scheme was the most efficient and met the needs of consumers.

6) Financing Mechanism

The SHS program is executed by the Development Finance Corp of Ceylon (DFCC) Bank of Sri Lanka. The financing has two components: $19.7 million US from the International Development Agency as credit and $3.8 million US in grants from GEF. The former is distributed as ten year loans by refinancing through participating credit institutions and MFIs. Credit lines provide 80% refinance with 10-year repayment. The GEF grant is used for a co-financing scheme in the form of a capital subsidy to reduce the initial cost and covers other costs such as consultants.

The GEF grant provides capital subsidy in the following amounts:

- US $70 for system capacities of 20-30 Wp
- US $100 for system capacities of 30-45 Wp
- US $150 for system capacities of >45 Wp

The initial cost of a system was approximately US$11/Wp. As local suppliers entered the market the price dropped to US$10/Wp. Initially a 30Wp system would have cost US$330 - US$70 (grant) = US$260.

The three basic financing models used for dissemination are as follows:

1. SHS Consumer financing by dealers: This arrangement saw credit extended by financing organizations directly to the SHS dealers. Subsequently, the dealers

completed the marketing, technical support and finance management. This method was largely found to be untenable because dealers were not equipped to manage customer financing, and dealers did not have an extensive network in the rural areas to facilitate collection and communication.

2. SHS Fee-for-Service: This arrangement saw the dealers install SHS systems but maintain ownership, instead collecting a monthly fee from customers. The dealer found that the collection costs were high and that lack of ownership often translated into poor maintenance.
3. Customer Financing by MFIs: Under this arrangement, a project developer/dealer approaches a PCI with a project, which the PCI evaluates. If accepted, the PCI applies to the DFCC for refinancing. The PCI/MFI pays the dealer/developer for installed systems. Eighty percent (80%) of this loan can be refinanced. The PCI/MFI designs a consumer loan package (for end users), including an initial down payment, with monthly payments following.
   The benefits of this method include: freedom of dealers to focus on marketing and technical support (and not financing), freedom of private sector and NGOs, who often have extensive rural networks, to manage financing.

SEEDS is an example of an MFI; this last method is described above.

There is a mandated "30 days money back guarantee". A customer can therefore return a system without reason in that timeframe. This prevents 'pressure-sales'.

The role of MFI in the above scenario is fulfilled by NGOs, such as SEEDS, private finance companies, rural cooperatives and banks, and commercial banks.

The initial failures of dealer financing and fee-for-service models show that grassroots infrastructure is a significant enabling factor for successful implementation.

7) Energy Technology

SHS marketed under the program are required to meet national certification standards. These standards ensure quality, safety and longevity of the systems, thus reducing commercial risk.

8) Ownership and Management Structure

As indicated in the financing section, ownership models can be either fee-for-service or privately owned by the end user; the latter is more popular. The most popular delivery model is the MFI financing model where a single organization such as SEEDs manages all aspects of the installation and finance.

9) Project Sustainability

The EDS solar home system project has been designed to provide financing for a number of years. Sustainability will depend on the success of delivery models such as the one provided by SEEDS, and the creation of a more bottom up demand for SHS. The current model does not have a capacity building component at the community level. There is a need to work with existing community development organizations and local governments to identify energy needs, increase public awareness of the program, and trigger the use of local micro-credit structures.

Several factors will help the project sustain itself:

- Warranties are provided for all systems, and there is a national body that performs verification.
- The program has resulted in an extensive network of technicians for servicing
- Sri Lanka has an extensive history and network for micro financing
- The program is part of a national government electrification program

10) Project Replication

The model continues to be applied throughout the country. Recently, SEEDS has opened branches in previously un-serviced provinces.

11) Lessons Learned

Key features of the program that could be used in other SHS programs include:

- Using existing financial infrastructure for awareness building, microfinance and technical support. This fosters increased trust among consumers that the product is viable and can be serviced if and when need be.

- A financing model that offers both installation and financing as a package deal through the same well established NGO like SEEDS

- Sufficient front end funding to set up the program and build capacity, and partial subsidies towards the cost of SHS – at least during the early days of the program.

- Quality assurance to ensure that all installed systems are installed properly and that they are functioning to specifications.

- Having a variety of accredited SHS suppliers is also important to keep prices competitive and to ensure product innovation.

- Government support for the program in the form of a renewable energy or rural energy strategy that includes community based systems like SHS, and in the form of awareness building and supply industry development (requirements for warranties, industry associations, training and accreditation of installers, etc.)

The Sri Lankan model does show, however, that a top down approach to financing and promotion has its limitations and needs to be supplemented with a community demand initiative driven by existing community development NGOs and local governments who are delivering other non-energy services. A capacity building program focused on these organizations would greatly increase local knowledge of the development benefits of SHS and provide the local infrastructure to purchase more systems.

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Case Study 5: Sagardeep Island, West Bengal, India

Community Solar Electricity Mini-Grid

1) Community Profile

There are many islands in the Bay of Bengal, and many villages amongst them. Two in particular, Sagar and Moushuni have had some success developing mini-grid based solar power. These islands are located 100km from Kolkata (Calcutta) by road, and another 6km by ferry.

One half of the land on the islands are currently being used for agriculture, the other half consists of waterways and embankments (this is an internationally significant area of mangrove forests). The economy of the island is based largely on the agriculture and fishing trades, with some specialization in cash crops and small enterprises.

Tourism is another economic activity: there is a large tiger sanctuary on the islands (which are relatively close to Calcutta); the area is home to famous mangrove forests – intensively conserved for their biodiversity; and there is a large annual pilgrimage to Gangasagar, the main city on Sagar Island, for a holy festival.

Kerosene fuel is the largest source of energy for lighting, and firewood is the most common cooking fuel.

There are no near term prospects for extending grid electricity to the islands in the region. There are some small conventional diesel power generation stations on the islands serving small grid networks, but distribution to villages is not foreseeable.

2) Project Context

The project was designed to bring electric power to villages from solar electricity distributed through local mini-grids. The project targeted the rural villages (both household and small business customers) on the islands. The provider collects a deposit to finance the establishment of a mini-grid in the community that distributes power to the consumers. Users are then charged a monthly fee for connection. Currently this system is being updated to include pre-payment meters in homes. The power is mainly used for lighting and the running of small appliances, machinery and radio/TV.

The solar cell capacity of each facility is 26 KWp with battery storage and inverters to provide AC power. The power plants supply stable 400 / 230 V, 3 phase, 50 Hz power for six to seven hours per day. The solar cells are imported, but the remainder of equipment is manufactured domestically.

A significant feature of this project is that during the day, when the grid is not being used to supply power, the solar electricity is used to run low cost conventional 3 hp water pumps which supplies clean drinking water from underground aquifers.

Improved lighting is expected to increase the capacity for children and adults to study in the evenings, thereby contributing to improved education levels. Further, lighting will also expand hours that residents can participate in income generating activities at the home and at their places of business. The solar powered TV has become an important source of information and entertainment.

The West Bengal Renewable Energy Development Agency (WBREDA) administers the mini-grids as part of a national initiative administered by the Rural Energy Corporation (REC) (largely based on conventional non-renewable technologies). WBREDA adopted a participatory approach by consulting and developing implementation plans with the local governments and communities. WBREDA is state owned, not an NGO or private organization. The mini-grids themselves are operated by local cooperative societies formed by people using the grid.

The first system was established in 1996 and had a capacity of 12.5 kWp. This system served 117 customers. Between 1996 and 2003, no less than 11 solar power stations were established, serving nearly 2,000 families.

WBREDA has also installed 80 solar powered streetlights (most operating independently of the grid) that can provide light, and safety, on the streets all night. Furthermore, two hospitals are powered with solar electricity, one of which operates on its own solar power station.

The program at Sagar Island is part of the Indian Government Special Area Demonstration Programme (SADP). The SADP was initiated in 1992 to demonstrated sustainable rural energy feasibility in remote and hard-to-access areas.

3) Energy Needs

In 1996, the Ministry of Non-Conventional Energy Sources (MNES) identified the area of west Bengal, and the islands in the Bay of Bengal in particular, as one of ‘high focus’ under its solar photovoltaic programme, and provided the necessary funds to WBREDA to establish power plants there.

WBREDA consulted with local governments and communities, seeking assistance for an alternative to expensive and polluting use of diesel generators as a primary electricity source. Given the remote island geography, it was recognized that grid connection is not likely to occur, as this would require installing high voltage power lines across tidal water.

Current capacity on Sagar Island is approximately 400 kWp, half of the total required to supply all the villages on the two islands. The stations supply power for 5-7 hours per day.

On Moushuni Island, the largest solar power plant in the country has been established, at 55 kWp. This system will serve 450 customers. The project on this island is parallel to that of Sagar Island, and as such this case study will focus only on the details specific to Sagar.

It has been found that use of kerosene for lighting in homes has been reduced 50%, and small businesses using power are able to eliminate 100% of kerosene.

4) Enabling Factors for Implementation

WBREDA had been operating in the area installing solar home systems before the beginning of this program, and as such their services were known in the community. WBREDA had been tasked by national and regional government to supply power to remote villages in the West Bengal region. To date, it has electrified over 800 villages, mainly with solar but also including other renewables such as biomass, biogas, mini-hydro and wind. Clearly, WBREDA is an organization equipped with the resources, experience and knowledge to carry out rural electrification programs.

Organizational structures and financial management plans were well established before commissioning of facilities. Using a cooperative operating structure for the mini-grid has increased the feeling of ownership by customers. Using local banks for grid accounts has also added to the feeling of local ownership.

The SADP support provided by the government removed many of the barriers for the program, particularly those government or legislative barriers that may be encountered in other areas.

Like many rural electrification programs, the solar mini-grids are only financially viable if the capital cost of the mini-grid and power source is funded by other sources. Operating costs can then be covered by revenues.

5) Barriers to Implementation

Operational funds are raised in the community in a fee-for-service model. In the early stages of the program, some users were ‘stealing’ electricity because there were no meters (see section 6: Financing Mechanism). Pre-pay meters are now being established to limit stealing, and the saved electricity will allow more customers (and revenue) to be connected.

6) Financing Mechanism

Fifty percent (50%) of capital funding for the solar mini-grids is provided by the national government (MNES), another 20% from the provincial government, both in grant format. The remaining 30% is derived from revenue from consumers and loans (a soft loan from Indian Renewable Energy Development Agency (IREDA) under the World Bank assisted

Solar Photovoltaic market development programme). Customer revenue currently covers 100% of operating costs, but only 20% of capital costs.

WBREDA charges a flat rate of $3 US for 120 Watts, and $9 US for 360 Watts, based on an average use per customer. This system has been abused though, as some customers are using much more power than they are paying for. Currently, WBREDA is installing pre-payment meters to eliminate losses and therefore allow extension of service to more homes. A connection charge is levied for all new customers, and customers are required to have all internal wiring completed and inspected (thus users have stake in proper functioning of system).

The mini-grids are operated by local cooperative societies with membership drawn from customers using the grid. The societies are responsible for selection of customers, choosing distribution routes and setting the tariff in consultation with WBREDA. Also, they are responsible for collection of payments from consumers (to be passed on to WBREDA) and for dealing with non-payment issues. Payments are made directly to a local bank.

WBREDA supports the cooperatives with advice on administrative and financial matters and provides technical input through a junior engineer permanently stationed on the island.

7) Energy Technology

The Solar Power plants operate a mini-grid system. Capacity of each facility is 26 KWp (composed of 52 PV modules, each 50 Wp). The battery bank capacity is 1400 Ah. The inverter capacity is 3 Nos. 15 kVA each. The power plants supply stable 400 / 230 V, 3 phase, 50 Hz power for six to seven hours per day.

The power plants are also designed to drive water pumps; these are 3 HP pumps with intelligent controllers to provide clean drinking water without incurring extra cost (aside from installation and capital).

8) Ownership and Management Structure

The assets created by the local cooperative societies are property of the society and not individual customers. Installations are maintained by the society and its members (who are also customers).

9) Project Sustainability

Local cooperatives established to manage the power plants are building local capacity.

The solar power is providing stable access to power for many households and businesses, improving opportunities for education and income generation.

Commercial viability is not the goal of these projects, as the capital costs are heavily subsidized by national and regional governments. However, operational costs are covered by user fees. This is quite similar to the approach taken to finance rural electrification in many countries.

10) Project Replication

Renewable energy projects are expanding throughout the islands, including a biomass gasifier plant that serves nearly 800 customers. Still, the replication of the solar powered mini-grid model is the most common activity.

Renewable energy spin-off benefits include a boat operator who now runs electric powered ferry service to customers that eliminate air and water pollution, as well as increased speed of travel.

The solar mini-grid model has been replicated in Zambia and Bangladesh.

11) Lessons Learned

The key lessons learned from this project include:

- Using an existing organization like WBREDA which had been operating in the area installing solar home systems before the beginning of this program and were well known in the community, made the project much more effective.

- Having a national rural electrification program and special demonstration program status for the communities helped both in securing the funding for the project and the implementation process.

- Using a cooperative operating structure and local bank accounts for the mini-grid increased the feeling of ownership by customers.

- Like many rural electrification programs, the solar mini-grids were only financially viable when their capital costs were funded by government programs. Operating costs were covered by revenues.

- The fee for service payment model is effective, but there is less abuse by customers when meters or pre-pay meters are used instead of a flat fee per connection.

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Lessons Learned and Implications for the LAC Region

The case studies illustrate several features of rural energy projects which ensured the success of the initiative and which would be useful to apply to new community energy projects in the LAC Region. These features are divided into the following categories:

- Existing infrastructure and enabling policies
- Needs assessment
- Choice of energy technology
- Community ownership and structure
- Funding and financing

Existing infrastructure and enabling policies

Several projects showed that having an existing organization in the community that had experience in some of the capabilities needed was extremely beneficial. These required capabilities were not necessarily technical. Experience in delivering community services and micro-finance are often all that was needed.

In the Sagardeep project, the West Bengal Renewable Energy Development Agency (WBREDA) had been operating in the area installing solar home systems before the project started, and was well known in the community. In Sri Lanka, trust among consumers about renewable energy technology was established by using existing financial infrastructure in organizations such as SEEDS for awareness building, micro finance and technical support. In the Char Montez in Bangladesh, the community already had experience with micro-credit, and local NGOs were working on providing other community services, before the project started.

Another important enabling feature for a successful project is to have government objectives, policies and/or programs in place that support the provision of community energy services. Having a national rural electrification program in India, and giving the Sagardeep project a special demonstration program status, helped in both the funding and the implementation process. In Sri Lanka, the government provides quality assurance to ensure that systems purchased under the Energy Services Delivery (ESD) program are installed properly. The Sri Lankan government also supports the ESD program by including it in its rural energy strategy, building awareness of rural energy options, and helping to establish a sound supply industry (through requirements for warranties, industry associations, training and accreditation of installers, etc.)

Needs assessment

Two of the projects undertook detailed assessments of the energy needs in the community that were used to help design and plan the project. In the Mbuiri Village project in Kenya, different needs were identified for men (power for community enterprises) and women (clean water). It is unfortunate that the energy needs identified by men in the community were given priority, and the project still has not met women's needs. This appears to occur quite often in community energy projects. For example, biogas generators are seldom built with latrines (a need often identified by women). It is important to design community energy projects to ensure women's needs are met. This was done in the Char Montez project in Bangladesh, where energy needs surveys of local women were undertaken by women staff members of NGOs and consultants before the project commenced. Women were also the owners and employees of the project.

Choice of energy technology

The Char Montez project in Bangladesh demonstrated how important it is to start with simple low cost energy products such as battery powered lamps, moving to more complex products such as solar PV lighting and battery chargers as the enterprise gains experience and cash flow. Starting with low cost simple products meant that cash sales were possible while a micro-credit scheme was developed, and the community enterprise could hire a relatively unskilled workforce and then add more complex products as cash flow and worker capability improved.

Another important aspect of technology is to create a structure that can source a variety of accredited product suppliers to keep prices competitive and to ensure product innovation. SEEDS was able to do this effectively in Sri Lanka for solar home systems.

An interesting feature of the Maphephetheni project in South Africa was the integration of several different technologies. This reduced overhead costs for training, travel, supervision and marketing. Those trained for installation and maintenance of solar technologies were utilized for school and clinics as well as homes, increasing the value derived for their training.

Community ownership and structure

The structure of the community enterprise established to deliver the rural energy technology or service is an important feature of any rural energy project.

In the Sagardeep project, a cooperative operating structure was used for the mini-grid (owned by the customers), and local banks were used for the mini-grid accounts. This increased the feeling of local ownership of the project.

Cooperative ownership was also used in the Char Montez project in Bangladesh where the women employed by the lighting enterprise were also the owners. This ensured democratic operation and a level of interest to maintain the enterprise. It was found that if women owned and operated energy enterprises, the quality of life, income, and status of women in the community was also improved. In the Maphephetheni project in South Africa it was also found that women were more successful at sales and were generally more reliable and delivered 'neater' installations of solar home systems.

Another successful model is community ownership supported in the early years by external managerial and technical assistance. In the Maphephetheni project in South Africa, the community itself owned and operated the solar home system supply and loan system. The Energy Committee which managed the project built its success on an existing spirit of community cooperation coupled with some outside technical and managerial expertise for capacity building from SES and SELF. Community ownership and operation was also used in the Mbuiri Village project in Kenya, with the community-based organization offering both cash and sweat equity shares. This organization established the uses for the generated power, thereby acting as development agency as well. Women are involved in management, and thereby have stronger influence in community development. The inclusion of sweat equity shares allowed participation of the lowest income villagers.

Another important feature of a successful community structure is to use or set up a body that can both supply and install technologies and provide the financing. The experience in Sri Lanka shows that using a well-established organization like SEEDS that offered both installation and financing provides the most effective delivery model for the ESD.

A final important element of an effective community structure is to have outside expertise available to provide training and technical support during the first few years. In the Mbuiri Village project in Kenya, the local development NGO, ITDG provided expertise and training. In the Maphephetheni project in South Africa SES and SELF provided the same services.

Funding and financing

All of the case studies showed that some form of up front capital grant/investment is needed for a sustainable community rural energy project. This was true for the establishment of a renewable energy mini- grid as in the Sagardeep project, the setting and training of the micro-enterprise in the Char Montez project in Bangladesh, and the purchase of an initial batch of solar home systems in the Kenya Mbuiri village project. Once these capital/ set up costs have been covered, most projects can then sustain themselves on a cost recovery basis through revenue for products or services.

- In the Sagardeep project, like many rural electrification programs, the solar mini-grids were only financially viable when their capital costs were funded by government investment. Operating costs were covered by revenues.

- In Sri Lanka, sufficient front end funding was provided to set up the ESD program and build capacity.

- In the Maphephetheni project in South Africa, grant financing was needed to provide the outside expertise and pay for the set up and initial management of the community organization.

- In the Mbuiri Village project in Kenya and in Char Montez, Bangladesh, core funding was made available for training and establishment of the enterprise during the first few years.

Once a project has been set up, an effective structure must be set up to recover operating and maintenance costs or build a revolving fund to purchase more products. Payments should be made for services provided (power from mini-grid) or the product purchased. In the latter case, micro-credit is effective in making the payments for the new technology, similar to those previously made to purchase kerosene, wood fuel, or other conventional energy source.

It may be necessary to partially subsidize some products to make them affordable to low income families - at least during the early days of the program. This is done in the Sri Lanka ESD program for solar home systems.

In the Sagardeep project, it was found that in a mini-grid, a fixed flat fee pricing system based on an average consumption was abused by some customers. Metered consumption was more effective.

Using existing financial institutions for loans and micro-credit was also a feature of several projects. In Sri Lanka, existing financing infrastructures like SEEDS are used to build awareness of the ESD program as well as provide micro finance and technical support. An existing financial institution – the Kenya Finance Corporation – was used in the Mbuiri Village project in Kenya.

The Maphephetheni project in South Africa uses micro credit to finance solar home systems (SHS). However, there have been quite a large number of loan defaults on the project resulting in repossession of the systems. This is mainly because SHS are quite expensive and current loan periods are only 3 or 4 years. A SHS project will not reach all community members unless longer loan periods are provided, or some form of rental or lease financing is introduced. Loan guarantees from outside agencies would help to reduce the risks of these longer terms.

All the projects except the Sri Lanka ESD originated in the community and therefore had the required community infrastructure and community support built into the project as well as the financing. In Sri Lanka, the “top down” approach to financing and promotion has its limitations and needs to be supplemented with a community demand initiative driven by existing community development NGOs and local governments who are delivering other non-energy services.

Conclusions

A summary of the lessons learned from the case studies is shown in Table 1. Analysis of the five case studies showed that the basic requirements for a successful rural energy project that provides local income generation, meets local needs defined by both men and women, is sustainable and can be replicated in other communities, and improves the status and capabilities of women, has the following characteristics:

1. Some experience and capability in community development already exists in the community
2. The national government has some policy or program support that includes improving access to energy in rural areas (rural electrification etc.) – at least in the form of a target or intent.
3. An energy needs assessment is carried out at the outset of the project involving defining both men and women's needs.
4. The design of the project is focused on women's needs and/or involves them in the project as owners, managers, advisors or employees.
5. The project starts by offering simple low cost energy products that can be purchased for cash or credit, moving on to more complex and expensive products as production experience and credit systems evolve.
6. The project has access to a number of product suppliers to keep costs competitive and encourage innovation.
7. Several target sectors (e.g. households, schools, community centers) are served by a single project to keep overheads and training costs down.
8. The project is delivered by a community or cooperatively owned organization that offers both financial and sweat equity shares.
9. The delivering organization is owned and operated mostly by women.
10. The delivering organization offers both technical and financial (credit) services, using local banks and other existing community infrastructure for financial accounting and other services
11. External technical and management assistance is available during the first few years of operation.
12. Capital or set up grants or investments are available at the beginning of the project, after which the project becomes self-sustaining through cost recovery for products and services rendered.
13. Mini-grid power is provided to users on a metered basis.
14. Micro-credit loan of at least 3 years are provided. Defaults could be minimized by offering longer terms and securing external loan guarantees.

Table 1: Summary of Lessons Learned

	Case Study 1 Char Montez, Bangladesh	Case Study 2 Mbuiri Village, Kenya	Case Study 3 Maphephetheni Development Program, Natal Province, SA	Case Study 4 Sri Lanka Energy Services Development Project	Case Study 5 Sagardeep Is., India
Existing infrastructure and enabling policies	Community had experience with micro-credit and active NGOs			Trusted well-known organization (SEEDS) used for project delivery. Linked to national Energy Services Delivery Program.	Established community enterprise used to delivery project. Area designated under Special regional Government and rural power programs.
Needs Assessment	Women energy needs identified by women staff. Women owners and employees of enterprise	Women's (clean water) and men's (income generation) energy needs identified separately.			
Choice of energy technology	Project started with simple technology and few credit sales that fostered cash flow. Expanded to more complex products and micro-credit system.		Integration of several technologies reduced overheads and expanded the skill sets of trainees	A variety of product suppliers kept prices competitive and encouraged innovation	
Community ownership &	Cooperative ownership by	Community based structure used both	Community ownership of project	SEEDS effective because it delivers both technical	Cooperative ownership of mini-grid and use of

structure	women employees improved status of women as well as quality of life. Women more successful at sales and delivered neater installations.	case and sweat equity to allow all to have a stake in the rural energy organization which also acts as development agency by establishing energy needs met. Sound external advice provided by ITDG	successfully built on existing spirit of community cooperation. Good outside technical and management assistance provided to the community (SELF, SES).	and micro-credit services.	local banks increased feeling of ownership.
	Case Study 1 Char Montez, Bangladesh	**Case Study 2 Mbuiri Village, Kenya**	**Case Study 3 Maphephetheni Dev Program, Natal Province, SA**	**Case Study 4 Sri Lanka Energy Services Dev Project**	**Case Study 5 Sagardeep Is., India**
Funding and financing	Core funding needed to set up enterprise and provide training. Users pay full price for products. Micro-credit successfully used for credit sales.	Core funding needed to set up enterprise and provide training. Existing financial institution (KFC) used to provide micro finance.	Grant financing needed to provide outside expertise and set up community structure. Longer loan periods (>4 years) needed to make products affordable to all.	Capacity built through ESD Program. GEF Subsidy Payments make solar systems affordable. Top down financing requires active and experienced delivery agents (SEEDS)	Capital grant used to fund mini-grid. Maintenance and management costs recovered through power charges. Metered consumption more effective than flat fee

Further Reading and Web Sites

Global Village Energy Partnership (GVEP)

The Global Village Energy Partnership www.gvep.org brings together developing and industrialized country governments, public and private organizations, multilateral institutions, consumers and others in an effort to ensure access to modern energy services by the poor. GVEP aims to help reduce poverty and enhance economic and social development for millions around the world. Its work will be carried out under a 10-year "implementation based" program. The Partnership's objectives are to:

- Catalyze country commitments to village energy programs and guide policies and investment in this area.
- Bridge the gap between investors, entrepreneurs and energy users in the design, installation and operation of replicable energy-poverty projects.
- Facilitate policy and market regulatory frameworks to scale up the availability of energy services.
- Serve as marketplace for information and best practices on the effective development and implementation of energy-poverty projects/programs.
- Create and maintain an effective coordination mechanism for addressing energy-poverty needs.

The Global Village Energy Partnership builds on existing experience and adds value to the work of its individual partners. It reaches out to non-energy organizations in the health, education, agriculture, transport and enterprise sectors, and offers a range of technology solutions to meet their needs. This covers renewable energy, energy efficiency, modern biomass, liquefied petroleum gas (LPG) and cleaner fossil fuels. The Partnership will help achieve the internationally recognized Millennium Development Goals. The partnership will also address gender issues in order to reduce health and environmental hazards and increase social and economic welfare; it will build on the knowledge and capacity of each member of the community in energy service delivery and use.

Integrated Renewable Energy for Rural Communities

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http://www.elsevier.com/wps/find/bookdescription.cws_home/703319/description

"More than two billion people worldwide have currently no access to grid electricity or other efficient energy supply. This is one third of humanity and the majority live in rural areas. The productivity and health of these people are diminished by reliance on traditional fuels and technologies, with women and children suffering most. Energy is the key element to empower people and ensure water, food and fodder supply as well as rural development. Therefore access to energy should be treated as the fundamental right to everybody. Renewable energy has the potential to bring power, not only in the literal sense, to communities by transforming their prospects. This book offers options that meet the needs of people and communities for energy and engage them in identifying and planning their own provision. It describes updated renewable energy technologies and offers strategies and guidelines for the planning and implementation of sustainable energy supply for individuals and communities."

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* Calculating energy and food production potential and requirements.
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* Economic dimensions.
* Legislative structures.

RE Focus Magazine: http://www.re-focus.net

This magazine now available in electronic format includes many articles on rural energy development. The recent January/February 2005 issue includes:
Solar Home Systems – Offering Credit and Ensuring Recovery (Sunderasan Srinivasan)
Rural Electrification – Big Markets, Big Challenges (Sebastian Golz)

Other Web Sites

Renewable Energy Information Network: http://www.lged-rein.org/

Sparknet: http://sparknet.info/home.php

ITDG: http://www.itdg.org/?id=home

TVE – Hands On: http://www.tve.org/ho/