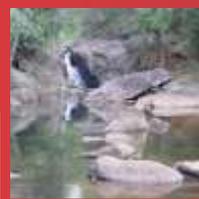


INTERNATIONAL CONFERENCE ON ENERGY ACCESS • 9-10 October 2012 • New Delhi, India

The Energy Access Challenge - Approaches by IT Power

A compendium of global clean energy case studies
for productive applications in rural areas



An outreach initiative by IT Power India





Disclaimer

The contents of this booklet reflect synopses of project activities worked on by IT Power in various countries in collaboration with partners. The facts and figures mentioned are as per the project period, followed by current updates in certain cases.

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October 2012

Acknowledgements

IT Power India would like to express its sincere appreciation to the IT Power Australia and UK offices for their content support.

The team effort of the following in the preparation of this booklet is acknowledged:

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Dr. Farooq Abdullah
Minister of New and Renewable Energy, India

Message

Expanding access to clean, reliable and affordable energy is a key catalyst to alleviate poverty and spur economic and social development in any country or region. The International Energy Agency (IEA) estimates that nearly 1.3 billion people around the world lack access to commercial electricity, while over 2.5 billion people continue to rely on traditional biomass for cooking. In India too, it is estimated that around 400 million people still lack access to commercial electricity; about 855 million rely on firewood, animal dung and agricultural residues for cooking and heating; and more than 100,000 villages are yet to be fully electrified. The annual per capita consumption of electricity in rural areas still hovers around 96 kWh as against a national average of 780 kWh.

Therefore, the challenges before us are to ensure that energy access happens rapidly, while ensuring that sustainability related constraints are not violated. I am of the firm view that renewable energy technologies, which permit local control of energy resources and power generating systems, and are suitable to smaller applications, can offer a viable means of providing electricity and clean fuel to presently un-served people, mostly in remote and rural areas. However, this requires tremendous innovation in technology choices, supportive policy frameworks, and mobilisation of additional public and private financial resources. It is here that nations would need to come together and work towards formulating strategies, sharing technologies and jointly facing the challenge of providing energy access sustainably and economically.

It is in this context that the Ministry of New and Renewable Energy, Government of India is organising an International Seminar on 'Energy Access'. The timing of this seminar is most appropriate as the UN has already declared this year as the 'International Year of Sustainable Energy for All'. I do hope that the seminar will afford multiple stakeholders the opportunity to share a common platform and jointly address issues of access and affordability. I also hope that the outcomes of the Seminar will provide credible road maps towards the goal of ensuring abundant clean and affordable energy for the citizens of the world.

Introduction

IT Power Group, in its 30 years of legacy, has worked on several sustainable energy projects that provide innovative approaches for addressing the energy access challenge.

Established in the UK in 1981 as IT Power, the Group now has a global network of offices in Africa, Australia, China, India and Latin America, in addition to its HQ in the UK. The company has delivered more than 1,500 sustainable energy projects in over 120 countries.

In this Compendium, we have compiled some select case studies that depict sustainable approaches to the energy access challenge across the globe. Most of these have helped promote productive applications in rural areas.

The International Conference on Energy Access in October 2012 in New Delhi organised by the central Ministry of New and Renewable Energy (MNRE) is a strong commitment of the Government of India to advance the agenda of energy access, a crucial component of sustainable development. It is an important initiative to provide an accessible platform to those who are committed to work towards addressing the challenge of energy access, particularly in developing countries.

IT Power India is proud to be associated with MNRE as Knowledge Partner for selected sessions of this Conference. It is hoped that the launch of this Compendium at this important event, will help accelerate more such initiatives in this sector and also identify and confront the challenges ahead.

Akanksha Chaurey, PhD
CEO, IT Power India

Bolivia & Paraguay: Linking income-generating activities and micro-enterprises with energy services for the poor

Project Fact Sheet

Challenges

The *Gran Chaco* region which spans 647,500 sq km is an extensive lowland plain in central South America. It is sparsely populated and extends across Paraguay, Bolivia, and Argentina. Some of the highest temperatures in the southern continent are attained in this region. To the north of the Pilcomayo River and to the west of the Paraguay River is a section known as the Chaco Boreal, most of which belongs to Paraguay. This is mostly arid land, dotted with swamps in the rainy season, with stretches of dense forest.

In 2001, the *Gran Chaco* had a population of about 4,000,000 inhabitants. In almost the entire region, aboriginal populations co-exist with descendants from different migratory populations, basically from European countries. The aboriginal population amounts to 100,000 inhabitants (approximately 2.5% of the total population), distributed among the three countries.

The *Gran Chaco* has enormous environmental and biological diversity. *After the Brazilian tropical forests, the Chaco is the second largest forest in Latin America.* However, increasing degradation of natural resources is leading to an important loss of biodiversity.

The Chaco region is one of the poorest natural regions in Latin America. Over 60% of the region's population lives below the poverty line. The rural population is strongly affected by the degradation of natural resources. The lack of income alternatives, insufficient basic services in health and education, no access to funding or communication, and frequent lack of equality and clarity regarding ownership of the land, has worsened the situation.

The main reasons for the poverty are:

- *Unequal access to information and knowledge*
- *Insufficient mediation in interests at the horizontal and vertical levels*
- *Little coordination among the various actors, and isolated actions*
- *Non-leveraged synergies, risk of overlapping and contradictions*
- *Asymmetries in the management of natural resources in the three countries*

Therefore, this project was initiated to address and alleviate the situation, and in the process develop methodologies, tools and training material that could be used throughout Latin America.



Funded by the European Commission, the Coordinator of the Crecer Con Energia (CCE) project was IT Power (UK) and the European partners were TramaTecnó Ambiental (Spain), Advies bureauvoorEnergiestrategie - AES (The Netherlands), Transénergie (France) and Planet Finance (France). The partners in South America were Instituto Nacional de Tecnología y Normativa - INTN (Paraguay), ESENERG (Paraguay), Energética (Bolivia), CINER (Bolivia) and ANED (Bolivia).



Activities

The project's objective was to link income-generating activities and micro-enterprises with Energy Services for the Poor in the Chaco Region in Paraguay and Bolivia. There were several activities carried out in order to create these linkages. A horizontal cross-linking communication platform was created that stimulated dialogue between all ministries and organisations involved in rural development and poverty reduction. A Social Cabinet for the Crecer Con Energia (CCE) project was created in Paraguay with representatives of the main ministers and agencies. The Declaración of Asunción was adopted during the final Regional Workshop in Paraguay in 2008 ensuring full cooperation from both governments.

Results & Successes

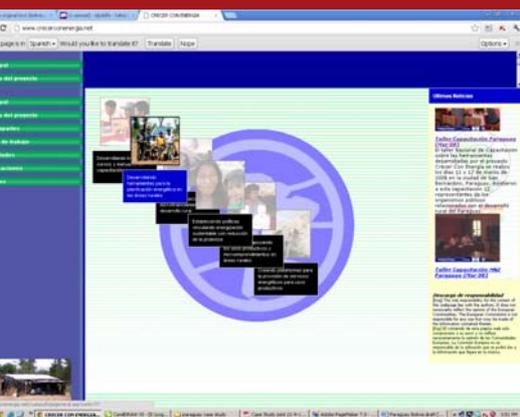
A key result from this project was a review document on the *Current energy policy linkages with the PRSPs (Poverty Reduction Strategy Papers) and sectoral priorities in Paraguay and Bolivia*. This document proved to be a key contribution to the ongoing review process of the PRSPs, which are revised and reissued approximately every three years.

The project also produced the following key documents and tools:

- An *Electrification Planning Tool* to be used by the energy ministries and Renewable Energy Agencies (REAs) to assist with the selection and identification of appropriate rural electrification options. This tool was divided into two:
 - A *General planning tool for Programmes* which describes a methodology oriented towards helping programme developers. It contains, among other things, multi-criteria decision analysis, integrated approach for programme development taking into account the specific reality of the region, and
 - A *Specific technical and financial tool for Projects* for project developers that includes demand forecast, technical pre-design, levelised cost comparison, and financial design and evaluation for project sustainability.
- A toolkit series on *Microfinance for Energy*.
- Three manuals for *Monitoring and evaluation of energy projects for social development, Monitoring and evaluation frameworks and indicator, and Monitoring and evaluating energy related programmes and projects*.

Training sessions for key staff members of ministers' offices as well as relevant non-governmental organisations (NGOs) were organised along with national consultative and regional dissemination workshops. Awareness generation programmes for local communities were held to emphasise that Sustainable Energy Services support income-generating activities.

An important part of the project was information dissemination and, hence, a project website (in the local language) was created at www.crecerconenergia.net. It includes an introduction, project description, partner description, news, feedback page, links and more. In addition, CCE newsletters were published and are available on the website, along with all project reports, summaries and tools produced.



Ecuador: Pico-hydro technologies promote rural development

Project Fact Sheet

In Ecuador in the year 2000, a large proportion of the 250,000 un-electrified low-income families lived within 300 metres of small streams in which pico-hydro systems could be installed for an individual or group of households. The Ecuadorian Ministry of Energy and Mines (MEM) was hence looking to stimulate the small-scale electrification market in the country. The other reasons were emerging potential for energy services, and sufficient capacity and willingness-to-pay for electricity by a large population of these un-electrified rural households.

Individual pico-hydro has been found to be one of the most affordable sources of electricity, especially for community-based projects. The life-cycle costs for pico-hydro ranges between US\$74 to US\$150, compared to the life-cycle costs of solar, hybrid, wind or fossil fuel-based options which start at US\$140 per household per year. In addition, a pico-hydro unit can provide power at 220 V AC instead of 12 V (from PV-SHS), which then requires expensive inverters to upgrade to AC power.

Challenges

By the year 2000, pico-hydro technology had widespread deployment in Asian countries such as Vietnam, China and Nepal. But even though hundreds of systems were installed, the poor quality and unreliable systems that dominated the market created a poor image for this technology. For example, less than half of the 120,000 units installed in rural areas of Vietnam were operating.

Also, only a few international donors or national governments were aware of the potential for pico-hydro in rural development programmes.

Project Activities

Since good quality systems were finally becoming available, and were substantially cheaper and more cost-effective than other options for electricity generation in many cases, the main aim of this World Bank-ESMAP (*Energy Sector Management Assistance Programme*) project was to help make pico-hydro more accessible to low-income households in Ecuador, with the view to replicate this technology in the Andean region and other developing countries.

This was done through five main activities – (i) assessing the main experiences in pico-hydro technology and market developments, looking particularly at Vietnam and the Philippines through a UK-government supported associated project, (ii) reviewing the existing use of micro-hydro in five Andean countries and assessing their potential pico-hydro market, (iii) establishing 29 pilot pico-hydro projects in five villages of two provinces of Ecuador with full participation of the end-users in local communities; (iv) encouraging sustainable local infrastructure for supporting pico-hydro technology in Ecuador through training local technicians and bringing local dealers forward to consider pico-hydro as a business venture, and (v) conducting a rapid rural appraisal in the communities before and



Pico-hydro Technology

Pico-hydro systems typically have capacities between 200-1000 watts of electrical power, but can include systems up to 5 kW. They are generally used for domestic electricity applications such as lighting, TV/radios and battery-charging. The units are small and cheap and are typically owned, installed and utilised by a single family, hence their commonly used name of ‘family-hydro’.

The ESMAP project was undertaken by IT Power UK as the international and lead consultant and TramaTecnAmbiental (TTA) – Ecuador as the local consultant, with specialist input from Ing. Milton Balseca, a local hydro expert and currently Minister of Energy and Mines of Ecuador.

The international and local consultants engaged all the relevant stakeholders in order to achieve the outputs for the project. This included the installers of systems, the end-users themselves, potential future dealers for pico-hydro technology, other government bodies interested in integrating pico-hydro into their electrification plans, state electricity utilities, NGOs and rural development operatives. At the same time, because of the international nature of the project, contact was maintained with suppliers of pico-hydro technology from Vietnam, and groups in other Andean countries and nations in Latin America interested in developing markets for pico-hydro.



Pico-hydro installed in Ecuador for family use

Market size for pico-hydro in the Andean Region

Country	Non-electrified rural households	Technical achievable no. of households that could use pico-hydro	Range of genuine household market, based on capacity and willingness to pay
Bolivia	515,815	355,000	55,000 – 109,000
Peru	1,462,783	671,000	98,000 – 197,000
Ecuador	249,199	137,000	16,000 – 32,000
Colombia	127,343	39,000	7,000 – 14,000
Venezuela	72,170	28,000	4,500 – 9,000
Total	2,427,310	1,230,000	180,500 – 361,000

Costs

With completion of the pilot demonstrations, the costs associated with deployment were US\$475 per unit with estimated operational and maintenance costs of US\$5 per year. Given a conservative equipment life of only five years, an end-user would need to save US\$95 per year to purchase another pico-hydro system. Given these costs, the opportunities for further expansion of the market for good quality pico-hydro products within Ecuador and neighbouring Andean Region countries and other parts of Latin America, clearly now exists.

after the installation of the pico-hydro pilots to consider the technological and social impacts in the Ecuadorian situation.

Nine pilot projects were installed in Chimborazo in the Andes Mountains and twenty in Napo in the lowland Amazonian rainforest. These projects have provided lighting and reliable AC power for a total of 193 people. The units are all operating, and continue to be used even in the village that subsequently had a grid connection.

Impact of the Project

- It has been proven that a dealer-based, private sector-led approach to pico-hydro projects can be financially viable. A deeper understanding about how to build local infrastructure for the commercialisation of pico-hydro in Ecuador has been gained.
- This project has enabled MEM to present one more hydro-based option within their current rural electrification programme in Ecuador.
- The benefits to users include better quality of life and better lighting systems enabling community activities during the evenings. The beneficiaries have pointed out that fuel has been saved, and productive outputs as well as opportunities for educational and social activities have increased.
- Through training, users have now developed confidence in maintaining the pico-hydro systems and have also acquired additional skills.

Recommendations for Future Actions

In Ecuador, much more awareness is required in rural areas of the potential benefits of this technology over other forms of off-grid electrification (e.g. diesel gensets). However, financial support may still be required to enable the poorest customers to be able to afford a good-quality pico-hydro system.

A more thorough understanding of the latest technology through inputs from manufacturers and suppliers from Asia will give local dealers confidence in the pico-hydro systems. Many more potential dealers would come forward if a proper evaluation is done of the actual market conditions and of how pico-hydro can add value to products and provide income-generating opportunities.

In order to make this model commercially viable and to scale-up pico-hydro in developing countries, it is now required to establish standards and certification/licensing for the products; provide technical support for feasibility studies, site level installation, operation, and maintenance and warranty; and for close community liaison to determine how pico-hydro technology is best organised at the end-user level. Beneficiaries need to take on their share of responsibility for achieving the sustainable deployment of pico-hydro projects in the locations where they are most needed, especially by offering their labour and local materials to reduce initial capital costs, paying for and carrying out proper operation and maintenance, and using the technology as per the specifications.

Support is required for quality assurance/licensing of the equipment from national energy ministries together with universities that have appropriate testing facilities; and to stimulate easier import of technology and new sales infrastructure through regional bodies and the appropriate government departments. Seed money is also required to help institutions set up engineering support services from international agencies. This can also be done in conjunction with the private sector [dealers, rural energy service companies (RESCOs) rural banks, entrepreneurs, etc.] as well as non-government organisations (NGOs).

Honduras: Linking income-generating activities and micro enterprises with energy services

Project Fact Sheet

Challenges

In 2007, the Government of Honduras was awarded a loan from the World Bank-supported Project of Rural Infrastructure for the construction of at least two Micro Hydro Power (MHP) Stations. These MHP plants designed earlier by IT Power, with an installed capacity of 63 kW and 86 kW (Las Champas and La Atravesada) respectively, were expected to provide electricity to a total of 300 homes in six rural communities.

The general practice surrounding the design of the MHP projects was centred on the accomplishment of specific technical goals, expectations and results, with little emphasis on development tools applied to sustainability. However, as experience has shown in countries that have succeeded in the sustainable operation of MHPs, such as Peru and Nepal (where conditions are similar to those in Honduras), long-term sustainability is defined by a large variety of factors. With this background, the World Bank advised the design of the Honduran MHP projects to be based on three fundamental principles:

- Use of electricity as a driver for socio-economic development
- Building of institutional and technical capacity of all participating stakeholders
- Monitoring and evaluation of the project, its implementation, and lessons-learned as seen from the perspective of the end-user

In designing the project in Honduras, several productive applications (by region) were identified and evaluated. Each of these applications were designed based on the socio-economic conditions of each community and their past productive vocation. The GAPFund project was designed to complement and support the construction phase of these MHPs by increasing awareness among rural developers of the synergies between projected commercial activities, community development, new microenterprise initiatives and the level of energy services to be provided.

In close coordination with the communities and stakeholders in these areas, a methodology was developed for implementing income-generation activities and micro finance models for productive applications that were supported by renewable energy projects. This methodology was then applied at the two MHP locations and its main components included:

- Analysis of local markets: availability of raw materials, access to markets, commercialisation, range of market, etc.
- Local market-based technological analysis
- Financial analysis
- Linking energy needs to financing and micro enterprise



IT Power, through the GAPFund facility developed two “Best Practice” enterprise models in the delivery and appropriate use of renewable energy technologies for sustainable rural development. This was planned through creation of income-generating applications that enhanced the quality of life of the families involved, while providing additional income to pay for the electricity services provided.





Tools, in the form of manuals and training programmes, were developed that supported, encouraged and strengthened capacity development activities and facilitated the financing of rural microenterprises focusing on sustainable energy technologies and services.

A set of documents (reports, technical guidelines, micro credit guidelines, training procedures, M&E plan model) were produced that could be used by the Government to develop sustainable productive uses in newly electrified communities.



One of the objectives of this project was the possibility of replication. To help replicate training activities in other communities in Honduras, a toolkit was developed to train instructors and to conduct advanced training programmes. Another document was prepared on the recommended mechanism for providing micro-financing services to the rural sector. The manual aims at capacity building in the establishment and implementation of such financial services and describes financial policies specific to the rural sector. It identifies the human resources required, and explains how these should be structured to provide such services, as well as regulations, procedures, support forms, etc.

The methodology described in this manual could be adopted or customised by any micro-financing institution (MFI) that wants to provide a financial service in rural areas. Hence, the manual is also useful for capacity building of credit officials from an MFI.

Activity Results

The two Best Practice demonstration projects using renewable power from the MHPs were designed for income-generating applications. The enterprise designed for the Las Champas community and its surroundings in the Municipality of Irione was for a select market of meat consumers. The population in this area was approximately 3,161, where most of the families consumed at least 1.5 pounds of meat a day.

The enterprise design for “La Atravesada” Coffee House included the purchase of beans, pulp removal and drying (in an organic manner), packaging and sales. The project, due to the level of coffee bean production in the area and the transformation of only 120,000 pounds of dry Pergamino coffee, would use electrical machinery for pulp removal, washing and drying. The set-up of the enterprise would make it easier for the partners to sell their product collectively and thus negotiate better prices.

In addition to the above, the following were also developed in the local language (Spanish):

- Guidelines to evaluate the connection between rural energy services and income-generating activities, including information that helps final users, project developers and micro financing institutions identify productive uses (by making recommendations on appropriate equipment and providing estimates on the investment and recurrent costs as well as operation and maintenance requirements)
- A micro-credit model to promote and improve access to financing for income-generating activities resulting from usage of energy from MHPs in Honduras
- A manual for business development advisory services for rural micro entrepreneurs in Honduras, including a catalogue of Financial Services with information on the types of financial and technical services provided as well as a comparison of different credit schemes
- Training/capacity building events designed specifically for the two communities where the MHPs were being installed, on MHP-based rural enterprises, along with training manuals for potential micro enterprises
- A Monitoring and Evaluation programme with guidelines for policy makers and project implementers to understand the impact of productive activities associated with the electrification process (with an emphasis on the reduction of poverty and indicators related to the Millennium Development Goals)

The two MHPs were commissioned recently in 2011.

India: Upgrading water mills to increase rural productivity

Project Fact Sheet

Challenges

The most elementary use of hydropower in the Himalayas has been in traditional water mills (or *gharats*) for grinding grain. Their widespread popularity was primarily due to the simple and cost-effective technology used.

Uttarakhand, in the Indian Himalayas is a mountainous state with rugged terrain. There are several perennial streams, rivulets and rivers in this part of the country wherein water mills located at the banks of these streams and rivers have been a part of all villagers' lives. There are believed to be about 200,000 waterwheels in India alone and many thousands more in Nepal, Pakistan, Myanmar, etc.

As the low-efficient traditional water mills could not cater to the increasing processing needs of people, many of these were abandoned for other better income-generating opportunities, sometimes far away in the plains; while the existing ones face stiff competition from diesel mills.

Almost all the water millers in the Himalayan region belong to the poorer sections of hill societies. Considering the annual aggregate income from milling, agriculture and livestock farming, the per capita income of a water miller family is 60 US cents/day, that is below the \$1 a day benchmark of absolute poverty.

IT Power India has been working with the water millers' community in the Indian Himalayas since 1996 to help bring about improvements in the way these communities harness water resources. IT Power India interventions involved small steps that were understandable to the community in the areas of hydro-mechanical technology, civil constructions, business and financial systems and eventually, information and communication technologies. These interventions, with emphasis on technology transfer and local capacity building, resulted in reviving a centuries old tradition using appropriate technologies. These activities also attracted support from agencies such as DfID, EAP, UNAID, UNDP/GEF, UNESCO and USAID.

Economics

As is the situation at most watermills, the local people pay for the service in kind. They bring their own grains to the mill to be ground, and on completion of the task they leave behind a percentage of the flour as payment to the miller. This payment is known locally as "bhagwari". The bhagwari varies depending upon the amount ground but is always in the range of 5-10%, with an average of 7.5%. The miller then sells this flour in the village for cash. He normally charges \$0.15 per kg, whereas the market price is typically \$0.19 per kg. He also takes from the bhagwari the full annual flour consumption of his family.



Two levels of upgrade have been developed under a project funded by the UK Department for International Development (DfID):

- The New-Gharat: a basic upgrade to the traditional watermill so as to maximise the milling output and compete effectively with diesel mills.



New gharat

- The Open-Crossflow: a low-cost crossflow turbine to develop at least 5 kW for operating a range of agro-processing machinery, plus generating electricity.



Open crossflow

Both turbines have been designed as simple, robust agricultural machines. They are manufactured in India and can be maintained by local technicians. They have been developed by IT Power in collaboration with Evans Engineering of the UK and transferred to a local manufacturer, Gita Pumps in Saharanpur. Local assistance was provided by Himalayan Environmental Studies and Conservation Organisation (HESCO) and the Chamoli Watermill Association.

The design drawings for both machines and the Business Model Report (to encourage rural and agricultural banks to offer appropriate finance for new projects, and includes an overview of the technical, financial, social and market characteristics of watermill upgrades) are available as a free PDF download from www.itpower.co.uk/watermills/

Escalating Effects

Following ITPI's work, CRT Nepal began upgrading mills using precision metal and synthetic parts. More durable than the original wood, they not only last longer, but grind faster and can work with less water. Estimates suggest that grinding capacity has doubled. The parts are manufactured locally by approved suppliers, generating much-needed employment, while subsidies cover some of the cost. Basic upgrades cost about \$350, whilst an extra \$700 adds the option of running a rice-huller, sawmill or electric generator.

By 2009, 5,700 water mills had been upgraded, providing better services to about 300,000 families. They have also decreased the use of CO₂-emitting diesel-powered mills which previously had been increasing as the traditional mills struggled with demand.

Operating a watermill is now a profitable one. Operators are expanding their activities and forming associations. And their clients are, in the words of one user, having shorter waits for better tasting bread.



An upgraded mill allows a miller to grind grain more efficiently

Both IT Power India and CRT Nepal are Ashden Award winners for their work on upgrading watermills (<http://www.ashden.org>).

The total cost of the equipment for the upgrade, including civil works, was approximately \$283 and the mill generates a cash surplus in a typical year of \$377. Payback for this upgrade can therefore be seen to be extremely rapid. The main economic parameters for the scheme are summarised in the above table.

Project Costs			
Project Cost		\$	289
Annual O&M costs		\$/year	39
Business Income			
Total annual Bhagwari		kg/year	58
Annual Bhagwari Wheat	60%	kg/year	35
Annual Bhagwari Millet	40%	kg/year	23
Bhagwari Wheat Price		\$/kg	0.15
Bhagwari Millet Price		\$/kg	0.11
Annual Income		\$	420

Results

A social impact assessment concluded that upgraded watermills were perceived as a faster and cheaper means of grinding flour. For the end-users, principally women, the upgraded watermills helped save them both time and money. The quality of the flour was also considered to be the best available. The income generated is sufficient for millers to run their business as their sole source of income.

Today, the technology for watermill upgrades is proven, understood and being manufactured locally. Capacity has been developed in the region to specify, own and operate these upgraded watermills. But a critical mass of installations still exists to increase the scale of efforts. A business framework involving the miller, watermill association, manufacturers and local banks needs to be galvanised to facilitate widespread uptake of this technology

IT Power India has currently been engaged by GIZ for the project *Assessment and improvement of the existing "Improved Watermills Programme" in Uttarakhand*. The project aims to address the challenges faced in the Improved Watermills Scheme in the state by documenting and recommending improvements for existing business models as well as exploring opportunities to develop a financing scheme together with the local banking sector to provide financing for mill owners willing to upgrade their water mills. As part of this project, IT Power India recently (in September 2012) conducted a stakeholders' workshop in Dehradun which was attended by watermill owners, NGOs, financing institutions as well as watermill manufacturers.

*Conversion rate has been taken as Rs 53 = 1 US\$

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India, Morocco & Nepal: Addressing quality issues in solar rural electrification

Project Fact Sheet

Challenges

Standalone solar PV systems can provide electricity reliably over many years, meeting electricity demands of households in remote rural areas where grid extension may not be possible. Yet efforts in this direction had mixed results. In the early 2000s, most project evaluations showed that a considerable number of these systems were not working anymore or only met part of the design load. Local or regional quality control systems were not in place. Technical failures often led to high costs for users, disappointment with solar energy solutions and resulted in strong negative publicity for solar rural electrification. This was often a reason for stopping credit installments. Thus, preventing technical problems was one of the main driving forces behind activities to enhance “quality in solar rural electrification”.

Funded by the European Commission, the TaQSolRE project was initiated to address this aspect of quality in developing countries. Universidad Politecnica De Madrid - Instituto de Energía Solar (UPM/IES), Energy Research Centre of the Netherlands, Innovation Energie Developpement (IED) and IT Power India (ITPI) worked together on this project.

Activities

The project dealt with measures to improve the low level of technical quality of PV stand-alone systems at that time (2003), which hampered their acceptance and the confidence of consumers. On the one hand, the TaQSolRE project promoted that quality control of PV systems should be carried out according to standards which could be verified at the local level. On the other hand, a tool was developed to resolve issues concerning the poor reliability of PV installations. Finally, a strategy was developed to improve confidence of stakeholders involved in PV electrification (private, public, financial) in developing countries. All the recommendations and tools were uploaded on a dedicated web site.

Based on findings from analysing literature and field visits across several countries in Asia and Africa, the study covered quality issues with solar home systems (SHS) in detail because they had become by far the largest part of the solar rural electrification market. Two other products were discussed in less detail: solar lanterns and solar battery charging stations.

Results & Recommendations

The main technical aspects of quality are service lifetime of the system and its components, performance (e.g. efficiency), safety, and reliability. From the social point of view, quality in solar rural electrification can be defined as the effectiveness and efficiency of PV in achieving general development objectives and more specifically rural electrification targets.

Based on these definitions, the following areas were identified as crucial in order to establish a long-term sustainable PV market:

Component Quality & Ongoing Service: The success of SHS implementation is determined by quality of the components and the availability of regular service and maintenance. When well-designed



In the project’s initial stages, during data collection, ITPI’s involvement in programmes such as the International Finance Corporation (IFC) funded Photovoltaic Market Transformation Initiative (PVMTI) helped provide access to a large number of SHS installations across India, Nepal and Morocco. While establishing quality procedures, ITPI extended valuable inputs based on its experience in establishing technical guidelines under PVMTI as well as monitoring and assuring quality of SHS installations in Morocco under a kW investment programme.

TaQSolRE wished to improve the reliability of and decrease the costs of stand-alone PV systems with the help of a normative and quality control process, and to increase the acceptability of and confidence in PV technology as an important energy source for rural electrification, especially in developing countries. The objective was to empower PV players (manufacturers, planners, electricity companies/utilities, etc.) with knowledge on PV reliability. It also aimed to carry out an analysis, with a socio-economic perspective, of the relationships between quality concepts and the different PV stakeholders, in order to propose strategies to improve the awareness of consumers.



Typical installations of Solar PV modules on the roofs of homes in Sundarbans

In Morocco for example, in the late 1990s, quality control of the SHS to be purchased was carried out by a Consultant for the government's proposed rural electrification programme. This included visits to the manufacturers in different part of the world, testing samples for each system (50 Wp, 75 Wp and 100 Wp) in an international laboratory and carrying out provisional and final inspections. Regular visits to the service company and checking users' satisfaction were also carried out.



systems received regular ongoing maintenance, they performed successfully over many years. Also, the availability of good quality local spare parts was an essential part of the process to enable smooth replacement of faulty parts, thus ensuring proper operation of the installed system.

Training of technicians and owners is the key to a successful programme. When people have the proper training, the solar systems are maintained and remain in service for longer periods of time. In addition to regular training for installers and maintenance staff, the training sessions conducted by the service company should include plans for updated/continued training.

It is important that maintenance visits are carried out by technicians to the sites regularly (at least thrice a year) to check the systems. When technicians are only available when there are problems with the system, technical difficulties are high and consumer satisfaction is low leading to reduced fee payment.

Role of Government in Quality Assurance: The Government Rural Electrification sector, including ministries and agencies, is usually concerned by the selection of least-cost electrification options for their renewable energy programmes. These ministries are the key actors in quality assurance system promotion because they are either directly or indirectly responsible to the funding organisation upstream and the beneficiaries of the programmes downstream. They can for example integrate quality requirements (standards/certification/accreditation) in the official tender documents (terms of reference).

Quality assurance systems should be developed that include standards, licences, certifications and specific documentation/guidelines to provide a basis for conventional risk analysis in evaluating loans and investment opportunities for PV projects. This quality assurance framework will allow financial institutions to evaluate the qualifications of all the actors concerned.

Some direct benefits of a certification process are the reduction of the time spent for money collection and the higher collection rates, considering that users will be less reluctant to pay for a reliable service.

Quality & Financing: Financing mechanisms for SHS systems are a critical element in the electrification of rural areas. Financing schemes should include the following:

- Installation and regular maintenance of the systems.
- Funds for extensive training of technicians and system owners, ensuring proper care for the systems at all levels.
- A quality control mechanism by an external body

The national utility must also be honest about grid extension plans; no financing plan can be successful if people have unrealistic expectations about receiving cheap grid powered electricity.

Creating Awareness: Rural people were not aware of the fact that PV systems could be an important tool to support sustainable development in their regions through improvement in their quality of life by the provision of appropriate electrification. They were more concerned with the actual power supply and not the actual source. As long as the power supply was reliable and cost-effective, they were satisfied. Therefore, the reliability of alternatives (to diesel/kerosene, etc.) such as SHS in the initial stages of implementation itself, were crucial for large-scale usage in the future.

In conclusion, establishing a long-term sustainable PV market in developing countries depends primarily on building appropriate infrastructure framework with a distribution, financing, installation and after-sales structure. Once an institutional and financial framework exists in which a sustainable PV market can be established, it will in turn offer assurance to end-users.

Mozambique: New tariff model to help promote off-grid systems in rural areas

Project Fact Sheet

Challenges

Before 2009, Mozambique did not have a regulatory framework to set tariffs for energy generated from renewable energy sources. Due to this gap in legislation, the Mozambique National Fund for Rural Electrification (FUNAE in the Portuguese acronym) used a very simple but unsatisfactory method to set electricity tariffs. The method consisted of surveying and assessing rural population's total spending on energy sources used (charcoal, paraffin, kerosene or batteries) and charge the same amount for electricity provided through RE sources, mostly solar PV.

The Ministry of Energy thus began looking at this issue as a way to foster renewable energy use, especially in rural locations and to further develop projects in this area. But first FUNAE needed a structured, reliable and accurate tariff-setting model, adjusted to the country's rural situation. This would aid FUNAE to guarantee the success of the projects in rural areas, and at the same time increase the sustainability of its operations. Further, this would increase the efficacy of the use of grant money since most of the projects implemented by FUNAE were funded by international donors.

Activities

Funded by the Renewable Energy and Energy Efficiency Programme (REEEP), IT Power began working with FUNAE to develop a tariff model to assist them in conducting an accurate and simple financial analysis of off-grid electricity generation systems. The results were to be used to evaluate projects from the end-user perspective by analysing their capacity and willingness to pay for a certain tariff. FUNAE expected to also strengthen its capacity of tariff structuring and subsidy allocation, using this model.

The main activities and outputs under this project included:

- Developing a balanced, accurate and easy-to-use tariff-setting tool which took into consideration the Mozambique rural reality
- Systematically considering additional sources of revenue from new renewable energy generation projects, such as Clean Development Mechanism (CDM) revenue
- Training FUNAE staff in conducting surveys in rural locations to determine end-user willingness and capacity to pay for electricity from renewable sources
- Building institutional capacity so that the tariff-setting tool was used by FUNAE efficiently and independently

The tariff calculation tool – which is Excel based – was presented by IT Power to FUNAE staff during a kick-off meeting in October 2009. With the feedback received, the tool was further refined and a User Manual prepared in 2010, explaining the set-up, use and assumptions in the tool.



Shortage of power supply and low electricity connection rates are affecting the people of Mozambique from achieving higher levels of human and economic development. Many renewable energy projects have failed because they focused only on the investment phase and not on the whole life-cycle. By failing to incorporate (or under-estimating) costs such as operation, maintenance, repairs and replacements in the electricity tariffs, many projects did not succeed.

The tariff-setting tool model was designed to perform financial evaluations of seven different technologies or a combination of technologies commonly used in Mozambique to provide electricity through off-grid systems. The model allows the user to:

- Customise the demand for energy and power from a system
- Estimate the evolution of the energy and power demands for a 20-year scenario
- Consider different sources of revenues for the project (including carbon credits)
- Calculate the net present value (NPV) considering only the maintenance and operation costs
- Calculate the NPV considering the total costs of the project
- Calculate the tariff which can cover the total costs of the project

The Mozambique Ministry of Energy is currently developing regulatory frameworks for RE. The use of the tariff-setting tool will enable a holistic approach to future rural electrification projects and improve overall sustainability of new projects.

Future Actions

By developing this tariff-setting tool, the project's output can easily be replicated amongst other stakeholders in the electricity sector in Mozambique (such as the EDM—the national utility, the Ministry of Energy or the national regulator—CNELEC), by converting this tool into a powerful decision-making instrument on tariff-setting and contributing to adequate policy recommendations on this subject.

This tariff-setting tool will be used as part of the preparation and implementation of rural electrification projects which will enable FUNAE to better assess projects and anticipate potential issues (financial, technical, social and environmental) and to customise technical specifications, business models, etc. Additionally the financial sector will be more willing to look into providing investment for these projects as this tool will enable demonstration of profitable business-cases. For many years, the lack of capacity and non-availability of tools giving detailed financial analysis has restricted the inflow of capital for these projects. This tool will help address this barrier.

Replication Potential By setting up electricity tariffs that reflect the reality of each investment and local market conditions, this tool has the potential to replicate and scale-up current off-grid rural electrification projects in Mozambique by:

- Increasing investors' confidence in developing new projects in rural Mozambique;
- Contributing to developing larger-scale projects that will provide energy to more people;
- If used by other organisations in the future (including in the private sector), stimulating the growth of renewable energy projects in rural Mozambique; and
- Making more profitable business cases which may help secure new loans/grants and attract more investors to such projects.

Despite the relevance that access to energy plays in poverty reduction and sustained economic development, it is not a goal in itself in the Millennium Development Goals (MDG). FUNAE is engaged in many different projects to provide renewable energy in rural locations not only to households, but also to schools, clinics, hospitals and other public buildings. By contributing to the provision of a good quality service to the stakeholders, this project will certainly help Mozambique achieve its MDGs.

Some of the projects that FUNAE develops are located in villages bordering neighbouring countries. Mozambique, as many other African countries, is increasingly working on local/regional networks and power alliances to supply electricity to participating countries. This project can have a spill-over effect to other countries with whom FUNAE may work in this particular area, as most neighbouring countries lack capacity on tools to set electricity tariffs in rural locations.



Source: IT Power UK

Nepal: Stimulating energy service provision

Project Fact Sheet

Challenges

In the early 2000s, poverty alleviation in rural areas of Nepal enjoyed high priority in the national policy of the Government of Nepal. Improvement of energy service supply was considered as one of the pre-requisites for further development of rural areas. At that time, only 5% of the rural population had access to electricity.

In order to improve standards of living and income generating activities, the Government of Nepal wanted to exploit Nepal's vast natural resources, mainly hydropower, but also other alternative renewable energy sources. They had proposed a project of alternative and renewable energy development to the European Commission (EC) with the main focus on solar energy.

The aim of the project was to ensure renewable energy resource development and rural energy service in Nepal by extending Solar System Technology to villages and communities where accessing the national power grid or micro hydro power was not economically or technically feasible.

In 2001, ESB International, Ireland and IT Power India worked together on this project to support poverty alleviation by stimulating energy service provision by creation of Community Energy Service Providers (CESPs) in Village Development Committees (VDC)/village communities with no grid connection or micro/mini hydro potential. It also improved solar energy product quality, availability, diversity and warranty support. Additionally it was planned to leverage European Commission (EC) resources by mobilising co-financing and interest accruals in the financial sector and drawing resources for social mobilisation through collaborating projects to help develop a sustainable financing strategy in co-operation with local financial institutions.

Activities

CESPs are entrepreneurial groups established by VDCs/village communities to provide energy to commercial and socially oriented end-uses. Under this EC project, measures were taken to develop and guide these CESPs to improve energy service delivery from solar resources – the CESPs would establish community-based business and technical expertise, carry out and manage the implementation of proposed applications, and thus deliver energy services to end-users who could not access power supply through the national grid or micro/mini hydro sources. In addition, revenue generating energy service end-use was created to help service loans and build community equity.



Domestic solar home systems in Phoolbari, Tanahu district, Nepal



Some EU activity areas in Nepal



Rural and alternative energy service centre in Damauli, Tanahu district, Nepal

Institutional leverage of the EC project was achieved through collaboration with multiple implementing programmes based on social mobilisation, specific institutional support, market development and partnership with a common apex entity (AEPC) for sector specific programmes of the World Bank/REDP, DANIDA/ESAP, and SNV/BSP.

Financial leverage of the EC project was achieved through co-financing derived from commercial loans provided to the CESP, district/community contributions, revolving fund interest accruals and accruals out of certain income-generating solar applications.

Existing networks from earlier projects such as the REDP (Energy from Micro Hydro), COPE (Education for under privileged children), DCDP (Rural health and education), and NEWAH, (Rural domestic water supply), programmes, provided an ideal base and framework to establish the EC project.

Using criteria such as poor electrification ratios, low Human Development Index (HDI) and districts with existing programmes/networks, energy service was provided to 50 communities initially, expanding to cover 310 communities in the final year of intervention.

A subsidy reducing policy, aiming at progressively replacing capital subsidy by appropriate and affordable financing schemes for community energy service provision and end-user groups or institutions was planned on the model used for the Biogas Support Programme in Nepal earlier.

Sustainability of the project was assured through making all project interventions self-supporting after termination of the EC financial support, basing on the developed and strengthened service infrastructure at the community level.

To support quality control of equipment and system performance, a Solar Energy Test Station, mainly focusing on PV technology was set up.

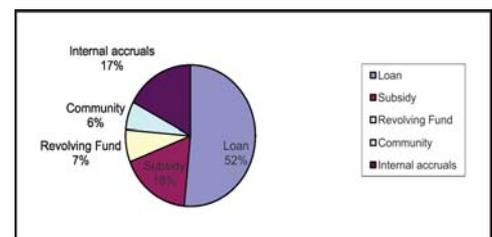
Other activities included:

- Social mobilisation to promote and establish community-based savings/lending activities – rural energy service groups will be responsible for credit management, and post warranty service.
- EC support to mechanisms to mobilise financial facilities in the range of NPR 10,000 to 2,500,000 to capitalise “fee for service” and micro-credit schemes managed and operated by the CESP.
- Support to commercial initiatives with value addition in the agricultural sector, implemented by village groups/stakeholders were encouraged, such as milk chilling, tea processing and crops drying where possible solar applications appeared economically promising, providing scope for future employment creation. Such commercially oriented initiatives offset the financial burden of more socially oriented interventions in the educational and health sectors.

The funding requirement was slated to be met as shown below:

Expected Results

- Improved economic strength and social services in rural communities
- End-uses of community energy services
- Institutional development at community, district and central levels.
- Investment and business opportunities for solar energy equipment manufacturers, suppliers and dealers, CESP and financial intermediaries.
- Sustainable financial instruments to progressively alleviate subsidies.



Health centre with solar refrigerator in Phoolbari, Tanahu district, Nepal

Sri Lanka: Piloting and replicating renewable energy based community development centres

Project Fact Sheet

Challenges

The Sri Lankan economy appears to be growing rapidly, and one of the factors has been increased levels of growth and employment in the services sector. However, the growth and associated development is benefiting the urban areas more than the rural areas where the majority of the population lives.

To cope up with the high increases in demand, the electricity mix in the country has changed over the years. The government has drawn up ambitious plans to electrify rural areas through grid extension and off-grid systems. Sri Lanka has also made impressive progress in renewable energy based off-grid systems such as village hydro and solar home systems in collaboration with the World Bank, and is now planning to adopt biomass energy.

As a result of reforms and privatisation, the communications and information sector has also witnessed high levels of growth in the last decade. The number of mobile phone/internet users has increased significantly. However, rural areas have generally been left out of this high growth.

Also, the power and communications infrastructure in the northern and eastern regions is either damaged or non-existent and is being developed in collaboration with international aid agencies.

Activities

IT Power was invited by the Industrial Energy Efficiency and Cleaner Production Branch of the United Nations Industrial Development Organisation (UNIDO) to develop a comprehensive programme proposal for developing small hydro power-based Community Development Centres in rural off-grid areas of Sri Lanka.

Achievements under this project included:

- Developed a Technical Assistance programme proposal for improving energy efficiency and identifying the productive uses of small hydro power and other renewable energy sources in the rural off-grid areas of Sri Lanka
- Established the framework for setting up pilot projects to demonstrate the potential uses of small hydro power and other renewable energy systems for income generating activities
- Identified and documented the barriers to the implementation of small hydro power and other renewable energy technologies in rural Sri Lanka.
- Established a methodology for the implementation of model common facility centres and set up a mechanism for replicating the model in other rural areas of the country



Renewable Energy for Rural Economic Development (RERED) Project of the Government of Sri Lanka (GOSL) supported by the World Bank and Global Environment Facility, and implemented by DFCC Bank.

The geo-climatic conditions in parts of Sri Lanka have led to the formation of a large number of streams that merge downstream to form major rivers. Small streams in the upper catchment areas as well as major rivers offer considerable potential for hydroelectric power development, which is estimated to be around 2,000 MW, out of which about 60% has already been developed.

In 1996, Ceylon Electricity Board decided to allow grid connection of privately owned mini hydro power plants, which, along with attractive purchase prices and favourable conditions, encouraged the plantation companies and private investors to invest in mini hydro.

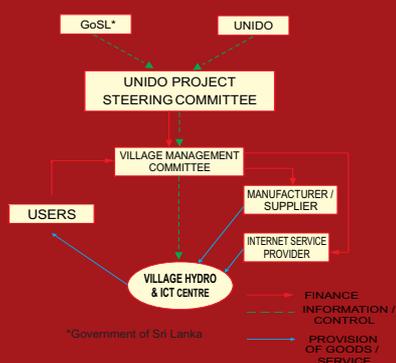
It is estimated that around 600 sites exist in remote areas. Absence of commercial activities has restricted the penetration of the national grid, but these are best suited for micro hydropower plants, which could provide electricity to the villages through a mini grid. More than 100 such power plants are already in operation, providing electricity for more than 3,000 families. Typical sizes of these power plants are in the range of 500 W to 50 kW, primarily in the tea estates.



Kudawa Village Site

Ratnapura district was considered to possess the highest potential for micro hydro power generation. On-site assessments included techno-economic feasibility, economic activity potential, local participation and relevance of information communication technologies; and Kudawa Village was chosen for the pilot project.

Institutional Arrangements for the Pilot Project



A Village Management Committee (VMC) will be responsible for administration and operation of the system. It will set up tariffs for households and commercial enterprises and ensure regular collection of the fee for services. Eventually there may be a need to establish the VMC as a legal entity such as a co-operative or a society to encourage long-term sustenance and better management of assets and liabilities.

It is expected that costs of the diversion weir and the channel could be borne by the community which would amount to about US\$10,000 or about 20% of the costs, which is in line with the past experience in village hydro. UNIDO would contribute the rest of the project costs.

- Provided advisory services for facilitating the establishment of a national focal point for small hydro power/renewable energy within the country under the UNIDO initiative on rural energy for productive use

Results

As per the development plan, the Community Development Centre (CDC) will be located close to the Government School adjacent to the Kudawa village en route to Sinharaja Forest. The CDC will have internet access provided by one of the service providers using wireless or radio technology.

There is potential for income-generating activities such as electric tailoring machines, rice hulling and spice grinding. Other possibilities include construction of tourist guest houses.

The envisaged economic activity requirements include powering the guest house, ICT centre with 10 PCs, printer and internet connectivity, an electric sewing machine and a rice huller and other energy requirements for lighting and entertainment for the 1,000 households. The total connected load is around 25 kW with the peak demand of 14 kW occurring during the day time. The estimated daily energy requirements are 117.3 kWh.

The electrical wirings, power-conditioning, furniture and fixtures will be provided to the CDC under the project. In addition, UNIDO will provide the 10 PCs.

Traditionally, in most village hydro projects in Sri Lanka, the community has contributed towards the costs of civil works and transmission and distribution by contributing labour through 'shramadana', cash and goods. The village community has also played a key role in management and administration of the power plant and related commerce. It was proposed to continue with this model in the present project as well (refer figure alongside).

Future Actions

There is good scope for replication of the pilot project in the provinces where damaged infrastructure is being reconstructed, using biomass, wind or hybrid systems. For example, revival of agro-industry such as rice milling could result in large amounts of rice husk being available for the production of electricity. Traditional industries such as textiles, rice, fishing and dairy offer scope for tourism as well.

But first an assessment of the renewable energy resources in the region, i.e. biomass, solar and wind should be available. IT Power, with IFC support also completed a comprehensive study in Sri Lanka and came out with a Biomass Fuel Supply Handbook, which is available to the public on the IFC web site.

Hydropower based electricity generation is expected to rise to 5,000 GWh in the next few years, thus increasing the contribution to local energy supply.

Tokelau Islands: Renewable power brings employment and energy independence

Project Fact Sheet

Challenges

Essentially all energy in Tokelau currently is from imported petroleum, except for that part of the electricity supply provided by solar photovoltaic (PV) to TeleTok (telecommunications provider for the Tokelau Islands) facilities on all three atolls and the University of the South Pacific (USP) facility on Atafu.

Annual imports of fuel in 2003 totalled 162,000 litres of diesel, 181,000 litres of petrol and 57,000 litres of kerosene. Each atoll has all households connected to the electricity grid and power is provided only during peak demand periods, typically 15-18 hours per day, though 24-hour power may be provided on special occasions. Petrol and kerosene is shipped in drums while diesel is transferred from tanks on the *M.V. Tokelau* (a government-run local ferry) to drums on arrival at each atoll.

LPG imported by individuals for cooking appears to be around 5 tonnes a year. The domestic sector is also the largest user of electrical energy. According to the 2001 census, 90% of households own a refrigerator or freezer, 62% own a video system and 57% a washing machine. Household usage appears to have been around 75 kWh per month per household in 2003. A change to 24-hour power is desired by residents, and if this is implemented, a significant increase in energy use is expected.

Commercial use is small. TeleTok is the largest single electricity user though commercial-scale fish freezers were installed on each atoll. Currently they are not in use but if they are put back into service, they will be the largest user by a big margin. The absence of air conditioning use by the government has allowed this sector to remain a modest user of energy.

Some of the other issues in the energy sector in Tokelau include:

- High access costs;
- Insufficient technically trained personnel;
- Lack of technical training facilities on Tokelau;
- A tropical, marine environment that includes severe weather, salt air contact, continuous exposure to very high ambient temperatures and humidity approaching 100%, which when combined, is a difficult mix for electrical and mechanical equipment;
- Access for spare parts is slow and communications with suppliers difficult; and
- Currently Tokelau has limited access to non-New Zealand capital funding.

To overcome these barriers, the Tokelau National Energy Policy and Strategic Action Plan (NEPSAP) 2004 aimed to achieve energy independence through the development of indigenous energy resources, with the goal of eliminating the territory's almost total dependence on imported diesel for electricity generation.



The high costs of importing fuel and the remote location of Tokelau mean that electricity supply on the islands has always been expensive and unreliable.

About Tokelau

Tokelau consists of three atolls (Atafu, Nukunonu and Fakaofu) located about 483 km north of Western Samoa. Each atoll consists of a number of reef-bound islets (motu) encircling a lagoon. The islets vary in size from 90 m to 6 km in length and from a few metres to 200 m in width. The largest atoll is Nukunonu at 4.7 sq km. The atolls are 3-5 m above sea level.



The South Pacific nation of Tokelau will soon have all its electricity needs met by solar power



Local people transporting and installing batteries on Tokelau

As there is no deep-water port on Tokelau, the logistics of shipping the equipment to Tokelau were a major challenge for the project. IT Power and PowerSmart had to develop special lifting rigs and slings to transfer the heavy batteries from the large ship onto the smaller boats, and then again onto the land. Together with the assistance and skill of the local people, the batteries are all now safely installed in the powerhouses.

“The project’s construction is providing employment for the people of Tokelau, and when complete will provide them with reliable electricity for years to come” – IT Power engineer



Completed Solar PV array on Tokelau

Presently, only solar energy and coconut oil-based bio-fuel technologies can be sufficiently developed in Tokelau to meet the NEPSAP’s goals. Although there is considerable potential for bio-fuel development in the long term, the use of solar generation options (PV) holds the most promise for petroleum substitution presently. Therefore it is the intent of the IT Power Australia Tokelau Renewable Energy Project to provide about 90% of power generation with solar PV, and the remaining 10% to be supplied with diesel engines fuelled by locally produced coconut oil.

Activities

Tokelau, with support from the New Zealand Government through the New Zealand Agency for International Development (NZAID), has undertaken preparatory work on how best to make the progressive shift from petroleum dependency to 100% renewable power generation. In 2006 a 10 kWp PV mini-grid pilot project in Fakaofu was implemented and a report on the feasibility of a 100% renewable-based power solution was completed in early 2008.

Now, IT Power Australia, in conjunction with PowerSmart Solar from New Zealand, is completing construction of a 1 MW hybrid (with diesel*) solar PV system, with 330 kW systems installed on each of the three atolls.

Successes

Installation of the system began on Fakaofu in early June 2012, with all systems planned to be operational by the end of the year. The three PV mini-grids will be the biggest of their kind in the Pacific, expected to cover all of Tokelau’s 1,500 residents’ electricity needs using only solar energy.

The electric power system on each of the atolls is also in the process of being upgraded and reconditioned. The new diesel generators will only be used in times of extreme cloudiness lasting several days. These, along with new powerhouses, and refurbishment and upgrading of distribution systems will provide improved reliability of energy service and supply efficiency.

Once the 1 MW system is complete at the end of the year, Tokelau will then focus on their medium- to long-term goal of producing locally made bio-diesel using the coconuts grown on the islands. With bio-diesel fuelling the back-up generators, Tokelau will be able to completely overcome their dependence on imported diesel fuel.

The Way Forward

In future, the project intends to replace the remaining imported diesel consumption (approximately 10% of electricity) with biodiesel made from local coconuts. If Tokelau achieves this, then this IT Power project will become a landmark in the Pacific region and may be used as a model for all the other small island nations in the region.

The local operators of the system in Tokelau are being trained, and are part of the construction team, so that when the project is completed, they will be able to operate the system themselves.

**The diesel generators are a necessary part of the system in order to provide emergency power and to charge the batteries during periods of unusually low irradiance. The PV/battery component of the system has however been sized to provide all of the power that is required during normal day-to-day operation.*

Some data has also been sourced from: <http://www.tokelau.org.nz/Tokelau+Government/Government+Departments/Power/Energy.html>

Zambia: Renewable power for isolated mini-grids

Project Fact Sheet

Challenges

Although Zambia has abundant hydropower (estimated at 6,000 MW), the installed capacity in 2001 was only about 1,700 MW. 50% of the urban population had access to electricity and only 2% of the rural population had been connected to the national power grid. The large land span, rugged terrain and sparse population in Zambia made it difficult to extend the national power grid to far-flung rural areas. The alternative in many remote rural areas, predominately serviced by diesel generators, was expensive imported diesel fuel with consequent environmental problems.

Thus, Zambia presented an ideal opportunity for international agencies to intervene and promote the use of its abundant renewable energy resources — biomass, solar, and mini-hydro, to facilitate rural electrification and promote linked income-generation activities.

Activities

The project primarily aimed at removing the key barriers and reducing implementation costs of renewable energy to accomplish this goal, and adopted a holistic approach by including two main components - technical assistance and business models.

The technical assistance component consisted of activities for barrier removal including strengthening of the enabling environment in terms of policy instruments, capacity building, institutional strengthening and information dissemination to support widespread replication and sustainability even after the project. Increased power supply and reliable energy services in rural areas would promote income-generation activities, which was a key element in the Zambian Government's efforts to alleviate poverty in these areas.

The second component aimed at setting up three pilot mini-grids to commercially demonstrate the technical and financial viabilities of using renewable energy technologies for electricity generation. The following sites were selected for setting up business cum investment models in Zambia under the project:

- A 1,000 kW mini-hydro business model at Shiwang'andu
- A 1,000 kW biomass gasification business model in Kaputa District
- A 36 kW PV business model at Chinsanka in Samfya District

Mini-hydro based business model: At Shiwang'andu Estate, diesel generators were being used to generate power for a metal/wood workshop, a hammer mill for grinding animal feed, and tourist lodges. The estate also needed electricity for irrigating the coffee and sugarcane plantations, processing the coffee produced and expanding the hammer mill to grind grains as well. The local community needed electricity for the hospital and health centre nearby, and for 100 residential homes. Thus, the total electricity required in the immediate future by the estate was 500 kW.

The hydropower would be harvested from Manshya River, based on a run-of-the-river design, i.e. no dam was to be built.



For this GEF-supported project, UNIDO was the executing agency for this project, with regional dissemination through UNEP. The national counterpart agencies were the Ministry of Energy and Water Development, Government of Zambia and Development Bank of Zambia (DBZ). IT Power India was the implementing partner.

Active participation of the private sector along with the national electricity utility was a pre-requisite for the successful implementation of the proposed business models at these three sites (*refer map*).





Mini-hydro is already commercially viable with a generation cost in the 3-5.2 ¢/kWh range. Its commercial deployment by private investors is fairly straightforward, and would be the first choice for rural electrification, as long as there are sufficient hydro resources with no adverse environmental or social impacts.

It has been proposed to set up a Centre for Renewable Energy Technology to build capacity at the national level, which would be a collaborative effort between the project and the University of Zambia (School of Engineering).

Subsequent to this project, the Global Environmental Facility (GEF) approved a US\$1.8 million project in April 2012 promoting renewable energy-based mini-grids for rural electrification and productive uses in Chad, to be implemented by UNIDO (<http://www.un-energy.org> and <http://africasd.iisd.org>).

Biomass gasification based business model: ZESCO had a diesel generator station serving (with two diesel generators of 267 kW and 181 kW). Due to the high imported diesel fuel cost, the cost of electricity produced from this station was in the 25-30 ¢/ kWh range. Diesel transport was extremely difficult due to the terrain and bad road conditions. ZESCO was servicing on an average 200-250 kW load amounting to about 0.9 million units (kWh) annually. Several businessmen in Kaputa had urged ZESCO to increase the power supply so that they could start fish processing plants.

In this pilot mini-grid, a biomass power generation unit (with two 500 kW gasifiers with gas engines) will replace all the diesel based electricity generations at ZESCO's Kaputa power station. The multi-fuel gasifiers will be able to use agro or forest residues as fuel. The Department of Forest under the Ministry of Tourism, Environment, and Natural Resources has agreed to participate in the pilot project, and will be responsible for managing the feed supply.

In this pilot mini-grid, the biomass gasification is expected to produce electricity below 12 ¢/kWh depending on the costs of collection, processing and transportation of biomass fuel.

Solar PV based business model: With no grid connection, the main economic activity in the rural areas of Samfya District was fishing in the nearby Bangaweulu Lake and surrounding swamp. Chinsanka is the biggest commercial centre in this district. It has 875 households and 70 shops, all clustered in an area of 2 km long and 1 km wide. Paraffin, candles, dry cells, firewood, and charcoal provide most of the current energy needs in Chinsanka.

Due to the steady income from the fishing activities, the local people in the district showed willingness to pay a higher cost for getting reliable energy services. The electricity provided could help the shops to run longer hours in business. It might also induce people to look for profitable business ventures, such as refrigeration of the fish catch to expand the sale and water pumping for irrigation of high value crops. The electricity produced might further find use in social sectors, such as providing light to schools, powering refrigerators for storing vaccines in clinics, and running water purification units to improve water supply quality.

The PV mini-grid being proposed has 36 kW peak capacity to serve 550 homes and 50 shops, including provision for overcapacity to meet future demand increase and fluctuations. The electricity charges to these homes and shops will be collected through the use of prepayment cards. The pilot project will also include 10 large solar lanterns and 10 small solar lanterns to demonstrate their use in fishing as a substitute for the kerosene lanterns. These solar lanterns will be charged by electricity generated from the PV panels during the daytime.

Expected Results in Rural Areas of Zambia

Enabling environment in terms of a legal, institutional and policy framework to support commercial deployment of renewable energy based mini-grids; Enhanced capacity at national and local levels for the commercial deployment of renewable energy based; Setting up new and innovative project financing mechanisms to attract private sector investments, including a "Risk and Replication Management Fund (RRMF)", to share the risks, and encourage replication of renewable energy based mini-grid projects; Implementation of Business Models to demonstrate the technical and commercial viabilities of mini-grids based on biomass gasification, PV and small hydro technologies with their applicable financing mechanisms; and Replication of renewable energy-based mini-grids for rural electrification in Zambia and the region to promote productive use and income-generating activities.

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Cover designed by Suzlon Energy Design Studio (CorpCom)

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IT Power India is a reputed international consulting firm in the areas of renewable energy, climate change & sustainability, and energy efficiency. The company's project portfolio expands both horizontally as well as vertically with more than 200 projects in over 23 developing countries.



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