ACCESS TO ENERGY SERVICES THROUGH RENEWABLE SOURCES IN LATIN AMERICA & THE CARIBBEAN

A CASE STUDY WORKBOOK

DECEMBER
2017





Source: ENDEV Peru, Acciona Microenergia, WISIONS, Green Empowerment

IDB

Alliance for Rural Electrification
Shining a Light for Progress

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Shining a Light for Progress

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About the Alliance for Rural Electrification

Established in 2006, the Alliance for Rural Electrification (ARE) is the only global business association that represents the whole decentralized renewable energy sector for integrating rural electrification in developing and emerging countries.

By consolidating the off-grid sector, ARE is there to assist decision-makers from both, private and public sector, by providing key policy, technical and financial recommendations.

The association's services are not limited to but mainly focus on supporting policy dialogues, private sector cooperations, capacity building / training and finance access.
www.ruralelec.org

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PREFACE

Dear Reader,

This workbook presenting case studies for clean energy access is a publication of the Alliance of Rural Electrification supported by the Inter-American Development Bank. We proudly present recommendations for the best working regulatory frameworks to facilitate clean rural energy access in Latin America.

These key recommendations, which cover questions of policy & business environment, organizational & coordination and funding & financing, have been developed after collecting and carefully analyzing more than 25 case studies on decentralized renewable energy projects in 19 Latin American and Caribbean countries featuring all different kinds of clean technologies and purposes. The publication shows also the key success factors and lessons learnt to enable successful implementations of innovative business models and projects in the future. To make the booklet easier to read and to work in a more systematic manner the case studies were divided neither by countries nor technologies but by objective, in four groups.

- The first group with five articles deals with the role of government and supra-governmental initiatives. These are not only coming from national governments but also from supranational institutions with OLADE as prominent representative and they might be implemented by private enterprises like in the case of the Brazilian Luz para Todos. We would like to direct the readers' attention to the financing of those initiatives who provide strong incentives to fund some of the costs through new created businesses or via the collection of residential beneficiaries' past spending for kerosene or wood replaced by the new source of energy.

- The second section deals with the question of how basic needs can be met. With 12 case studies, it is the largest section stressing the importance of basic needs projects. It does not only show how clean energies help to provide light to communities but how they facilitate potable water, clean cooking, transportation and better health stations. The reader will note the variety of different technologies employed which contrasts with the portrayed dominance of solar home systems. Many systems are made to be upgraded to the next level, while covering basic needs is seen as a necessary step towards a more comprehensive energy supply.

- The difference with the third group of articles is not the micro-grid technology itself but the way electrification is scaled up to the next level with enhanced micro grids. From the moment one employs three phase substations or one-to-one productive use technologies, one can cover a growing demand by residential users, as well as empower three phase electrical equipment like pumps, mills, electrical saws, dryers. Four examples of enhanced micro-grids show how these give place to an enriched social and economic community life as the examples in this section show.

- Finally, the fourth section elaborates on eight different examples of how clean energy facilitates productive use. While easy operation is indispensable for any community project in rural areas, productive use projects with some logistics in place allow a different scope of technology. Biogas as baseload source of energy becomes a prominent alternative specifically in agriculture projects.

While the subsections aim to give structure, they do not prevent this booklet to be as diverse as life is – with many positive examples showing how to make it better each day.

The articles themselves are all following a similar but not necessarily the same structure giving a quick insight into a specific project or an initiative answering questions about objectives, beneficiaries, financing needs or funding and the results achieved. Even though we tried to harmonize spelling and units, we have opted not to synchronize currencies nor some other details. If this affects the reading blame goes to the editors – not to the authors. Readers can find a contact at the end of each article so they are welcome to follow up to get more information if required.

Given the many differences, all articles have one conviction in common: renewable energies are specifically apt to be used for the electrification or the empowerment of remote areas. In these areas the operative logistics costs are high, with the result that potentially higher capital expenditures pay back more easily and in a shorter period of time.

We start the booklet with our own lessons learnt and political recommendations after going through so many positive examples across the Latin American continent. It might be worth to read this again after going through the case studies collected. We are happy if the readers agree with our own findings but definitely strive to to encourage a broad discussion about political instruments and possible frameworks that facilitate new business models for clean energy access.

December 2017

Marcus Wiemann
Executive Director
Alliance for Rural Electrification (ARE)

Karl Kolmsee
ARE Board Member
Chair of ARE Sub-Working Group Latin-America

FOREWORD BY IDB

Latin America and the Caribbean (LAC) may be the first developing region to achieve universal access to electricity.

Statistics indicate that electricity coverage in the region is at present about 97%. However, this means that some 22 million people – about six million households – still lack service. Providing electricity access to these people requires solutions based on an evaluation of factors such as technology, environmental and social context, economic viability and a cost-benefit analysis, and requires the mutual collaboration of both the public and private sectors.

Available solutions include grid extension and off-grid systems (individual or mini-grid). As coverage advances, the technical difficulty and cost of projects increase due to remoteness of the location, low population density, and low energy consumption. The bank conducted a high-level analysis which estimated that about 60% of the electricity access deficit in LAC could be resolved with urban and rural grid extensions and the remainder via off-grid solutions. About 30% of the off-grid solutions could be in the form of mini-grids and the rest would rely on individual systems.

This report prepared by ARE and commissioned by the Bank provides valuable reflections and lessons learned on clean energy access projects from the business association perspective. Part of the strategy to reach universal access in the region involves joining forces with other energy access initiatives and networks such as ARE.

Ariel Yepez
Energy Division Chief
Inter-American Development Bank

Source: IDB

FOREWORD BY ARE

Dear Reader,

In autumn 2016, IDB and ARE - two organisations who are fully committed to the objectives of Sustainable Energy for ALL (SEforALL) - started to investigate on how the clean off-grid industry could support the development bank in its keen efforts to make Latin-America the first continent in the developing world fully electrified.

As a result, IDB asked ARE to select successful case studies on Clean Energy Access and develop key recommendations for best working regulatory frameworks for LAC from a private sector industry perspective.

This publication shall serve public and private sector as well as civil society decision-makers and practitioners to not only further advance their knowledge and understanding of decentralized renewable energy technologies and business solutions in LAC, but more importantly to also apply them for the direct advantage of the beneficiaries.

Since its creation in 2006 ARE with its 130+ Members worldwide in 2017, which are active along the whole value chain for rural electrification, has been active as a business and knowledge exchange and development hub to advance socio-economic development in the emerging and development world:

- to enhance market and business development through the sharing of intelligence and best practices of the sector;
- to promote multi-stakeholder dialogues (including NGO, academia and civil society);
- to raise awareness and to increase visibility of ARE as industry representative in LAC.

Thus, with this new edition focusing on LAC, ARE complements the series of its earlier Best Practices which mainly addressed Africa and the global level. We also hope that we can mobilise more private actors to join the ARE Sub-Working Group Latin-America and the common initiative with IDB to allow the sector to better raise its voice. Providing well defined key policy, technical and financial recommendations to incentivize framework conditions, will allow more investments into sustainable and business driven rural electrification markets.

We sincerely thank all contributors who have helped us to develop this guide and hope that it will enable interested players to improve their skills and business models by making use of lessons learnt and thereby to engage more effectively in project implementation and deployment as well as in operations and management of commercially viable business models.

Ernesto Macias
President
Alliance for Rural Electrification (ARE)

Source: WWF - Brazil

WHAT NEEDS TO BE DONE – COMMENTS FOR A POLICY TOWARDS CLEAN ENERGY ACCESS

Given the strong position of traditional hydropower in many Latin American countries, there is a tradition of renewable energies in the continent. Renewable energies like photovoltaic, wind and biomass plants have become an important part of the energy mix in some countries with an investment superior to USD 80 million; and countries like Chile and Mexico appear frequently on the list of the 10 best markets for renewable energies on a global level.

During the last five years there has been an increased interest in using renewable energies specifically for electrification in remote areas. Large governmental tenders for solar home systems like in Peru, Bolivia or Brazil helped bring electrification to inhabitants of rural areas. But even though natural resources are abundant and different technologies to make use of these are available, there is still too little initiative from the private sector to develop this market opportunity. Financing and institutional structures supporting projects still mainly come from the public sector. Research to adapt technologies to local needs is still mainly done by public universities. Private initiatives are often based on efforts of not-for-profit organizations or corporate social responsibility projects which lack replication on a large scale.

This booklet presents a broad scope of case studies along the different technologies, different climate zones of the continent and embedded in a diversity of cultures. They show how successful projects are structured, financed and implemented.

While we found many successful projects, there are many more needed to serve the growing demand of the people along the continent. From a policy perspective the question is how to facilitate private sector project development, how to design policies towards clean energy access.

While the first chapter presents different institutional programs, the diversity of the projects show clearly that it is not possibly to simply copy a certain program design – we could not judge whether a project which was successful in Brazil or Bolivia would work the same under different economic and cultural conditions. But by analyzing the different successful programs and the successful projects, we have clearly seen certain characteristics which can be found in both. Instruments which support these key success factors should be found in each policy for clean energy success.

Therefore, the following is not outlining a blueprint for a modern energy policy. After having analyzed the inspiring examples collected in this booklet, we present guiding principles or a toolkit which we feel appropriate for a successful policy design.

These principles cover mainly five areas:

1. Technology Benefits – this means the question of whether governmental policies should discriminate between different technologies by pre-selection or special funding or whether the policy level should be technology-neutral leaving the selection to private sector developers. The case studies show a certain dominance of photovoltaics, but it can also be observed that for certain usage cases with higher demand on capacity or under certain environmental conditions small hydro, wind and biomass are valid options.

2. Prioritization of Basic Needs Projects discusses which characteristics these projects need to show to be upgradable to the next level. The rise in demand is consistently mentioned by case studies on basic needs.

3. Scope of Policy shows how traditional sector policy does not cover the needs of rural electrification projects and how integration could help in doing so. Education and entrepreneurial incentives are beyond the scope of energy politics but they are surely needed to make rural electrification successful.

4. Financing Instruments need to cover different kinds of investments and should not only focus on one specific project volume. The case studies cover projects starting with less than USD 1,000 and others with a multi-million budget.

5. Guarantees by the State are necessary because only governments are able to cover unknown risks and as active market development supporters they need to cover risks resulting from dissimilar information. Some case studies show how changes in government policies affected private sector projects and devaluated prior investments.

Source: Guakía Ambiente

Renewable energies offer an alternative to the diesel generator as the most common energy source in rural areas. Energy access in remote areas means access to clean energy – for competitiveness as much as for environmental constraints, while photovoltaic is the most prominent technology it is not the only one. The projects offer a broad range of technologies regarding the source of energy and the distribution. This is even true for projects which seem similar at first glance.

Openness to different solutions gives space to the creativity of project developers who know local conditions better than anybody else. How then should different technologies be compared and judged? While cost per $kW_{installed}$ is a common way of comparison, it is misleading. This can be seen by comparing the project costs or more specifically the capital expenditure (CAPEX) of the projects and which differ a lot: CAPEX / $kW_{installed}$ – though a common key performance indicator – is questionable when considering different technologies as output (in kWh) and operational costs (OPEX) may differ significantly. So, leveraged costs of electricity (LCOE) in costs per kilowatt-hour seem a more appropriate performance indicator. Ideally this refers to kilowatt-hours used not simply generated as different technologies adapt better or worse to the demand curve of the specific project. Does this mean technical specifications are forgotten?

Definitely not. Again, the project examples help. It is a policy task to define industry standards for off-grid projects. This applies to the distribution system in micro-grids and the connections to the end-user as much as for the technology employed. As a general rule we do see that operational stability and durability outweigh by far efficiency (which might mark the difference to the central grid in urban areas).

In addition, it is the project owner (private or governmental) who defines the performance criteria whatever the technology employed needs to meet. One of the articles discusses the case of batteries which needed to be replaced as much as possible by other storage alternatives due to the remoteness of the project. Defining the right performance criteria may lead to a different choice of technology and not simply to a redesign of the project.

Some consider energy access as a civic right. Light, communication, in some cases heat and more frequently potable water depend on energy access. This is why meeting basic needs in this collection of case studies has such a prominent role. There are many good arguments to prioritize basic needs projects – as it has already been done. But the case studies collected here, as well as, the initiatives show a specific characteristic of successful basic needs projects: they bear the seed of further development.

The articles outline different ways on how to achieve this. It might be by oversizing a basic need project to add productive use in a second phase. Or it might be a technology which is offered through modules to the end user whose demand grows beyond his or her basic ability to pay. But in all cases, the step from covering basic to enhanced demand is not disruptive. It is characterized by incremental growth. This has to be considered in energy policy and project planning. Technology and servicing need either to be flexible or easy to grow in a modular way to meet the rising demand.

One recurring topic can be found in nearly all studies: the importance of training and community preparation. While this might be obvious, the case studies go well beyond the obvious. Trainings start with community building, include technical training and go towards the efficient use with entrepreneurial or agricultural courses offered to the users. The beneficiaries are not only asked to get acquainted with a technology, they are invited to appropriate it. What does this mean for the policy supporting energy access projects? It has to be as comprehensive as the projects; it has to cover technical and social and economic aspects of electrification and empowerment. This requirement conflicts with the traditional way politics is organized and policies are developed and employed by areas. Traditionally social or educational policies are not linked to energy policy. But it is exactly this comprehensive approach which makes projects successful. Access to clean energy in remote areas needs to be accompanied by access to social workers, education, technical and entrepreneurial training.

In our call for articles, we have explicitly asked all contributors to comment on the total costs of their project and how it was financed. There are several interesting observations. Firstly, there is always some financing needed – be it small four-digit numbers or up to multi millions. Even if projects are self-sustainable and profitable, extended payment terms drive capital costs and require an intelligent financing scheme. Secondly, one can note that many projects are at least partly grant financed. Allowing access to clean energy and often starting with basic needs requires some form of subsidy or grant. Thirdly the funds often come from diverse sources include the private sector (be it as corporate social responsibility or simply commercial) and always include some contribution by the beneficiaries. This might be small in basic needs projects where the contribution equals the existing opportunity costs for kerosene or wood or it might be part of a percentage of the new earnings facilitated by a productive use project.

From a policy perspective, this stresses the importance of accompanying other instruments or measures through a financing scheme which covers micro-credits by local (agricultural) banks or similar institutions as much as large structured financing mainly by international

Source:Comunidade Cassianã, Resex Médio Purus / Ldbrea

(development) banks. Relying purely on debt financing is not enough to facilitate basic need projects. There are many different possibilities like one-time infrastructure financing or continuous subsidies on part of the costs per kWh. As projects mature and become self-sustainable, it is important to find a scheme which does not hinder private commercial initiatives.

Even though it has not been made explicit in any of the reports, it is obvious that none of these successful projects struggled with competition neither from other potential projects addressing the same community nor from grid extension. Off-grid projects giving access to energy require the same kind of guarantees as any other generation projects. The investment – whether private or public – should not be devaluated by a sudden change in policy. And this guarantee does not only address the investment into generation. It needs to also address the beneficiaries of a project. Beneficiaries take their own investment decisions on lamps, chargers, ventilators or even electric mills or electric saws – even on a small scale – based on a certain minimum availability of energy at a given maximum price. While guarantees do not necessarily need to determine the status quo, they need to ensure that those who make a project successful are not risking losses.

The state needs to integrate its energy access programs into its energy policy. Off-grid projects might become easily grid-connected if the technology has already been chosen accordingly. The individual solar home solution might be a first, indispensable step towards a more comprehensive microgrid solution. State-guarantees are not only a sign that the government is taking risks individuals (investors and beneficiaries) are not willing to take, but state-guarantees might as well simply reflect a disparity of information. Energy policy including energy access initiatives need to follow a development plan developed and implemented by the federal governments. Path contingent interdependencies have to be detected and be dealt with by the governments, risks should not be transferred to investors and beneficiaries.

You will have noted that we refused to comment on detailed tender mechanisms or the detailed design of concessions for distribution in off-grid areas. Even though these seem to be valid policy instruments to enhance efforts in rural electrification, the specifics depend on the maturity of national energy markets and the areas which could benefit by these concessions. Whatever the specific design is, we believe that the outlined toolkit will help to make it more efficient for the good of the Latin American people.

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Karl Kolmsee
ARE Board Member
Chair of ARE Sub-Working Group Latin-America

Source: Carl de Souza/ AFP – Resex Ituxi/ Lábrea

1. PRIVATE SECTOR, GOVERNMENT & SUPRA-GOVERNMENTAL PROGRAMS

CASE STUDY 1

RURAL ENERGIZATION IN ISOLATED AREAS OF GUATEMALA THROUGH THE APPLICATION OF CORPORATE SOCIAL RESPONSIBILITY

Alexandra Arias, OLADE

Summary

The Latin American Energy Organization (OLADE) is promoting through their Member Countries, a Methodology for Rural Electrification, including social variables and Corporate Social Responsibility. As part of the pilot projects, the project Micro-Hydroelectric Plant Batzchocolá was implemented, located in Guatemala, villages of Batzchocolá, Department of Quiché. The implementation was carried out from 2009 until 2017 (including project assistance and evaluation). The total investment cost amounted to almost USD 800,000.

The Organization

The project was supported by OLADE, an organization comprised of 27 Latin America and Caribbean countries, its purpose is the integration, protection, rational use and protection of energy resources. OLADE promotes the progress towards the Sustainable Development Objectives approved by United Nations, among its Member Countries.

The Objective

In Guatemala, the objective of OLADE was the application of a Proposed Methodology for Rural Electrification, to improve the living conditions of the population through partnerships with the private and public sectors, to stimulate productive activities that contribute to the sustainable development of the community. The three beneficiary communities are 300 km from Guatemala City, the power grid for home connections closest to the communities of the Batzchocolá micro hydro plant is 28 km away. Taking advantage of local willingness and the potential for water resources in the Quiche region, assistance was provided to enhance the living conditions, create jobs and increase the incomes for all inhabitants of the beneficiary communities.

The Challenge

These communities didn't have access to basic services like water, telecommunications, and electricity. Access to the communities was limited due to the quality of roads (trails). One of the main barriers was the limitation of financial resources for setting up the infrastructure, the payment capacity and personal limitations of villagers, who were in (extreme) poverty and the low educational level.

Renewable Solution

Potential sources of energy were analyzed and water source was the best option for these communities. Once negotiated with the different entities, project implementation began with plant construction, using a large percentage of labor supplied by the communities as counterparts. Women and men worked together to make their dream of electric service come true.

The sustainability project is based on creating a community enterprise (in this case Asociación Hidroeléctrica de Desarrollo Integral Norte del Quiché (ASHDINQUI) which includes all community members, and on forming teams to develop and adopt the rules needed for proper implementation of the proposed activities. In addition, partners are responsible for appropriate management of the projects' financial resources, of the energy resources once projects are implemented, and of the available natural resources for environmental sustainability. Production projects were created for partners to generate the revenues needed to pay for the energy and enhance their living standards. Furthermore, a market study was conducted so that these production projects can remain truly competitive and generate the necessary revenues.

Training the beneficiary population was another key point in project sustainability. At the beginning, demonstrating working projects and equipment helped with information, awareness-raising activities, and training. Furthermore, experience has shown that training for specific purposes was grounded on the basic principles of consultation, prior informed consent, and a gender equity approach. This was done by designing processes and activities that led to training sessions, information and awareness workshops, consultation gatherings, and community assemblies. This process empowered communities to approve and consent to the rules and measures taken for project implementation, and to establish the partnerships needed to implement them.

Project Financing & Costs

To fundraise it was crucial to implement a multi-stakeholder model consisting of INDE, ELAGUA, MEM/OLADE, HIVOS, the Municipality of Nebaj, ASHDINQUI and OLADE. The engagement of companies near the communities, through Corporate Social Responsibility, strengthened their commitment to respect and advocate for the rights of all participants in the community electrification projects and gave them the benefit of financing for specific actions to achieve project sustainability.

An agreement was signed to distribute activities and funding. This model, which engaged the Government, international cooperation, private initiatives, NGOs and organized communities, enabled technical and financial management to

Source: OLADE

develop the Batzchocolá project, providing these communities with access to energy. The total investment cost amounted to almost USD 800,000. The unskilled labor provided by all partners was not recorded in detail, but their contribution was highly significant at each stage of the project.

Project Outcome

Inaugurated on 17 July 2014, the power plant of 90 kW, supplies energy through a distribution grid. Project management, operation, and maintenance were entrusted to the ASHDINQUI, which operates like a small community enterprise for electricity generation and distribution. Its 170 connections currently supply power to over 140 families, 19 small businesses and other services in the three com-munities. In the dry season, when the plant does not generate the energy needed, an upscaling of the plant is planned to increase the generating capacity as well as to promote new productive projects.

Currently, the Methodology is applied in Guyana and Bolivia in order to gather more lessons to improve the Methodology of Management of Rural Energy Projects with the inclusion of Social Variables and Corporate Social Responsibility, to be implemented by the Member Countries to carry out their rural electrification plans.

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CASE STUDY 2

IMPLEMENTATION OF CORPORATE SOCIAL RESPONSIBILITY & SOCIAL VARIABLES IN RURAL ENERGY SYSTEM IN ISOLATED AREAS OF BOLIVIA

Alexandra Arias, OLADE

Summary

The Rural Energization Methodology implemented by OLADE, in this case for Bolivia, proposes to include Corporate Social Responsibility (CSR), in addition to social variables, with the aim of financing projects. These companies with a close action range to the beneficiary communities participate with concrete tasks and financing of activities that seek the benefit of the communities and their sustainable development, in turn, companies obtain a social network that in many cases is essential to working in the region where they are developed. The project is currently in progress and the total investment cost amounted to almost USD 300,000.

More information about OLADE in previous article.

The Objective

In Bolivia the objectives of OLADE, besides the incorporation of other organizations within the development of rural energy projects in isolated areas as part of the CSR concept and achieving the participation of public and private companies within the project sustainability plan, are to:

- Create rural organizations for the technical and financial development of the project;
- Create agreements between public and private companies and the rural organization for the development and sustainability of energy projects and
- Implement the construction of energy projects with the support of partner companies.

The Challenge

The project aims to improve access to electricity from renewable energy sources in rural areas and to promote the productive use of the electricity in order to reduce poverty. After reviewing the updated Bolivian Plan of Rural Electrification in coordination with the Vice-Ministry of Hydrocarbons (Energy), the communities were defined: El Espino, El Carmen and Itayovai in Charagua Norte Region. El Espino is the only community with electricity, which is generated by a photovoltaic plant and is supplied through a mini-grid. The three communities have about 1,000 inhabitants.

Furthermore, some public and private companies were identified to support the communities. Since the 1990s, PLUSPETROL had oil concessions in the area of Charagua Norte, one of the largest regions in the country. PLUSPETROL collaborated with productive projects in the communities within its area of action. The communities were very organized and have representations in La Capitanía Zonal APG Charagua Norte. An agreement was signed amongst Pluspetrol, Capitanía Zonal APG Charagua Norte, the three communities and OLADE in order to finance and implement the projects. The communities committed to providing the workforce and materials for the construction of the infrastructure.

By consensus, the communities decided to set up a chicken farm in each community managed by the community organization. The project provided energy to make community farms functional. The projects will be managed by women. In the area it was shown that women were very well-organized, represented in different committees within the community and part of the Capitania, which meant they had the right to speak and vote.

Training the beneficiary population was another key point to empower rural population. Self-empowerment is a key concept in the sustainable development of the communities. It helps them to become the main characters of their own change towards a better future, giving them control and mastery over their reality, making them responsible for the actions they take and which affect them, in order to achieve an alternative that improves their quality of life. Self-empowerment is based on the idea of giving the community skills, resources, authority, opportunity, motivation, as well as making them responsible for individuals and responsible for their own actions.

Renewable Solution

Potential sources of energy were analyzed in the communities and the main energy source suitable for the region was solar energy.

Project Financing & Costs

The communities were active within their organizations to find sources to finance the projects. PLUS-PETROL agreed to, throughout its Corporate Social Responsibility Programs, provide funding to finance productive projects. Work was undertaken with the APG Charagua North zonal captaincy with its contribution of funds and OLADE financed most of the productive projects.

Source: OLADE

The total investment cost amounted to almost USD 300,000. The communities have provided the land to locate the barns of the farms, materials, and the workforce for its implementation.

Project Outcome

Lessons learned in project implementation have identified the main barriers to the sustainability of rural electrification systems. The project focuses on empowering people from rural areas, promoting productive use of electricity, giving them access to public and social services. Furthermore, the program increased the electricity coverage in the country, helped to reduce CO_2 emissions associated with the use of fuels use by isolated communities and improved the living conditions of populations in isolated areas.

The program, besides Corporate Social Responsibility and Social Variables, includes a gender approach, that seeks to increase the participation of women with equal rights and obligations in the process of comprehensive management of projects and decision-making which affect the economy of the society of the communities.

The methodological contribution of the experience can be capitalized through its reproduction and scaling. Programs of electrification in isolated zones are unexpectedly also of interest for the development of projects in areas such as the generation and transport of energy in the Latin American countries.

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CASE STUDY 3

IMPLEMENTATION OF SOCIAL VARIABLES & SOCIAL RESPONSIBILITY IN RURAL ENERGY SYSTEM IN ISOLATED AREAS OF GUYANA

Alexandra Arias, OLADE

Summary

In Guyana, OLADE implemented the Methodology for Rural Electrification that includes social variables and Corporate Social Responsibility. Three isolated hinterland communities from three distinct geographical regions of Guyana were the beneficiaries of the project. The communities are: Powiakuru, Kangaruma and Shulinab. The key factor used to choose the communities was their level of poverty. The project consists in the installation of photovoltaic systems to generate electricity for a food center, a center for storage and sale of fish and wild meat as well as the installation of a fruit processing plant using solar dryers. The project is currently in progress and the total investment cost amounted to almost USD 150,000.

More information about OLADE in previous article.

The Objective

In Guyana the objective of OLADE was to prove the proposed methodology for rural electrification in Caribbean Countries throughout the stimulation of productive activities that contribute to the sustainable development of the communities. Communities' requirements were based on their collective needs. Notably, several social services which were normally provided to communities within Georgetown (the Capital) were missing. Due to the potential of solar radiation in the zone, OLADE and the Guyana Energy Agency provided assistance to enhance the living conditions, create small businesses and increase the incomes for the inhabitants of the beneficiary communities.

The Challenge

These communities did not have access to basic services like water, telecommunications, and electricity. The villages have significant challenges related to access. Access to Powiakuru was via a tidal creek that takes many hours. Access to Kangaruma was difficult, with no regular transportation via trails. The only way is by river but this again has to be organized on an adhoc basis and is based on the availability of the operators in that area. Access to Shulinab is easier, villagers can travel from the coast via a laterite roadway to Lethem, which is a border township on the Guyana-Brazil border.

The communities are involved mainly in subsistence activities such as small-scale farming, hunting and fishing. Due to the relatively small amount and value of economic activities in Guyana, not many commercial or industrial entities were involved in any extensive CSR based activities.

The sustainability project is based on generating production projects to generate profits from the everyday activities of the villagers.

In Shulilnab, the women are very active with yearlong fruit processing using whichever fruits are seasonal at the time. The ability to store the fruit pulp and juice in a freezer allows them to utilize more of the fruits as they come into season. There is also demand for dried fruits which will be enhanced by the introduction of solar dryers. So, a fruit processing centre was implemented, equipped with solar sreezers, solar dryers, small solar power system to power kitchen equipment and a wood stove to process the pulp and juice.

The villagers have their own cattle and sell beef and any wild meat the hunters can catch. However, due to the lack of an effective storage system, the meat sales centre was provided with solar freezers.

In Powaikoru, a village shop center was developed to store fish and wild meat caught during the week which allowed the hunters and fishermen to make one trip per week to sell their products. It was also used to develop a village shop to provide primary food supply for all the villagers since the closest shopping center is many hours away by small boats. A food processing centre was also installed to process ginger, red beans and peppers, in order to sell these products to nearby towns.

In Morakaibai, the guest house and the catering center were equipped with a solar power system to power the kitchen equipment, solar freezers, lighting and a solar hot water system.

Training the beneficiary population was another key point in project sustainability. They had training in basic use of solar equipment and coaching on the production on their productive projects as well as training for strengthening administrative and organizational capacities of villagers to manage the projects.

Renewable Solution

Potential sources of energy were analyzed and based on the interventions suggested for the villages and the data form the country, it was decided that the main energy intervention would be based on the use of solar energy. As Guyana is so close to the equator and is not a very large country, it is possible to use the same solar irradiation of approximately 5 kWh/m^2/day; this can be equated to approximately 5.5 peak sun hours per day.

Source: OLADE

Project Financing & Costs

In Guyana, it was not possible to find entrepreneurs close to communities. The experience revealed that companies were only willing to participate with CSR if they obtained a social revenue. To finance the projects, only three organizations were willing to work in order to implement the projects: Canadian Cooperation, OLADE and Guyana Energy Agency.

The total investment cost amounted to almost USD 150,000. It is important to point out that the companies used for the implementation of the projects were purely Guyanese. Solar dryers were built with local manpower as well as with local design.

Project Outcome

Data is being collected from the application of the Methodology in the Caribbean Region as well as in Central America and South America in order to gather more lessons to improve the "Methodology of Management of Rural Energy Projects with the inclusion of Social Variables and Corporate Social Responsibility", to be implemented by the Member Countries to carry out their rural electrification plans. It is clear that each region and country has its own characteristics and that the methodology must take into account the differences in order to be implemented on a regional basis.

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Source: OLADE

CASE STUDY 4

CHALLENGES OF RURAL ELECTRIFICATION IN BRAZIL

Eduardo Borges, Eletrobras

Summary

In Brazil, providing universal access to electric energy really gained force with Law 10,438/2002. The Decree 4,873/2003 created the rural electrification program Luz Para Todos, which aims to finance and provide subsidies for investment in rural electrification projects, covering the whole country. The operating program consists of the Ministry of Mines and Energy (MME - the coordinating agent), the Electric Energy Commercialization Chamber (CCEE - the resource management agent) the electric distribution concessionaires (the executing agents) and Eletrobras (operating agent). The program is designed so that each household has enough electricity for lighting, communication and refrigeration.

Since 2004, the Luz Para Todos Program has provided more than 3.3 million new electricity connections to rural households, benefiting nearly 16 million people, with investments in the range of R$ 23 billion, of which R$ 13.4 billion came from subsidies. According to information from the Brazilian Institute of Geography and Statistics (IBGE), the rural electrification rate, which was 71% in 2000, reached 98% in 2015, showing the great contribution of the program to universal energy access.

The Organization

Eletrobras is the largest electricity company in Latin America, a leader in generation and transmission of electricity in Brazil, in particular in the segments of commercialization, distribution and energy efficiency.

The Challenge

Despite the progress of the program, there are still many rural households without electricity, located in the North Region, including the Amazon region, where the rural population is more dispersed and communities are remote.

Renewable Solution

With the objective of helping communities with no access to energy, Eletrobras, in partnership with the distribution concessionaires, developed pilot projects: the Xapuri Pilot Project, with individual photovoltaic systems, testing three types of electric power supply: alternating current (AC), direct current (DC) and a mixed system (DC + AC), the Project of 12 photovoltaic mini power plants and the Araras Pilot Project, with collective photovoltaic systems and mini-grid distribution. The studies, works and pilot projects have brought lessons, which include the following:

- In the Xapuri project, it has been proven that the mixed individual photovoltaic system had greater energy efficiency and reliability in relation to the AC system. The results of the pilot project were presented to the regulatory agency and contributed to improved regulation.
- The refrigerator was the appliance that represents the greatest potential to reduce the investment cost of the system. Although the cost of a DC efficient refrigerator was higher than that of an AC efficient refrigerator, the size of a system needed to supply energy to the DC refrigerator was considerably lower. Thus, the investment cost of the whole (system + refrigerator) could be reduced by 32%.
- The battery was the weak point in remote systems. It was the equipment of the system that most impacts the cost of energy, with variations of 20 to 25%, while other equipment present variations of 1 to 4%. The preservation of the battery life is fundamental for the sustainability of the systems.
- In systems of collective electric power generation, like in Araras, it was important to adopt a demand control system so that the use of energy by one consumer did not harm other consumers.
- The equipment of the system had to be adequate for the tropical conditions, for operation in hot and humid tropical forests, suitable for automatic operation, and approved in Brazil in accordance with the Conformity Assessment Regulation (RAC INMETRO - the national quality guarantee organization).
- A well-qualified workforce was indispensable for systems in remote regions, because these systems have limited energy and were located in hard to access areas. In Brazil, the concessionaires, accustomed to rural electrification with distribution grids, had difficulties adapting to the cultural change to renewable alternatives.
- The cost of operation and maintenance of the systems was strongly influenced by issues related to logistics, such as community location and transportation. Given the high operation and maintenance costs of the isolated systems, grants and subsidies for these costs became essential.

Project Outcome

The perspective of applying isolated energy generation systems within the Luz Para Todos Program is the electrification of more than 27,000 residences in remote rural regions, with an estimated 19.5 MWp of power for solar systems. In order to prepare ourselves for this challenge, the standardization and quality of the systems are very important, together with training of the workforce, technically preparing the installers, operators and managers for renewable energy, especially with regards to photovoltaic systems.

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Source: Smart Hydro Power

CASE STUDY 5

MICRO HYDROPOWER: AN ALTERNATIVE FOR CLIMATE CHANGE MITIGATION, ADAPTATION & DEVELOPMENT OF MARGINALIZED LOCAL COMMUNITIES IN HISPANIOLA ISLAND

Michela Izzo, Guakía Ambiente & the GEF Small Grants Program

Summary

Guakía Ambiente supported by the GEF Small Grants Program implemented a micro hydropower plant as an alternative for climate change mitigation, adaptation and development of marginalized local communities in Hispaniola Island. The project started in 1997 and is still running. Total project budget was more than USD 14.5 million.

The Organization

Guakía Ambiente is a Dominican NGO. Since 2008, we have been working for sustainable development with a focus on people and community empowerment. Our work aims to improve living conditions and environmental conservation and resilient communities.

The Objective

The main objective of the interventions was to provide access to electricity to isolated rural communities through renewable energy sources managed by means of a community based sustainable system.

The Challenge

One of the priority structural problems of the Dominican Republic was the provision of electricity, since the country electrical system was characterized by low stability, reduced quality, and an insufficient supply. Despite the installed capacity (3,005 MW) exceeding the national demand (1,800 MW), the average generation was below 1,500 MW. Furthermore, the Dominican Republic had the most expensive electrical structures in the Caribbean and Central America, where the final customer has to pay more than USD 0.20/kWh. This is more than three times the USD 0.06/kWh which people pay in the 16 off grid micro hydro systems examined in this paper. In this context, rural areas were worst impacted, and more than 5% of the population do not have access to electricity services. These conditions were worse in Haiti, where rural areas lacked electricity and even in urban zones where only 30% of population were connected to electrical grid, and the service was not stable.

Opportunities for Renewables

Both countries are located in the Caribbean region on the island of Hispaniola, which is dominated by young mountainous structures, with steep slopes and narrow valleys, where water resources are abundant in the majority of the areas.

The above conditions offer a suitable solution for responding to electricity provision needs for many rural communities in the country.

Several favorable and synergic developments supported the development of micro hydro systems in the Dominican Republic. First, in 2007, the Renewable Energy Incentive Law was approved (Ley 57–2007); at the same time, the community micro hydro systems proved to be an effective way of addressing the problem of electrification of remote rural areas. In this context, the UNDP GEF Small Grants Program (SGP) developed a network of collaboration with the Dominican Government, international cooperation agencies, and several civil society organizations (NGOs), turning the problem of electrical provision into an opportunity, especially in rural areas, opening the way to innovative models of development.

Renewable Solution

The GEF SGP Dominican Republic and Guakía Ambiente have become leader institutions in community micro hydropower generation, having developed an innovative model of intervention based on multi-stakeholder participation and people and community empowerment. These systems are the ideal space where this model can develop and expand: electricity is only the first significant result, but not necessarily the main one, since the improvement of all community capitals is the main achievement.

At present more than 4,500 families have access to electricity through 47 community micro hydropower systems, with a total installed capacity of more than 1.3 MW.

After the systems start working, each family had a better energy service and reduced its costs between USD 100-300 annually. Furthermore, job opportunities originated from system management and other local enterprises based on electricity.

We worked to strengthen the Dominican Network for the Development of Renewable Energy (REDSER), a second level CBO constituted by over 40 CBOs whose communities use renewable energy sources. With REDSER, we worked to improve autonomy and sustainability of communities, thereby reducing their vulnerability.

Globally we are contributing to climate change mitigation, with more than 24,000 tons of CO_2 avoided and/or absorbed annually.

Source: Guakía Ambiente

Project Financing & Costs

The construction of 47 micro hydropower systems required an investment of more than USD 14.5 million.

These projects are possible because of the synergic participation of numerous stakeholders, such as international agencies, public institutions, civil society organizations, and private sector, who interact and give their contribution to reach a common objective, with a focus on empowering people and local communities. Since the first projects, a multi-stakeholder platform has been working to build these systems and the Dominican State, in particular, has inserted these initiatives as part of the national energy policy, having introduced this specific scheme of intervention in its action to solve the problem of access to electricity in feasible rural areas.

Each system works under a community management mechanism, where a local elected committee is responsible for guaranteeing users to receive the service and the system to be sustainable. For this reason, each user pays USD 4-12 per month, depending on the consumption, which contribute to grow a community fund, used for the maintenance of the system.

According to financial analyses performed, local communities will be able to pay for a new system, once its shelf life (estimated at 50 years) will have been exceeded.

Project Outcome

More than 20,000 people are directly benefited through these systems, accessing electricity, the main benefits are:

- More than 4,500 families access reliable electricity from renewable sources.
- More than 4,000 women have considerably reduced the time spent doing house chores, especially laundry.
- More than 100 enterprises were born from the use of electricity from renewable sources, with an increase of more than 50% in family incomes.
- More than 200 direct jobs were created directly linked to micro hydropower systems.
- Each family saved USD 100-300/year for energy needs and accessed 4-9 times more electricity.
- More than 5,650 BEP were saved in energy production, with a total annual saving of more than USD 550,000.
- Children and youth have more time to study and access to communication technologies: 4 Internet WiFi systems were developed in isolated communities.
- More than 40,000 gal/year of kerosene gas were avoided, reducing domestic pollution.
- More than 7,000 hectares of land were conserved in upper basins.
- More than 24,000 tons of CO_2 were avoided and/or absorbed annually.

Our experience taught us that, whenever local groups were directly involved in their own development, there was an improvement in their living conditions, which also benefitted the protection and conservation of nature.

Furthermore, sustainable common use of natural resources promoted the sense of ownership towards them, and prevented negative externalities from happening in local communities.

Looking forward, the Dominican Republic and Haiti have the potential to further scale up of these successful experiences, and to continue their contributions to solve the problem of electrical supply, as well as disseminate innovative and sustainable models based on local community empowerment.

Source: Guakía Ambiente

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2. BASIC NEEDS

CASE STUDY 6

ELECTRIFYING THE LAST MILE IN MEXICO

Ana Maria Martinez, Ilumexico

Summary

Since 2010, Ilumexico is running a project which brings basic energy supply to remote areas in Mexico. While the majority of users start with a 25 W light only supply, they can pass over time to 50 to 100 W allowing for the addition of other electrical devices.

The Organization

Ilumexico is a social enterprise that sells and installs solar systems to marginalized communities of Mexico without access to the conventional electric grid.

The Objective

To catalyze development through solar energy in off grid communities of Mexico.

The Challenge

In Mexico, two million people still lack access to electricity and rely on expensive and dirty sources to light their homes and businesses. Access to reliable and affordable energy is a foundational step to eliminating poverty, but power lines are not coming anytime soon to Mexico's remotest villages due to their geographical location and isolation conditions which makes them hard to reach and expensive targets for government infrastructure and electrification.

Opportunities for Renewables

Ilumexico emerged in 2010 in response to this situation by providing solar electricity to these communities. As a social enterprise that tackles poverty and catalyzes development through solar energy in marginalized communities of Mexico, Ilumexico provides a holistic approach to community development through energy access, working with technology development, last-mile distribution, flexible financing and gender equity programs that can ensure all Mexicans have electricity by 2025.

We offer isolated solar systems with different capacities to satisfy various energy needs in off-grid houses, schools, clinics and community centers, and have diversified the range of products for different applications in small business, agriculture and other economic activities.

Through our network of ten regional retail branches, Ilumexico has brought solar energy to nearly 10,000 households in the most remote regions of Mexico, where the lack of roads and infrastructure is the biggest obstacle to overcome.

The difficult socio-demographical conditions of the rural communities that Ilumexico targets, create perfect opportunities for isolated solar solutions.

Renewable Solution

Our experience has provided us with important lessons to reach off-grid communities that have shaped our four core pillars, which differentiate us in the market:

1. Proper products and services: We develop, integrate and manufacture solar systems based on direct customer feedback, prioritizing quality and durable technologies that are affordable and adapted to rural needs. We offer modular options for different levels of income energy access demands (from lighting to electrification) that can be easily upgraded. Our product portfolio includes solar technologies that promote community energy services and products for income generation such as water pumps, electric fences and refrigerators. Furthermore, we provide warranties, on-going maintenance and after-sales support that guarantees product durability and builds brand trust and loyalty.

2. Consumer finance: We provide flexible financing to our target communities and give them the possibility to replace their current spending on expensive, polluting and hazardous lighting sources (such as diesel and candles) with solar systems that they can pay in instalments from 3-18 months, while creating their first financial experience.

3. Last mile distribution: Through our network ILUCentros we access remote communities and our targeted communities. ILUCentros are located in strategic points and are staffed by local employees (Community Engineers) who are trained in sales, technology, maintenance and finance. We have also established an effective sales and service channel in communities by working with well-connected agents (Ambassadors) who earn commissions for their work.

4. Social Empowerment: Our electrification projects are accompanied by workshops that ensure technology transfer and adoption so that energy can be used as a platform for economic development.

Project Outcome

We have installed over 9,800 solar systems in 375 communities, electrified 72 rural schools and 21 health centers, benefitting 41,000 Mexicans and displacing more than 5,300 tons of CO_2.

To achieve this, we currently employ 44 people directly (27 in rural areas of which 14 are indigenous), and 22 indirectly in rural communities (through our Community Ambassador Program).

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Source: Ilumexico

CASE STUDY 7

RURAL ELECTRIFICATION IN HAITI

Rachel McManus, EarthSpark International

Summary

EarthSpark International works within the Scaling SEforALL program building up Community Microgrids in Haiti. The project period is from 2012 to 2020 with a total project budget of USD 15 million.

The Organization

EarthSpark International is a US-based non-profit with the mission of eradicating energy poverty and the method of doing the research and development on business models that can spin off and scale. To date, EarthSpark has spun off Enèji Pwòp, SA a Haitian social enterprise and SparkMeter, Inc a smart meter technology company. Enèji Pwòp has sold over 18,000 small-scale solar products and improved cookstoves. SparkMeter has sold over 25,000 meters in 17 countries. EarthSpark is now working on a business model for microgrid development.

The Objective

EarthSpark's primary objective was to move microgrids into the market. The project de-risks the process of building and operating community scale microgrids in Haiti. This spin-off development company will serve Haiti and also provide business and technology solutions relevant to other countries.

The Challenge

Only 30% of the population of Haiti has access to electricity, serving the capital and some major cities. Unreliable generation, transmission, and distribution plague this electricity infrastructure with total system losses thought to be about 50%. Those off the grid rely on kerosene, candles, diesel gensets, or third party phone charging for their energy needs, spending 6.5% of their annual income. EarthSpark market research, carried out with local partners in 2015, has identified 80 communities as ideal locations for microgrids.

There are still challenges to microgrid development in Haiti. The legal and regulatory framework is in flux, and there are significant process, technical and environmental risks. EarthSpark believes in 'de-risking by doing' and is working to mitigate these risks through the development of its next three grids and building a track record toward a replicable model for the subsequent tranche of 20 grids.

Opportunities for Renewables

The majority of Haiti's electricity comes from diesel and heavy fuel oil generation, but there is abundant potential for solar and wind power generation. EarthSpark's flagship microgrid in Haiti is a solar-diesel hybrid grid with storage. It is powered with over 95% by solar energy, demonstrating the enormous potential for PV in solving energy access.

Renewable Solution

In 2012, EarthSpark developed Haiti's first pre-pay microgrid with just 14 customers in Les Anglais, Haiti. This was made possible through collaboration with Digicel, Haiti's largest telecommunications company, by using the excess capacity of a diesel generator powering a Digicel tower. In 2013, the grid was expanded to 54 customers using the same diesel genset but introducing smart meters that were the pre-cursor to what would become SparkMeter technology. In 2015, with funding from USAID Powering Agriculture, the grid was expanded to a town-sized solar smart grid serving ~450 customers.

The grid consists 93kW of PV panels; a 30kVa back up diesel genset and 450kWh of battery storage. It serves 450 homes and businesses with reliable, affordable electricity 24/7. Customers purchase electricity in the form of pre-pay credits from local energy vendors in units and timing that fit their energy budgets. The grid has tiered service levels tailored to community needs. Smart meters from SparkMeter allow for time of use pricing and load limiting, allowing operators to optimize grid resources. Designed as high-quality infrastructure, an EarthSpark grid is powerful enough to energize local industry yet progressive enough to serve every single household within its footprint.

EarthSpark spin-off Enèji Pwòp, SA is contracted to operate and maintain the grid with a staff of six in Les Anglais and management oversight from two staff members in Port-au-Prince.

Project Financing & Costs

EarthSpark has raised and spent approximately USD 3 million in feasibility studies, pre-development, and the pilot Les Anglais grid. It is working on developing three more grids to fully de-risk the operational model as it develops an investable plan for a further 20 grids. For these grids, EarthSpark will raise USD12 million in debt, grant and equity for CAPEX and corporate development for a microgrid development company.

Source: Earthspark

HAITI

EarthSpark is working with various stakeholders to develop a comprehensive public-private-partnership model for the next tranche of towns. This will consist of a locally and internationally vetted suite of contracts and documents for municipalities to issue concessions for microgrids.

EarthSpark spin-off Enèji Pwòp continues to serve those beyond the reach of its microgrids with stand-alone small-scale solar lanterns and home systems. Each new microgrid built will provide business infrastructure to facilitate sales of these products. EarthSpark also provides financing for microgrid customers' purchase of highly-efficient appliances or machinery for productive uses of electricity, particularly for agricultural and food-processing applications.

Project Outcome

EarthSpark's ultimate goal is to build 80 grids in Haiti and a model that can be replicated in other countries. They will directly serve 200,000 individuals in rural towns, unlocking enormous economic opportunity as well as improving quality of life. Together with improved central grid service for those on the national grids and with stand-alone solar solutions for those living in extremely remote locations, community microgrids can play an important role in achieving high-quality universal electrification in Haiti.

Customers on the Les Anglais grid were seeing savings of 50-80% over the cost of their energy expenditures before the grid was built. The use of kerosene is virtually eliminated, improving indoor air quality and preventing burns and fires. In order to fully unlock rural potential, EarthSpark worked with local entrepreneurs on productive uses, introducing an electric mill and a corn thresher. In future grids, EarthSpark will introduce electric cooking providing customers with the possibility to swap charcoal for electricity.

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CASE STUDY 8

PV-BATTERY POWERED MICROGRID IN COLOMBIA

Ana Maria Murillo, Tecmac Ingenieria

Summary

Trojan Battery Company and Tecmac Ingenieria implemented in 2015 a PV-battery powered microgrid replacing a diesel generator in Choco, Colombia.

The Organization

Founded in 1925, Trojan Battery Company is the world's leading manufacturer of deep-cycle batteries. From deep-cycle flooded batteries to deep-cycle AGM and gel batteries, Trojan has shaped the world of deep-cycle battery technology with more than over 90 years of battery manufacturing experience.

Tecmac Ingenieria is an engineering company created in 2009, dedicated to the development of the solar photovoltaic industry in Colombia. Tecmac provides solutions ranging from basic engineering, financial modeling, supply, installation and maintenance of solar generation systems focused on the concept of Efficiency and Energy Sustainability.

The Objective

In the northern state of Choco, located in western Colombia, is the Municipality of Acandi, an area that is mainly jungle along the Caribbean Sea bordering Panama. This region is located in a remote area of the country that is not tied to an electrical grid. Residents have access to electricity provided by diesel generators only for a few hours a day. Through its Ministry of Mines and Energy, the government of Colombia issued a mandate to expand the availability of electricity to these remote areas by building five solar hybrid installations, or microgrids, in ACANDI. Trojan's Industrial Line of batteries with Smart Carbon were installed as the energy storage solution for all five microgrids with a total system capacity of 191 kWp.

The Challenge

Prior to the microgrid installations, residents could only use power when the generators were turned on.

Opportunities for Renewables

The Colombian government issued a mandate to expand the availability of electricity to the remote area of Acandi by building five solar hybrid installations, or microgrids. Acandi is mostly jungle, located on the Caribbean Sea bordering Panama. There is no connection to the electrical grid there, and residents had access to electrical power provided just a few hours a day with diesel generators. One of the greatest incentives to installing these microgrids was to reduce the use of diesel fuel. Not only were the generators loud and noisy, but because the area can only be accessed by boat, transportation costs are prohibitively high. They also wanted to become less dependent on the generators, because when a generator broke down, the community would have to go without electricity until someone could fix it - which could be a while in these remote locations.

Renewable Solution

Prior to the microgrid installations, residents could only use power when the generators were turned on. Now, with electricity for more than 5 to 6 hours a day, they do not have to plan their day around the time that they have electricity. The kids can study at night, the mothers can cook in the evening without the need of using candles. In addition, an added benefit is that the solar hybrid systems provide more consistent and reliable energy than using diesel generators alone.

Trojan provided guidance on what battery types and models would provide the most effective energy storage solution for this microgrid project. The battery models selected and installed were the Trojan Solar Industrial Line with Smart Carbon™ -IND294V & Trojan IND136V. These batteries are designed to reduce the impact of partial state of charge (PSOC).

Project Financing & Costs

The microgrids include solar panels from Trina Solar, batteries from Trojan Battery, and Sunny Boy and Sunny Island inverters from SMA. Four of the PV systems were designed to cover most of the electricity demand, but not all. For example, the microgrid in TriganaChoco covers 60% of demand and those in Chugandi & Caleta cover 80%. Because of this, the systems also included Cummins diesel generators, which provided the additional power when needed and they also act as a backup in case of several days of rain. The Aguas Blancas installation covers 100% of the needed electricity, but it also has a diesel generator as backup. The project was 100% financed by GENSA. The customers will pay in monthly basis to the utility company for their electricity consumption.

Project Outcome

This project is the first of its kind in the Choco region and has allowed 431 households, including an indigenous community, to have access to clean, affordable and reliable energy for the next 20 years, said Ana Maria Murillo, Business Director of Tecmac Ingenieria, the project's solar installer. One of the greatest incentives to installing these microgrids was to reduce the use of diesel fuel.

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Source: Trojan Battery Company

CASE STUDY 9

STAND-ALONE PV WITH CUSTOMER FINANCING: A SOCIAL ENTERPRISE MODEL PROVIDING ACCESS TO ELECTRICITY IN RURAL HONDURAS

Richard Hansen, Soluz Inc.

Summary

This is a case study of Soluz Honduras, a social enterprise supplying stand-alone PV systems for over two decades in rural Honduras, in places which are not reached by the national utility. The case study is intended to contribute to the thinking about how to reach universal access to electricity in the Central American Region while recognizing the co-existence of private PV supply initiatives and government PV projects in the sector. To understand how this enterprise is positioned in the marketplace to provide PV systems and services over many years, it is important to understand the characteristics of the social enterprise model. A social enterprise is an organization that applies commercial strategies to maximize improvements in human and environmental well-being - this may include maximizing social impact alongside profits for external shareholders.

The Organization

In 1994, Soluz Honduras was established by Soluz, Inc. a company based in Massachusetts, USA. As a market study activity, Soluz Honduras initially sold PV system components to several rural solar technicians, while developing a business plan to introduce a pioneering PV rental offer while also selling PV systems on cash and short-term credit terms. The Soluz Honduras PV rental offer was essentially a "Pay-as-You-Go" (PAYG) option but without the PAYG automatic PV system shut off feature (a recent technology) that is now being used by the PAYG operators that were established in the past decade, primarily in sub-Sahara Africa.

Soluz Honduras raised USD 500,000 in specialized capital through impact investment funds for the PV Rental operation that was launched in June 1998. The company had reached 200 rental customers, when, in October 1998, Honduras was hit by Hurricane Mitch. The country had been devastated. All but one of Soluz's stand-alone PV system survived Mitch, but it was a costly recovery period for Soluz Honduras, a start-up enterprise.

Despite the devastation caused by Mitch, Soluz Honduras pushed forward, and by the end of 1999 the company had a PV rental portfolio of 500 customers. In 2000, Soluz Honduras raised an additional USD 1 million in debt and equity investment to expand the PV rental operation to the financial breakeven point. Included in these funds was a USD 500,000 investment (USD 100,000 equity and USD 400,000 debt), from the private sector arm of the World Bank, the International Finance Corporation (IFC).

By 2002, the Soluz Honduras PV rental operation had reached 1,500 customers. To reach breakeven, the enterprise was going to require additional investment and a refinement of its business model to be developed in coordination with government electrification plans. At this stage, rather high customer "churn" was experienced because of several donor-funded electrical grid extension projects being implemented by the ENEE in some of the same areas where Soluz's PV rental customers lived. By 2003, there were still 500,000 households without access, a substantial potential customer base.

While Soluz Honduras was evaluating the performance of its innovative PV rental business model, another risk emerged for the company. In 2004, the World Bank Group's International Bank for Reconstruction and Development (IBRD) began working with the Government of Honduras to design PROSOL, a PV electrification project. While Soluz Honduras had developed an unsubsidized PV rental operation, when Governments in the LAC region design PV projects they understandably tend to incorporate subsidies for the rural households. At the same time, donor funded, conventional grid electrification was also gaining momentum. Facing the prospect of both government electrification activities, Soluz Honduras realized that it had to shift out of the unsubsidized PV rental model. It could not put more long-term capital at risk with subsidized government PV projects entering the marketplace.

From 2004 to 2006 Soluz Honduras sold off the PV rental assets on favorable terms for customers and the company paid back the lenders based on a negotiated memorandum of understanding. While Soluz's PV rental option was perhaps ahead of its time and not adequately supported with a policy framework, what it did accomplish was the initial introduction of PV systems into the rural marketplace providing Soluz Honduras with a unique and valuable experience. The company adjusted its business model away from PV rental, focusing exclusively on its sales with cash and short-term credit terms, and later participated in the World Bank-funded PROSOL project.

New Market Environment

Supported by international donors, the government of Honduras started two major PV electrification projects.

PROSOL Project

From 2004-2008 the World Bank worked with the Honduran government for the planning of the PROSOL project, one that was administered by FHIS, the Honduran Social Investment Fund. The model had several positive features:

- It engaged multiple PV supply companies to sell, install and maintain solar home systems (SHS). The design of the project was intended to strengthen the local capacity for PV supply companies. The project allowed sales throughout

the country - sales that were driven competitively by the participating companies.
- The project provided a beneficiary subsidy of USD 230 - 365 that represented discounts passed on to customers for 40-50% of the PV system price. For PROSOL the solar home systems that received subsidies ranged from 30 W to 85 W.
- The project engaged Micro-Finance Institutions (MFIs) to finance the balance of the PV system price.
- Product specifications were enforced by the project which was implemented by FHIS. System installations were verified to assure compliance with standards.

The PROSOL project was implemented from 2008 to 2012. The initial phase of the PROSOL project accomplished its goal of providing PV systems for 5,000 households and 150 schools.

Soluz Honduras began selling and installing PV systems under PROSOL in 2008 when the project began. There was a one-year period beginning in June 2009 when the PROSOL project was paralyzed due to political instability.

In what became the first phase of the PROSOL project, Soluz Honduras supplied 2,400 household PV systems and 76 schools PV systems as one of five participating companies working under the PROSOL project. While the MFIs previously did not show interest in financing PV systems, when they were provided support from the PROSOL project, they entered this sector. However, the MFIs required the PV supply enterprises to guarantee the customer payments as well as to buy back the PV systems in the event of default. Clearly the MFIs were not willing to assume the financial risks that they would normally assume as a financial institution.

From 2012-2014 a new round of planning was done by the FHIS and the World Bank for a second phase of the PROSOL project. The Phase II goal was to reach an additional 4,000 households. From 2015-2016 PROSOL Phase II was implemented. Soluz Honduras chose not to participate in PROSOL Phase II because the prices of the PV systems were "fixed" quite low, which would have required the enterprise to reduce the quality of its PV systems to reach that pricing level to still have a viable profit margin.

One issue with the PROSOL project was that of ongoing, longer-term service and battery replacement. The project was initially supposed to require two years of service visits that were to be paid for by the PROSOL project itself. However, these payments never materialized so service calls were not made.

PRONADERS Project

In February 2012, it was announced in the national press that the South Korean government would provide a USD 40 million loan for a PV electrification project. Once this project was announced, in the six western departments targeted by the project, the sales of Soluz Honduras PV systems were negatively affected. This early market impact, which affected even the World Bank funded PROSOL project, was due to the communications made by the local mayors who informed their constituents that PRONADERS was going to provide PV systems as gifts from the Honduran government. It certainly made sense for the prospective users to wait for those gifts.

Planning for this project continued through 2016 until a Korean company was awarded the contract in December 2016. The USD 35.6 million contract requires the Korean company to provide PV systems for 21,036 households (130 W each), 416 schools (500 W each), and 34 clinics (2,000 W each) which is a total of 3 MW. For this project, the PV systems were imported directly from Korea. Each of the 130 W solar home systems, which include four 5 W 12 V DC lights, and a 110 V AC outlet, would cost the government approximately USD 1,500. A similar system offered by a local enterprise such as Soluz Honduras costs under USD 1,000.

The families waited for over five years to get these donated 130 W solar home systems.

With regards to future maintenance services, the installation team in the Copan Department indicated that their understanding is that the beneficiaries of the project were supposed to pay 130 Lempiras (USD 5.50) per year to cover future maintenance needs. It was not clear to the installation team to whom the beneficiaries would need to pay the fee or how that would be managed. A critical issue with this project will be the provision of ongoing maintenance after the installation teams have left. This is particularly a concern for the beneficiaries who, when their battery reaches the end of its useful life, will require a replacement battery at a substantial expenditure, which may be beyond their means.

Soluz Honduras chose not to participate in the PRONADERS project as a system installer since that did not align with its strategy as a social enterprise.

Soluz Honduras a Social Enterprise Model

Soluz Honduras is a for-profit social enterprise that has made a commitment to increasing access to electricity in Honduras, thereby contributing to the goal of universal access to energy by 2030. By September 2017, Soluz Honduras has served approximately 20,000 households. Soluz Honduras has a robust social enterprise model that allows it to provide stability and continuity of service through natural disasters and changes of government administrations - among other challenges.

The business model combines solar products and financial products tailored to the rural Honduran customer base.

Source: Trama TécnoAmbiental

- Unlike some government PV projects that only provide one-system-size for everyone, Soluz Honduras imports and sells a range of product sizes from 10 W to +300 W to meet the needs and buying power of its customers.
- One of the most important aspects of the Soluz Honduras social enterprise model is the inclusion that is achieved by providing financing. Soluz Honduras is a partner with KIVA, a non-profit organization that developed an online crowdfunding platform. Worldwide KIVA has provided over one billion dollars in loans for social impact. Soluz Honduras offers loans of 6 to 24 months for PV systems using funds sourced from KIVA. The interest rate that Soluz Honduras charges its rural customers is 18% p.a.
- To increase affordability, Soluz Honduras can also channel smart customer discounts as it did with the PROSOL project. When Soluz Honduras is allied with a sponsor willing to cover part of the system cost, it can provide an invoice to the customer that reflects the amount of the discount that has been funded by a third party.

Lessons Learnt & Policy Recommendations

There has been a significant contribution made to PV electrification (or pre-electrification) in Honduras by private enterprises. While data on the total of PV systems installed is not available, an educated estimate is that in rural areas of Honduras over 50,000 households and rural enterprises now get basic electricity services from stand-alone PV systems.

The social enterprise model provides solar solutions for which customers regularly demonstrate that they value the product by making payments. The model can provide low cost solutions as well as channel customer discounts from sponsors. The social enterprise model can move quickly as a form of pre-electrification to serve needs until subsidized government PV projects can be developed and implemented.

Results Based Funding (RBF) could use the efficiency of the social enterprise model to quickly make progress on electricity access, even if it is a pre-electrification service, in areas that present a commercial challenge.

Finally, there is a need for clear/easy exoneration of import duties and sales taxes on solar products. For example, Pico PV products, such as solar lanterns that serve the poorest Hondurans, are still not readily recognized as an exonerated solar product by the Honduran Customs.

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Source: Soluzusa

CASE STUDY 10

IMPLEMENTATION OF IMPROVED COOKSTOVES IN PERUVIAN HOMES

Ana Moreno Morales, ENDEV Peru

Summary

The EnDev Peru program for the Implementation of improved cookstoves in Peruvian homes is part of the Energising Development Programme. From July 2009 to June 2019, a total of Euro 17,520,000 has been allocated to invest in the adaptation of new technologies for improved cookstoves as well as the distribution of these new technologies to remote areas of Peru.

The Organization

Energising Development (EnDev) is an Alliance whose mission is to promote access to basic energy services to 18 million people around the world until 2019. It is supported by six benefactor countries: Germany, Holland, Norway, United Kingdom, Sweden and Switzerland and is currently implemented by the German initiative GIZ in 26 countries throughout Africa, Asia and Latin America. The EnDev programme began in 2009. Of the country's 30 million inhabitants, there are still two million people who lack access to electricity and one and a half million homes without clean cookstoves. An elevated percentage of this population lacking modern power is concentrated in rural areas which are largely hard to access, making it impossible in many cases to supply these areas with power. To address these challenges, EnDev Peru has focused on fomenting the development of a market consisting of several power services by acting as coordinator and liaison between public administrations, the private sector and potential consumers.

The Objective

To facilitate sustainable and safe access to thermal energy for cooking in Peruvian households.

The Challenge

In Peru, according to the National Institute of Data and Statistics (INEI) in 2016, there were approximately 34.6% of homes that frequently used solid fuels such as firewood, charcoal, dung, etc. for cooking edible goods. Despite Public and Private Institutions having installed about two million clean and efficient cookstoves over the last decade (liquid petroleum gas and improved firewood kitchens), 1.5 million homes still use inefficient cooking appliances such as open flame and/or traditional stoves. With this in mind, the World Health Organization has found that using solid fuels in inefficient traditional cookstoves has significant health consequences and impacts on socioeconomic development. In Peru, the homes that use this type of fuel are mostly located in rural areas in the Peruvian Andes, and as a result of cooking meals inside their homes, the local inhabitants are continuously exposing themselves to home air pollution – the greatest global environmental health risk of today (Bates *et al.* 2014).

Opportunities for Renewables

The technologies that EnDev Peru has promoted and continues to promote are two types of improved stoves: permanent cookstoves (constructed with brick, adobe, clay, etc.) and portable cookstoves (assembled by small businesses. In both cases they allow for efficient solid fuel use (firewood and dung) and by their design, optimized heat transfer, thereby achieving fuel savings when using firewood, for example, as opposed to using firewood in traditional or open-flame cookstoves, thus creating an economic impact on the households that buy said fuel. Moreover, this technology manages to reduce the concentration of home contaminants by about 100% (CO and PM2.5) within the kitchen environment. Its use has direct effects on health, since these households are no longer exposing themselves to the aforementioned contaminants.

Renewable Solution

The strategy EnDev Peru has been employing in the country has been one of a dynamic and focused nature:

- Facilitate financing mechanisms for retail demand (end consumers who buy the technologies at direct market prices) by joint cooperation with the IMF and non-reimbursable incentives (FASERT and FIDECOP).
- Assess institutional demand (frequently, the State or other benefactors) who pool their resources together to purchase the technology through a third party allowing the end consumer to absorb only minimal costs.
- Develop impact mechanisms and knowledge management regarding improved stoves, thereby achieving product standardization by way of an evaluation process for model certification.
- Identify and train local small businesses, which, through a coordinated approach in the marketing chain, accommodates both retail and institutional demand.

Project Financing & Costs

To implement improved cookstoves, EnDev liaises with its partners (public and private institutions) in order to finance the costs directly associated with purchasing and installing the technology, while EnDev provides financing by offering technical assistance in social programs starting from their design (development of strategy), awareness campaigns, skill development, monitoring, etc.; in the case of small businesses,

Source: ENDEV Peru

financing is offered for fomenting skill development, strategy development, etc. This strategy implemented by EnDev managed to leverage every Euro 1 investments with additional Euro 3 from public or private institutions and Euro 1 from customer/clients. The model for setting prices is varied. State social programs donate the technology to the consumers who are families living at or below the poverty level. Families with more purchasing power buy the technology at a price, which varies from USD 100 to USD 300 depending on the cookstove model as well as geographic location. EnDev Peru promotes cooperation between approaches (social programs or small business endeavors) to develop the improved cookstove market. additional power when needed and they also act as a backup in case of several days of rain. The Aguas Blancas installation covers 100% of the needed electricity, but it also has a diesel generator as backup. The project was 100% financed by GENSA. The customers will pay on a monthly basis to the utility company for their electricity consumption.

Project Outcome

Currently, EnDev Peru, through its partners, has been able to benefit 206,000 homes, mainly beneficiaries of the programs/projects implemented by the Government with improved permanent cookstoves, as well as those implemented by clients of subsidized small businesses, who have directly purchased their stoves (permanent or portable). One of the main challenges from the technical point of view pertains to standardization of the materials and the technical specifications related to the construction of permanent stoves; as well as the logistics of transporting the materials. In this regard, EnDev Peru is currently promoting the use of portable cookstoves that overcome the aforementioned hurdles, specifically, in state programs/projects. Moreover, other challenges are associated with making the cookstoves market more dynamic, which is why EnDev Peru is financing two funds, as is the case with the Renewable Thermal Energy Access Fund (FASERT) (http://www.fasert.org/) and the Portable Stove Innovation and Development Fund (http://fidecop.com/).

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Source: ENDEV Peru

CASE STUDY 11

LUZ EN CASA AMAZONIA, A NEW ELECTRICITY DELIVERY MODEL FOR THE ISOLATED COMMUNITIES OF THE RAINFOREST

Julio Eismann, Fundación Acciona

Summary

Starting in 2015, ACCIONA Microenergia Foundation works in the Peruvian Napo basin with solar home systems giving light to rural households. Total budget (up to now) has been Euro 370,000.

The Organization

ACCIONA Microenergia is the corporate foundation of ACCIONA, one of the foremost Spanish companies, leader in the development and management of infrastructures, renewable energy, water and services. The ACCIONA Microenergia Foundation channels ACCIONA's activity of bringing basic services of energy, water and sanitation to remote communities, by driving development cooperation projects; its rural electrification programs "Luz en Casa" provide more than 46,000 people in Peru and Mexico with affordable, modern and safe electricity by means of solar home systems.

The Objective

The objective of "Luz en Casa Amazonia" is to give an electricity delivery model, which is based on the user participation, the shared responsibility and the multi-stakeholder partnerships, which is adapted to very complex settings, and which applies the most advanced clean technologies, to communities living in the Peruvian Napo basin. Thus, both the development of those communities and the protection of the Amazon environment are promoted.

The Challenge

"Luz en Casa Amazonia" brings electricity to low-income communities living in remote sites of high ecological value, with exclusively fluvial access, and extremely hot and rainy weather. Those conditions imply very complicated logistics that, together with the low power demand levels of those communities (about 3.6 kWh monthly per household), have made it technically and economically unfeasible to connect to the national grid. "Luz en Casa Amazonia" overcomes those problems.

Opportunities for Renewables

The electricity delivery model implemented with "Luz en Casa Amazonia" is based on the technology of the third generation solar home systems, which have no pollutant elements, are easy to transport, install and maintain. The 3GSHS ousts damaging pollutants elements provoked by diesel generators, oil lamps and candles that are used by people without access to electricity services.

Renewable Solution

The ACCIONA Microenergia Foundation – through its local organization ACCIONA Microenergia Peru, which implements "Luz en Casa Amazonia" on site – supplies third generation solar home systems (3GSHS) including one 50 W panel, one integrated Lithium-battery & controller with a pay-as-you-go system (PAYG), two LED lamps, one torch and connections for high-efficient 12 VDC devices, in order to give an affordable, basic electricity service to remote, low-income communities.

The plug & play architecture of the 3GSHS allows anyone to install it after a basic training. Thus, ACCIONA Microenergia Peru trains users to install it, as well as to use it correctly, meet the payments of the fee for service, and log in the code to unblock the PAYG to have electricity. Payments can be made through the Photovoltaic Electrification Committee, the body promoted in every attended community to represent it in the management of "Luz en Casa Amazonia". Users can also pay directly in the Customer Service Centre (so called CAU) installed in a reference locality, as a branch to collect payments, offer repair services and sell electric devices. This CAU, which is managed by local personnel specifically trained, guarantees the technical sustainability of the initiative.

Project Financing & Costs

So far, "Luz en Casa Amazonia" comprises two projects with a total investment of Euro 370,000. Those funds come from the subsidies of the National Fund of Scientific, Technological and Technological Innovation Development of Peru (FONDECYT) (10%) and the Spanish Cooperation (54%), as well as from ACCIONA Microenergia (30%) and other partners (6%). ACCIONA Microenergia has plans to continue scaling up the

Source: Acciona Microenergía

action, probably with additional funding from FONDECYT, so as to serve 1,000 users and then being self-sufficient to cover operation & maintenance activities and recover its investment, with the incomes from the fee of S/.30 (Euro 7.75 approx.) collected from users every three months.

Project Outcome

Since February 2017, 325 people (61 households), who are beneficiary of the pilot project in the Napo basin, use the electric lighting provided with the 3GSHS of "Luz en Casa Amazonia" for an average of six hours daily. The main uses for that lighting are study (67%), work (43%) and preparation of meals (21%). Many families have left the use of alternative lighting elements such as torches (79%), oil lamps (30%) and candles (25%), whose smokes and insufficiently intense lighting provoke eye and lung diseases. There is also a positive environmental impact, by avoiding the use and uncontrolled disposal of batteries, as well as the emission of CO_2. In addition, users have reduced their energy expenditure (average of 50% approx.).

Now, a new project is being performed to extend the activity to 350 additional households in the Napo basin, by means of installing 3GSHS and hybridizing some existing diesel generators with photovoltaic installations.

In addition, ACCIONA Microenergia is part of the conversations to include the rural electrification with 3GSHS in the Peruvian regulatory framework, so as to have a social tariff that could guarantee the affordability and economic sustainability of the service given with that technology. That would accelerate the replication of this delivery model in many remote communities, such as those in the Amazon basins.

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Source: Acciona Microenergia

CASE STUDY 12

PV MICROGRID WITH ENERGY MANAGEMENT METERS POWERS A REMOTE VILLAGE OF 20 HOMES WITHOUT DIESEL BACKUP IN ECUADOR

Unai Arrieta, Trama TecnoAmbiental S.L.

Summary

Trama TecnoAmbiental S.L. (TTA) has implemented in 2012 a PV microgrid with energy management meters which powers a remote village of 20 homes without diesel backup in Las Balsas community, Parroquia San Gregorio, Muisne, Esmeraldas, Ecuador.

The total project budget had been approximately Euro 60,000.

The Organization

TTA is an international consulting and engineering firm working since 1986 in the field of renewable energies. TTA specializes in distributed generation through renewable energy sources (RE), energy management and efficiency, rural electrification, self-generation, integration of RE in buildings and sustainable architecture, as well as specialized training, education and technological development related to its activities. In rural electrification, TTA has been involved in studies, policy and implementation in many developing countries, especially RE microgrids.

The Objective

The main objective of the "Fostering of rural development in communities of Esmeraldas project", in Ecuador (FOMDERES), has been to provide modern electricity services through a solar microgrid generation to two communities in the province of Esmeraldas in Ecuador. Phase I (2005) consisted of electrifying the community called "La Y" providing access to 19 families, while Phase II (2012) reached 20 families of the community of Las Balsas. Specifically the project aimed at:

- Providing 24h access to electricity to the community at standard AC;
- Improving the socio-economic development of community through enhanced and affordable and high-quality energy services;
- Introducing and validating the concept of Energy Daily Allowance (EDA) and
- Using amorphous-silicon (a-Si) PV modules to validate their efficiency in tropical climates

The Challenge

The access to the remote community is cumbersome, taking up to four hours of combined walking and horse-riding. Locally generated electricity is thus the most feasible solution.

Due to the impact on the project's financial sustainability, ensuring that a long-lasting battery is operational over its lifetime is necessary. Besides, the energy supply depends on resource availability and the technical conditions of the area and thus ensuring that the limited solar resource is shared without conflicts and ensuring service reliability is the main challenge. The energy management provisions in place using Electricity Dispensers allow for a rational electricity supply and ensure that equipment (including batteries) operates within safe and designed technical thresholds.

The community has a nucleus population of 12 families, plus eight more disperse households, besides communal uses. To reach all dwellers a combination of technical solutions was implemented through:

- one solar PV micro grid to supply 12 interconnected families and communal services,
- eight individual installations for the houses located further from the nucleus.

All users remain under the same operation scheme, which eases the O&M of the system and is not exclusive to the village nucleus.

Opportunities for Renewables

Grid extension costs are too high for the level of energy demand. In the case of Las Balsas, the remoteness of the community justified harnessing solar energy for electricity generation.

Renewable Solution

With a mixture of clustered and scattered buildings in the village, the solution is based on a combination of a solar PV micro-grid and individual PV micro power plants under the same operation scheme. Thus, electricity is supplied to households and communal services like street lighting, school, and community house. TTA's award winning Energy Dispensers are used with a project-tailored tariff system to ensure the energy usage is according to the resource availability and the technical conditions.

In the microgrid, a single 9.2 kWp PV generator (without diesel generator backup) supplied a DC coupled micro power plant with a 107 kWh battery storage and 7 kVA battery inverter, for 12 households and communal services. The eight solar PV individual installations had each 384 Wp, 3.2 kWh storage, and a 650 VA inverter. All consumers are supplied with 120 Vac electrical energy. The system is managed and operated by the community which created a Rural Electrification Board, which is composed of community members.

Source: Trama TecnoAmbiental S.L.

Besides the renewable energy solution, the Electricity Dispenser meter was essential to manage each single user electricity consumption for the microgrid and individual installations and ensure an adequate energy daily allowance. Finally, local staff were trained to do the first-level maintenance.

Project Financing & Costs

The project was financed by a grant from the Municipality of Barcelona, Spain, and executed by the Spanish NGO SEBA, the local counterpart FEDETA and technology partner TTA. Operational costs were covered with tariffs. Tariffs were flat rate, fixed for each consumption tier (in the microgrid, between 1,000 Wh/day and 1,650 Wh/day for households; 550 Wh/day for the individual PV systems) pre-contracted and agreed by the community. Electricity Dispensers designed by TTA offered dynamic energy management.

Project Outcome

Despite being grouped and scattered houses, all community members and communal uses were provided with access to affordable electricity, under the same tariff and management scheme. Electricity Dispensers with management of energy and power available to users allowed for efficient use of energy and control within the microgrid and also assist throughout the learning process of users. The Ministry of Energy in Ecuador has replicated the microgrid model in other regions using these components.

Lessons learnt

The key aspects of a sustainable and durable electricity service were:

- Logistic costs and challenges needed to be taken into account, especially material transport to remote locations.
- Successful implementation required user involvement and commitment to anchor the sustainability of project into the existing socio-cultural structures, encouraging social dialogue and communications among the community members.
- There was a right balance to find between the ability and willingness to pay by potential users, and the sustainability of the electrical services business.

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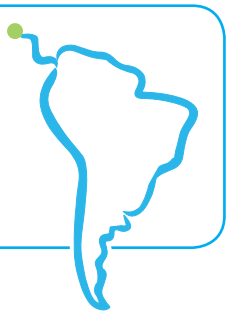
Source: Trama TécnoAmbiental

CASE STUDY 13

LUZ EN CASA OAXACA, LIGHTING UP THE PRESENT TO THRIVE IN THE FUTURE

Julio Eismann, Fundación Acciona



Summary

From 2012 to 2016, ACCIONA Microenergia Foundation implemented in Oaxaca (Mexico) basic electrification. More than 30,000 people benefitted from an investment of Euro 2.5 million.

More information about ACCIONA Microenergia Foundation in previous article.

The Objective

The objective of the "Luz en Casa Oaxaca" program is to bring an affordable, feasible, sustainable, basic electricity service to the most remote, low-income households of the State of Oaxaca (Mexico), via the forthcoming utility (Comisión Federal de Electricidad) plans of electrification. According to the data given by the Government of Oaxaca, in 2010, there were almost 50,000 homes without access to electricity, of which 55% were in regions of priority attention due to rural poverty and high population dispersion, and around 9,000 were in villages with less than 100 inhabitants.

The Challenge

"Luz en Casa Oaxaca" brings electricity to households in rural communities with less than 100 inhabitants, of which the majority come from the indigenous population (Oaxaca is the Mexican state with more ethnic groups). Their households are scattered over the territory and have a weak infrastructure of communication. All that complicates their access to basic services and contributes to their isolation, inequality and lack of opportunities for development. The electricity service offered with Luz en Casa Oaxaca mitigates that situation, and pays attention to the long-term sustainability of the project.

Opportunities for Renewables

The electricity delivery model implemented with "Luz en Casa Oaxaca" is a public private partnership for development (PPPD). The technological model is based on third-generation solar home systems, which have no polluting elements, easy to transport, install and maintain, and also provide an alternative for damaging technology such as diesel generators, oil lamps, candles that are used by people without access to electricity services.

Renewable Solution

The ACCIONA Microenergia Foundation – through its local organisation ACCIONA Microenergia Mexico, which implemented "Luz en Casa Oaxaca" on site – supplied third generation solar home systems (3GSHS) including one 25 W panel, one integrated lithium-battery & controller, two LED lamps, one torch and connections for high-efficient 12 VDC devices, in order to give an affordable, basic electricity service to remote, low-income communities.

The plug & play architecture of the 3GSHS allowed anyone to install it after a basic training. Thus, ACCIONA Microenergia Mexico trains users to install it, as well as to use it correctly. During the program development, these have been promoted to a Photovoltaic Electrification Committee in each attended community - mainly for representation and dissemination purposes. In addition, to offer repair services and sale of electric appliances, a Supply & Service Centre (so called Centro Luz en Casa) was installed in reference localities serving about 1,000 households. These centers, which are managed by local specifically trained personnel, guarantee the technical sustainability of the initiative and promote entrepreneurship on renewables.

Project Financing & Costs

"Luz en Casa Oaxaca" implies a total investment of Euro 2.5 million or Euro 330 for every 3GSHS installed. The alliance had enough technical, managerial, institutional, and economic resources to implement the program. The Government of Oaxaca State contributed with 30% of the investment, the users paid another 30%, and the Spanish Agency for International Development Cooperation (AECID) and ACCIONA Microenergía contributed with 20% each. Those users with the lowest income had access to one-year micro loans, which were crowdfunded through the NGO Kiva. The user fee was less than the previous alternative energetic expenses.

Project Outcome

Since December 2013, 30,000 people (more than 7,500 households) have had access to the electric lighting provided with the 3GSHS of "Luz en Casa Oaxaca". They represent almost 30% of the houses electrified in the last 6 years in Oaxaca (70% of those electrified with non-conventional methods).

Every year, the beneficiaries had access to more than 11,000,000 hours of electric lighting, of which 4,750,000 hours were used for additional activities, saving Euro 800,000 in energy, and six Centros Luz en Casa were set up for technical services (three of them managed by women). There is also a positive environmental impact because batteries were no longer needed (13.3 tons), contributing to CO_2 savings of 1,200 tons.

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CASE STUDY 14

E-MOBILITY IN THE COLOMBIAN AMAZON BASED ON HYBRID PV-HYDRO-POWER

Karl Kolmsee, Smart Hydro Power

Summary

Financed by a program of the German Government, German communities can cooperate with communities in selected countries like Colombia in climate change projects. The Bavarian community of Schondorf supports by means of school transport with an electrical boat in a small town called Jiri Jiri in the Colombian department Putumayo. The boat and a charging station using PV and hydrokinetic as energy sources were installed in December 2016 with a total budget of Euro 50,000.

The Organization

Due to its experience in the Colombian market, Schondorf selected Smart Hydro Power as its technology supplier and project implementers.

Smart Hydro Power develops and fabricates micro hydro-kinetic plants and hybrid PV-hydro energy management systems for rural electrification. Smart Hydro Power has so far realised projects in Brazil, Peru and Colombia.

The Objective

School transport in Jiri Jiri depended on the affordability and availability of diesel for the boat motor. As Jiri Jiri is remote and not always accessible, availability itself was an issue in the past. With the employment of an electric boat, Schondorf and Jiri Jiri wanted to make school transport more reliable.

The Challenge

Jiri Jiri is located in the Amazon Putumayo region with limited accessibility making transport of whatever technology a venture. Jiri Jiri had so far no experience with electricity.

Opportunities for Renewables

Even though there are abundant renewable resources like biomass, water and sun, the difficulty was their accessibility and the distribution of resources over the year. During the rainy season, biomass is wet and there is little to no radiation during these six months of the year. Water alone is abundant in this region.

Renewable Solution

As no heavy equipment can be transported into the region, it was decided to go with a hybrid PV-hydro-kinetic plant. A hydro-kinetic water turbine uses only the flow of the water and does not require damming. This makes it a specifically environmentally friendly solution particularly for smaller projects (up to 100 kW). Servicing (cleaning of the turbine) can be done after some training.

The SMART turbine is a 5 kW turbine which was integrated with 3 kWp PV panels so that the generation power could easily balance seasonal variability. To allow a second-use of the electricity, the electricity was provided to the charger of boat batteries with 230V and separately with 110 V to the installed community kitchen with fridge and mixer.

Installing a community kitchen helped raise the interest of women of the village of the new technology and how it worked. We noted that this helped to maintain servicing and thereby added to the sustainability of the project.

Project Financing & Costs

The budget of Euro 50,000 was given by the German government initiative with some additional in-kind contribution by the village and Smart Hydro Power.

Source: Smart Hydro Power

Project Outcome

The small village of Jiri Jiri with 20 households has today a reliable source of energy for fluvial transport and for its community kitchen. Adjacent communities benefit from the school transport service. Local servicing currently runs with no reported problems.

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Source: Smart Hydro Power

CASE STUDY 15

IMPROVEMENT, EXPANSION OF THE DRINKING WATER SYSTEM & SANITATION OF THE COMMUNITIES OF AMANTANI ISLAND, AMANTANI DISTRICT, PUNO

Karen Sofia Villanueva Saberbein, CROSIVA

Summary

In 2014 and with a total budget of S/ 11,289,540.33 (USD 4,020,000) CROSIVA implemented a drinking water and sanitation system for the communities of Amantani Island, Puno.

The Organization

CROVISA is a Peruvian Company working from 1985 on the execution of infrastructure works such as irrigation, sanitation, environmental restoration, hydropower plants and photovoltaic applications. Its customers include major mining, electrical, industrial companies and government institutions. CROVISA GROUP develops its work under strict management systems quality, safety, occupational health, environmental care and works continuously to improve the quality of life of the communities.

The Objective

To improve the health and the quality of life of the island population by enhancing the drinking water supply and sanitation system.

The Challenge

Amantani is the biggest island located in the Peruvian side of Lake Titicaca. The island has a circular shape with an average diameter of 3.4 km, surface area of 9.28 km^2 and an elevation of between 3,820 – 4,150 m. The average slopes are 19.4%, which is considered hilly and rocky terrain. Prior to the project, the island was not provided with basic services of drinking water, sanitation and electricity. Although power distribution lines were laid all over the island, the diesel power system has not been working for a few years since its installation in the 90s due to the lack of reliable diesel supply. Currently, the energy sources in the island came from candles, batteries and residential solar panels for lighting and small appliances; and wood, dung and kerosene for cooking.

The project was awarded to CROVISA in a public tender summoned by the Municipality of Amantani in 2013. Since the beginning of the project, several technical problems were detected. Starting with the technical dossier of the project which presented several flaws. The most notorious flaw was the lack of consistency of the engineering studies, whereby the dossier was suspected to be a 'copy-paste' from a similar project. Initially, the project mandated the installation of a hybrid wind and solar energy system, but no weather data was recorded. As a result, CROVISA used the information provided by NASA in order to determine the renewable resources availability. Concerning the renewable resources of the island, the average solar radiation was 5.3 kWh/m^2/day and wind resources was found to be insufficient. In addition, CROVISA collected relevant information of the island and all the records were sent to CROVISA´s strategic partner in China, Hangzhou Yatai (HY). The governmental Chinese institution calculated the adequate pumping system dimensions and the location of the eight solar pumps across the island. HY also supplied the equipment from Chinese manufacturers. The new system eliminated the wind energy conversion system and only solar panels were used to power the pumping system.

CROVISA implemented the new project which received various social complaints, that would later require CROSIVA to hire a full-time sociologist. The sociologist was in charge of negotiating with the inhabitants of Amantani on issues relating to unskilled labor, property acquisition and training of the new drinking water and sanitation system.

The project was delivered on time to the municipality and without extra cost for the new project designed by HY, in late 2014. In November 2014, a newly elected Mayor declared that the drinking water and sanitation system was not officially handed to him, and he decided that the system was not under the municipality's responsibility. At that time, there was neither information nor evidence that the municipality had an operation and preventive maintenance procedure in place. The municipality only coordinated with CROVISA on corrective maintenance.

Opportunities for Renewables

The new drinking water and sanitation system required water to be pumped from Lake Titicaca (up to 182 m) in order to cover the entire island inhabitants. The water pump required energy to function. Since the national electric grid could not reach the island, on-site generation was the ideal option. Even though the cheapest investment option was to integrate a diesel generator, the experience of the island with diesel electrification proved to be a complete failure in the long run. In this sense, renewable energy which did not need fuel supply was ideal, among suitable technologies solar and wind were appropriate for a successful project.

Renewable Solution

The new drinking water system obtained water from a tubular well built on the shore of the island. The water extracted from the well was naturally filtered and complied with the Peruvian drinking water requirements. Thus, the only treatment to the water was made through drip chlorination in the first reservoir which also served as the drinking water treatment plant. In order to serve the whole island which had a mean slope of 19.4%, a water pumping system was installed. The drinking water system included eight subsystems composed of a

SYSTEM	SYSTEM REQUIREMENTS		SUBMERGIBLE PUMP					SOLAR PANEL (UNIT)	COST (USD)
	WATER HEAD (M)	DAILY WATER FLOW (M^3)	RATED POWER (KW)	RATED WATER HEAD (M)	RATED WATER FLOW	SIZE (MM)	OUTLET DIAMETER (INCH)		
1	95	418	37	99	95	2562*200	5"	216	66,835
2	87	31	3	119	5	1190*100	1 "112	18	8,535
3	45	65	4	54	12	1415*100	2"	26	6,460
4	85	30	3	119	5	1190*100	1 "1/2	18	6,635
5	87	74	7.5	87	17	1610*133	2"1/2	48	14,175
6	88	53	7.5	92	12	1910*100	2"	32	9,940
7	50	148	7.5	62	30	1666*133	3"	48	14,110
8	85	33	4	98	8	1623*100	2"	26	8,535

submergible pump, inverter and combiner box, and a solar panel array composed of polycrystalline Silicon 250 Wp 36 VDC panels. The characteristic of the subsystems are described in the following table.

Project Financing & Costs

The project total cost was USD 3,411,900 in May 2012. The project was financed through the public budget of the Amantani Municipality. The public budget came from ordinary national resources transferred to the Municipality. The drinking water and sanitation system operation and maintenance did not have any cost implications for the inhabitants of the island. The municipality agreed to provide the service for free for 20 years.

Project Outcome

The project was designed to benefit up to 3,924 inhabitants by 2032. The beneficiaries included residents, local commerce, a primary and secondary school and a medical post. This project gives support to the suitability of renewable energy when energy generation is required on an island where no electricity service is provided.

The project was at risk many times from the beginning of the project. Firstly, it was well known that Peruvian public infrastructure technical dossiers were both poor and inconsistent. As a result, it was important to review the technical proposal extensively in order to double check that the project was feasible or if it was necessary to design a better solution. Moreover, in the case of renewable energy, there were no technicians certified to install solar panels. It is therefore important to create procedures to ensure that technical international and national framework are followed.

From a social perspective, remote communities such as Amantani produce their income from insipient agriculture and commerce. Hence, all Amantani inhabitants were keen to work on the construction of the system to earn extra money. The problem was that not enough job positions were available. This situation delayed the project until a sociologist was hired by CROVISA, who finally reached an agreement with the inhabitants allowing them to earn the extra money as unskilled laborers in the construction of the project.

The major hazard to the system was the political zeal. The construction of the system was delivered at the end of the Municipality mandate (August 2014). In November 2014, the new mayor who joined the municipality administration rapidly distanced himself from the responsibility of the system. As a result, the project lacked operational supervision and preventive maintenance. At the beginning of 2015, CROVISA asked the Municipality for an inspection to the system. It was denied, and it was only in July 2016 that the municipality demanded CROVISA to solve problems presented in some subsystems. During the inspection, CROVISA confirmed that the system had no operation supervision or preventive maintenance program for over two years. It is important to note, that CROVISA has no contractual responsibility for the operation of the system. However, the company has taken note of this incident and will ensure that projects overlaying two mandate periods will include communicating with the former and new administrations.

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CASE STUDY 16

AUTONOMOUS DESALINATION BASED ON RENEWABLE ENERGIES IN COLOMBIA

Joan Tarrago, Infinite Fingers

Summary

Infinite Fingers GmbH and Membran-Filtrations-Technik GmbH installed a decentralized and renewable energy powered desalination systems in Colombia in La Guajira, Colombia. The project started in February 2016 and will end in January 2018. The total budget is Euro 400,000.

The Organization

Infinite Fingers GmbH offers cloud-based monitoring and control solutions for off-grid power systems. We help off-grid operators to keep systems up and running for their entire lifespan by offering a platform which can integrate technology from any manufacturer.

Membran-Filtrations-Technik GmbH (MFT): a medium sized company based in Cologne, Germany. It has over 20 years' experience in designing, building and operating/servicing membrane-based water purification systems for fresh, drinking, salt, process and waste water.

The Objective

Establishment of a proven operating model to provide clean drinking water from sea water in underdeveloped regions powered only using renewable energies based on sound data.

The Challenge

Even though La Guajira is on the coast in the northeast of Columbia, it is a very dry area.

The local residents, many of whom are indigenous, are poor and suffer from a lack of clean drinking water.

Colombia is experiencing more extreme weather conditions which are gradually destroying the fragile centralized water infrastructure. There is little chance in the region to access drinking water suitable for human consumption.

Opportunities for Renewables

The potential for renewables in this area is huge. La Guajira area is basically a wild desert where sun, wind and salt water were abundant, but clean drinking water remained scarce.

As a result, windy area studies were being carried out to build larger wind farms.

Renewable Solution

Infinite Fingers and MFT developed a renewable energy powered, remotely controllable micro-reverse osmosis water desalination plant, named RO 100 Sea.

Infinite Fingers designed and developed the off-grid power unit, the controller and the web-based data visualization while MFT brought their expertise in energy efficient reverse osmosis water desalination to the project.

The plant is powered with wind and solar energy, which is stored in lithium-ion batteries.

All data of the plant, including the separate weather station, was monitored and recorded using the Infinite Fingers Controller. The data was sent via GSM to a server so that actionable decisions could be taken in real time by MFT back in Cologne.

Main Specification:

- Capacity Up to 120 l/h drinking water output
- Energy Sources: 7.5 KWp PV, 350 W Wind turbine
- Storage: 11.2 kWh Lithium Ion

The remote-control system made it possible to see in Cologne how the system was performing in real time. The system recorded the weather condition, how much electricity was being provided by wind and solar sources, how much water was being produced and at which quality. If the drinking water quality fell below a certain limit, the system switched off automatically to prevent unfit water from being supplied to consumers.

Local staff were first trained in Cologne and subsequently at the installation site to maintain and troubleshoot the system if needed. Although only low maintenance was needed, we ensured that the beneficiaries were ultimately autonomous for the long-term operation.

Project Financing & Costs

The project was partially funded by KfW DEG as well as MFT. A short video has been produced shortly before the unit was prepared for shipping.

https://www.kfw.de/stories/economy/innovation/drinking-water-demineralization-colombia/

Source: Infinite Fingers

The total project costs were around Euro 400,000. KfW subsidiary DEG co-funded this project from budget resources of the International Climate Initiative of the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety.

It was set up as a research project until 2018, at which point the technology would be ready for series production.

Project Outcome

The beneficiary of this first pilot plant was a school in La Guajira. The plant was already installed onsite, and gathering first data that would soon be analyzed.

The goal was to operate a large number of decentralized, stand-alone and CO_2 free drinking water systems via a centralized, cloud-based platform powered exclusively with renewable energies.

There are plenty of various applications possible from the learnings of this pilot unit. We can mix and match different raw water qualities (sweet/salt water), different water output quantities, we can freely adjust power production and power use for different purposes such as water purification or micro water and energy grids by fully remote access.

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Source: Infinite Fingers

CASE STUDY 17

ELECTRIFICACION OF A GARIFUNA HOSPITAL IN HONDURAS

Emilio Gudemos

Starting Point

The Iriona municipality is the second largest in Honduras. Its first inhabitants were of African descent. Its territory encompasses the Sico and Paulaya Rivers and the fertile valley of the same name, belonging to the legally protected biosphere regions Río Plátano and Sierra Río Tinto.

The municipality was established in 1892, at that time called Iriona Viejo. The region is considered to be a 100% rural by the Institute of Statistics (INE) and is home to more than 28,000 inhabitants. The population lives in five zones defined by their geography and natural resources, as well as their culture and land use by the local population: Costera, belonging to the Rio Plátano Biosphere, Wetlands, Valley, Mountain Range and the Tinto River. The population is distributed in 11 villages that comprise the political divisions of the municipality among natives and people who have migrated to this region over the past 50 years, comprising 125 settlements, communities and hamlets, most notably, the main homesteads of Iriona, Sico, Punta Piedra, Sangrelaya, Cusuna and Champas.

The region is not connected to the electrical power grid and only some homes have electrical power.

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First Garifuna Hospital Able to Carry Out Minor Surgeries

The lack of electricity has not been an obstacle for doctors at the First Garifuna Hospital in the country to regularly treat patients seeking daily medical attention for health issues.

This model operates in the communities of Ciriboya, Iriona, Colón, which, if it existed in at least half of the country, the nation's population would not have such difficulty in obtaining medical care as it does now. Over the last five and a half years, this free clinic has been in operation, its medical staff has treated nearly a million patients, not just from Iriona, but from other municipalities as well.

However, the lack of electrical power has impeded the hospital from providing major surgery to its patients; all of its cases that have to do with minor surgeries, treating labor complications and providing urgent care have only been possible due to a solar-powered energy panel, reaping the benefits of the sun's rays which fall perpendicularly on these abandoned communities.

Source: Emilio Gudemos

3. ADVANCED MICROGRIDS

CASE STUDY 18

HYBRID DIESEL-WIND SUPPLY FOR MID-VOLTAGE MICROGRID IN SOUTHERN CHILE

Javier Castillo

Summary

The rural electrification of the Los Lagos region of Chile has mainly been made possible by extensions of the conventional electrical grid; nevertheless, given the proliferation of rural dwellings in the region, and knowing that in some places the extension of the power grid is primarily a social enterprise rather than a market-based endeavor, the Regional Government of Los Lagos, in conjunction with the National Energy Commission (CNE) of the time (1995), carried out an assessment of possible electrical energy power supply alternatives for families that did not have access to the conventional power grid.

Opportunities for Renewable Energy

Within the framework of the Cooperation Agreement between the USA and Chile, through the Department of Energy, DOE and CNE, respectively, an effort was made to seek and implement rural electrification alternatives using non-conventional renewable energy (solar, wind, water, etc.). To do this, in the case of wind energy, a wind energy map of the Chiloé Archipelago was drafted using satellite modeling, then corrected using terrain models and anemometric tower measurements. One of these towers was installed on this small island known as TAC Island.

The main point of interest in this region for the use of alternative energies has been the Chiloé Archipelago, as it is obviously impossible to access these islands with the power grid for technical and economic reasons. Therefore, based on the wind energy map drawn up, a project was devised to provide electrical power to more than 3,500 families inhabiting the 32 islands of the Archipelago by way of hybrid wind-diesel systems, projects which were conceived according to the availability of the required resources.

Renewable Solution

As a first step in finalizing this ambitious Archipelago project, the pilot trial run TAC Island was launched to provide electrical power to 71 families who lived on the island at that time.

The project supplied electrical power in the amount of 220 V, 50 Hz, 24 hours a day to 71 families, the Rural Post and the TAC Island's school.

The project was built based on a wind generator powered by two turbines of 7.5 kW e/u, a deep cycle battery panel of 2,100 Ah in 48V, a diesel generator backed by 12 kW of rated power output, 24.5 kW e/u parallel-connected inverters, electronic control systems and a charge manager, a 13 km medium- to low-voltage distribution network, various transformers and 71 interior installations. One of the interesting characteristics of this project was how it limited the power output at the transformer level. This forced people to "regulate" the heavy load match factor (such as washing machines or centrifuge dryers), since using all these electrical appliances at the same time overwhelmed the control circuits and left everyone without power. Finally, following a learning period, families connected to the same transformer solved the problem by mutually agreeing on use hours.

The project was designed as a joint collaborative effort between the U.S. Renewable Energy Laboratories and Chile's CNE.

Since the beginning of the project, the operation and maintenance of the system has been in the hands of the electrical power company of the interconnected areas, which signed a supply agreement for the next 10 years with a renewal option for the same term, charging a sustainability surcharge covering an estimated minimal wind energy contribution of 50%. Due to the high cost of maintaining the wind power system, in large part resulting from the lack of service providers, the wind energy system ceased functioning; however, the robust nature of the contract it signed obligated the company to continue providing the service, without incurring any cost to the community it served. Currently, the company is carrying out the necessary studies in order to reestablish wind power services and revert to the conditions of operation that initially determined the fee.

Project Financing & Costs

The financing and the donation of equipment for the execution of the project was a joint effort between the United States (15 million Chilean Pesos (CLP), national beneficiaries (CLP 7 million to finance interior installations and meters), the electric company (CLP 41 M) and the National Fund for Regional Development (FNDR) (CLP 59 million), in the form of an investment subsidiary).

Project Outcome

This project was one of the first mini-grid rural electrification projects carried out in the world and has served as a testimonial for lessons learned, having enabled the implementation of many other similar projects.

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Source: Javier Castillo

CASE STUDY 19

SMALL HYDROELECTRIC POWER PLANT IN NICARAGUA

Patricia Rodríguez, MULTICONSULT Y CIA.LTDA

Summary

Thanks to the small hydroelectric power plant, Las Nubes-El Naranjo, the El Naranjo community, Waslala municipality, Caribe Norte, Nicaragua has obtained a microgrid to supply basic power to its residents as well as to small businesses in the area. The project has been operating for 10 years. The budget was USD 1,500,000.

The Organization

The small hydroelectric power plant is managed by a company made up of 355 partners in total, coming from the El Naranja community and other local communities. Among the partners are producers, small business owners and community leaders.

The Objectives

The main objective of the small hydroelectric power plant is to use renewable energy sources to supply electric power to communities that are disconnected from the power grid. The small hydroelectric power plant supplies electric power to nearly 1,000 families in eight communities in the Northern Caribbean region of Nicaragua: El Naranjo, Las Torres, Las Praderas, Waslalita, Aguas Calientes, El Guayabo 1, El Guayabo 2 and El Porvenir.

El Naranjo, one of the main communities benefitting from the power plant, is located along the highway that links the Waslala and Siuna municipalities. The population center has a recent history. It was a war zone in the 1980s and after the 1990s, as the peace process progressed, the population experienced rapid growth. The region is a thruway for neighboring villages, which, in addition to its own economic processes, generates many business activities for these communities. For these reasons, the region is a development hub with its cattle and dairy industries acting as a local economic engine, driving growth in the region.

The Challenges

Ten years ago, the communities currently served by the hydroelectric power plant did not have electrical power. At that time, there were less than 400 homes in the area. The region is rich in water sources and therefore exhibits great potential for generating hydroelectric power. Electrifying homes via the interconnected national grid not only carried with it significant cost but also, no electrification programs existed to extend the preexisting grid. The energy demand in the region currently amounts to some 150 kW at a consumption rate of 53 MWh/month. The main uses of electrical power in the area are for businesses and homes. There is some industrial use mainly related to milk production, since cattle farming is one of the principal socioeconomic activities. There is also some use in carpentry businesses (furniture, particularly, doors).

A significant obstacle is the lack of consumer subsidies. Clients who consume electrical power sourced from electrical companies belonging to the National Interconnected System, (SIN), receive a high subsidy percentage. For up to 150 kWh/month, these consumers do not even pay production costs; they are subsidized by the national budget and other high-consuming customers, as well as the commercial and service sectors. The lack of a subsidy causes consumers of energy stemming from the small hydroelectric power plant to compare the price they are paying versus what their SIN counterparts are paying. The price also contributes to the population investing in productive businesses which utilize the electrical power.

Opportunities for Renewables

The small hydroelectric power plant could be built because it, in first place, benefited from the abundance of water and topographic conditions of the area. Secondly, it benefitted from financing by multilateral and bilateral organizations who matched investments in the project. The power plant was determined at the time to be the less costly option.

Renewable Solution

The small hydroelectric power plant is a run-of-the-river power plant with installed power output of 220 kW. While it has been in operation for the past ten years, construction was initiated in 1999, 18 years ago. The experience of other small hydroelectric power plants in the area such as the El Bote plant was an important factor in constructing this one to reach the same supply capacity. Since 1999, following the example of the El Bote plant, those in charge of the construction project took great care of the water sources in order to maintain the water basin in optimal conditions ahead of the construction of the new plant. Project leaders purchased certain critical territories in advance and prohibited clear cutting in the upper region of the hydrographical basin.

The design flow rate of the plant exists in the river at least 92% of the time. The Pelton type turbine works quite efficiently at partial loads. Company personnel and directors who manage and operate the hydroelectric power plant, its distribution system and associated business operations received training in all administrative, business and technical aspects of this type of system through the support the Nicaraguan government received from multilateral organizations such as the World Bank and the Inter-American Development Bank. The project also received support from bilateral organizations, particularly European organizations managed by PNUD.

Project Financing & Costs

The investment was some USD 1,500,000 from the United States of America. Multilateral organizations financed it by matching investments of up to nearly 65% of the entire amount. The contribution of the hydroelectric power plant's partners was 35%, by way of proprietary funds (6%) and concessional loans (29%) from the local development bank. The price was determined by costing an actual net value near zero with an internal rate of return on investment of 15% and a discount rate of 10%.

Project Outcome

The majority of energy consumers are residential. There are many businesses specifically related to the commercial and service sector. Most of these businesses are operating in homes. Only 8% of the real estate in the region houses solely business operations, 29%, solely household operations, and 63%, combined business and household activities.

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Source: MULTICONSULT Y CIA.LTDA

CASE STUDY 20

FACILIDAD SUR SOLAR IN DOMINICAN REPUBLIC

Kathia Mejia, Fundación Sur Futuro

Summary

The Fundación Sur Futuro has built from 2012 to 2016 the project Facilidad Sur Solar in the Dominican Republic using different small-scale technologies for energy generation and water cleaning within an integrated setup offering high quality utility services to its remote beneficiaries. Total project budget was approximately USD 2,200,000.

The Organization

We are a private non-profit organization that began operations on 16 November 2001, promoting the development and social welfare of communities in the Southern Region of the Dominican Republic. We seek to reduce the high levels of poverty and marginalization of the inhabitants of this region by promoting the development of the social, natural and productive capital of the communities, contributing to improving the quality of life of vulnerable populations and supporting sustainable management of the environment and natural resources.

The Objective

To increase access to affordable sustainable energy services with renewable solutions in poor and very poor communities in the Southern Region of the Dominican Republic, by improving the living conditions of the community and using renewable resources.

The Challenge

The problem faced by communities can be summarized as being poor or very poor communities and located in places that are difficult to access, away from traditional electricity distribution networks, which are not included in the expansion plans of electricity distributors and where their income levels did not allow access to other sources of energy.

Participants (beneficiaries) were inhabitants and small entrepreneurs of rural communities in the southern region of the Dominican Republic, with special attention to mountain communities in the periphery of protected areas. They faced serious problems of access to basic services (drinking water, electricity, education and health) and with income levels that place them below the poverty line. The economy of these people depended almost exclusively on agricultural production, for which they irrationally exploitated the forest, sustained production in a slash and burn system that had a negative impact on the environment and on the conservation and production of water. The Sur Solar project barriers gave limited access to energy sources including supply from public networks. Lack of energy also limited access to potable water, as communities supplied water sources without potable conditions such as irrigation channels and had no capacity to treat them.

Opportunities for Renewables

Solar technology offered simple systems that were adaptable to local conditions. Solutions for lighting, refrigeration and water purification were implemented in the rural area, mainly the upper part of the territory (upper basin) that did not have electricity. The project developed a financing scheme to offer subsidized systems (not in the case of schools) for families to improve their quality of life through the new energy services that would allow them to reduce the investment on fuel to light their homes, reduce the possibility of fires occurring within the households from traditional fuel spills, burns on children and the reduction of respiratory diseases by constant inhalation of smoke.

Renewable Solution

The project developed a financing scheme to offer subsidized systems (not for schools) for:

- Individual solar panels for lighting and energy in homes.
- Solar purification systems for human consumption.
- Efficient fuel wood stoves.
- Solar lighting and refrigeration for schools.
- Solar freezers for microentrepreneurs.

Project Financing and Costs

The total investment in the project was USD 2,211,330: 75% from European Union and 25% from Sur Futuro and other donors.

Source: Fundación Sur Futuro

Project Outcome

At the end of the project:

- 500 families had access to lighting and energy in 500 homes from the installation of individual solar panels.
- 1,330 families had access to water from ten solar purification systems for human consumption.
- 1,122 families reduced the use of fuel wood through the use of more efficient stoves.
- 25 schools had access to energy for night lighting, inclusion of new technologies and refrigeration for the conservation of school breakfast meals from solar systems.
- 40 microentrepreneurs had financial support to expand their services with freezers powered by solar energy.

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Source: Fundación Sur Futuro

CASE STUDY 21

INNOVATIVE HYBRID MICROGRID & DISTRIBUTION SYSTEM FACILITATING COMMUNITY KITCHEN & LIGHTING RESIDENTIAL HOMES IN PERU

Karl Kolmsee, Smart Hydro Power

Summary

Via its agency Innovate, the Peruvian government sought to introduce technical innovation to remote places in Peru. Together with its Peruvian partner ECI Consulting, Smart Hydro Power showcased a comprehensive hybrid solution addressing residential and community needs. With a limited budget of Euro 105,000, electricity supply, water treatment system and a biogas system based on organic waste were implemented.

The Organization

Smart Hydro Power develops and fabricates micro hydro-kinetic plants and hybrid PV-hydro energy management systems for rural electrification. Smart Hydro Power has so far realized projects in Brazil, Peru and Colombia.

Smart Hydro Power puts specific focus on technology appropriation as most important means for facilitating sustainable projects.

The Objectives

The aim of the project was to showcase a new microgrid technology based on advanced load management allowing different types of demand to run (residential, productive use, deferrable load) depending on generation capacity.

It was also important to introduce the technology to the rural population allowing a proper appropriation which makes electrification projects sustainable.

The Challenge

The village of Bellavista in the Peruvian Napo basin was remote from the federal capital of Iquitos and had no prior experience with electricity.

Migration to Iquitos and Lima affected the village adversely with young talented men and women leaving.

Opportunities for Renewables

There were abundant renewable resources like biomass, water and sun – with some limitations on the radiation as a result of the rainforest. As diesel was expensive and often not available, renewables were extremely competitive.

Renewable Solution

The solution implemented in Bellavista was based on Smart Hydro Power's standard module with two kinetic turbines, 4 kWp photovoltaic, 20 kWh batteries and an advanced energy system with a micro-processor controlling three different circuits for the community kitchen, the residential homes and a pump for a water treatment system. The water treatment system itself worked with the water relying on gravity from a tank through a membrane filter. The tank was storing energy as supply and demand were decoupled. The energy management system did have a GPS interface which worked with satellite or telecommunication coverage – which had not been installed so far due to the lack of available satellite services. The micro controller steered the system in a way that the community house with a small kitchen (mixer, fridge, ice cube production for commercial orange juice processing) had priority, electricity was served from 06:00 to 10:00 p.m. by the turbines and the batteries which were loaded during the day to the households while overnight generation was run by the turbine drives the pump.

In addition, a biogas plant with 1 m^3 volume was used to transform organic waste to gas which in turn could be used for cooking.

Due to the strong positive impact of the community kitchen on the average household income, the power electronics were well-received and were properly serviced. The biogas plant was under-utilized as the direct positive advantage of biogas over wood were not yet fully accepted.

Project Financing and Costs

The budget of Euro 105,000 was sponsored by Innovate and the Peruvian Government Agency.

Project Outcome

The small village of Bellavista with 20 households has now become a lighthouse project within an underprivileged area. Local servicing ran with no reported problems.

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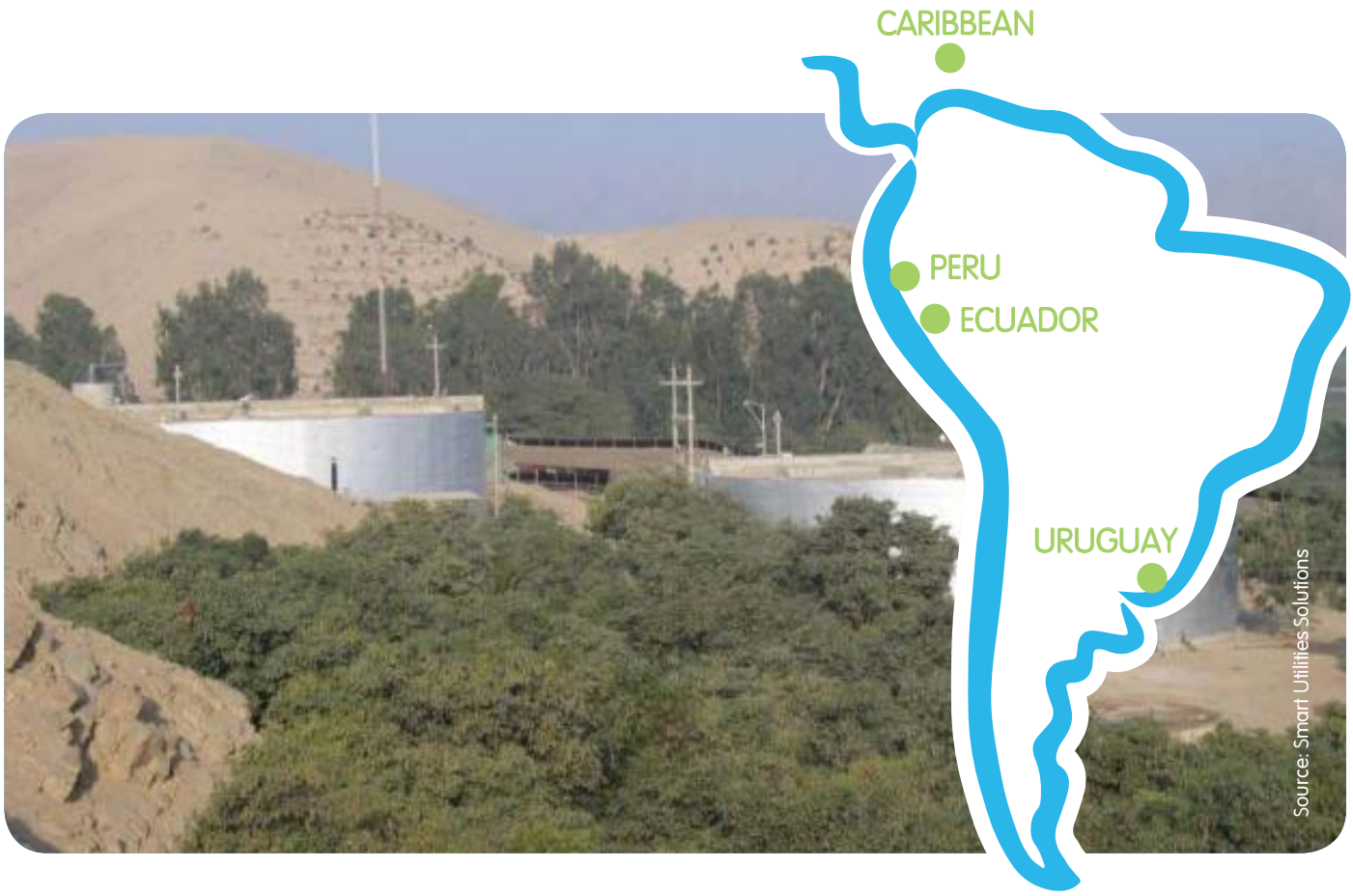
Source: Smart Hydro Power

4. PRODUCTIVE USE



CASE STUDY 22

INFORMATION REGARDING THE BENEFITS OF USING ANAEROBIC DIGESTION TO TREAT ORGANIC WASTE IN THE CARIBBEAN

Mariela Pino, Red de Biodigestores para Latino América y el Caribe

Abstract

Since 2009, the Biodigesters Network of Latin America and the Caribbean (RedBioLAC) offers its services in supporting innovative projects in the region. This article introduces the organizations and the benefits of the technology, giving examples in several countries. The organization has an annual budget of approximately Euro 100,000.

The Organization

The network defines its vision as the flagship organization in the investigation, development, implementation and distribution of biodigesters for the stimulation of suitable natural resources management and to promote socioeconomic wellbeing in Latin America and the Caribbean. The network's mission is to bring related institutions together under the rubric of applied research and distribution of anaerobic biodigestion technologies to foment the holistic treatment and management of organic waste, conceived as strategies for the improvement of the wellbeing of the populations where the organization works.

The Objective

- To exchange information and experiences between institutions participating in RedBioLAC.
- To identify and overcome technical, environmental, social and economic barriers.
- To propose projects, mechanisms and ideas for distributing the biodigester technology throughout Latin America and the Caribbean.
- To build alliances that facilitate the adoption of biodigester technology.
- To standardize research and dissemination among partners (health-related, financial, political, educational, industrial, and business).
- To promote the incorporation of other organizations, institutions and researchers into the biodigester field.
- To engender action to influence and affect biodigester-related policy.

The Challenge

As opposed to other non-conventional renewable energy sources, biogas still has not acquired a critical mass of qualified experts in the field, nor does it enjoy subsidies or specific support, as does solar energy, for example. However, it offers other benefits that are worth knowing. Liaising remotely with different network actors that seek to develop, promote and mass distribute a technology that is still not widely known, nor is 100% refined, namely, adding value to organic waste (which contributes to environmental pollution and incurs additional treatment costs without offering an alternative product!) as well as generating biogas and biofertilizers.

Opportunities for Renewables

The technology makes a fuel available that on a domestic scale meets sustainable development objectives, above and beyond the Sustainable Development Goal number 7; and improves the competitive edge and productivity of small and medium-sized producers, replacing fossil fuel consumption by providing in exchange self-sufficiency, regular energy supply, a better-quality fuel, and the possibility to diversify revenue sources and business models among those who invest in the technology. Biogas can be used as heat or at high production levels, by transforming it into electricity or biomethane gas (equivalent to natural gas).

Renewable Solution

In Costa Rica, cow manure and the whey byproduct of cheese production from only 35 milk cows were both used to produce 20 m^3 of biogas per day, sufficient to substitute 360 liters of petroleum per month sufficient for use in boilers; biofertilizer was used to fertilize and irrigate pastures. In another pasture of 60 milk cows, 50 kWh per day were produced following the introduction of a biodigester of 180 m^3 treatment capacity, providing a return on investment in five years.

In Mexico, a municipal butcher discarded waste that produced 240 m^3 of biogas per day, capable of providing 48 kWh of power to a facility that slaughters 40 pigs and 30 cows per day.

In Argentina, the treatment of poultry butcher waste and poultry excrement in a covered biodigester reservoir of 16,800 m^3 daily treatment capacity provided 700 kWe from 2,300 m^3 of biogas /day.

Domestic organic waste also has a high potential for producing biogas, reaching 96 liters/kg on average (equivalent to 576 Wh) according to research carried out in Colombia on applied technology in domestic continuous flow biodigesters.

All the above described projects must generate capacity and empower consumers or biogas plant operators with the objective of maintaining operative biodigesters.

Project Financing & Costs

Investment in biodigesters is variable - a domestic system could cost USD 1,000, while an industrial system, USD 30,000

- 45,000. In this type of project, it is still difficult to find innovative business solutions or co-financing opportunities to match investments. There are still very few public incentives. Banks are not widely aware of the technology, even though environmental regulations are creating frameworks that require the treatment of waste.

Project Outcome

All countries in the region have biogas projects in development, Brazil, Costa Rica and Colombia being the most advanced in terms of social and environmental benefits, providing various business opportunities in this area. The regulatory frameworks are still in development, giving greater quality assurance.

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Source: RedBioLAC

CASE STUDY 23

BIOGAS AND EGG PRODUCTION IN PERU

Karl Kolmsee, Smart Utilities Solutions

Summary

La Calera is an agriculture corporation producing eggs with close to 1 million chickens and oranges for the national and international market. The boxes for transporting eggs were made on-site with a high demand for heat from the coal-fired burner. A biogas plant using chicken manure was installed replacing coal and thereby supplying high quality liquid fertilizer to the fields.

The Organization

La Calera asked German based Smart Utilities Solutions with a broad expertise in different kind of biogas plants to serve as the owner's engineer.

Smart Utilities Solutions provides consultancy and engineering services to adapt renewable energy technologies to local environment mainly in Latin America. Smart Utilities Solutions runs projects in Brazil, Chile and Peru.

The Objective

To replace coal with biogas, thereby reducing costs and CO_2 emissions.

The Challenge

La Calera is located 150 km South of Lima in the coastal desert. Water came from the mountains but required a sophisticated distribution system to irrigate the land.

Chicken manure is extremely aggressive due to its relatively high dry mass content (DM > 25%) and high N-content (> 3% of DM). This made it a very good fertilizer and soil improver – using only small quantities. However, La Calera was not able to sell or use chicken manure itself as the local market was already fully saturated.

The professional egg producing process was energy and was mainly heat intensive (washing, egg boxes etc.).

Opportunities for Renewables

While La Calera already had a mixed experience with biogas plants, generally biogas plants based on chicken manure only faced several challenges: (a) high N content, (b) feathers, (c) high dry mass content. Therefore, and for cost reasons it was not possible to adapt a 'from the shelf biogas solution'.

Renewable Solution

Firstly, we installed a rather sophisticated feed-in line where the chicken manure was mixed with water to soften nitrogen content which gave us a liquid feed-in stream. Feathers, stones and other parts which could build up sediments in the digesters were removed.

The two 3,000 m^3 digesters were made with a local construction company from concrete and – different from most European models - with the gas storage outside as this allowed us to use simple gas sacks instead of expensive membrane coverages specifically for biogas plants. Despite the mild climate, the digesters were heated and continuously mixed as sedimentation proved to be a major issue with the existing biogas plant on La Calera.

The extract after the plant was liquid and could be pumped into large lagoons where it led to furthered sediments. The liquid fraction went towards the irrigation system. The dry sediment was used for soil melioration.

The gas was dehydrated and desulfurized into two independent process phases from the digesters to the storage. Sulfur could be used again in the plantation, together with the liquid extract.

The gas was used mainly for the production of egg boxes in an oven. Smaller fractions went towards the heating lamps for the chicks and heating water.

The entire project was implemented from fall 2008 to mid-2009.

Project Financing & Costs

Project costs were approximately USD 1.5 million which was financed by La Calera. Re-financing could partly be achieved through the sales of CO_2 emission certificates.

Project Outcome

Project amortization could be achieved in less than two years as the project not only replaced the coal with the burner but also produced large parts of nitrogen fertilizer which could be used on the fields.

In addition, the biogas process reduced the strong smell of chicken manure.

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CASE STUDY 24

IMPROVING CACAO PRODUCTION AND PROCESSING WHILE MEETING COOKING FUEL DEMAND IN ECUADOR

Willington Ortiz (Wuppertal Institute) & Samuel Brody Schlesinger (Green Empowerment)

Summary

Green Empowerment introduced the Project Improving Cacao Production and Processing While Meeting Cooking Fuel Demand in Ecuador (CRECER) from June 2014 to January 2016 with less than Euro 100,000.

The Organization

Green Empowerment is a US non-profit organisation working with local partners in developing countries to provide access to affordable and renewable energy, WASH solutions and complementary productive and environmental activities, thereby improving health outcomes and livelihoods for rural communities.

The Objective

This project aimed to stimulate the adoption of biodigester and passive solar dryer designs and provide training on sustainable cacao cultivation to improve the yield, quality and price of cacao crops and satisfy the cooking fuel demands of farmers in Rioverde, Esmeraldas, Ecuador.

The Challenge

Rioverde is one of Ecuador's poorest regions and a widespread lack of basic infrastructure limits efforts to improve rural livelihoods. However, the growing market for sustainably-produced cacao, the region's traditional cash crop, offers rural smallholders new opportunities. To increase producers' shares in the value chain and meet domestic and productive energy demands, biogas digesters and solar dryers were customised for local conditions, thereby reducing the carbon footprint of the processing chain while increasing yields and product quality.

Opportunities for Renewables

Small geomembrane biogas digesters can generate four hours' worth of cooking gas and substantial amounts of organic fertiliser, replacing the imported LPG traditionally used for cooking and the chemical fertilizers used for cacao production. Passive solar cacao dryers work at least 20% faster and provide more uniform results than traditional open-air drying methods, while also reducing monetary and quality losses. Improved passive drying also decreases the need for secondary LPG drying and facilitates transportation.

Renewable Solution

The project oversaw the installation of ten 6 m^3 geomembrane biogas digesters and nine wood and polyethylene sheeting solar cacao dryers, designed to reach high internal temperatures (> 45°C) and provide increased ventilation to reduce humidity. Each digester directly benefitted and was maintained by a single household, while the production of fertiliser created the possibility of sharing the benefits of the digester with other households through its sale or exchange. The solar dryers (similar to greenhouses) were maintained either by small family groups in outlying areas or by communal groups in population centres.

The delivery model placed emphasis on developing the local skills necessary to ensure long-term operation and facilitate further diffusion. The installation of the biogas digesters and dryers was, therefore, accompanied by intensive operation and maintenance training courses for the owners, exchanges between the beneficiary communities and other potential adopters of biodigester and solar drying technology, a course on sustainable cacao cultivation and a series of related workshops on gender equity, community involvement and environmental conservation. Moreover, the project aimed to build capacity for the further promotion of the technologies among organisations already active in the region, such as cacao cooperatives and farmers' associations.

Project Financing & Costs

Basic financial support was provided by WISIONS of Sustainability. The implementation strategy included in-kind and financial contributions from beneficiaries for both technologies - biodigester adopters paid 20% of the USD 500 costs of non-local materials through an instalment plan, and contributed local materials valued at around USD 75 for the installation.

Multi-family solar dryer management followed a similar model: a small group (generally relatives of dryer owner-operators) provided local materials and labor valued at around USD 200. Each group was supported to create a savings plan to provide for replacement plastic sheeting (around USD 150 every two years). In the case of the larger communal dryer, users contributed around USD 900 in labor and materials for its construction and elected a committee charged with overseeing operations, maintenance and the financial management of funds collected from dryer user fees.

Project Outcome

The key results of the project were a 30% reduction in the consumption of LPG for cooking by rural beneficiary families and improvements in cacao drying (10% reduction in the weight of the final dry cacao). Organic fertilizer sales have not yet become an income source, but chemical fertilizer savings were perceived as a further motivation.

An estimated 300 people in three communities of Rioverde benefitted from the project. Nearly 100 participated in at least one of the training programmes and 15 completed "training of trainers" courses. Due to its socio-economic impact in the region, the CRECER project was selected as the 2016 Ecuadorian national winner of the Energy Globe award.

In Esmeraldas alone, more than 15,000 families could potentially benefit from the further roll-out of training, biodigestion and solar drying technologies for cacao. Barriers to wider uptake include limited access to credit, the need for long-term support of biodigester adoption and the lack of guaranteed price premiums for quality cacao.

Due to the high replication potential of the project, WISIONS supported a follow-up phase to further disseminate project results and initiate national meetings to increase support for biodigester technology and agro-ecological practices. This helped trigger the formation of a national network (RedBioEc), which aims to improve knowledge exchange and coordination among diverse Ecuadorian stakeholders interested in developing the country's biodigestion sector.

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CASE STUDY 25

SANTA ISABEL URUGUAY: WATER SUPPLY TO A RURAL ENTERPRISE FOR CATTLE DRINKING TROUGHS

Alberto Fernandez, KIVOY S.A.

The Organization

KIVOY S.A is a private Enterprise from Uruguay committed to support by its work the cultural and social change as well as the change of the energy portfolio. The enterprise is formed by professionals to provide sustainable Solutions using the most modern equipment for renewable energy.

The Objective

To supply to a rural enterprise for cattle drinking troughs (6,500 cows), distributed over 1,500 ha of artificial pastures.

The Challenge

Santa Isabel Facility is a rural business operation which required water supply for its cattle and local irrigation efforts. Solar energy was used, supplied by solar panels. 350 m^3 per day of water was supplied.

Opportunities for Renewable Energy

The opportunity for installing photovoltaic solar panels was assessed in order to supply the power necessary for operating the pump system and to back up the existing electrical infrastructure, providing the opportunity to sell power to the national government agency when not being used for internal operations.

Renewable Solution

The problem was solved using a submersion pump supplied with power from a collection of 23 x 5 solar panels. The installation was completed with regulators supplied by KIVOY a representative of LORENTZ.

Project Financing & Costs

The total investment was USD 52,000 of proprietary funds. The project was included as part of Uruguay's national energy policy.

Project Outcome

The project ultimately benefits the Santa Isabel Facility, and secondly, the population that lives around it.

Lessons Learnt

At first, the installation of solar panels was not considered because there was already an electrical power grid in the area. Following the analysis, however, it was determined that it would be beneficial to design a hybrid system to provide a self-sufficient energy supply for certain periods and to sell the excess power during other periods. Therefore, the important lesson learnt was to analyze the project in its entirety over an acceptable life of the investment.

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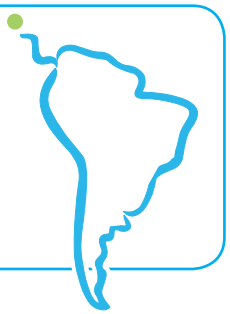
Source: Kivoy

CASE STUDY 26

REMOVING BARRIERS TO GREENHOUSE GAS MITIGATION IN MEDIUM-SCALE AGRICULTURAL LIVESTOCK ACTIVITIES IN MEXICO

Willington Ortiz (Wuppertal Institute), Alexander Bennet Eaton & Monserrat del Carmen González Espinosa (IRRI Mexico)



Summary

With the Support by Wision (an initiative of the Wuppertal Institute of Climate Change), the Instituto Internacional de Recursos Renovables A.C and the International Renewable Resources Institute (IRRI Mexico) – ran a project from 2014 to 2016 on removing barriers to greenhouse gas mitigation in medium-scale agricultural livestock activities in Mexico. Total budget was Euro 65,000.

The Organization

IRRI fosters sustainable development at the cross-section of social justice and environmental sustainability, striving to foster low emission and highly resource-efficient households, farms and communities through holistic approaches to technology development, transfer and capacity-building.

The work of IRRI is context-driven, gender responsive, participatory and fully transparent, taking traditional and indigenous knowledge into account together with eco-technologies to help communities become more autonomous, resilient and able to protect their surrounding environment.

The Objective

To improve the productive use of biogas from livestock waste on small and medium-sized farms in central Mexico by demonstrating various applications of biogas and adapting 'off-the-shelf' electric motors to run on biogas.

The Challenge

Biogas is widely promoted as a sustainable energy option for small and medium-sized farms. However, a limitation has been the ability of such farms to exploit biogas energy for mechanical and electrical uses. The most common application of biogas in the sector is often confined to covering thermal loads, such as those linked to cooking and hot water needs.

Opportunities for Renewables

Biogas can be used to fuel small motors and provide mechanical and electrical power for the different productive processes on small and medium-sized farms, such as milking, pumping, grinding or chilling milk. While large scale biogas engines above 50 kW are a well-established technology, small biogas motors are not.

Renewable Solution

The specific objective of the project was to create an engine platform that could provide reliable mechanical and electrical power for small and medium-sized farms. The technical focus was on small gasoline engines available on the market and easily accessible to small and medium-sized producers, as well as on the development of appropriate technology for adapting these engines to run on biogas.

The project comprised two main phases. In the first phase, four 'Sistema Biobolsa' biodigesters, waste water treatment systems and biogas use systems were installed at four medium-sized livestock farms (two pig farms and two dairy farms). Baseline data was collected on the volumes of livestock and waste production at each farm, as well as on energy use and opportunities for reusing the effluent nutrients as organic fertilizer. The biogas now being produced on these farms is used for space heating for pig maternity areas, for heating water for cleaning purposes, and as gas for cooking.

In the second phase, the project adapted 20 small (5-10 kW) commercial gasoline motors available on the Mexican market so the farmers could produce mechanical and/or electrical power from biogas. Of these motors, 16 were installed in existing small biogas plants and four in the new medium-sized demonstration plants, totalling 152 kW of new capacity. This phase included five significant areas of R&D: biogas filtration, matching energy production and use, motor sizing and design, grid interconnection, and training and maintenance.

Project Financing & Costs

The project applied a mixed financing approach. Grant funding from the WISIONS of Sustainability initiative provided an economic incentive to the farmers at the demonstration sites. The investment for the four waste water treatment systems was co-funded through the crowd-sourcing KIVA loan platform, with a small payback period of between 7 and 15 months. The research team and the biodigesters were financed by the USAID Mexico Low Emissions Development Program (MLED).

Project Outcome

The project led to various significant advances.

- A three-stage treatment approach was tested at two of the waste water treatment systems, one pig farm and one dairy operation. It comprises a sedimentation and grease trap phase, a subsurface wetland phase and a surface lagoon with aquatic plants. Tests undertaken during the project showed that this system enabled farms to meet national water quality discharge standards.
- The project proved that small gasoline engines can be effectively converted to biogas and that local technicians can be trained to provide servicing and monitoring. The lessons learned during the project helped to develop a kit for the conversion of gasoline engines, which is currently being commercialised by Sistema Biobolsa in Mexico. Moreover, the converted engines effectively provide mechanical energy for productive and recurrent tasks such as milking, water pumping, forage grinding and de-graining.
- However, the provision of electrical power on a small-scale still faces notable challenges; for instance, the difficulty of ensuring stable frequency and voltage which, in turn, is linked to inconsistencies in the properties of the fuel, i.e. pressure, moisture and methane content. The biogas-converted engines have rather narrow range of capacities, which hinder the proper matching of the diverse load levels needed for daily tasks. Moreover, grid electricity is still highly subsidised in Mexico, with the result that producing electricity was the least economic option for biogas use. However, the recently-introduced National Electricity Norms allows users to sell power to the national grid, so this option is currently being explored.

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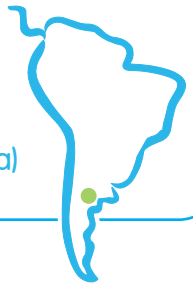
Source: WISIONS

CASE STUDY 27

SOLAR MOBILITY IN THE ANDEAN HIGHLANDS OF ARGENTINA

Willington Ortiz (Wuppertal Institute), Barbara Holzer & Heinrich Kleine-Hering (Eco Andina)



Summary

With a budget of less than Euro 75,000, the Fundación EcoAndina introduced Solar Mobility in the Andean Highlands of Argentina. The project was realized between July 2014 to December 2015.

The Organization

As a small Argentinian NGO, Fundación EcoAndina is committed to ecological and social issues. Over 20 years, EcoAndina has developed the Solar Andean Village concept, where solar energy is used for cooking, heating water, heating schools, water pumping, mobility and electrification. More than 20 Andean communities in the Argentine Highlands have already transformed into Andean Solar Villages.

The Objective

This project aimed to introduce and test electric bikes (e-bikes) and electric motorcycles as mobility options for short and medium distances in the Andean Highlands of Argentina (Puna region and San Salvador).

The Challenge

Mobility in this region of Argentina is limited due to inadequate public transport, fuel shortages, high fuel costs and a deficient road network. It takes a long time to travel even a short distance and travel costs are high for local communities. The maximum daily distance that inhabitants in the rural Puna area need to travel to carry out economic activities such as farming, construction and gold-panning is 30 km, so electric vehicles must be able to last this distance before requiring recharging.

Opportunities for Renewables

Solar mobility is a step on the pathway to replacing the use of fossil fuels in the Puna region. Due to the area's abundant solar energy and lithium resources, EcoAndina is particularly interested in combining solar mobility (e.g. e-bikes) and other solar energy concepts with the development of the local lithium extraction and processing industry.

Renewable Solution

In this project, 15 e-bikes were introduced to the participating communities and tested by the local population for short and medium distances. The energy for recharging the e-bikes' batteries was provided by six mobile solar PV power stations.

The project comprised two main phases. In the first phase, 15 specially designed e-bikes were assembled and tested by staff to ensure they were suitable for use in rural areas and were easy to maintain. The e-bikes were equipped with 350 W and 500 W motors, at first with heavy lead batteries and later with light lithium batteries. The e-bikes were provided to various organisations in three different areas of the province of Jujuy. Furthermore, five German-manufactured mobile solar battery charging stations were installed in accessible locations, each one consisting of a regulation unit connected to a 65 W PV panel.

In the second phase, a stock of spare parts was amassed and five men from the participating communities were trained in e-bike construction and maintenance to ensure the long-term sustainability of the project.

Project Financing & Costs

In this prototype development and testing project, the WISIONS of Sustainability initiative provided initial financial support to make the e-bikes available on loan to the users at no cost.

The average cost of an e-bike for the duration of this project was around Euro 2,300. Since 2016, the import trade has become less restrictive and prices for e-motors, regulation components and lithium batteries have dropped, leading to potential cost reductions of over 20%. Additional future cost reductions are expected through large-scale bike production, the development of locally-manufactured lithium batteries and access to micro-credits.

A journey of 30 km by pick-up truck (a common practice in the region) costs approximately Euro 5; fuel costs for an estimated 200 journeys of 30 km per year would amount to Euro 1,000 per year. Therefore, a simple projection suggests that investing in an e-bike could have a payback period of two to three years.

Project Outcome

The major impact of this project was the breakthrough in introducing an innovative technology into a challenging environment. On this basis, a local entrepreneur, in cooperation with EcoAndina, has applied for finance to support the commercial production of e-bikes. EcoAndina itself is planning follow-up projects with the aim of improving the performance of the e-bikes and lowering their cost. The current price is likely to be too high for the indigenous population, who tend to have low incomes.

In this pilot project, the e-bikes were very well received by users and there were a broad range of user types. At various dissemination events, the e-bikes were demonstrated to over 500 people and a hundred of these, including several decision-makers (e.g. local mayors and Members of Parliament), experienced e-bike rides. One central difficulty for further diffusion is the strong market competition from extremely cheap, fuel-powered motorbikes, which have been growing in popularity over the last decade in rural regions of Argentina.

Valuable lessons have been learned. For example, trial and error showed that it was more expensive to adapt second-hand bikes than to work with newly-bought components. It also became clear that substantial research, development and demonstration efforts are required to customise e-bikes for the harsh conditions and terrain of the mountain tracks in the Andes.

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Source: WISIONS

CASE STUDY 28

"EXTRACTIVE" NATURAL RESERVES WITH CLEAN ENERGY IN THE BRAZILIAN AMAZON

Alessandra Mathyas, WWF - Brazil

Summary

The WWF Brazil supported the introduction of clean energy into natural reserves (Reservas Extrativistas or Resex) in the Amazon. Total spent budget (on a 24-month basis since project start) is USD 440,000 from WWF and partners..

The Organization

WWF-Brazil is a non-governmental organization, a global network member in 130 countries, with a long history of supporting Conservation Units in Brazil since 1996. It works with Climate Change and Energy, Agriculture, Water, Finance for Sustainability and Agriculture, in the Amazon, Pantanal, Atlantic Forest and Oceans. It is a protagonist in the implementation of the ARPA-Protected Areas Program in the Amazon, in partnership with the Ministry of Environment and the Chico Mendes Institute for Biodiversity Conservation - ICMBio.

The Objective

To support a regional development system, using natural reserves (called RESEX-extractive reserves) as pilot areas for access to solar energy, with support to productive chains for the political and technical empowerment of communities, through the micro-generation of clean energy. We intend to build and present to the Government a proposal for a National Program of Extractive Reserves for Clean Energy Producers.

The Challenge

The Resex are a model of Brazilian protected areas, a result of the struggles of the extractive community movements of the Amazon for the right to land. There are currently 90 Resex in the country, representing a population of approximately 700,000 inhabitants. The traditional populations of the Amazon promote the conservation of the forest with their traditional ways of life. This population, for the most part, does not have access to energy and uses diesel generators with high social, environmental and economic costs.

The Resex Ituxi and Purus Medium, with more than 6,000 people, are located in the municipality of Lábrea, which has the highest rate of deforestation in the state of Amazonas. The strengthening of sustainable production is essential as a strategy against deforestation. Without electricity this is almost impossible. The families depend on diesel generators, consuming R$ 450/month, making it impossible to use electricity for sustainable production, considering an income of R$ 465 for 63% of the residents.

As an example, these reserves have a production potential of more than 50 tons per year of pirarucu, the most noble fish in the Amazon, but due to lack of refrigeration, only 3 tons were fished. Knowing the benefits of photovoltaic energy, organizing the productive chains and unlocking the financing for the extractive populations to acquire their renewable systems were the main obstacles to overcome.

Source: Comunidade Cassianã, Resex Médio Purus/ Lábrea

Renewable Solution

We started the work by holding meetings with ICMBio (federal agency) responsible for the implementation of the Resex, extractive leaderships, governmental institutions (MMA, MME, MDA), private companies: Usinazul, Schneider Eletric and others, to present possible uses of solar energy in isolated communities: lighting, pumping, refrigeration, etc.

Subsequently, it was defined where the systems offered by the project would be installed. For Resex Ituxi would be installed with a solar freezer, water pumping and fruit pulping. In the Medium Purus Resex, electrification of two schools with water pumping was set up. A primer (5,000 copies) was prepared and distributed with all possible uses of photovoltaic energy and other alternative sources (http://www.wwf.org.br/informacoes/bliblioteca/?57443/Cartilha-apresenta-usos-com-energy-renewable-for-communities-isolated).

In partnership with the Mamirauá Institute of Sustainable Development, a capacity-building workshop was carried out for 23 people between residents of the two Resex, city hall employees and university students. A solar system of 1 kW in the school of the Cassianã Community was installed serving 35 families and 60 students. In September, the other five systems were installed.
In June 2017, WWF won the auction of the Ministry of Mines and Energy, receiving a donation of 35 kWp in equipment, which would be destined to other communities.

Financing & Project Costs

The initial budget was USD 300,000 which covered equipment, meetings and seminars, preparation and distribution of leaflets, training and field logistics. Transport costs for the Amazon were above the Brazilian average, burdening the project. As partners of the project, Schneider Electric offered didactic material and components of photovoltaic systems, JA solar company with the donation of photovoltaic modules, institutional support from ICMBio, the City Hall of Labrea, State University of Amazonas and donation of equipment by MME (USD 100,000). By 2018, WWF-UK will contribute a further USD 40,000.

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Project Outcome

- Still in progress, 1,000 beneficiaries stand out as results. Considering the first installation, the economy with fuel for the generator of the school will be R$ 400 / month, an asset that should be destined to the improvement of the facilities.
- Indirectly, the project reaches all the residents of the two reserves: 6,000 people, as it is generating the interest of the regional public and private sectors.
- In the work plan with ICMBio, it was defined as a goal to have a Resex model in sustainable extractive production with clean energy, with the potential of replicability for more than 80 Resex in the country.

Source: Carl de Souza/ AFP – Resex Ituxi/ Labrea

CASE STUDY 29

COMPADRE: SOLAR COFFEE ROASTING WITH PHOTOVOLTAIC IN PERU

Juan Pablo Pérez Panduro, ACCESOL S.A.C.

Summary

Starting in 2014 ACCESOL S.A.C. runs the project "Compadre: Solar Coffee Roasting" based on photovoltaic. The project is based in Satipo (Junín), Perú, and is financed with USD 185,000.

The Organization

Compadre is a social company seeking to improve small rural agriculture through the commercialization of organic solar roasted coffee that gives more income to the coffee farmers that process the coffee. They have developed machines that can be used by the farmers to roast their own coffee beans with the sunlight.

The Objective

To increase small coffee farmers' participation in the coffee value chain by training them in the selection processes, peeling and roasting of the coffee beans.

To make small farming sustainable in economic, social and environmental terms.

To position a responsible coffee brand inside the Peruvian market.

The Challenge

Small coffee farmers' incomes were hardly enough to pay for their everyday expenses: education for their children, healthcare and food. Their regular income levels were usually not enough to pay for work staff and organic fertilizers needed to take care of their crops. These conditions made small agriculture less and less attractive to the younger generations who end up migrating to the city, leaving the agriculture lifestyle. Because of this, the average age of farmers is high since youths choose higher paying jobs that are less demanding and more prestigious in the city.

Compadre has developed a technology that capitalizes solar energy to allow coffee beans to be roasted in rural areas. They make this technology (and other technologies to cover the complete coffee value chain) accessible to farmers on specific locations, so they can give added value to their product and earn more from its production.

Opportunities for Renewables

The only way for small farmers to be involved in more processes inside the coffee value chain is by giving added value to their products. Most farms were in areas that had no access to the electricity grid, so it became extremely difficult for small farmers to execute any additional processes. For example, coffee roasting needed either electricity or gas, and the technology needed to perform these processes was too expensive for them.

The energy supply came from the sun, since this resource is available everywhere. And, in the case of coffee roasting, since heat was what was needed, it was more efficient to use solar thermal energy. For that, machines used for the process needed to be design according to energy source available.

Renewable Solution

Building upon the open-source Scheffler's solar concentrator, we developed a special drum that harvested the heat gathered by the parabola to roast coffee beans. This energy concentration rose the temperature in the drums to above 200°C and coffee could be roasted without electricity or gas. Later, to guarantee coffee production, we improved the design of the drum, and added an electric resistance to roast the coffee. The electricity to roast using this system came from PV panels. This off-grid system allowed the farmers to roast close or in their own farms, since there was no access to other sources of energy in the area.

Compadre has implemented a production plant that ran 100% with solar energy. The plant's capacity is of 1,500 Wp PV and 2,000 Wp Thermal, and can process up to 200 kg of roasted coffee a month. Implementation of other types of renewable energies and increasing the size of the PV system was possible if more production was required.

Project Financing & Costs

Compadre was registered as a company in Peru in 2014, under the name of ACCESOL S.A.C. The founding members won

Source: ACCESOL S.A.C.

some funds to carry out the idea at a pilot level. It was tested throughout 2015, were they validated the technology and the quality of the roasted coffee. After making some changes in the business model, sales started in November of 2015. Since then, Compadre has been operational. Through their work, they have made important partnerships and alliances to keep working on making an impact. So far, they are part of NESsT's portafolio, UTEC Ventures (equity), Empowering People Network, and winners of StartUp Peru (a Ministry of Production funding program given by the government). Compadre will reach its breakeven point by July 2018.

Project Outcome

The project's beneficiaries are small farming families in the Peruvian Amazon. In Peru there are more than 220,000 farming families that feed 85% of the national coffee production and are in conditions similar to those described in previously. Globally, this is the situation of 25 million coffee farmers families.

So far, we have been able to work with 18 families, increasing their incomes by an average of 56%. Currently, four farmers have received training in solar roasting and coffee selection. Our plan is to teach those, and more trades related to coffee production and chores inside the solar station (like PV system installation and machines maintenance). The application of renewable energies is allowing us to create more job opportunities inside these coffee farming communities.

Our intention is to open several solar stations of decentralized production throughout the country where communities with small coffee farming families with organic productions and good coffee are located.

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Source: ACCESO, S.A.C.

SUMMARY OF THE CASE STUDIES

Country	When	What	Size	Beneficiaries	Costs (USD)	Financing
Guatemala	2009 - 2017	Community HPP	90 kW	140 HH, 20 SE	800,000	CSR - public
Bolivia	2017	PV microgrid		200 HH	300,000	CSR
Guyana	2017	Rural Food Center			150,000	Public
Brazil	2004	3.3M connections		3.3 M HH	7 Bn	Public
Dom. Rep.	1997	Community HPP	1.3 MW	4,500 HH	14.5 M	Public
Mexico	2010	Solar Home Syst.	25-100W	9,800 HH		Commercial
Haiti	2012	PV micro grid	93 kW	450 HH	3 M	Publ.-private
Colombia	2015	PV micro grid	190 kW			CSR
Honduras	1994	Solar Home Syst.	30-85 W	3,000 HH		Publ.-private
Peru	2009-2019	New stoves	n.a.	206,000 HH		CSR-public
Peru	2017	Solar Home Syst.	50W	61 HH		CSR-public
Ecuador	2012	PV micro grid	9.2 kW	20 HH	69,000	Public
Mexico	2012-2016	Solar Home Syst.	50 W	46,000 HH	2.87 M	CSR-Public
Colombia	2016	Hybrid Micro Grid	8 kW	20 HH, e-boat	57,000	Public
Peru	2013	Potable wáter plt.	70 kW	780 HH	3.41 M	Public
Colombia	2016	Potable wáter plt.	7.8 kW	120 l/h wáter	460,000	Public
Honduras	2002	Hospital	5 kW	Hospital		Public
Chile	1995	Wind Micro Grid	15 kW	71 HH	282,000	Public
Nicaragua	2008	Community HPP	220 kW	355 HH	1.5 M	Publ.-private
Dom. Rep.	2012-2016	Indiv. PV Systems		1,300HH, 40SE	2.2 M	Public
Peru	2015-2016	Hybrid microgrid	13 kW	20HH	120,000	Public
Chile	2009	Small biodigesters	50 kW	Agricultural SE	45,000	Private
Peru	2008-2009	Biogas for heater	1.5 MW	Agro-ME	1.5 M	Private
Ecuador	2014-2016	Solar dryer		Communities	115,000	Public
Uruguay	2015	Solar pumps		Agricultural SE	52,000	Private
Mexico	2014-2016	Small biogas plts.	150 kW	Agriultural SE	75,000	Public
Argentina	2014-2015	E-Bikes	350W	Bs. Promotion	84,000	Public
Brazil	2017	Fish Industry		1,000 HH	440,000	Public
Peru	2014	Coffee Industry	PV Dryer	1.5 kW	185,000	Private

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About the Alliance for Rural Electrification (ARE):
ARE is an international business association focusing on the promotion and the development of off-grid stand-alone and mini-grid renewable energy solutions for rural electrification in developing countries.

For more information: www.ruralelec.org

About the Inter-American Development Bank (IDB):
IDB works to improve lives in Latin America and the Caribbean. Through financial and technical support for countries working to reduce poverty and inequality, IDB helps improve health and education, and advance infrastructure.

For more information: www.iadb.org/en

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Shining a Light for Progress

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