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GENUS
GLOBAL ENERGY NETWORK FOR URBAN SETTLEMENTS

GLOBAL ENERGY NETWORK FOR URBAN SETTLEMENTS (GENUS)

Sustainable Energy Access: Best Practice Casebook

Acknowledgements

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List of Acronyms and Abbreviations

ABC	Aerial Bundles Cables
ALIN	Arid Lands Information Network
APRO-ECO	Association Pour La Protection De L'eco-Système
AREED	African Rural Energy Enterprise Development Programme
BTAL	Biogas Technology Africa Limited
CBO	Community Based Organization
CFL	Compact Fluorescent Lamp
CIPRE	Centre International De Promotion et De Recuperation
CNE	Comisión Nacional De Energía (National Energy Commission)
CSET	Centre for Sustainable Energy Technology
CUC	Central University College
EMDI	Engineering Materials Development Institute
ENDA	Energy, Environment, and Development For Africa
ENVODEV	Enterprise for Vocational Development
EPP	Emergency Power Program
GDP	Gross Domestic Product
GENUS	Global Energy Network for Urban Settlements
GHG	Greenhouse Gases
GIZ	German International Cooperation
GoK	Government of Kenya
GoL	Government of Liberia
GoN	Government of Nigeria
GPOBA	Global Partnership on Output-Based Aid
ICT	Information and Communications Technology
IDA	International Development Association
IIT	India Institute of Technology
INR	Indian Rupees
IRG	International Resources Group
KARI	Kenya Agricultural Research Institute
KPLC	Kenya Power and Lighting Company
KWH	Kilowatt Hours
LEAP	Liberia Energy Assistance Program
LEC	Liberia Electricity Corporation
LESEP	Liberia Electricity System Enhancement Project
LPG	Liquefied Petroleum Gas
LV	Low Voltage
MOU	Memorandum of Understanding
MPOS	Mobile Point of Sale
MYTO	Multi-Year Tariff Order
NASENI	National Agency for Science and Engineering Infrastructure
NERC	National Electricity Regulatory Commission
NESF	National Energy Stakeholders Forum

NGO	Non-Governmental Organization
PNB	Punjab National Bank
PRODA	Project Development Institute
PTD	Plastic Tubular Digester
PVC	Polyvinyl Chloride
SHP	Small Hydropower
UBRBDA	Upper Benue River Basin Development Authority
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO RC SHP	UNIDO Regional Centre for Small Hydro Power
USAID	United States Agency for International Development

Introduction

Current patterns of energy production, distribution and utilization are unsustainable, and there are wide disparities in the level of energy consumption within and between developed and developing countries. One third (2 billion people) of the global population has no access to basic energy services. Most of them (1.6 billion people) live in developing countries, mainly in South Asia and in Sub-Saharan Africa. They depend on inefficient biomass fuels, such as wood, animal and crop waste for cooking and heating, which have detrimental effects on air quality and health. About three-quarters of the world's commercial energy is consumed in urban areas, and many of the people in direst need of access to modern energy systems are located in rapidly growing informal urban settlements (slums) throughout the developing world. In-migration into cities has created very dense informal settlements where 30 to 40 per cent of the urban population lives in abject poverty and dismal conditions. Despite such numbers, the energy needs of poor urban households, and particularly of women, in developing countries have not been properly addressed, as development efforts have focused intensely on the rural poor.

It is widely assumed that precisely because the urban poor reside in the cities of the world that they must have no energy needs or challenges at all. But nothing could be further from the truth. For example, it is important to note that even if there is availability of electricity in urban areas, this does not automatically translate into accessibility by the urban poor. UN-HABITAT recent studies show that the urban poor and especially slum dwellers are particularly hard hit by lack of access to modern energy. In part due to poor infrastructure and prohibitively high up-front costs, the poor often face much higher energy costs than the non-poor. They pay more for their cooking, water and electricity than wealthier people connected to the service networks.

Access to affordable, modern energy services is a pre-requisite for sustainable development and poverty alleviation and, more specifically, for achieving each of the Millennium Development Goals (MDGs). Lack of access to reliable, safe and mostly environmentally-friendly energy is a strong constraint on human development. Energy services can play a variety of direct and indirect roles to help achieve MDGs, as follows:

- Access to energy facilitates economic development, since value-adding income generating activities can be enhanced, and micro-enterprise/livelihood activities can be extended beyond daylight hours, creating additional employment opportunities.
- Access to energy reduces hunger and improves access to safe drinking water, through pumping facilities.
- Access to energy reduces diseases and child mortality, as energy is a key component of a functioning health system, through refrigerating medicines, sterilizing equipment and providing transport to clinics.
- Access to energy facilitates the achievement of universal primary education and the empowerment of women, since it reduces the time spent by women and children on basic survival activities (e.g. fetching water, firewood and cooking) and permits improved levels of home study for children.
- Access to energy for affordable transport enhances urban mobility and allows better access to wider employment and other economic opportunities within the city.

Cities in developing countries require a rapid increase in energy production and consumption to accelerate economic development, alleviate poverty and meet the basic needs of their populations. Urban areas offer

special opportunities and need thus special attention. They are a hub for economic development and high population density offers possibilities for good economics in terms of electricity access. The current political/environmental agenda in many of those countries is still fragile, and different challenges constrain the capacity of city managers to conceive and design appropriate programs and policies in support of energy access for poor urban settlements.

UN-HABITAT, through its Urban Energy Unit of the Water Sanitation and Infrastructure Branch, supports the implementation of the Habitat Agenda, which acknowledges the importance of energy in promoting sustainable human settlements development.

The Global Energy Network for the Urban Settlements (GENUS) is a dynamic partnership of institutions to promote collaboration among the public and private sectors, governmental and non-governmental organisations, grassroots groups, national and international development agencies working in the urban energy sector. GENUS aims at creating a platform of multiple institutions and stakeholders including the public and private sectors, governmental and non-governmental organizations, grass-roots groups, national and international development agencies, working in the urban energy sector to facilitate a new and dynamic collaboration, dialogue and information sharing.

The main objective of the network was to work for encouraging and supporting the implementation and replication of affordable and environmentally sustainable energy programmes and projects for the urban poor worldwide by:

- Working for a better understanding of the links between sustainable energy and other development priorities, and technology and policy options leading to better formulation of practical policies that can be adopted to promote and highlight the crucial role of energy for sustainable development in poor urban settlements.
- Working to provide analytical input to governments to consider in formulating their policies and programmes, and the private sector to attract investments in the urban energy sector, so that these favor energy sector growth for sustainable development especially for the urban poor in the developing countries.
- Promoting a communication infrastructure that provides a means for the network members to share experiences and draw on each other's strengths, expertise and skills.
- Strengthening South-South and North-South exchange of knowledge and collaboration on urban energy issues of common interest.
- Strengthening the ability of the network members to acquire, assimilate and apply existing knowledge and experiences.

The increased sharing of global best practices and technologies was to improve capabilities and knowledge within the urban energy community, as well as strengthened South-South collaboration and North-South exchange of knowledge, expertise and collaboration on energy issues for the urban poor.

Structure of the Casebook

The casebook consists of case studies submitted by authors from various disciplines organized into nine sections: Section 1 deals with biogas applications and highlights case studies from Chile, Kenya, Ghana and Uganda. Section 2 provides sustainable charcoal production. This draws two case studies from Chad and biomass charcoal briquettes training from Cameroon. Section 3 highlights sustainable water access using windpump in urban and peri-urban areas in Uasin Gishu County in Kenya. Section 4 deals with electricity access in informal settlements and draws experiences from Liberia and Kenya. Section 5 deals with solar energy which powers a library (Maarifa Centres) in Kenya. Section 6 deals with small hydro projects in Nigeria. Section 7 deals with a Climate Change Project from Cameroon. Section 8 deals with energy efficiency drawing from improved fish smoking ovens in Senegal. Finally, Section 9 deals with pro-poor urban transportation issues in India.

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Section 1: Renewable Energy: Biogas Applications

Title of case study:	Energy Supply from Biogas in a Chilean Rural Sector Dwelling
City/ Town:	Comuna de Empedrado, VII Región del Maule
Country:	Chile
Contact person's details:	José A. Guardado, Cubasolar Specialist and Rosa María Argomedo, Rural Electrification Area Manager, CNE.
Source of information:	Cubasolar , Cuba and Comisión Nacional de Energia (National Energy Commission), Chile

Background

During a working visit to Cuba in September 2007, representatives of the Comisión Nacional de Energía (National Energy Commission) de Chile (CNE), engineers Daniel Vargas, Carlos Estay, Cubasolar, and CNE expressed the need to work together and signed an MOU to collaborate.

As a result of Cubasolar's experience with renewable energy power supply in remote rural areas, a joint workshop with Cuban specialists was organized to design theoretical and practical training courses, and a demonstration project with the goal of seeking appropriate solutions to energy problems specific to Chile..

Under MOU number CHI/00/G32, a training course was organized in the *Comuna de Empedrado*, VII Maule region, Chile from 18th February to 8th March. The following representatives from CUBASOLAR were selected as trainers: Dr. José Angel Guardado Chacón, (engineer and project specialist) and José A. Flores Ruiz, building and construction technician as master mason.

The training was organized as follows:

- A one day theoretical training workshop for 20 families and officials that previously had photovoltaic systems
- A three day theoretical training workshop for participants from three families
- One day theoretical workshop for participants of the first Workshop, CNE specialists professionals from different regions of the country, officials and others interested in the technology
- And 15 day hands on step by step practical workshop from initiation to completion

Process and Innovation

A work schedule was drawn up (Table 1), including onsite adjustments to make better use of the biogas effluent as fertilizer.

Table 1: Preliminary Schedule and Main Tasks

Task Descriptions	Time
Opinion poll about biogas plant behavior and working order. User's observations and criteria.	Perm.
Physical plant survey, including user observations and criteria	Perm.
Measurement to determine real biogas generation and consumption	Perm.
Checking manometers and pressure lectures	Perm.
Determine real quantity of bio fertilizer produced	Perm.
To establish conditions to achieve efficient use and benefits of bio fertilizer	1 day
Reconstruction of compost-dryer bed to enhance bio-fertilizer storage volume during critical periods.	1 day
Cleaning and maintenance of different buildings and plant area	1 day
Drawing up of adjustments and indicators to operate the biogas plant	1 day
Results and analysis	3 days
Preparation of community workshop	2 days
Preparing the Final evaluation document	5 days

Note: Perm. – Activities whose character is permanent during the onsite course

The physical plant survey, (including observation and user criteria; actual biogas production and consumption measurement results) was resumed as follows:

Accepted user's observations and criteria, checked and/or corrected, from practical experience are:

- Useful, gas-meter or bell, volume is 0.5m^3, with a 150 kg/m^2 pressure
- Useful, gas-meter or bell, volume, allows 12 work hours of refrigeration
- Volumes of bio fertilizer in 9 months in 2008 (10th March to 10th December) resulted in 10 tons
- Refrigerator biogas consumption is 0.04 m^3/h (higher than observed in literature and reports)
- Digester feeding loads in summer, was only from horse manure, with an average of 10 hours stabling and 11.5 kg (higher than observed in literature reports)
- Winter loads are increased in 24 hours with bull's stabling. Average contribution is about 40kg.

All measurements and observations were made during complete cycles of 12 and 24 hours, which made the observations more precise.

Similarly, main activities and tasks were accomplished and executed in 7 days. As a result, the biogas system was completed with a combination of technological processes able to accomplish the complete run of the cycle, avoiding liquid effluent spills onto the environment. The following table illustrates the results of some of the measurements and observations.

Table 2: Observations and measurements by date

Determinations	Average minimum values				Average maximum values			
	8/12/08	9/12/08	10/12/2	11/12/08	8/12/08	9/12/08	10/12/2	11/12/08
gas consumption (m^3/ h)	0.0 5	0.04	0.03	0.03	0.07	0.06	0.04	0.04
gas generation (m^3/ h)	0.006	0.009	0.01	0.02	0.07	0.09	0.09	0.1
manure contribution (kg/día)					65			40
Recirculation period (h)	0.25					1.5	2.0	

Note: Re-circulations and loads were made irregularly

The data obtained, tasks and observations made lead to the following conclusion:

- Organic matter in the evaluation time is five times lower as predicted in digester design.
- Biogas consumption data was taken directly from the rigid dome digester, causing variable pressure and the need to adjust the pass valve in the refrigerator frequently. It was unpleasant and not an efficient solution.

Another aspect to consider is that lower temperature during winter causes lower biogas production. During the evaluation period, lower productions corresponded with lower temperature values, about 10^0C. This implies that the winter-accumulated loads were not totally exhausted and may affect the measurement of production during the evaluation process.

Outcome of the Project

Course objectives were satisfactorily accomplished, especially those related to the finishing stage of the biogas plant, which surpassed hydraulic and technological tests without leaks or other problems.

In the demonstrative workshop, two main problems of Campo's family were solved. There was no place to store food and no personal waste facility. The project provided them with a refrigerator which works with biogas and a toilet bowl with direct outlet to the digester.

The objectives for the community to use biogas were achieved. Until this moment, biogas was not an accepted technology because its benefits were unknown. Also, as officials of Empedrado Municipality became convinced of the advantages of biogas, they offered their support and participated in the workshop.

More than 60 people from different social strata, cultural, and literacy level were trained on biogas technology. With regard to construction and installation, five monographs were written and printed, including a user manual. All these documents are part of the CUBASOLAR bibliography funds.

Motivated by these results, a Chilean delegation from the Comuna de Empedrado Municipality and The Comisión Nacional de Energía, participated in "CUBASOLAR 2008". A workshop in progress where evaluation

involving the municipality and the community was held

Sustainability

The main impact of biogas technology use, on family and community, after nine months is:

- *Economic effects:* About 200,000 Chilean Pesos was saved every month by Campo's family from gas buying and traveling to preserve food.
- *Social impact:* The Campo families' biogas plant is the first one to be built in Comuna de Empedrado. This installation allowed the community to learn and share the benefits of biogas. More than 300 people of different social and economic conditions visited the installation in less than a year.
- *Environmental impact:* Preventing the spill of over 10 000 kg/year organic wastes into the environment. Improvement of environment, hygienic, and sanitary conditions.

Lessons Learned

1. Biogas generation from animal manure as a renewable source of energy allows the beneficial use of final products of this process (bio fertilizer, bio manure).
2. The Cuban and Chilean local case study results show that biogas technology is a good option to consider for use of renewable sources in energy supply.
3. To be sustainable, biogas technology must be adapted to the characteristics and specifics of users, taking the environment into consideration.
4. Biogas technology implementation improved the Campo family's welfare and produced a positive social and community impact on the people of Comuna de Empedrado.

Transferability

Holding the project near a border helps to reduce rural-urban migration of the people from Comuna region to other areas in search of better quality of life. It can be replicated in other regions in Latin America and the Caribbean. Some of these statements are compared in the following table:

Table 3: Impact of the Workshops

Concept	Before workshop	After workshop
Community biogas motivation.	None and high uncertainty	Local authorities and community became motivated
Handling of animal manure by families	It was commonly used as fertilizer around dwellings	Producing biogas and fertilizer. Better hygienic and sanitary conditions are observed around the dwelling
Necessity to preserve food	No refrigeration i.e. a lot of spoiled food	With the installed biogas refrigerator they can conserve food.
Budget for family support.	About 200 000 pesos/year was spent to compensate the lack of refrigeration and the necessity to buy gas.	They saved about 200 000 Chilean pesos because of food, ice and gas they need to buy for food preservation.
Family conditions	They used a latrine some 30 meters	Indoor plumbing was now possible

	away from the house.	
Other expenses and benefits for family support.	They bought chemicals and fertilizers for the potatoes harvest.	They produce organic fertilizer to substitute chemicals with no additional cost.
Community training	The benefits of biogas technology were not apparent	More than 100 people, from different social strata were trained on biogas technology; use and sustainability in Empedrado communities were created.

Title of Case Study Project:	Introducing Tubular Biogas Digesters in East Africa's Arid Lands
City/Town:	Nairobi
Country:	Kenya
Contact Person's Details:	Anthony Mugo Deputy Director ALIN P. O. Box 10098 00100 Nairobi Email: amugo@alin.net
Source(s) of information	Field Work

Background

Arid Lands Information Network (ALIN) is a Kenya-based international NGO that facilitates knowledge exchange among arid lands communities in Kenya, Uganda and Tanzania. Using a network of rural-based *Maarifa* (Knowledge) centers, ALIN has established a close connection with rural communities making the centers effective entry points for new innovations that impact positively on the livelihoods of those communities. This approach has won global accolades. In fact, ALIN was the 2012 winner of the Global Access to Learning Award given annually by the Bill & Melinda Gates Foundation and the 2012 winner of the Global UNESCO IPDC Prize for Rural Communications.

More than 80% of Kenya's rural population rely on wood, agricultural waste, charcoal and paraffin for cooking and lighting. These energy sources all have negative environmental impacts; families suffer from health problems because of indoor air pollution from smoke inhalation; wood for cooking are in short supply because of extensive deforestation and demographic pressures; and fuels like paraffin and liquefied petroleum gas (LPG) are expensive and out of reach for low income people. As a result, women and children walk long distances to search of firewood.

Deforestation has been determined as a significant contributor to climate change through the release of carbon dioxide into the atmosphere. Alternative energy options like biogas are safer, cost-effective and efficient, and climate-friendly. In order to help farmers and rural folks adapt to these inevitable climatic changes, Kenya needs to find alternative energy sources and contribute its own quota in mitigating climate change.

Plastic Tubular Digester (PTD) biogas technology uses organic waste to produce fuel for heating, cooking and lighting. The organic waste, which includes cow dung, goat and chicken droppings, is mixed with water (in a 1:3 ratio) and kept in an anaerobic environment – a large tube made of sheet plastic to ferment and produce gas that can be used for cooking.

Process and Innovation

A 2009 study by the Kenya Agricultural Research Institute (KARI) assessed the socio-economic and environmental impacts of PTD technology: They concluded that the adoption of PTD reduced household energy

and labour costs, reduces deforestation, as well as the following advantages:

- PTD increases crop productivity because the waste slurry can be used as organic fertilizer for farming.
- Majority (80%) of respondents in the study said it improved the cooking environment in the kitchen as it is smoke-free.
- PTD is affordable for small-scale farmers than other types of biogas systems. Installation costs vary, but a 'two cow' unit costs around KShs 6,500 (US$ 65) – about 10% of a conventional floating or fixed-dome biogas units.

Working with communities living in proximity to two of its Maarifa centres namely: Isinya (Urban and rural) and Nguruman (semi-urban/rural) in March 2011, ALIN trained 10 community members on how to install plastic tubular biogas digesters. 10 households installed the digesters and used them in place of the traditional three-stone hearth.

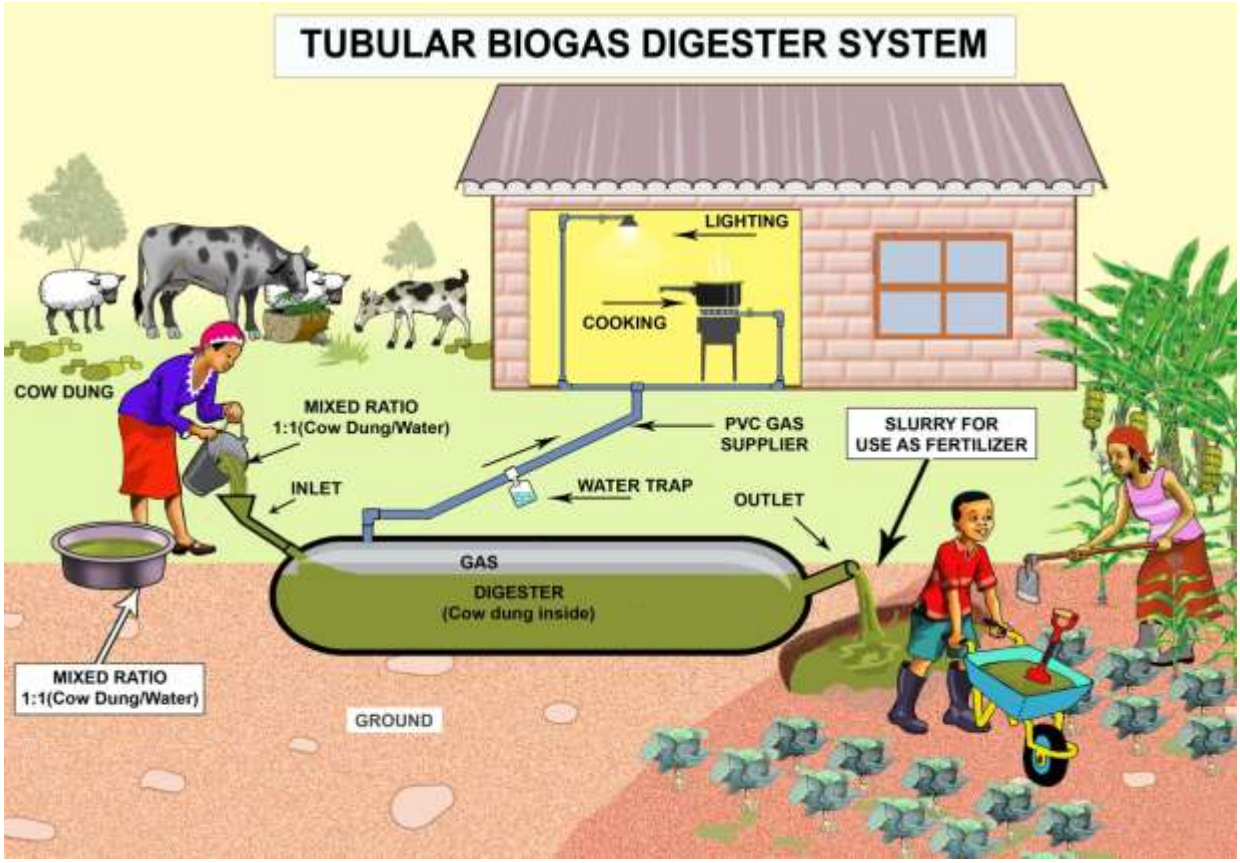
After three months, the community members who had installed the digesters were visited and interviewed. All of them reported the following direct benefits from using the PTD biogas system:

- Improved cooking environment that is smoke free
- Ability to cook meals faster
- Cheaper cost of cooking in terms of time and money
- Saving of time spent gathering and transporting firewood
- Reduced need to cut down trees

Organic waste such as cow dung, goat or chicken dropping is mixed with water and poured into an airtight space provided such as the plastic sheeting tubes, which is often used in making silage. The mixture is allowed to sit for 1 to 7 days depending on the ambient air temperature, during which the process of anaerobic respiration sets in. A highly inflammable gas – methane is produced during this process. This gas can be used to cook and even run electric generators.

Requirements of a PTD

1. 5 cubic meters of thick plastic tubing
2. PVC pipes
3. Valve and tap
4. Equal parts water and organic waste



The set-up of a tubular biogas digester system

Methodology

The digester requires a trough-shaped trench with a top width of 65 cm, a bottom width of 50 cm, a depth of 65 cm and variable length, depending on the number of animals. For a 2-cow or 8-pig unit, 8-10m is adequate. The trench should have a flat floor, firm sides and a gentle slope (about 5%) to ensure overflow of exhausted slurry.

One of the 2 polythene tubes is inserted into the other to create a double layer for added strength. Each of the 2 openings of the plastic tube is folded around the one-meter, 10-15-cm diameter PVC pipe and an airtight joint is formed using tire-tube straps to ensure air-tightness. One end becomes the inlet while the other becomes the outlet. A small hole (about one centimeter in diameter) is punctured through the 2 walls about 1 meter from the inlet end. A piece of 1.2cm diameter, 30cm long PVC pipe is then inserted into the dome and an airtight joint made. The gas pipe is fitted to the external end of this pipe. The gas pipe passes through the 1.2cm diameter PVC "T" whose stem is a 30cm PVC pipe.

The 3 - 4m polythene tube is sealed on one end by folding and tying it into an airtight joint while the other end is folded and connected to the stem of the PVC "T", thus completing the gas storage structure. The gas tube then passes on to yet another PVC "T" whose stem dips into a container of water to allow bubbling of gas in excess of the gas storage capacity. The gas tube is finally connected to a 1.2cm diameter piece of pipe which is equipped with a gas control valve and connected to the gas burner or stove.

To set the system in motion, the digester is laid horizontally in the trough-like tunnel with the inlet, outlet and gas tube facing upwards. Animal waste/water mixture in the ration of 3:1 is fed into the digester until it is about 75% full. The system is then given about 1 week to activate, after which the gas can be used. To keep the system active, it should be fed with a thoroughly stirred mixture of 1 20-litre bucket of animal waste and 3 similar buckets of water as often as necessary, but most often daily.

Outcome of Project

The benefits of the project are well captured in the testimony below by one of the beneficiaries: Mrs. Lucy Ndung'u, a business lady who runs a mini-hotel in Nguruman, Kajiado Districts in Kenya said:

> *"Since ALIN brought us this technology through Nguruman Maarifa Centre in March 2011, my family activities have changed. I have reduced firewood consumption and the money (USD 40 monthly) I used for buying firewood; I am saving for family projects. I am also able to serve my customers with clean food cooked from a smoke free environment. Before I started using biogas, I was having recurring chest congestion but this problem has ceased and I can attribute this to using biogas since it doesn't smoke. I have always been worried when I see changing rain patterns. I now feel good to be a key player in mitigating climate change".*

Sustainability

The approach adopted by ALIN ensured that the trainees understood that they were being equipped with a skill that can earn them money. They were encouraged to charge a modest fee for their services and to market themselves widely to the community. As a result, they have been called to install PTD systems in several homes, thus earning residual income in the process while passing the benefits of adopting the biogas technology to more and more community members.

Combining the use of PTD with entrepreneurial skills training has helped to make the adoption of biogas use in the two communities sustainable. Because the trainees earn an income for their work, they are highly motivated to encourage households to adopt the technology. Also, the availability of abundant cow dung, goat and chicken droppings in the area has facilitated the adoption of the technology in the two communities that have embraced the system.

Lessons Learned

- It is easier to get communities to adopt a good practice if it is introduced to them by their peers. In this case, ALIN worked with a community member from a Maarifa center based at Laikipia County to train community members in Kajiado County. The trainer and the trainees lead a similar kind of lifestyle and this enhanced trust in the information provided.
- Community members need to invest or contribute towards acquiring a new practice or technology. For households that installed biogas digesters in both Isinya and Nguruman, they had to buy the materials used. This ensured that they valued and took care of the system.
- It is easier for a household to adopt a technology when the potential saving in time and energy is significant as compared to their total household income. In this case, follow up after six months showed

that four households had abandoned the project. Further inquiry as to reasons for that revealed that those households were relatively well to do and could afford to buy LPG gas for cooking.

- Ensuring that the introduction of a new technology into a community provides direct benefits to the beneficiaries guarantees its sustainability.

Transferability

Transferability for the biogas digesters is high. This project was essentially based on the transfer of the technology from Laikipia County to Kajiado. The use of locally trained installers enhances transferability. Since ALIN organizes occasional exchange visits between communities, the introduction of tubular biogas technology in Kajiado was partially the result of demand by community members who had witnessed the use of the technology during an exchange visit.

Title of Case Study Project:	Central University College Biogas Plant
City/Town:	Miotso, Greater Accra Region
Country:	Ghana
Contact Person's Details:	Dr John Afari Idan Biogas Technologies Africa Limited Tel: +233 21 810487 Mobile: +233 244 461959 E-mail: info@biogasonline.com / info@btwal.com Website: www.biogasonline.com
Source(s) of information	Biogas Technology Africa Limited

Background

Central University College (CUC) is a non-profit making educational initiative of the International Central Gospel Church (ICGC) in Ghana. It has its origins in a short-term pastoral training institute, which was started in 1988 by ICGC. It was later incorporated in June 1991 under the name Central Bible College. The name was later changed to Central Christian College in 1993. The College later upgraded its programmes to the baccalaureate level. In line with the national aspirations, the College expanded its programme to include an integrated and practice-oriented business. To reflect its new status as a liberal arts university, the name was changed to Central University College in 1997.

CUC is currently the biggest private university in the country with a population of 7,650. It is located in Miotso which lies within the Greater Accra Region. The biogas project was spearheaded by Biogas Technologies Africa Limited in collaboration with Central University College. The project aimed at treating human waste into soil additive and production of biogas for cooking and facilitating laboratory operations. The university had a central sewerage treatment plant that frequently required an exhauster (cesspool tracks) services.

Process and Innovation

This project aimed at substituting central sewage treatment plant with waste to energy plant. Central University College has a student population of 7,650 (excluding staff) which was enough to provide adequate feedstock to sustain the project.

This project was implemented by Biogas Technologies Africa Limited (BTAL) who have vast experience on biogas having implemented biogas projects across the continent. BTAL did the design and construction of the biogas plants. Biogas plants with a capacity of 450m^3 were constructed next to the ablution blocks. BTAL provided the technical skills required for this kind of project while CUC provided the funding. The local community provided skills such as masonry and other non-skilled manpower.

Three digesters built at the Central University College

Outcome of the Project

The biogas generated from the project is used in cooking at the university cafeteria. The university laboratories also use the biogas to conduct their experiments. The slurry from the digester is used as fertilizer on the tree farm at the university. Use of biogas has significantly reduced consumption of liquefied petroleum gas (LPG). Social barriers such as handling of human waste especially as feedstock for the biogas production was overcame. As a result of the project, consumption of LPG was significantly reduced.

Biogas collection and storage balloon at the CUC. The gas is used in cooking and heating purposes in the laboratories

Sustainability

- The project made use of human waste whose supply is free and readily available. This makes the project very profitable and sustainable.
- There was reduced consumption of LPG as a result of the alternative provided by the project. Social barriers regarding use of human waste as feedstock for biogas generation were overcome.
- Experiences gained by BTAL across the continent guaranteed quality of the implemented project.

Lessons Learned

- BTAL specialization in installing biogas plants has proven to be instrumental to the success of projects across the continent.
- BTAL acted like a local champion – the existence of a committed champion (within or outside government) is crucial for success. The local champions should not only demonstrate longer-term commitment but should have significant control over the design and implementation of the project.

Transferability

This project can be replicated to any other institution such as prison, secondary school, etc. Biogas technology knowledge is easily transferable through localized trainings. BTAL has implemented similar projects in Mozambique, Ethiopia and Kenya.

Title of Case Study Project:	Biogas Application at Accra Psychiatric Hospital
City/Town:	Accra
Country:	Ghana
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Source(s) of information	Biogas Technologies West Africa Limited

Background

Accra Psychiatric Hospital was commissioned in 1906. The hospital has the capacity to accommodate 600 patients at any given time. However, this has not been the case as the hospital continues to be over crowded with an increasing population and therefore a growing demand on the limited facilities.

The hospital had previously installed an aerobic sewerage treatment plant that occupied a lot of space. It also included an open top sewerage storage system which emitted foul smell. In addition to this, raw sewerage was allowed to enter the main sewerage storage system. With all these intrusions, it eventually broke down beyond repair.

Exhausters were used to handle wastes from the ablution block at an extra cost to the hospital

Process and Innovation

The biogas digester is designed to treat the effluent fecal matter on site. The fecal waste will not be transported

to a distant treatment pond, which requires the use of vehicles like cesspool emptiers. Land wastage associated with the traditional shifting-construction techniques and methods such as pit-latrine is being overtaken by time. The life span of a bio-latrine can be greatly enhanced with proper care of the facility. A perfectly built Bio-Latrine is robust and the digester has a life span of at least 50 years.

Digesters under construction

Outcome of Project

The nuisance of bad-odor associated with, pit-latrine, bucket or pan-latrine and flush toilet connected to the septic tanks in the hospital was eliminated.

The effluent from digested biomass of a biogas digester is odorless and contains no or very minimal pathogens. Moreover, it is nutrient rich and thus can be used as green fertilizer. The effluent is also flies expellant, and does not harbor flies, other infestations and pathogens.

Biogas plant at the Accra Psychiatric Hospital

Sustainability

- The project made use of human waste whose supply is free and readily available. This makes the project sustainable.
- There was reduced consumption of LPG as a result of the alternative provided by the project. Social barriers regarding use of human waste as feedstock for biogas generation were overcome.
- Experiences gained by BTAL across the continent guaranteed quality of the implemented project.

Lessons Learned

- BTAL specialization in installing biogas plants has proven to be instrumental to the success of projects across the continent.
- BTAL acted like a local champion – the existence of a committed champion (within or outside government) is crucial for success. The local champions should not only demonstrate longer-term commitment but should have significant control over the design and implementation of the project.

Transferability

This project can be replicated to any other institution such as prison, secondary school, etc. Biogas technology knowledge is easily transferable through localized trainings. BTAL has implemented similar projects in Mozambique, Ethiopia and Kenya.

Title of Case Study Project:	A sustainable Waste Management Solution in Uganda
City/Town:	Kampala
Country:	Uganda
Contact Person's Details:	Vianney Tumwesige P.O. Box 10235 Kampala-Uganda info@greenheatinternational.com
Source(s) of information	www.greenheatinternational.com http://greenheatug.wordpress.com/

Background

Green Heat (U) Limited develops medium-scale commercial biogas systems from organic waste for household and institutional use. Biogas is produced when microorganisms break down organic wastes in the absence of oxygen, creating a complex mixture of gases such as methane that is used for cooking. It offers an innovative, cost-effective one stop waste management solution, based on a simple and affordable technology used to generate biogas.

Currently, schools, hospitals, prisons, businesses in slums and some tourist lodges depend on firewood, charcoal and LPG for cooking. Increasing costs of these fuels are major issues that institutions would like to do away with. The decision to obtain a biogas digester is arrived at after a study of the energy demand, available organic waste, fuel cost and manageability.

Green Heat helps meet an existing market demand for an affordable alternative to charcoal, firewood and LPG, that is in short supply, and some customers are forced to wait for up to one month to refill their empty gas canisters. Biogas is a viable product that helps meet the energy needs of Ugandans while delivering essential social and environmental benefits associated with waste management. In areas where there is a problem of of collecting and disposing of household waste, using this waste to generate biogas becomes a sensible solution to the problem of waste management. Uncollected waste usually blocks sewaged systems and lead to floods that threaten the ecological integrity of the Lake Victoria watershed, destroy property, spread waterborne illness, and cause loss of life in some of the poorest and most vulnerable areas in the region.

Nsambya Children's Home, a charitable, non-governmental organization runs a Child Welfare and Adoption Agency. Nsambya Children's Home cares for babies who have been neglected, abandoned and orphaned by family members, civil war, diseases and natural disasters. The Home (and many other institutions and households in Uganda) uses firewood and gas to cook for staff and the children. Every year, Nsambya Children's Home consumed 40 tons of firewood and 20 cylinders[1] for cooking, costing US$ 1800 and 550 respectively, which constituted a substantial portion of its annual budget. Another issue faced by the Home was that during the rainy season when firewood was not dry, to further inefficiencies in cooking and the children got their meals late. The management of the home was also concerned about the rapid rate of deforestation and the

[1] 12.5 kg of Liquefied Petroleum Gas

effects this is having on water supply and soil erosion in the country.


A smoky kitchen brought about by use of improperly processed firewood and a heap of animal waste

Process and Innovation

Green Heat Uganda carried out a study on the potential of biogas at Nsambya Children's Home. We looked at factors to determine the optimum installation; the amount and nature of organic waste, the energy demand, the cost of the system, space installation and the human factor.

A $12m^3$ biogas digester was proposed to generate gas for at least 55% of the Home's cooking needs. The digester is fed with cow manure, food leftovers and cow urine. Biogas technology is an integrated waste management system that is a clean, renewable, naturally produced and an under-utilized source of energy. The gas produced is composed of 50-70% flammable methane, thus providing on-site energy production, storage and access.

The decision taken by Nsambya Children's Home to install a biogas unit was for both economic and long-term environmental reasons. The initial investment of US$ 2,089 for the biogas installation was high for a local NGO; however, the Home is able to save approximately US$ 870 every year by using biogas for cooking. The money saved goes directly towards improving services, accommodation and to support more orphans.
The environmental benefits of a biogas digester to Nsambya Children's Home are in the provision of energy, the disposal of organic wastes, the improvement of air quality through reduced concentrations of indoor air pollutants and the provision of a valuable organic fertilizer. The fertilizer is applied to crops fields (at the Home) thus providing an additional source of income.

Green Heat has conducted biogas site assessments at over 150 institutions and private entities. Green Heat, Ltd has a portfolio of 26 operational biogas digesters that continue to meet the energy needs of various schools and households in Uganda. Some of the biogas systems installed by Green Heat include:

1. Nsambya Children's Home (orphanage),
2. Mbarara (FREVASEMA processing factory)
3. Bwindi (Buhoma Community Rest Camp)
4. Soft Power Education Centre (school/health center)

5. Wakiso Children's School of Hope (Wakiso)
6. Arlington Academy of Hope (Bududa)
7. Kagando Hospital (Kasese)
8. Busoga High School (Kamuli)
9. Monastery Sisters in Butende, Sisters of little Francis and Four grail homes (Catholic convent)
10. Kasiisi Primary School (Fort Portal)
11. Five digesters are under construction in, Karambi Secondary School, Butiru Christian School, Christ School Bundibugyo, Kiwooko hospital, and Nkuumba Secondary School.

Completed institutional latrines which are connected to a biogas digester

An inlet into a biogas digester

Green Heat has found that systems are often more appropriate for small or medium-sized institutions (100-1500 people). Schools, orphanages, hospitals, tourist lodges, and religious communities make ideal customers. Farming cooperatives and medium-sized farms can also benefit from our larger systems. Our

company has been working to make affordable household-level system design that generates cooking fuel for smaller families and farms. We are working to install about seven of these systems right now. Institutions and individuals in urban and rural settings can benefit from waste management, clean-burning cooking fuel, and high-quality fertilizer at an affordable price.

Advantages of Biogas

Improved indoor air quality: Biogas is a clean-burning cooking fuel that reduces the risk of indoor air pollution and associated lung diseases when compared to firewood and charcoal.

Forest conservation: Biogas reduces dependency on limited fuelwood and charcoal resources. Firewood collection and charcoal production are the second leading cause of deforestation in Uganda, which is home to some of the last remaining wild great apes on the planet.

Food security: Biogas systems produce high-quality slurry that is used as fertilizer and can increase agricultural yields. As a result of low agricultural output due to infertile soils, Ugandan farmers are forced to expand agricultural production into critical forest habitats. Biogas reduces this problem.

Waste management & improved public hygiene: Biogas systems offer a safe and affordable solution for waste management, helping schools and communities manage human and animal waste safely. Public spaces—including water resources—stay clean and safe.

Energy security: Biogas systems empower communities to be self-sufficient with a sustainable cooking fuel. As long as people produce waste, Green Heat can produce energy.

Sustainability

Attacking the root causes of deforestation: Forests in Uganda provide critical habitat for a range of threatened and endangered species, including some of the last wild populations of chimpanzees and gorillas. In addition to the intrinsic value of ecological beauty that biodiversity confers on a landscape, biodiversity also helps maintain an ecosystem's goods and services such as regulating local hydrology, filtering local air and water supplies, and mitigating erosion.

Climate change adaptation and mitigation: Biogas supports climate change mitigation in Uganda by reducing green house gas emissions through:

1. Capturing methane emissions from decomposing wastes
2. Offsetting CO_2 emissions from carbon-intensive fuels such as wood and charcoal, and
3. Reducing emissions from deforestation and forest degradation. Deforestation is one of the world's most significant contributors to climate change, accounting for 17% of global greenhouse gas emissions. Reducing deforestation in tropical countries like Uganda has the potential to mitigate 30 percent of global carbon emissions.

As a sustainable energy source, biogas supports climate adaptation by offering an alternative source of energy to a fast-growing, forest-dependent communities threatened by diminishing fuelwood resources.

Watershed and wetland management: Poor waste management in urban centers leads to pollution of the sensitive environmental areas within the Lake Victoria watershed. This region and its associated wetlands are home to a variety of threatened and endemic species. Water degradation has contributed to losses in fishing revenue and concerns about water quality and safety. By providing an effective waste management strategy, it protects the important Lake Victoria ecological area.

Tourism is a significant sector in Uganda, contributing 8% of the country's Gross Domestic Product (GDP) and generating US$ 600 million in revenue in 2008. The majority of tourists are interested in seeing mega fauna like chimpanzees, monkeys, and mountain gorillas – Uganda's most popular attraction. Deforestation threatens critical habitat, and, by proxy, the livelihoods of thousands of Ugandans engaged in the tourism industry.

Waste management: There are several waste streams associated with anaerobic digestion – in particular the solids associated with digestion and the wastewater from the scrubber. The focus of treating both effluent streams is to prevent deleterious impacts to public health and the environment. The solids from the digestion process will have undergone an initial treatment that reduces much of the pathogens that were contained in the original waste stream. However, care will be taken to ensure that these are used beneficially as a fertilizer while ensuring no contamination to such applications as food crops. The wastewater can be treated by a variety of techniques to include chlorination, aeration, and filtration (carbon filters). A more detailed assessment to characterize the waste stream and choose an appropriate technology will be conducted.

Cost savings: Biogas systems last for 30 years or more, eliminating the need to construct new pit latrines every three years, a huge expense and public safety issue for many institutions. Fuelwood and charcoal prices continue to increase, making biogas an affordable alternative. We have not extended any credit facilities to our clients; however, we are soliciting for a revolving fund that will be extended to households.

Lessons Learned

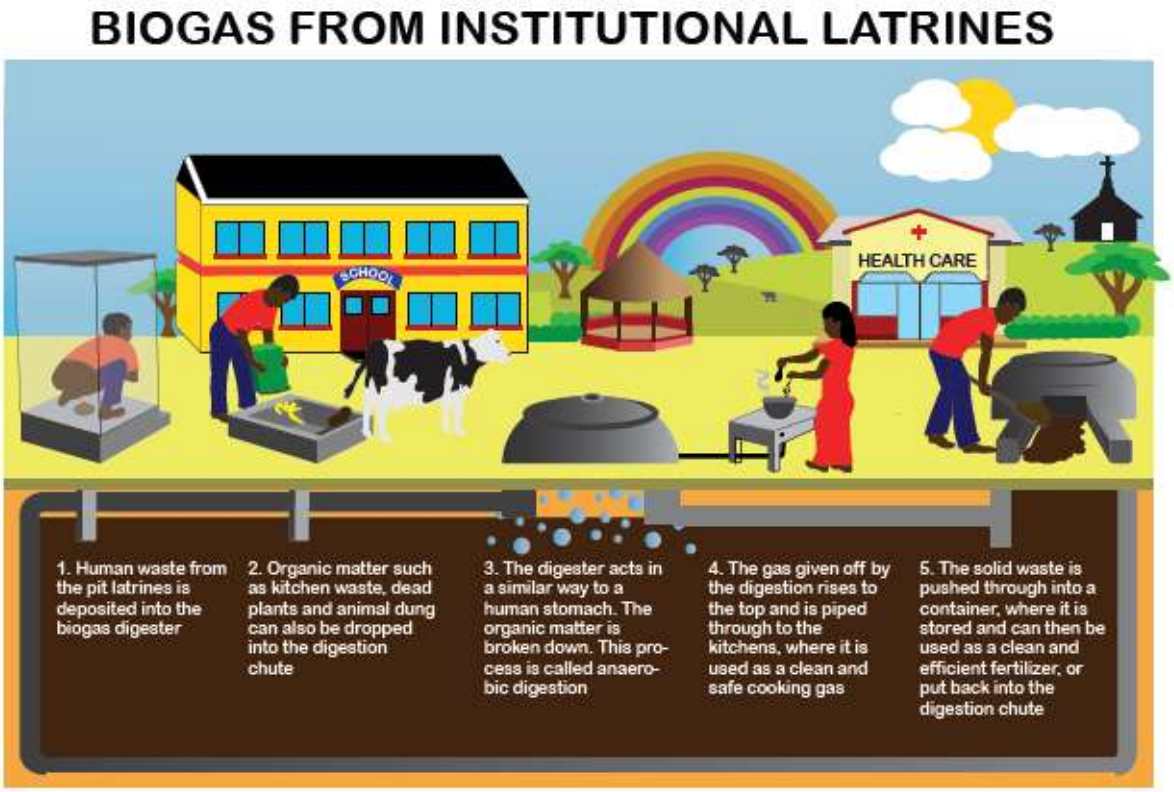
Foreign donors supported the construction of a biogas system at a school where the leaders were not supportive, and so the system failed.

- Installations require relatively high upfront costs that are compensated through fuel savings within 2-3 years. The initial investment may deter many potential users. Co-financing by financial institutions or donors can support further implementation of the technology.
- Even though the principle is simple and low-tech, the construction of biogas systems requires skilled masons.
- The well-being of the biogas-producing bacteria is critical for the proper functioning of the systems. A regular and consistant supply of appropriate feedstock is therefore necessary.
- Maintainance: Inlet pipes need to be kept clear and water (condensation) should be regularly removed from the gas pipes.
- The switch from firewood and charcoal to biogas requires a considerable behavioral change. To make this transition easier, Green Heat offers training and after sales services to all clients. After every installation, a graphics with information about biogas and how it works will be painted on the backwall of the latrine. The information is availed in both english and the local language

Transferability

At Green Heat, we strongly believe in knowledge transfer. We have worked over the course of time to train a skilled team of three senior masons and six junior masons in e biogas construction and training. This team has the capacity to build and maintain biogas digesters.

We have also developed an education tool, which has provided a basis of our knowledge transfer material to a wider community. We have translated the text into 4 local languages.



Section 2: Sustainable Charcoal Production	
Title of Case Study Project:	Belaba Rice-Straw-Based Eco-Charcoal Project
City/Town:	Belaba
Country:	Chad
Contact Person's Details:	David De Armey ENVODEV International Director France : +33 6 95 48 12 79 OR + 33 7 70 94 63 62 Chad: +235 63 92 76 16 Email: david.dearmey@envodev.org
Source(s) of information	MIT D-Lab, Rainforests Mongabay

Background

From 1990 to 2010, the total forest cover of Chad dropped 12%, and the current total land cover stands at 9%; this means that in 20 years Chad lost 1.6 million hectares of forest cover. For this reason, in December 2008, the Chadian government banned the production, transportation, distribution, and utilization of wood-charcoal in its entire territory to mitigate deforestation, the leading cause of the country's desertification. Deforestation is mainly due to the fact that 99% of the Chadian population uses wood-charcoal as the primary source of energy for cooking. The only proposed alternative source of energy has been LPG, which is scarcely available to or affordable for the vast majority of the population. Moreover, the ban on charcoal has prompted economic tension. The price for charcoal, now sold on the black market, has increased virtually by 500%, encouraging the population to turn to raw wood as a source of fuel. Raw wood burns less efficiently, requiring more wood to meet household needs, hence exacerbating the problem of deforestation. The immediacy of energy needs for cooking has driven ENVODEV to pursue vocational opportunities in response to the energy crisis.

In 2008, ENVODEV began studying solutions and carrying out experiments in southern Chad, where different types of biomass are extensively available. ENVODEV created a production method derived from a process developed by Amy Smith, founder of the innovative D-Lab at MIT. Significant progress was made when the pyrolysis of rice-straw yielded positive results, and the creation of rice-straw-based charcoal, or Eco-charcoal, saw the light.

ENVODEV's objectives are to utilize rice-straw as an alternative biomass for charcoal production in an effort to fulfill current cooking needs, bring an immediate solution to the environmental crisis, and create a legal and self-sustainable form of economic activity.

ENVODEV has partnered with a co-operative comprised of women and farmers around Moundou. The co-operative, *Association Pour la Protection de l'Eco-système* (APRO-ECO), was created in October 2011, and is led by a committee of seven women who oversee the production and sale of Eco-charcoal. ENVODEV led the members of APRO-ECO in a weeklong training session.

All startup costs, including local fabrication of tools and training, were covered by ENVODEV´s project funds

raised through its private donor base that exists both in France and the United States of America.

The families of the members of APRO-ECO, who depend on revenue generated by the women, benefit economically from this project. The Eco-charcoal also benefits a broader range of people as it is sold on the local public market.

Deforestation in southern Chad for charcoal production

Process and Innovation

ENVODEV began the process by hiring a local welding shop to build simple and affordable tools, modeled after MIT's steel kiln and manual presses, necessary for the carbonization process. Then APRO-ECO received training in the pyrolysis method (the mixing of carbonized rice-straw with manioc paste) and the production of charcoal briquettes.

One challenge encountered was the gathering of the rice-straw from the many small fields to centralize the pyrolysis process in Belaba. Because rice-straw is voluminous, ENVODEV decided to create mobile pyrolysis teams and transport the charred rice-straw back to a centralized station for the mixing and pressing process. Another challenge was that, initially eco-charcoal was not fully accepted; unlike wood-charcoal, an Eco-charcoal briquette cannot be partially consumed and then extinguished with water for later usage. However, that issue was quickly resolved by communicating to potential buyers that briquettes could be broken into quarter pieces in order to prevent waste.

APRO-ECO's production station is located on the co-operative manager's property. The manager is a recently-widowed woman who, given the energy crisis, quickly understood the potential of Eco-charcoal.

Local government officials, including the mayor of Moundou, came to celebrate the official inauguration of APRO-ECO. City authorities, along with the Prefect, are encouraging both ENVODEV and APRO-ECO to persevere and find ways to expand the project. The Head of State has made the energy crisis a top priority across the country, and any other solutions are encouraged and welcomed.

(From top left to bottom right) 1. Pyrolysis training; 2. Carbonized rice-straw; 3. Briquette pressing; 4. Briquette drying

Outcomes of the Project

- Rice is cultivated across the entire southern region of Chad, and the rice-straw is virtually unused. The project has fulfilled the primary objective of making rice-straw a usable resource that has yet to be more widely utilized in Chad. Many households in Belaba, Moundou, and N'Djamena have extensively tested the Eco-charcoal.

- While respecting traditional cooking methods, Eco-charcoal has also proven to reduce cooking time by 60%: what usually takes two hours to cook with wood charcoal now takes approximately 50 minutes with Eco-charcoal, thus improving the working conditions for women who spend long hours preparing food every day.

- The product remains affordable, and those involved in the production have benefited from the economic activity. Furthermore, because Eco-charcoal has become a solution to the energy crisis, many people who have been exposed to it are now accepting and understanding the broader reasons that lie behind the wood-charcoal ban.

- The requirement for manioc flour as the binding agent in the production of Eco-charcoal is a benefit for manioc cultivators. Making Eco-charcoal does not put a strain on manioc availability. In fact, the opposite is true; cultivators, who produce according to market demand and have only partially-exploited lands, are able and willing to increase their manioc yields.

- Local authorities hope to see the production of Eco-charcoal as a way to alleviate the increasing hostility between the population and law-enforcement agents who are mandated to enforce regulations on the wood charcoal ban.

Note the subtle differences between both sides: Side 1 is using regular wood charcoal which burns less efficiently, generates toxic fumes, and is the underlying cause of deforestation problems; Side 2 is smokeless, efficient, and still corresponds to current cooking methods

Sustainability

- The project has resulted in the reduction of raw wood or wood-charcoal use. This reduction has been relatively limited since the quantity of Eco-charcoal produced has not yet been significant enough to reduce the consumption of non-renewable energy sources. On the other hand, the production of Eco-charcoal has decreased Co2 emissions: rice-straw was typically burned as waste, thus burning and destroying useful microbes in the soil instead of helping replenish it. Furthermore, the usage of Eco-charcoal has provided an opportunity to raise awareness about the necessity of using better cooking-stoves. The introduction of a new form of charcoal has encouraged broader awareness about deforestation and dialogue since most people who typically use either wood-charcoal or raw wood are not engaged in the environmental or energy-efficiency conversation.
- ENVODEV provided the necessary tools and training free of cost, while the co-operative agreed to finance its own start-up costs (e.g., buying the initial amount of manioc flour) and the eventual purchase of new kilns or manual presses, which are to be built by welders ENVODEV has partnered with. Reimbursement is therefore not a requirement.

- Dependency on imported goods and products causes massive cash outflow. Imported gas, the only alternative fuel for cooking to date, maintains that status quo, while local Eco-charcoal production keeps Chad's cash flow within its borders.
- Many people around the Moundou area are no longer burning the rice-straw in their fields, greatly reducing field smoke and air pollution and its side effects.
- For the past year, the local government has been following our project. The government, recognizing that Eco-charcoal responds adequately to the charcoal ban and enables families to carry on with local cooking practices without added financial strain, has been less hesitant in enforcing the wood-charcoal ban, thus forcing citizens to look for alternative fuels.

Lessons Learned

- Communicating the project's positive impact on the environment before training. The majority of people involved, though severely affected by the current charcoal ban, have not been motivated to seek or use alternative fuels due to the fact that various governmental and non-governmental initiatives have either been poorly implemented or proved unsustainable.
- Refining the eco-charcoal based on consumer critiques and observations. This has led, for example, to systematically explaining the importance of breaking down the charcoal briquette into pieces before consumption—a measure that greatly reduces fuel waste.
- Centralizing the mixing and pressing process while de-centralizing the carbonization process, consequently augmenting sustainability by reducing rice-straw bulk-transportation costs.

Transferability

The project was implemented near Chad's second-largest city of Moundou, where rice-straw availability depends on small rice fields in urban and rural areas. The technique is simple enough to be replicated in other biomass-abundant areas of Chad and other countries. Wherever there is unused biomass in the form of straw (e.g., corn stocks, rice-straw, guinea corn stocks, and so on) and manioc, if it is not a primary source of nutrition for local populations, transferability of the project is possible.

Title of Case Study Project:	Charcoal Briquettes Training from Biomass
City/Town:	Batouri-East-Cameroon
Country:	Cameroon
Contact Person's Details:	Common Initiative Group for the Promotion of Sustainable Development Zakari Njoya, World Food Program, Batouri; Email: zak.njoya@gmail.com Michael Burbidge Agroforestry Extension Agent Peace Corps Cameroon Email: mburbidgepccam@gmail.com OR gicclairnet@yahoo.fr Tel : (+237) 79 23 32 38 / 99 01 36 30 / 75 88 31 25
Source(s) of information	Fieldwork & Training

Background

More than 2 billion people use wood, charcoal, dung or agricultural residues as the primary fuel for their cooking and heating needs, leading to significant health, economic and environmental consequences. More than 1.5 million deaths a year are caused by acute respiratory infections from breathing smoke from indoor cooking fires. Women and children are generally exposed to greater levels of pollution and it is children who suffer the greatest health risk. In the year 2000, indoor air pollution from solid fuel use was responsible for more than 1.6 million annual deaths and 2.7% of the global burden of disease.

Families can spend over 25% of their income on fuel, leaving them with less income to cover other basic needs such as medicine, food and clean water. As a comparison, even the poorest 20% of the U.S. population spends only 1% of their income on energy for their household. Several attempts have been made to introduce environmentally friendly, cleaner cooking alternatives such as solar cookers, fuel-efficient stoves and charcoal briquettes made from paper. Solar cookers can be slower than traditional stoves, may work only during limited hours on sunny days, and are often unable to fry foods, which preclude them from being used to cook many traditional dishes. For alternatives to traditional cooking to be met with better success, they must prove to be affordable, effective and culturally acceptable.

In the case of Cameroon, especially in the East, 80% of the population use firewood and charcoal for their cooking. The source of this energy is deforestation for those who are far from the logging companies and the production of charcoal for those who are close to forest companies. Very few people living in this region use agricultural residues as fuel. This practice destroys agricultural residues that could be composted or used for making charcoal briquettes from biomass. The situation is the same for sawdust, which is burned by the logging companies if it is not utilized.

The production of briquettes from sawdust, crushed wood charcoal or carbonized agricultural refuse seems to be a plausible solution to with the energy crisis in Africa. Making these briquettes at the local level has been successful with the methodology of MIT D-Labs "Fuel from the Fields". Unfortunately, experience has shown so far that, although it is possible to fabricate briquettes in this fashion at the local scale the economy of

operation for exporting is not yet practical. We are working to change this by creating a cooperative between GICs in the East to unify our resources.

Photo 1 and 2 - Trash thrown along road that can be turned into briquettes; photo 3 – burning of sawdust; photo 4 - charcoal waste that eventually get thrown away.

Charcoal dealers and sellers have some form of loss that may be recovered in form of charcoal dust. Transportation and handling of charcoal to market produce the charcoal bits and dust, which at best can represent 10% by weight and 20% in the worst case. These discarded portions of wood charcoal contain more than 50% of coal, depending on the degree of impurity, but it is still difficult to find uses. The bits and dust of charcoal cannot be burned by the usual simple methods used for charcoal, and is therefore unsalable. If we could use it entirely, this would mean an increase in the production of charcoal from 10 to 20%.

Process and Innovation

Members of GIC CLAIRNET developed this new technique of making briquettes from sawdust and powdered wood charcoal after having success with the “Fuel from the Fields” process. GIC CLAIRNET has been working to organize and develop a cooperative between non-timber forest product GICs to export ecological coal from the East throughout the grand North regions of Cameroon. We started our journey by inviting an official from each organization to attend a training of trainers on MIT D-Labs “Fuel from the Fields” methodology. These leaders will in turn share the process within their GICs and eventually community. We believe our goal can be achieved with the sensitization of this new methodology and collaboration of GICs in the East region.

Our goal is twofold: At the local level, train Cameroonians on making charcoal briquettes from carbonized agricultural refuse and sawdust. At the regional level, unite GICs into a cooperative to export ecological coal from the East throughout the Grand North. With these goals we hope to alleviate the health, environmental, and economical issues of fuel collection and use in Cameroon. The following pages are a report on the "Fuel from the Fields" training held in Batouri, Cameroon. The training was funded by German International Cooperation (GIZ) and taught by representatives of GIC CLAIRNET and the Peace Corps agroforestry volunteer of Batouri.

Training

The training was conducted in three (3) days. Day one dealt with theory and day two and three with application and practice. The project was organized and executed by GIC CLAIRNET and PCV Michael Burbidge. GIZ evaluated and determined the final budget.

There were not many challenges during the training with the exception of transferring the concept of creating a "new" kind of coal in the region with the most wood resources of Cameroon. Although there are environmental, health, and economic benefits to this new idea, initially it did not outweigh the precedent of what Cameroonians are habituated with. This was an issue during the first day, but by the end of the training the leaders of these GICs opened their minds to the new idea to better the lives of Cameroonians countrywide.

We held the application portion of the training at the scrap wood lot of Batouri where wood charcoal is made. This allowed the citizens of Batouri to witness this new concept even though they were could not participate. This was advantageous for the sensitization of the methodology. Participants were also given titles and jobs for the training to unite them into a team.

The following topics were explained during the theoretical phase (day 1):

- The acquisition and production equipment
- The provision of equipment
- The preparation of carbonization and carbonization of biomass
- The grinding of coal and biomass binder preparation
- The mixture
- The process releases the mixture using a mold
- Obtaining briquettes and drying

Photo 1: Theoretical training Day 1; Photo 2: Application phase (day 2 and 3) Crushing wood charcoal bits and carbonized agriculture refuse; Photo 3: Mixing sawdust and charcoal powder with binder before pressing into briquettes; Photo 4: Using molds to press mixture into briquettes

Outcomes of the Project

- The heads of the associations are trained and capable of relaying technique
- The existence of coal briquetting of biomass in the East region
- The effective use of agricultural residues and sawdust available in wood processing companies
- Establish an effective way to deliver coal briquettes in large northern Cameroon to help the fight against deforestation

With the exception of the representatives from Bertoua, all participants are from a small town or village setting where this process is most beneficial and applicable. Most residents of the East, outside of the regional capital Bertoua, live minimally and have limited work opportunities. Water and electricity are not constant or non-existent in these communities. Most individuals are uneducated lacking the skills to read or write proficiently in French or English.

It is too early to say there has been a change in attitude or behavior as a result of bringing this methodology to the East, but the process has been replicated by Cameroonians outside of the training. The training of trainers

was the most recent formation on “Fuel from the Fields” in Batouri. Previous to this we have shared the process with a handicap youth group, their parents, and members from the neighborhood of PCV Michael. The members of that neighborhood are predominately farmers.

Briquettes dying out before use(L); training participants pose with their certificates.

Table 3: Number of trainees/participants from Kadey Division

N°	Location	GIC represented	Number of representatives
1	Batouri	Association ou GIC de charbonniers	02
2		Association ou GIC agropastoral	02
3		Association ou GIC de femmes	02
4	Mbang	Association ou GIC de charbonniers	02
5		Association ou GIC agropastoral	02
6		Association ou GIC de femmes	02
7	Mindourou	Association ou GIC de charbonniers	02
8		Association ou GIC agropastoral	02
9		Association ou GIC de femmes	02
10	Bertoua	Association ou GIC de femmes	02
TOTAL			**20**

Sustainability

Environmental: With time we hope to observe a change in behavior with regard to traditional fuel use in Cameroon. Our goal was to introduce this methodology as a preventative measure against deforestation in Eastern Cameroon, which holds the most remaining rainforest in the Congo Basin. At the same time encourage the public to use resources normally viewed as trash (agriculture refuse, sawdust, charcoal bits) for fuel.

Financial: We have been presenting to individuals who lack the concept of financial planning or don’t have the means to take a small loan out from a bank. As a result we have been encouraging adults to pool money together to purchase the few items required for the process and share. We share a simple cost benefit analysis to illustrate how quickly not buying or searching for fuel each day will recuperate the initial money spent.

Socio-Economic: For all formations on “Fuel from the Fields” we have strived to include individuals from all demographic backgrounds. Usually men make wood charcoal in the communities we have shared with, but we have been encouraging women’s groups to view this as an opportunity to generate income. When asking for

volunteers to practice the process we always include men alongside women because that can be an issue in most African cultures.

Cultural: Eastern Cameroon is one of the most underdeveloped of Cameroon's 10 regions. This is a result of many factors, including the resistance to divert from traditional practices. This has been a hurdle, but also an opportunity when we present this new concept. We motivate the participants by explaining how they can be leaders of their community and maybe to other regions by developing the process and making it more widespread. Specifically when we describe the goal to export briquettes to the grand North and improve the lives of their fellow Cameroonians. The strength of community in Cameroon helps to overcome the hurdle of change.

Lessons Learned

1. Have briquettes pre-made before the formation to give to participants. A question we received at each training is, "How are the briquettes used?" There is a simple answer to this, but a better response is to provide participants with the briquettes to try at home. Allow them to make the comparison themselves between eco-coal and traditional fuel. My counterpart and I also make briquettes to give to community members and leaders. This is to share information about our eco-coal project without having community members be participants in formations. Curiosity has been an advantageous tool to sharing the process.
2. Find creative ways to motivate participants apply the procedure after the formation within their family. Food security, HIV/AIDs, war, poverty, and other more pressing issues are usually concerning the minds of Africans. Even though benefits can be realized shortly after creating your own eco-coal it is not a solution to the more pressing issues. Explaining our wish to provide eco-coal to Cameroonians throughout the grand North has opening the minds of some who initially had no interest in idea of ecological coal.
3. Always experiment. The process is already simple, practical, and affordable; but Africans are some of the most resourceful people on the planet. We have been researching and experimenting with designs for new molds that produce more than 1 briquette at a time. Along with that we are researching different carbonization processes and the differences between resources carbonized.

Transferability

The transferability of this methodology has been facilitated by Massachusetts Institute of Technology (MIT) D-Lab's presentation of their concept. They freely provide information on all aspects of the process (background, process, tool construction). The process is simple enough to convey completely in illustrations and demonstrations for those individuals who cannot read. The materials required could be acquired locally and at a low cost, which makes it available to most everyone who is interested in practicing. The process is also not a mentally or physically demanding which allows individuals of all ages and genders to apply it in their lives.

Title of Case Study Project:	Scaling up of Biomass Based Charcoal Production in Moundou
City/Town:	Moundou
Country:	Chad
Contact Person's Details:	David De Armey ENVODEV International Director France : +33 6 95 48 12 79 OR + 33 7 70 94 63 62 Chad: +235 63 92 76 16 Email: david.dearmey@envodev.org
Source(s) of information	MIT D-Lab, Rainforests Mongabay

Background

By scaling up from a single production point outside Moundou, the second largest city of the country, the eco-charcoal will have greater capacity to meet the high demand for cooking energy. By decentralizing the pyrolysis process to villages within a 100km radius of Moundou, and transporting the raw materials (carbonized biomass and binder) to a centralized briquette production site, ENVODEV will reduce the logistical complexity of bringing all the materials and tools to different locations. By producing in Moundou, the eco-charcoal will be readily available and accessible in the city, where the energy crisis is the most experienced.

All startup costs, including local fabrication of tools and training, are covered by ENVODEV´s project fund raised through its private donor base that exists both in France and the United States of America.

Central charcoal production site, where molds and kilns are also built

Process and Innovation

As earlier stated, the process is based on an earlier project implemented in the suburban village of Belaba,

where a mobile pyrolysis team transported rice-straw back to a centralized briquette production site. This model has been adapted to a larger scale, where new villages become biomass providers. The Belaba team has been regrouped into this up-scaled project and its members have assisted ENVODEV in training new teams in the villages of Nya, Tilo, Badei, and Domane. The Belaba team members have also participated in the production of eco-charcoal from the carbonized biomass provided by the aforementioned villages.

The innovative steps ENVODEV has taken are the following:

1. In order to meet the charcoal demand, ENVODEV has run production tests and succeeded in transforming other forms of biomass, such as sesame straw, guinea cornhusks and straw, and corn straw, into bio char. The diversification of biomass has broadened our capacity to produce eco-charcoal and has expanded the production period.
2. A new form of binder has been tested, using a widely available plant called Grewia Bicolor. This new binder has proven to be effective, and a sustainable supplement to manioc.

Outcomes of the Project

The project has resulted in a number of positive outcomes:

- The decentralisation of the pyrolysis process has reduced logistical costs and increased the possibility to include a greater number of people in the project. ENVODEV has already trained over 50 rural Chadians.
- Participating villages have had an alternative to wood as a source of biomass to make charcoal. Villagers are typically the producers of wood charcoal. This new activity pulls them away from the current environmental dilemma of deforestation.
- Having a centralised briquette production site has provided a better environment for product quality control.
- The manageable scale has allowed ENVODEV to identify the viable transportation systems already in place, and use them to reinforce rural presence in the economic spectrum of the country. Bags of bio char are being transported between the villages and our central production site in Moundou, thus local transporters also become beneficiaries of the project. Since the charcoal ban, transporters have been the first of suffer.

Members of Belaba Team produce eco-charcoal at centralized production center in Moundou

Sustainability

In terms of sustainability, the environmental, financial, social, economic, cultural, and institutional elements addressed by the project are as follow:

- The project has resulted in the reduction of raw wood or wood-charcoal. The production of eco-charcoal has decreased CO_2 emissions: along with all the types of biomass used to make eco-charcoal, rice-straw is systematically burned as waste.
- The usage of eco-charcoal has reinforced the awareness about the necessity of using better cooking-stoves. In continuation with our Belaba project, offering a new form of charcoal has generated an interest among villagers and city dwellers in the environmental implications of wood charcoal.
- The scaling-up of the decentralised pyrolysis process and the centralisation of the charcoal production has created a sustainable financial system by which eco-charcoal sales generate enough income for the production site to buy bio char from participating villages, that in turn can sustain the pyrolysis process.
- As mentioned before, creating economic exchange between villages and cities is reinforced through the charcoal project. Since the ban, transporters, who depend on the constant flow of goods from villages to urban areas, have greatly suffered due to the fact that they are the ones who are fined, punished or incarcerated when caught transporting wood charcoal.
- Many people around the Moundou area are no longer burning the rice-straw in their fields, greatly reducing field smoke and air pollution and its side effects.
- For the past year, local government has been following our project. The government, recognizing that Eco-charcoal responds adequately to the charcoal ban and enables families to carry on with local cooking practices without added financial strain, has been less hesitant in enforcing the wood-charcoal ban, thus forcing citizens to look for alternative fuels.

Dried eco-charcoal ready to be used.

Lessons Learned

ENVODEV has learned of key factors for successfully implementing and sustaining the project:

- The charcoal crisis is above all an urban crisis. It is therefore crucial to appease the need by concentrating on urban areas. Villages have relatively free and safe access to wood charcoal while urban areas do not. Therefore including villages in the provision of energy for urban areas has proven to be very efficient and more easily sustainable.

- Training and communication is best done through local employees. The common tendency for villagers to seek advantages when dealing with foreigners is diminished when local personnel takes charge of establishing the right relationships in view of sensitizing and training a group. Foreign presence is consequently not necessary.

Transferability

The environment in which the project has been implemented carries a set of economic and social patterns that largely equate those found in the greater Sahel and Sub-Saharan Regions. Market demand varies depending on energy availability and environmental policies in place. Notwithstanding, the project is adaptable and eco-charcoal can be used for different activities, such as in Bangui, Central African Republic, where ENVODEV conducted a small-scale eco-charcoal project. Though market demand for eco-charcoal is much harder to establish, the eco-charcoal has been used to fire clay beads for jewelry and excess charcoal has successfully been sold on the local market place.

Section 3: Renewable Energy: Water Access in Urban and Peri-urban Areas

Title of case study project	Davsam Windpump Water Project
City/Town	Eldoret
Country	Kenya
Contact person details	Kennedy Muzee P.O. Box 26415-001000 Nairobi Email: sagwa.k@gmail.com Tel: +254 734 654 878
Source of information	Field data

Background

Water access for domestic use in the urban and peri-urban areas is very crucial for the major towns in developing countries. Moreover, urban agriculture is gaining momentum in most towns owing to the high cost of food. Davsam windpump project was formulated to help address the challenge of water access in the urban and peri-urban areas. The broad goal of this project was to support households and communities get access to water for domestic and small scale irrigation (watering kitchen gardens). The long term objective of this project was to develop a sustainable technology that could help with cheaper and less laborious means to access water for domestic and irrigation purposes. The technology adopted was to provide an alternative to treadle and diesel pumps which are common in developing countries. Diesel pumps have numerous disadvantages: they require constant maintenance and a dedicated operator, who most of the time would require to be housed. Access to diesel is also another problem especially in cases where there is no adequate communication network e.g. poor road network (remoteness), absence or far-flung petrol stations and usually the fuel will be very expensive. Furthermore, owing to the portable nature of diesel and petrol pumps, they can easily be stolen. The biggest drawback with diesel pump is its environmental impact. Diesel pumps emit greenhouse gases that contribute to climate change.

According to UNDP (2006), approximately 1.1 billion people in developing countries have inadequate access to water and about 700 million people in 43 countries live below the water stress threshold of 1,700 cubic metres per person per year. This is despite the fact that between 1990 and 2004 the proportion of people in developing countries with access to an improved water source increased from 73% to 80% and the number of countries with more than half the population without access fell from 24 to 11 (based on UNDP's 113 country observation).

In the case of Kenya, rural water access is estimated to be around 40% (these include piped water, water from boreholes, streams, rivers, wells, lakes, etc.) and the network expansion has been slower (or stagnant) relative to population growth and 80% of the country is classified as either arid or semi-arid. In addition, most of Kenyan agricultural activities are rainfed and when the rains fail, there is massive drought. The drought spells have led to rampant starvation for humans and animals, power rationing as a result of significant reduction of

water levels in hydro dams and high cost of living. The windpump project provides an avenue through which these impacts of drought can be alleviated. In addition, education, rural poverty, health and water access can be improved through upscale of this technology.

Process and Innovation

Davsam windpump project is located in Uasin Gishu County along the Nakuru-Eldoret highway. Although the workshop is located in an agriculturally productive area, more of the windpumps have been installed in less productive areas i.e. where water access is a challenge. The project employs two individuals on permanent basis with numerous casuals depending on the number of orders placed for the windpumps. The use of windpumps for water access and irrigation purposes is now on the increase owing to the frequent droughts experienced in the country brought about by climate change.

Potential users (clients) of the windpump usually approach Davsam with the details of what they want. This may include: planned use of the water, number of households, number of animals, size of land, etc. Once this is ascertained, the client pays a deposit which allows Davsam to procure the necessary raw material to assemble a windpump. On completion, the full balance is paid up and the windpump is installed on his/her farm. It takes approximately two weeks to fully assemble a windpump. With each windpump going for approximately US$ 1,200, most clients prefer getting a loan from their Savings and Credit Cooperative Society (SACCO).

Outcome of the project

Some of the notable benefits of Davsam windpump project include:

- *Improved water access to households and the community* - a windpump installed at Gatongora (outskirts of Ruiru town) supplied approximately 40 households with water. The windpump was installed after the community found the cost of electricity for powering a generator to pump water very prohibitive.
- *Reduced physical exertion especially by women and school-going children* - before installation of a windpump on his farm in Kipchumo, Mr. Chumo, an employee of Moi University, used to get his domestic water approximately 20km away while his neighbours relied on a nearby seasonal river and when it dried up, they could walk for about 1.5km to the nearest well. Installation of the windpump has improved the health of the households as a result of increased food production and nutrition.
- *Affordable food* - through all-year-round irrigation, food items that were expensive (or hard to come by) to the local community such as vegetables and fruits can now be found locally and much more affordable which has significantly improved the diet.

Windpump used to water animals and for irrigation of vegetables in Cheptiret, Uasin Gishu County.

- *Improved academic performance* - school-going children can now dedicate more time to education as opposed to fetching water from distant locations.
- *Diversified income generating activities* as ranching, horticulture and fish farming have been taken up. Mugie Ranch which is situated north of Rumuruti Town is now able to rear 15,000 head of sheep. Another farmer in Outspan in Uasin Gishu now earns an additional KShs. 2,000 (US$ 24) per day from the sale of tomatoes, kales and onions from a 5 acre plot.
- *Developed local skills in new agricultural activities* such as horticultural production. A retired production manager from Delamere Farm in Naivasha holds clinics to create awareness on horticultural production in and around Eldoret. So far, it is estimated he has reached about 53 small scale farmers including the neighbouring Kitale County.
- *Offered employment to the women and the youth* - field surveys indicate that 80% of the employees employed by the farms that have installed the windpump are women and youth.
- *Improved vegetation* – the vegetation around Lerata Makutano (close to the Samburu National Park) improved as a result of watering from the windpump that was installed in the area.

This windpump is used to water dairy animals.

The Davsam windpump project has so far installed over 80 windpumps in typically arid and semi-arid areas in Kenya such as Mwingi, Kang'undo, Kitui, Kibwezi, Emali, Kibogo, Maralal, Kongowea, Mpeketoni and Samburu.

Sustainability

With the onset of climate change and the burgeoning population in urban areas, access to water is becoming an agony to residents. This is further complicated by the polluted nature of surface water sources or drying up of rivers and lakes. Thus, use of windpump has made it the only sustainable way of accessing water for domestic and agricultural purposes. Moreover, several financial institutions have been established which has made credit accessible and affordable to both farmers and small and medium scale enterprises (SMEs). The project built the capacity of the local community who became technicians and led to growth and development of other supporting industries such as scrap metal, stockists of water pumps, iron rods, etc.

Lessons Learned

Access to affordable credit to both SMEs (Davsam) and farmers is crucial to adoption of windpump technology. Majority of potential users cited access to credit as the biggest hindrance.

Transferability

Windpump technology is relatively low-tech with most graduates from technical colleges and polytechnics being able to fabricate one. Furthermore, once the installation is complete, there is very minimal maintenance. This makes it very cheap in the long term.

Section 4: Promoting Electricity Access in Informal Settlements

Title of Case Study Project:	Low-income Urban Community Electrification Pilot Project
City/Town:	Wroto Town and Bushrod Island in Monrovia
Country:	Liberia
Contact Person's Details:	M. Hady Sherif mhsherif@csetliberia.org mhadys@yahoo.com
Source(s) of information	LEAP Final Report/LEAP Urban Community Pilot Impact Assessment Report/M. Hady Sherif's Presentation @ GENUS 2009 Expert Group Meeting

Background

Liberia's electricity infrastructure was almost completely destroyed during the one and a half decades of civil conflict. Power plants, transmission lines, fuel storage tanks and depots were all devastated. Total pre-war capacity was 412MW of which 191MW was provided by the national utility, the Liberia Electricity Corporation (LEC). The devastation included the 64MW hydropower plant located in Mount Coffee near Monrovia along with other thermal/diesel power plants in rural Liberia owned by government and private concessions. Public access to electricity then became non-existent. The level of poverty increased as well as urban migration of rural dwellers, returnees and displaced populations which increased the spontaneous creation of slums/low income/informal settlements in the nation's capital, Monrovia, thus increasing its population from 400,000 (pre-war level) to over one million.

In 2006, upon the inauguration of the first post-war democratically elected government, the Emergency Power Program (EPP) was launched. With the assistance of international partners including the USAID, Ghana, Norway, the European Union, and the World Bank, over US$ 40 million was provided in grant funding and technical assistance to revive the Liberian electricity sector. By 2009, the LEC generation capacity grew to 9.6 MW providing electricity in the capital, Monrovia, and its immediate environs. Public buildings and businesses as well as education and health facilities and few residences were prioritized for electricity supply. The LEC had less than 2000 customers at the time. Nationally, of the nearly 3.5 million people, only less than 10% of urban residents and 2% of rural residents had access to electricity, largely produced by small private generator sets at prohibitive costs.

The LEC had had no special electrification program for slums/low-income/informal settlements in Liberia. In addition, though the Cabinet-approved National Energy Policy guarantees universal modern energy access for all Liberians, there was no specific program targeted at informal communities. Between 2006 and 2007, the then USAID-funded Liberia Energy Assistance Program (LEAP), a supplement to the EPP, implemented among others, an Urban Community Development Pilot project. The specific objectives were sustainable electrification of two low income communities; evaluation and dissemination of results of pilots (expected to demonstrate that prepayment for electricity eliminates problem of arrears, helps to prevent electricity theft, and reduces

operating costs of LEC); and provision of a road map for residential service, including technical and financial approaches for electrification of sub-standard residential structures.

The overall goal was to support the growing need to extend (i.e., restore, improve or establish for the first time) access to modern energy/electricity service in the urban areas of Liberia, starting in Monrovia. The approach was unique/unprecedented in Liberia as it was first of its kind and it involved donor, government, utility, NGO and beneficiary community partnership. Prepayment electricity meters were used to connect the pilot beneficiaries. Besides, a limited number of streetlights were installed in the pilot communities.

The pilot project partnership involved USAID, the donor; the Government of Liberia through the Ministry of Energy; the national utility, LEC; the main contractor, US-based International Resources Group (IRG); sub-contractors: US-based Smyser Associates and the Liberian energy NGO, Center for Sustainable Energy Technology (CSET); and the pilot communities' leaderships as well as the beneficiaries themselves. The above described donor-government-utility-consultants-NGO and community collaboration was a unique model which enhanced successful implementation of the project.

With a combined estimated population of 20,000 (approximately 230 households/connections were made at the time) in the two pilot communities, a modest number of 230 prepayment electricity meters were installed in both areas (128 in Wroto Town and 102 in Bushrod Island).

The result of the pilot project served as an eye-opener for both the LEC and the Government to consider the methodology and technology used in this project for future plans. It signaled an opportunity to improve the quality of life (social and economic conditions) of the low-income urban community inhabitants.

Illegally connected electricity in one of the slums in Monrovia

Process and Innovation

The process was unique and unprecedented. First, there had been no government-targeted electrification program for low-income/slum communities in the country. In addition, the novelty partnership or collaboration between and among international, national, local and community groupings made it a unique participatory

model. Furthermore, the introduction of prepayment electricity metering system was first of its kind in Liberia which benefitted both the utility and its beneficiary customers and communities. Energy efficiency and conservation advises were provided through community engagements which were unique to customers. Leaflets/fliers as well as community meetings were held prior to, during and after installation of meters.

USAID provided the financial support while the IRG served as the main/lead management and technical consultant.

Smyser Associates, with vast expertise in urban energy development and access provided support to CSET in its local project coordination and community engagements. CSET ensured a weekly coordination meeting with the LEC, the MLME and provided project progress update to the task project manager for subsequent update to other key stakeholders/partners.

CSET engaged the community through focus groups discussions and baseline surveys: socioeconomic survey to determine ability and willingness to pay; and technical survey to determine suitability of structures and right of way. CSET also conducted awareness/sensitization/education campaign on energy efficiency and conservation in the pilot communities. With connection fee subsidized and financial assistance from the donor, CSET also coordinated the wiring upgrade of structures.

Pilot/beneficiary communities' organizations provided their cooperation and support, while direct beneficiaries paid the labour cost for structure wiring. Direct beneficiaries also signed electricity supply service agreement with the LEC.

The national utility, LEC, with technical support/assistance from the main contractor/management (IRG) did the pilot design and built the distribution system, trained the pilot communities' electricity vendors, and installed the entire prepayment system including the meters at both the main station and the structures/homes of the beneficiaries.

Electricity vendors use a mobile point of sale (MpoS) equipment which is connected via a GPRS system to the main station at the national utility to pre-purchase electricity in bulk which is in turn sold to community customers at a an greed rate for a commission on each kWh sale.

The government through the Ministry of Energy gave its acquiescence in line with its policy oversight role.

Key challenges encountered during the implementation process included the following:

1. Official recognition of the existence of slums/informal settlements and incorporating or integrating their electrification in national plans/programs
2. Solving issues of tenure in slums/informal settlements
3. Risks/safety issues involved with electrifying such communities with makeshift structures
4. Such communities are also characterized by social deviants (criminals, drug abusers, etc.)
5. Power theft
6. Financial viability - cost of providing service in such areas vis a vis revenue expectations(ability to pay)
7. To include electricity in the provision of basic social services by Government to such areas (usually electricity supply- not part of package)

8. Utility's Policy (e.g. third party connection/vending)
9. Other challenges/constraints specifically faced with the current prepayment system include vendor's kWh sales period within the community, vendor's contact with the main station at the utility and down-time issue (no control)

The first two challenges have legal implications. Many slum areas are public property and therefore its inhabitants are considered squatters that could be evicted anytime. Socioeconomic planning including land tenure depends on the political will and development objective of the government. However, portion of some areas within the slum communities that were obviously targeted for demolition was not considered in the project. On other challenges such as electrification of unsafe mat structures were deferred so as to put better safety mechanism in place for such structures to be electrified. Awareness and sensitization on the vices and consequences of criminality and power theft were carried out in addition to installing streetlights at major intersections and populated and criminally infested areas within the communities for security and safety. Streetlights were also installed at main water collection points (public hand pump) and public toilet areas. Prepaid electricity meters were installed so as to afford the opportunity of low income dwellers to purchase electricity based on their ability to pay. Customers could buy as low as US$1 worth of kWh of electricity from the nearby community kWh vendor. The project management negotiated with the utility to relax their policy of prohibition on third party vending so as to allow the project's kWh electricity community vendor to operate as a pilot which eventually proved worthwhile for the utility as it eliminated the burden and cost of monthly meter reading, billing and collection. The national utility operates on a one-shift basis (8 hours) and so vendors must pre-purchase adequate kWh of electricity to meet customers' demand throughout or at any time. Vendors were mandated as part of an agreement to provide at least 18 hours of vending to customers within their community. Finally an assessment was conducted to determine the impacts of the project.

An electricity technician in the process of getting the low income households in Monrovia connected to the national grid

Outcome of Project

The project's outcome signaled a lot of opportunities as it significantly met its objectives based on perspectives of beneficiaries, the utility (LEC), the community as a whole and policy goal of the government. Among some of the opportunities identified include the following:

- Improvement in economic and social conditions (quality of life)
- Poverty reduction/alleviation (helps in meeting target)
- Improvement in security (home lighting and streetlights)
- Increase in commercial activities (extending business hours)
- Budgetary/fiscal discipline (beneficiaries staying within their means)
- Beneficiaries paying less for legal connection as opposed to illegal services and inefficient traditional energy service alternatives including own generators
- Increase in number of customers and hence increase in revenue
- Reducing rate of power theft
- Arrears accrual negligible or eliminated, thus benefitting the utility
- Promoting universal access to electricity as per the NEP's goal/objective
- Signaling opportunity for improving the lives of the poor

Results from the pilot project impact assessment were encouraging and buttressed the above opportunities. On the side of the utility the project demonstrated that prepayment metering is the way forward for LEC, and the strategy through which the utility can be able to improve its revenue and creditworthiness, which is essential for bankable power purchase agreements needed for system expansion. Furthermore the use of non-utility vending showed an effective privatization of the electricity retail business, which brings the power sector in Liberia in line with international best practice.

The prepayment metering system indeed proved compatibility with and usefulness to improving LEC commercial and technical operations. The objective of effective billing and collection system was achieved as indicated by the collection of 100% revenue from the energy supplied to the assessed customers.

The prepayment meters helped to reduce arrears normally owed to LEC by customers in the pilot community during the use of conventional meters. The system also helped to reduce non-technical losses to the LEC as there was no incidence of power theft in the pilot community then. The system helped to reduce the operating budget of LEC, and if scaled up, it could further reduce it as it decreases the logistics involved in metering, billing and collection.

The number of staff's time required for connection and disconnection reduced by 7% due to the use of prepayment meter. The times saved from the prepaid meters could be used to improve performance and efficiency.

The prepaid meter system boosted the capacity and performance of commercial, technical, IT and financial performance of the LEC. These include: collecting, compiling, analyzing and interpreting data and the ability to advice on energy efficiency and conservation

The prepaid meter system also pointed the potential to create development impacts and to achieve financial sustainability objective provided certain potential operational problems with the master station are solved.

Though, a total of 230 customers benefitted from the pilot, but assessment covered just above 10% of total beneficiaries which were in only one pilot area, Wroto Town. The main reason for this was that not all customers were connected at about the same time during the project period, and of the 100 meters energized (28 in Wroto Town and 72 in Bushrod Island), only Wroto town was continuously energized due to limited loading capacity. However, from the side of the beneficiaries, prepayment customers, on average, appeared to manage their purchases and power consumption better than their counterparts on conventional or credit meters. Only three of the 27 customers assessed experienced problems with their meters during the pilot period. These problems generally involved the tripping of their meters or intermittent switching of meter on and off. All the customers who encountered meter problems reported that it took LEC at most 24 hours to solve the problem.

Customers or beneficiaries no more subscribe to the notion that electricity is only for the non-poor. Beneficiaries realized that even with what they spend on their inefficient sources of lighting such as candle, kerosene, dry cell battery or palm oil, they could get some reasonable amount of light with high quality. Furthermore, beneficiaries now use electricity efficiently and safely as they control their own budget subject to their means.

From the perspective of the community, the assessment focused on the impact of increased street lighting in the community. The distributional impact of electricity in schools, clinics, business and corresponding social and economic changes could not be adequately captured due to the project's inability at the time to connect all customers/beneficiaries selected for prepayment meters.

At the time of the assessment, about 50% of the street lights in Wroto Town were functioning. Notwithstanding, feedbacks from the community about the street lights were encouraging. Benefits of street lights as articulated by a cross-section of the inhabitants include: improved security; post dusk businesses/sales; increased business hours and income (street vendors sell up to 10pm daily); reduced theft; and students without electricity were able to study at night under the street lights.

Through the project, the low income households can now enjoy the benefits of legally connected electricity

Sustainability

This section describes how the project addressed the financial, social, economic environmental, institutional and cultural elements of sustainability.

- *Environmental:* The project baseline survey reported massive community use of expensive and inefficient traditional alternative sources of lighting such as candle, kerosene-powered lamp, dry cell battery-powered light and locally made palm oil powered light ("jacko lantern"). The provision of more grid-based prepayment electricity meters helped to enhance the displacement of the use of the inefficient lighting sources mentioned above. This will reduce emission of carbon and indoor air pollution due to palm oil and kerosene combustion thereby protecting the environment and reducing health hazards. Furthermore, the problem of disposal of dry cell batteries after use will be reduced and hence protect the environment. The project also enhances energy efficiency as beneficiaries were sensitized on how to use electricity at low cost. Safety measures were also thought.

- *Financial:* The project which was funded through a grant helped the utility in the capital expenditure involved in procuring electrical hard ware and other related equipment given the utility's immediate post-war financial constraints. It supported the already existing limited grid lines in Monrovia. On the other hand, the beneficiaries who would not have had the ability to purchase electricity meters and internal wiring and other related items or materials benefited from the grant which enhanced their access to modern energy services. Above all, the relatively prohibitive cost incurred by end-users using the traditional inefficient sources of lighting will be significantly reduced, and savings could be used to purchase more electricity or diverted to satisfy other important needs or productive ventures.

- *Social and Economic:* Over the short monitoring period, the project helped and will continue to help improve the standard of living and quality of life of beneficiaries in all sectors including education, health, commerce, etc. as reported in the pilot impact assessment. Having access to electricity which is a key ingredient to socio-economic development has the potential to improve health, education, business/commercial activities and other productive ventures. Health facilities will operate at night while vaccines will be refrigerated and other equipment sterilized using electricity. Women could also do more chores at night to ease some of their burdens during daytime. As also evident during the project impact assessment, children will have the opportunity to study at night (using home or nearby community streetlight) thereby increasing study hours while commercialists will extend their hours of business, thus assuring additional income and alleviating poverty.

- *Cultural:* The perception that many non-affluent households had that they cannot afford to pay for electricity service began to fade away as the prepayment electricity metering system affords customers the opportunity to control their budget and electricity consumption. The pattern of going to banks to pay electricity bills has also been eliminated by the introduction of a community electricity vendor. Finally, the

attitude of wasteful use electricity and using it in various unsafe ways has been replaced with energy efficient and safety behaviours.

- *Institutional:* The resolve of the 2005 National Energy Stakeholders Forum (NESF) held in Monrovia involving over 300 participants from all over the country encouraged the development of the National Energy Policy of Liberia which articulated the liberalization of the energy sector and introducing methods and modern technologies based on international best practices so as to enhance universal access to modern energy services. The forum led to the development of the Energy Sector White Paper and later the National Energy Policy (NEP). The then Liberia Energy Assistance Program (LEAP) funded by USAID which was a supplement to the Emergency Power Program (EPP) served as the basis for this project and some others. In view of this a bilateral understanding/agreement between the Government of Liberia (through the Ministry of Energy) and USAID was signed. LEAP was managed by the International Resources Group (a US-based private consultant company) which worked with and provided technical assistance as well to the national utility, LEC, in implementing the project. Key policy issues and decisions were made through a Steering Committee headed by the Ministry of Energy which met on a weekly basis to discuss progress on the EPP including LEAP. The Steering Committee comprised the Ministry of Energy, the LEC, the donor and/or the consultant.

Lessons Learned and Recommendations

The following observations are lessons learnt from the implementation of the project including the performance of the prepayment meters installed:

- Various stakeholders collaboration proved to be a worthwhile approach aimed at electrifying slums/low-income settlements in Liberia
- Some collaborative efforts or the role of some partners may not continue indefinitely, and so an appropriate exit strategy will be required

- Depending on the type of prepayment meter system used, it could largely help in combating/minimizing power theft
- Payment process was simple and easy for customers, and so connection process must also be the same
- Electrification program design for slums surely varies from the normal as the condition of the area is different from formal settlements
- National utilities must endeavor to study best practices used in other countries with the aim of adopting innovative approaches to improve effectiveness and efficiency and hence attract more customers (e.g. urban poor) for sales and revenue maximization
- Subsidies and other forms of financing by government and donors could also help increase electricity access to the urban poor
- Government support to have a dedicated electrification program for the urban poor will be essential
- The use of non-utility vending has worked very well, providing the utility with the equivalent of two creditworthy customers who had no problem recovering money from their end-use customers. This fact has attracted the interest and confidence of potential IPP developers.
- On average prepayment customers appear to manage their purchases and power consumption better than their counterparts on conventional meters. Average consumption for prepayment customers has dropped

by 12% and none of the 27 customers were disconnected. In contrast, 71 out of 106 on conventional meters in the same area were disconnected for non-payment at least once.

- Although so far no theft or meter tampering was reported, the current wiring standards leave the integrated prepayment meters with the same level of vulnerability to electricity theft as conventional meters due to the long cable loop between the utility pole and the meter. The split meters are expected to resolve this as the metering unit is up on the pole and the customer has to ensure that no one taps into the cable loop at his expense. Unfortunately the supplier has had problems with the design and delivery of the split meter and this is yet to be tested.
- If the utility were to connect all new customers on prepayment meters it would not need to extend its current metering, billing and collection system. The staff can be re-deployed towards energy management and theft control duties.
- Since vending can only take place when the mobile points of sale (MPOS) can communicate with the System Master Station, the absence of a 24⁄7 service has proved to be an inconvenience. Therefore, any roll out will have to give consideration to providing 24⁄7 availability to the master station and some vending points.

Additionally, given the success of the project based on stakeholders' feedbacks, the system performance, observations and lessons learnt, it is evident that prospects for the roll-out of the prepayment meter to include more urban communities and possibly phase out the use of conventional meters are very good. However, roll-out or replication of the project can be assured if the following recommendations are considered:

a) To sustain the system, additional human resource capacity development (technical training) should be carried out at the LEC to facilitate the repair of the prepayment meters, MPOS, and system software as well as other related hardware in case of breakdown, malfunction, and need for troubleshooting, upgrade, modification and recovering of system and prepayment meters.
b) In addition to data back-up, a system back-up at the master station will be appropriate.
c) The best financial model for the prepayment system is the identification and use of a credit worthy and community based vendor for the bulk purchase of electricity from the utility and retail to customers.
d) The GSM vending back-up (using text message) must be on the stand by at all times
e) An effective communication mechanism to swiftly inform the vendor and customers in case of system breakdown and/or power cut will be necessary.
f) Adequate spare meters and MPOS must be in stock to serve as back-ups for existing ones in case of theft, damage, malfunction, etc.
g) Mechanism should be put in place to keep the master station and the server on for at least 18 hours daily to facilitate vending beyond the official working hours of the LEC. This could be done through the use of a solar power system or battery back-up.
h) Considering the limited sample population (27) in the impact assessment, a further probe to include all 230 prepayment meter customers should be conducted in a reasonable period of time in order to generalize the findings. However, the findings based on the limited sample size are sufficient to maintain all the prepayment meters intended for the pilot project and that they also give positive indications that the prepayment metering system is the way forward.

Transferability

Using prepayment electricity meters was new in Liberia but the technology had previously been introduced in many other sub-Sahara African countries including South Africa, Kenya, Gabon, Cote d'Ivoire, etc. Given the positive impact assessment conducted just on small sample of customers/beneficiaries signaled an opportunity for scaling up or replicating the project in other parts of urban Liberia. Lessons learned including challenges and constraints as well as other shortcomings experienced during project implementation could be used as a basis for improvement by identifying mitigation measures and executing them. In replicating or scaling up, one key issue that needs not be overlooked is that electrification design in slums or poor communities may be challenging given the deviant attitude, perception, economic status, community congestion, state of repair of structures vis-a-vis safety, etc. With the model multi-stakeholder collaboration used, especially community engagement in terms of education, sensitization and awareness on various issues so as to mitigate various challenges that may be encountered, this project could be easily transferred, replicated or scaled-up elsewhere in Liberia.

Title of Case Study Project:	Electrification of Poor Households in Monrovia's Low-income Communities
City/Town:	Monrovia (21 low income priority areas)
Country:	Liberia
Contact Person's Details:	M. Hady Sherif Email: mhsherif@csetliberia.org OR mhadys@yahoo.com
Source(s) of information	Center for Sustainable Energy Technology (CSET)

Background

Liberia is located in West Africa with a size of 111,370 km^2 of which 96,320 km^2 accounts for the land area. The country has been recovering from nearly one and a half decades of armed conflict which ended in 2003. The war devastated all of the major infrastructures including electricity. Power plants, substations, transmission lines, fuel storage tanks, and depots were all looted and/or vandalized. Pre-war installed electricity generation capacity (public and private) totaled 412 MW of which 191 MW (including the 64MW hydropower) was produced by the national utility, the Liberia Electricity Corporation (LEC).

The democratically elected post-war government of Liberia along with assistance from international development partners has been making tremendous strides in rehabilitating the electricity infrastructure in a bid to increase access to modern energy services. Since 2009, the LEC's generation capacity has increased from 9.6MW to current 22.64MW, of which only 15MW is currently active, providing electricity in the capital, Monrovia, and its immediate environs. Yet, the country, with a population of about 3.5 million, has probably the lowest rate of access to public electricity in the world (1.5% nationwide and 4.6% in the Capital City). The LEC, currently being operated under a 5-year Management Contract (since 2010) with the Canadian-based Manitoba Hydro International, has so far connected 9,913 residential customers (households) out of an overall total of 12,955 utility grid customers as at October 2012. The vast majority of the population still relies on small diesel generators, dry cell battery-powered lantern/lamp, kerosene lamp; palm oil lamp and candle for lighting, while charcoal and firewood are used for cooking and heating.

Until 2006, the LEC has had no special electrification program for informal settlements in Liberia. In addition, though the Cabinet-approved National Energy Policy guarantees universal modern energy access for all Liberians, there was no specific program targeted at informal communities. However, between 2006 and 2007, the then USAID-funded Liberia Energy Assistance Program (LEAP) implemented among others, an Urban Community Development Pilot project with the objective of providing modern energy services to two low-income urban communities in Monrovia. About 230 (two hundred and thirty) low-income customers were connected to the national electricity grid. The result of the pilot project served as an eye-opener for both the LEC and the Government which signaled an opportunity to improve the quality of life (social and economic conditions) of the low-income urban community inhabitants. It also pointed out a remedy to some of the major challenges (bills payment and power theft) facing the LEC.

Though the LEAP urban pilot project proved successful and worthwhile, access to utility power remain significantly low with inadequate and unreliable power supply. The majority of Liberians is forced to rely on costly and polluting alternatives mentioned above to meet their lighting and electricity needs. This poses a key constraint to economic growth and development. Further exacerbating the situation is the electricity tariff of US$ 0.567/kWh (tariff: US$ 0.42; FAC: $0.11; GST: 0.037) given the very high cost of fossil fuel (petroleum products) which is vulnerable to fluctuations in the world market.

In March 2012, the World Bank's Global Partnership on Output-Based Aid (GPOBA) launched the Monrovia Improved Electricity Access Project with the LEC to increase access to electricity among the poor in Monrovia, Liberia. The objective of the GPOBA is to help ensure broad-based and inclusive access to electricity and significantly improved living conditions among the poor. The project is part of the Liberia Electricity System Enhancement Project (LESEP), approved by the World Bank's Board of Executive Directors in late 2010 which has been specifically designed to support the expansion of the distribution network in Monrovia and the enhancement of associated power generation facilities.

The partnership involved in the project comprised the donors, the World Bank/GPOBA, the Government of Norway and the Government of Liberia (through the Ministry of Energy) as the beneficiary country government. The national utility, LEC, serves as the project implementer providing the technical and human resources required for the implementation.

The GPOBA grant of US$ 10 million is expected to partly cover the capital investment required for connecting 16,806 households as part of a US$ 16 million project, of which the Government of Norway is contributing nearly US$ 6 million. The two-year project, when completed is expected to increase Monrovia's electricity access rate from 0.6% to nearly 9%. The target areas are 21 priority low-income communities in Monrovia that have been identified by the LEC.

The 21 priority areas have a combined estimated population of 250,000 people. LEC has so far commenced connections in 6 communities and at least 4,000 households have been connected to the grid using prepaid electricity metering technology. These communities include major Monrovia slums or low-income areas such as West Point, Buzzy Quarter, New Kru Town, Point Four, Slipway and Clara Town. Other key slums are among the rest of the 21 areas.

Illegal connections prevalent in informal settlements before Liberia Electricity Corporation began electrifying the residents

Process and Innovation

The project is still ongoing and its process is unique and unprecedented. It is the first ever large scale targeted electrification of low income/slum communities since independence in 1847.

Given the significant number of beneficiaries (nearly 17,000) in this project, a GPOBA-funded baseline consumer survey to estimate the willingness and ability to pay for electricity services was conducted. The survey gathered information on energy consumption patterns among Monrovia residents, in order to estimate their willingness to pay for grid electricity. The survey covered a total random sample of 958 households in Monrovia equally divided between those with and without access to LEC grid electricity. The survey results were the basis for the design of this GPOBA project. This comprehensive energy baseline survey was unprecedented as it was part of a 2500 household sample spread in 10 of the 15 counties of Liberia. A local Liberian energy NGO, Center for Sustainable Energy Technology (CSET) was contracted to conduct the survey between 2010 and 2011.

Project beneficiaries have been selected through geographic targeting combined with some screening at the individual household level. The service provider, LEC, identified 21 priority low-income neighborhoods where connections supported by GPOBA will be provided to households living in single-room per family, one-story dwellings with sub-standard structures and/or in characteristic disrepair. This time, the partnership or collaboration is among multilateral and bilateral donors, Government, the national utility, LEC.

The LEC's role in the project involved building the distribution network including poles installation, setting and installing the entire prepayment system at the utility's main station and finally connecting low-income beneficiaries using prepayment electricity metering system. Unlike the previous LEAP integrated prepayment meter, split meters (separate units for customer and meter interfacing) have been used for this project. All beneficiaries connected are new to the LEC grid. The LEC is to some extent sensitizing beneficiaries and providing them brochures on how to operate the prepaid meter. Trained electricity vendors have been

deployed in selected areas within the city for customers to purchase any amount of kilowatt hours. Like the previous LEAP pilot project, electricity vendors use mobile point of sale (MpoS) equipment which is connected via a GPRS system to the main station at the national utility to pre-purchase electricity in bulk which is in turn sold to community customers at a an greed rate for a commission on each kWh sale.

The LEC built upon and expanded the then LEAP prepaid electricity metering system to accommodate this large number of potential beneficiaries under this GPOBA funded project. The LEC will periodically electrify the selected low income homes in the 21 designated priority areas and periodic samples of the connections will be verified based on set social and technical criteria through an independent verification commissioned by the World Bank/GPOBA management. Verification is expected to commence before the end of 2012. The verification agent is a consortium led by France-based Hydroconseil along with Innovation Energie Developpement (France-based) and the Liberian energy NGO, Center for Sustainable Energy Technology (CSET). To encourage accountability of and risk sharing by the provider, GPOBA subsidy/financing will be paid in two phases (80% and 20% respectively) upon the verification of outputs. The verification must establish that a connection has been verified in one of the priority areas and is functional with at least three months of satisfactory service delivery.

The government through the Ministry of Energy expressed its official support to the project. Key challenges encountered during the then LEAP implementation are being mitigated:

a) The fact that a national utility implemented project endorsed by the government which is directly targeting low-income urban communities suggests some form of official recognition of slums/informal settlements as their electrification is now being incorporated or integrated on a national level.
b) Government is also carefully finding solutions to issues of land tenure on a national level which includes slums/informal settlements
c) The LEC is making some effort in sensitizing customers on safety issues as well as the consequences of power thefts. Mechanisms are being put in place to avert and or minimize such problems on a general level.
d) This time, split prepayment electricity meters have been used throughout and the couple of hundred integrated (prepayment) meters previously installed have all been replaced with split meters. The number of community vendors has also increased to provide services to the thousands of customers currently benefitting from the LEC's supply.
e) Key issue of physically identifying customers and providing a more precise address of each customer including a GPS location of transformers as well as getting each customer's phone number have been significantly improved upon.
f) Finally, the utility's timely responses to technical and other problems facing customers will need to be further improved though efforts are being made but lack of adequate manpower; logistics, etc. continue to pose more challenges given the increasing rate of connections since early 2012.

The community participation largely involves their full collective and individual customer cooperation as they see this development as an opportunity provided by donors given the numerous development challenges the Liberian government is faced with.

As earlier mentioned, this project is the first ever single large scale electrification program. It is also the first ever large scale electrification targeted at low income urban communities. Besides, the elaborate baseline

willingness and ability to pay for electricity and energy consumption study conducted nationally which inform the design of this GPOBA funded project was unprecedented. Furthermore, introduction of the split prepayment electricity metering system is a positive technological shift which helps to mitigate if not eliminate the high vulnerability to theft using the previous conventional/credit or integrated prepayment metering system. Finally, the introduction of a verification portion of the project helped to encourage accountability and risk sharing prior to re-imbursements to the utility. All of these innovative methods, among others, continue to enhance the success of the project which is still ongoing.

Wroto Town Community members along with the then LEAP project implementers and the former Board Chair of the LEC

Outcome of Project

The project's outcome signaled similar opportunities as the then USAID funded LEAP project. It is significantly meeting its objectives from perspectives of beneficiaries, the utility (LEC), the community as a whole and policy goal of the government as well as the overall goal of the World Bank GPOBA program. Among some of the opportunities identified include the following:

- Improvement in economic and social conditions (quality of life)
- Poverty reduction/alleviation (helps in meeting target)
- Improvement in security (home lighting and streetlights)
- Increase in commercial activities (extending business hours)
- Budgetary/fiscal discipline (beneficiaries staying within their means)
- Beneficiaries paying less for legal connection as opposed to illegal services and inefficient traditional energy service alternatives including own generators
- Increase in number of customers and hence increase in revenue
- Reducing rate of power theft
- Arrears accrual negligible or eliminated, thus benefitting the utility
- Promoting universal access to electricity as per the NEP's goal/objective
- Signaling opportunity for improving the lives of the poor

As the project is still ongoing, the following are expected as outcome:

Further demonstrate that prepayment metering is the way forward for LEC, and the strategy through which the utility can be able to improve its revenue and creditworthiness.

Non-utility vending is expected to continue to be an effective privatization of the electricity retail business, which brings the power sector in Liberia in line with international best practice.

The prepayment metering system continues to prove it relevance to LEC commercial and technical operations.

It is also expected that the prepayment meters will continue to help reduce, if not eliminate, arrears owed to LEC by customers during the use of conventional/credit meters.

The system is also expected to reduce non-technical losses to the LEC as the incidence of power theft could be significantly reduced by the large scale introduction of split prepayment electricity metering system. The system could help to reduce the utility's operating budget as it will reduce or eliminate the logistics involved in metering, billing and collection.

The number of staff's time required for connection and disconnection is expected to be significantly reduced due to the use of the prepayment meter. Saved times from the use of prepaid meters could be used to improve performance and efficiency.

It is anticipated that the prepaid meter system will further boost the capacity and performance of commercial, technical, IT and financial performance of the LEC in terms of collecting, compiling, analyzing and interpreting data and the ability to advice on energy efficiency and conservation.

The prepaid meter system also points to the potential to create development impacts and to achieve financial sustainability objective as long as the entire prepayment electricity system work effectively.

Customers or beneficiaries are expected to further realize and confirm that even with what they previously spend on inefficient sources of lighting such as candle, kerosene, dry cell battery or palm oil; they could get some reasonable amount of light with high quality. Furthermore, beneficiaries will learn how to use electricity efficiently and safely as they control their own budget subject to their means.

Many households have been legally connected to the grid. Moreover, public places have been lit thus improving security in public spaces.

Sustainability

Given the elaborate willingness and ability to pay for electricity survey conducted which informed the design, the results indicated an overwhelming willingness and ability which shows that even with the amounts spent by low income customers on their traditional inefficient alternatives for lighting, they could still purchase kWhs from the national utility guaranteeing cleaner, safer and high quality light (lumens). Therefore at the minimum, the project's sustainability is assured since it mainly depends upon the ability of newly connected low-income customers to pay for electricity. The survey which was conducted among both LEC and non-LEC customers (those using non-utility lighting/electricity/energy sources) revealed that the national grid electricity is consistently and significantly cheaper than the more common substitutes currently used for lighting and for powering appliances. Besides, in spite of the level of poverty, surveyed households spend almost half of their monthly income on energy, a third of which is spent on lighting and battery powered appliances. Access to grid electricity would replace most of the spending on lighting and batteries and could earn significant savings to households even at much larger energy consumption levels.

It was also indicated that the utility has strong incentives to serve even low consumption levels given the flat tariff set at recovery of operation and maintenance costs.

- *Environmental:* The sustainable environmental consideration is the same as the previous LEAP project. The key advantage here is that this project is being operated on a large scale which delivers significant positive environmental impact and hence its continuity. The project baseline survey (consumer WTP study) reported massive community use of expensive and inefficient traditional alternative sources of lighting such as candle, kerosene-powered lamp, dry cell battery- powered light and locally made palm oil powered light ("jacko lantern"). The provision of more grid-based prepayment electricity meters will further enhance the displacement of the use of the inefficient lighting sources mentioned above. This will reduce emission of carbon and indoor air pollution due to palm oil and kerosene combustion thereby protecting the environment and reducing health hazards. Furthermore, the problem of disposal of dry cell batteries after use will be reduced and hence protect the environment. The project also enhances energy

efficiency as beneficiaries were sensitized on how to use electricity at low cost. Safety measures were also thought.

- *Financial:* The donor funding is a subsidy to cover the capital cost involved in connecting the customers. The project is designed in a way that the national utility is reimbursed on every connection verified based on connection criteria developed.

  The project is implemented by the national utility, LEC, and relies on the procurement procedures and management team already in place at LEC for the execution of LESEP, which was assessed and found satisfactory.

- *Social and Economic:* As this project is still operational, indications from the previous LEAP pilot, suggests this large scale implementation will continue to improve the standard of living and quality of life of beneficiaries in all sectors including education, health, commerce, etc. and hence ensure a significant level of socio-economic development. With nearly a fourth of the total connections achieved, indications are that the socio-economic elements of sustainability have begun to be realized, though it is too early to generalize. Health facilities will operate at night, thus increasing service hours while vaccines will be refrigerated and other equipment sterilized using electricity. Female headed households were part of the selected beneficiaries. Women could also do more chores at night to ease some of their burdens during daytime. Children will have the opportunity to study at night thereby increasing study hours while commercial activities will extend their hours of business, thus assuring additional income and alleviating poverty.

- *Cultural:* The fact that many low-income households are now using electricity will erode the perception that they cannot afford to pay for electricity service. Community electricity vendors have now replaced the pattern of going to banks to pay electricity bills. Finally, many households will now change their attitude of wasteful use of electricity and using it in various unsafe ways. They now have the opportunity to controlling their own electricity budget.

- *Institutional:* The project is guided by the overall goal and vision of the National Energy Policy of Liberia and the LEC's mandate for generation, transmission and distribution of electricity/power. The Ministry of Lands, Mines and Energy plays the policy oversight role. Building on the principle of public-private partnership, the Government of Liberia (GoL) mandated LEC's operational control to a Management Contractor, the Canadian Manitoba Hydro International (MHI) in mid-2010, who would, among other things, bring the utility to a level of "full functionality". The Management Contract has been funded by the Government of Norway (GoN). The Contract envisages an articulated investment plan including extension of the distribution network, customer connections for low-income households, enhancement of supply options, and technical assistance for LEC.

  The Monrovia Electricity Access Project (the GPOBA project) is a component of the Liberia Electricity System Enhancement Project (LESEP), approved by the World Bank's Board of Executive Directors in November 2010. LESEP has been specifically designed to support the expansion of the distribution

network in Monrovia and the enhancement of associated facilities for power generation. GBOPA funding will supplement resources allocated to LESEP's first of three components (enhancing delivery of distribution services, including for low-income households) and partly cover the capital investment required for connection of poor households.

Lessons Learned and Recommendations

As the project is still ongoing, observations during early implementation of the project suggests the following quick actions in addition to recommendations suggested in the event of any direct or indirect scaling up of the prepayment electricity meter project such as the then LEAP project:

- The continued use of the split prepayment electricity metering system as learned during the previous LEAP pilot project
- Improved customer service including quick response to technical and other customer related problems.
- Study the cause(s) of frequent meter tripping, burning and fuse blowing off and applying some mitigation measures.
- Apply vigorous mechanism in averting meter by-pass by customers which could be easily detected given periodic review of consumption history, among others

Transferability

Replicating this project will be smooth at all times as long as recent and updated lessons learned and experiences used to mitigate any previous or new challenges that may crop up. In addition to using/implementing prepayment electricity metering in other countries such as Kenya, South Africa, Gabon, Cote d'Ivoire, etc., it was piloted in Monrovia and the LEC, through this project, and based on recent experiences obtained there from, is building upon it. Given the positive impact assessment conducted just on just small sample of customers/beneficiaries during the previous LEAP urban pilot signaled the opportunity for scaling up or replicating the project in other parts of urban Liberia which is currently taking place. Lessons learned including challenges and constraints as well as other shortcomings experienced during the pilot implementation coupled with other current ones earlier mentioned is being considered for an improved implementation of the current GPOBA funded Project.

Title of Case Study Project:	Kenya Slum Electrification Project
City/Town:	Nairobi
Country:	Kenya
Contact Person's Details:	Harun Mwangi National Coordinator Rural and Slum Electrification Projects P. O. Box 10098 00100 Nairobi, Email: HMwangi@kplc.co.ke
Source(s) of information	Field Work

Background

Kenya Power and Lighting Company (KPLC) is responsible for managing, operating, and maintaining the transmission and distribution network, and selling power to retail customers. This includes responsibility for operating and maintaining the customer network, and selling power to customers connected under the rural electrification program.

The Kenyan Slum Context

Kenya is one of the fastest urbanizing countries in Sub-Saharan Africa. The country's informal or slum settlements are absorbing an increasing share of the expanding urban population and are home to the vast majority of the urban poor with inadequate access to basic services such as water, sanitation, electricity, and transportation. For example, a recent study of Nairobi slums[2] shows that only 22 percent of slum households have electricity connections (typically through informal/illegal providers). In comparison, for Nairobi as a whole, electricity access is 52 percent. The same study has revealed a correlation between access to electricity and the poverty level. Apart from raising living conditions, access to electricity can have direct impact on household income. For illustration, about 30 percent of households in Nairobi slums report that they operate an enterprise, and access to electricity can increase their productivity. Practically all residents in slums are classified as poor. About 73 percent of the dwellers in these settlements live on less than US$ 42 per adult equivalent per month, excluding rent.

Informal power providers have emerged in Kenya in response to lack of electricity, and the service is more expensive and is of poor quality. These systems are illegal and are maintained by criminal cartels, which add more insecurity to already very impoverished areas. The service is more expensive than KPLC tariff, is typically provided at poor quality and hazardous safety standards. For example, surveys of Nairobi slums carried out by KPLC in the framework of the preparation of their Connection Policy[3] show that peri-urban slum residents pay a very high proportion (33%) of their income for their energy related expenditures.

[2] World Bank: Kenya, Inside Informality: Poverty, Jobs, Housing and Services in Nairobi's Slums, Report No. 36347-KE, 2006

[3] KPLC: Review of Customer Connection Policy, 2006

Furthermore, increasing lower-income households' access to electricity is also challenged by the cost of initial connection charges for the electricity service provided by KPLC, which is often beyond many households' ability-to-pay. The costs are high because of the substantial investments needed to build new distribution facilities, combined with the high operating cost of electricity network.

The Government of Kenya (GoK)'s strategy for expanding electricity infrastructure to support the achievement of *Vision 2030* addresses, among others, issues including the equity of access to quality energy services at least cost in a sustainable manner. The Government's target is to reach 40% electrification rate by 2030, with an immediate target to connect one million households in the next five years.

Process and Innovation

With a country-wide connection rate of about 20%, and recognizing the special characteristics of slum residents, the Government and KPLC introduced a special reduced connection fee for slum amounting to KShs 1,160 (US$ 15) or about five percent of the connection cost in these settlements to encourage households to switch service from informal (illegal) service providers to KPLC. This significant reduction in the connection fee has made it more affordable and spurred demand for new connections.

However, the special fee has also created a funding gap. As the average connection costs in slum areas are almost US$ 400, the remaining US$ 380 per connection is underfunded. KPLC has used its own internal funds to close this gap, but progress has been slow, as funds are limited, and only a portion of these investments can be justified on commercial terms. The company is a partially private-owned utility, with its shares floated on Nairobi Securities Exchange, which has to operate on commercial principles and deliver expected returns on equity to its shareholders**.** KPLC has no legal obligation to connect poor slum residents, and its capacity to subsidize connections is therefore limited.

KPLC is interested in displacing informal/illegal electricity providers with its own service because electricity theft and poor technical conditions of illegal lines in poor areas do contribute to KPLC power system losses (17%). It creates danger and causes deaths among the slum dwellers and innocent visitors.

The design of the project incorporates innovative technical and financing components to fit the unique requirements of poor households living in informal areas in Kenya. These requirements include:

1. Limited ability to pay the full connection fee up front,
2. Serious security risk, and
3. Lack of legal options for electricity provision.

The estimated cost of connection in densely populated areas is US$ 395. User connection charges in slum areas have recently been mandated by the regulator US$ 15 – leaving a US$ 380 "funding gap".

The electricity connections will be part of the national electricity grid and must comply with all regulations set by the Energy Regulatory Commission and Kenya Power & Lighting.

Targeting

The project uses geographic targeting by focusing on the large Nairobi slums with one of the highest poverty levels in the country, as well as slum settlements in other counties. Practically all Kenyan slum residents can be classified as poor. The 2006 study of Nairobi slums[4] revealed that 73% of the slum dwellers live on less than US$ 42 per adult equivalent per month, excluding rent. The high rate of economic poverty is accompanied by extremely low living conditions and other forms of non-economic poverty. The housing units are mostly illegal, sub-standard in quality, and crowded. Yet the rents are high. An extraordinary 92% of the slum dwellers are rent-paying tenants (rather than "squatters" who own their units). Unit owners are mostly absentee landlords who seem to be operating a highly profitable business in providing shelter to the poor.

Slum dwellers have poor access to gainful employment[5]. About 49% of adult slum dwellers have regular or casual jobs and 19% work in a household micro-enterprise, but at least 26% are unemployed (49% of the women report that they are unemployed).

Slum dwellers pay a very high proportion of their income (33%) for energy-related expenditures, either to the informal providers or for kerosene, batteries, cooking fuels and other alternative sources of energy. According to the surveys carried out in the framework of the preparation of KPLC Connection Policy,[6] an average slum household pays KShs 2,400 (US$ 30) monthly for energy-related expenditures, of which about half can be substituted by electricity. For comparison, the same amount would buy over 160kWh of electricity under the current KPLC tariff structure. For many households, therefore, access to electricity may represent actual monetary savings of about US$ 15 per month (assuming average consumption of 94 kWh/month), while simultaneously improving their living conditions.

Target Customers

Customers are eligible for connection if they are a resident of an informal settlement; a total of 66,000 customers are expected to be connected to the electricity grid. This distinction is made by the Energy Regulatory Commission and KPLC. The table below shows KPLC's estimates for the number of households in several of the largest settlements which will receive a grid power connection[7]. KPLC began with connections in Kibera because of their past experience there, but then moved into making connections in slums across the counties in Kenya. There is a recently approved World Bank project focused on slum upgrading and the team will work to coordinate which slums are targeted by the projects where we think it will be beneficial.[8]

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[4] World Bank: Kenya, Inside Informality: Poverty, Jobs, Housing and Services in Nairobi's Slums, Report No. 36347-KE, 2006.

[5] A survey conducted as part of the preparation of this project showed a much higher percentage of residents with formal employment. There are two potential sources of this discrepancy: (1) surveying error due to the scope of households surveyed and (2) demographic shifts in Kibera resulting from the election violence in 2007/8.

[6] KPLC: Review of Customer Connection Policy, 2006.

[7] Not all households will be eligible because in some cases the very poor quality of the housing may make it unsafe to bring electricity.

[8] Some of these figures may be updated based on the 2009 census report.

Table 4: Estimates for the number of households to be connected to the Grid power

People Settlement	Expected Electrifiable Population	Name of Region
Kibera	300,000	Nairobi
Mathare Valley	75,000	
Korogcho	50,000	
Kariobangi	50,000	
Mukuru	25,000	
Nyarenda	75,000	Kisumu
Nyawita	50,000	
Muthata	25,000	
Kaptembwa	70,000	Nakuru
Kwa Roda	30,000	
Kiandutu	100,000	Thika
Kiawara	45,000	Nyeri
Majengo	35,000	
Total	**930,000**	

Kenya Power will be using GPS and Google Earth to tag (and locate for follow-up) the connections made under this program so it can be verified that the connections are within the informal areas.

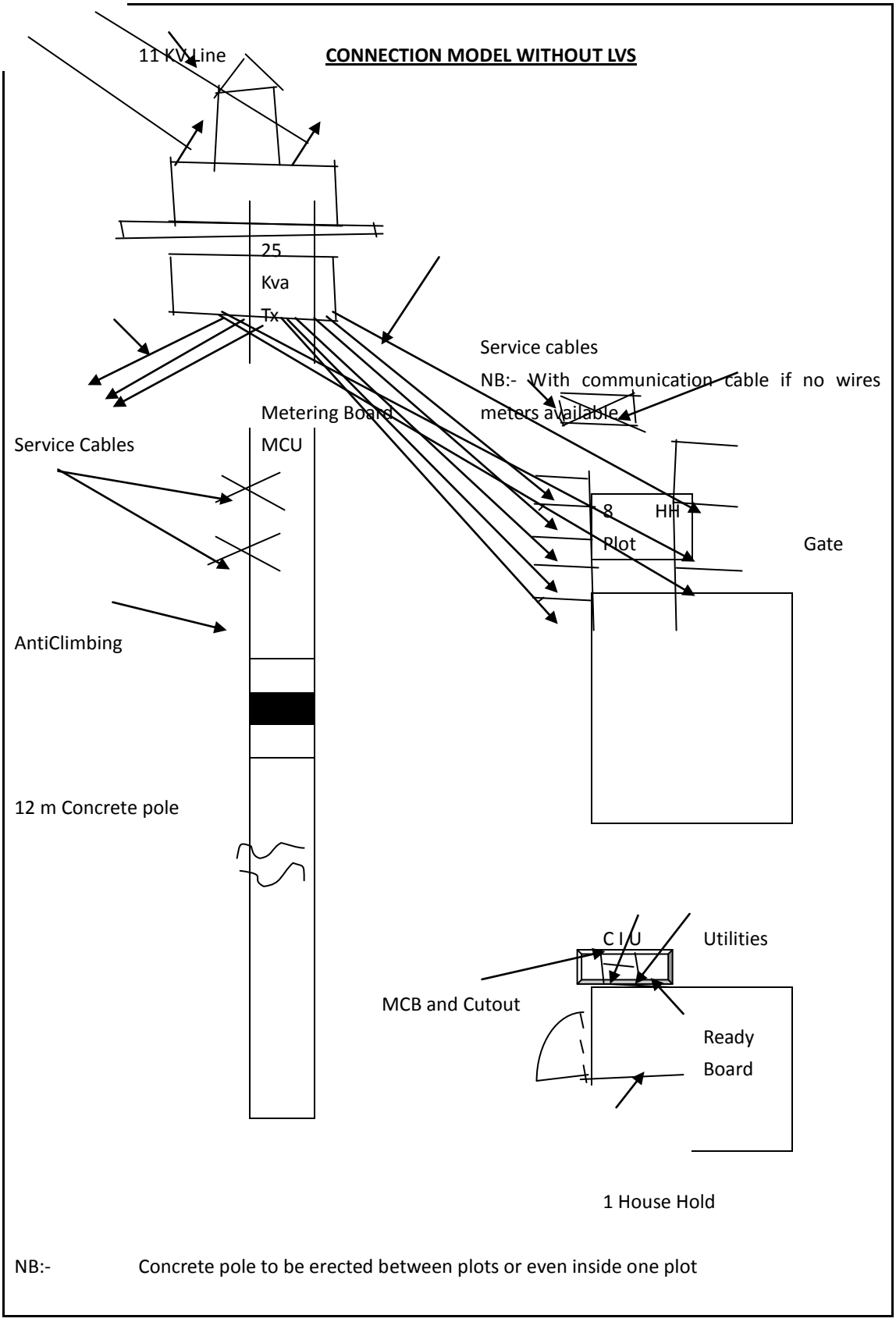
Description of Technology

KPLC is penetrating the slum areas using only single phase transformers erected on single concrete poles. The single phase transformers have low installation costs in terms of transportation, labor and maneuverability.

The maximum number of connections are approximately 17 customers connected to the biggest 25 Kva transformers. No new LV network will be constructed and only insulated service cables will come from the transformer installation[9]. Any unavoidable LV network will be constructed above the 11 KV High Voltage (HV) network. Where a three phase load is required which is rare, three single phase transformers will be installed. In this proposal, there will be no LV network for the power thieves to have access for connection. The small number of customers per transformer will create a sense of ownership to the customers who will offer its security from external/strange people intending to steal power or vandalize the transformer. The use of small size transformers will limit the number of affected customers if and when it fails.

Due to lack of wayleaves into most slum interiors, the proposed 11 KV HV network will mainly use fully insulated Aerial Bundles Cables (ABC). On the main streets where there are adequate wayleaves, the conventional bare conductor will be used. Use of insulated cables, though slightly expensive, will offer safe clearances to the houses and limits possible electric shocks and fires. The 11 KV ABC cables will over-fly the households. Concrete poles are being used because they do not catch fire and can be installed right inside the house holds. They will not rot with time and hence will not require to be replaced. The figure below shows the layout of the technical design.

[9] The LV network contributes to 65% of the total technical losses and it therefore makes sense to reduce it.



Technical design of connections

KPLC is installing pre-paid meters to enable customers access legal power in the small amounts they can afford.

The top of each pole will house one half of the "split" meter for each household (individual meters for each household). The other half of the meter will be part of a ready board installed in the house. The ready boards are well suited for slum settlements because they are low cost and do not require household wiring. Each board contains a light and an AC socket for plugging in appliances. KPLC has agreed to distribute CFL bulbs with the ready-boards.

With regard to the illegal connections already in the areas, disconnection of all illegal lines will be done hand in hand with the installation of the small size transformers and removal of the LV network so that those disconnected customers ready to pay are connected at the same time to the KPLC System instead of reverting to the cartels.

Financing the project

KPLC shall pre-finances the cost of connection, the World Bank (IDA) and Global Partnership Output Based Aid (GPOBA have agreed to reimburse KPLC based on the number of meters/customers connected. The OBA re-imbursement (subsidy) is intended to help bridge the gap from the regulated connection charge compared to the actual cost of connection. The following tables show the breakdown of costs and the subsidy contributions from GPOBA, IDA and KPLC. GPOBA and IDA are disbursed on an output basis, but the KPLC funds cover the installation cost.

Table 5: Connection cost break-down

Contributor	**Amount (KShs)**	**Amount (US$) (1US$=77.25 KShs)**	**Percent of total**
Household – Down payment	600 KShs	US$ 7.8	2 %
Household – Credit	560 KShs	US$ 7.2	2 %
Subsidy	29,360 KShs	US$ 380	96 %
Total	**30,520 KShs**	**US$ 395**	**100 %**

Table 6: Subsidy break-down

Contributor	**Amount (KShs)**	**Amount (US$)**	**Percent of total project costs**
GPOBA (grant)	5,794	US$ 75	19 %
IDA (credit to KPLC)	11,588	US$ 150	38 %
KPLC (internal funds)	12,259	US$ 155	39 %
Total	**29,360**	**380**	**96%**

Note: Box 1: Comparison of Living Conditions in the Slums of Nairobi and Dakar

Living Conditions in the Slums of Nairobi and Dakar[10]

A study analyzing development in the slums of Nairobi and Dakar finds, that incomes, education and jobs are not sufficient conditions to ensure high quality living conditions. Slum dwellers in Dakar have a far superior living standard compared to those in Nairobi, even though they are poorer and worse educated than their Kenyan counterparts. Assessing the slums against the criteria of dwelling unit, infrastructure, tenure, location and the slum environment, the living conditions in Nairobi's slums are worse than those in Dakar.

Infrastructure access in Nairobi is appalling and much lower than in Dakar, for instance, in Nairobi only 22% of slum dwellers have access to electricity and 19% have access to piped water (in-house connection or stand pipe. By contrast, 84% of Dakar's slum dwellers have piped water connection and 82% have electricity. Housing units in Nairobi are smaller, more crowded, and constructed with poorer building materials. Although land tenure is largely "informal" in both cities, the tenure mix—proportion of renters versus owners—and turnover rate differ significantly in the two cities. In Dakar where 75% of its residents own their slum dwelling, turnover averages 19 years in the same unit. In Nairobi, 92% of the residents are tenants and relocate in about 5 years. Combined with a complex political economy, this has created a situation in Nairobi in which none of the three stakeholders—the tenants, the absentee "shack owners," and the government as landowner—have been investing to improve the quality of living conditions in the slums.

[9]This comparison of living conditions in the slums of Nairobi, Kenya and Dakar, Senegal was adapted from work done Professor Gulyani et al during 2008.

The following photos show the slums where the electrification project is being carried out:

Photo 1: Kibera slum in Nairobi; Photo 2: A ready board; Photo 3: Witemere slum in Nyeri town; Photo 4: Resident of Witemere slum listening to the District Commissioner and the KPLC team

[10] This comparison of living conditions in the slums of Nairobi, Kenya and Dakar, Senegal was adapted from work done Professor Gulyani et al during 2008.

Summary of challenges experienced

- Land ownership wrangles
- Structure ownership disputes.
- Poor quality of building materials used for the structures
- Fluid movement of tenants
- No demarcation of roads, difficult to access and construct lines
- Illegal gangs resisting change (it would deprive them of their livelihood
- Lack of right of way
- Non ownership of the program
- Government intention to upgrade the slums
- Politicizing of the slum upgrading process.
- Poverty – inability to pay for the service

Photo 1: Delivery of the electricity poles in Mukuru slums in Nairobi. Photo 2: KPLC staff poses in front of the first pole erected in one of the slums in Nairobi. Photo 3: A typical power structure in the slums; Photo: 4: Power transformer.

Section 5: Solar Energy Application

Title of Case Study Project:	Using Solar Energy to Power Maarifa Centres
City/Town:	Nairobi
Country:	Kenya
Contact Person's Details:	Anthony Mugo Deputy Director Arid Lands Information Network P. O. Box 10098 00100 Nairobi Email: amugo@alin.net
Source(s) of information	Field Work

Background

Arid Lands Information Network (ALIN) is a Kenya-based international NGO that facilitates knowledge exchange among arid lands communities in Kenya, Uganda and Tanzania. Using a network of rural-based *Maarifa* (Knowledge) centers, ALIN has established close connections with rural communities, making the centers effective entry points for innovation that impact positively on the livelihoods of those communities. This approach has won global accolades. ALIN was the 2012 winner of the Global Access to Learning Award provided annually by the Bill & Melinda Gates Foundation and the 2012 winner of the Global UNESCO IPDC Prize for Rural Communications.

Process and Innovation

In order to ensure that marginalised communities can access the information and knowledge they need to improve their livelihoods, ALIN has set up 12 community knowledge centres known as Maarifa centres. Maarifa is Kiswahili for knowledge. A *Maarifa* center is a room or in some cases, a fabricated shipping container where communities access ICT information resources. The center is equipped with computers and internet access. It is an information hub where local knowledge is documented by communities with the support of field officers and shared widely. Each center has a rich information resource base that includes publications, newsletters, research reports and electronically stored information that includes CD ROMs, audiovisual material and compendiums. The ICT equipment enhances information access via the Internet, content creation and skills development among rural communities. *Maarifa* centres are operated by field officers employed by ALIN. An advisory committee drawn from a local group oversees the *Maarifa* center operations in collaboration with the field officer.

Two of the centres, Nguruman *Maarifa* Centre located in Kajiado Country in Kenya and Songambele *Maarifa* Center located in Kongwa District near Dodoma in Tanzania use solar power to run computers and other equipment such as printers and photocopying machines.

A Maarifa center offers the following services:

1. Easy access to information and knowledge resources through the internet. An article published by the New York Times profiled one of these knowledge centers, and the advantages that it provides to folks in the rural areas.
2. Capacity to develop local knowledge databases /reservoirs.
3. Improve community livelihoods through access to new knowledge and innovations.
4. Engage youth in productive activities and access to IT skills.
5. Increase institutional capacities – the field officers have trained staff from organizations affiliated or in the vicinity of the centers helping to build their IT and information management capacities.
6. Global presence: Nguruman Maarifa center was named as one among the 10 most remote parts of the world.
7. Capacity to develop online marketing portals enabling communities to trade globally.

Left Photo: An ALIN field officer assists a farmer with information at a Maarifa Centre; Right Photo: A fabricated shipping container to house a Maarifa center.

To establish a center in an area, ALIN usually works with a local organisation that has similar objectives usually a non-governmental or community-based organisation. Prior to setting up a center, an initial baseline survey is undertaken to determine current information needs of the community as well as existing channels of information access. A process of community mobilization follows. At this time, community members are informed about the intention of setting up the knowledge center and the services that the center will offer to their community. The use of ALIN's *Maarifa* centres is free of charge.

The initial community mobilization process is followed by an exercise that involves organizing community members into focal groups. The focal group supports the running of the center and rallies the community to a shared understanding that the center is co-owned by ALIN and the host community. The focal group then appoints an advisory committee with ALIN's facilitation ensuring the representation of women, youth and persons with disabilities. Since a *Maarifa* center can be located in a room or a fabricated container, the most suitable structure is determined depending on whether or not there is a hosting organisation or if it should be stand-alone.

The next step is to equip and furnish the center and progressively stock information including books, DVDs, CD ROMs, periodicals "how-to" manuals and leaflets. A field officer is then appointed to manage the center on a day to day basis.

Outcome of Project

The Nguruman *Maarifa* center has been in operation since 2006 while the Songambele *Maarifa* center is relatively new - set up in October 2012. It was relocated from Karagwe District in North Western Tanzania where it had operated since August 2011.

Sustainability

The fact that the centres are using renewable energy is a big positive factor in their sustainability. Since they are co-owned by the community and they help communities meet their livelihood needs, there is a high incentive for communities to sustain their operations.

They serve as neutral points for community members to convene and share information and knowledge including news. As such they have additional utility value that serves as an incentive for communities to sustain them.

Lessons Learned

- Community co-ownership of development initiatives is enhanced if they are involved in the conception and implementation of the initiative.
- Development initiatives that address local needs stand a better chance of succeeding when the community is given an opportunity to present their needs in such a manner that form the basis for the development intervention
- Creating knowledge centres empowers communities in many indirect ways including reduction of technophobia; spreading ICT skills and building community confidence to seek and demand services for which they are entitled to, hence catalyzing the development process.
- Availability of alternative energy sources facilitates delivery of services that would otherwise never be available in areas not served by grid power.

Transferability

In the experience of ALIN, transferring the knowledge center concept from one place to another is not difficult because they constitute a resource which is often missing in many rural communities and yet the need for such a resource is always high.

Section 6: Small Hydro Applications in Nigeria

Title of Case Study Project:	Local Fabrication of Turbine in Nigeria for Ikeji-Ile Small Hydropower
City/Town:	Akure, Ondo State
Country:	Nigeria
Contact Person's Details:	Engr. Dr. A. A. Esan UNIDO-Regional Centre for Small Hydropower in Africa, Abuja, Nigeria
Source(s) of Information:	Engineering Materials Development Institute (EMDI), Akure, Ondo State. National Agency for Science and Engineering Infrastructure (NASENI), Idu Industrial Area, P.M.B 391, Garki Abuja, Pt Entec, AG Switzerland

Background

Energy is crucial and indispensable ingredient for economic developemnt as it is a major component input in the production of goods and services at a cheaper rate for sustainable development.

Energy is so crucial that the classification of the world into developed, emerging and developing (under-developed) economies matches easily the capabilities of these three different classes/groups to harness their various sources of energy. Africa is an important member of the developing economy with its population of 800 million people.

Developing and emerging economies face a two-fold energy challenge in the 21st Century: Meeting the needs of billions of people who still lack access to reliable, affordable and socially acceptable energy services is a pre-requisite to alleviating extreme poverty and meeting other societal developmental goals.

Secondly, greenhouse gas emissions from developing countries are growing rapidly and are contributing to environmental problems, such as climate change and poor air quality that put the health and prosperity of the majority poor in developing countries.

Historically, humanity's use of energy has been marked by four broad trends which have largely been positive. The problem is that the rate of technology imrprovement has not been sufficient to keep pace with the negative consequences of rapid growth in energy demand. Development of indigenous renewable energy industires will have the additional benefit of creating new economic opportunities, reducing countries' exposure to volatile world energy markets and conserving resources for internal investment by curbing outlays for important fuel/items.

Small hydropower (SHP) is considered as a means of achieving rural industrialization and poverty reduction in developing countries. Having identified several barriers to small hydropower development in Nigeria and neighouring countries, United Nations Industrial Development Organization (UNIDO) took various steps to build capacity for enabling self-sufficiency in SHP development. For that purpose, this project was initiated to develop local manufacturing capabilities for turbines and control systems. The project focused on transfer of technology of Cross flow turbines for capacity of 100kW and below. Licenses, designs and drawings were provided by ENTEC AG Switzerland to select institutions in Nigeria such as National Agency for Science and

Engineering Infrastructure (NASENI) and Project Development Institute (PRODA). Hands on practical training was provided to the trainees at the ENTEC turbine manufacturing facility in Bandung, Indonesia.

This case study project presents some design criteria and manufacturing processes of the second 35kW capacity turbine carried out in Nigeria by the Trainees organisations involved in the training programme, i.e UNIDO Regional Centre for Small Hydropower in Africa (UNIDO-RC SHP), NASENI, and PRODA. NASENI and PRODA are Federal Government parastatals under the Federal Ministry of Science and Technology.

Process and Innovation

Staff of UNIDO-RC-SHP, NASENI and PRODA were on training in Indonasia for the manufacture of Cross flow turbine. The participants were given intensive training on the fabrication of the cross flow turbine after which they participated in the fabrication of one unit of the T15 Cross flow turbine. The aim was that after acquiring relevant skills in Bandung, they should return to Nigeria and fabricate the second unit to be installed at the Ikeji-Ile SHP. The cross-flow turbines technology was transferred to NASENI through licensing. Designs, drawings and 2 set of tools and jigs where equally provided for the local fabrication in Nigeria. Below are the pictures during the training in Bandung, Indinesia.

The team returned to Nigeria and sucessfully fabricated the second unit of the T15 Cross flow turbine at the EMDI workshop in Akure, Ondo State, Nigeria. Pictures taken during the fabrication process, both in Bandung Indonesia and EMDI Akure are shown below.

Indonesia: Turbine housing and runner; ***Indonesia: Turbine manufacture;*** *Fabricated CrossFlow turbine in EMDI*

Outcome of the project

The project will have tremendous impact on the lives of the people and the government of Nigeria and Africa at large as SHP scale-up is envisioned. The power generated by installation of the turbines at Ikeji-Ile SHP will enhance the lives of the people and the fact that this turbines are locally fabricated will bring about a great boost in the economy of the country and at the same time impact on the energy cost-tarrif.

The benefits envisaged from the construction of this turbine and its installation at the Ikeji-Ile small hydropower scheme can be categorized into local and national benefits.

Local Benefits

- Enhances the development of cottage industries and commercial enterprise, which will utilize the electricity generated from the SHP for their operations.
- Job creation and improved standard of living as well as poverty alleviation for the members of the benefiting communities.
- Financial benefits as income realized from the sale of electricity to the consumers.
- Enhancement of agro-allied industries such as processing of cassava, grains, rice – milling etc.

National Benefits

- The creation of awareness for small hydro power schemes as an alternative, effective and more reliable source of power for rural communities, state and the country at large.
- Generation of electricity in an eco-friendly way as electricity will be supplied without polluting the environment.
- Subsequent indigenous manufacture of the turbines will impact on the Gross Domestic Product (GDP) of the country.

Sustainability

Environmental: Power generated from the fabricated turbine is eco-friendly in the sense that, it does not emit green house gases and the source of energy is renewable. The electricity generated will be used locally and this will enable the local communities have access to clean energy and creatse a better alternative for them to shift from the crude and inefficient energy methods like fire wood for cooking and kerosine for lighting. By reducing the dependence on fire wood, it will reduce the rate of deforestation and thereby reducing the green-house-gas-emission effect and making the environment more friendly.

Finacial Sustainability: The electricty generated from the projects where such turbines are to be installed will be sold to the community to generate revenue. The average cost of electricty in Nigeria is about US$ 0.083/kWh, this cost is reasonable to recoup the investment cost of the project within the shortess possible time. Generaly, when SHP equipment are manufactured locally, it will “leap-frog” the process of rural

electrification and further bring down the per kilowatt installation cost of Small Hydro Power plants.

Social and Economic: When the local people in the communities are involved in the development of Small Hydro projects and the local content of the projects increases, installation costs are reduced. Security of equipment and investment are also guaranteed, as such are viewed as community investment. The technology is not sophisticated and the fabrication process when fully domesticated will carry along the skilled, semi-skilled and unskilled person including women but more importantly, the energy generated from the turbine will relieve the women from the burden of searching for firewood or queing up in filling stations for a long period of time in search for enrgy for home use.

Institutional: The National Electricity Regulatory Commission (NERC) has recently reviewed the price of electricity in the country according to its Multi-Year Tarrif Order (MYTO) mechanism which is the standard guiding the pricing of electricity in the country. According to this review, customers within this area are to pay $0.083/kwhr of energy which is favourable to the recovery of the investment in the project. There is or a regulation in favour of Small Hydropower that; any hydropower scheme generating between 0-1000kW of power does not require any licence before operating in the country. The turbine which license is obtained is just 35kW which far below the licensing range of NERC and therfore makes it easy for implementation.

Lessons Learned

After the sucessfull completion of this project, several lessons were learned and are further recommended as corrective measures in the course of replication of similar projects in Nigeria and Africa. This include:

i. Proper site investigation and design will determine the suitability of the turbine and hence the efficiency will as well be improved. Any site intended for development and installation of this type of turbine should be properly studied by experts in SHP design and developemnt.
ii. It will be faster and cheaper if the fabrication of the various comoponents can be shared among professional to allow for professional to specialize in some components.
iii. Involvement of the private sector in the fabrication of this turbines will boast the market for turbine fabrication.

Transferability

Nigeria and Africa at large has a large potential of generating electricity through the Small Hydropower Schemes. Nigeria alone has an identified potential of 3500MW of SHP which exist on already completed dams and virgin rivers and streamsand the potential well distributed across the country.

The T15 Crossflow turbine was fabricated for Ikeji-Ile small hydropower plant but can also fit into several other sites in Nigeria and across Africa.

Replicating this project in Africa is highly feasible and advisable to help tackle the challenge of blackouts on the continents. Countries like China and Brazil have achieved huge succes in the implementation of SHP and have since being reaping the benefits just because they have the capacity for indegenous fabrication of equipment and they are making use of it.

Title of Case Study Project:	Ikeji-Ile, Ijesha Pilot Small Hydropower Power
City/Town:	Ira/ Ikeji-Ile, Ijesha
Country:	Nigeria
Contact Person's Details:	Engr (Dr.) A. A. Esan Technical Director/CEO Unido RC-SHP in Africa WAEC Building, Plot 10, Zambezi Crescent Maitama P.M.B 175, Garki Abuja, Nigeria 08056072928
Source(s) of Information:	Unido Regional Centre for Small Hydropower in Africa, Abuja, Nigeria. Osun State Water Corporation, Osogbo Ministry of Works and Transport Osogbo, Osun State.

Background

Traditionally, the people of Ikeji-Ile/Ira engage in Agriculture and produce sufficient food as well as cash crops as raw materials for Agro-allied industries. Large segment of the populace are traders and artisans. Other occupations include hand- weaving and wood carving among others, Yams, maize; cassava, plantain, kola-nuts, and cocoa are major cash crops in the locality and the state. These agro products are consumed and sold as raw materials either for food or for other factories as raw materials outside the vicinity. The major problem has been the epileptic nature of the power supply to the community by PHCN, the only power utility.

River Okun whose source is from Ekiti state meanders through Ikeji-lle Ijesha and serves as the water source used for both water supply and generation.

The people in Ikeji-lle and Ira-Ijesha with a combined population of 10,089(2008) are Yoruba, while the predominant religions are Christianity and Islam. The two communities in Osun state located in the South-Western part of Nigeria has an area of approximately 14,875 km^2.

Over two billion people across the globe still are without access to electricity. Lack of this creates an immense barrier to the economic and social development of rural communities like, Ikeji-lle and Ira. Migration by youth from rural to urban area in search of ICT can be halted in these communities by providing civic centers in the villages where internet facilities can be provide and energized through Small Hydropower (SHP) as a renewable energy source is proven, clean and environmentally benign.

The Osun State Government plan is to set up artisan village industrial park to utilize the electrical power produced by Ikeji-lle SHP. The objective of these initiatives is:

1. To construct a Small Hydropower scheme for generating electricity to Ikeji-lle Ijesha community and environs in an environmentally friendly way and at cheap and affordable price.
2. To provide reliable power (electricity) to Ikeji-lle Ijesha, so that it can meet its expected development programmes.

3. To improve the quality of life and economic situations of the rural communities, develop cottage industries to provide jobs for rural dwellers by the provision of electricity to remote rural communities and improve the skills by local artisans and technicians in Oriade LGA, Osun state, where SHP project is located.
4. To create awareness and knowledge on mini Hydro technology for electricity generation for large cooperative farms, schools, villages and remote communities so as to ensure improved living standards and effective health facilities in rural areas.
5. To seek avenues for partnership and collaboration with the government of Osun state in the promotion of SHP projects for sustainable development of rural communities in Osun state.
6. To act as catalyst for large scale use of these technologies in Osun state with special emphasis on stimulating private sector participation (PSP).
7. To promote market development for SHP equipment through support for pilot/commercial project, financing and training of end-users.

The Unido-NASENI programme on local fabrication of turbine supplied the cross flow turbine used in the project, while the Osun state government funded the equipment installation and civil works components of the project.

Right from the inception of the project the community leaders (The obas and chiefs) and women organization in the community were involved in the project implementation programme, through consultancies meetings and decision making on the location of the project.

The Osun state government awarded the civil construction component to Sparta Engineers and according to the design specifications.

Process and Innovation

The contract for the construction was awarded by the state government to Sparta Construction Engineers on 15th March 2012. Ministry of works and Transport is the supervising Ministry and coordinator while Unido Regional Center for Small Hydropower in Africa is the consultant for the supervision the construction of the project.

The major challenges of the project are:

1. The terrain between the forebay and the power house, which is hilly.
2. The geology and morphology of the terrain, especially in the location of forebay, which is rocky.

The alignment of the penstock route adopted the meandering route of the river due to steep nature of the terrain between the forebay and the power house. Support, piers and anchors were used for the stability of the penstock. There was considerable rock blasting at the location of the forebay for it to be properly positioned /sited. The community youths were employed as laborers, welders and masons at the site during construction.

There were frequent consultation between UNIDO RC SHP, Sparta Engineers and Osun state Ministry of works and housing on daily decision making on the project.

Outcome of the Project

This project is on-going and it is expected planned commissioning in December 2012. The effect of the project on the community will then be monitored, as soon as it becomes operational /functional.

Construction Photos

Photos at different stages of construction and sensitization awareness creation process shown below.

Ikeji Ile Expert with Client during site visit Visit to Kabiyesi of Ikeji Ile during handover of site to Sparta Engineers

Experts taking flow of the River handover of site to Sparta Engineers

Site visit during the handover of site to contractor

Form work for tailrace canal

Setting out of the power house floor

Locating the position of Turbine

Power Evacuation poles

Sustainability

The business model recommended for the SHP scheme is a public private partnership (PPP) with great involvement of the benefiting communities. The management of the scheme will likely be a collective/cooperative participatory between the organized private sector (OPS) and the Osun state government.

The scheme shall be sustained mainly from revenue generated from the collection of tariffs on electricity consumed by residential/commercial loads and the technology incubation center. The current domestic tariff charged by PHCN is N12.30/kwh, as approved by the regulator (NERC).

Some members of the community, especially the educated youth will be trained to operate, maintain and manage the scheme.

Lessons learned

1. The initial cooperation between the Osun state, Ministry of works and housing was transferred to the contractor at the commencement of construction. This is laudable as issues are resolved quickly between the tripartite bodies easily.
2. Early involvement of the traditional rulers of the two major communities Ikeji-lle and Ira helped to resolve issues that arose from claims from land of the penstock route.
3. It is important that contractors that are competent are given job on SHP project. This has helped the UNIDO RC-SHP to ease communication between project supervisors, UNIDO RC-SHP and the contractor handling the project.

Transferability

The project components including the following:

1. Design
2. Fabrication of turbine
3. Installation of structures

Installation of turbines was carried out by Nigerians and within Nigeria. The project can therefore be easily replicated anywhere in Nigeria, the W.A sub-region and Africa, in general.

Title of Case Study Project:	Waya Dam Small Hydropower Project
City/Town:	Bauchi, Bauchi State
Country:	Nigeria
Contact Person's Details:	Engr (Dr.) Ayodele Afolabi Esan UNIDO-RCH-SHP in Africa, Maitama, Abuja P.M.B., Garki, Abuja.
Source(s) of Information:	UNIDO-RCH-SHP Abuja, Upper Benue River Basin Developement Authority, Bauch State Government.

Background

Small hydropower (SHP) is considered as a means of achieving rural industrialization and poverty reduction in developing countries. Having identified several barriers to small hydropower developement in Nigeria and neighbouring countries, UNIDO has taken various steps in capacity building, awareness creation and sensitization for enabling self-sufficiency in SHP development.

In November 2002, a memorandum of understanding (MOU) was signed between IC-SHP Hangzhou, Peoples Republic of China and Energy Commission of Nigeria (ECN) for the development of small/mini/and micro hydropower through technical co-operation, capacity building and establishment of pilot demostration projects. In this regard thirteen potential sites were surveyed across the country within five River Basin Development Authorities. The outcome provided two sites, one of which is Waya dam, under Upper Benue River Basin Development Authority, for the pilot demonstration project.

Waya Dam Small Hydropower Project is integrated into the Waya dam which was constructed by Upper Benue River Basin Development Authority (UBRBDA) with a storage capacity of Thirty (30) million cubic meters of water to principally provide water for irrigation of 2,000 hectares of land, municipal water supply and fishery production. The project is located 20km from Bauchi, off Bauchi-Maiduguri road.

A cost sharing arrangement was put in place for all the major stakeholders: UNIDO, VIENNA procured the equipment; the Upper Benue River Basin Development Authority constructed the power house, penstock and rehabilitation of the dam; UNIDO-IC-SHP, Hangzhou, supplied the turbines, generator and control system including installation experts; Bauchi State Government-Rural Electrification Board constructed the transmission and distribution network to four villages close to the dam site, while Energy Commission of Nigeria transported the equipment from port to Waya Dam, Bauchi.

The project has an installed capaity of 150kW of power with an annual energy generation of 1,080,000kWh/yr and it is basically targeted to provide electricity to Kimni, Gilliri and Yuli villages that are located within the 5km radius of the pilot project. An estimated population of 2,250 persons and average of 336households (1991 census), the inhabitants of these communities are basically farmers. Before the introduction of this project, there was no electricity supply to the area, the community was living 100% on traditional energy such as firewood to meet their energy needs for cooking and kerosine for ligthing. The use of these sources were highly inefficient, unhealthy to human and was causing harm to the environment resulting in deforestation and green house gas emmission. The rural women within the community suffered the

hardship of going long distances to get firewood and expose them selves to the excessive heat produced using the fire wood for cooking and exposure to the carbon-dioxide emmitted from the kerosine used for ligthing.

The SHP pilot project civil works construction started in january 2006 and was completed in December 2007. The installation and test running of turbines and generators was completed in December 2007 by installation experts from IC-SHP Hangzhou, together with two of the on-the job trainees from two river basins, who had earlier been trained by IC-SHP, Hangzhou, China. The total cost of the SHP plant both civil and electro-mechanical components is estimated as ₦56.25million (US$ 356,012.66). The figures below show the progress of work at the site.

The objectives of Waya dam small hydropower project set out by UNIDO was;

1. to establish a pilot Small Hydropower project for generating electricity in an environmentally friendly way,
2. to create awareness on the use of this type of SHP scheme in meeting the energy needs of the rural communities in Africa,
3. to provide electricity to Kimni and Gilliri villages to enhance the living standard of the people,
4. to harness the untapped potential of Waya dam which was constructed several years without being put to maximum use, and
5. to reduce technical, institutional and informational barriers to the implementation of community based micro-hydropower schemes.

Integrating an SHP project to Waya Dam was projected to supply the communities with electricity for lighting, semi-food processing, food preservation and enhance communication and entertainment through veiwing centres.

Process and Innovation

The pilot SHP demonstration project was indentified as a result of reconnaisance survey by Engr. (Dr.) A. A. Esan from Energy Commision of Nigeria ECN and Mr. Jossy Thomas from (UNIDO) office Abuja, Nigeria, in March, 2003.

An installation expert from IC-SHP Hangzhou and two of the on-the-job trainees from two River Basins Development Authorities in Nigeria, Upper Benue, Yola and Lower Benue, Makurdi, Fig 2.1 and 2.2 who had earlier been trained ats IC-SHP Hangzhou, China

Supply of electricity to the rural communities with an estimated population of over 2,250 people and 336 households (Kimni, Gilliri and Yuli) started in January 2008, Total load demand for the communities was estimated at 150.5kW to cover only the Kimni and Gilliri communities.

Installation of Turbines by Trainee Engineers and Technicians

The State Government Team Inspect The Project During Equipment Installation

The Community

The community was fully educated on the need and benefits of the SHP project. The community was involved in the implementation process through unskilled labour needed during the construction work.

The Community During the Equipment Installation Process

Challenges

Planning, implementation and commissioning of the project was not devoid of challenges as it is with every other project. The major challenges encountered during the process includes:

i. Insufficiency of funds,
ii. Community interuptions as a result of compensation settlement and poor awareness views on SHP
iii. Lack of specialized/Skilled personnels
iv. Logistics

The challenges were however overcomed as a result of effective project management and implementation strategies. Community eligthment was also carried out to improve the awareness of the people for smooth projects implementation.

Methodology/Institutional Involvement

The methodology employed in project implementation was the partnership and cost sharing arrangement, that involved many stakeholders handling different activities and shown in the table below.

Table 7: Schedule of works handled by different Stakeholders

S/N	TASK	RESPONSIBLE AGENCY
1	Electro-mechanical Equipment procurement	UNIDO, Vienna
2	SHP Civil works construction	Federal Government of Nigeria through UBRBDA
3	Supply and Equipment Installation	IC-SHP* Hangzhou, China
4	Transmission and Distribution networks	Bauchi State government
5	Transportation of equipment from sea port to site	Energy Commission of Nigeria
6	Provision of secuirity	Community

*International Centre for Small Hydropower

Project Outcomes

Three communities presently are benefiting from the electricity generated, while the cottage industries are yet to commence operations. Plans are on for the irrigation activities that will produce the agro raw materials for the cottage industries.

Waya dam SHP is now functional and has enhanced the standard of living of the people and has improved thier lives in so many ways including:

i. Ease of food processing (Cassava grating for gari processing, and corn milling),
ii. Fish preservation (Refrigeration),
iii. Ligthing,
iv. Communication and entertainment (viewing centres),
v. Reduce dependence on fire wood for daily cooking,
vi. Stimulate developemnt of cottage industries and commercial enterprises which are ultilizing the electricity generated for their operations,
vii. Created jobs and improved standard of living as well as poverty alleviation for the members of the benefiting communities,
viii. Generate electricity in an eco-friendly way as electricty is being supplied without carbon dioxide and other green house gas emmissions, and
ix. Reductions in health hazards as most households have electricity repplacing kerosine lamps. This reduces the risk of respiratory and eye problems.

Completed Waya Project Showing the installed Francis turbine

Completed Waya Project Showing Power House and Transformer

Inspection of power house by Officials from UNIDO Hqts

Installation of transmission grid in progress

Visit by UNIDO officials to benefitting communities

Stakeholder vist to the completed project site and community

Sustainability

The sustainability methods employed in the operations of the project are as follows:

a. *Operations:*

i. Operation and maintenance iss carried out by the community

ii. Elctricity users association established to collect tarrif of electricity consumed

b. *Environmental:* There is a reduction in the use of fire wood and Kerosine in the area, hence the threat on deforestation is being tackled together with the pollution in the environment by consuming kerosine. Most of the inhabitants have adopted sthe use of electricity for ligthing instead of kerosine.

c. *Financial:* The investment cost of the project is to be recovered in ten years period from the sales of electricity to the communities at the cost of US$ 0.043/kWh.

d. Social and Economic Sustainability:

The soci-economic indicators of the project are as shown below:

Total project cost	=	US$ 478,000.00
Estimated project life	=	30 years
Total annual energy generated	=	1,080,000kWh/yr
Cost of energy	=	US$ 0.043/kWh
Annual revenue generation	=	US$ 45,360/yr
Benefit cost analysis ratio	=	1:3
Pay-back period	=	10 yrs

e. *Institutional:* The National Electricity Regulatory Commission (NERC) recently reviewed the price of electricity in its Multi-Year Tarrif Order (MYTO), which is the standard guide for the pricing of electricity in the country. According to this review, customers within this area are to pay US$ 0.083/kWhr of energy which is favourable to the recovery of the investment in the project.

f. *Training of Personnel:* UNIDO Regional Centre for Small Hydropower in Africa in 2011 organized a training on Operation and Maintenance of Small Hydropower Project for engineers and technicians in Nigeria and Waya Dam SHP was the venue and case study. The training was to use the success story to sensitize and create awareness in the people. It was equally to make available knowledge on how to maintain functional SHP plant thereby building the required manpower skills for operating and managing SHPs.

Training Session on O&M at Waya Dam SHP Project

Lessons Learned

Since the sucessfull completion of the Waya Dam SHP project, some lessons have crystalized and include:

i. The use of Community based Organisations (CBOs) in educating the community and by giving them the responsibility of assigning them the security of the project site.
ii. The decision to consume the generated power locally and convincing the cottage industry entrepreneurs to relocate or open new shops within the load centres. By this arrangement, the cost of transmitting the power through long distances and the resulting voltage losses will be saved. It is therefore necessary to ensure that for all SHP projects, the load centres demand are met fully before exporting the energy to other places if there is excess, for energy trade.
iii. Public Private Partnership arrangement should be encouraged in the implementation of SHP project with the possibilty of involving the local community to buy shares in the project to become part of the ownership structure of the projec. This strategy can create additional earnings from the project to ensure the sustainability of the project.

Transferability

Nigeria and Africa at large has a large potential for generating electricity from Small Hydropower Schemes. Nigeria alone has an identified potential of 3500MW of SHP which exist on already completed dams and virgin rivers and streams well distributed across the country.

The gestation period of SHP is relatively small as can be seen from the Waya dam case. It takes about 1-2yrs to complete a project and the cost of operation of SHP is also very minimal because it does not require fueling and the routine maintenance is also minimal as a result of miniature and simple components involved.

Replicating this scheme in Africa is highly feasible and advisable to help tackle the challenge of energy poverty in the continent. Countries like China and Brazil have achieved great succes in the implementation of SHP and have since being reaping the benefits.

Section 7: Climate Change Project in Cameroon

Title of Case Study Project:	Climate Change Project
City/Town:	Douala
Country:	Cameroon
Contact Person's Details:	Lucien Yoppa, FCTV Cameroon, Office Phone: (+237) 33 20 94 32 Mobile: (+237) 79 74 64 25, 99 73 52 07 Email: lucienyoppa@live.fr Office Email: terrevivantecameroun@yahoo.fr website: www.fctvcameroun.org
Source(s) of information	Field Work

Background

The climate change project is an opportunity for slum dwellers in Douala to mitigate climate change by creating business opportunities that will contribute in improving their living conditions through the low carbon energy market.

This project is managed in close collaboration with the following partners:

1. Comic Relief - the main project's sponsor
2. Living Earth Foundation, UK - responsible for developing a climate change strategy and acting as technical advisor
3. Centre International de Promotion et de Recuperation (CIPRE), in charge of providing technical training to companies and local governments
4. Living Earth Foundation of Nigeria and Living Earth Foundation of Uganda., information sharing partners.

The project started on 1st February, 2011 and is scheduled to run through 31st January, 2015. It is now in the implementation phase.

In Cameroon, as in many other African countries, the effects of climate change are becoming very apparent, for example, flooding; high temperatures and shortage of drinking water, excessive salinity of sea water around Douala etc. These problems are having untold effects on the population, and it is within this background the FCTV is working alongside the local population to mitigate some of these challenges.

Process and Innovation

The main activities of this project were, firstly, e*nergy awareness raising in Douala* - campaigns to raise awareness on green energy (briquettes from biomass) and climate change are integrated in civic education programme targeted at slum dwellers, CSOs and policy makers. Secondly, d*eveloping a climate change strategy through i*ntroduction of low carbon energy options like renewable energy technologies to mitigate and adapt to climate change issues.

Outcome of Project

At the close of the project in 2015, at least 3,000 slum dwellers, mainly female headed households and 6 public institutions (schools, dispensaries, and local government offices) in Douala will have adopted one new low carbon product to provide sustainable energy. A green energy market was established.

Sustainability

Environmental - This project will contribute in the reduction of GHGs emission like the use of low carbon emission technologies like improved cookstoves, solar lights etc.; and above all improve environmental sanitation.

Financial - The project will deliver business management training and advice to 170 entrepreneurs for start-up activities in the green energy sector.

Social and Economic - Focusing on female headed households will enable the project to be sustainable because it has been demonstrated that females perform well in their own businesses, and although they have limited access to financial resource.

Institutional - Local governments will be encouraged to seek green solutions and even adopt green technologies.

Lessons Learned

This climate change project takes its cue from the experience of LEF in Kampala with the promotion of biomass fuel briquette market which has had a number of positive outcomes: reduction of waste to landfill; increased uptake of low carbon energy; reduced household energy bills; improved household health, and employment and income creation.

Transferability

Even though there is no clear national policy on climate change in Cameroon, we will help the population to work with the private sectors to adapt and mitigate climate change by adopting a pro-business format that will yield profit.

Section 8: Energy Efficiency

Title of Case Study Project:	**Improved Fish Smoking Ovens in Senegal**
City/Town:	Dakar
Country:	Senegal
Contact Person's Details:	Touria Dafrallah ENDA Energy Tel: +221 33 822 2496 Email: touria.dafrallah@hotmail.com
Source(s) of information	Field Work

Background

They are built from cement bricks not resistant to high temperatures. These poorly dimensioned ovens (lengths, width, height and access ports) cause enormous losses of heat and products of lower quality. Apart from leading to very difficult working conditions, the ovens do not last for more than one term. Subsequently, it is necessary to repair them in order to initiate a new production season. Furthermore, these ovens pose risks of air pollution, burns and injuries for the women involved in the processing.

Traditional fish smoking kilns in use before introduction of the improved kilns

Process and Innovation

The Foundiougne mutual for savings and loans (MECIF in central Senegal) launched the renewable energy project for economic empowerment of women in the fishing industry. The project involves equipping women with improved ovens for smoking fish in the islands of Saloum in Senegal. MECIF received US$82,000 from Sen'finance under African Rural Energy Enterprise Development Programme (AREED) warranty for improved smoking ovens as well as working capital.

The improved ovens are constructed by reinforced concrete and stabilized with iron. The foundation is also constructed using reinforced concrete. The appropriate dimensions are thus standardized: Length = 2.32m; width = 1.26cm; height = 95cm. The ovens are equipped with access ports, lids and gratings. They do hardly

have any heat escaping, hence reducing the fuel consumption, cooking takes less time, and the final products are of high quality. The kilns have more than 10 year's lifetime.

Outcome of the Project

Improved fish smoking kilns which have been reinforced with concrete.

Improved smoking ovens have allowed women to increase their production capacity by as much as five times and more; it has reduced wood consumption by close to 30% and thus reducing the pressure on the mangrove ecosystem. It has also led to an improvement in the quality of products and save time in the smoking process.

Sustainability

The various training courses initiated by ENDA-Energy have developed a sustainable value chain and better positioned women in the local economic system.

Lessons learned

Technologies that have visible impacts are greatly embraced by the target group. For instance, with the improved kilns, the reduction of smoke has made it more acceptable to women who operate them.

Transferability

The improved fish smoking kiln is low-tech and can be constructed by any mason. Fishing communities in sub-Sahara Africa and other developing countries can adopt this technology.

Section 9: Pro-Poor Mobility

Title of Case Study Project:	Dipbahan Rickshaw Bank Project
City/Town:	Guwahati
Country:	India
Contact Person's Details:	Dr Pradip Kumar Sarmah (Founder, Centre for Rural Development, Guwahati)
Source(s) of information	• Arora A, M Jarnhammar, and F Jawed. 2010. "*Green and Pro-Poor? The role of Informal Public Transport in India*" Presented in the Conference on the 'The Environments of the Poor', 24-26 November 2010, New Delhi. • Anju Mohan. *Dipbahan: Bank of Ideas*, 2012. Available at http://www.ha rmony indi a . o r g /hpo r t a l /Vi r tua lPa g eVi ew. j sp?pa g e _id=18682&index1=2. • Pradip Kumar Sarmah. "Rickshaw Bank: Empowering the Poor through Asset Ownership", Journal – Innovation: Technology, Governance, • Globalization. Special edition for Tech4Society: A celebration of Ashoka-Lemelson Fellows. MIT Press, Hyderabad, 2010.

Background

In most small- and medium-sized cities of India, cycle rickshaws play an important role in meeting the mobility needs of the population. There are around 10 million rickshaw drivers in India.

Typically, in Indian cities, cycle rickshaw drivers do not own the rickshaw. Some studies suggest that almost 95% of them hire the rickshaws on a daily basis and pay a rent. In this type of a financial arrangement the driver usually pays a fixed rent to the owner and the rest of his earnings become his income. The fixed rents generally comprise one-third of the income of cycle rickshaw drivers, or sometimes even more, thus reducing their net earnings significantly. According to a study, many of these rickshaw drivers spend around Rs. 90 000 as rental over a duration of 10 years, which is many times, the cost of a rickshaw. As a result, the working conditions become highly exploitative for the rickshaw drivers as they tend to work overtime (12–14 hours) to make a decent living. The typical income per day ranges from 50-80 INR (US$1 to US$1.60). These drivers continue to remain below the poverty line and without any social security and with no access to formal finance.

"Dipbahan Cycle Rickshaw Bank Project" was initiated in 2010 in Guwahati by Dr Pradip Kumar Sarmah (Founder, Centre for Rural Development, Guwahati) to enable the cycle rickshaw drivers to own a cycle rickshaw through a simple financial scheme. In order to ease the physical efforts of the rickshaw drivers and to increase the comfort of the passengers, design changes were made to the cycle rickshaw. The ownership of these newly designed rickshaws was then transferred to the rickshaw drivers at a minimal daily installment payment through micro asset loans. In addition, social recognition was conferred to this section of the society through issuance of licenses, photo identity cards and uniforms. Other initiatives included provision of

insurance, health care, cooking gas and training programs.

The organization has been able to access finance easily because of various partnerships and collaborations with banks like Punjab National Bank (PNB) which has come up with its own scheme for rickshaw finance. The others partners are AIDS Control Society of Assam and GOONJ, an NGO based in Delhi.

A cycle rickshaw in Guwahati

Process and Innovation

Under this scheme, the rickshaw driver is required to pay a sum of US$ 0.75 (INR 40) per day towards the cost of the cycle rickshaw, and within a year or so he is able to own one. The main challenge faced by finance institutions/banks in providing loan to rickshaw drivers was that they had no security and could not provide assurances of paying back the loan. “Dipbahan Cycle Rickshaw Bank Project” used social networking among the rickshaw drivers to address this challenge. Groups of rickshaw members (5 members each) were formed at the members’ discretion to bring in group liability. The formation of such groups was compulsory to qualify for a loan.

The design of the cycle rickshaws has also been improved through this scheme and new light weight, comfortable, and cost-effective cycle rickshaws have been developed in association with the Indian Institute of Technology (IIT), Guwahati. This was enabled through stakeholder consultations with the rickshaw drivers

The reluctance of the banks to provide finance for this project was overcome by starting with pilot rickshaws

on a lease-purchase basis. The outcome was that within 18 months of paying approx. US$ 0.5(INR 25) per day, the drivers could become owners of their vehicles. The success made the banks come forward to provide loans and earn commercial rates of return. The Rickshaw bank provided the premium and the guarantee. The scheme also included provision of insurance; each cycle rickshaw driver was provided with low cost third-party insurance. Additional revenue was brought in through lending out advertisement spaces on the rickshaws. This revenue helped reduce the risk of rickshaw drivers not being able to manage repayments on time.

All Dipbahan drivers are given a uniform, a pair of slippers, a license, an insurance policy, and an identity card. Under the scheme, the rickshaw drivers are provided with additional benefits like health check-up, fuel package (LPG gas with stove), and educational exchange programme for the children of rickshaw drivers. The distinct identity is helping the rickshaw driver community gain a sense of dignity, while they continue to provide their services to meet a significant part of urban mobility needs.

With each Rickshaw group comprised of 5 members; it has brought a sense of brotherhood within such groups with each one vouching for each other. Also, peer groups have been formed consisting of 5 such rickshaw groups which meet at assigned locations and make daily payments, keep records, manage their savings, repair their rickshaws, etc. These activities have helped build community bonds and helped in carrying this venture forward. The rickshaw drivers are also diffusing the benefits of the scheme and bringing in more members to the venture. Rickshaw Bank has also selected some drivers as field collectors to collect repayments and improve relationship with the community.

The Rickshaw Bank has collaborations with various banks for providing them with access to finance. The organization also forms a partnership with the Municipal Corporation and police to provide licenses and conduct training classes for rickshaw drivers. Also, by working with local institutions, the organization has been able to reduce the costs of basic necessities such as free health care and affordable clothing, and eased procuring of cooking gas licenses.

A scene cycle rickshaw workshop

Outcome of Project

The living conditions of the beneficiary community - The rickshaw drivers are now proud owners of their rickshaws and have been freed from the control/shackles of rickshaw lenders. This has helped them in earning more income. Through the availability of other loans from the Rickshaw bank, they now have financial access to other ventures. Thus through its various interventions, Rickshaw Bank has increased the standard of living of the rickshaw drivers and has made them financially independent.

Changes in attitudes and behaviour brought about as a result of the project - By providing the rickshaw drivers with access to financial services and proof of identify and licensing, the organization has helped in protecting this class of people from harassment and associated social stigmas. The distinct identity, the issuance of low cost insurances, monthly discussion forums and peer groups among the rickshaw drivers have instilled a sense of pride regarding their occupation. The license system has also reduced corruption because policemen cannot take bribes from drivers on account of absence of proper registration.

Improved capacity of the community and institutions - The rickshaw bank has emerged as one of the largest cycle rickshaw service provider in India, by offering low-cost innovative financial solutions to the cycle rickshaw sector. The membership of the bank has now reached more than 30,000 families.

The new designed cycle rickshaws

Sustainability

Cycle rickshaws are the most eco-friendly vehicles; they do not consume fuel and thus do not cause atmospheric pollution. The improved design features have made these rickshaws more pleasing and attractive to the customers and the light weight new design helps the rickshaw drivers to carry more passengers in a day.

These improved rickshaws also have longer life than the conventional rickshaw, which further contributes to sustainability.

The total amount recovered from each Rickshaw Driver is US$ 281 (INR 15,473/-) and the repayment rate is US$ 0.73per day (INR 40/-) for 385 days for a maximum period of 18-24 months. The loan provided under the scheme includes the cost of rickshaw, uniform, license fee for two years and three years' premium for life. Additional revenue is gained from the advertisement revenues, which is about US$ 36 (INR 2000/-) per rickshaw per year. 35% of this revenue is given to the rickshaw driver once the loan repayment is over and till then the amount goes to the organization as risk cover. The sources of revenue for the organization are the membership fees and deposits and revenue from franchisees.

The NGO (Centre for Rural Development) arranged for municipal license, health insurance and insurance for rickshaw and passenger. More than 3,000 rickshaw drivers have benefitted in Guwahati, Assam (India) alone. With the same financing norms adopted for cycle rickshaws, the other carts are provided to the people for employment generation like vegetable carts, food carts, etc.

The Rickshaw Bank and an NGO called GOONJ have provided the families of the rickshaw pullers with free and reduced-price clothing. The bank has made free condoms available to the drivers to promote family planning and safer sex with the help of AIDS Control Society of Assam.

Lessons Learned

A small organization with a strong leader can make changes in the society and work towards empowerment of the weaker sections - A small NGO had taken up the cause with the leadership of Mr. Pradip Sarma who is involved in all the aspects of working of Rickshaw Bank. The cause taken up has improved the living and social conditions of one the most suppressed section in the society and also provided a valuable public service.

The financial model developed by Rickshaw Bank is very simple and innovative - The financial model involves micro financing, rickshaw puller self-groups and peer repayment collectors. The small charge of approx. USD 0.75 (INR 40) per day is reasonable to the rickshaw drivers and also includes insurance schemes, which they never would have been able to access otherwise. Another interesting feature is that even after loan repayment, the rickshaw drivers can choose to remain with the organization and avail its facilities.

Technical intervention was crucial in uplifting the image of the rickshaw and also in attracting new passengers - The design was finalized after many iterations and stakeholder consultations. The Rickshaw Bank was innovative in adapting the design to city specific needs. In house manufacturing units were set up to reduce the cost of the rickshaw and they also provided local employment.

Transferability

The initiative has been a huge success, not just in Assam state but throughout India. By 2012, there were around 5,000 Dipbahan rickshaws operating in various cities of Assam. The initiative has expanded to cities like Lucknow, Varanasi, and Allahabad in the state of Uttar Pradesh, with a combined total of around 12,000–14,000 Dipbahan cycle rickshaw drivers in all these cities. As of now, this model is being replicated in over 100 cities

across the country. This was possible because the creditworthiness of the rickshaw drivers was proven by their repayments to the Rickshaw bank and governments, commercial banks, and grant makers who in turn realized the potential of this business model. To take up projects in other cities, partnerships are being sought to get acquainted with different cultures and practices. To further scale up this project, Centre for Rural Development (CRD) has developed a franchise model where CRD will share its vision, expertise, knowledge and arrange financing with a local microfinance partner. The Local microfinance partner will be responsible for providing a local network of coordinators. Such models have already been implemented in cities like Lucknow, Allahabad, and Varanasi.

Title of Case Study Project:	Reducing the Environmental impacts of Informal modes - Clean Air Program
City/Town:	Puerto Princesa
Country:	Philippines
Contact Person's Details:	
Source(s) of information	Presentation on The Puerto Princesa Experience, 13th Poverty and Environment Partnership Meeting, Asia Development Bank, Manila

Background

The city of Peurto Princesa had been facing the problem of deteriorating air quality due to the increasing number of tricycles, which account for about 60% of the city's vehicles and constitute the principal means of transport. To address the problem of increasing air pollution, the Clean Air Program was initiated by Mayor Hagedorn in November 2003. In February 2004, the city developed a strategy to reduce the harmful emissions from tricycles with the technical assistance from the United States–Asia Environmental Partnership (US–AEP). The strategy was officially launched in April 2004; reduction in hydrocarbon and carbon monoxide emissions from tricycles was given priority in the programme for cleaning the air. The objectives of the program were:

- Reduce the hydrocarbon and the carbon monoxide emissions from tricycles by 25% in 2005 and 50% by 2007;
- Support implementation of the Philippine Clean Air Act of 1999; and
- Reduce air pollution in the city

To achieve these objectives, five key strategies/ areas identified for improvements included:

- Improved traffic management and infrastructure development
- Inspection and maintenance
- A financing scheme for cleaner tricycle engines (e.g., buy-back scheme for old tricycles, shift to four-stroke engines)
- Public awareness programme
- Promotion of alternative livelihood for tricycle drivers

Mayor Hagedorn requested technical assistance from US-AEP and a Core Group also was formed in the city to work on the program. Funds for the various initiatives under the program were received from United States-Asia Environmental Partnership (US-AEP) and Asian Development Bank.

Two-stroke tricycles on the road prior to the program

Process and Innovation

- *Project Implementation*

The Puerto Princesa Clean Air Program was officially launched and stakeholders' workshops and consultations were held. The consultations were held with City Government officials, tricycle operators and Drivers associations & civic leaders. Experts in Air Quality Management, Transportation and Engine Mechanics were brought in to help create the Plan.

The project involved different components, for ease of implementation. There were public awareness components, traffic management component, and efficient technologies component, inspection & enforcement component, maintenance component and legislative component.

The main initiative under the traffic management component and the first to be implemented was the "50/50" scheme aimed at reducing the volume of tricycles plying in the city by 50%. Under the 50/50 scheme, tricycles with a number "1" sticker were allowed to operate only on Monday, Wednesday, Friday, and Sunday. Those with number "2" were allowed to operate on Tuesday, Thursday, Saturday, and Sunday only.

The proposal was initially opposed by the tricycle operators, as a result of which a two-week trial period was first observed. Within one day, drivers/operators observed that the scheme had doubled their day's income from an average of P400 to P800 (approx. US$ 10 to US$ 20) and the drivers actually maintained their weekly income despite operating only for four days. The other challenge faced was that the commuters' complained about longer commuting time. The city government tackled this issue by raising the franchise cap to 4,000. A consensus was then achieved between the drivers/ operators, commuters after which the scheme was formally adopted.

Under the efficient vehicles component, it was decided to promote the use of more efficient tricycle units and technologies to reduce air and noise pollution. Since most of the drivers had no access to finance to adopt two-stroke vehicles, financial assistance was made available to tricycle drivers opting for more efficient engines. People were given understanding about the significance of using more efficient engines and about the importance of maintenance through various workshops and stakeholders consultations. It was observed during

stakeholder consultations that the proposal to ban two-stroke engines in order to make way for cleaner four-stroke engines was controversial. It was, therefore, decided to "encourage" the shift to four-stroke engines "or other more efficient technology" over a period of four years rather than ban four-stroke vehicles.

- *The participation of the community*

To ensure that the community was well aware of the different initiatives, the Clean Air Program was officially launched in the city. Public-awareness programmes were held to make people/tricycle operators and drivers aware of the economic benefits of traffic volume reduction, generation of alternative livelihood opportunities, health impacts of pollution, etc. The public awareness component included extensive consultations, dissemination through radio broadcast, Television & radio features and print materials. Various outreach programs like maintenance training for tricycle organizations' member drivers were held. About 12% of the total tricycle drivers were trained in these preventive maintenance workshops through lectures and hands-on lessons. School programs were modified by developing modules on air pollution for students. Livelihood development training workshops were held for the tricycle drivers and their spouses after assessing their skills and need for alternative livelihoods.

The programme was a success primarily as a result of the extensive stakeholder consultations carried out to reach consensus for programme implementation.

- Organizations and institutions involved in implementation and decision-making

The Core team for the planning and implementation of the project comprised of the City Planning and Development Office, City Legal Office (for legislation), the City Environment and Natural Resources Office (for inspection and maintenance) and the traffic management group (traffic management).

Various non-governmental organizations like the Environmental Legal Assistance Center and TagBalay Foundation were invited for formulating a draft ordinance and conducting public awareness campaigns respectively. The public awareness campaigns held by TagBalay Foundation's were financed largely through a P300,000 (approx. US$ 7320) grant from US-AEP. The stakeholder consultations in the drafting of ordinance were financed by a P900,000 (approx. US$ 21950) US-AEP grant administered by The Asia Foundation. Asian Development Bank (ADB) has approved a US$260,000 grant that the city will use to develop alternative livelihood projects for tricycle drivers and their families.

The official launch of the Clean Air program, Peurto Princesa

Outcome of Project

- *The living conditions of the beneficiary community*

Congestion is no longer a problem in the city and the environment officials claim that the scheme may have had an impact in terms of reducing emissions of hydrocarbon and carbon monoxide by at least 50%. The maintenance workshops have also helped in improving driving and maintenance practices. Tricycle drivers have maintained their average weekly income even though they now operate for only three to four days. The three-day break enables them to have more time for maintenance activities as well as quality time for their families. Surveys show that drivers claimed improvement in health conditions because of the three-day rest and less exposure to air pollution and enough time to spend with their families.

- *Changes in attitudes and behaviour brought about as a result of the project*

The 50/50 scheme has helped the tricycle operators to have more free times which can be dedicated to maintaining their tricycles, spending time with their families and also to explore and adopt alternative livelihoods increasing their incomes. The maintenance workshops have helped in improving driving and maintenance skills and practices of the tricycle operators.

- *Improved capacity of the community and institutions*

The capacity of the concerned community i. the tricycle operators was enhanced through various workshops and training programs. The training sessions on maintenance particularly increased their awareness on preventive maintenance. The mechanical skills and capability of drivers were thus boosted to properly maintain their tricycle units and some of the participants were certified as mechanics.

One of the main focuses of the project was also to strengthen local capacities on Clean Air Act enforcement. The City's enforcement capability was enhanced through collaboration with national government agencies, academics, civil societies and local communities. Capacity-building initiatives were also undertaken to ensure enforcement and monitoring; trainings on the installation, operation and maintenance of ambient air samplers and gas analyzers were conducted and actual roadside monitoring was initiated.

New four-stroke tricycles

Sustainability

The scheme is attributed to have reduced emissions of hydrocarbon and carbon monoxide by at least 50%, a claim raised by the environment officials. The maintenance activities have been shown to have reduced hydrocarbon and carbon monoxide emissions by 40% and 30%, respectively. The Ordinance No 278, mandated that a City Air Management Board (CAMB) be created to ensure city's clean air program is carried forward and to ensure that both the mobile and stationary emission sources strictly comply with the emission standards set by the Clean Air Act. Also P3.5 million (approx. US$ 85380) was granted by the ordinance every year for the clean air program, provided by the local government through the Mayor's office. There will also be a trust fund established through the collection of fees and fines from motor vehicle owners during routine testing. The trust will have stakeholders from private sector, civil society groups, academic institutions, etc.

The "Trike Fund" created by the local government with US$150,000 seed money for providing micro credit to discounted rates and flexible repayment schemes. Loans were made available to the tricycle operators/ drivers at discounted rates and flexible repayment schemes. The fund has been a success with 94% repayment rate.

The livelihood & entrepreneurial skills of tricycle operators/drivers were developed and with the skills and needs requirements were assessed. Training sessions were held on various livelihood options for the tricycle operators and their spouses and financial assistance was also extended for the required capital to start alternative livelihoods.

The 50/50 scheme has enabled the tricycle operators to spend more time with their families, play with their children and also help in household activities.

Political will and skill of the city's political leadership was also very important in the success of this programme;

the Mayor went ahead with the implementation of the 50/50 scheme despite upcoming elections. Also, close coordination with civil society groups and local government institutions enhanced the credibility of the Clean Air Program among the general public.

One objective under the legislation component was to enact a comprehensive City ordinance on clean air. The city council therefore passed City Ordinance No. 271 which formally adopted the 50/50 scheme after a trial period and reaching consensus. Existing city ordinances like "Sagip Hangin" (Save Air) City ordinance was updated and operationalized to include the inspection and enforcement component. Roadside Smoke Check, Traffic Code amendment and Anti-Smoke Ordinance amendments were included in the Clean air Ordinance along with the 50/50 scheme.

Lessons Learned

- *Local government initiative and collaboration- t*he Clean Air program was initiated by the local government and ordinances were enacted to support the program. Related existing ordinances, were reviewed and updated for inclusion in the proposed Clean Air Ordinance rather than making entirely new ordinances.

- *Pilot testing of strategies held before bringing out ordinances - t*he 50/50 scheme was initially carried out for a trial period of 2 weeks followed by stakeholder consultations to receive feedback about the initiative before enacting it.

- *Wide stakeholder involvement and public dialogue was pivotal in the identification and prioritization of strategies - t*he tricycle drivers have been instrumental in the Clean Air Program in all the aspects. The 50/50 scheme was made permanent after reaching a consensus with the various stakeholders. The public complain about reduced tricycles and increase in commute times was addressed by increasing the tricycle franchisee numbers. Similarly, the initial idea to compulsorily convert two-stroke vehicles to four-stroke vehicles was dropped after receiving strong opposition during the stakeholder consultations. Thus both the tricycle operators and public grievances about the program were heard and then a decision was taken.

Transferability

This program can be replicated in any other city which has polluting informal modes. The adoption of this program in any other city would require strong political leadership and strong support local government like that was shown by the city of Puerto Princesa. The applicability and the response of the stakeholders could be tested by conducting pilot runs of the scheme and then taking a final decision.

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