BEST PRACTICES for CLEAN ENERGY ACCESS in AFRICA






Africa-EU Energy Partnership

Alliance for Rural Electrification
Shining a Light for Progress

Africa-EU Energy Partnership

Imprint

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The Partnership Dialogue Facility (EUEI PDF) is an instrument of the EU Energy Initiative (EUEI). It is currently funded by Austria, the European Commission, Finland, France, Germany, the Netherlands and Sweden. The EUEI PDF acts as the Secretariat of the Africa-EU Energy Partnership.

The Africa-EU Energy Partnership (AEEP) constitutes one of the initial eight partnerships under the Joint Africa-EU Strategy (JAES), a long-term framework for cooperation between the two continents. The African Union Commission, Germany, Italy and the European Commission are the Steering Group members providing political guidance to the Partnership.

Table of Contents

Foreword

Africa is the continent of opportunities. African societies and economies are accelerating their rise and integration into the world economy. Building on a strong agricultural base and on vast natural resources, industrialisation and the service sector - e.g. through innovations such as mobile banking - are generating jobs and welfare for the African people.

None of this would be possible without access to affordable and reliable energy. Energy is the pre-requisite for economic activity and for human development as well as for water supply, health care, education, and recreational activities.

Africa has progressed in great strides towards building up its energy infrastructure. And yet, vast areas of the continent remain literally in the dark. Rural electrification has reached hundreds of communities through the extension of national grids. However, geography and technology dictate that there are economic limits to further advancing the power networks also in view of the available alternatives.

It will not be possible to provide all Africans with access to modern and sustainable energy services without increased private contributions. It is widely acknowledged that the energy sector urgently needs private capital and investment to complement the scarce public resources. The private sector, however, does not commit without minimum requirements being met in terms of stable and attractive policy environments.

This latest edition of the Best Practices thus shows innovations and affordable rural electrification solutions with a unique focus on Africa. The aim of this publication is to support both energy decision-makers to develop market frameworks tailored to local needs and entrepreneurs with a passion and commitment to improve energy access in Africa to extend their know-how on how to best integrate off-grid renewable energy solutions in developing countries, particularly in Africa.

This publication is a tangible result of the work undertaken by key stakeholders under the Africa-EU Energy Partnership (AEEP) and lessons learnt from members of the Alliance for Rural Electrification (ARE), who act as AEEP private sector focal point. It is produced in conjunction with the Africa-EU Energy Partnership (AEEP), a long-term framework for cooperation on energy between the two continents. The AEEP (and its interventions) is thus proving to be an important complementary initiative to the African priority agenda, the Programme for Infrastructure Development in Africa (PIDA). While PIDA focuses on large-scale power generation, transmission and distribution infrastructure, the Renewable Energy Cooperation Programme, RECP (a programme under the AEEP) provides highly appreciated and valuable support to the development of opportunities in the field of small- and medium-scale renewable energy. The African Union Commission (AUC) has been providing political leadership in the AEEP and remains committed to supporting and facilitating the formulation of conducive policy environments for the African energy markets.

We commend the members of ARE working on rural electrification projects in Africa on their efforts and contribution to this valuable publication. It is our expectation that this publication will build a stepping stone for shaping up the policy and regulatory frameworks, and thus for attracting the highly needed investment into Africa's energy markets.

Mr. Aboubakari Baba-Moussa

Director, Infrastructure and Energy,
African Union Commission (AUC)
Co-chair of the Africa-EU Energy Partnership (AEEP)

Introduction

The new edition of the Best Practices for Clean Energy Access in Africa prepared by the Alliance for Rural Electrification (ARE) and the Africa-EU Energy Partnership (AEEP) is a compilation of 20 case studies and business cases on access to energy and services successfully implemented by ARE members and partner organisations.

Interested parties are welcome to make use of this professional international network in order to replicate and upscale proven experiences along the complete value chain for renewable energies and rural electrification.

What makes the fourth edition of this publication so valuable is that it shows the latest innovations and affordable rural electrification solutions with a unique focus on Africa. Given the increased knowledge of the continent and the high interest in participatory and partnership models as well as in productive use in addition to sole consumption, there is a need to bring sustainable benefits to the local people.

To provide access to sustainable electricity and services, different types of renewable energies (biomass, geothermal, small hydro, small wind and solar) and technologies can be used or combined. Scaling options range from pico-systems to mini-grids to best address local needs.

The publication also shows the strong involvement of a wide diversity of international stakeholders from public sector to donors that have recognised both the need and the potential of renewable energy business evolution in Africa.

Modern energy services are crucial to human well-being and to a country's economic development; and yet 1.2 billion people are without access to electricity. More than 47% of these people live in Africa[1]. It is expected that about 60% of the additional generation capacity needed to reach universal access to electricity by 2030 will be off-grid[2]. Off-grid renewable energy is part of the answer to power the needs of the world's poor, and a prerequisite for development.

Rural areas are characterised by their remoteness and low population density. While often grid extension is not a feasible option, decentralised renewable energy solutions are the better alternative to alleviate energy poverty: they are cost-effective over the system's lifetime, easy-to-deploy, install and maintain and their design can be tailored according to individual needs. With appropriate training, they can also be operated and maintained by local engineers and service providers. In addition, these regions offer abundant renewable energy resources.

As the following case studies will show, the available technologies are able to serve the market needs by offering a competitive range of products with breakeven periods of sometimes less than two years. Furthermore, this selection of projects has resulted in considerable reductions of CO2 emissions.

Renewable energy solutions should become a key element of rural electrification roadmaps and working programmes in Africa, as they can also support local business creation, improve water irrigation and sanitation systems, as well as offer new opportunities for public health, education and gender equality.

As the trends in the current international policy agendas indicate, to achieve the global challenge of universal clean, reliable and sustainable electricity services, it is vital to keep developing the still young rural electrification markets until they become mature and self-sustainable.

The purpose of this publication is to enhance market and business development through experience sharing, intelligence and best practices of stakeholders from both the public and the private sector. With this brochure, the Alliance and AEEP aim to contribute to the establishment of a suitable regulatory, policy and financial framework to foster better market conditions for the renewable energy industry in Africa. We are delighted that ARE has become a private sector partner organisation of Sustainable Energy for All (SE4ALL) which we believe is a strong driver to make access to energy one of the main priorities on the development agenda at local and international level.

We wish you a pleasant reading.

Ernesto Macías, ARE President

Marcus Wiemann, ARE Secretary General

[1] International Energy Agency: World Energy Outlook 2013
[2] International Energy Agency: World Energy Outlook 2012


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About the Alliance for Rural Electrification

The Alliance is an international business association representing the decentralised energy sector working towards the integration of renewables into rural electrification markets in developing and emerging countries.

www.ruralelec.org

Alliance for Rural Electrification
Shining a Light for Progress

About the Africa-EU Energy Partnership (AEEP)

The Africa-EU Energy Partnership (AEEP) constitutes one of eight partnerships under the Joint Africa-EU Strategy (JAES), a long-term framework for cooperation between the two continents, established in 2007 at the Lisbon Africa-EU Summit.

www.africa-eu-partnership.org

Africa-EU Energy Partnership

ARE Project locations in AFRICA

1. Bornay, Democratic Republic of Congo
2. Eauxwell Nigeria Ltd., Nigeria
3. Fondazione Madre Agnese, Democratic Republic of Congo
4. Foundation Rural Energy Services (FRES), South Africa, Mali, Uganda, Burkina Faso & Guinea-Bissau
5. Generalia Group, Kenya
6. Innovation Energie Développement (IED), Mauritania
7. IT Power Ltd., Mozambique
8. Kafita Co-operative Society, Zambia
9. Mobisol GmbH, Tanzania
10. Phaesun, Somaliland
11. Photalia & Studer Innotec SA, Mauritania
12. Reiner Lemoine Institut (RLI), Africa-wide
13. Renewables Academy AG (RENAC), Kenya
14. RVE.SOL, Kenya
15. Selectra, Botswana
16. Smart Hydro Power GmbH, Nigeria
17. Solar Electric Light Fund (SELF), Benin
18. Trojan Battery, Nigeria
19. Trama TecnoAmbiental (TTA) and Studer Innotec SA, Chad
20. University of Southampton, Energy and Climate Change Division, Kenya

Case study 1

Bornay

Project Ditunga

DEMOCRATIC REPUBLIC OF CONGO

Bornay 1500 wind turbine, Ditunga Radio Station

PV-wind hybrid system, Ditunga

The company

Bornay was founded in the early 70s by Juan Bornay and still today remains a family business now in its second generation. Currently, Bornay has about 30 employees, internal and external to the organisation, that make their teams of differential intangible value. Today, Bornay has developed more than 6,000 installations worldwide, mainly PV-wind hybrid systems for off-grid applications.

Throughout this whole experience, the main business motivation has always been based on two aspects: to bring renewable energy where there is none and make our company a source of inspiration. Bornay produces small wind turbines and supplies quality products to produce energy at isolated placements. Bornay can bring its expertise to all stages of a project including design, installation, support, etc.

The challenge

Project Ditunga is a small community with different services including a community, a radio station, one school and businesses for different people. The main problem was that there was no access to energy. When the problem of financing the supply of all the equipment needed was successfully solved, the next step was to supply energy according to peoples' needs at any time.

Even after the project setup, transportation remains the largest problem. Transit times and custom problems are the main obstacles at this moment. Up to six months will be needed for a container to arrive in Nagandajika, scheduled to be delivered at the end of October 2014.

Opportunities for renewables

Main electricity was possible, but cost and service guarantee was a handicap. Therefore, renewable energy was presented as the best possible solution.

Renewable solution

The project was executed in different stages.

- 1) Radio Station: The radio station receives energy from a Hybrid System composed by a Bornay 1500 wind turbine and 2400 Wp solar system, both systems charging a battery bank of 24 v. 1200 Ah. The power conversion is done by a Victron Energy inverter / charger of 3 kVA.
- 2) School: A hybrid system with 3 x Bornay wind turbines and a solar system, charging a 48 volts battery bank, provides energy to 28 school rooms, all of them equipped with light systems, computer, printer and general installations with computers, printers, copiers, etc. There is a diesel generator for emergency use on this installation.
- 3) Chicken farm: The hybrid system with Bornay Wind turbine and solar system provides energy to a chicken farm that satisfies the alimentation needs of the students at the school. Bornay provides all the energy supply and the incubator systems for a production of more than 2000 chicken a month.

Project financing and costs

Various institutions including Caritas, banks, NGOs and municipalities in Spain have financed this project. During the last three years, the investment reached nearly 400,000 €.

Project outcome

Initial estimation is that this investment will benefit a population of around 20,000 habitants. Among these are the 2,000 students at the local school, which is being upgraded to accommodate up to 6,000 students.

Thanks to this investment, the size of the community is increasing exponentially and new businesses such as chicken farms, electricians, micro solar stations providers, installers and transportation are appearing.

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Case study 2

Eauxwell Nigeria Ltd.

Mini-grids for remote and rural communities

NIGERIA

PV plant on children's hospital

The company

Eauxwell Nigeria Limited, established in 1987, is the leading water and renewable energy-engineering firm in Nigeria. Eauxwell is committed to the growth of the alternative power sector in Nigeria through the use of innovative products and concepts. The company specialises in product sales, installation and project services in the field of solar street lighting, solar water pumping, rooftop and ground mounted off-grid systems, as well as hybrid and backup power supply systems.

The challenge

The Federal Government of Nigeria commenced a pilot scheme to provide rural areas with access to electricity in order to increase rural electricity penetration. Decentralised systems were preferred due to difficult terrain and high costs associated with grid extension. In some cases, communities are only accessible by waterways. Lighting represents the principal electrical requirement in most communities.

Opportunities for renewables

Due to the decentralised and remote nature of the locations, the obvious choice was to design mini-grids powered by solar or wind energy. Solar photovoltaic (PV) was preferred due to its minimal maintenance requirement during the life cycle of the project.

Renewable solution

Installations of mini-grids using 90 x SolarWorld SW140 poly, 1 x SMA Sunny Island SI5048, 48 x Hoppecke OpzS solar power 1220. Upon completion, two technicians were trained on basic maintenance operations. Transmission lines were installed along 800m of the community with each of the 40 transmission poles holding a 20 W LED street lamp. Each of the 120 households was provided with four to five 7 W LED bulbs.

Project financing and costs

The project was fully financed by the Federal Government of Nigeria and executed within a period of four weeks in technical partnership with SolarWorld Africa. End users are not required to pay for any costs but need to provide land and security for the installations.

Project outcome

All the installations benefited over 700 residential households. Some of the sites led to the setup of small clinics. The success has led to plans for 50 kWp systems based upon similar applications. Incorporation of a billing system is being discussed for future installations.

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Case study 3

Fondazione Madre Agnese

From water sources to homes

DEMOCRATIC REPUBLIC OF CONGO

Hut with PV system and water tank

The organisation

Fondazione Madre Agnese Manzoni is an Italian non-profit organisation recognised by the Governments of Italy and the Democratic Republic of Congo. The Foundation develops solidarity projects in the fields of social welfare, nature, renewable energies, water collection and distribution, sewage techniques, food and water safety.

The challenge

In the hilly region of the Lower Congo, the water sources flow at the bottom of deep valleys while the population lives on the top of the ridges. In order to obtain drinkable water and to bring it to the households, a minimum of 2,000 W per 100 m of rise difference is required. The principal technical difficulty lies in recharging the batteries during the dry months and in conducting training programmes.

Opportunities for renewables

Three types of renewable energy have been used: solar photovoltaic (PV), wind and hydro. Solar energy has been used to recharge the batteries and to directly feed the water pumps from a lower tank to an upper one. Wind is used at night to compensate for the lack of sun.

Renewable solution

The project consists of the installation of a base system of solar panels (approx. 2 x 90 Wp), electrochemical batteries (60-80 Ah) and low consumption pumps, which results in reduced hydraulic head (approx. 15 m).

The systems are constructed in huts that are strategically located perpendicular to the source. These huts are connected to other huts through pipelines which are placed laterally or on a slightly lower level.

Trained locals have the task of running the pipeline and the installation of solar panels. This enables them to verify if the system has been properly maintained and can therefore be sustained.

Project financing and costs

The total investment depends on the implementation phase because the project is based on a modular intervention depending on the zones where water sources are found.

Every module requires the installation of at least 10 to 15 systems in as many main huts as chief points for water storage and redistribution.

Each unit cost is approx. 540 USD, and a total of approx. 5,800-9,800 USD, depending on the difference in height.

All the costs of primary material are fully met by the Foundation, while transport and installation costs are borne by the end-users.

The project will be serviced by each user-family, which will contribute a weekly fee in return of the water received. Each family can make use of the funds coming from the sale of vegetables, whose cost increases considerably in markets found along the ridge during the dry months.

Project outcome

Each module benefits 400 to 500 people, with an initial specific cost for hardware material of about 18 USD per person. The project can be replicated.

Furthermore, the population feels involved in the global functioning of the system.

To improve its efficiency, it would be useful to double the power of the solar panels. In the case of huts being fairly close to each other, it would even be possible to install one single solar system, which could serve all the huts.

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Case study 4

Foundation Rural Energy Services (FRES)

Investing in rural electrification in Sub-Sahara Africa

SOUTH AFRICA, MALI, UGANDA, BURKINA FASO AND GUINEA-BISSAU

Site Kolondieba in Mali

Source: FRES

The foundation

Foundation Rural Energy Services (FRES) advances electrification in rural areas in Africa by establishing small-scale, commercial energy companies. They provide households and small companies with electricity, preferably generated by solar energy. In this way they contribute to the social and economic development of rural areas. FRES is a non-profit, small multinational, founded in 2004, and consists of companies in Mali, South Africa, Burkina Faso, Uganda and Guinea-Bissau. Its head office is in Amsterdam, the Netherlands.

The challenge

- **Tariffs for mini-grids:** Mini-grid tariffs in Mali are currently sufficient for covering operational expenses and replacement of components, but insufficient for accumulating the necessary reserve funds to finance the replacement of key mini-grid components in the long term.
- **Payment arrears:** Maintaining a high payment rate is an ongoing challenge for all FRES companies and requires constant attention.
- **Political instability:** Developments in West Africa show that political stability is a factor that needs to be taken into account. In 2012 and 2013, political unrest occurred in both Guinea-Bissau and Mali.
- **Qualified personnel:** Finding the right employees, especially skilled technicians is a challenge, as is retaining qualified employees. This, however, is a challenge that all companies face.

Opportunities for renewables

The United Nations have declared 2014-2024 the decade of "Sustainable Energy for All" to provide 1.3 billion people worldwide, i.e. 20% of the global population, with access to electricity in the near future. FRES contributes to this initiative by providing people in Africa with affordable electricity in a sustainable way.

Renewable solution

FRES companies use Solar Home Systems (SHS), as it is the cheapest option to provide electricity in rural areas with sparsely populated communities. A standard SHS delivers sufficient electricity to power several lamps and/or power sockets for a radio, small ventilator, cell phone charger or television. In Mali, FRES has built solar power plants that provide power to the people via a mini-grid. In some cases, the solar power plants replaced (polluting and expensive) existing diesel generators. If customers have higher energy demands, for instance for business usage, an SHS does not suffice and a solar mini-grid can provide a suitable solution. Currently, only the company Yeelen Kura in Mali exploits solar mini-grids.

Project financing and costs

FRES is using the fee-for-service concept, according to which customers pay a monthly fee for a chosen number of lamps and sockets. FRES companies install and maintain ownership of the installed SHS, and take care of maintenance and replacement investments, thereby ensuring a sustainable long-term electricity solution for the customer. Customers of mini-grids pay a standard fixed fee for the connection as well as an amount per kWh consumed. The costs for customers of the delivered services are on par with or lower than the traditional alternatives (candles, car batteries or lamp oil). Only capital costs are financed by subsidies and FRES's own capital.

Project outcome

By the end of 2013, in total 30,252 customers were supplied with SHS. In South Africa, the number of customers increased from 16,500 to 19,398. In Mali, there was an increase from 4,881 to 5,536, falling short of the targeted 6,000 customers. The majority of growth was realised with connections to solar mini-grids, which now account for more than half of Yeelen Kura's customers. Uganda: In its second full year of operation, FRES Uganda registered significant growth, increasing its customer base from 1,019 to 2,655. Burkina Faso: the company registered minimal growth in 2013, increasing the customer base from 1,372 to 1,643. Guinea-Bissau: In its first full year of operation, FRES Guiné-Bissau continued to build on the solid foundation established in 2012, increasing its customer base from 299 to 1,020, exceeding its year-end target of 1,000 customers.

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Case study 5

Generalia Group

Mini-grid for multi-purpose use in a sustainable village

KENYA

General view

Containerised Mini-grid

The company

Generalia Group is a Spanish company founded in 2004, focused on Research & Development. The company has developed solutions for the utility scale PV market. Based on its successful experiences in this area Generalia has decided to focus its activities in the rural electrification market for developing countries. To date we have designed and manufactured Plug & Play Micro Stations (from 1 kW to 10 kW) and have containerised mini-grids (from 10 kW to 120 kW).

The challenge

The use of fossil fuels drained the scarce resources in Nyumbani village, whose population is mostly composed of orphaned children. The need for electricity at the Polytechnic school, in which young people are preparing for their return to Kenyan society, is a priority that had to be addressed by Generalia's energy mini-station. A second main objective of the project was to derive energy from pumping drinking water to the village. The Spanish NGO, Energía sin Fronteras (ESF), coordinated this unique project and thereby demonstrated its professionalism and defense of renewable solutions. However, Generalia's mini-grid still needed to overcome difficult challenges in order to succeed, including the electrical peak demand during engines start-up and the significant distance between the village and pumping system which amounted to more than 500 metres.

Opportunities for renewables

Connecting the eco-village to the grid was not possible given the distance from the eco-village to large power lines. In such a common situation, a mini-grid represents the ideal solution: installing the energy source close to the consumers. Solar PV has been the main technology used, since the solar resource is abundant and the levelised cost of energy (LCOE) is lower than diesel.

Renewable solution

Generalia mini-grid manages the electricity generated by a 45 kW solar field, integrating a pre-existing diesel generator.

To feed the pumping system, Generalia included a variable-frequency drive to limit current peaks at the start-ups. Together with ESF, it offered diverse training to managers in order to support the mini-grid operation and develop awareness among users of how to consume and harness the energy; all aspects necessary for the sustainability of the plant.

Project financing and costs

The project was funded by contributions from several private donors, including Generalia. The market price of all equipment was over 150,000 €. Savings made from the implementation of the project will be partially reinvested in the mini-grid maintenance and, hopefully, in its future extension.

Project outcome

Achieving plant startup in just 40 hours is unprecedented worldwide. September 2014 marked six months of uninterrupted electricity supply to the Polytechnic, which is highly valued by the community. Building on this success, the village has started benefiting from other "industrial" applications of the system.

The eco-village is now considering how to meet other needs as street lighting and basic electrification of the households. As it is, a standardised and containerised solution, pre-assembled and pre-tested at the factory, it is possible to scale up the solution in this location or to replicate it in other areas of the continent with sufficient guarantees.

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Case study 6

Innovation Energie Développement (IED)

IPES RURAL – Solar powered infrastructures for rural isolated settlements
MAURITANIA

Source: IED

The company

IED is an independent consulting and engineering firm involved in the provision of sustainable energy services since its creation in 1988. The involvement of IED extends from the study phase right through to the construction and commissioning of infrastructure such as distribution networks and renewable energy production plants.

The challenge

Rural settlements in Mauritania lie in a very rough environment characterised by a warm and dry climate, poor access, low income and low power demand. Most dwellings are scattered in desert areas and very few localities are electrified, generally with costly and unreliable diesel gensets and mini-grids. With the fixed regulated tariff (0.27 €/kWh), the private operators can only operate with a high subsidy level from the Government to cover operating costs. The lack of professional maintenance skills is another constraint for sustainable and affordable power supply.

Opportunities for renewables

There are a few hundred rural centres with sufficient power demand to benefit from stand-alone mini-grids, supplied with as much solar as possible. Solar hybrid generating systems combined with LV/MV mini-grids are seen as the most suitable solution for those populations, allowing more reliable and affordable electricity for domestic and non-domestic demand. Wind power is a relevant alternative for several spot areas.

Renewable solution

The IPES-SOLAR project is electrifying six isolated localities with solar/diesel supplied mini-grids ranging from 16 to 50 kWp. One of these localities is the village Ain Ehel Taya (Adrar) which was previously equipped with a mini-grid supplied by a 55 kVA diesel generators for 250 customers (mainly households). The diesel share of operating costs was about 0.35 €/kWh and the operator received a subsidy of 0.25 €/kWh, making this business hardly sustainable when considering the low load factor and the high maintenance and replacement costs.

The hybridised system includes a 17.6 kWp solar PV array, 165 kWh 48 V battery, 6 x 7 kVA Studer inverters and the 55 kVA diesel genset. "Private Delegates" (appointed by state implementing agencies) are trained to optimise the operations (fuel saving and loss reduction), to maintain the generation and distribution system and to efficiently manage their customers (through support tools). Post-project measures include periodic technical and commercial trainings for operators and information to customers.

Project financing and costs

The total investment costs for hybrid generation systems (8-11 €/Wp) and for distribution systems (15k €/km of low voltage lines) are pretty high due to the low attractiveness for bidders (i.e. political instabilities) and to the hard environment for delivery and installation. The whole project is co-financed by the EU Energy Facility (73.81%) and the Mauritanian government (24.09%). Local beneficiaries' contribution is about 2% through the monthly tariff and connection fees. The funding of the project allows an expected 58% reduction on kWh cost and 8,000 € subsidy savings per year for the Ain Ehel Taya site. For the system to be sustainable in the long run, new concessional funding will need to be found for battery replacement.

Project outcome

This EU project counts as a pioneer for solar hybrid systems in Mauritania. The potential for replication of this technology solution is high with more than 300 identified centres, most non-electrified and few electrified with diesel gensets. Several donors have shown interest in supporting larger programmes using hybrid systems. A first lesson learnt is the need for a mitigation system for coping with high load spikes that occur when starting cereal mills. Further lessons learnt from this project are awaited, in particular how far government (fuel) subsidies can be actually reduced, how operators can develop safe businesses, and how variable and growing demand can be handled.

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Case study 7

IT Power Ltd.

Off-grid electricity tariff model for renewable energy projects

MOZAMBIQUE

Off-grid tariff-setting in Mozambique has helped establish new renewable energy projects

The company

IT Power is an international renewable energy and climate change consultancy founded in 1981 that provides advisory and engineering services in sustainable energy and climate change to clients around the world. It has offices in the United Kingdom, India, China, Australia, Argentina and Kenya, working for governments and multinational agencies as well as public companies and private clients.

The challenge

Grid electricity tariffs in Mozambique are typically fixed by the Ministry of Finance. However, there was no regulation on how to set tariffs for off-grid electricity generated from renewable energy sources. This posed a problem for off-grid renewable energy projects set up by the Mozambique National Fund for Rural Electrification (FUNAE).

To ensure that sustainable off-grid renewable energy projects could be developed in Mozambique, it was vital for FUNAE to have an accurate tariff-setting tool created. This tool needed to assess financial, economic, social and environmental impacts on the cost of renewable energy electricity generated in rural off-grid locations.

Opportunities for renewables

Rural communities in Mozambique are ideally positioned to benefit from off-grid renewable energy projects. It is important to understand what tariffs can be charged to local communities and determine their capacity to pay for renewable off-grid electricity before constructing projects.

Renewable solution

IT Power developed a tariff-setting tool for FUNAE and provided capacity building and training to the organisation. The tool presents a balanced, accurate and easy to use way to calculate the tariff needed for energy services in remote locations of Mozambique. It includes data on Mozambique's most suitable renewable energy resources – namely small hydro, solar, wind and biomass technologies, and their off-grid capacities.

IT Power provided capacity building support and technical training to FUNAE staff to conduct surveys in rural locations. The surveys determined the willingness of end users to pay for renewable energy electricity in rural locations.

This tool directly improved FUNAE's regulatory capacity to develop more off-grid rural electrification projects in Mozambique and had a positive impact on the rural electrification policy throughout the Mozambican territory.

Project financing and costs

FUNAE funded the project themselves to stimulate inward investment into the Mozambican market for rural electrification.

Project outcome

The tariff-setting tool has been a worthwhile instrument for FUNAE to calculate the feasibility of developing off-grid renewable energy projects in rural locations. It has stimulated follow-on projects (including the mass roll out of 544 PV systems to schools, clinics and villages in rural communities).

Additionally, the tool has been made accessible to other key stakeholders include the national utility (EDM), the Ministry of Energy and the National Regulator (CNELEC). The work carried out by IT Power has helped stimulate the rural electrification market in Mozambique and has set a precedent of best practice for other countries to follow.

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Case study 8

Kafita Co-operative Society

Mpanta Solar Mini Grid, Mpanta's First Light

ZAMBIA

Source: Rural Electrification Authority Zambia

Source: Rural Electrification Authority Zambia

The company

Kafita Co-operative Society is a non-profit organisation located in Mpanta, Samfya District. Formed in the year 2010, it aims to encourage fish farmers to venture in other forms of farming such as aquaculture, poultry farming, vegetable growing and animal husbandry.

The challenge

Mpanta is an isolated area about 45 km away from the main grid. The area has been relying on traditional methods of lighting such as paraffin lamps and candles. Since the site has abundant sunlight throughout the year, solar was the energy source proposed. The estimated demand for the area was billed at 60 kW. To further expand the plant in case there would be a further increase in demand, an extra 40 kW was needed. Power is mainly used for basic home appliances such as lighting, TVs, radios and cell phone charging. The major barriers, which the plant needed to overcome, included having an alternative backup power-source as well as the community's ability to pay.

Opportunities for renewables

Renewable energy is a vital source of energy and a key driver of economic activity meant to improve the standard of living in the area.

Renewable solution

This project brought new life to the area as the standard of living by the people in the area improved. Kafita gained new skills through entrepreneurship training as well as marketing skills. To increase its capacity of 60 kW, it made steps to source for funding to expand the plant through another solar generation plant as well as to purchase a three-phase generator during times of emergency. To reduce the risk of shortfall in payment, it came up with a program called investment subsidies and micro financing in which all the beneficiaries would be included. These steps taken meant that the cooperative would increase the number of its users and therefore breakeven and realise an optimal return on investment.

Project financing and costs

The total project cost was billed at 875,000 €. It was financed through a long-term loan facility by UNIDO. Venture capital was not considered. The pricing model used is a fixed monthly charge based on estimated usage per household. The project is currently not economically viable as it is unable to meet the productive use capability. It is expected to pay off through government funding.

Project outcome

480 household benefited from having regular access to electricity. The community experienced a new renewable energy source that was pollution free. This has led to new plans to develop a renewable energy agricultural farm. This project has been a learning experience as it has enabled the project developer to improve on the type of equipment and business model to use in other projects. The lesson learnt has enabled the project developer to plan for upgraded solar mini grids to be undertaken in other parts of the region with more advanced equipment to sustain demand.

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Case study 9

Mobisol GmbH

Mobisol Solar Home Systems: Combining solar energy, micro-financed mobile payments and comprehensive after-sales services

TANZANIA

Mobisol Tanzanian technicians installing PV panel

Presentation Kikatiti Maasai market

The company

Mobisol is a German renewable energy service provider dedicated to facilitating the sustainable electrification and supporting the economic development of rural households in developing countries with solar home systems (SHS).

The challenge

Current electrification rate in rural Africa stands at around 15% to 20%. The high costs of grid extension adversely impact the pace of grid services, especially for rural households. These households rely on kerosene for lighting and generators for appliances and productive use. Off-grid solutions exist, but often entail two main bottlenecks: a lack of micro-payment methods and the inability to offer long-term loans needed to purchase a quality system complete with after-sales services.

Opportunities for renewables

Mobisol SHS increase living standards by leapfrogging the non-existent electricity grid and replacing the usage of kerosene and/or diesel. Combining solar energy with micro-financing schemes reduces the barriers usually faced by the rural poor to access the finance needed to shift from fossil, fuel based energy sources to renewable energy technologies.

Renewable solution

By using mobile money services, payments can be made conveniently via customers' mobile phones following a 36-month installment plan. Systems are available in different sizes ranging from 30 W to 200 W. The smallest unit can light two rooms, run a radio and charge four mobile phones per day. The largest powers multiple lights and appliances like a laptop, a television or a DC refrigerator. Excess electricity can be used to run Mobisol business kits to charge businesses and barbershops. Mobisol SHS come with an extended warranty and a full service package for three years including free maintenance. Through an integrated GSM modem, technical data are tracked and monitored by local technicians in a web-based interface. The remote monitoring allows potential maintenance problems to be swiftly addressed and enables systems to be locked automatically in case of theft or overdue repayment. As a result, the Mobisol Akademie was established in 2014 to train local entrepreneurs working as Mobisol technicians and sales staff to effectively service customers and to represent Mobisol as a leader in the sustainable energy industry in East Africa.

Project financing and costs

The total project investment to date is 13 million USD. Mobisol was able to attract private investors, as well as grants and preferential loans by inter alia the German Development Cooperation (DEG), the Energy and Environment Partnership (EEP) and the Africa Enterprise Challenge Fund (AECF). Other partners include the mobile network operators Vodacom, Airtel as well as local partners such as Kakute Ltd.

Project costs include the pre-financing of SHS, overhead and set-up costs when establishing a local service infrastructure (including local facilities and capacity, efficient after-sales-maintenance). The total sales price of an installed SHS is the cumulative amount paid over the three-year period via monthly instalments. The project will be economically viable by early 2015.

Project outcome

Mobisol has installed over 6,000 SHS in Tanzania. Due to its sustainable business model, grants to replicate the project in Rwanda could be attracted from GSMA Mobile for Development and the European Union. Mobisol entered the Rwandan market in 2014 and has so far installed more than 1,300 systems. All sales and installation processes have been devised to be robust and replicable in order to guarantee a fast scaling to cover the ever-increasing demand.

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Case study 10

Phaesun

BOSS – Business Opportunities with Solar Systems
SOMALILAND

Somaliland solar bar

The company

Since 2001, Phaesun GmbH, based in Memmingen (Germany), has specialised in the sale, service and installation of off-grid photovoltaic and wind power systems. As one of the world's leading system integrators of off-grid energy systems, Phaesun offers products of all reputable manufacturers. International project management, training courses for customers and technical support complete the range of services offered. Phaesun has a daughter company in Vendargues, France, holds subsidiaries in Eritrea and Panama and can fall back on a worldwide partner and distribution network.

The challenge

The electricity grid in Somaliland is poorly developed and the roads are rough. Refrigeration of drinks and food in shops or restaurants is not common in remote areas. It is estimated that 75% of the population have mobile phones and the need for recharge is huge. In these areas the unemployment rate is huge but on the other hand it is difficult to find local technicians for maintenance.

Opportunities for renewables

Solar systems can increase the service quality of existing shops, bars and restaurants in rural communities. The opportunity to run electric light, recharge mobile phones, operate fridges and entertainment devices such as TVs or music boxes with solar power can improve service quality and service portfolio.

The Phaesun BOSS solutions specifically target the private enterprise sector in non-electrified areas. The systems are developed for the target countries, well adjusted to local requirements and with little maintenance needs. These systems bring autonomy and jobs to the people. Off-Grid solar systems are the only option for reliable energy supply in those remote areas.

Phaesun works closely with its partner Horn Renewables, based in Somaliland. Horn Renewables actively targets small businesses in rural areas and develops specific solar systems to improve their service portfolio.

Renewable solution

The Phaesun refrigeration kit is the best solution for reliable cooling and freezing needs. These kits include the solar fridge Steca PF 166, as well as the entire equipment for charging and installation.

In 2013, the first customers of Horn Renewables bought refrigeration kits and a solar systems for mobile phone charging for their shops. The local partner gave instructions to the shop owners on how to run the solar systems. The solar systems are almost maintenance free.

Project financing and costs

These activities are not subsidised and they fully rely on private market mechanisms. The shop owners invest privately. This is a typical calculation for the pay-back period of the solar system:

Total investment made: €2,400
Daily income with the solar systems:
Sale of 45 drinks per day with an extra price of €0.12 for being cold = around €162/month.
Charging of 15 mobile phones per day at €0.12 = around €54/month.

With this additional income, the investment in the solar system is paid back within less than one year.

Project outcome

Some of the shop owners have already invested in the upgrade of their solar systems with fans or other devices - an indication that they are already making money and investing more in solar. Their customers are happy to charge their phones while enjoying cold drinks.

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Case study 11

Photalia

Implementation of infrastructures of solar electric production for isolated localities (Rural IPES)
MAURITANIA

Source: Photalia

Source: Photalia

The company
Photalia belongs to the Vergnet Group, an internationally recognised energy and water supply specialist for remote or complex locations. It benefits from Vergnet's 20 years of field experience and strong presence on every continent. Photalia provides customised solar energy systems adapted to all specific constraints of isolated sites.

Studer Innotec is a Swiss manufacturer of inverters and MPPT solar charge controllers for solar and hybrid energy systems.

The challenge
This project is intended to provide energy to very small towns with a fluctuating and unknown electric charge. As the sites were very isolated, it was necessary to avoid depending too much on fossil fuels (mainly for supplies, maintenance, etc.) and optimise on renewable production. Consequently, Photalia opted for a solar diesel hybrid solution with a battery bank mainly used during solar production.

Opportunities for renewables
Solar production is very important and reduces the dependence on fossil fuels. By linking it with storage technologies, living conditions can be considerably improved as energy services such as lights can be used after sunset.

Renewable solution
Three mini hybrid power plants for three towns Nebaguiya, Kser Torchane and El Ghediya, including the distribution network. Photalia completely designed the system based on Studer Innotec's technology. Photalia also took care of the local team management as well as training for the good running of power plants.

Project financing and costs
The total project investment amounts to 1,276,911 € for Photalia, in joint-venture with their local partner: COGER. This project was financed by the EU Energy Facility (75%) and the Mauritanian Government (25%) through the Association of Development of Rural Electrification (ADER). The power plants were managed by ADER.

Project outcome
About 8,000 inhabitants (through 555 individual connections and 25 industrial connections) benefit from this project. Every power plant consists of a solar field of 25 kWc, a group of 100 kVA, 6 x Studer inverters XTH 6000 and 6 x Studer MPPT regulators V-T80.

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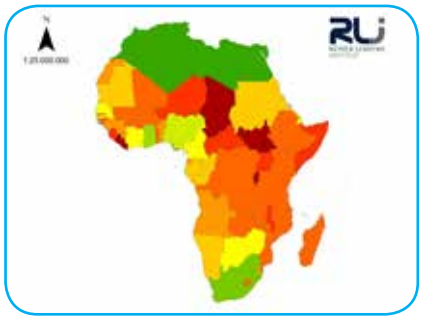
Case study 12

Reiner Lemoine Institut GmbH

The potential for hybrid PV systems

AFRICA WIDE



Source: Reiner Lemoine Institut 2014

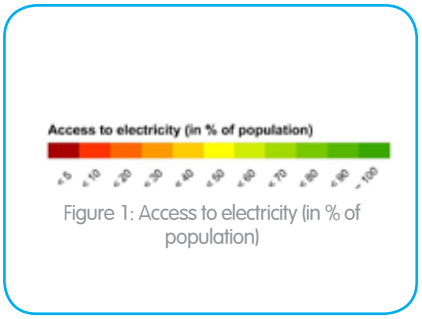


Figure 1: Access to electricity (in % of population)

The institute

The Reiner Lemoine Institut gGmbH (RLI) is a German non-profit research institution founded in 2010 that performs research on renewable energy, integration of different energy technologies, grid management, energy storage, hybrid power plants and off-grid electrification.

The challenge

The African energy sector faces high power-generation costs. The intensive use of oil-based power generation, such as diesel generators, is one of the reasons. Also due to the fact that fuel prices tend to fluctuate rapidly, related electricity production costs are highly unpredictable. Therefore African countries often spend significant parts of their GDP on subsidising electricity prices in order to enable access to electricity to a wider part of the population. Nevertheless, more than 590 million people, most of them living in rural areas, find themselves without electricity access; its provision consequently remains a major challenge.

Opportunities for renewables

With the rising price competitiveness of renewable energy technologies, decentralised renewable off-grid solutions represent a viable alternative, especially in rural areas. In particular hybrid systems consisting of photovoltaic modules, battery storage and backup diesel generators are of great interest, since they make use of the high solar power potential in Africa and can be integrated into the pre-existing infrastructure of small diesel grids.

Renewable solution

The methodology developed at the RLI combines GIS-based data analysis with a simulation model of hybrid systems to quantify the economic potential and localise the most attractive areas for diesel substitution and rural electrification. By combining several datasets off-grid electricity generation can be identified and the local economic attractiveness of a renewable hybrid system can be evaluated. For this particular study the simulation model is fed with the site-specific input parameters (e.g. PV potential, fuel transportation costs, load demand) supplemented by the general input parameters (e.g. cost parameters and diesel fuel base price). Please find more information here: (http://www.reiner-lemoine-institut.de/en/publications/off_grid_systems).

Project financing and costs

The methodology has been developed at the RLI and is constantly refined in projects, research cooperation and in collaboration with industrial partners. The RLI itself is co-funded by the Reiner Lemoine-Stiftung.

Project outcome

The analysis shows that hybridisation of diesel-based off-grid systems with PV and storage systems can lead to a significant power-generation cost-reduction for producers. If current world market diesel prices are assumed as base prices the renewable-based hybrid system outperforms the diesel-only system nearly all over the African continent. The renewable share (PV + battery) in the majority of hybrid system covers a range of 35% to 40 %. In very remote areas affected by high additional costs for the transportation of fuels, the share of renewables rises to very high percentages (Figure 2). Overall, renewable energies bear a high potential for reducing power-generation costs and increasing access to electricity in the African context.

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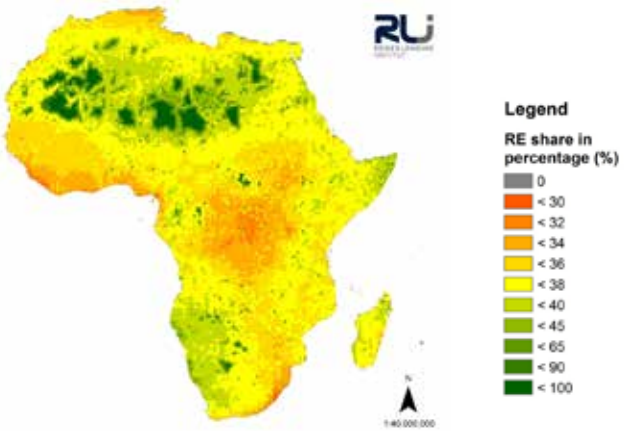

Share of renewables (PV + battery) in cost-optimised system (Reiner Lemoine Institut 2014)

Case study 13

Renewables Academy AG (RENAC)

Fuel saving in Kenya: Capacity building on PV-Diesel-Hybrid mini-grids

KENYA

Source : RENAC

Source : RENAC

The company

RENAC provides international training and capacity building services on renewable energies and energy efficiency. Since the founding of the German-based organisation in 2008, about 4,500 participants from more than 130 countries worldwide have participated in training programmes by RENAC.

The challenge

Kenya has an electrification rate of only 5% in rural areas. In these regions, electricity is often supplied by means of diesel generator powered mini-grids. The limited supply of spare parts, nontransparent transportation of diesel fuel, its storage in remote areas and, of course, the ever-increasing price are severe risks for a secure and reliable electricity supply in rural areas. Moreover, carbon emissions, leakages, noise and air pollution from diesel generator pose substantial threats to people, animals and the environment.

Opportunities for renewables

In order to avoid the high costs of diesel in remote areas, the Government of Kenya (GoK) decided to look for alternative energy solutions. As a result, renewable energy was included in the plan to provide areas far from the national grid with electricity. As part of its first stage, several pilot projects were installed with GoK's funds. The state utility Kenya Power & Lighting Company (Kenya Power) and the Rural Electrification Authority (REA) undertook the design of the systems. Capacity building was necessary to scale up the electrification programme.

Renewable solution

In November 2013, RENAC provided Kenya Power and REA with 3-day training in Nairobi. The objective was to learn how to optimally design tenders that incorporate solar PV in diesel mini-grids and raise awareness on state-of-the-art technology solutions for these systems.

Among the most important topics covered during the training were:

- Assessment of existing PV-Diesel-Hybrid systems in Kenya;
- Energy audits and load profile recording;
- System engineering, components, design, energy yield calculation;
- Working with software design tools;
- Operation & Maintenance;
- Kenyan Rural Electrification policy and
- Tendering.

Project financing and costs

The training was provided within the framework of the Project Development Program (PDP) Sub-Saharan Africa by the German development agency (GIZ) with the support of the Exportinitiative Erneuerbare Energien (EEE) of the German Federal Ministry of Economics and Technology.

Project outcome

Representatives from Kenya Power, Strathmore Business School, GIZ, the United Nations Industrial Development Programme (UNIDO), the Department of Energy and REA attended the workshop. The discussions during the event confirmed the great interest in PV-diesel hybridisation. Based on the knowledge gained, all participants developed a good understanding of the technologies and its potential. The project established a solid knowledge base for the authorities to save costs and to secure and expand rural electrification throughout Kenya making it a best-practice for other countries to follow.

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Case study 14

RVE.SOL – Rural Energy & Water Solutions Lda.

KUDURA: Changing rural life forever in Sidonge "A" Village

KENYA

Kudura, sustainable development in action

The company

RVE.SOL from Portugal believes that access to sustainable energy and fresh water is key to eradicating rural poverty. Its sustainable development solution 'KUDURA' provides communities, schools and clinics with fresh drinking water, electricity for lighting, biogas for cooking and fertiliser for crops. It contributes to the development of rural communities through increased access to education, better health and lower energy cost.

The challenge

Sidonge lies in the west of Kenya and was chosen as the most suitable site to implement the pilot project. The objective was to demonstrate how a renewable energy mini-grid could increase the living standard of the village within the context of a community-based model. According to this model, electricity is provided to 26 homes on a pre-paid, flat-rate, night-time basis for lighting, mobile phone charging, as well as powering radio and TV. In addition, an entrepreneurial kiosk is provided for charging mobile phones and hair cutting.

Opportunities for renewables

Africa is rich in natural renewable resources, making renewable energy the obvious choice for decentralised energy generation.

Renewable solution

KUDURA comprises a 5 kWh/day hybrid solar mini-grid, a water purification system and a biogas generation system. The battery bank offers two days of autonomy, while a generator provides backup and battery maintenance capability. A remote monitoring system enables real-time visibility of the performance and security by the system.

Project financing and costs

RVE.SOL financed the 2011 pilot project, the cost of which amounted to 87,000 USD. Local community-based organisation CABE Kenya provides on-the-ground know-how and is in contact with the community management committee. The fees for provision of water, biogas and electricity services fund the day-to-day operation of the project. The project is expected to break even after a 12-year period of operation.

Project outcome

- Reliability of payments for services by consumers: it is critical to contemplate a remote mechanism of service discontinuance after a reasonable grace period for lack of on-time service payment.
- In the same line of thought, a remote, pre-payment mechanism significantly improves fee collection rates.
- Financial management of project accounting: The capacity of the project management committee to conduct transparent and accurate accounting is critical to demonstrate project breakeven.
- Financing the extension of the mini-grid in terms of reach within the community and increase of capacity generation: effective and transparent project management is of utmost importance to achieve long-term sustainability as this reduces finance risk perceptions for financiers.
- Mini-grids can be implemented according to local standards at cost-effective prices.
- Total installed costs can be reduced by up to 20% if project developers leverage local import tariffs and duty moratoriums for renewable energy technology.
- An increase in solar panel capacity by at least 25% above calculated requirements improves system performance and autonomy. Low relative cost provides great benefit in terms of ensuring that the battery bank is charged quickly and effectively.

RVE.SOL plans to conduct a follow-up social impact study to show the health, education and financial improvements experienced by the families of Sidonge. The community is seeking funding to expand the grid to provide power to another 30 households.

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Case study 15

Selectra

Dairy Power Box: Anaerobic Bioenergy from Dairy Waste

BOTSWANA

Inside power box AD container (Selectra)

Plant operator training (Selectra)

The company

Selectra, established in 1987, is one of the pioneers of the biogas industry in Southern Africa. Using the expertise of experienced biologists and engineers, the company designs, develops and implements sustainable solutions in the waste, energy and water sectors for clients in agriculture, industry, mining and infrastructure across Africa.

The challenge

On average, the daily waste of one dairy cow equals that of 20-40 people. In Southern Africa, around 2,500 dairy farms produce almost 3 million tons of milk annually, adding up to a lot of waste [3]. Besides large quantities of nutrients in animal waste affecting the local land, dairy farms use a lot of costly grid electricity to run chillers, vacuum pumps, and to heat water to clean the milking equipment, resulting in smaller dairies struggling to compete with larger operations. The objective of this Botswana-based project was to install a co-generation of heat and power (CHP) unit to take the plant off-grid. One challenge the project faced was the inconsistency of feedstock availability, which was solved by educating plant personnel.

Opportunities for renewables

Selectra focuses upon energy recovery using anaerobic digestion, nutrient recovery and water reuse, which reduces operating costs and facilitates cleaner, greener agriculture. Most farm-generated organic wastes can be managed through their biogas technology system known as H2E AD, which not only solves waste disposal issues, but also generates the energy to power the farm operations; reducing costs, damage to the environment, and the need for grid electricity.

Renewable solution

The Selectra-developed 'Dairy Power Box' is a containerised Waste-to-Power Solution specifically for dairies. It provides off-grid power through anaerobic digestion of the waste and wastewater from the dairy to produce biogas. A biogas-fuelled CHP generator displaces up to 100 kW of grid electricity. The system is housed in ISO shipping containers, with a plug & play design; enabling easy installation and minimum disruption to farming operations. The system requires minimal maintenance and professional training is provided at the time of installation. The indicative process yield is 1 kW of electrical power and 2 kW of thermal energy per 36 cows.

Project financing and costs

Project investment was ZAR 2,500,000 (180,000 €) financed by the Energy and Environment Partnership (EEP) scheme. Purchases of the system fully rely on private market mechanisms, with the Dairy Power Box system providing reliable off-grid power at a reasonable cost, and an expected payback of between 3-5 years depending on site-specific criteria.

Project outcome

The project benefits have been job creation, increased job security at the dairy (due to increased financial competitiveness), and free energy for the staff to cook meals. Many H2E systems have already been installed throughout the world, with Selectra serving all of Sub-Saharan Africa. Replacing grid electricity makes the Dairy Power Box attractive for African countries, most of which lack access to electricity. Given the right political and financial support, this technology can be replicated across Africa.

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[3] http://www.milksa.co.za/sites/default/files/BIPSSM255%20September%202014.pdf

Case study 16

Smart Hydro Power GmbH

GADA hamlet
NIGERIA

Source: Smart Hydro Power

The company

Smart Hydro Power from Germany develops, fabricates, commercialises and operates pico hydropower plants. Its standard off-grid plant is a 5 kW kinetic system which does not require any other infrastructure than an anchor point. It can be combined with other sources like photovoltaic and installed in a modular way up to 25 kW.

The challenge

Nigeria struggles with severe energy shortages. Many rural areas, and even large cities like Abuja villages and populations are not connected to the grid. Gada is a small hamlet (village) based in the north of Nigeria which is not included in any development plan.

Opportunities for renewables

Gada lies directly at a river with year round water flow. In the dry season, stones form a natural canal with high flow stream.

Renewable solution

Smart Hydro Power Nigeria built a single-phase grid between the seven houses of Gada and a machine house for the inverter and all other electrical equipment. Together with the villagers and the help of the parent company, Smart Hydro Power Nigeria employed the first rural electrification project with kinetic hydropower in Nigeria. One single turbine generates approx. 15 kWh per day to the inverter house and the small village. Villagers participated in the entire installation process and were empowered to run operations.

Project financing and costs

The reference project was financed by Smart Hydro Power Nigeria. The people from Gada consider building up a workshop, which, in future, would contribute to this unique source of power supply.

Project outcome

The small hamlet of Gada with seven huts and approximately 40 members benefits in total from the project. The project is thought to be an example of an inexpensive and mainly standardised way of rural electrification ad has been presented to the Nigerian officials.

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Case study 17

Solar Electric Light Fund (SELF)

Scaling the Solar Market Garden

BENIN

Solar drip

The organisation

SELF is a United States non-profit organisation, whose mission is to create solar energy solutions to assist those living in energy poverty with their economic, educational, health care and agricultural development. Since 1990, SELF has completed projects in 22 countries and pioneered applications of solar power for drip irrigation, health care (installing 328 kW at 71 health centres in seven countries since 2006), and other uses.

The challenge

The goal for Scaling the Solar Market Garden™ (SMG) is to enhance food security and increase income in semi-arid regions off the grid. Energy is needed to pump enough water to irrigate fields large enough to grow crops for sale as well as consumption, particularly during the dry season.

Opportunities for renewables

Stand-alone, battery-less solar photovoltaic (PV) systems can pump enough water to meet this challenge. The passive, closed systems – requiring only cleaning the arrays and minimal maintenance – are ideal for delivering energy to locations with limited access to fuel, spare parts and technical expertise.

Renewable solution

The SMG combines PV water pumping with drip irrigation to irrigate half-hectare fields, big enough to grow crops mostly for sale. The water is pumped into a reservoir from where it is gravity-distributed into the drip lines. The array size and pumping strength vary, depending on well depth and other factors. Eight SMGs were installed to validate the results from three earlier pilot SMGs, whose women farmers (~35 per SMG) consumed 21% of the produce and could sell the balance.

System equipment includes: solar arrays (0.6 to 2.3 kW each); water wells (pump depths: 45 to 61 m); submersible pumps; water tanks (21 m3); drip lines; and metal fencing. Consumables include seeds and fertiliser. Capacity building for the local partner has included hiring and training solar technicians, hiring agricultural technicians and an accountant, as well as providing management support.

Project financing and costs

Total expenses, including start-up costs (project design and development, capacity building, travel and management) were 896,000 USD. Funding came from private foundations and development agencies (e.g. from Nordic Development Fund and United States Africa Development Foundation). Direct installation expenses, including equipment, well-drilling and training, were 326,000 USD (~41,000 USD per SMG). Annual earnings per SMG (estimated from 8,000 USD to 12,000 USD based on pilot phase results) will cover inputs, operations and maintenance, equipment replacement reserves and financing. Replication will reduce expenses through public-private partnership financing, elimination of start-up costs, economies of scale and less reliance on imported labour.

Project outcome

264 women farmers and their families have improved nutrition and income, and 48,000 residents have year-round access to fruits and vegetables. Reportable results from these 8 SMGs will be known following the dry season ending in spring 2014. Variances from the three earlier SMG results – each women farmer earning 7.50 USD per week and each garden yielding ~2 tons of produce per month – will be monitored. Replication is occurring in Haiti and international agencies are investigating partnership opportunities. The need for a strong local partner is the most important lesson learnt, and the biggest challenges are securing sufficient start-up financing and public sector interest to help take the model to scale.

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Case study 18

Trojan Battery Company

Grid-tied battery backup

NIGERIA

Source : Eauxwell

Source : Eauxwell

The company

Founded in 1925, Trojan Battery Company is the world's leading U.S. manufacturer of deep-cycle flooded, AGM and gel batteries.

The challenge

Serving as the main business and financial centre of Nigeria, Victoria Island's business district has expanded rapidly over the last 25 years, and is now one of the busiest centres of banking and commerce in the country. The implementation of a "cashless policy" by the Nigerian government resulted in fast-tracking the installation of ATMs by the nation's banking institutions ensuring customers have access to accounts when needed, regardless of banking hours.

A major challenge to the operation of ATMs is the unreliability of the country's electric grid. As a result, operation time goes down six to eight hours at a time, and in certain situations is unavailable for up to 24 hours. The lack of a dependable power source to support the operation of ATMs significantly impacts the ability of customers to access their bank accounts for any given period of time.

Opportunities for renewables

To address the challenge of an erratic power supply, Nigeria-based Diamond Bank worked with Eauxwell Nigeria Ltd., and systems integrator The Solar Shop Ltd. to develop a backup power solution for consistent ATM operation. Combining Trojan's expertise in energy storage with Eauxwell's success in deploying solar systems, a reliable solar hybrid system now operates the bank's ATMs. The backup power system also controls surveillance and security cameras and alarm systems.

Prior to implementing a solar power solution, Diamond Bank used diesel generators to operate ATMs and related equipment. However, diesel fuel is expensive and the generators produced noxious emissions. With the implementation of the solar power backup system, the bank is saving significant costs and is now a "green," environmentally friendly company.

Renewable solution

System Specifications:

- Batteries: 16 x Trojan L16RE-B Deep-Cycle, Flooded Batteries
- Solar Modules: 20 x 3.5kWp SolarWorld AG Solar Modules
- Inverter: 1 x SMA Sunny Island SI5048 5kW 48VDC
- Charge Controllers: 2 x Steca TAROM 4401
- Monitoring System: 1 x SMAWebbox
- Equipment Supported: ATMs, Closed-Circuit TV for Surveillance/Security, Fire Alarm, Burglary Alarm, Signage Perimeter Lighting

The solar power solution required use of deep-cycle battery technology to provide reliable energy storage. Trojan's Premium line was chosen because the batteries are designed for deep-cycle use and optimised for deep discharge and recharge cycles characteristic of solar systems. In addition, Trojan's L16RE offers optimum functionality in tropical environments and regions, such as Victoria Island.

Trojan's Premium Line is designed to deliver maximum life under harsh operating conditions. Its robust grid design, thicker separators and advanced paste formulation offer optimum reliability and peak performance. Trojan customers receive the best long-term value when considering the total cost of ownership over the life of the battery.

Project financing and costs

The project was fully financed by the Diamond Bank.

Project outcome

The customers of Diamond Bank now have reliable ATM service 24 hours every day. This same model can easily be replicated in other branches of the bank.

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Case study 19

Trama TecnoAmbiental (TTA) and Studer Innotec SA

ERDET (Électrification Rurale pour le Développement Économique au Tchad)

CHAD

Source : TTA

Source : TTA

The organisation

TTA is a firm based in Barcelona working since 1986 in the field of renewable energies and rural electrification that provides services and turnkey solutions worldwide. Studer Innotec is a Swiss manufacturer of inverters and MPPT solar charge controllers for solar and hybrid energy systems.

The challenge

Chad is a poor country with low population density and a very low electrification rate. Electricity is demanded by the population to improve their quality of life, access to communications (TV, radio, telephone), community services (schools, clinics, street lighting, etc.) and to enhance income generating activities (irrigation, crafts, services).

Diesel genset based solutions exist in some villages, but supply of fuel is expensive and unreliable and cannot be sustained from tariffs by the subscribers. Solar radiation is abundant throughout most of the year and although the initial investment for RES rural micro-grids is high, its operating costs could be sustained by tariffs alone.

The project objective is to be a replicable demonstration of technology, management scheme and institutional framework. It has also overcome multiple challenges on the technological side (lack of local skills, logistics, security, etc.) as well as institutional (local capacity building, legal framework, willingness to pay, etc.).

Opportunities for renewables

Stand-alone, battery-less solar photovoltaic (PV) systems can pump enough water to meet this challenge. The passive, closed systems – requiring only cleaning the arrays and minimal maintenance – are ideal for delivering energy to locations with limited access to fuel, spare parts and technical expertise.

Renewable solution

TTA started its activities in early 2013 with field studies to assess needs, local capacity, social conditions and development benchmark indicators for five villages. Based on these factors and budget constraints, the technical specifications and sustainability model were designed for the villages and procurement and construction for three of villages started at the end of 2013. The technical solution for the Microgrids with Solar Generation (MSG) is based on a DC coupled PV hybrid power plant, an underground LV, a three-phase distribution line and smart electricity dispensers at each subscriber's interface. The table shows the general characteristics for the village of Mombou:

MOMBOU MSG : GENERAL CHARACTERISTICS	
Client	UNIDO / MEP
Contractor and Operator	TTA and Local Association
Electrical service	24 h/day, 230 V/400V three-phase
Number of user connections	129 (135 potential) and street lamps
Type of tariff	Energy Daily Allowance (EDA)
Rated Daily Solar Production	140,4 kWh/day – 5,91 HPS
PV HYBRID POWER PLANT	
Total PV capacity (STC)	39.600 kWp
PV charge controller	Studer-Innotec VT80
EMERGENCY GENSET	
Rated power	50 kVA
Battery	Lead acid deep cycle OPzS
Rated Voltage	48 V
Total capacity / Practical capacity (-70%) (C_{100})	434 kWh / 304 kWh
Dual mode inverter	Studer-Innotec XTH 6000-48
Total rated power (5" – 30')	90 000 VA – 36 000 VA
Emergency Genset Rated power	50 kVA Diesel
ELECTRICITY DISPENSER – ENERGY METER	
Power supply	230 VCA 50 Hz
Model	CIRCUTOR Electricity Dispenser BII
Algorithm	Energy Daily Allowance (EDA) configurable
DISTRIBUTION	
Feeder Type of cable	Aluminium XPLE
Type of distribution	Underground
Power supply	230 VCA 50 Hz
Smart Electricity Dispenser/meter	CIRCUTOR Electricity Dispenser BII
Algorithm	Energy Daily Allowance (EDA) configurable

Local companies were trained to install the equipment. The community was involved with the project from the beginning and played an active role during construction. A village association was created in June 2014 to support the service operation activities by TTA.

Project financing and costs

The investment funds come from UNIDO and the Government of Chad and the demonstration micro-grids are one of the project's components. The capital investment for one village, including engineering, construction of PV hybrid plant, distribution grid, user's internal installations and capacity building came up to 370,000 € and the expected yearly target revenue from tariffs is 21,000 € for operation costs and replacement of components. Users pay a monthly flat fee according to the contracted EDA (Energy Daily Allowance).

Project outcome

800 people from the village and an additional 200 from nearby hamlets now benefit directly from the installation. The MSG has surpassed the initial expectations of beneficiaries and national authorities, but the impact on development and the sustainability model will be assessed a year later with the objective to replicate it in other candidate villages.

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Case study 20

University of Southampton, Energy and Climate Change Division

Energy for Development (E4D): Replication of rural decentralised off-grid electricity generation through technology and business innovation

KENYA

Kitonyoni village market solar PV project

The university

The Sustainable Energy Research Group (SERG), with the Energy and Climate Change Division at the Faculty of Engineering and the Environment, University of Southampton is the forefront in energy research, development and teaching. For this particular area of E4D, projects and network aim to enable a step-change in collaborative research and project development addressing the energy needs of rural communities in developing countries.

The challenge

To address the development and implementation of sustainable projects in rural communities in East Africa. This encompasses social, technical, economic and cultural knowledge generation as well as understanding needed to allow replication. The approach established by the E4D team is holistic, incorporating community and government participation as well as multidisciplinary researchers.

Opportunities for renewables

Renewable off-grid solutions in many cases can be constructed to provide cheaper options than grid extension when incorporated with business models which result in income generation through an energy supply company (ESCO) supported by a community cooperative.

Renewable solution

This project is based on solar photovoltaic and storage system coupled to a mini-grid. The latter connects to all buildings (business, schools, health centres, churches etc.) and provides energy services to the rest of the community through electrical charging of LED lighting, mobile phones and other appliances. This is the concept of the Kitonyoni village market solar project established in 2012 in Makueni County (Kenya). E4D's goals are to establish an economically sustainable approach, whereby the community is responsible for the operation and maintenance of the plant. Income is generated for the cooperative/ESCO through share ownership and local sales of electricity, which also finances capital cost. Together, E4D engineers, local contractors and villagers were able to assemble the 13.2kWp PV plant and the mini-grid within one week. The premise of the modular design is to make it easy to replicate.

Project financing and costs

The Kitonyoni project was financed by research grants awarded to the SERG at the University of Southampton. The project implements a business model, which can incorporate set interest rates for future investors, generating pay back durations. This model requires end users to pay a tariff for the electricity they use. The ESCO provides end users the option to purchase LED lanterns to replace their current paraffin lamps and delivers an affordable means for the majority to access sustainable electricity.

Project outcome

Up to 3,000 people can now benefit from electrical service. The school, health centre, maternity unit and 40 businesses have round-the-clock stable electricity, allowing them to provide services such as food refrigeration, lighting, phone and battery charging facilities.

Additionally, the solar canopy of the PV system was designed to act as a rain collector, enabling water storage for use by the villagers throughout the year. To bring the social, technical, economic and humanitarian benefits of this project to other villages, replication is key and the team is now working with Kenyan, Ugandan and Mozambique partners as well as financiers and donors to make this happen.

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List of Abbreviations

Ah	Ampere Hour
ADER	Agence de Développement de l'Electrification Rurale
AEEP	Africa-EU Energy Partnership
AG	Aktiengesellschaft (Incorporated Company)
ARE	Alliance for Rural Electrification
ATM	Automated Teller Machine
AUC	African Union Commission
CHP	Co-generation of heat and power
CNELEC	Conselho Nacional de Electricidade
DC	Direct Current
EDA	Energy Daily Allowance
EDM	Electricidade de Moçambique
ESCO	Energy Service Company
€	Euros
FUNAE	Mozambique National Fund for Rural Electrification
GDP	Gross Domestic Product
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für internationale Zusammenarbeit (German Federal Enterprise for International Cooperation)
GoK	Government of Kenya
GmbH	Gesellschaft mit beschränkter Haftung (Company with Limited Liability)
GSM	Global System for Mobile Communications
GSMA	Groupe Speciale Mobile Association
H2E AD	H2E Anaerobic Digester
km	Kilometre
kVA	Kilovolt-Ampere
kWc	Kilowatt crête (Kilowatt Peak)
kW	Kilowatt
kWh	Kilowatt Hour
kWp	Kilo Watt Peak
Lda	Limitada (Limited Liability Company)
LED	Light-Emitting Diode
Ltd	Limited
LV	Low Voltage
MPPT	Maximum Power Point Tracking
MSG	Microgrids with Solar Generation
MV	Medium Voltage
m	Metre
NGO	Non-Governmental Organisation
OpzS	Ortsfest Panzerplatte Spezial (Stationary Tubular Plate Special)
PIDA	Programme for Infrastructure Development in Africa
PV	Photovoltaic
REA	Rural Electrification Authority
RECP	Renewable Energy Cooperation Programme
RES	Renewable Energy Sources
RECP	Renewable Energy Cooperation Programme
SE4ALL	Sustainable Energy For All
SERG	Sustainable Energy Research Group
SHS	Solar Home System
SMG	Solar Market Garden
TV	Television
UN	United Nations
UNIDO	United Nations Industrial Development Organization
USD	US Dollars
VDC	Voltage Direct Current

Best practices for Clean Energy Access in Africa

Fourth edition

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About the Alliance for Rural Electrification

ARE is an international business association representing the decentralised energy sector working towards the integration of renewables into rural electrification markets in developing and emerging countries.

About the Africa-EU Energy Partnership

The Africa-EU Energy Partnership (AEEP) constitutes one of the initial eight partnerships under the Joint Africa-EU Strategy (JAES), a long-term framework for cooperation between the two continents. The African Union Commission, Germany, Italy and the European Commission are the Steering Group members providing political guidance to the Partnership.

Alliance for Rural Electrification
Shining a Light for Progress

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AEEP Steering Group

Federal Ministry for Economic Cooperation and Development

European Commission