Mulanje: pioneering a social enterprise approach in clean energy mini-grid schemes

Clean energy mini-grids (10 kW to 10 MW) are increasingly seen as a viable solution. Systems of 10 to a few hundred KW are also referred to a 'micro-grids'. These can be a viable and cost-effective route to electrification where communities are far from the national grid or where population is not dense enough to justify a grid connection, but demand of households and local businesses is at such a level that cannot be provided by off-grid solar home or pico-solar system. The challenge has been to provide adequate financing and management and operation models for mini-grid systems, that range from the pure utility or government agencies model, to private sector companies, community-driven ownership-operator models and hybrid combinations of these.

To address issues and options in clean energy mini-grid implementation and business models in Malawi, UNDP is supporting the project, "*Increasing Access to Clean and Affordable Decentralised Energy Services in Selected Vulnerable Areas of Malawi*" with co-financing support from the Global Environment Facility (GEF).

Site: Mulanje
Business and financing model: community-based social enterprise with partial subsidy

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This case study in one of five that seeks to understand the possible role of energy mini-grid and off-grid systems in Malawi.

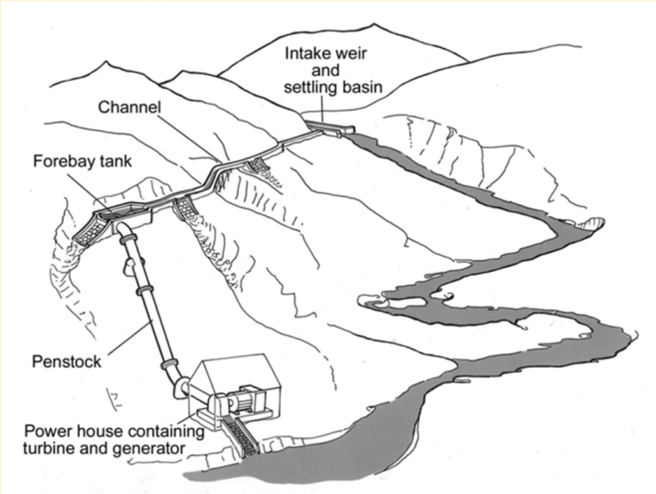
1. Mulanje area

The Mulanje Mountain massif is located in southern Malawi, measuring about 30 km from west to east and 25 km from north to south and its highest peak towers up to 3,000 metres over the surrounding plains. The area has a very rich forest reserve, which is a home to a rich and diverse endemic plant species (such as the Mulanje cedar) and plenty of wildlife. The Mulanje Mountain Conservation Trust (MMCT) aims at conservation of biological diversity and sustainable utilization of natural resources of the Mulanje Mountain Forest Reserve. The Trust works together with Malawi's Department of Forestry by bringing in community participation, maximising benefits among users of the forest reserve, and protect and reforest its watershed area.

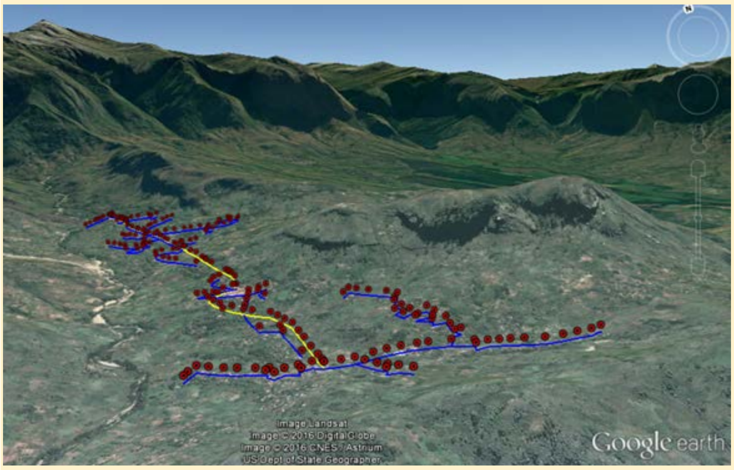
Mulanje has high levels of rainfall attracted by the mountain. It is, therefore, a very fertile area and home to many tea estates that employ large numbers of people and engage thousands of smallholder farmers that live on the peripheries of the estates. The lush climate also supports a rich fruit harvest of pineapples, mangoes, avocados, and bananas.

It is also a catchment of headwaters and a source of nine perennial rivers and tens of streams. This offers scope for generating power derived from the energy of falling water, fast running water. The concept of a community-based mini-hydropower project was first discussed in 2008 and led to the establishment of the Mulanje Energy Generation Agency (MEGA) in 2011 by three founding partners. Two of these have a place on the Board of Directors; these are MMCT (majority owner) and the Mulanje Renewable Energy Agency (MuREA, itself an implementing arm of MMCT), while the third founding partner, the international NGO Practical Action, has been providing project management and technical assistance. MEGA also works with Fairtrade Foundation on community development and the Scottish SgurrEnergy in project engineering and management.

MEGA's mini-grid scheme, Lower Bondo, Mulanje



The hydropower generation is run-of-the-river, i.e. it requires no water storage but instead diverts some of the water from the river, which is channelled along the side of a valley before being 'dropped' into the turbine via a penstock pipe (see figure). The 60 kW Lower Bondo system operates with 200 litres per second of water with a head of 50 metres. The weir is a permanent concrete structure and the channel is some 600 metres long. The turbine is a three-jet Pelton wheel. The system is regulated by an electronic load controller that monitors demand and dumps excess power.



The powerhouse is 8 km from the national grid, though the mini-grid extends to within 3 km at the closest point. The mini-grid network consists of over 12 km of medium voltage (11 kV) transmission and seven substations at this point, distributing three-phase power at 400 V over a 1 km radius. The substations are strategically placed at centres in the village to maximize customer reach.

The system runs 24 hours and caters currently to over 600, including over 30 businesses, public institutions such as schools, a clinic and churches. Peak demand is between 5-10 PM in the evening and 4-7 AM in the morning. The off- peak demand is 10 PM to 4 AM and 7 AM to 5 PM.

The water resource is readily available but the quantity reduces during the dry season and affects electricity production. The system can power 2 maize mills during off peak hours.

Figure above: schematic of a micro hydropower system (Source; Practical Action)
Figure below: MEGA's mini-grid. (Yellow = MV line. Blue = LV line. Red = Distribution poles)

With financial support from the European Union and the OPEC Fund for International Development (OFID), a 56 kilowatt (kW) mini-hydropower scheme at the Lower Bondo on the Lichenya River (on the southern side of Mount Mulanje) started in July 2013 and became fully licenced and operational in January 2016. Technical details on the plant and operations are given in the text box above.

The Bondo community was targeted for a reason of its relatively high population density and high incidence of (energy) poverty, as described in the text box on the next page. By providing improved access to health, education services and provision of electricity to 180 households in the first phase, the project developers hoped that the community would benefit and be incentivised to invest further in the energy model and ensure expansion to the neighbouring villages.

Additional financing for a second 80 kW hydropower facility is expected to come from UNDP/GEF and funding from the Scottish Government. This mini-grid will serve the Bondo, Nessa, and Namainja communities and provide electricity to an additional 400 households in the service area, maize mills, businesses and additional schools.

Socio-economic description of the Bondo area and community involvement

The tea industry employs between 10-18% of the adult Mulanje population. About 40% of the district population can be said to be directly benefiting from the tea industry. Some 8,280 smallholder farmers are engaged in tea growing. This makes tea the backbone of Mulanje's economy; providing cash income and creating demand for goods. Bondo is a community of seven villages on the lower slopes of Mount Mulanje with about 25,000 inhabitants. All the beneficiaries are of low but steady and reliable income that is generated by employment on nearby tea estates and the smallholder horticultural production of fruits, such as pineapples, mangoes, avocados, bananas and litchis. People in Bondo (predominantly women) also grow tea on a small scale, which they sell to the larger tea estates through the Sukambizi Association.

An energy survey undertaken in 2014 showed a high level of poverty, perpetuated by the inability to access good health services, and lack of income-generating agro-processing and good educational services. The average household cash income was estimated at MWK 5,337 per month (about USD 14). Before electrification, households in Bondo relied on the commercial services (milling, battery charging) and other commodities) that are found in the electrified towns on the main tarmac road, about 8 km away. Travelling to these areas costs money; the alternative of hiring the services of someone to take the battery to the charging station also costs money. Lighting needs were met by paraffin bought from local re-sellers who add their own margin on to this expensive commodity (MWK 220 to MWK 375 per litre).

Practical Action and MuREA also conducted a separate gender mainstreaming exercise which helped to direct the appropriate gender interventions for the project. The focus on including Bondo Health Clinic, for example, is a direct effort to influence a reduction in maternal and/or child mortality. The clinic has welcomed MEGA's electrification; the solar power system installed previously was abandoned after malfunctioning, while the Ministry of Health had removed the clinic from a planned electrification scheme.

The involvement and dedication of the community has been evidenced by the manual excavation of a 238-m trench for the first-phase hydropower facility that passes through difficult rocky and undulating area. In addition, female community members donated productive land (on their small-holder plots) for the canal to pass through. Community in-kind support also had some negative effect at first; many local people were at first given the impression that electricity will be free due their community participation during the construction of the scheme. This thus brought challenges of revenue collection during the first year of operation.

* Of which an estimated MWK 3,465 spent on food, MWK 1,025 on energy and MWK 1,176 on health care. Source: *Energy Access in the Southern Region of Malawi, Results and Analysis of Total Energy Access,* by Practical Action and MuREA (2014). Other sources: www.iodparc.com; *Community Renewable Energy Toolkit for Malawi* (CES-MuREA, 2014)

This is part of MEGA's overall aim to provide the rural, off-grid villages of the Mount Mulanje area with access to affordable and available electricity and energy services, locally generated through a series of up to ten mini-hydropower schemes (of about 40 to 100kW each) in which up to a total of 5,000 households (about 30,000 men, women and children) are expected to be directly connected.

There were some technical issues in the beginning. The Bondo hydro-electric power plant was not functional for four months in 2014 and was finally repaired and components replaced under the supervision of MuREA and Practical Action. Learning from this experience, MEGA is now closely managing the design and development of their projects. Inspection of MEGA, by the Malawi Energy Regulatory Authority (MERA), revealed minor safety issues to be addressed. These issues were resolved and MEGA obtained its Power Generation license in 2014.

2. A new business model

MEGA is being set up as an independent social enterprise, in which the Mulanje Mountain Conservation Trust (MMCT) is the shareholder. The model allows for community members and/or investors to have a share. Being a socially-oriented company MEGA will not seek to maximise profits but will balance the pricing of its electricity tariffs between its social objective of offering low-cost electricity and being financially viable.

The MEGA business model aims to achieve economies of scale for central operations by developing multiple sites. MEGA aims to establish a new micro-hydro turbine site (with an accompanying distribution system), every year for 10 years. Achieving this requires initial donor grant funding to cover the cost of all infrastructure investment of the micro-hydro turbine sites, and depreciation costs, plus a contribution to the operations in the years 1 to 5. After the fifth year, MEGA is projected to reach economies of scale and will start making operational profits and will progressively improve its asset base to be able to meet an increasingly larger part of the investment costs of new clean energy mini-grids.

Comparison between MEGA and ESCOM pre-paid tariffs

	MEGA	ESCOM	
(tariff in MWK/kWh)	Single phase	Single phase	Three phase
Community institutions	32	38.56	59.57
Households	64	38.46	59.57
Commercial	106	66.21	79.45

Source: MEGA, ESCOM (2016-17 tariffs).
USD = MWK 720 (Apr-Oct 2017, www.oanda.com)
MEGA has now introduced a connection fee for their consumers. Each new household applicant is required to pay MWK 5,000 whereas each business applicant is required to pay MWK 6,500.

The business plan forecasts that revenue from sales will cover all running costs, including staffing, operations, maintenance, VAT, site insurance and a contribution to a payment for eco-systems (PES) scheme. For sustainability, it may be a challenge for MEGA to achieve both its social and financial objectives. MEGA has sold electricity at approximately twice the current rate that the national utility ESCOM (Electricity Supply Corporation of Malawi) uses in other parts of the country. This price point is needed to generate enough revenue to create a financially viable operation. This pricing policy seems high but is justified when compared to the current average household expenditure on meeting the same energy needs through substitute products: kerosene, charcoal, and wood. It has been estimated that each connected household is likely to save 16% of its current expenditure by switching to MEGA energy.

Revenue will be generated from households, businesses and productive uses through electricity consumption charges and connection fees. The revenues collected per month ranges from MWK 500,000 to MWK 1,000,000. The consumers pay for their electricity through prepaid meters. There is an agent in the community who receives payments for electricity units from the consumers. After receiving the payment, the agent communicates to the system's electrical engineer who is in-charge of the billing system. The electrical engineer then sends a token (through the mobile network) to the agent for entering on the prepaid meter of each consumer who has purchased the electricity. So far, the prepayment model has proven effective at recovering revenue from customers.

3. MEGA working on sustainable development

MEGA's focus on sustainable development means that MEGA's business model and value chain remain closely intertwined with MMCT and its social objectives.

Livelihoods and community use

MEGA supports local businesses to establish and grow with the aim of raising entrepreneurs' incomes and availing new products and services in the community. It already powers two maize mills; small businesses in the area, which are welding and machine shops, a carpentry and bakeries. Entrepreneurs will be given business and skills training and linked with finance providers for investment. These efforts are mutually beneficial for the commercial users and MEGA itself, i.e. MEGA's commercial viability hinges on revenue from high-power productive users.

In the near future, business centres will act as energy 'hubs/kiosks' and offer a range of services to their customers (including off-grid households and businesses). These services encompass indirect energy services (such as charging batteries and charging mobile devices, as well as offering, ICT (computer & internet use) and basic business services.

Watershed management

Watershed management activities target protection and improvement of the hydro system's catchment area and the generation infrastructure. The trees of Mount Mulanje are under threat from timber cutters, charcoal-makers, and upland agriculture. Deforestation increases the risk of flash floods that can damage the intake and generation infrastructure. It also reduces the water-holding capacity of the watershed area which leads to low river levels and reduced power generation in the dry season. For this reason, some 200,000 trees are planted in the hydro system's catchment area and place bamboo and grass around the power canal. Farmers are trained in conservation agriculture and the community sensitised on the harm of deforestation.

4. Lessons learned, challenges

Impacts

Electricity has brought a drastic change in people's lives. Before the mini-grid scheme, after a day's farming, the people of the village had to light their homes with candles, log fires, kerosene lanterns or battery-powered lamps, that provide families with only one or two hours of light in which to read and cook. In Mulanje, as in many African rural areas, it was rare, for example, to find teachers willing to live in an area without electricity. In Bondo village, schools had to turn down computers from the Ministry of Education because there was no electricity to run them. In the local health centre pregnant women were asked to bring their own candles to light the delivery room. The lack of electricity constrained opportunities to grow small businesses that could not use power tools.

Power is now being distributed to households, shops, and social services, such as the health clinic. Small shops are achieving greater turnover due to extended trading hours enabled by lighting. New enterprises are being set up. Bondo's school has nearly doubled the number of teachers on its books. Households now actually spend a lower percentage of household income on energy, in comparison with the expenditure on fuels such as kerosene, wood, and charcoal.

Lessons learned

MEGA is first licensed (social) independent power producer (IPP) in Malawi; it has been a steep learning curve for all involved and there are many experiences to share. If MEGA is able to achieve and maintain momentum, there is potential to influence the wider energy landscape in Malawi, paving the way for further investment in private energy provision.

The centralisation of core business functions in a cross-community 'hub' makes MEGA's model different from other community-based models used in distributed energy schemes in neighbouring countries. In other schemes, mini-grid energy infrastructure has typically been initiated by a third party and then handed over to a community group after construction. There is an opportunity for MEGA to establish itself as a model of commercially viable distributed rural energy solutions – if the social enterprise model succeeds.

MEGA's own financial analysis shows significant donor funding is needed to enable MEGA's business model to succeed in providing sustainable affordable available energy to consumers. The reason is that tariffs are higher than ESCOM's (subsidised) tariff, but still do not reach what would be needed to function as a fully commercial enterprise, not dependent on grants. However, by expanding to up to 10 mini-hydropower plants, the company wants to achieve certain economies of scale, in which increased revenues accrued by the realised hydropower facility are able to cover larger parts of the initial investment needs of the future facilities. In case of MEGA, a break-even point is expected to be achieved halfway the construction of the chain of the mini-hydropower facilities.

It also opens the option that the various mini-hydropower facilities are interconnected. On one hand, the interconnection transmission line would mean additional cost; on the other hand, this allows a hydropower facility (not yet producing power at maximum power demand) to already deliver power to the next village to be electrified (and thus accruing revenues, while benefitting the next village already with a first power supply). Overall system reliability is increased.

Regarding supporting social services in the area, MEGA has connected and wired schools and has supported the purchase of medical equipment for the health clinic. Electrification of schools (wiring and consumption costs) will need to be covered by donor grants and/or parental contributions as neither MEGA nor the Department of Education is able to (fully) cover these costs. Also, power for hospitals and health centres is paid for by local government.

Successes

Successfully establishing the first site at Lower Bondo has been critical to the realisation of the business plan: communities needed to be convinced that electricity access is possible and MEGA has demonstrated that tariffs can be collected and are sufficient to cover operational costs. The success of MEGA hinges on a combination of success factors:

- *Affordability* of energy to the target market (of households, social services, and small local businesses). This means having a tariff minimisation policy in place to keep tariffs as low as possible but within the limits of pursuing a commercially viable business;
- *Accessibility* of electricity and of payment credits to the target markets. MEGA has community-based energy credit vendors in the communities, so that connected households can purchase electricity as need, while working on the retail model for businesses and energy kiosks/hubs;
- *Availability and reliability* of energy in the distribution system by means of well-maintained operations with the local community. Further local training and engagement will help in ensuring a consistent and reliable energy supply.
- The latter factor is linked to c*ustomer awareness and engagement* of product/service offering and understanding of the economic and social benefits, for which MEGA has set up a community engagement plan.

- The *safety of generation, distribution, and use* is addressed through the training of operators on proper use and maintenance.

Challenges

Despite achieving key milestones, there remain some question marks around the capacity of community-based organisations to run mini-grid energy projects. MEGA faces particular challenges as the upfront infrastructure investment is high and largely charged in US dollars while the potential tariffs are limited by consumers' ability to pay and are largely in Malawi Kwacha (MWK). The economies of scale needed to realise commercial sustainability can be difficult to achieve with community-by-community ownership. MEGA hopes that close management of the infrastructure by professionals will assist its commercial viability.

The scheme has long off-peak periods which could have been utilized for productive uses. The current level of productive use of electricity is at lower than expected levels needed to ensure operational profits. MEGA is seeking larger commercial users for the electricity such as mobile telephony service providers. Also, hampering the feasibility of mini-grid hydropower plants is the fact that, initially, these do not function at the maximum power demand that are designed for. The reason is that in practice not all households are willing to be connected (and all productive uses are not in place). In the first year, maybe only part of the households is connected, while in the subsequent years, more households are connected, thus densifying the coverage of the mini-grid facility and raising revenues in the process. Despite the (partly) subsidised social tariff, prospective clients may be reluctant initially to be electrified due to cost reasons. Households do not face the connection fee only, a household needs to invest in up-to-standard internal wiring, sockets, switches that may cost about MWK 100,000.

The dual focus on socio-economic benefit and commercial viability presents challenges in making MEGA commercially viable. MEGA has learnt that a clear understanding of the sales volumes (of households and productive uses) is needed. For example, one way to overcome the internal house wiring and connection cost barrier, is to include some cost internal wiring in the electrification scheme and let the household pay over time through the power tariff. Reportedly, this has not been an issue in Mulanje, but often is found to be so in other off-grid projects. The more early adopters, the easier the demonstration of the financial and other benefits of using MEGA energy.

Other challenges relate to external risk factors. For example, MEGA needs to work with and employ skilled business people, engineers, trainers, and operators. This is largely lacking in the Mulanje area. Secondly, critical for MEGA's success as the target market is the engagement of the households and businesses. In principle, the residents of Mount Mulanje can participate in the ownership and governance structures of the organisation, and they have supported in-site construction, operation, and retail. Nonetheless, community members have commented that 'waiting' for 5-10 years to be electrified is too much time to wait for, and there are complaints that the village community is not really involved in day-to-day management decisions. The MEGA Board plans to invest in greater community awareness and collaboration with village leaders.

As the first IPP in Malawi, MEGA has faced challenges in going through the licensing procedure with MERA. The procedure has been designed with large grid-connected IPPs in mind, but for small village-level producers this means in practice time-consuming efforts at relatively high cost. MEGA's legal problems have challenged the Malawian administration to review their current licensing framework for privately owned energy companies. Time will tell, if the new mini grid regulatory framework will make it easier for other (small) privately owned transmission and distribution entities to operate.

Opportunities

In low-density scattered communities, where mini-grids are less viable as the cost of distribution becomes prohibitive, electricity kiosks and stand-alone technologies such as solar lanterns or solar/wind home systems become more attractive. Mini-grids are most appropriate in areas such as the Bondo area that has relatively high population density above 250 inhabitants per km^2

ESCOM, which supplies the national grid, does not reach remote areas of Mount Mulanje. The nearest point in the Mulanje grid is about 5 km from the medium-voltage grid line. The area may be connected to the national grid in the near future. This may pose a challenge as well as an opportunity. The MEGA mini-grid should not face competition from direct power supply. Instead, MEGA should be allowed to connect to the grid and sign a favourable power purchase agreement with ESCOM as the off-taker of its energy. Energy sales to ESCOM would bring MEGA an additional and stable flow of income and make the power facility sustainable by enabling to generate and sell power at full capacity. However, such energy sales should take place under the condition that the electricity to the Mulanje clients at the current tariff arrangements remains guaranteed.

5. Concluding remarks

A financially viable microgrid balances grant money for investment, revenue streams from tariffs with debt, equity, and operational expenses obligations both in the short and long run. The MEGA 'social enterprise' provides a successful example of a "partially subsidised business model" that simultaneously espouses private sector values for financial and operational sustainability and social values for inclusion. In other words, it tries to pass on the lowest possible energy services costs to its customers and considers local ability to pay while also ensuring that the microgrid is reliable and financially viable.

The social enterprise management may, therefore, prove to be an alternative to the community-based model and the private business model). Community-based systems are often hampered by local management issues and poor revenue collection, while private-owned systems aim at profit maximization (and prefer investments in larger systems to sell power to the grid at commercial feed-in tariffs over investments in small village systems at social tariffs).

The UNDP/GEF project is currently supporting an expansion of the Lower Bondo mini-hydropower scheme with a 80 kW power station. At an estimated investment of USD 780,000, GEF provides investment co-financing and UNDP technical support. In addition, the UNDP/GEF project could provide assistance regarding the options regarding the possible connection to the main grid in the future and its technical and economic implications.

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The series was drafted by Jan van den Akker and Diliza Nyasulu, and coordinated by Emmanuel Mjimapemba and Etta Mmangisa (UNDP Malawi). Editing was done by………. We are grateful for MEGA and other contributors for the information shared.
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Planning solar photovoltaic mini-grid solutions, Mchinji

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Sites: Sitolo (Mchinji District) and other sites
Business and financing mode (Mchinji): social enterprise with partial subsidy

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1. Area and location; proposed energy solutions

Community Energy Malawi (CEM) is proposing to install a **solar mini-grid** at **Sitolo Village**, which is situated 18 km from Mchinji Boma (and 12 km from the national grid), to generate and distribute power. Sitolo village is not included in the national Malawi Rural Electrification Programme (MAREP). The village covers 3 Village Group Headmen (Sitolo, Kaluzeze, and Faifi) under Traditional Authority Mlonyeni.

Sitolo village has 300 households and 1 primary school and a small health facility. The 80-kW solar PV facility will initially connect 150 households, grocery shops, a salon and barber shops, one bar, a maize mill, the local school and health clinic as well as six street lights. In future, the system coverage could include more households and other productive uses (such as milk cooling and metal workshops). Also, CEM Trading may start a rolling programme of selling solar pico-products and battery charging in an '**energy hub/kiosk'.**

Community Energy Malawi is a registered Malawian trust and was formed as part of the Community Energy Development Programme (CEDP). CEDP was one strand of the Scottish Government funded Malawi Renewable Energy Acceleration Programme (MREAP). Between 2011 and 2015, the CEDP successfully delivered 46 community energy projects that directly impacted 20,378 people in 12 districts across Malawi.

Technical details of the proposed solar PV mini-grid, Sitolo

The Project will involve the installation of a 80-kW solar mini grid complete with a 1-km long transmission (11 kV) and distribution (400/230 kV) system targeting 150 households. This project is supported by UNDP working in close collaboration with Department of Energy Affairs with CEM offering on the ground implementation supervision of the deliverables.

The project engineering design is done by Mzuzu University (Energy Department). A first modelling, based on the estimated peak demand of 28 kW and energy production of 300 kWh per day, an 80-kW system may be able to meet all of the peak load (84%). The system would cost USD 435,000 including equipment (with 164 batteries of 3300 Ah), accessories and installation, of which half would be covered by a grant provided through the UNDP-GEF project (plus an additional USD 100,000 for technical assistance and staffing, local capacity building and village awareness creation). At this capital cost of USD 435,000, the system could produce energy at USD 0.08 per kWh (break-even) and sell at USD 0.10/kWh (allowing for a small margin).

A second review of the energy demand (by CES) suggests a higher household demand (by including refrigeration). The village maize mill would represent the largest single load on the system. In the village expectations are high and local mobilisation for the mill is well-established with the building for the business under construction. Without load management, it would take system capacity requirements beyond the 80-kW threshold. However, the inclusion of the mill will bring sustainable income to support system operation, economic development for the village, and wider socio-economic impacts with the time saved from not having to travel 18km on foot to similar facilities. Currently, the load demand is being studied, in particular how the mill can be accurately included.

Sitolo village	Demand kWh/day	Total load kW
Second demand assessment (CES)		
Households (100)	454.20	26.65
Shops, bar (3)	25.95	2.58
School, church	10.55	2.31
Clinic	4.41	0.29
Maize mill	181.05	15.16
Public lighting	3.60	0.30
Total	679.76	47.29
PV system capacity (incl. PV efficiency), kW		
Without HH fridges		60
Plus mill, no HH fridges		120
No mill, plus HH fridges		180
All connected loads		240

Source: CEM-commissioned reports

2. The social enterprise ownership-operation model

The project will be implemented by CEM and CES (Community Energy Scotland), but operations will be vested in **CEM Trading**, which will be a 'social enterprise' under CEM. The involvement of CEM and CES as trusts will guarantee the successful mobilization of the community and development of the site. IEEE-Smart Village will support the development of the productive uses like maize milling, irrigation and cooling, and processing of milk. The UNDP/GEF project is supporting CEM in the design and construction of the solar PV mini-grid by providing technical assistance and some financing support.

This setup follows the business model pioneered by the Mulanje Energy Generating Agency in the Mulanje area (see the Case study for more information). MEGA is the first operational private energy company and operates as a 'social enterprise', managing a hydropower mini-grid in the area. The MEGA business model focuses on making energy available and affordable to its target market – promoting price minimisation - within the parameters of building a financially sustainable business. To achieve this, MEGA's business model requires donor grant funding to cover (part of) the initial investment in the power production facility and distribution grid. MEGA sells electricity at approximately twice the domestic rate that ESCOM uses in other parts of the country, differentiating between households, businesses and community institutions (e.g., schools, health centres). This pricing policy seems high but is justified when compared to the current average household expenditures on kerosene, wood fuels, and batteries, and is profitable enough to achieve financial operational sustainability. In the business model, the ownership of the social enterprise is an NGO or local entity. In the model, rural residents may participate in future in the ownership and governance structure of the organisation. The beneficiaries have been actively involved in the design (site assessment), construction, and operation.

The MEGA business model has attracted interest from donors (such as UNDP) and the lessons learned could be replicated to other mini-grids. Hence, the UNDP-GEF Clean Energy Mini-grid Project will support the establishment of solar PV mini-grid in Sitolo village in Mchinji District, replicating the MEGA approach.

Sitolo village. Photo credit: V.d. Akker

To ensure local technical sustainability, CEM Trading will employ a skilled technician for the continuous monitoring of the system, its maintenance and, fault troubleshooting, and to oversee locally-appointed technicians (who will install house wiring and maintain the power lines). CEM intends to utilize this powerhouse manager to sell prepaid electricity units and collection of rentals. Later on, CEM plans to get tariff payments through mobile money payment and physical revenue collection by village agents.

Implementation of the Sitolo solar PV min-grid project would have various positive impacts on the environment (solar energy has zero greenhouse gas emission) and social well-being. People are currently walking long distances (22 km) to charge their phones and other services (such as milling) at cost of transportation and of the (energy) service. The fact that the rural communities will have access to modern energy services can stimulate other productive users and thus economic growth.

Solar kiosks and battery charging

Centralized community energy systems have a common source of electricity generation, a mini power plant, from which energy is distributed among households or several communities, such as the above-described solar PV mini-grid. Individual household energy systems are also very common in Malawi. People purchase their own pico-solar devices or install household solar PV systems at their houses which generate energy for own household needs only. These needs include lighting, communication, and entertainment. The Government and NGOs are also installing solar PV at clinics and in schools.

In between these individual systems and mini-grids are solar energy kiosks (or hubs) that function as a kind of non-wired or mobile mini-grid with basic energy services. These services include rentals of battery boxes and appliances or lamps, phone charging, battery charging, or even offering power-dependent services like barber shops, video show, cold drink sales, printing and computer services. The centralization of the system allows for 'community appliances', i.e., appliances that require more power and give a benefit to the whole community, e.g. a water pump or purifier. This system can be easily scaled-up and adjusted to the community's size and requirements.

3. Lessons learned and challenges

The **Sitolo solar PV mini-grid** case indicates how important it is to accurately size the power system. If under-estimated, the mini-grid will not be able to meet (peak) power demand, leading to load shedding and/or unmet demand, and customer dissatisfaction. If over-estimated, the system will have a large excess capacity, leading to high unit costs of energy that have to be covered by high tariffs that the beneficiaries would be unwilling to pay.

Experience with solar kiosks in Malawi

The Dutch organisation Hivos Foundation contracted Sonlite Electrical Contractors in 2016 to design, supply and install 2.7 kW solar energy kiosks in 6 centres in Chikwawa District (in Chikula and Oleole) and in Nsanje District (in Nguluwe, Mulukwa, Melo and Nyamvuwu in 2016 (one centre will be a solar-powered mini-grid). Plans are underway to supply and install 2.7 kW in Chimombo in Nsanje District. The systems are currently managed by the HIVOS Foundation and have not started operating yet. After finalising administrative procedures, and completing user training, and training of the community management committee, the systems will be handed over.

The energy kiosk is comprised of 14 solar panels of 195 W, 4 batteries of 183 Ah at 20 degrees, one 30-A charge controller, two 45-A charge controllers, one 1000-W inverter, and 20 solar lantern charging stations with 500 solar lanterns for each site. Each solar lantern charging station can charge 10 lanterns at a time. The inverter is used to power lights, AC fridges, desk top computer and a printer. The energy kiosk will also provide such services as TV shows, cold drinks, printing and internet services.



Solar kiosk building (left), solar lantern charging (middle) and computer, printer, refrigerator and TV (right)

The **energy kiosks** may provide an alternative for those communities whose houses are far apart, whose energy needs are not high, or whose households cannot afford the connection fee and regular tariff payments (households with low income levels). It is possible to implement the kiosk in a business model in which the initial investments, as well as the recurring running costs of the kiosks, are ideally recovered over a period of five to seven years (allowing for a return premium for investors) Thus, these systems can be owned and/or operated by a local entity or communities without further costs on their behalf after these have been paid off, thus creating a solution that is financially sustainable to both their customers and the owner. However, it should be pointed out that the success will depend on the buying power of the households who will get the services from the energy kiosk.

4. Concluding remarks

The various off-grid options, i.e. solar PV mini-grid, solar kiosk with battery charging, stand-alone PV systems, do not exclude each other. Mini-grids (powered by solar PV as in the Mchinji case, or by other sources of power) may serve communities that have a relatively high settlement density and have high energy needs apart from residential, such as for the maize mills and other productive uses, or for social services and telecommunications. It should closely monitor the progress of MEGA (in Mulanje) and CEM Trading (in Sitolo) and provide guidance where needed. For now, the social enterprise model offers great promise for replication to other off-grid areas in Malawi.

The full series of case studies:

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Kavuzi: pico-hydropower schemes, a people's initiative

Clean energy mini-grids (10 kW to 10 MW) are increasingly seen as a viable solution. Systems of 10 to a few hundred KW are also referred to a 'micro-grids'. These can be a viable and cost-effective route to electrification where communities are far from the national grid or where population is not dense enough to justify a grid connection, but demand of households and local businesses is at such a level that cannot be provided by off-grid solar home or pico-solar system. The challenge has been to provide adequate financing and management and operation models for mini-grid systems, that range from the pure utility or government agencies model, to private sector companies, community-driven ownership-operator models and hybrid combinations of these.

To address issues and options in clean energy mini-grid implementation and business models in Malawi, UNDP is supporting the project, "*Increasing Access to Clean and Affordable Decentralised Energy Services in Selected Vulnerable Areas of Malaw*i" with co-financing support from the Global Environment Facility (GEF).

Sites: Kavuzi area (Nkhata Bay District)
Business and financing model: local private with no subvention

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This case study in one of five that seeks to understand the possible role of energy mini-grid systems in Malawi.

1. Kavuzi area

The Kavuzi pico-hydropower schemes are found in Nkhata Bay District in the Northern Region. Kavuzi is situated at 15 km distance from Mzuzu city in the area under Traditional Authority Timbiri and Traditional Authority Kabunduli. In these two Traditional Authorities there are about 150 pico-hydropower schemes that are using the Kavuzi and Kadeti Rivers as the hydro resource. Most of these schemes service one house.

The origin of these schemes lies in the development of micro hydropower scheme by the Malawi Industrial Research and Technology Development Centre in the area which was used by a youth organization to provide power to its youth centre building for lighting and a computer. However, after some time the youth organization disbanded and the equipment of the micro-hydropower scheme was scavenged. Fortunately, the knowledge of generation of power by utilizing water was not lost. One technician started generating power from the Kavuzi River using a bicycle dynamo and supplied power to the house of his parents. This gave impetus to other artisans in the area to start their own pico-hydropower schemes, using hands-on technology, that now supply electricity to several houses in the area.

The systems visited for the case study are in three villages of the above-mentioned Traditional Authorities, covered by the traditional leaders Group Village Head Chipimbininga, Village Head Yavimba, Village Head Moseni, and in which about 25 pico-hydroelectric systems are operating. Currently, there are four to six artisans in the area who are developing pico-hydropower schemes for households. Business is booming. An artisan can set up a pico-hydropower plant in about one month and the craftsmen interviewed mentioned that they receive about five orders a year, implying that about 20 new hydro schemes can be installed each year on average.

Pico hydropower schemes in Kavuzi

Turbines smaller than 10 kW are usually called "pico". Pico turbines can provide power for small clusters or even single households to power one or two fluorescent light bulbs and a TV or radio. The hydropower generation is run-of-the-river, i.e., it requires no water storage but instead diverts some of the water from the river which is channelled along the side of a valley before being ‘dropped’ into the turbine via a pipe. The pico-hydro power schemes in Kavuzi usually utilize one forebay. There can be more than four turbines utilizing one forebay each having its own penstock.

The Kavuzi schemes have readily available water which is perennial and the catchment areas of the rivers are not heavily affected by deforestation due to charcoal production and shifting cultivation. In Kavuzi, the artisans typically build the pico-hydropower plant from scratch, using starter motors of cars or broken-down motors from factories, and rewind the motors by getting conductors from old compressors of refrigerators. The turbines are made out of fans from cars, rims of cars as well as metal caps made from pipes.

Number of 100W bulbs	Pen stock size (diameter in mm)	Cost in WMK
4	50	60,000
7	70	80,000
8	70	90,000
10-15	90	110,000
20	110	150,000

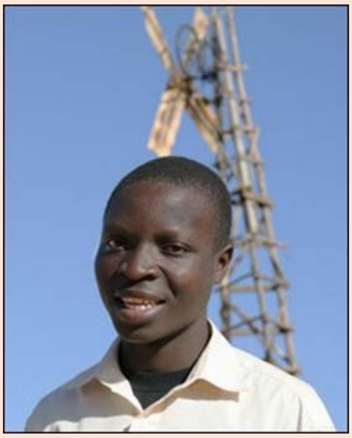
2. A bottom-up approach and business model

The system is owned by the user. The artisan sells the system to the user at one-off cost, the size of which depends on the number of 100 W bulbs that it can handle (as described in the table in the text box above). Most pico-hydro schemes service one house only and can provide a basic power service (for one or two lights, TV, phone charging, and for haircuts). However, the users are free to extend their power to their neighbours and there are a few pico-hydro schemes which power two or even five houses. It should be mentioned that the extension to the other houses does not attract an additional cost, but some users do charge those who come from outside their neighbourhood for charging phones (costing about MWK 50 each charge).

The maintenance of the system involves worn-out bearings, conductor, magnets and pipes. The cost of maintenance depends on the part that has been damaged and needs to be replaced. The labour cost ranges from MWK 1,000 to MWK 2,000, while worn-out parts can cost as much as MWK 6,000. For example, replacing bearings will cost MWK 4,000 and changing magnets will be at MWK 6,000 each.

The users and non-users have formed a Committee to look into the more organised development of the pico-hydro schemes with the objective of looking at regulatory issues (see ‘Challenges’) and of encouraging bigger schemes that can cater for several households. The Kavuzi Committee started in September 2017. The basic idea is that the bigger scheme will be owned by the community and managed by the Committee. Every household that likes to join the Committee is requested to contribute MWK 1,000 per household per year. There are already 42 contributing members at this moment.

Home-made wind mills in Malawi



In October 2009, the story of William Kamkwamba appeared in news channels such as BBC and CNN, who build an electric windmill out of junk to provide electricity for his family and his village. Frustrated by the lack of light after sunset and the inability to pump water to irrigate his family's maize plants, he saw a picture of a windmill in a book and decided he would build one himself. He managed to put together a machine from spare bicycle parts, a tractor fan blade and an old shock absorber, and fashioned blades from PVC pipes (flattened by being held over a fire) and a bicycle for gearing, and thus was able to provide power for his family. Before long, locals were queuing up to charge their mobile phones. After that, he installed a solar-powered mechanical pump, donated by well-wishers, above a borehole, adding water storage tanks and bringing the first potable water source to the entire region around his village.

Source: CNN (5 Oct 2009), BBC (10 Oct 2009), Community Energy Malawi (CEM)

The Committee functions as a communication bridge between the community and any stakeholder such as Department of Energy, Malawi Electricity Regulation Authority (MERA), the District Assembly and UNDP. It is the vision of the committee that the District Assembly will assist the Committee's formalization into a Kavuzi electricity generation trust or cooperative (depending on the available funds from interested stakeholders).

The Committee also looks after environmental issues, such as protection of the watershed area. For example, the District Assembly has already pledged to donate tree seedlings to the committee to plant trees in the catchment areas so as to reduce environmental degradation of the catchment areas of the two rivers Kavuzi and Kadeti.

3. Lessons learned, challenges

Lessons learned

The Kavuzi pico-hydropower and Kamkwamba small windmill examples clearly show that local people are able to initiate an energy project to reduce energy poverty in the area without waiting for Government or donors to reduce their energy poverty (by granting funds and/or installing an energy scheme).

The Kamkwamba windmill is situated in one of the windiest parts of Malawi, while the Kavuzi area has sufficient water resources year-round. But, as long as the resource for energy production is within their reach, the examples reveal that communities have innovative ways of managing their resources and solving energy problems, and show that scattered or far-flung settlements can organise their own basic energy services.

Purely demand-driven, these locally-built schemes are able to organise access to electricity much faster than the conventional grid electricity, provided by the Malawi Rural Electricity Programme (MAREP), and at much lower cost. In reality, the villages are considered to be too far away from the nearest transmission line for the power company or the households too scattered to consider connecting.

The availability of artisans at local level provides the technical sustainability of the scheme. This is often a reason of failure of many mini-grids around the world (that often lack local operators and technicians and do generate sufficient revenues to cover operation and maintenance expenses). As all the investment cost are paid upfront, there is no issue of lack of fee collection, which often poses difficulties in community-managed energy schemes.

Challenges

As the power is used by household situated at a distance from the generator, the transmission becomes an important issue. The distribution of power from the generators to the houses in Kavuzi is through very thin, bare, conductors with strands of wires, of which the ground clearance is not in line with the standards of electricity distribution (the wires are just hanging on poles as shown in the photo). Apart from the safety issue, there are heavy distribution losses as the power goes to the houses.

Inspection by MERA led to the conclusion that the systems should be upgraded to a certain quality and safety level or otherwise would need to be dismantled. Therefore, the provision of practical training to the village artisan is urgently needed to be able continuing producing hydropower and distribution systems that are really people-owned, affordable and that can meet minimal safety standards.

Local manufacturing of small energy systems – dream or reality?

- Installers need to have the capacity and know-how to install the small energy unit and village distribution systems so that these can provide power in a reliable and safe way according to national technical standards. This includes basic knowledge on civil, mechanical and electrical systems and low-voltage power distribution.
- The Kavuzi pico-hydropower systems and the Kamkwamba wind mill are made from scrap materials. A better-quality product could be made if some parts could be manufactured in a batch process meeting certain quality standards. This would mean local manufacturers need to be incentivised to manufacture the products through having sufficient orders to be able to cost effectively manufacture the products
- Further research is required to ensure that pico-technology can be used well in the future. This includes synchronising multiple pico units, distribution systems, storage for load peaks and low power matching equipment such as LED lighting or low-power labour-saving machines. Customised packages can be designed that are attractive to different types of end-users/stakeholders
- Rural communities in Malawi need to be made aware of pico-technology through village mobilisation and technology demonstration and be made familiar with subsidy and financial support options at local and national level.

4. Concluding remarks

The UNDP-GEF Clean Energy Mini-grid Project will be instrumental in organising and providing training to local artisans and technicians in Kavuzi to enable them to build locally designed small energy systems in a safe way and will encourage the mobilisation of communities. The Project should also create awareness amongst energy policy-makers on the potential of the pico-technology as a bottom-up, community-owned approach to local energy supply that supplements national electrification efforts at low cost.

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Photo credits: J. van den Akker, except the Kamkwamba photo

Solar villages: solar-wind hybrid mini-grids

Clean energy mini-grids (10 kW to 10 MW) are increasingly seen as a viable solution. Systems of 10 to a few hundred KW are also referred to a 'micro-grids'. These can be a viable and cost-effective route to electrification where communities are far from the national grid or where population is not dense enough to justify a grid connection, but demand of households and local businesses is at such a level that cannot be provided by off-grid solar home or pico-solar system. The challenge has been to provide adequate financing and management and operation models for mini-grid systems, that range from the pure utility or government agencies model, to private sector companies, community-driven ownership-operator models and hybrid combinations of these.

To address issues and options in clean energy mini-grid implementation and business models in Malawi, UNDP is supporting the project, "*Increasing Access to Clean and Affordable Decentralised Energy Services in Selected Vulnerable Areas of Malawi*" with co-financing support from the Global Environment Facility (GEF).

Sites: Mdyaka and Kadambwe
Business model: government with full subsidy

This case study in one of five that seeks to understand the possible role of energy mini-grid systems in Malawi.

1. Area description

Mdyaka is located in Nkhata Bay District in the Northern Region (situated about 100 km from Mzuzu city), serving about 150 houses in the village of Head Thuli under Traditional Authority Fukamalaza. Kadambwe is in Ntcheu District in the Central Region (situated about 180 km away from Lilongwe city), serving the village of Head Chiwiza under Traditional Authority Ganya.

2. DoE-installed solar-wind hybrid systems: a top-down government-led model

Six solar-wind hybrid systems were installed during 2007-2009 at a cost of MWK 50 million per system (about USD 370,000 at that time) with water pumping (the first three systems) and USD 42 million per system (second phase, without water pumping), with 50% funding from the state utility ESCOM and 50% from Treasury. The case study focusses on two of these solar villages. The **Mdyaka system** is a solar-wind scheme comprised of 35 solar panels (30 of 190 W and 5 of 150W), 100 solar batteries of 200 Ampere-hours (Ah) and 3 wind turbines of 4.5 kilowatts (kW) with control units. The **Kadambwe system** was comprised of 40 solar panels of 230 W each, 120 solar batteries of 200 Ampere-hours (Ah) and 3 wind turbines of 4.5 kilowatts (kW) with control units. The load estimate assumed 150 houses per village with 5 lighting points (of 14 W) and a socket for TV and phone charging (with water pumping in the first phase).


Mdyaka. Photo: J. van den Akker

Both the systems at Mdyaka and Kadambwe experienced set-backs from the onset by bad design and installation and failing maintenance thereafter. The systems are now out of operation. The cost estimates for repair were higher than of extending the grid, and therefore these systems are now scheduled for decommissioning, as DoE has decided that the communities were to be connected to the main grid. To all the six solar villages, the electricity grid will now be extended.

Failing solar-PV hybrid systems in DoE solar villages

Although there has been no formal evaluation conducted, evidence collected during the field work in Mdyaka and Kadambwe suggests that the following factors have caused or contributed to failure:

- Lack of community consultation on local energy needs and lack of resource assessment (cf. with the Likoma feasibility assessment) prior to installation. Also, the design lack proper wind speed data and, hence, the sizing and the generation mix design was with errors. For example, the bidder to the contract proposed a system based on 40% solar and 60% wind, which advisory engineers later proposed to be changed to 70% solar and 30% wind respectively, but the advice was ignored in the first phase (with water pumping). While 60% of rated power capacity has been wind, records of the site analysed by the case study team showed that the share of wind to have been very low, indicating low wind speeds for large part of the year. The second phase did consider the 70-30% solar-wind proposal, but there were no good specifications in the tender documents given to installers and suppliers, leading to problems as described below.
- The battery banks were not adequately designed or protected. Some systems had no PV charge regulator or limitation on the village loads. The Kadambwe system was put out of order by theft of the batteries. At the other four systems, the batteries reportedly had failed and have not been replaced;
- The wind turbines did not have a non-functional automatic braking system rendering them susceptible to damage due to high wind speeds. The operators would go to the power house and manually shut down the wind turbine to prevent it from being damaged. There was no lighting protection. The Mdyaka hybrid system worked until December 2012 when it was struck by lightning that destroyed the wind system. Also, the inverter and other electronics were destroyed, implying that the solar panels (although not damaged) cannot provide power to the beneficiaries anymore.
- The Department of Energy assumed that ESCOM would take the system (and operate it by means of its cross subsidies) but ESCOM turned down the offer due the supposedly low quality of the distribution lines and high probabilities of failure. Indeed, it has been reported that quality issues in the structures led to system failures due to short circuits. Instead, the systems were operated by a village committee with each household paying MWK 100 per month (about USD 0.70). The revenues were just enough to pay the local operator and watchman (in Mdyaka: MWK 5,100 and MWK 4,000 respectively; equivalent to USD 36 and USD 28), but consequently no funds were available for maintenance and overhaul.

3. Lessons learned

Mini-grids in other countries have been operated and maintained properly by a government entity or the national utility. The case studies of the government-funded and government-administrated solar-wind hybrids in Mdyaka and Kadambwe show an opposite picture. With ill-defined ownership and maintenance responsibilities, the operation had to be managed by an ill-prepared community. The low revenues (power is sold at low tariffs) provided too big a challenge for proper maintenance with no funds available for the overhaul of the energy systems when disaster struck. The formulation and design were fraught from the beginning by political influence and the projects were to showcase the government's commitment to renewable rural power. In the drive to get the projects realised quickly, no proper technical and social assessment was made of demand and supply options in the villages concerned, in a top-down decision-making approach in which the villagers were informed, rather than engaged. The systems were installed by the contractor without a vision on how the systems should be technically maintained and administratively operated.

4. Concluding remarks

The Mdyaka-Kadambwe case studies show the detrimental effect of unclear ownership, poor and administration, and lack of design data (such as energy demand and wind speeds) with decision-making based on political reasons, rather than common sense and with engagement of stakeholders and beneficiaries.

At the time of writing this case study, the Department of Energy still has to decide on what will happen with the solar equipment. One option is that some use is found in the villages. For example, the systems could be divided in smaller parts (solar power is modular) to benefit households that are too far or for another reason cannot be connected to the newly arrived distribution grid. The systems could be repaired with upgraded devices (e.g. better protection against adverse weather) and be made to deliver power to the grid and thereby forming a source of income for the villagers. Alternatively, the systems could be used to power villages that are not planned to be electrified in the foreseeable future.

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Likoma: Powering mini grids by solar-wind-diesel hybrid systems as an alternative to diesel

Clean energy mini-grids (10 kW to 10 MW) are increasingly seen as a viable solution. Systems of 10 to a few hundred KW are also referred to a 'micro-grids'. These can be a viable and cost-effective route to electrification where communities are far from the national grid or where population is not dense enough to justify a grid connection, but demand of households and local businesses is at such a level that cannot be provided by off-grid solar home or pico-solar system. The challenge has been to provide adequate financing and management and operation models for mini-grid systems, that range from the pure utility or government agencies model, to private sector companies, community-driven ownership-operator models and hybrid combinations of these.

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Sites: Likoma Island
Business model: government or state-owned utility with full subsidy

This case study in one of four that seeks to understand the possible role of energy mini-grid systems in Malawi.

1. Likoma Island

Likoma Island is the larger of two inhabited islands in Lake Malawi, in East Africa, the smaller being the nearby Chizumulu, that together make up the Likoma District. Although both islands lie just a few kilometres from Mozambique, they are both exclaves of Malawi surrounded by Mozambican territorial waters.

Source: en.wikipedia.org; malawitourism.org, turnkey-visit.com

Likoma is densely populated, with about 14,500 inhabitants dispersed in a dozen settlements. Despite a high population density, the natural environment of Likoma island is largely unspoiled. The coast is varied, with rocky slopes, sandy bays, and swamps. The interior of the island is mostly covered by grassland, with a large number of baobab and mango trees.

Likoma Town and the town of Mbamba host busy markets. The island is known for the Anglican cathedral of St Peter, one of the largest churches in Africa. As Likoma is a relevant tourist destination, there are a few hotels, lodges and hostels. The waters around Likoma are appreciated for snorkelling and diving. Access to Likoma is currently by boat or charter aircraft. The island's main mode of transportation is provided by the MV Ilala steamer boat that circumnavigates Lake Malawi, stopping over at all the main settlements on the

Energy supply at Likoma Island

The state-owned Electricity Supply Corporation (ESCOM) supplies power Likoma Island from diesel generators owned by EGENCO. Two 3-phase 400 V 250 kVA gensets run synchronously with a third on standby. The mini-grid was established under the Malawi Rural Electrification Programme (MAREP) which is a socio-economic programme of the Malawi Government. The consumers pay for the electricity at the Post Office, where they can purchase prepaid units.

The generators are switched on only from 7 a.m. to 12:30 pm and from 2pm to 10 pm during week days and 7 am to 12:30 pm and 2 pm to 10:30 pm during weekends. Electricity supply may not be available for successive number of days when logistical challenges of bringing the diesel (by boat) become severe. These blackouts affect the functioning of health services, telecommunication, clean water supply and the island's tourism and accommodation providers. The hospital and those business and homes that can afford it use their own generators but are prone to the same logistical fuel supply problem.

The main challenge is the high cost and erratic availability of diesel. The system uses about 32,000 litres of fuel a month. This implies, at a cost of USD 1.9 per litre of diesel, a monthly fuel bill of about USD 61,180. The power generation cost is estimated to be about USD 0.89/kWh, but ESCOM sells the power at an average of USD 0.085 per kWh, according to its national tariff system. With sales of about USD 7,000 per month, this means that ESCOM is operating Likoma at a loss, selling at only 11% of the cost. To keep costs manageable, power is supplied for only 14 hours a day on the island.

Source: A. Nkoloma (Global Group); C. Zalengera (Mzuzu University*). Photo:* A. Nkoloma (presentation)

coast and the islands. In addition, the MV Chambo links the island with the town of Nkhata Bay on the west side of the lake once a week.

Almost 2,000 households live on the Island; the total population is about 16,500 (2016 projection). Likoma Island forms a low-income community. A 2013 survey[1] showed that the average monthly income is about USD 137. About 90% of the population relies on fishing as a source of income. On average, a household on Likoma spends about USD 11 per month on energy services. Apart from fishing, key economic activities on Likoma Island include the tourism industry, offices, and small and medium enterprises in the form of retail shops and restaurants, and grain mills.

Likoma Island is counted as 100% electrified. Although every household can have access to the grid, about 45% is actually connected. Other sources of energy on the island are firewood for cooking, as well as kerosene and dry-cell-battery-powered torches for lighting. Apart from lighting, households typically use electricity for refrigeration, entertainment (TV, radio and satellite decoder) and cooling fans. Some households may use a hotplate for cooking.

Some social amenities and services, including surgical procedures at the hospital, suffer from the power shortage. Likoma Island could easily be transformed into a high tourist destination if electricity would be available 24 hours a day. There is one main hospital, St Peter's (which needs energy for medical equipment, lighting, and catering services for patients), one boarding secondary school (Likoma), one community secondary school (Chipyela), nine primary schools, and a community library. The main energy needs in education services are for lighting, refrigerators, and computers for teaching. Likoma Island also has a water treatment plant and two telecommunication towers using electricity from the diesel generators.

[1] *Putting the End-User First: Towards Addressing Contesting Values in Renewable Energy Systems Deployment for Low-Income Households—A Case from Likoma Island, Malawi,* by Zalangera, C, Blanchard, R. and Eames, Ph.

Result of comparison analysis between 24-hrs solar/wind-based and 24-hrs diesel-based with existing 14-hrs diesel-based power supply, Likoma

	System configuration					Financial indicators		
Type of system	PV (kW)	Wind (kW)	Diesel (kW)	Batteries (number)	Converter (kW)	Initial capital (USD million)	LCOE (USD/kWh)	Net present cost (USD million)
Diesel gensets, 14 hrs/day	-	-	600	0	0		0.888	10.18
Diesel gensets, 24 hrs/day	-	-	600	-	-		0.883	14.64
PV-wind-diesel-battery	1250	150	400	1710	500	4.02	0.441	7.30
PV-diesel-battery	1500	-	400	1900	500	3.60	0.452	7.49
PV-wind-battery	2000	150	-	4180	500	6.89	0.535	8.86
PV-battery	2500	-	-	4750	500	7.07	0.569	7.07

Annual power production (at 24 hrs per day availability) of 1.825 million kWh per year. Peak demand (based on 2012 population data): - 375 kW (maximum). Batteries are 1150 Ah.

Source: *A study into the techno-economic feasibility of photovoltaic and wind generated electricity for enhancement of sustainable livelihoods on Likoma Island in Malawi;* by C. Zalengera, Loughborough University (2015)

2. Renewable energy as a cheaper, environmentally friendly alternative to power the mini-grid

ESCOM acknowledges that the current system is expensive (augmented by the high cost of transporting the diesel) and not sustainable and is considering other options, such as solar and wind. In 2014, a techno-economic feasibility study was carried out (doctoral thesis research, see text box) on solar and wind-generated electricity. Supplying electricity for 24-hours with diesel generators would raise the operation and lifecycle costs by 44% compared to the costs of 14-hours supply schedule. The study shows that the power provided on a 24-hour basis by a solar PV-diesel-battery (with or without wind turbine) would be cheaper than the 14-hour electricity supplied today.

The cost of producing photovoltaic and wind-based electricity could be between USD 0.44 and USD 0.56 per kWh, depending on the interest on capital finance, which is considerably less compared to USD 0.89 per kWh for diesel-fired electricity. Thus, PV-wind-diesel hybrid systems could reduce the subsidy spent by the government on grid electricity on Likoma Island from USD 0.80 per kWh by about half.

Photo: Planetbell.me

3. Lessons learned and challenges

Lessons learned

In general, subvention or grant funding will be necessary to pay for the initial investment cost of mini-grids in Malawi, whether the source of energy is diesel, solar, wind or a hybrid configuration. The Likoma case shows that mini-grids (set up with Government funding) can be operated and maintained properly by the national utility. However, the diesel generator faces high diesel costs and this is one reason why the system is only switched on for 14 hours. Adding solar and wind, in a hybrid configuration, can potentially lower the cost per kWh by half and expand availability to 24 hrs a day.

Challenges

However, the predicted cost of PV-and-wind energy is higher than the feed-in tariffs which were introduced in Malawi in 2012. The feed-in tariff for PV electricity is USD 0.20 per kWh and USD 0.10 per kWh for firm and non-firm power respectively whereas the feed-in tariff for wind electricity is USD 0.13 per kWh. There is need for a review of Malawi feed-in tariffs for isolated grid systems to enable renewable energy investment which could displace the costly electricity generation by the diesel generators at Likoma Island[2].

The new legal framework of the power sector in Malawi saw the unbundling of state utility ESCOM, in 2016, into a generation company, EGENCO, owning power generation, and a distribution and transmission company, retaining the ESCOM name. In Likoma, also the mini-grid is split up between EGENCO and ESCOM. This should not be the case because the network is too small to be handled by two companies with an unnecessary increase in overheads. Both ESCOM and EGENCO are well placed to operate the Likoma mini-grid on a single-entity basis rather than two entities.

Opportunities

The above-sketched plans for solar energy for Likoma island are being taken into serious consideration. EGENCO has a plan to set up a 1 MW solar plant in a hybrid configuration with the existing diesel plants plus battery storage. Airport Development Limited also has plans in the pipeline to invest in renewable energy on Likoma Island to boost the tourism industry. At the time of writing of this case study, the plan was at a concept stage[3]. It has also been suggested in the past to have the island connected via an underwater cable to the mainland, either to the Malawian or Mozambican shore. There is a need for detailed feasibility studies in which the various options (diesel generation, renewable energy, marine cable) can be compared.

4. Concluding remarks

If not solved, ownership issues of the existing diesel-based power infrastructure will hamper future decision on establishing renewable energy-based power generation on Likoma Island. The Department of Energy Affairs should coordinate energy investment activities to avoid conflicts between stakeholders and avoid duplication of investments. In general, the Likoma case shows the need for a separate legal-regulatory framework for mini-grid systems as a subset within the overall power sector framework, including a review of the feed-in tariffs of small grid systems. The UNDP/GEF project can be a vehicle to provide advisory assistance on legal-regulatory issues on mini-grid systems in Malawi.

Source: Google Maps

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- > Kavuzi: pico-hydropower schemes, a people's initiative
- > Likoma: Powering mini grids by solar-wind-diesel hybrid systems as an alternative to diesel
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2 *Investigating the Feasibility of Solar Photovoltaic and Wind Electricity Integration for Likoma Island in Malawi,* by C. Zalengera, R. Blanchard and Ph. Barnes, Loughborough University, UK (2014).

3 See EGENCO website (projects)