Business case for

# Low-Carbon Microgrids

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# Contents

# 1. Introduction

The success in limiting climate change and achieving a 2°C pathway will also depend on the solutions deployed to electrify remote areas around the world. Addressing the lack of clean, reliable and affordable energy for billions of people and industries alike in places remote from a reliable power grid is one of the world's most critical development challenges, highlighted in the Sustainable Development Goal Number 7: Affordable and clean energy.

The majority of existing, remote electricity supply is based on diesel – a low CAPEX, high OPEX solution often subsidised by governments. Continuing this business-as-usual for remote electrification will cause a significant increase in greenhouse gas (GHG) emissions, besides aggravating local pollution. As such, viable alternatives must be deployed that establish renewable energies as the primary energy source for electrification of remote areas across the world.

Through the WBCSD REscale program, a group of leading energy and technology companies are working to prove that low-carbon microgrids are a key solution to this challenge. The required technologies for low-carbon microgrids have been commercially tried and tested and many customer profiles can be economically served with those technology options today.

The cost of key technology components, such as solar photovoltaic (PV) and battery storage, will continue to decline as a result of the economies of global scale and innovations in materials and manufacturing. Renewable energy is, in many cases, the most economical solution for electrification, with the Levelised Cost of Electricity (LCOE) lower than diesel[1], provided this fuel is not heavily subsidized. Some countries now have subsidised / incentive driven renewable programmes, but very often no framework for microgrids in particular.

The main drivers to build a microgrid in remote locations (focusing mainly on access to electricity) are very different to those triggering microgrid construction in existing networks. Already connected customers are keen to improve service quality or system resilience, achieve energy independence and lower emissions.

[1] IEA Africa Energy Outlook 2014

## WBSCD's REscale program

Through the WBCSD REscale program, a group of leading energy and technology companies are working together on solutions to accelerate the deployment of renewables and the transition to a low-carbon electricity system. Three upcoming reports are directly addressing crucial barriers to fully unlock the potential for renewables: access to finance, ensuring bankability of renewable projects and improving integration of growing levels of renewables into electricity markets – particularly in regions where billions of people currently lack access to clean, affordable energy.

- The "Pathways to Scale Finance for Renewable Energy" report focuses on opportunities and challenges associated with scaling finance for renewables.
- The report on "Corporate Renewable Power Purchase Agreements – Scaling up globally" highlights the benefits of the corporate renewable PPA business model and present recommendations to overcome challenges faced by buyers and developers.
- This "Business case for Low-Carbon Microgrids" report establishes microgrids as a viable business opportunity.

While each of the reports focuses on particular barriers, they are proving that underlying changes in financing methods and business models are driving the increased take-up of renewables.

In both circumstances, businesses are critical actors in building and operating domestic and industrial microgrids offering innovative technologies and services, management and technical capabilities and financial resources.

The participating companies of WBSCD's REscale program are some of the leading innovators for delivering microgrid solutions: e.g. distributed and/or renewable energy components and systems, project delivery and investment.

Through a literature review and dialogue with experts, a gap has been identified in current efforts around microgrids. Namely, in the provision of low-carbon energy solutions for customer demand profiles characterised by medium energy demand (size ~ 100kW-2MW) in contexts where the centralised electricity grid is either not available (and won't exist in the near future) or does not meet customer needs. There are many players looking at solar home systems as well as small microgrids of a few kW and similarly large grids of over 10MW are often built for industrial sites and as such face a different set of challenges.

This report highlights key success factors for deploying low-carbon microgrids - not only in isolated areas but also where electricity networks already exist - in four chapters: policy and regulation, technology, economics and financing, and the socio-economic context. It also illustrates the viability of microgrids in the medium-sized segment using a number of case studies. Only economically sustainable businesses will have the ability to scale up their activities in the longer term. The case studies include both brown- and green-field sites, gridconnected and isolated systems as well as developed and developing country contexts. The report concludes with recommendations on how different stakeholders can support the future growth of microgrids.

The participating companies of WBSCD's REscale program are ready now to scale up deployment of sustainable low-carbon microgrids and provide standardized and affordable solutions to individual customer needs.

Microgrids use a variety of different technologies to meet a wide range of customer demands as evidenced by the emerging International Electrotechnical Commission (IEC) definition: "Group of interconnected loads and distributed energy resources (including micro-turbines, diesel turbines, storage energy, renewable resources and so on, and all kinds of distributed energy resources…) at distribution level with defined electrical boundaries that may have black start capacity and can operate in island mode and/or gridconnected mode."

IEC/TS 62898-1 Ed.1: Guidelines for general planning and design of microgrids.

# 2. Key success factors

The following key success factors are based on business experience on the ground developing, building and operating microgrid projects in various countries. Their lessons learned are displayed here to help other businesses design new projects more easily and quickly.

## Policy and regulation

Kisii

Marsabit

Case studies

## Technology

Marble Bar

Mayotte Island

ONCOR

Town Island

Titimane

Case studies

## Economics and financing

Kisii

Manjhariya

Case studies

## Socio-economic context

Manjhariya

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Case studies

# Policy and regulation

**Clear and stable policy and legal frameworks are key enablers for growing microgrid developments.** Microgrids are not new. They have been used for decades to supply electricity to remote customers, usually with fossil-fuel based systems. In the past, their legal status was not a concern since they were either operated by public / regulated utilities or private companies using them for their own energy needs. This is changing with the liberalisation of electricity sectors, combined with new opportunities enabled by technology developments which offer innovative operational models for microgrids. Independent actors (e.g. private companies, private utilities, Energy Service Companies, industry suppliers, communities, etc.) have now the opportunity to develop and operate microgrids in many markets serving various categories of customers. The broad deployment of these new models would not be possible without the establishment of clear and stable policy and legal frameworks. These enabling frameworks are being driven by progressive policy-makers who have recognised the need for clean or more secure energy systems and the value of microgrids as an integral part of this.

**Collaborative and well-defined participation by public and private sector stakeholders is crucial for successful microgrid developments.** Microgrid developments involve many entities, each with a crucial role to play. The interplay between these roles can become quite onerous if not managed in a collaborative manner given that developers and operators interact with these entities on issues as varied as licensing, environmental impact assessments and community engagements. Stakeholders usually include regulators, energy ministries, local authorities, rural electrification agencies, national utilities, environment protection agencies, etc. It is therefore imperative that there is collaboration between all

Iratapuru Amazonia, Brasil - EDP

these stakeholders particularly to ensure that there are clear guidelines (technical, administrative, legal, economical, etc.) for developers to navigate bureaucratic processes in a time-efficient manner and to promote the sharing of information through, inter alia, access to one-stop shops which facilitate and shorten project's development procedures.

**Clear and distinct roles for independent actors and public utilities in microgrid development is key to developing amicable legal and business relationships.** In several countries, independent actors are now authorized to own and/or operate microgrids. The legal and business relationships between those private actors and regulated utilities (e.g. ownership of assets, operating coordination and technical standards, contractual agreements, allocation of costs, etc.) must be clearly defined, especially to allow for seamless integration of microgrids to the main grid if and when this becomes necessary. Depending on the local regulation, independent actors can have different options to generate, distribute and sell electricity. Without a long-term contract with a secure off-taker, microgrid operators often obtain a licence to sell electricity to the end customers. In this case, receiving a utility concession to operate in a given area during a predetermined timeframe is a key success factor: the concession allows the operator to scale up its activities and enhance the company's ability to attract financing.

**Transparent electricity tariff structures and incentives strengthen the ability of independent actors to demonstrate the full value of micro grids.** The true economic value of renewable energy systems is only apparent where they do not compete with subsidised fossil fuel systems, where they are given concomitant subsidies or where there is a structural cost benefit compared to the retail price. As microgrid operators are required to develop tariffs based on transparent cost structures, independent actors favour countries where regulation allows them to set appropriate cost-reflective tariffs or alternatively where incentives are provided by governments for reduced tariffs.

Click here for the following Case studies

Kisii

Marsabit

# Technology

**The fast development of new technologies is making high renewable microgrids increasingly competitive with fossil fuel-based systems for the electrification of isolated areas.** Solar photovoltaic costs have decreased a lot faster than expected - PV module prices declined by around 75% between 2009 and 2014 according to IRENA[2].

Achieving a high share of renewable generation with solar, wind, heat pumps, etc., which is key to displacing fossil fuels, without compromising grid stability is a challenge for operators of isolated microgrids. But innovative solutions are now available for enabling grid stability with a high portion of renewables. Also energy storage technologies are closer to commercial maturity and have enhanced performance and lifetimes while their costs are decreasing (lithium batteries, flow batteries, flywheels, water splitting into hydrogen and oxygen, etc.). The key drivers of inclusion of battery storage components within a microgrid system is to store excess renewable energy (avoiding curtailment) and discharge this during periods of peak demand as well as to regulate power quality with high speed corrections.

This provides the microgrid with a higher renewable energy utilisation factor. In a context of Green House Gases emissions reduction and concerns about energy independence, low-carbon microgrids for the electrification of isolated areas have as such become a profitable opportunity to seize for developers.

**In existing electricity systems, microgrids are a real possibility to improve the supply reliability for the customer** and increase the resilience of the electricity system as a whole, especially in cases of extreme weather events. These microgrids are often owned by private stakeholders such as companies, industry or universities, but operated by a utility or technology provider. Some grids can be split into different parts and operated in isolation to distinguish critical loads from sheddable loads. Depending on the regulation and economic value, grid-connected microgrids can benefit from additional revenue streams by providing grid services, e.g. frequency regulation, spinning reserve, voltage support, black-start, etc.

2 IRENA, "Renewable power generation costs in 2014", January 2015

Painéis, Bafatá, Guiné - EDP

**Quality assurance and/or technical standards will ensure the sustainability of microgrids.** Technology standards should not be underestimated when developing low-carbon microgrids.

A growing number of international and national companies are active in this field: experienced suppliers or manufacturers can guarantee the quality and the sustainability of equipment and infrastructures. Developers are looking for companies with the ability to provide services and training, as well as technologies compliant with international standards. On this matter, standardization of microgrid technologies is still work in progress that will be a key enabler for the future development of the sector. Implementation of system standards will facilitate the product purchase, defective parts replacement and grid implementation. It will also guarantee that microgrids can be "connection ready" if the main grid reaches them.

**Low-carbon microgrids can be efficiently and easily implemented thanks to modular and scalable technologies.** Matching power generation capacity rigorously with demand is a key success factor for the reliability of supply, but also for the economic performance of the microgrid. Identifying load patterns precisely is necessary to design each component of the grid properly. Modular and scalable technologies such as solar PV or battery energy storage systems offer the possibility to design a microgrid in a demand-driven approach. They also allow operators to build additional generation capacity when the demand is growing. Fully modular solutions will also be crucial achieve the lowest possible CAPEX for each individual project, to reach industrial scale and to de-risk projects.

**Microgrids provide a rich breeding ground for innovation.** New technologies are being developed by international manufacturers, academic institutions as well as emerging start-ups. Innovation can make microgrids smarter, e.g. optimising systems design from the onset, remote grid monitoring and management, real time data collection including weather sensing or matching demand-side with supply side. Technologies already available today include e.g. advanced controllers that allow an increased penetration of renewable energy into the microgrid thus optimizing the return of investment of the project.

Click here for the following case studies

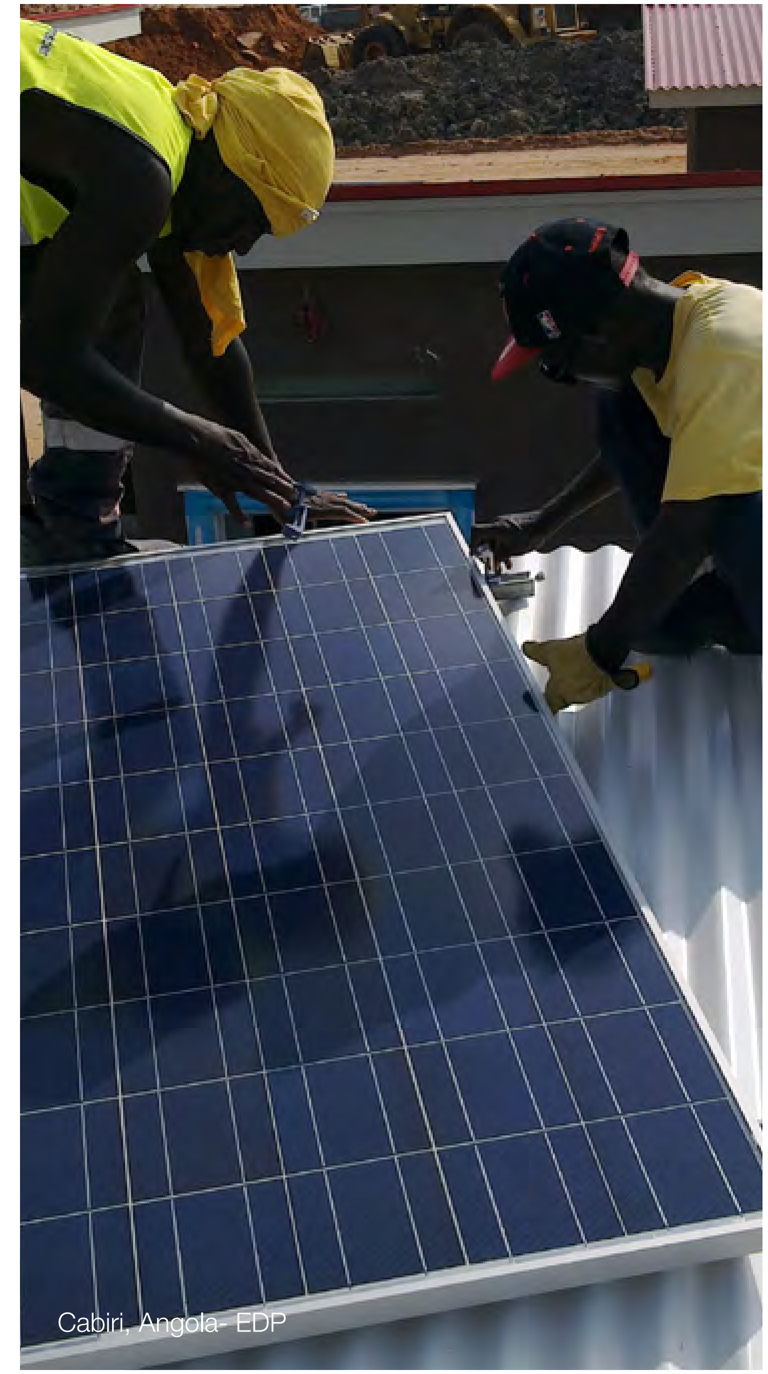
Marble Bar | Mayotte Island | ONCOR | Town Island | Titimane

# Economics and financing

**Developing low-carbon microgrids makes economic sense in many contexts, especially in remote off-grid areas where the cost of fossil fuels and long transmission lines is prohibitive.** For independent operators, establishing a business model which allows the full value of a microgrid to be captured is a main challenge. Successful experiences show that operators can optimize their revenue stream through a value proposition which is well adapted to the customers they serve, and which is not necessarily of the same nature as the main grid. Cost-reflective electricity tariffs are hence desired, provided they are socially and legally accepted, but they do need specific adaptations (e.g. prepaid tariffs, customer class tariffs, etc.) to the circumstances of the microgrid in question. Selling energy services instead of electricity could also be an option, whether for large industrial customers (e.g. power supply contracts with a guarantee of reliability) or for low income population (e.g. lighting as a service).

**Developers and/or operators are currently putting a lot of effort into educating investors on microgrids' economic benefits.** Indeed, microgrids are very specific assets for which some investors still have a high risk perception, especially when the policy and legal frameworks are not clearly defined and when a number of independent actors are involved. Developers are proving their business models' profitability by means of tangible evidence underlying the business plan: references proving the technology maturity / reliability, data supporting the hypothesis on load patterns, initial studies assessing the customers' ability / willingness to pay and their engagement, etc. Providing a long term vision in business planning with market growth perspectives is a key enabler to attract investors (e.g. through a "clustering approach" for microgrids serving communities[4]).

[4] By developing a cluster of projects in a given area, the microgrid's operator can aggregate key activities and build-up efficiencies in administration, equipment purchase or O&M services.



Cabiri, Angola- EDP

**Funders and lenders will be key actors in the broad expansion of the microgrid sector, through the adoption of innovative financing / funding schemes.** Microgrid systems with a high share of renewables are capital intensive (particularly if, for example, battery storage is included at current price levels) and this higher upfront investment requirement can be a barrier to deployment, even if LCOE is lower. Developing countries with cityconcentrated electricity grids and large remote areas without electricity are very promising markets but funding / financing solutions offered by local institutions / commercial banks are often inappropriate for microgrids (e.g. loans with high interest rates and short term paybacks).

Developers active in those countries are hence often relying on international actors such as multilateral development banks, to provide concessional loans, or pioneer private equity funds. New strategies for financing beyond traditional project finance or equity finance are needed to unlock new sources of capital and reduce transaction costs for low-carbon microgrid development.

Aggregation of projects and other risk diversification strategies will be critical, and new financing vehicles such as green bonds and impact bonds could present a promising avenue towards increased institutional investment.

**Establishing long-term contracts such as Power Purchase Agreements (PPA) with secured off-takers provides guarantees to investors, but relies on clear and stable local regulation.** Under a PPA model, a private actor procures, installs, and operates the microgrid and enters into a secured long-term contract with a unique off-taker purchasing the electricity. While this model has been used broadly to supply large industrial customers, establishing a PPA for community microgrids requires a specific legal framework, with the off-taker being a financeable public or private entity, such as a utility.

**Community funded microgrids are becoming popular as an alternative form of investment and electricity supply.** This business model can be applied where distributed roof top solar may be mounted on a large building, such as a community centre, which has relatively more roof space. Shares in the distributed microgrid may be purchased by interested residents, including those without roof space such as apartment dwellers, and a commercial framework governs the electricity supply to shareholders or supply back to grid.

Click here for the following case studies

Kisii

Manjhariya

# Socio-economic context

A mix of drivers trigger the development of low-carbon microgrids and equally determine the population's social appetite. Access to electricity is a major issue for off-grid populations who rely on traditional energy resources such as biomass or kerosene. For electricity consumers currently connected to expansive fossil fuel-based systems, renewable power generation provides opportunities to lower energy costs, to reduce GHG emissions and to reach energy independence. Besides, customers that value power supply reliability (e.g. hospitals, data centres, military bases, etc.) look to microgrids, although with a higher cost, when the main grid does not meet their quality requirements.

Customers' ability and willingness to pay for electricity services are key to a project's cost-effectiveness. Involvement of local stakeholders is essential from the first studies to the day-to-day operations: they can support the microgrid's operator in strengthening customer relationships, facilitate system operation, deal with social conflicts, etc. The pivotal matter to address during initial surveys is the customers' ability and willingness to pay for electricity services, since those determine the feasibility and the profitability of the business model. In many off-grid areas, low-carbon microgrids are affordable options for the population, businesses and public actors, as they provide an alternative to the purchase of expensive energy resources such as kerosene for lamps, CAPEXintensive energy solutions such as individual solar kits or OPEX-intensive ones such as diesel generators. In on-grid areas, adoption may be driven by higher retail pricing in some electricity markets and a move to self-generation. Customers' ability to pay, however, strongly depends on the national circumstances (e.g. income level, subsidies for fossil fuels, electricity tariffs, etc.).

Operators should aim to increase productive use over time. Contracting with "anchor customers" (e.g. productive businesses) secures a constant income at the start of a project. Providing incentives to customers for the acquisition of electrical devices and machinery is an option to grow the revenue stream while enabling the population to take up (business) activities that enhance their productivity, earnings and health.

Local employment and capacity building safeguard the longevity of microgrids. In remote areas, providing appropriate training programs to the local staff involved in construction, operation and maintenance of a microgrid ensures sustainability of a built grid. Increasing local knowledge on technical, administrative or managerial aspects can help reduce potential problems such as system failure, low recovery rates or electricity / equipment theft, and thus improve project economics significantly. Microgrids enable decoupling of economic growth from environmental impact.

Click here for the following case studies

Manjhariya

Ayeyarwady

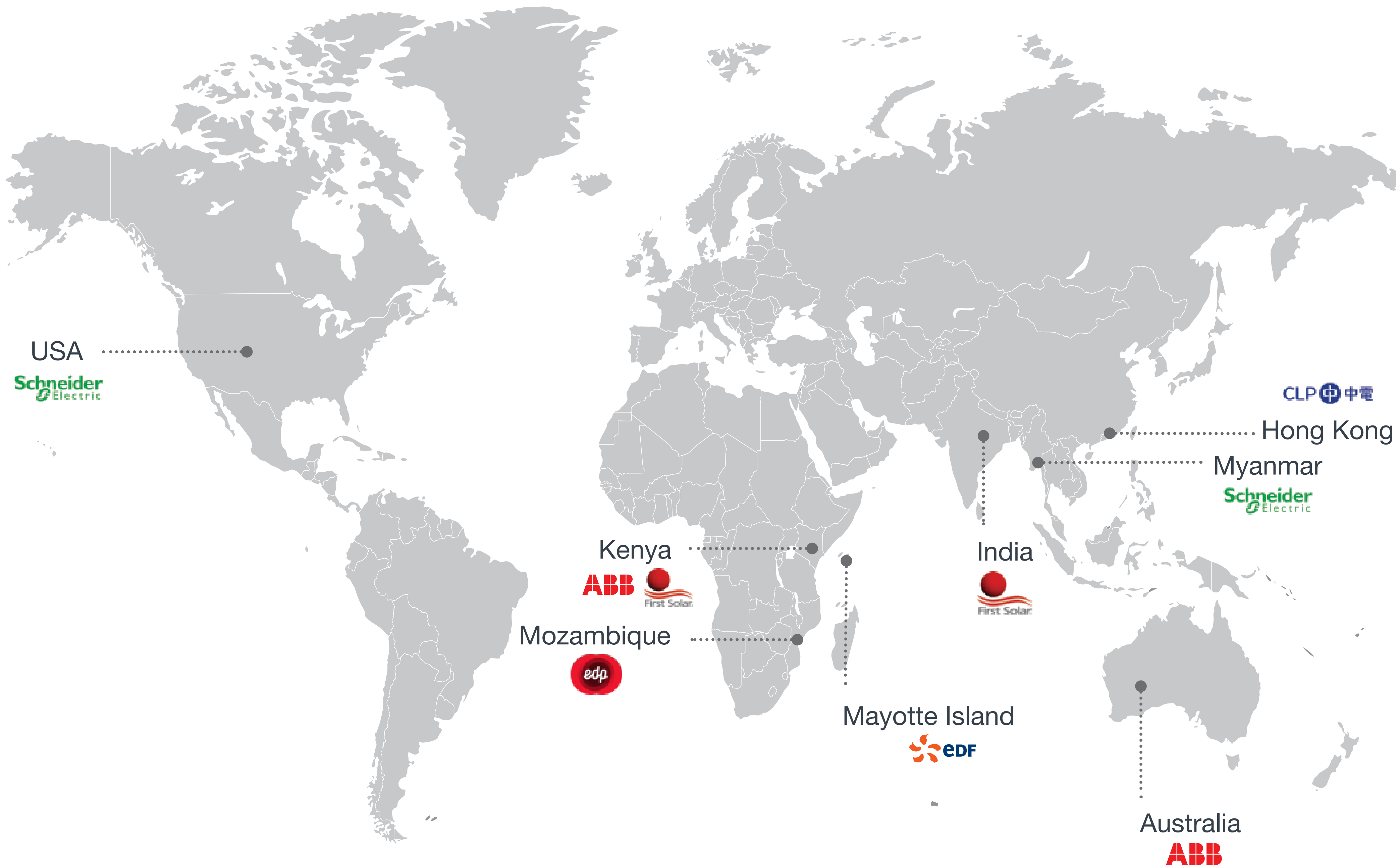
Titimane

# 3. Case studies

The following case studies provide an overview of different micrgrids supplied or operated by the member companies of the REscale program. The information focuses on the main characteristics of the project and the reasons why they are successful.

A couple of the case studies are smaller than the specified target rangestarting at 100kW. They are however showcasing a particular interesting aspect of a microgrid project which is worth highlighting.

A longer Business Model analysis of the case studies is available online accessible via the link beneath it.



## Marsabit, Kenya, ABB

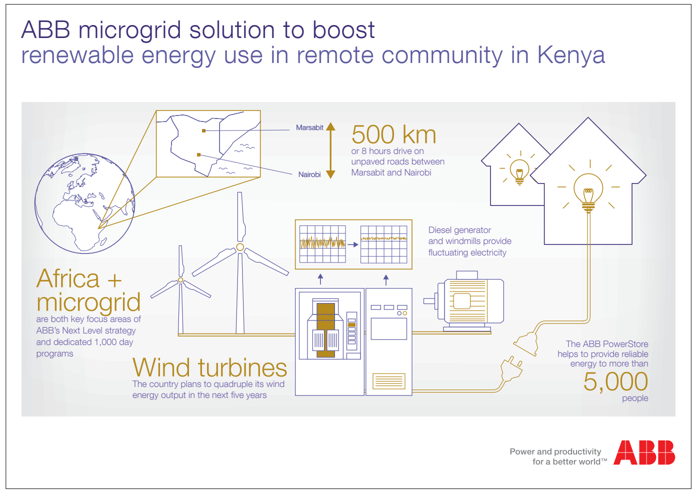
In 2011, Kenya Power and Light Company (KPLC) contracted the EPC, Socabelec East Africa Ltd., to provide a turnkey solution for a green-field, hybrid microgrid for the city of Marsabit, located at the edge of the desert in a windy area of northern Kenya. The isolated microgrid serves a population of 5000 – around 2200 customers – and consists of 800 kilowatt (kW) diesel generation and two 275 kW wind turbines. In 2015, to improve grid stability and increase renewable penetration, ABB was commissioned to provide a 500 kW flywheel-based grid stabilization system.

To be finalized in 2016, this system optimization will help to ensure utility-grade power quality, avoid curtailment of excess wind power and allow for addition of further renewable resources.

The government of Kenya aims to provide near-universal access to electricity by 2020, through both grid extensions and development of isolated microgrids, where renewable energy will play an increasingly important role. The Rural Electrification Authority (REA) holds institutional responsibility for rural electrification and works closely with the national distribution company, KPLC. At present, the majority of microgrids in Kenya are developed and owned by REA and are operated by KPLC on exclusive concessions, with uniform national tariffs for both grid and offgrid.

While government funding covers the full CAPEX investment in microgrid infrastructure, KPLC finances the OPEX by charging end users the uniform national tariff.

They also pass on the cost of fuel used in power generation in the microgrid to all KPLC customers to make up for the difference between the national tariff and actual microgrid electricity cost. Hence, increased renewables penetration directly improves affordability for consumers. Currently, microgrid electricity in Kenya is highly subsidized; the framework is now under revision to allow for PPAs and privately owned microgrids.




Australia

## Kisii, Kenya, Powerhive & First Solar

Since 2012, Powerhive East Africa, a wholly owned subsidiary of Powerhive, has been operating microgrid pilots in different villages in the county of Kisii, Kenya, in partnership with the photovoltaic modules manufacturer First Solar. The four microgrids constitute a total solar generation capacity of 80 kW and serve four remote villages with over 1500 people (~300 connections), ranging from residential users to small businesses. Powerhive was hence able to test and refine its range of solutions, including several proprietary technologies to design, build and manage advanced 100% solar microgrids (site selection tool, smart meters, cloud-based management tool, etc.). In order to ensure revenues from electricity supply, Powerhive also developed a pre-payment platform on which customers credit their account using mobile services.

The pilot projects - which were mainly financed by First Solar - demonstrated that setting cost reflective tariffs was socially possible in future microgrids.

In 2015, Powerhive East Africa became the first private utility in Kenya's history to receive a concession to generate, distribute, and sell electricity. By guaranteeing the exclusivity right to supply power in the counties of Kisii and Nyamira for 25 years, the concession allows Powerhive East Africa to scale up its operations in the region and to increase the company's ability to attract financing.

Due to their cost efficient methods for billing, operations, customer service and development at scale, Powerhive will be able to cover investment and operational costs from the collected revenues.

The company has now plans to expand its coverage to over 200,000 connections in Kenya.

Read the full case study

Australia

## Titimane, Mozambique, EDP

partnered with UNEP to implement a pilot rural microgrid project in Mozambique.

The key objective of this project is to demonstrate the commercial viability of clean energy microgrids by testing a new business model (a mini-utility based on fee-for-service) with innovative technologies as a first step into a potentially large, attractive and unserved market.

Titimane was selected as the target location due to its enabling conditions: a strong local partner (SAN-JFS – one of the major cotton companies in the country), an excellent biomass-to-energy potential and a compact village well-suited for microgrid electrification. The hybrid microgrid will have an installed capacity of 160 kW, consisting of photovoltaic power (100kW), biomass gasification (60kW using pellets from cotton residues), battery storage and diesel backup.

The cotton residues will be bought from the farmers providing additional revenue and an increase in yield per hectare. Part of the produced electricity will also be used for pumping water, irrigation and increased agricultural production.

Besides their equity investment into the project, the partners also obtained external grant financing from EEP (Energy and Environment Partnership) and OFID/ ARE (the OPEC Fund for International Development) for implementation, amounting to a total budget of 1,75 M€. However, the business model was designed to guarantee that maintenance

and operation will be commercially viable via tariffs. During operation, electricity is delivered through a pre-payment scheme, covering OPEX and replacement CAPEX.

The construction of the microgrid will begin in 2016 and operation is expected to start during 2017.

The microgrid will generate 232 MWh of clean energy per year and will avoid 150t/y of $CO_2$ emissions.

Australia

## Ayeyarwady, Myanmar, Schneider Electric

Through its Access to Energy program, Schneider Electric partnered in 2014 with agro-chemical company Golden Key (GKC) to provide energy services to three villages in Ayeyarwady, Myanmar. Solar-powered smart DC microgrids were installed for various clusters in three villages supplying 800 households with electricity (880Wp to 1.4kWp each). These innovative off-grid solutions contain centralised generation and distributed storage. Each household is equipped with highly efficient appliances such as LED lights or radios to cover basic energy needs and mobile charging facilities. Schneider Electric implemented training for a network of Village Electrification Consultants (VECs) managed by GKC to develop skills of local unemployed youth in the field of renewable energy. VECs create awareness and advise on solar energy, establish points of sale, train local entrepreneurs to own and operate collective installations and manage installations and after-sales services.

The three pilot projects testify for a replication in more than 500 similar villages that could benefit more than 200,000 farmers. The presence of the GKC in rural areas is an essential factor for the Ayeyarwady microgrids and the future expansion of the business model: The projects can rely on GKC's existing rural distribution network to ensure proximity with end-customers, and GKC's ability to manage the VECs. Despite the small kW size of the projects, this essential factor for success is worth featuring for replication.

Relying on the national Rural Electrification Program, the project benefited from subsidies through a governmental tender to cover the initial investment costs of the microgrids, while the revenue stream from end-customers ensure future maintenance and material replacement costs. Schneider Electric expects this business model for community-based needs to require subsidies for part of the CAPEX in the future. Revenue generating activities (i.e. small businesses) are key to stabilizing the revenue stream that covers the OPEX and can increasingly contribute to the reimbursement of the CAPEX, but are not yet expected to fully cover the investment costs.

Read the full case study

Australia

# 3. Case studies

## Manjhariya, India, Husk Power & First Solar

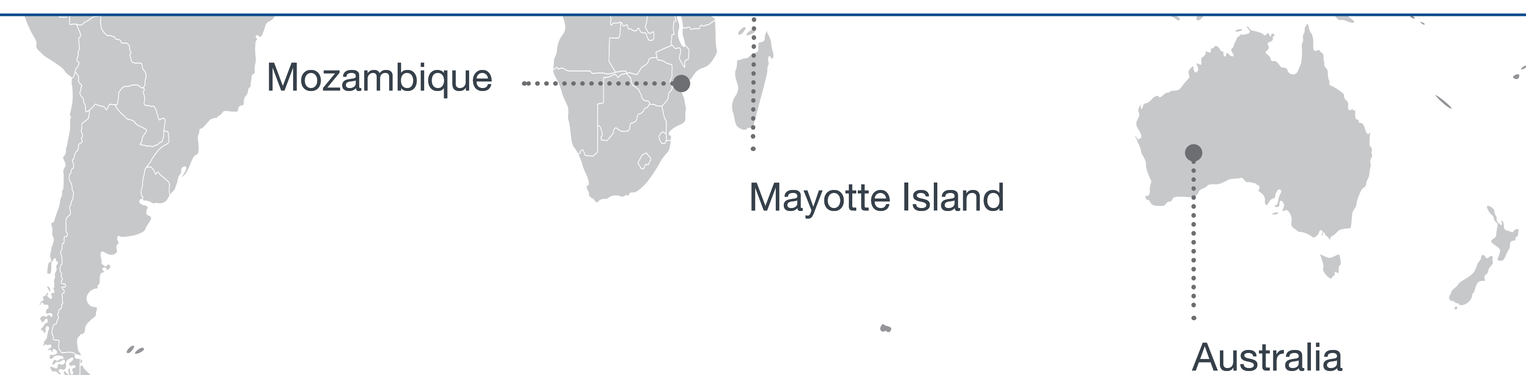
Husk Power Systems serves 15,000 customers through more than 70 installed power plants in India and Tanzania.
Although Husk's initial mini-grid systems were powered by biomass, Husk started serving customers with 24/7 renewable power by introducing hybrid biomass and solar PV mini-grid solutions in 2015.

The Manjhariya project in India's state of Bihar, which is one of Husk's first hybrid mini-grids, began operation in October 2015 with 25 kW of biomass generation capacity, 20 kW of solar PV (powered by First Solar's thin film modules), and 70 kWh of battery storage.

The success of this project is due in part to Husk's low cost model and focus on demand side management and customer service. By combining biomass and PV generation with battery storage, Husk is able to provide 24/7 renewable power to both homes and businesses at very low cost. By using a variable tariff model for different types of users at different hours of day, the company is able to manage customer loads and ensure very high availability of power.

Husk's proactive focus on customer service through activities like introducing a voice interactive system to remind customers when their credit is getting low, and notifying customers about planned downtime in advance, has been successful in managing customer expectations and keeping satisfaction high. In response to this project's success, Husk is replicating the hybrid mini-grid model in forthcoming projects in both India and Tanzania.

Read the full case study



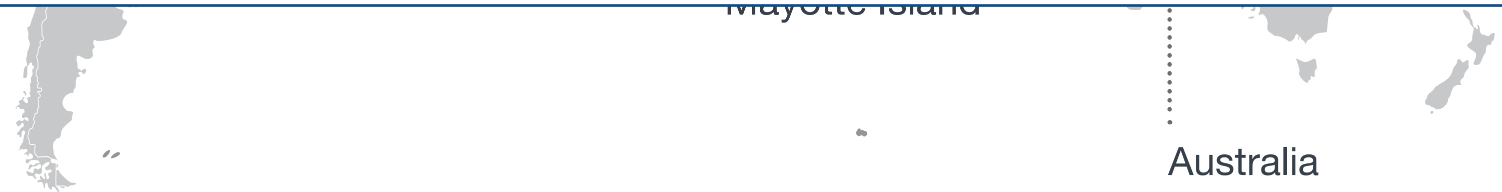
## Town Island, Hong Kong, CLP

CLP Power installed Hong Kong's first commercial-scale standalone renewable energy generation and storage system on Town Island. The system includes 672 solar panels, two wind turbines and 576 batteries capable of storing over 1,000 kWh of electricity to supply power for around 30 hours. The system has an installed generating capacity of up to 192kW (180kW PV solar and 12kW wind), which is sufficient to meet the power needs of the island's drug rehabilitation centre and its future development. The stand-alone system can generate 125,000 kWh of electricity per year.

CLP anticipates that the system can save an estimated 70,000kg of $CO_2$ emissions per year. The project was funded like any other capital projects in CLP Power Hong Kong and the residents pay the same tariffs as any other customers within the CLP service territory. The commitment to deliver a reliable and reasonably priced power supply in Hong Kong is the driving force behind the project. While the projecte cost of a standalone microgrid solution was found comparable to an alternative conventional submarine cable, the additional advantage of this solution were the learnings. CLP grasped the opportunity to build up their capabilities to integrate solar, wind and storage devices in a microgrid configuration.

The key success of this project was attributed to the professional engineering and technical support in designing, developing, building and maintaining the system. Of course, the cooperation of the island residents was also key to the success.

Read the full case study



## Mayotte Island, France, EDF

In the existing microgrid of Mayotte Island, PV power has frequently reached 30% of total power demand, showing its important role substituting heavy fuel (today 94.4% of island electricity consumption) but meanwhile creating new concerns for the stability of the electrical system.

Hence, a consortium composed of EDM (Électricité de Mayotte, local utility) and EDF Store & Forecast has been created in order to identify and deploy solutions able to secure the electrical system operation, to limit the increase of primary reserve cost and to support PV development as well as demand side management.

In order to reach these objectives, the OPERA project consortium implements a threefold solution: a highly-reliable PV production forecast (day-ahead and hourahead with 30 min precision), the installation of a battery storage system and the implementation of demand side management with a few major electrical consumers of the island.

The first two equipment have been provided by EDF Store & Forecast whereas EDM owns and operates these assets.

EDM compared the cost of the additional investment to the savings realized on primary reserve cost, and estimated a payback time of less than 8 years. With the required equipment already available, this solution allows a lower cost of electricity thanks to PV production and is replicable in many electrified islands.

Australia

## Marble Bar, Australia, ABB

The world's first high-penetration solar photovoltaic (PV) diesel power stations were commissioned in 2010 in the remote inland communities of Marble Bar and Nullagine in Western Australia. The utility company Horizon Power decided to test the possibilities for renewable integration when updating the systems that supply these two towns and the adjacent aboriginal communities with electricity. The utility worked with ABB and SunPower to design and build a hybrid system. The microgrid for Marble Bar includes 300 kilowatt (kW) single-axis tracking solar PV, four 320 kW diesel generators, kinetic flywheel grid stabilizing technology and control solutions. The projects' AUD 30 million capital cost was 50% funded by Horizon Power and 50% by a Federal Government grant.

The hybrid microgrid solutions now supply both towns, a combined population of around 400 with 65 percent of their daytime electricity demand through solar generation, saving up to 40 percent (400,000 litres) diesel and 1100 tonnes of greenhouse gas emissions per year.

The systems are now more reliable, have not increased electricity tariffs and have demonstrated the feasibility of high penetration renewables in isolated power systems. Both towns also operate  with better energy efficiency thanks to a customer engagement campaign conducted by Horizon Power prior to implementation of the new system, which helped ensure overall community buy-in for the change.

Mayotte Island

Australia

# 3. Case studies

## ONCOR, USA, Schneider Electric

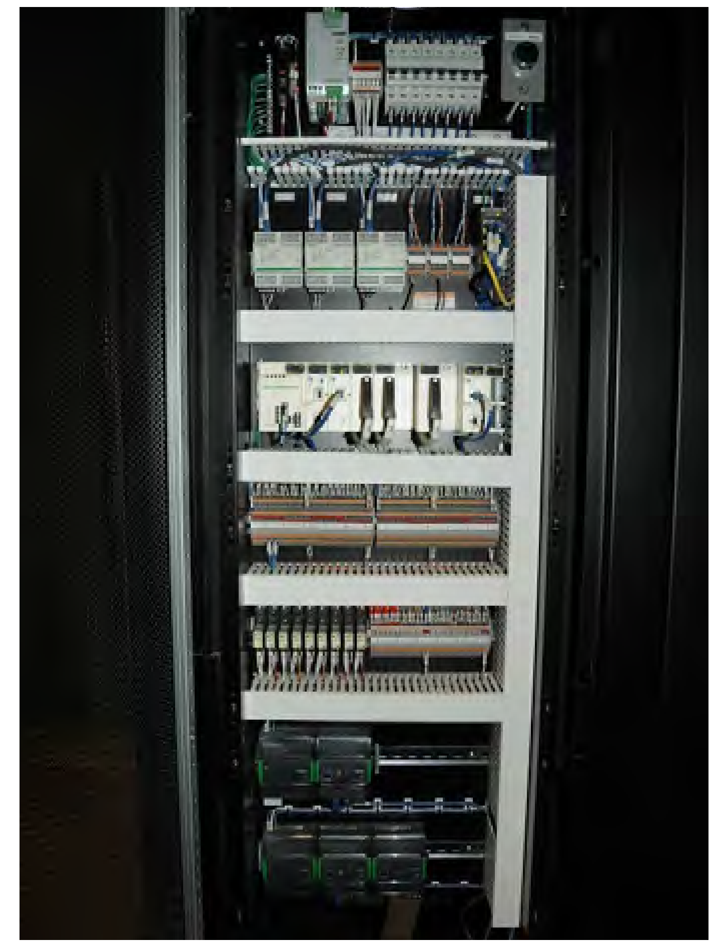
Microgrids can also be a suitable solution in non-remote locations to ensure continuity of electricity supply in case of grid interruption (real time power control).

Moreover, microgrids can optimize energy consumption cost and carbon footprint (predictive energy control) of its managed loads through self-consumption and can also participate to the main grid stability through ancillary services.

Oncor, a distribution and transmission system operator in Texas, aims to ensure uninterrupted delivery of power – even during extreme weather events or other emergencies. Hence, they built a microgrid solution which can operate independently or in conjunction with the main grid and avoids single points of failure.

The solution in Texas embeds two solar PV arrays (100 kW), a microturbine (65 kW), two energy storage systems (200 kW) and four generators.

Schneider Electric enabled predictive energy control of the microgrids´ Distributed Energy Resources (DERs) in order to optimize energy usage in connected mode, while a microgrid controller provides real time power control of DERs and loads in isolated mode. A combination of Schneider Electric and S&C Electric Company equipment using advanced, high-speed communications and distributed grid intelligence allows to automatically detect faults and switch to alternative distributed power source for isolated mode. As a private utility, Oncor financed the CAPEX with equity.



Read the full case study

# 3. Case studies

## Videos

Kisii, Kenya, Powerhive

Click on the buttons

Ayeyarwady, Myanmar, Schneider Electric

Click on the buttons

USA

Titimane, Mozambique, EDP

Click on the buttons

Marble Bar, Australia, ABB

Click on the buttons

# 4. Growing the microgrid sector

The case studies featured in this publication highlight the actions taken by the first movers of the microgrid market in the past years. We are now into a market phase where most of these companies have demonstrated pilot projects successfully and are working to increase the build rate of second generation projects. The market as a whole however is far from mature.

To really drive the scale up of microgrid projects in developing countries, **business needs a transparent, stable regulatory and legal framework.** This is a minimum requirement for any company to consider investing equity or debt. Here support from authorities and regulators is essential for any substantial development pipeline of projects.

**Fossil fuel subsidies distort the market.** The subsidies currently still in place in many countries negatively impact the economic case for microgrids. Low oil prices offer a good opportunity to phase out these subsidies. We support initiatives such as The Prince of Wales's Corporate Leaders Group and institutions such as IFC and development banks to maintain their strong advocacy with governments.

Thirdly, **innovative instruments to finance microgrids and reduce upfront CAPEX are vital for the growth of the market.** Given the size of microgrids, aggregation mechanisms which can group projects and diversify risk are necessary to access large funds. This group has identified multilateral banks as suitable organisations to take the main role in developing such alternative finance tools.

Aggregation of different projects would at the same time motivate the banks to streamline their funding processes and reduce lead time for funding.

Microgrids are one of the most versatile solutions for off-grid electrification in many countries and physical circumstances. Microgrids can also provide grid-connected customers with improved service quality and system resilience with lower emissions. Barriers to achieve market growth have been consistently lowered over the past few years in terms of available and proven technology, maturity of funding vehicles and regulation. This report demonstrates that business is able to build fully decarbonised microgrids and is ready to scale up solutions to reach and supply more customers.

Dawn island - CLP Power Hong Kong

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## About the WBCSD

The World Business Council for Sustainable Development (WBCSD), a CEO-led organization of some 200 forward-thinking global companies, is committed to galvanizing the global business community to create a sustainable future for business, society and the environment. Together with its members, the council applies its respected thought leadership and effective advocacy to generate constructive solutions and take shared action.

Leveraging its strong relationships with stakeholders as the leading advocate for business, the council helps drive debate and policy change in favor of sustainable development solutions.

The WBCSD provides a forum for its member companies - who represent all business sectors, all continents and a combined revenue of more than $8.5 trillion, 19 million employees - to share best practices on sustainable development issues and to develop innovative tools that change the status quo. The council also benefits from a network of 70 national and regional business councils and partner organizations, a majority of which are based in developing countries.

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The Low-Carbon Microgrid working group within REscale currently consists of the following companies:

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