ENERGY
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Tackling challenges in mini-grid development: An innovation showcase

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Introduction

This research presents an overview of the challenges to mini-grid development, and highlights a selection of innovation projects, supported by Energy Catalyst, with the potential to address these challenges. It will also draw out relevant learnings and insights from these case studies.

Energy Catalyst is an Innovate UK programme funded by the Foreign, Commonwealth and Development Office (FCDO) and the Department for Science, Innovation and Technology (DSIT) under the Ayrton Fund, part of the UK's International Climate Finance commitment. Through financial and advisory support, and by building strategic partnerships and uncovering new insights, Energy Catalyst accelerates the innovation needed to realise a just and inclusive clean energy transition across communities in Africa, Asia and the Indo-Pacific.

Energy Catalyst aims to accelerate progress on Sustainable Development Goal (SDG) 7 to ensure access to affordable, reliable, sustainable, and modern energy for all. Renewable energy-based mini-grid development is tied closely to this mission, particularly the imperative to take urgent action to combat climate change as covered in SDG 13. Mini-grids can play a vital role in furthering climate action while strengthening the resilience and adaptive capacity of off-grid communities.

Authored by Energy Catalyst implementing partner Mercy Corps-Energy 4 Impact.

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Mini-grid market overview

Mini-grids and energy access

SDG 7 aims to provide affordable, reliable, and modern energy services to all by 2030. Significant progress has been made on electricity access, with the percentage of the world's population who have access to electricity increasing from 83% in 2010 to 91% in 2020[1], resulting in 1.3 billion more people gaining access to electricity globally. However, the progress in electrification has slowed down in recent years due to the difficulty in reaching more remote and economically marginalised regions, and the number of people without access to electricity is more than 733 million . Less than half of the population of sub-Saharan Africa (SSA) has access to electricity[2].

Mini-grids and off-grid systems offer an alternative to grid extension and an opportunity to ensure that citizens have access to electricity while also strengthening local economies in off-grid communities. Mini-grids have a vital role to play in furthering climate action by reducing climate change and reliance on fossil fuels while strengthening the resilience and adaptive capacity of off-grid communities. They can be defined as a generation and distribution system providing electricity to a local community not connected to a national electricity grid. Typically, they supply electricity for domestic, commercial, and industrial demand, ranging in size from a few customers up to tens of thousands. (See Figure 1)

Mini-grids have an advantage over other off-grid systems in that they can also play a crucial role in promoting socio-economic development in rural communities. This is achieved by providing more and better quality electricity with greater availability and reliability. Where well-designed and managed, they can support income-generating uses of electricity which benefit everyone involved, including mini-grid developers, rural entrepreneurs, communities, and national utilities. Switching to affordable mini-grid electricity offers significant cost savings for entrepreneurs and small businesses, who would otherwise have to rely on expensive diesel generators. However, there are many cases in which mini-grids have been shut down, because their income did not cover the maintenance and management expense involved in keeping them operational.

Size of the mini-grid market

Mini-grids have evolved from being a niche solution to a mainstream and often cost-effective way of providing modern energy services. By 2022, around 21,500 mini-grids were operational globally, providing electricity to around 48 million people with an estimated investment cost of US$29 billion[4]. Of these, approximately 50% are powered by solar PV and more than 75% are in Asia. There are another 29,400 mini-grids planned, with 95% of them to be located in Africa and South Asia. Almost all of these (99%) will be powered by solar PV and aim to connect more than 35 million people. However, the current rate of growth in all electricity access technologies is not enough to achieve universal access to electricity by 2030, in line with SDG 7. For that, ESMAP estimates that around 217,000 mini-grids need to be constructed globally, serving 490 million people, and requiring an investment of US$127 billion[5].

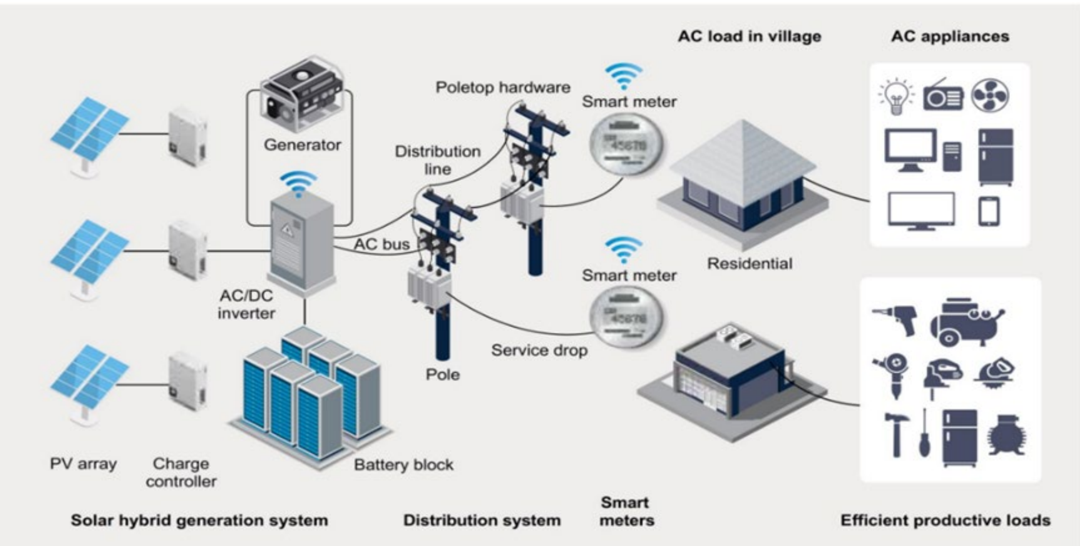


Figure 1: Mini-grid illustration (Source: World Bank, ESMAP; 2020[3]).

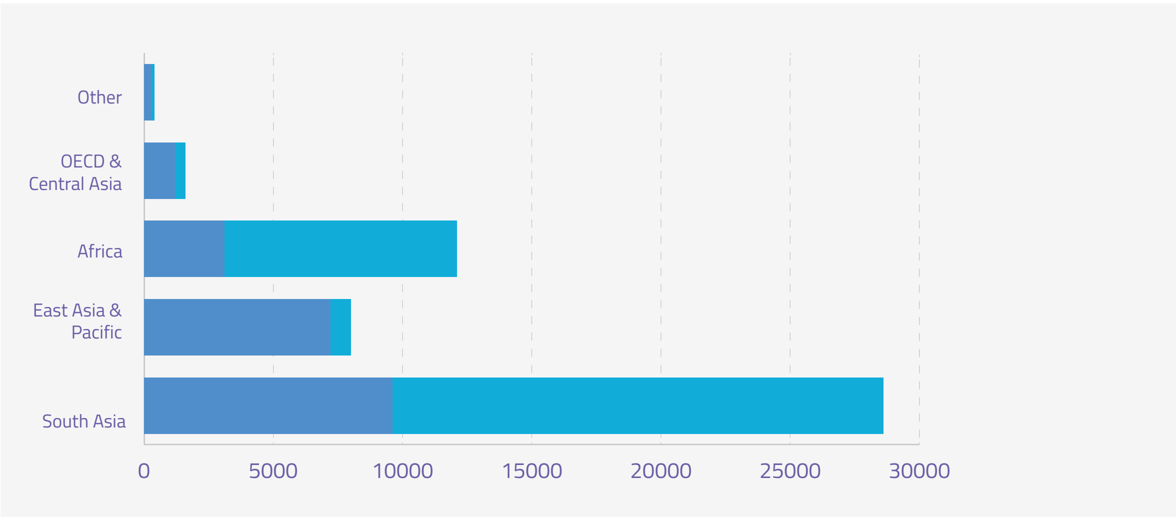
In Africa, the same research estimates that 160,000 mini-grids are needed to serve 380 million people. In comparison, the International Energy Agency (IEA) estimates that 216 million people could be served by mini-grids in sub-Saharan Africa[6]. CrossBoundary developed a least-cost approach model to electricity access and estimated that a minimum of 100 million people in Africa would be most cost-effectively served by mini-grids[7].

In sub-Saharan Africa there has been a significant increase in the number of solar mini-grids, from 500 in 2010 to over 3,000 in 2023 (as shown in Table 1), with approximately 9,000 more planned for development in coming years[8]. At the current pace, only 12,000 new mini-grids, set to serve 46 million people, will be constructed in Africa by 2030. However, to achieve SDG 7, as stated above, more than 160,000 mini-grids will need to be built by 2030 at an estimated total cost of US$91 billion, which equates to constructing roughly 20,000 mini-grids annually.

Financing and business models

Mini-grids are developed by governments, private sector, communities and NGOs, or a combination of these players. One of the key factors holding back development is the difficulty in accessing affordable finance and the enormous sums required.

For example, the current commitment to electrification projects in the 20 countries with the highest access deficit, which constitute around 560 million people, is worth US$32 billion per year[9]. Blended and diverse financing methods are required for different types of mini-grid developers, which usually include a combination of debt, equity, subsidy, and risk-sharing mechanisms. Larger international and local firms typically have greater access to equity and debt, while smaller local firms usually struggle to secure these financial resources.



	South Asia	East Asia & Pacific	Africa	OECD & Central Asia	Other
Installed	9600	7200	3100	1200	300
Planned	19000	800	9000	400	100

Table 1: Mini-grid installation numbers (Source: based on ESMAP, 2022).

According to the 2022 ESMAP report *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers*, there has been a significant increase in both the pace and scale of investments in mini-grids. It states that between 2010 and 2022, there were 188 unique investment deals with active private sector mini-grid developers, totalling US$557 million in 2022. These deals were completed between 54 developers and 100 investors, with an average of US$3 million per deal. The number of deals between investors and private sector developers grew from an average of just 3 per year from 2010 to 2014, to an average of 28 per year from 2017 to 2021. The largest investors are a mix of private companies and organisations, as well as funds supported by governments. Four out of the top five most active investors are government-supported impact investment funds or entities. However, even this level of investment is a small proportion of what is needed in the mini-grid sector.

Mini-grid business and delivery models vary by ownership, size, and customer base, and there are different strategies used to make them successful. In most cases, mini-grids have been developed with support and regulatory guidance from government institutions and other entities (see Figure 2).

Typical mini-grid delivery models

Build-own-operate

Private sector carries out all steps from design to operation and co-finances the mini-grid alongside development partners, the government and lenders.

PPP

Contractual: Government builds and owns the mini-grid private sector operates it.

Split Asset: Private sector builds all or part of the mini-grid; government and the private sector divide asset ownership; private sector is operator.

Concession

Government grants a concession to the private sector under a contractual arrangement usually for a pre-specified duration, with terms to which developers must adhere in exchange for service area exclusivity.

Utility

The national utility carries out all steps from design to operation, or may contract with the private sector for some of these steps.

Cooperative

Local communities co-finance (typically through grants) and own the mini-grid, often contracting with a third party to design and build the system and train the community on operations and maintenance.

Figure 2: Typical mini-grid delivery models (Source: World Bank, ESMAP; 2020).

Challenges and trends in mini-grid development

Despite the enormity of the market opportunities, mini-grid developers face a number of interrelated challenges to ensure the economic and commercial viability of mini-grids. They must balance the relatively high investment costs against the relatively low income levels of local communities. This can render it difficult for mini-grids to operate viably and makes mini-grid development a high-risk business. Whilst some of the mini-grid development challenges lie beyond the control of individual developers, others fall within their scope and innovation has a role to play in mitigating them. The following provides an overview of some of the key challenges faced in mini-grid development.

Ecosystem challenges

These challenges relate to the wider environment in which mini-grid developers operate, including:

Plans, policies and regulations:

It is not surprising that countries with the lowest energy access rates are also those with the least developed electrification plans, policies and regulations around mini-grids. For example, when electrification plans are not clear, it is not straightforward for a developer to find suitable sites. Many countries lack policies that protect developers operating isolated mini-grids if the main grid arrives. Without such regulations, the state may confiscate such assets with no compensation or leave the mini-grid stranded. In an ideal scenario, mini-grid developers that follow the requisite national operating standards should have clear assurances, such as exclusivity for a long period or allowances to operate in parallel to the main grid. Even where regulations are established, obtaining the necessary permits and licences in various countries can be time-consuming and expensive. Investors typically require permits and licences to be in place before committing any funds, but regulatory authorities may request proof of funds to approve these permits. This misalignment can lead to significant delays.

To remain as flexible as possible, developers are making progress in building mini-grids that can integrate or interconnect with national utilities. These "grid interconnection ready mini-grids" are typically built to higher standards and can be an improvement over isolated mini-grids. Such an approach improves on technical and service standards, such as quality of power, supply and construction. With such infrastructure, both the developer and national utility will be able to integrate and establish mechanisms for asset transfer or ownership if and when the grid arrives.

Tariff-related regulations:

The level to which tariffs are regulated for mini-grids varies enormously between countries. Some have no regulation, allowing the mini-grid to charge whatever they like, some allow mini-grid developers to charge a pre-approved cost-reflective tariff, whilst others regulate that a common affordable tariff is charged across the country. These regulations have a big impact on the viability of the grids. The plans, policies, regulations and processes are usually out of an individual developer's control, although mini-grid associations have a role to play in lobbying for change.

Long payback periods:

Developers need sufficient upfront capital to fund the project development (site visits, feasibilities, community engagement, licensing and permitting, and due diligence) as well as the capital costs. The upfront costs are high for renewable-based mini-grids and they have long payback periods. This means that in many cases it is necessary to get funding from multiple sources, a portion of which must be in the form of grants to make a viable project. Available grants are often results-based, which leaves a financing gap to be addressed at the outset of projects.

Financing:

The perceived risks of projects, depending on the country and communities to be served, makes it difficult to attract affordable financing, resulting in a delayed financial close, or even the cancellation of the project. Even if specialised programmes are available to fund projects, the tendering, due diligence and contracting processes can be cumbersome and time-consuming. This burden can prevent developers from reaching scale, which is probably the most important factor in rendering mini-grids a success. In addition, there is often a need for expensive bridge financing, considering many grant investments are results-based.

Design and operational challenges:

While recognising that all challenges are interlinked, the aforementioned challenges are largely dependent on multiple stakeholders. The broad challenges below highlight the need for innovation in the design and operation of mini-grids, and can be addressed by the developer. Some companies tackling the challenges, and supported by Energy Catalyst, are described in the next section.

Commercial viability is key for the sector to scale. Project developers aim at reducing the levelised cost of electricity (LCOE). The LCOE is defined as the off-take price per kWh required to recoup a certain equity return on an investment in a mini-grid project. The two key factors influencing LCOE are the capital expenditure (CapEx) and operational expenditure (OpEx) of a system and the sold energy (the load factor).

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Improving the load factor

The load factor is the proportion of available electricity that is utilised. An expensive system with significant fixed operating costs, or a lack of energy sold which results in the under-utilisation of the asset, can both drive up LCOE. The subsequent rise in tariffs make them unaffordable for low-income communities. This, in turn, makes it difficult to finance mini-grids, and increases the reliance of developers on subsidies or grants. Developers are adopting new technology and innovative strategies, such as GIS technology, distribution infrastructure, remote monitoring and control of assets, energy management systems, and smart metering. These initiatives aim to optimise design and better understand customer consumption to reduce LCOE over time. Productive use of energy (PUE) has emerged as a compelling approach to maximise the use of the power that is generated. For this to be successful, developers need to plan for such initiatives in the early stages of grid design and sizing. Furthermore, PUE initiatives need to align with the needs of the community, which may involve initiatives around agri-processing, cold storage, e-mobility and SME support.

Predicting demand for off-grid communities over the lifetime of a project is one of the hardest challenges to overcome. No two communities are the same and since it is usually a service rendered to communities not used to a reliable energy service, the demand is harder to predict. This has been made easier in the recent past due to greater availability of data, but it still remains daunting. For mini-grid developers, sustained demand is a necessity increasingly considered at the project development phase. The ideal scenario is to have an anchor customer, who is a sustainable off-taker of a substantial proportion of the electricity available, assuring utilisation and revenues. However, such customers, or off-takers, are difficult to find, particularly in areas not used to electricity services.

Developers are also stimulating demand by driving PUE activities in the form of facilitating appliance financing or setting up productive hubs. The benefits of demand stimulation help lower LCOE by reducing the CapEx and OpEx per kWh, since more PUE demand results in higher guaranteed demand and better utilisation of the assets. Greater demand often also requires a larger system, thereby driving economies of scale.

However, stimulating PUE is easier said than implemented due to the following challenges:

- The demand for PUE requires knowledge of the opportunity. While provision of electricity is relatively simple and can be standardised, PUE opportunities vary significantly from one site to another. This creates an additional risk to the cashflow and hence to the model which relies heavily on the PUE demand.
- PUE interventions are likely to need further financing as the community themselves do not have the funds upfront. Where mini-grid developers are financing appliances for their customers, these are additional assets that the developers need to manage. A lack of entities providing this service, or expensive lending rates from micro-finance institutions, results in developers including these assets on their books and having to service the loans, thereby adding risk to an already risky business.
- Understanding community needs is vital for the success of any PUE intervention. This generally involves market experts mapping the existing value chains and designing PUE interventions with the aim of assuring customer growth through increased savings or additional revenues, which ensures a stable demand for electricity. Value chains differ significantly between geographies and sites. There is a need for entities who have the technical know-how and capacity to drive this demand. While developers are experts in providing electricity as a service, most of them lack this business development or market expertise, or find it expensive to hire personnel to perform this function.
- Investors understand that PUE remains key to a mini-grid's success, but often consider demand prediction for PUE, and the resulting potential revenues, as speculative, which compounds the perceived risk involved in an already high risk business.

The room for innovation to improve the load factor of mini-grids is massive, with further opportunities emerging from PUE demand prediction, PUE stimulation, community engagement, finance mechanisms, and innovative appliances in sectors such as agro-processing and e-mobility.

This report highlights Energy Catalyst companies already tackling these challenges within projects with the potential to lower LCOE, thereby addressing the financial viability gap for mini-grid developers, reducing the risk for investors and making the service more affordable to communities. For instance, Energy Action Partners is engaging communities to predict demand, optimise system design and manage community expectations. Powerhive is looking at using e-bikes as additional load and Gommyr is designing mini-grids around productive hubs to ensure high load factors.

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Reducing CapEx, OpEx and improving efficiencies

The high upfront capital expenditure of mini-grids drives up the cost-reflective tariffs, often to a rate higher than communities can afford. While larger systems and multiple systems can drive economies of scale to reduce costs, there remains a focus on reducing the CapEx and OpEx of a mini-grid system to reach commercial viability. To achieve this requires further innovation. Whilst the cost of solar PV modules and storage has significantly reduced, these costs are still high considering the fact so many mini-grid projects are small (the majority are under 100 kWp in size). Other than the PV panels and batteries, there is still scope to reduce other costs to improve the CapEx, OpEx and other efficiencies.

In a bid to reduce CapEx, installation time, and manage demand, some developers are turning to pre-assembled modular mini-grid systems. This approach delivers a full turnkey solution, including hardware and smart metering at a reduced cost. The modular nature also enables developers to respond to changing needs over time, redeploying capacity across sites as demand increases.

In a business sense, CapEx and OpEx can reduce LCOE by clustering sites and standardising sizes. Procurement of module mini-grid systems across a cluster of sites is economically more efficient through negotiations and long-term relationships with suppliers. Also, clustering grids within a reasonable proximity helps with reduction of operating costs by reducing the staff required, as well as maintaining a centralised inventory and maintenance schedule.

Another trend is employing weather-resistant containers to house the battery and energy management system beneath a solar panel-covered roof, eliminating the necessity for additional structures to create a powerhouse. While the capital expenditure of this system is marginally lower than alternative solutions, the primary cost savings arise from reduced transportation and installation expenses.

Mini-grid enterprises rely on frequent, small payments from their customers. This makes tasks such as metering, billing, and collection time-consuming and expensive. However, innovative metering and payment systems can automate these complex tasks. The latest smart meters allow end-users to pay for energy in advance via pre-paid meters. Customers can use mobile phone-based banking platforms like MPESA in Kenya to facilitate this process. Pay-As-You-Go (PAYGO) meters also help users budget for electricity more effectively. Additionally, for mini-grid developers and operators, PAYGO meters reduce payment collection costs and eliminate the risk of non-payment. These smart meters will turn off when a user's pre-paid credit is consumed, and have in-built safety relays to reduce theft of electricity.

Remote software is also being used for system management and optimisation, battery management, assessment of losses, and business intelligence to improve the OpEx. Two Energy Catalyst companies developing such systems are profiled here. SteamaCo has developed remote dynamic management to optimise efficiency and enable more productive use and protection of assets, whilst Powerhive is developing software to better match demand and supply to optimise usage.

Energy Catalyst companies working in the mini-grid space

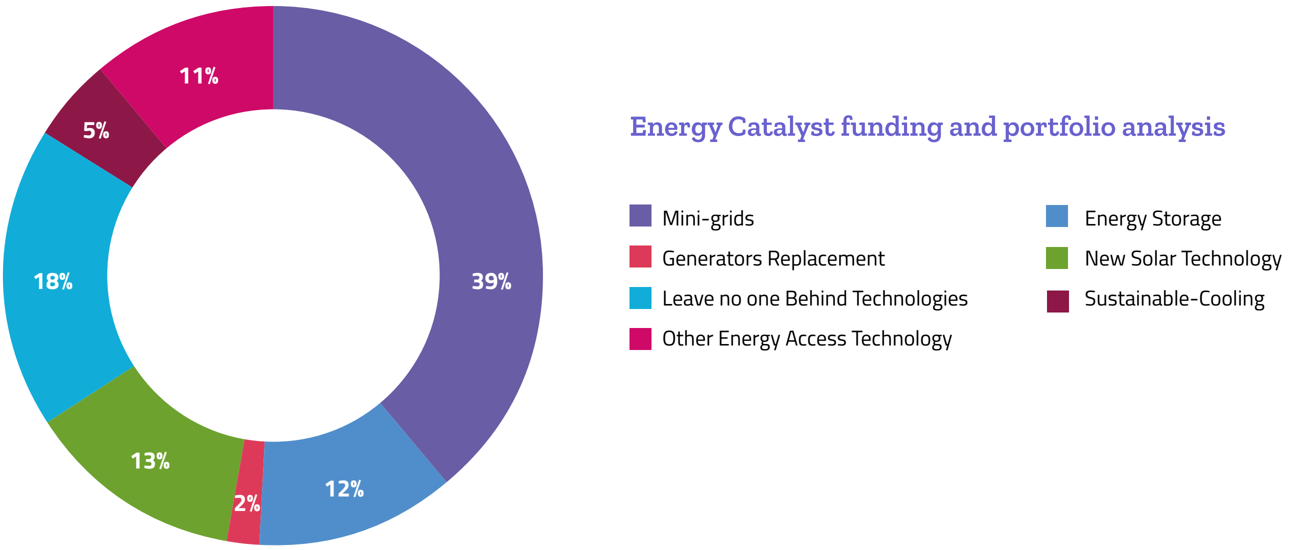

Figure 3: Share of different technology areas supported through the Energy Catalyst (Rounds 7-10).

36% of the investment is allocated to smart green grids.

39% of the 208 supported projects in the last four funding rounds are classified as smart green grids.

Through Energy Catalyst, the UK government supports the development of solutions that have the potential to address challenges in the mini-grid sector, given it is a key technology for achieving the aims of SDG 7. In the last four rounds of investments (Rounds 7, 8, 9, and 10), the Energy Catalyst programme has invested approximately £114 million in innovative companies across Africa and Asia. This funding cuts across seven broad energy and related technology areas, as seen in Figure 3. The smart green grids category includes work related to mini-grids and main grid technologies.

Approximately 39% of the investment, and 36% of the 208 supported projects in the last four funding rounds, are classified as smart green grids. This forms the largest technology area to receive Energy Catalyst funding.

Energy Catalyst supports a wide variety of innovations related to mini-grid development, as demonstrated in the following case studies from the portfolio. Support on technology and business models is provided to projects working across a range of categories, including energy networks and systems, metering and optimisation, energy generation and storage, energy efficiency, productive uses, community engagement, clean cooking and financing models.

The smart grid projects supported by the Energy Catalyst are distributed across 29 countries, with the majority operating in sub-Saharan Africa, as seen in Figure 4. Hosting ten projects each, Nigeria and Kenya account for 46% of the African budget.

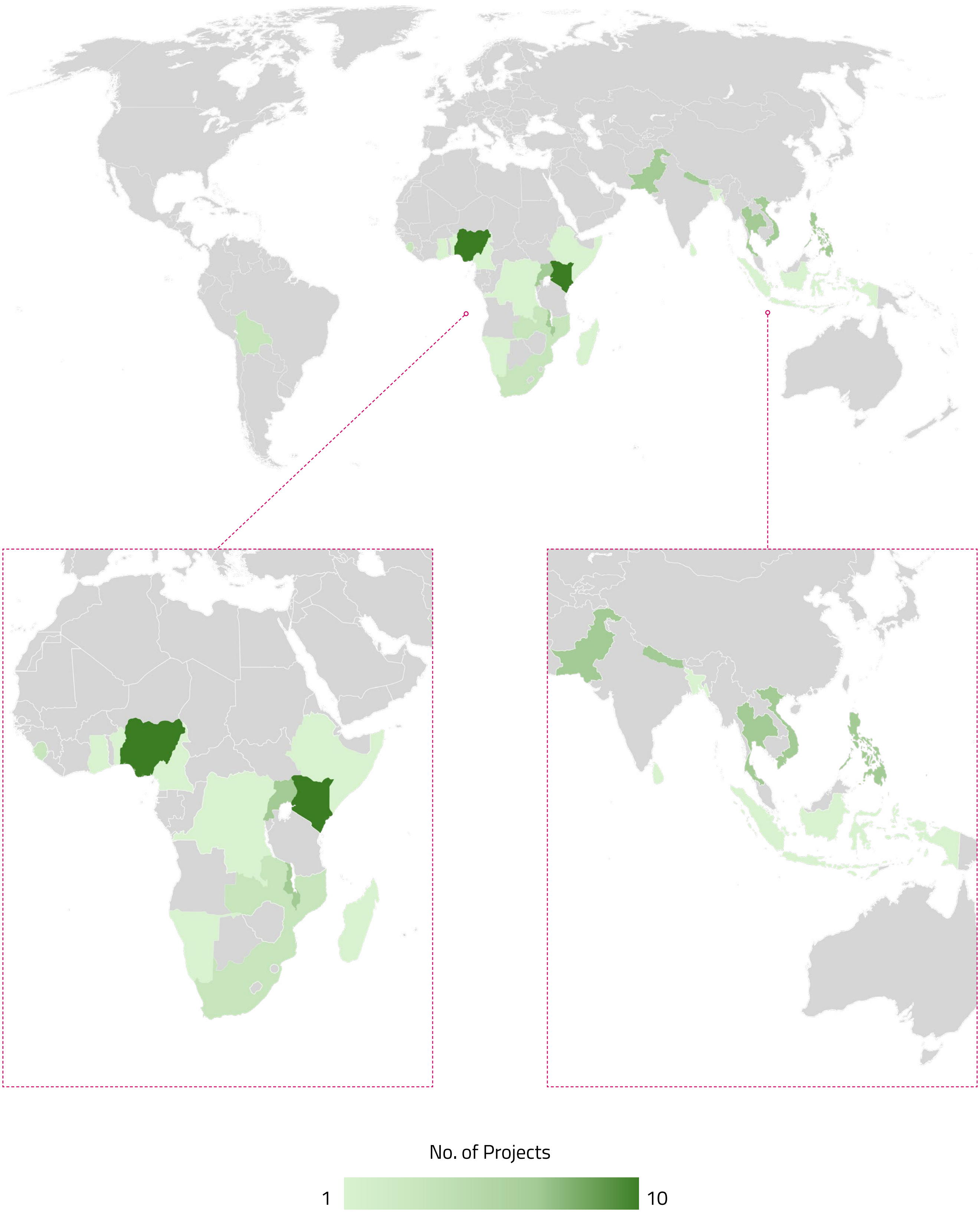

Figure 4: Map representing the number of smart / mini-grid projects supported by the last four rounds of Energy Catalyst funding.

Powerhive

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Powerhive

Powerhive is a global technology company founded in 2011 that provides access to clean, affordable and reliable mini-grid electricity as well as pioneering electric mobility solutions. Powerhive's Kenya subsidiary owns and operates 15 solar mini-grids in Kenya selling electricity to around 4000 households, small businesses and institutions.

Facing the same challenges as other mini-grid developers, Powerhive has explored a wide range of productive use activities to increase mini-grid sales and provide economic opportunities for the local community. They now focus on the key productive uses of poultry incubation, internet access, e-cooking, and high value agriculture (e.g. water pumping and grain milling). The company provides customers with low-cost appliance leases and business loans combined with enterprise development support. As a licensed internet service provider in Kenya, Powerhive also offers a low-cost internet for customers, both in the form of distributed WiFi hot-spots and simple plug-and-play cyber cafes.

Powerhive is also developing their electric vehicle (EV) battery swapping model. Initially they piloted a 3-wheeler EV with a mini-grid in Kisii, Kenya. Now they have 60 more robust third generation e-motorbikes in use with 14 swapping stations in Nairobi. Although capital-intensive, there is enough demand and profitability to expand the model. The swapping stations are based at petrol stations with most connected to solar power as well as the grid. Stations with solar have shown to be more profitable than those that are grid-only. Powerhive aims to introduce the e-motorbike battery swapping model to its mini-grids.

The PUE initiatives have successfully increased the mini-grid load factors but load management is challenging, given much of the use, including e-cooking and grain milling, takes place outside daylight hours and therefore uses expensive batteries. Energy Catalyst Round 9 funding is being used to develop Powerhive's "Bee-Smart" technology which will deploy machine learning software to help mini-grid operators better match their supply and demand. This will allow systems to be designed with smaller batteries and so reduce costs.

Bee-Smart will take data from different uses, across businesses and households, and combine this with weather data to make daily recommendations to users. By offering incentives to customers to shift demand to sunlight hours, it will optimise system usage. Customers will receive a text offering them discounted electricity if they operate their grain mill or other appliances in the afternoon. The software then provides analysis on the predicted usage versus the actual usage to further improve on the future recommendations.

The advantages of Bee-Smart will vary by community and the size of the mini-grid system. The biggest advantages are likely where a system is operating at capacity, whereas a mini-grid running below or above capacity is likely to see fewer advantages. Support from Energy Catalyst has been instrumental in enabling Powerhive to reach out to other mini-grid operators to validate the problem they aim to solve and in providing introductions on the investment side.

The Energy Catalyst grant is allowing Powerhive to test the concept and to understand what level of incentive is required to change behaviour. As customers are also often busy in the day, it is possible that some demand cannot be shifted, for example e-cooking. Powerhive is currently consulting on a manual trial where they plan to test six or seven scenarios. In parallel, Powerhive have seen that there is also scope to use and optimise the same technology for the battery swapping business. Drivers will be sent a message through their app, asking if they want to swap their not-yet empty battery with a full one for a discounted price.

The longer-term aim is that Bee-Smart could be sold as Software-as-a-Service (SaaS) to other mini-grid operators, technology and billing service providers. They are keen that the technology will be compliant with other operators, as the more systems and data included, the better the system can learn. Powerhive would like feedback from other mini-grids on their challenges so the technology can support as many operators as possible.

Energy Action Partners

Energy Action Partners

Energy Action Partners are a small non-profit organisation based in Malaysia. Energy Action Partners was established in 2014 to bridge the gap between technology providers and communities, and they have collaborated on energy access projects in Asia and Africa. New technology and infrastructure are clearly important parts of the solution, but their effectiveness depends on how communities are engaged. When mini-grid development is supported by an informed and empowered user base, the resulting grid is more sustainable, and contributes more effectively to socio-economic development and other community-level benefits.

Demand assessment is a standard step in mini-grid development and normally relies on resource-intensive surveys and questionnaires. However, where a community has had limited exposure to electrification, the responses tend towards inaccuracy. Energy Action Partners engages the community to raise their understanding of energy provision through mini-grids, in order to get a more realistic reflection of likely demand. This community engagement results in optimised mini-grid design and more satisfied customers. To achieve this, they developed the Community Energy Toolkit (COMET), a mini-grid simulation software. The software provides developers with a better confidence level of likely future demand, at a more granular level. By helping to assess and mitigate demand-side risks, it has the potential to unlock greater project finance.

The organisation received funding through Energy Catalyst Round 7, in partnership with Smart Villages Research Group, to look at optimising PV mini-grid storage systems through community simulations of demand in three communities in Somaliland. They wanted to see if it was possible to build a more cost-effective system with a smaller battery and a reduction in CapEx and OpEx, while still providing everything the community needs. The use of the tool informed the design of the three mini-grid systems.

The software, COMET, formally branded as "The Mini-grid Game", is a role-playing game built around a representation of a mini-grid system. It is used as an educational and collaborative planning tool in designing a community-sized mini-grid system. Highly graphical and intuitive, the tool has been successfully deployed in low literacy populations with limited exposure to digital or smart devices. Networked players come together to play out household consumption and make important energy choices, like purchasing appliances, setting energy tariffs, and managing finances to pay their bills on time. Players' individual behaviour, like switching appliances on and off, or failing to make a payment, are immediately visible to everyone else. The software can model different design scenarios, including tariff structures, so the end users fully understand what a mini grid can do for them. The users better understand the likely level of service and align their expectations with the grid to be built. The tool enables the community to collectively decide on an appropriately sized system and a tariff that pays for system costs, preparing them to consume amounts of energy within the mini-grid's limited capacity. Energy Action Partners work with local partners (e.g. mini-grid developers and operators), whom they train and support to deploy COMET in their communities.

COMET can also be used to support mini-grid developers to recruit new customers as well as to drive demand in existing grids, for example by modelling productive use. It is being used by UNDP in Nepal to optimise hydro mini-grids by exploring the potential to increase load factors with electric cooking, and by ASU LEAPS in the design and planning of 75 new solar mini-grids in Fiji. Furthermore, there is scope for its use for on-grid applications such as grid extension and grid densification.

COMET has now been spun off from Energy Action Partners into a mission-driven enterprise as it continues to develop the toolkit. Energy Catalyst acceleration support was instrumental in rolling COMET out and helping to promote what it can do. Work continues on data analysis, appliance data sets and demand simulation to further refine its business model.

However, challenges remain as mini-grid developers need convincing to take a different approach and further finance is required to continue to develop the tool. As the tool is used in more systems and evidence grows that using this approach can result in lower CapEx and OpEx, COMET looks likely to gain popularity as a useful tool in mini-grid modelling.

Gommyr Power Networks

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Gommyr Power Networks

Gommyr Power Networks (Gommyr), established in 2012, champions the adoption of renewable energy through innovative microgrid development and project management. In collaboration with a network of local partners, Gommyr works on renewable microgrid projects across Africa, including in Sierra Leone, Ethiopia, Nigeria, DRC and Mozambique, as well as other territories such as Greece. Their work on renewable microgrids has grown to include fostering green economic development through the productive use of electricity, a crucial factor in improving the viability and scalability of mini-grids and microgrids. By stimulating demand, incorporating productive activities and implementing larger systems, the company is better positioned to address the economic and technical challenges of off-grid projects.

In line with this, Gommyr developed the "eStreet" concept in DRC. This innovative approach centralises business users in a single hub, optimising energy demand and enabling the system to become sustainable both economically and operationally. The eStreet model offers a comprehensive suite of services—energy, water, sanitation, security, and telecoms—tailored to allow businesses and productive users to successfully operate in challenging off-grid environments. This strategy allows Gommyr to optimise loads across the system, rather than being under the control of individual businesses. This not only enhances system efficiency, but also fosters a conducive environment for commercial activities, including specialised services like cooling-as-a-service and ice production, pivotal for local sectors such as fishing. Gommyr is also looking at integrating the charging of electric vehicles (EVs) into the model.

Funding from Energy Catalyst Round 6 for an eStreet feasibility study identified Mbandaka, an off-grid city in the north-west of DRC, as a strong pilot site. Any electricity in Mbandaka is currently provided by expensive diesel gensets or with solar home systems, which do not stimulate economic activity. This eStreet pilot is currently under construction supported by Energy Catalyst Round 7 funding. It will demonstrate eStreet's potential to promote green growth and economic empowerment in off-grid communities, as well as provide insights on the types of activity that are attracted to eStreet as well as the mini-grid viability. Mbandaka's strategic location at the confluence of two rivers, and the introduction of ice production and cold chain services could revolutionise the local fishing industry, enabling broader market access and fostering job creation.

Looking ahead, Gommyr aims to expand the eStreet concept, beginning with an upgrade of the pilot system in Mbandaka from 150 kWp to 600 kWp of solar PV capacity. Gommyr has adapted the model to other markets, including incorporating a hub with an off-grid mini-grid in Nigeria and developing a productive hub for the artisanal fishing sector in Mozambique. The incorporation of eStreet could allow mini-grid tariffs to be kept at a reasonable level while driving local economic development which supports the customer's ability to pay.

The journey is not without its challenges, notably the cost and accessibility of capital in frontier markets. However, by demonstrating the economic viability of the eStreet concept, Gommyr aspire to mitigate financial risks and lower capital costs, paving the way for sustainable, replicable, and economically viable renewable energy solutions worldwide.

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SteamaCo is an Anglo-African B2B business offering a smart metering platform to utilities and independent power producers in sub-Saharan Africa . SteamaCo's staff are split between the UK, Kenya and Nigeria. They started out as a mini-grid developer in Kenya in 2012 and later transitioned into a technology company providing innovative smart grid services to both on and off-grid sectors. Initially, they developed a smart meter to address the challenges of collecting cash in the mini-grid model. With Energy Catalyst Round 4 funding support, SteamaCo developed an IoT cloud-based system for revenue collection using smart meters. However, they faced challenges overcoming hardware compliance in each territory, as well as competition from Chinese manufacturers. At the same time, it was clear that mini-grid developers across Africa faced the same payment challenges, particularly in areas with no connectivity, which impacted the time between the customer making a payment and their power switching on (pay-to-power). This led to their strategic pivot to a cloud-based software company.

SteamaCo now provides turnkey smart metering services to mini-grid developers, allowing them to manage all their payments remotely and more efficiently. The SteamaCo IoT smart metering platform combines smart hardware and cloud-based technology. SteamaCo helps install the system, including meters and a data concentrator unit (DCU), and links it to their cloud-based user face (Nimbus AMI). Mini-grid developers pay an upfront system installation cost and a monthly SaaS and data charge. The cloud-based system allows mini-grid developers to remotely manage their grids, analyse data and understand their billing and metering performance.

SteamaCo sees great opportunities for mini-grids developers across Africa if they can get the business model right, with the push on productive and anchor loads driving progress. Focussing on the anchor and productive loads, SteamaCo, in partnership with Differ Community Power (DCP), received Energy Catalyst Round 6 funding to develop systems centred around health centres in Malawi. The PV system powers the lighting, vaccine storage and water pumping for the health centres as well as using excess daytime power to extend power to the community and offer additional services, such as chilling. The model is based around using the income to help fund operation and maintenance costs, which until now have been disregarded.

The project will now be scaled up as part of Energy Catalyst Round 10, where, with their partner DCP, they plan to introduce EV charging, agro-processing on site, water pumping and battery charging. The increase in productive uses makes the system more viable. SteamaCo is also designing software to manage these systems effectively.

In addition to mini-grid services, SteamaCo is developing its proposition for grid companies. They have developed an AI product called "Aurora AI" that detects losses in grids by analysing meter anomalies and network branch reconciliation, whether the loss is from a meter bypass, meter tamper or an illegal connection. This is possible even where customers do not have smart meters, which is the case in most distribution networks. SteamaCo claim that combining this with its Nimbus AMI product has increased utility revenue by up to 150% in pilots conducted in Nigeria.

SteamaCo continues to innovate and is exploring further developments for smart grids such as dynamic pricing, load monitoring and weather forecasting, and battery management. They are also looking at how they can support carbon credit registration for electric cooking.

Learnings and insights

Mini-grids play a crucial role in achieving SDG 7 by diversifying the energy mix and extending electricity access to remote and underserved areas. Additionally in most cases, it is seen as a driver of economic growth and social impact. The challenges associated with building and operating profitable mini-grid projects are acknowledged as significant, but the many benefits for end users makes overcoming them a worthwhile endeavour. The need for innovation and access to affordable finance should be emphasised as critical factors in the success of mini-grid projects.

With scale, mini-grids can become profitable and less risky, potentially qualifying for commercial lending.

While breakthrough innovations in the sector could certainly bring plenty of added value, part of the solution will also come from the sum of smaller innovations applied at the very local level, which together can greatly improve both the viability and scaling of mini-grids.

This report underscores the positive role that innovation has in increasing viability and reducing risk for investors in the early stages of a project, and therefore contributes to the sustainability and scalability of mini-grids.

Innovation can take time and requires a complete design cycle, including thorough testing and improvement of prototypes.

This patient capital is crucial for further developing innovations and supporting mini-grid systems to pilot and refine these innovations.

The unique challenges of the energy sector, with longer lead times for impactful results, calls for patient capital.

The proposal that investors should finance both mini-grid systems and associated innovations is put forward as a strategy to incentivise developers to take bold steps in deploying more projects. This comprehensive approach addresses not only the immediate needs of energy access, but also fosters an environment where continuous innovation and improvement can thrive in the long run.

However, innovation alone will not revolutionise the sector.

Innovation plays an important part in the design and operation of systems, in business models and productive use, and in community engagement.

To achieve the scale of mini-grid development, work needs to be undertaken in parallel by multiple stakeholders, prioritising improving the policy and regulatory framework in support of mini-grids, planning, improving the ease of doing business, scaling up skill development, and making affordable finance available.

In summary, the report highlights the importance of patience, support and holistic financing to drive innovation and sustainable growth in the mini-grid sector, ultimately contributing to the achievement of SDG 7.

Endnotes

[1] *Tracking SDG7. The Energy Progress Report* (IEA, 2022).
[2] *Sustainable Recovery - World Energy Outlook Special Report* in collaboration with the International Monetary Fund (IEA, 2023).
[3] *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers* (ESMAP, World Bank; 2022).
[4] ibid
[5] ibid
[6] Assuming 30% of 90 million connections over 8 years (based on data from IEA, 2023)
[7] "Minigrids Are the Cheapest Way to Bring Electricity to 100 Million Africans Today", Tilleard M., Davies, G. and Shaw L. (Greentech Media, 2018).
[8] ESMAP, 2022.
[9] ESMAP, 2022.
[10] For more info, see "Empowering Paradise: Fiji's Solar Revolution Lighting Up Remote Islands", Kanvar V. (Arizona State University, 2023).