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Kuungana Insights

Mini-grids: new players, new business models, and a need for a new regulatory paradigm

Kuungana Advisory Limited
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Kuungana Advisory

About Kuungana Advisory

Kuungana Advisory Limited ("Kuungana") works on advisory projects that facilitate the transformational change required to increase access to environmentally sustainable and affordable energy supply.

Our name, Kuungana, is the verb 'to connect' in Swahili. This encapsulates our involvement in projects increasing energy access in some of the most energy hungry parts of the world, and also on projects in both developing and developed economies that innovate with new business models and commercial arrangements in our rapidly changing sector.

Acknowledgements

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1. Setting the scene

The role of mini-grids is one that is receiving an ever increasing amount of attention across the power sector. In developing countries mini-grids could have a role in rapidly accelerating access to power, something that 1.2 bn people globally still lack. And in the developed world there is even talk of grid defection as mini-grid costs become competitive with the cost of centralised power systems. This Kuungana Insights report will focus on the former, but it is worth bearing in mind the potential wider applications for mini-grids.

The status of mini-grids

A recent report[1] from the International Renewable Energy Agency (IRENA) suggested that 26 million households, or an estimated 100 million people, are now served by 'off-grid' renewable energy systems. Of these, most are through home solar systems, but it is estimated that 5 million households are connected to renewables-based mini-grids. This number does not, of course, include the many diesel-based mini-grid applications installed globally. According to Navigant Research's Q1-2016 update[2] on micro-grids, by the end of 2015 there was 582 MW of micro-grid capacity installed in the Asia Pacific region, and 491 MW installed in North America.

Mini-grids are at an earlier stage of development in Africa, but given that it is in Africa where access to energy remains lowest, the developments there are of particular interest. For example, according to the IRENA report:

- Kenya has 19 MW of operational mini-grid capacity, compared to peak demand of ~1.5 GW;
- Cameroon has over 23 MW of mini-grid capacity, over ~30 installations, compared to peak demand of ~900 MW; and
- Tanzania has ~22 MW of isolated diesel grid operators, compared to peak demand of ~1.7 GW.

While mini-grids only account for ~1-3% of peak demand even in these countries today, some African countries have explicitly recognised the role that mini-grids and other 'off-grid' projects could play in helping them to meet their energy access targets:

- Rwanda has a target of increasing energy access to 70% by 2017, but much of this is to be met through off-grid solutions. The target for 'on-grid' access is 48%.
- Uganda is targeting rural electrification of 22% by 2022, and plans to meet this through a combination of 1.28m on-grid connections and 140,000 connections using solar PV systems and mini-grids.

In addition, donors are increasingly paying more attention to mini-grids:

- The latest Power Africa roadmap[3] places much more emphasis on the "Beyond the Grid" programme. One of Power Africa's goals is to add 60m new electricity connections. Of those, 25m connections are now expected to come through Beyond the Grid, with 8m of those in turn being from mini-grid projects.
- The Sustainable Energy Fund for Africa (SEFA, a multi-donor facility funded by Demark, the UK, and the US) is launching a Green Mini-Grid Market Development Programme, which aims to reduce market barriers for new mini-grid projects.

Across Africa, mini-grids are increasingly being cited as part of the solution in improving energy access, but the actual contribution made by mini-grids remains small.

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[1] http://www.irena.org/DocumentDownloads/Publications/IRENA_Off-grid_Renewable_Systems_WP_2015.pdf
[2] https://www.navigantresearch.com/research/market-data-microgrids
[3] https://www.usaid.gov/sites/default/files/documents/1860/power-africa-roadmap-v2.pdf

Looking to the future

The mood music therefore suggests that mini-grids might play an increasingly important role in improving energy access. If this is to be the case, there are some important questions we need to try to answer:

- What exactly are mini-grids? How robust is the access to energy they provide? And what do we actually mean by access to electricity anyway?
- Is the economic case to support a role for mini-grids in increasing access to energy robust? If so, how big a role can mini-grids play? How big will the market be?
- If mini-grids are to have a greater role in future, then what is required to facilitate the scaling-up of the sector?

It is these questions that we start to address over the following pages.

Our survey of key stakeholders

To challenge some of the observations and suggestions made in this paper, we asked mini-grid developers to respond to a short survey to tell us a bit about their business, and the challenges that they face in scaling up their activities. Some of the outputs from that survey, for example about the regulatory and financing barriers faced by mini-grid developers, are used in this report.

2. What is a mini-grid?

One of the things that is perhaps most confusing when first considering mini-grids is that the term itself can mean so many different things. There is no single agreed definition for what a mini-grid is. Sometimes the terms mini-grid and micro-grid are used interchangeably; sometimes they are used intentionally to distinguish between different grid sizes. The term might be used to describe a system with a load of a few kW, or with a load of a few MW. Just a few of the definitions that we have come across in researching this paper are presented in Table 1 (and even these could be debated!).

For the remainder of this paper, we'll try to stick to the term "mini-grid". We won't set any strict boundaries, but we'll stick closest to the IRENA definition: grid systems that are at least normally isolated from the main national grid, grid systems that accommodate loads generally up to a few MW, and where there are no high voltage networks.

The rest of this section will examine what mini-grids are in more detail:

- We ask how much of a contribution mini-grids make to increasing access to energy; and
- We present an overview of some of the business models being deployed by mini-grid developers in today's market

Who really has access to energy?

This paper is examining the future role of mini-grids in improving access to energy in parts of the world where access is currently poor. So it is only right that we challenge what we really mean by 'access to energy' at this point. A single voltage DC system with 10 kW of solar PV may transform lives by providing households with the means to light their homes and charge their mobile phones, but it will not sustain a manufacturing plant. The system clearly greatly improves access to energy for the affected households, but it does not provide the same access to reliable power that we take for granted in the developed world.

Table 1 Example definitions of mini-grids

Source	Definition
IRENA: Off-grid Renewable Energy Systems Report, 2015	Any grid system up to 100 MW in size, where local generation is satisfying local demand, where transmission is limited to 11 kV, with multiple connected customers. Note the IRENA report includes separate definitions for micro-grids (5-100 kW), nano-grids (0-5 kW), and pico-grids (0-1 kW).
Africa-EU Renewable Energy Cooperation Programme (RECP): Mini-grid Policy Toolkit[4], 2014	Grids that involve small-scale electricity generation (10 kW to 10 MW) and that serve a limited number of consumers via a distribution grid that can operate in isolation from national electricity transmission networks.
US Department of Energy	In this case, the Department of Energy actually refers to micro-grids, rather than mini-grids. Micro-grids are defined as a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A micro-grid can connect and disconnect from the grid to enable it to operate in both grid-connected and island mode.

So when we look at energy access statistics, what do they really mean? We mentioned earlier that Uganda, for example, is looking to meet its energy access goals partly through the use of simple solar PV systems. The IEA's energy access database (which suggests that 1.2 bn people worldwide do not have access to energy) focuses on two aspects of energy access:

- **Access to electricity** – as well as having an electricity supply, household consumption must meet a minimum threshold: 250 kWh p.a. for rural households, and 500 kWh p.a. for urban households. The IEA suggests that the threshold for rural access could equate to the use of a fan, and mobile telephone, and two fluorescent light bulbs for ~5 hours per day. To reach the urban threshold, households might also be using an efficient refrigerator, a second mobile phone, and a television, for example.
- **A clean, safe means of cooking** – the IEA energy access definition also requires households to have cooking facilities that can be used without harm to health and also that are more sustainable and energy efficient than the average traditional biomass stove. This might be a biogas or LPG stove, or an improved biomass stove.

Clearly this is a judgemental area. It is a perfectly reasonable definition of energy access, but it is also clear that a country could reach very high levels of energy access under this definition, but still not have an electricity system that supports the demands of a modern economy, either for households or businesses.

Recognising the scope for debate over such definitions, there have been numerous attempts to define more granular definitions that capture the 'quality' of energy access. The World Bank's Sustainable Energy for All (SE4ALL) programme has proposed a 5-tier energy access framework (see Table 2), although we are not aware of any statistics having been prepared using this framework yet. We also note that even Tier 5 access under this framework remains focused on domestic/household requirements, rather than those of the wider economy. This level of energy access could be provided by many mini-grid systems.

[4] http://minigridpolicytoolkit.euei-pdf.org/policy-toolkit

Table 2 SE4ALL Global Tracking Framework for Energy Access

Attributes	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Services	Nil	Task light AND phone charging	General lighting AND television AND fan	Tier 2 AND any low power appliances	Tier 3 AND any medium power appliances	Tier 4 AND any higher power appliances
Peak available capacity (W)	-	>1	>50	>500	>2,000	>2,000
Duration (h)	-	>4	>4	>8	>16	>22
Evening supply (h)	-	>2	>2	>2	>4	>4
Affordability			✓	✓	✓	✓
Legality				✓	✓	✓
Quality (voltage)				✓	✓	✓

Source: SE4ALL

Given the importance of energy access targets to many donors, the quality of energy access is an important point when considering the role of mini-grids, especially smaller mini-grid systems. Such systems could be a very cost-effective solution in some situations (e.g. in rural areas that the main grid is highly unlikely to reach for many years), but might not be appropriate to use in, for example, more peri-urban settings where a mini-grid might actually delay grid expansion and with it broader-based economic development.

What do mini-grids look like?

Isolated mini-grid systems are developed by a diverse range of organisations. The business models and the policy and regulation context also varies widely. Table 3 presents an overview of the models deployed for projects that have already been implemented. This is a synthesis of case studies prepared for the Africa-EU RECP Mini-Grid Policy Toolkit[5].

The table illustrates that there is currently no one business model that has been adopted – the case studies adopt a wide range of different business models. The different models also involve different stakeholder groups, ranging from utilities, to private sector operators, to communities.

Table 3 Summary of Africa-EU RECP Mini-Grid Policy Toolkit case studies

Location(s) and project(s)	Key players	Technology	Business model and subsidy requirement
Kenya 19.2 MW across 10 projects	REA (Rural Electrification Authority) manages overall programme KPLC, majority Gov't owned utility, develops projects Ministry of Energy funds the projects	Mostly diesel, supplemented by 0.6 MW wind and 0.5 MW solar PV	Ministry owns assets KPLC operates and maintains the mini-grids National uniform tariff applied with Government covering any losses Rural energy levy on all electricity bills covers this cost

[5] http://minigridpolicytoolkit.euei-pdf.org/casestudies

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Location(s) and project(s)	Key players	Technology	Business model and subsidy requirement
Cape Verde 40 kW system in Monte Trigo	Municipality of Porto Novo – invested 25% of funds ACP-EU Energy Facility – donated 75% of funds Municipal utility – responsible for O&M	40 kW of solar PV plus 2 lead acid batteries with 370 kWh storage	75% of capex met through a grant Energy Daily Allowance (EDA) tariffs proposed with a monthly fee Current tariffs cover O&M, but not initial investment
India 80+ mini-grids using rice husk gasifiers, normally 25-50 kW	Husk Power Systems (HPS) – private limited company	Rice husk gasifier and gas engine	20% government subsidy for capex Mostly BOOM (Build Own Operate Maintain) where HPS is an off-grid integrated utility For some projects HPS now brings in other investors, some of whom take on operating responsibilities Revenues mostly fixed monthly amounts following EDA model
Tanzania 2.5 MW at Njombe	TANWAT (Tanzania Wattle Company) – private sector developer of biomass project TANESCO – state-owned utility owns the grid	Biomass	Initially fully private operation, but the project was then integrated with the grid – TANESCO is now responsible for the grid itself Now, the project is essentially a small-scale IPP project TANWAT sells wholesale power to TANESCO, and consumers pay national grid tariff rates
Uganda Isiizi hydroelectric 354 kW mini-grid	Kisiizi Hospital Power Ltd (KHPL) – a local private company that owns and operates the grid Church of Uganda – co-investor	Hydro run-of-river, with 80 kVA standby generator to provide backup to hospital	70% grant from World Bank Energy for Rural Transformation programme Tariff information is not available, but tariffs appear to be set by the grid owner
Senegal 18 mini-grids up to ~15 kW	ERSEN (Renewable Energy for Senegal) Off-grid Solar Energy Programme – government run programme ERIL (Local Rural Electrification Initiatives) – consortia of private companies, NGOs, community groups	Typically solar PV (5 kW), diesel (10 kW), battery hybrid	Equipment costs paid by GIZ Assets owned by Government and licences to private operators for 15 years Tariffs vary by project to reflect cost differences and are regulated to achieve a 12% IRR
Rwanda Micro-hydro projects ~50-500 kW	Private sector investors in the hydro projects REG (Rwanda Energy Group) is offtaker from these projects MININFRA (Ministry of Infrastructure) – signs concession agreement with developer	Micro-hydro plants	50% investment subsidy grant Initially designed as mini-grid projects, but grid extension meant that they converted to IPPs Plant receives a REFIT tariff leading to an IRR of ~20%
Namibia Tsumkwe ~1 MW mini-grid project	Otjozondjupa regional government – owns assets Ministry of Public Works – provides O&M	Solar PV (202 KW), battery (1.05 MWh), and diesel (total 650 kW) hybrid	State owned project Tariffs below cost, with subsidy paid by the regional government

Source: Mini-Grid Policy Toolkit

There are a few common themes across the case studies covered in the table:

- The cost of energy generated by the projects is generally higher than bulk power from the national grid. This is unsurprising given the expected economies of scale when building larger generation plants.
- Most of the projects received substantial capital subsidies, often from donors.
- Tariffs have often been set at a level that is not cost reflective for the mini-grid. Privately financed projects are often kept whole through capital or operating cross-subsidies.

These observations suggest that the economics of mini-grid systems can often be challenging – something we analyse in the next section – and also point to some of the difficulties experienced by developers today, that need to be addressed in order to scale up the role of mini-grids.

3. The economics

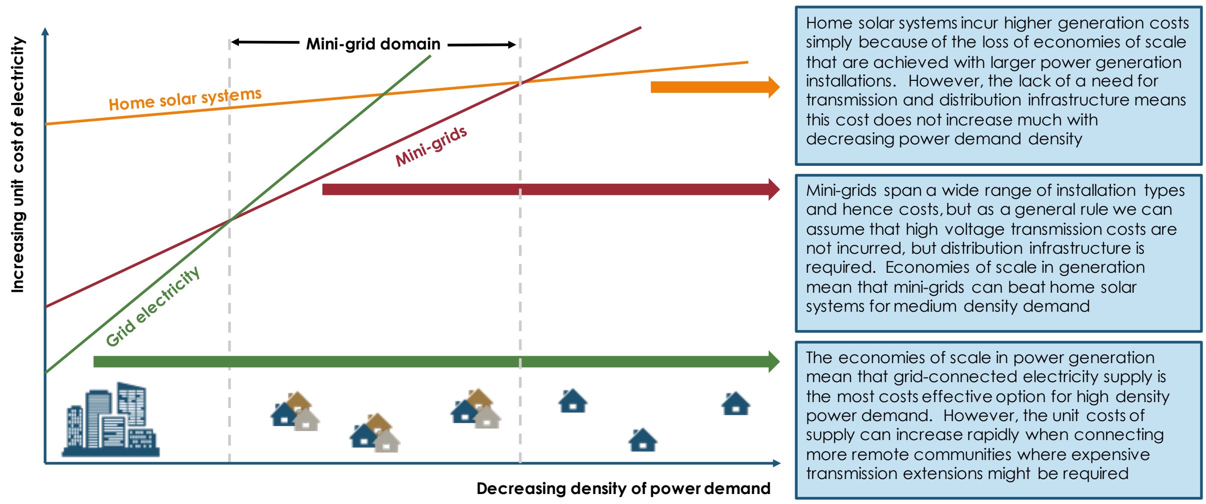
Let's take stock – this is a sector that is receiving an increasing amount of attention, and where there is a consensus that further financing needs to be unlocked to scale up activity. In order to understand what those requirements might be, we first need to understand the economics of the opportunity. Where will mini-grid interventions make sense, and how big might the opportunity be?

In this section we analyse the basic economics of mini-grids and consider where mini-grids are most likely to be a value-for-money intervention. We also consider the ability and willingness of potential electricity consumers to pay for such interventions. Finally, we evaluate what all of this might indicate for the future role of mini-grids.

Where do mini-grids work?

An assessment of whether a mini-grid is the preferred solution for a given location needs to take into account the alternatives, and the value for money delivered by each alternative. One framework for thinking about this is schematically presented in Figure 1. The figure illustrates the change in the cost of a unit of electricity from the national grid, a mini-grid system, and from a home solar system, from a densely populated urban centre (on the left) to the most isolated rural communities (on the right).

Figure 1 Schematic representation of mini-grid economics



Source: Kuungana Advisory

On the left of the figure electricity from the national grid is the cheapest option. The economies of scale of centralised power generation yield lower generation costs, and with a high density of power demand network costs are low on a $/MWh basis. As we move from left to right the importance of network costs in distributing power to ever more remote demand centres increases. Eventually those network costs increase to an extent that they outweigh the benefits of centralised generation. First mini-grids become the most attractive option, and then home solar systems.

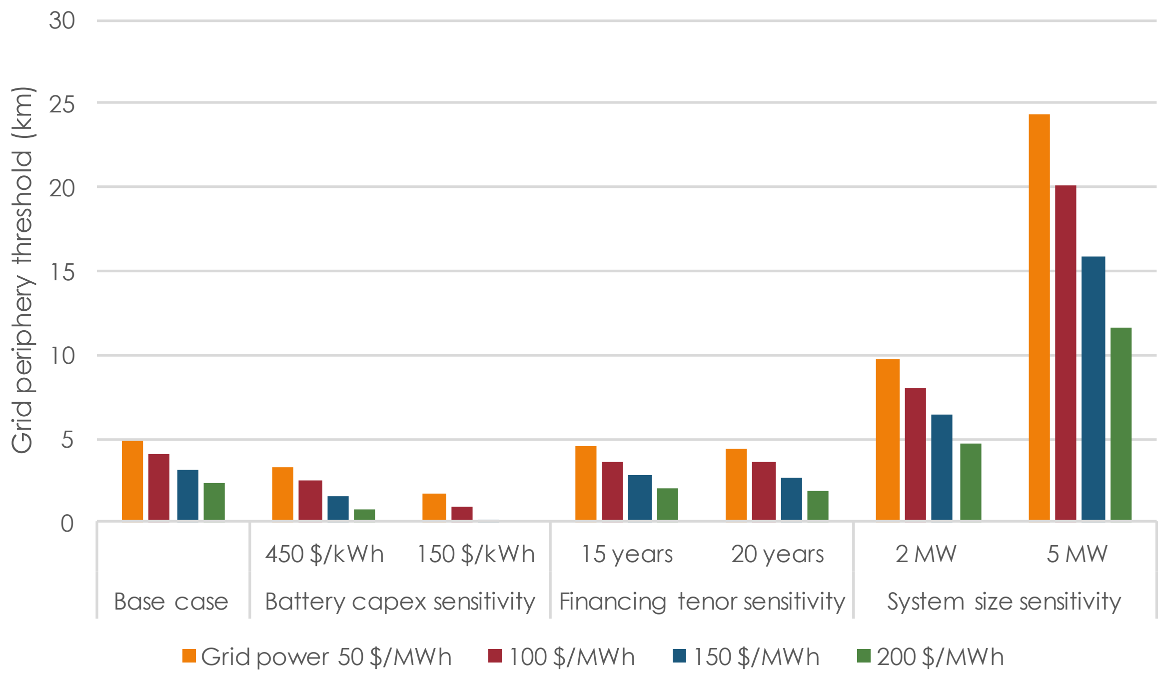
This representation is, of course, simplified. Political and commercial constraints might be a more important driver of mini-grid development in some areas. A centralised solution might be the most economically attractive, but exogenous constraints (e.g. a financially unviable utility) may be blocking such a solution, making a mini-grid implementation an attractive option.

Conceptually this is straight-forward, but it is far from straight-forward to determine exactly where mini-grids might be the optimum solution, because there are so many uncertain variables that go into that calculation. To demonstrate this, we can perform some simplified calculations to estimate where the 'grid periphery' should be. In other words, how far from the transmission system should a load centre be before it is considered a candidate site for a mini-grid? This is the equivalent of the intersection between the green and red lines in Figure 1.

Figure 2 presents a simplified analysis to estimate what the threshold might be. On the far left of the figure we present a Base case view for four different grid power prices ranging from 50-200 $/MWh. The cheaper grid power gets, the further out from the existing transmission system grid extension makes sense. In our Base case grid extension makes sense 2-5 km out, depending on the power price. Some of the assumptions made in this analysis include:

- A solar / battery / diesel hybrid system has been modelled, assuming 2 MW of solar is installed for every 1 MW of battery and 1 MW of diesel back-up. In the figure this configuration is referred to as a 1 MW system; a 2 MW system has 2 MW battery and diesel back-up and 4 MW of solar.

Figure 2 Analysis of grid periphery threshold



Source: Kuungana Advisory

- Capital costs assumptions are 2,000 $/kW for solar PV, 750 $/kWh for the battery, and 400 $/kW for the diesel back-up.
- Transmission costs are assumed to be $6m/km.
- Mini-grid financing costs are assumed to be 15%, with financing of the transmission assets available at 5%.
- In the Base case financing is on a 10-year tenor.
- The analysis does not take into account any loss of economies of scale in overhead costs and cost to serve.

Clearly any one of these assumptions could be debated – there are endless sensitivity tests that could be executed, and of course the parameters can vary greatly between different mini-grid projects.

Figure 2 also includes results for a range of sensitivities. These sensitivity tests show that:

- The grid periphery threshold moves ever closer to the existing transmission network as battery capex costs fall. If grid power remains expensive, it could even make sense to halt grid expansion at battery costs of 150 $/kWh.
- Access to longer term finance would (slightly) reduce the $/kWh cost of the mini-grid, also increasing the number of mini-grid opportunities.
- The distance over which it is cost-effective to build out the grid increases dramatically for larger systems – the benefits of economies of scale start to outweigh the saved transmission costs.
- It is also worth noting that the results vary significantly depending on the cost of power from the national grid. This is important as many sector reform activities taking place in parallel are aiming to increase the affordability of grid power e.g. through moving away from diesel-based generation. The success of reform in this area, could reduce the number of areas in which mini-grids are economically viable.

Finally, it is important to note that the analysis presented above is of the overall economics, and does not take into account policy incentives or commercial arrangements. Lump-sum capital grants might make mini-grid options more attractive than the analysis indicates, or tariff cross-subsidies could mean that the most attractive option to a consumer is not what would be suggested by the underlying fundamental economics.

Ability and willingness to pay

The analysis presented so far seems to suggest that there is a role for mini-grids, and that this role may grow as the cost of technologies such as solar PV and battery storage continue to fall. However, this interpretation makes some previously unstated assumptions about the ability and willingness of consumers to pay for electricity. It assumes that potential electricity consumers are able and willing to pay for mini-grid electricity. On the flip-side it assumes that consumers will take the cheaper option i.e. if connecting to main grid would be cheaper, that is what they will choose. On the ground, a utility may be struggling to expand the main grid quickly enough to keep up with demand. This might mean that there is demand for more expensive mini-grid technology even in locations where it would theoretically be cheaper to connect to the main grid.

This issue is addressed in a 2014 report[6] about off-grid power supplies in Kenya by Economic Consulting Associates for KfW. Analysis in the report suggests that, based on the displaced cost of kerosene, dry-cells, and phone charging services, low income households might have an ability to pay close to 1.52 $/kWh.

However, as the report for KfW also notes, this does not mean that consumers would be willing to pay this amount:

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[6] http://www.renewableenergy.go.ke/asset_uplds/files/ECA%20Kenya%20Minigrids%20Report%20-%20revised%20final(1).pdf

- Consumers will expect there to be at least some saving compared to their current energy costs, and if the mini-grid cannot demonstrate a clear saving this could undermine demand and hence the business case for the investment.
- If consumers are aware of on-grid tariff levels, communities might expect tariffs to be similar or the same. In some countries regulation might even impose a universal tariff. On-grid tariffs vary by country, but in sub-Saharan Africa, for example, are typically between 0.02-0.30 $/kWh.
- It is also likely that consumers would see access to a mini-grid (or any grid) as an opportunity to increase their consumption of electricity. Even if consumers were willing to pay a high price to replace their existing energy consumption, this may not carry to additional consumption.

While it seems reasonable to assume that consumers' willingness to pay is considerably lower than the 1.52 $/kWh number, it also seems likely that at least for a basic level of electricity supply, consumers would pay an amount that would not undermine the conclusions drawn from the economic analysis presented above.

The potential of mini-grids

So what share of the population currently without access to a reliable electricity supply could be served by a mini-grid? Innovation Energie Développement (IED) tackled this question in a 2013 report[7] on Low Carbon Mini-Grids for the UK's Department for International Development (DFID). The report performed analysis on the potential for mini-grids using data on population density, existing electricity infrastructure, and resource availability for renewable generation. If it is assumed that mini-grids are viable anywhere >5 km from the main grid, and with a population density of >250 inhabitants per km^2 then the IED analysis suggests that mini-grids could be very significant.

The IED analysis suggests that mini-grids could be more appropriate than grid extension for 28% of the population in Rwanda, for 27% of the population in Malawi, 23% of the population in Kenya, and 20% of the population in Tanzania. However, the analysis suggests that the potential in other countries could be much lower (see Figure 3, over the page). For example, it suggests that mini-grids might only be suitable for up to 1% of the population in Mozambique, where the grid network is more extensive, and only 6% in DRC, where the population is too disperse for mini-grids to be viable.

The International Energy Agency (IEA), in its 2011 Energy for All report[8], presented analysis that suggests that more than 50% of the rural population currently without energy access would be best supplied with electricity from mini-grids. This compares to ~18% for stand-alone systems and ~30% for the main grid. As with our own analysis, presented earlier, there are of course a lot of assumptions behind this number, which is perhaps surprisingly high. But all of this analysis points towards mini-grids having a significant role to play in countries that have low access to electricity today.

The same IEA report suggests that by the mid-2020s >$25 bn of new investment in mini-grids will be required annually. That is a lot, and is financing that is not being delivered by the market today.

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7 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/278021/IED-green-min-grids-support-study1.pdf

8 http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/weo2011_energy_for_all.pdf

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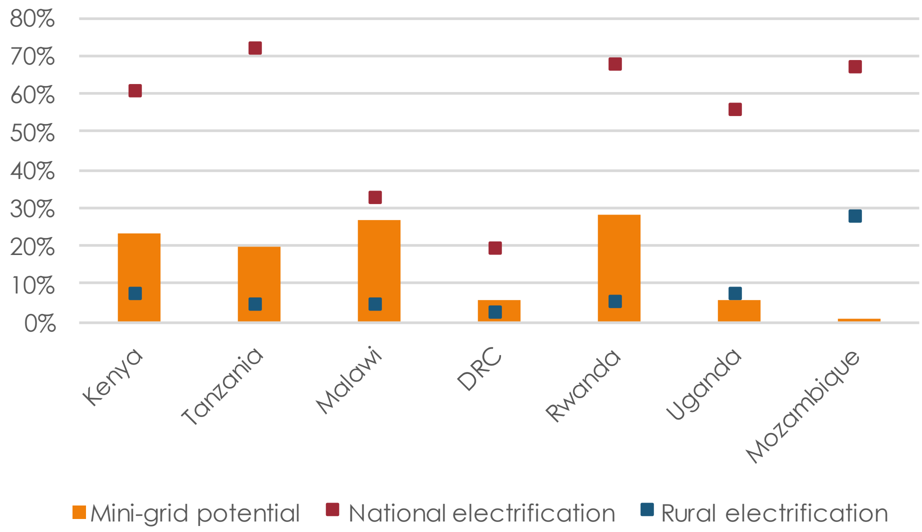
Figure 3 **Potential of mini-grids across selected countries in sub-Saharan Africa**



Source: IED analysis for the Department of International Development, IEA World Energy Outlook 2015

4. Scaling up

While the exact scale could be debated, it is clear that mini-grids could have a significant role in increasing access to energy in parts of the world where access rates are low today, especially in more rural areas. However, despite the increasing number of companies operating in this space, the vast majority are financed with a combination of high cost equity, philanthropic funds, and grants and aid. A radical shift in the funding model needs to take place for the sector to scale up. This, in turn, will require many of the existing regulatory barriers to development to be addressed.

In the final section of this report we summarise some of the changes that will be required before the sector can unlock the potential outlined above.

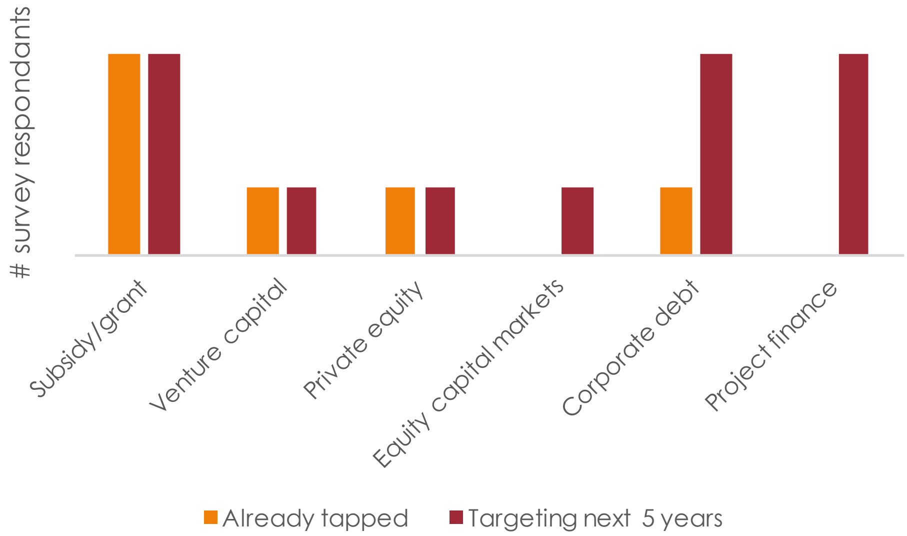
Funding for mini-grids

There is a disconnect between the types of funding currently prevalent in the mini-grid sector and the types of funding that will be required to scale up the sector. Figure 4 presents results from our survey of mini-grid developers, which illustrates developers' desire to move from a model that, to date, has depended largely on subsidies and grants, to one that taps into a wider range of financing sources.

There are two particularly notable conclusions to draw from the figure:

- There is clearly an expectation that subsidies, grants, and aid will remain important over the next five years. It is difficult to see how the sector can truly scale up while this remains the case. This highlights the importance of addressing some of the regulatory barriers highlighted over the remainder of this report.
- There is also a desire to tap debt markets. This will help the sector to scale, but clearly banks will have stringent requirements that need to be met before they will invest, especially before project finance is made available. In most countries the regulatory and commercial security package required to secure such facilities is simply not in place. Again, reforms will be required to convert this ambition into reality.

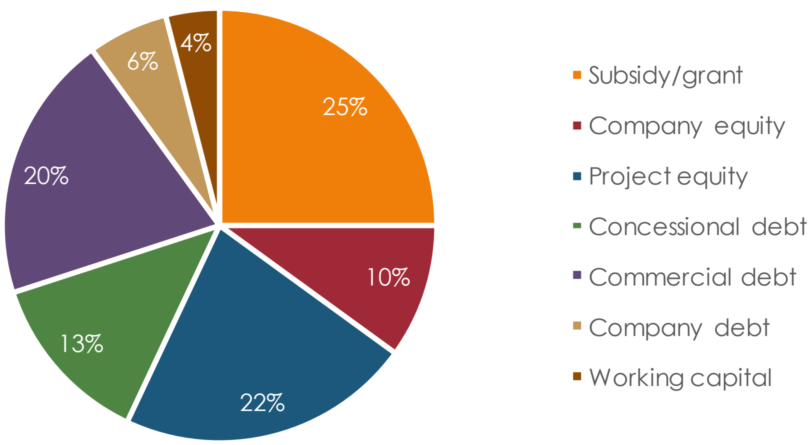
Figure 4 Survey respondents saying they have, or hope to, tap each type of finance



Source: Kuungana Advisory survey of mini-grid developers

The findings from our survey are support by evidence presented in the 2015 Directory of Investment and Funding Opportunities[9], published by the United Nations Foundation's Energy Access Practitioner Network. The survey used to prepare the Investment Directory identified $524m of immediate funding requirements in the mini-grid sector. This is well short of the $25 bn p.a. requirement highlighted by the IEA's report, cited earlier, giving an indication of how far the sector has to go to fulfil its ambition. But the mix of funding types sought by developers, summarised in Figure 5, mirrors the findings of our own survey. Developers are indicating that the current regulatory framework necessitates a continued need for subsidy and concessional debt, but are also indicating a desire to tap more conventional and commercial types of finance.

Figure 5 Types of finance sought by mini-grid developers



Source: Energy Access Practitioner Network

[9] http://energyaccess.org/wp-content/uploads/2015/12/InvestmentDirectory2015.pdf

Regulatory barriers to scaling up mini-grids

So, if there are barriers to wider deployment of mini-grids, how has the sector grown to date? Many of the projects to date have followed A-B-C model, whereby projects are secured by an **A**nchor load, before then extending out to local **B**usinesses and then **C**ommunities. This model can be helpful, but it can only be applied in situations where there is a significant anchor load, which simply isn't there in many of the rural locations where mini-grids could be used to increase access to electricity.

In order to scale-up the development of mini-grids, our exchanges with mini-grid developers in Africa and Asia have highlighted a number of key challenges that policy and regulation needs to address:

1. Mini-grid planning;
2. Licensing requirements;
3. Access to longer-term finance;
4. Tariff regulation;
5. Credit risk with counterparties; and
6. Eventual grid extension and integration.

Below we briefly describe each of the issues listed above.

Mini-grid planning

For mini-grid developers originating project opportunities on the ground, it can be difficult to judge which locations are best suited to mini-grids. Economic analysis, such as that presented earlier in this report, can be performed and there are many examples of GIS analysis being used to identify appropriate load centres. However, a lack of coordination with overall system planning could increase project risk and reduce bankability. If a utility subsequently extends the main grid that could undermine the earnings potential of the mini-grid project. This risk could be mitigated through:

- A single planning body, independent of the utility, and government, designating areas suitable for mini-grid development, where the main grid is unlikely to extend in the near future.
- A clear regulatory framework that protects mini-grid investors in the case of grid extension (discussed under a separate header below), while allowing consumers to realise the benefits of grid power.

Licensing requirements

Licensing regimes have often been designed solely with large-scale, centralised grid-based generation in mind. Applying for, and complying with, a licence can be burdensome for developers of projects that are much smaller in size, such as mini-grid systems. This burden ultimately translates to time and money for developers and can undermine the viability of some potential projects.

Lighter licensing requirements, or even licence exemptions, could be considered where these are not already in place for mini-grid projects.

Access to longer-term finance

In a sense this is the issue that lies at the heart of scaling-up mini-grids. As highlighted above, most funding to mini-grid developers to date has been through a combination of aid-based grants, output-based aid (OBA), impact investment, and venture capital. While contributions from each of these sources is clearly important and valuable in a sector that is still at an early stage of development, other sources of funding will need to be tapped in order to scale-up activity in the sector. Many of the developers we have surveyed have indicated their desire to tap corporate debt and project finance, for example. These sources of finance are unlikely to be available before the policy and regulatory risks highlighted are comprehensively mitigated.

Tariff regulation

Some countries have universal tariff requirements, meaning that mini-grid developers can only charge the same tariff as that charged by the main utility. This clearly makes some projects unviable, especially in cases where the universal tariff is not properly cost reflective for even grid power. This is a complex issue and ability and willingness to pay needs to be considered alongside designing a solution, but there are a few different paths that can be followed:

- Mini-grid developers can be allowed to charge their own tariff. In the absence of subsidy or aid, however, this can lead to ability, or at least willingness-to-pay challenges.
- A universal tariff could be charged but with a cross-subsidy transfer to the mini-grid developer funded by a surcharge on all consumers.
- Even where the mini-grid is totally separate from the main grid, power injected to the mini-grid could be sold to a single buyer, with a state utility (for example) owning the interface with end-consumers, charging a universal tariff. In this case a mini-grid project starts to look a bit like an IPP.

Credit risk with counterparties

Shifting to a commercial model where a state utility becomes the main counterparty of the mini-grid project then increases the importance of the wider power sector being regulated in a commercial and financially sustainable manner. If the state utility is not able to charge cost-reflective tariffs, and is therefore financially unsustainable, it will be difficult to convince long-term money of their credit-worthiness.

Eventual grid extension and integration

A challenge that is constantly repeated in the literature, and by most mini-grid developers we speak to, is that of grid extension. A major risk for investors is that the main grid is extended and that the mini-grid essentially becomes a stranded asset. The challenge for regulators is tackling this uncertainty for investors, without disincentivising grid extension projects that might bring net welfare benefits.

An independent planning body could help to mitigate this risk, but even with such a body it is likely that investors would require additional clarity over what would happen in the event of grid extension. Utilities could guarantee that generators are integrated into the main grid, subject to meeting certain technical standards, and possibly even MV and LV network infrastructure for the mini-grid could be integrated. Assets would be sold to the utility at a price determined by some regulated formula.

How feasible this option is would of course depend on how sophisticated the mini-grid is – there is a wide spectrum here. If this were an option acceptable to both utilities and potential mini-grid investors, then it would be important to define a common set of technical standards to ensure that mini-grids are developed in a way that ensures they can be integrated in the event of grid extension.

It is also worth noting that this issue is seen as less important to some mini-grid developers we have spoken to, who are developing projects that essentially work in parallel with the main grid. These mini-grids aim to provide back-up to the main grid, essentially replacing the role of diesel-fired back up generators today.

Table 4 **Summary of survey responses on the regulatory risks faced by developers**

Risk	Average rating (1= highest risk; 5 = lowest risk)
Access to longer-term finance	2.3
Licencing requirements	3.0
Eventual grid extension and integration	3.0
Tariff regulation	3.3
Credit risk with counterparties	3.3
Mini-grid planning	3.7

Source: Kuungana Advisory survey of mini-grid developers

Views of mini-grid developers

In our survey of mini-grid developers we asked them to rate the risk that each of these reform requirements present an obstacle to scaling up their business. We asked them to rate this risk on a scale of 1 to 5 (1 representing the highest risk). The results are summarised in Table 4 and suggest that access to finance is the biggest concern, followed by licencing requirements, and regulation around grid extension. No individual risk was consistently rated very high or very low in the survey, perhaps reflecting the range of different strategies that developers are following.

Concluding remarks

The analysis presented in this Kuungana Insights report points towards a number of actions that need to be taken forward by stakeholders across the power sector to facilitate the scaling up of mini-grid activities in parts of Africa and developing Asia where there are still large populations with low access to electricity. Some of these actions are listed below:

- **Developers** need to continue innovating to overcome some of the regulatory barriers in place and to unlock the longer-term finance that scale will require. Overcoming many of the barriers discussed here will require developers to be pro-active in engaging with regulators, and with donors funding Technical Assistance work in the sector.
- **Governments and regulators** need to work with developers to address some of the barriers highlighted, especially around licencing regimes and regulations concerning integration with the main grid. Political barriers that discourage governments from making changes that might reduce the role of incumbent state-owned utilities need to be overcome.
- **Utilities and planning authorities** also need to adapt and take into account the potential role of mini-grid projects on wider system planning. Too often all stakeholders are guilty of treating on-grid and off-grid activities as totally separate, rather than as different means of achieving a single outcome (i.e. increasing energy access, albeit accepting that the quality of that access might vary, as discussed earlier).
- **Donors** also need to think more holistically. Without a common agenda and agreement on the role of mini-grids it is difficult to see how investors will have the confidence to make the significant investments required to scale up the sector.
- **Investors** should also be pro-active in engaging in the sector. The potential opportunity for investors is huge, as indicated by the IEA analysis cited earlier, but

investors will need to work closely with developers, regulators, and other stakeholders to unlock this opportunity.

A final thought – this Insights report has been focused on mini-grids and their role in increasing access to energy in the developing world. But there is increasing interest in mini-grids in developed countries too; most notably in some of the US markets and in Australia. In these markets the dynamics and the drivers are different: a very rapid decentralisation of energy resources, and the growth of electricity storage technologies, is increasing talk of defection from an existing grid infrastructure. The economics are different, but there will be many parallels and opportunities for two-way learning in the regulatory challenges that need to be addressed in these very different markets.

Kuungana Advisory

How can Kuungana Advisory help?

Kuungana works on advisory projects that facilitate the transformational change required to increase access to environmentally sustainable and affordable energy supply.

Our name, Kuungana, is the verb 'to connect' in Swahili. This encapsulates our involvement in projects increasing energy access in some of the most energy hungry parts of the world, and also on projects in both developing and developed economies that innovate with new business models and commercial arrangements in our rapidly changing sector.

Mini-grids are a great example of where Kuungana can help, whether it be helping donors and regulators on the design of policy, working with developers to influence policy and develop new business models, or working with investors to understand and model the financial performance of mini-grid projects.

Please do get in touch with us if you want to discuss anything in this report, or if you think we can help you as you consider the way forward for this sector.

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