LOW CARBON ENERGY FOR DEVELOPMENT NETWORK

BRIEFING PAPER 1

LESSONS FROM COLLECTIVE ACTION FOR THE LOCAL GOVERNANCE OF MINI-GRIDS FOR PRO-POOR ELECTRICITY ACCESS

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Executive Summary:

Access to modern energy can be a key enabler for human development through improvements in livelihoods, education and healthcare. Over the last two decades decentralized energy options using renewable energy sources have enabled faster access to reliable energy services for communities across developing Asia and Africa. These Decentralized Renewable Energy (DRE) solutions include both standalone systems such as Solar Home Systems (SHS) and solar lanterns, and interconnected systems such as micro and mini-grids.

In the current context, Development Finance Institutions (DFIs) such as the African Development Bank (AfDB) and national governments are actively developing policies around mini-grids and accelerating their deployment as part of rural electrification plans. There is, thus, an urgency to research and collate both practice and learning that ensures the long-term sustainability of these systems. While the technical and financial factors affecting the operational sustainability of rural mini-grids in developing countries are comparatively well-researched, the social and institutional aspects critical for longer-term sustainability are relatively under-researched and form the basis of this paper.

This briefing paper builds on studies of mini-grids in Kenya and in Bangladesh to illustrate the relevance of community governance in the deployment and management of DRE systems in underserved and off-grid regions of the Global South. Mini grids are highly dependent on community cooperation and good governance mechanisms to succeed. Understanding this role of local institutions is a pertinent challenge because, despite recent developments in the mini-grid sector, pro-poor, operationally sustainable and easily replicable approaches for mini-grid-based rural electrification remain difficult to find. This understanding holds considerable promise in connecting knowledge gained from both community-based and private-sector mini-grid operation.

1. Introduction

The challenge of achieving universal electrification as demanded by the Sustainable Development Goals (SDGs), still remains monumental. The overall electrification rate for developing countries reached 78% in 2013, which represented 1.2 billion people, and was considerably higher in urban areas (92%) than in rural areas (67%) [1]; plainly this overall figure varies considerably between countries and regions. While China has accomplished universal electrification and India has already electrified four-fifths of its population, the situation remains most dire in sub-Saharan Africa. More than half of the total global population currently lacking access to electricity lives in this region, and the overall electrification rate is only 32% (Ibid). Rural areas in particular are underserved in Africa, where an average of only 17% of the population have access to electricity (Ibid). Providing access to reliable and affordable electricity to rural populations in sub-Saharan Africa in particular therefore still poses a huge challenge.

2. Approaches to Rural Electrification

The extension and expansion of national grids, alongside the addition of centralised electricity generation capacity, is traditionally used as the default mechanism representing a solution to this problem. While this is often seen as the ideal way to electrify urban and peri-urban areas, it is far more difficult, costly and inefficient in rural areas with widely dispersed populations [2]. Using East Africa as an example, and assuming fixed costs of USD 22,000 per kilometre of transmission lines and USD 18,000 per kilometre of distribution line, Anderson et al. [3] estimate that grid extension is not economically feasible in areas that would average less than five connections per kilometre of grid extension. Given the fact that over 80%, 65% and 60% of the population live more than 20 kilometres from the nearest substation in Tanzania, Kenya and Uganda, respectively [4], it is unlikely that grid extension is a feasible solution in large parts of rural East Africa. Physical difficulties aside, the quality of grid electricity provision in most African countries is low, creating a dependency on back-up diesel and oil generators – transmission losses are high, load-shedding, black-outs and brown-outs frequent and tariffs are among the highest in the world. Other issues relating more specifically to poor countries also afflict maintaining and operating grid distribution systems, such as the destruction of pylons and the theft of cables for the metal they contain (see Figure 1).

Figure 1 - Pylons destroyed in Lenasia, South Africa, so that the power cables could be stolen for their copper (Source: Faizel Patel via Twitter in Eyewitness News)

One possible solution to this challenge has been sought in solar home systems (SHS), which have been successfully implemented across the developing world and sub-Saharan Africa, especially in Kenya [5,6]. There are measurable benefits from purchasing or hiring an SHS (reducing indoor air pollution caused by kerosene lamps, providing light for study, enhanced security, etc.), but how much the SHS addresses the poverty of the household and enhances the ability to generate income is less clear - evidence suggests that it does not and, in some cases, actually imposes additional financial burdens.

Alternatively, instead of electrifying individual households, it is possible to connect whole communities or villages by constructing mini-grids (see Figure 2). In the past, this approach has been realised very successfully, particularly in East Asia and Latin America, typically relying on small hydro plants or diesel generators as the source of electricity [7]. Compared to SHSs, mini-grids offer benefits in terms of generation capacity, proper load management and the ability to support economically productive uses. They generally involve generating capacities that can be high enough to support productive uses, such as pumping water for irrigation, agro-processing, refrigeration and powering small motor-based livelihood appliances thereby improving the ways in which electrification can catalyse economic development.

Figure 2 - The staff of the United International University Centre for Energy Research at the SEBL 249.6 kWp Solar Minigrid they built at Kachikata, Vedarganj, Shariatpur, Bangladesh (Source: CER Director Shahriar Ahmed Chowdhury)

As demand increases, their generation capacities can be up-graded and their reach expanded relatively easily compared to SHSs, which are typically fixed in size and less modular. Benefits can be distributed more easily to provide collective benefits to the whole community as well as to individual households and businesses - public facilities, such as energy for schools, health clinics and street lights (a frequently-voiced concern for women globally in terms of night-time security). [8]. However, despite these enhanced benefits of rural mini-grids over SHS, long-term operational sustainability continues to be an issue.

Sustainability largely depends on the ability to cover costs and maintenance as well as the approach taken – community-based or private sector (see Table 1 for key characteristics of these approaches). The evidence shows that community-based approaches have a clear focus on being pro-poor but often suffer due to the lack of strong monitoring and collection mechanisms at the local level.

On the other hand, the private sector ones may work well operationally, but are often driven by the need to earn larger returns on invested capital (albeit small compared to other investments bearing similar risk). This may result in unfair hikes in tariff rates and limited engagement of the community in decision making. The involvement of local institutions must transcend the specific approaches to ensure that independent of funding source, the community plays a role in decision making and planning around the energy system. The following pages discuss how this could happen.

Characteristics/ Facets	Community owned approach	Private sector approach
Tariff	Fixed monthly tariff	Metered tariff (based on consumption)
Capital expenditure	Donor funded/ Government funded	Investor/ financier funded (through energy enterprise)
Monitoring/Collections	Village committee or similar mechanism	Collections through local staff or paid commission agents
Operational Expenditure	Dependent on strong collections/ repeat donor support	Annual service contracts or Fee-for-service (with user contribution)

Table 1 - Typical characteristics of the main models for mini grids based on examples from Kenya and Bangladesh (see Boxes 1 and 2)

3. The Challenges of Operational Sustainability

Sustainability in this context is less a concern with ecological sustainability (although this is still a potent argument for the deployment of mini-grids using renewable sources for electricity generation); rather, ‘sustainability’ in this context is defined as the ability of the mini-grid to:

- Cover its operating costs through regular payments for electricity produced
- Enable maintenance, repair and upgradation of the system (using available resources)
- Ensure proper financial planning and management, including unforeseen expenses in the future
- Operate a system of governance, to understand the needs of the end users in order to avoid and resolve conflict and prevent a mismatch of supply and demand patterns.

The research summarized in this briefing paper concerns itself in particular with this challenge of creating institutions for sustainable governance and operation of mini-grids based on lessons learned from empirical research in Kenya. It should be noted that in this context institutions are understood to mean established norms, customs and practices, which are acted upon by local specialised organisational structures for the management of a resource system with clearly-defined boundaries.

Box 1 – Mini-Grids in Kenya

Throughout the early 2000s, approximately 10 small-hydro mini-grids were installed by intergovernmental and nongovernmental organisations, often using donor money from multilateral or bilateral organisations such as the UNDP or the European Commission. These mini-grids had generation capacities ranging from 1kW- 100kW covering 60-200 households each. As solar PV became more affordable, more mini-grids using solar PV panels as their main means of electricity generation were installed, yet they still followed the same approach of a community-based ownership model financed with donor money.

A few private sector companies began to install and operate (mainly solar PV) mini-grids in rural Kenya as for-profit businesses in recent years, i.e. since 2012, a development that was also facilitated by the reduction in solar PV prices. This development was led by three main companies: SteamaCo (www.steama.co), PowerGen (www.powergen-renewable-energy.com), and Powerhive (www.powerhive.com), which between them now operate 20–30 mini-grids in rural Kenya. Compared to the early community-based mini-grids, these follow a completely different approach, using prepaid electricity meters and remote monitoring and control technology to track consumption and payments.

Figure 3 - SteamaCo minigrid, Entasopia, Kenya

4. Electricity as a Common Pool Resource and the Potential for Collective Action

Since institutions for the governance of rural mini-grids play an important role in achieving operational sustainability new approaches towards thinking about these institutions and conceptualizing the form they might take, is needed – above all, these new approaches need to centre on ownership, participation and community control. Theories of collective action represent one potential area of study, which are commonly associated with the study of long-lasting institutions for the management of common-pool resources (CPRs). They are particularly suitable for the study of the local governance of a rural mini-grids, because such a mini-grid as a closed resource system shares many characteristics with a CPR.

A CPR is defined as being rivalrous (or exhibiting high subtractability), meaning that a resource unit consumed by one resource user can no longer be used by another and that exclusion from access to the resource is difficult [9]. It is important to note that a common-pool resource does not imply open access to all – exclusion is difficult but not impossible. In particular, water for irrigation has been studied extensively as a CPR and established as a case in which collective action can be a successful way of managing the resource [10–15]. The similarities between an irrigation system and a rural mini grid can broadly be outlined in terms of:

- Resource system characteristics: total amount of water is dependent on storage capacity of the reservoir and the recharge rate, just as the total amount of electric energy in a mini grid is dependent on storage capacity of batteries and power generation capacity (from PV panel/ other source)
- Operational challenges: In the case of mini grids, if one electricity user with an open-access electricity connection continues to add powerful loads and increases her demand, the consequent system overload will result in voltage drops and potentially causing a blackout. In such circumstances, action by one person leads to reduced performance and potential damage to the system (e.g. droughts and blackouts affecting all users)

Given these similarities, analysing the operational challenges and institutions involved in managing a mini-grid from a common-pool resource perspective can yield novel insights.

As has been mentioned above, theories of collective action have been applied very successfully to the study of long-lasting institutions for the managements of CPRs (see [13,16,17] for three seminal publications in this field) and can therefore potentially be used and adapted in order to analyse and design institutions for the sustainable governance of electricity provision in rural mini-grids. In particular, the study of long-lasting institutions for collective action in the presence of CPRs has resulted in the development of 33 so-called enabling conditions for sustainable management of CPR, which are collated and grouped under six categories (see [18] for a detailed treatment of this theoretical framework): group characteristics, resource system characteristics, institutional arrangements and external environment as well as two categories with overlapping characteristics.

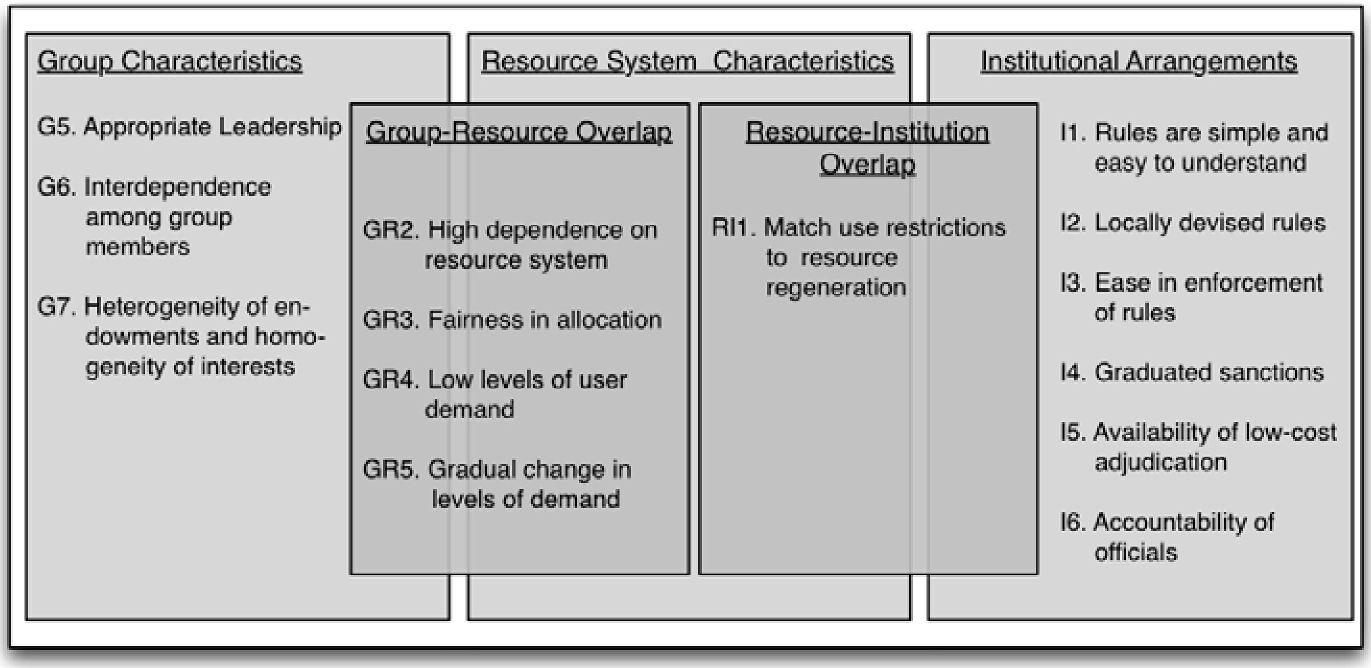

Figure 4 - Enabling Conditions for Sustainable Management of a CPR
Source: Authors, adapted from Gollwitzer et.al (2017)

In order to reduce the framework to a more manageable size, and make it relevant to the context of electricity in a mini-grid, these enabling conditions can be examined based on the extent to which, and the ways in which, they relate to the management of electricity as a CPR in the mini-grid context. While the detailed analysis of this theoretical framework is beyond the scope of this briefing paper, it suffices to say, that this refinement process results in the set of 14 enabling conditions presented in Figure 4, which are largely focused on the group characteristics, the overlap between group and resource characteristics, and the institutional arrangements governing the interactions between the group and the resource, as well as within the group itself.

Box 2 – Community Governance - Solar Nanogrids (SONGs) in Bangladesh

Two solar nanogrids (SONGs) were constructed in Bangladesh in 2016 in the communities of Baroihati and North Faitang. Both arrays were constructed to service small clusters of households in two very different villages, one long-established with an open plan, the second a new internally displaced persons community comprised of close accommodation in converted army barracks. Intensive community consultation in the two communities revealed fairly hierarchical communities, controlled in the one case by the Awami League political structures, the other by a small group of wealthy families.

Although Grameen Shakti (GS, acting as the in-country partner – ICP) had plenty of experience in managing the massive SHS programme being rolled out in Bangladesh, the SHS were being provided on a purely payment-for-services basis. GS and the controlling actors in each community were reluctant to implement the community energy committee and community fund elements of the project (corresponding to the G5 and G6 elements of the CPR diagram) as being outside their experience and requiring greater involvement than they were used to. As the project currently stands, GR3, fairness of allocation, is dictated by ability to pay and, at least in the wealthier community, by proximity to the elite families. Both communities exhibit relatively low levels of demand but this is likely to increase steadily once technical issues with the meters are resolved.

Despite these technical issues, small businesses have begun to develop productive uses of electricity such as payment for mobile phone charging and the making of clothes. Nonetheless, in Bangladesh the full potential of the concept cannot be realized without appropriate governance structures being in place with active participation of the community in tandem with the ICP so that the issues of appropriate leadership indicated in GR5 in the CPR framework can be addressed. Nonetheless, project collaborators at the United International University (UIU) in Dhaka are working on livelihood enhancing ideas. For instance, the initial consultation with the community in North Faitang suggested using the solar power to pump water for irrigation of rice and tobacco. The research showed however that the community were sharecroppers under an arrangement in which the landlord took 50% of the crop, and that furthermore the poorest 20% of the community had no access to rice or tobacco – solar irrigation would therefore have increased profit for the landlord and excluded that 20%. The project team came back with the suggestion that a solar-powered rice-husker to polish the rice for the community would increase the value of the rice produced substantially, allow that profit to be kept in the community and allow
enough energy for incubators for chicken and egg production for the 20% with no rice or tobacco.

Figure 5 - Solar nanogrid array on top of the children's school in North Faitang, Chakoria, Bangladesh

Figure 6- rice-husking machine developed by UIU to be powered by the solar nanogrids

5. Analytical Utility of Enabling Conditions for Collective Action

In order to demonstrate the analytical utility of the framework presented in Figure 4, flow charts can be constructed in order to systematically discuss and understand particular challenges that regularly occur in the operational management of rural mini-grids. One challenge in running a rural mini-grid with limited electrical generation capacity, as is the case with most of the private and community-based mini-grids that are currently in operation in Kenya and Bangladesh (see Boxes 1 and 2), is scarcity of electricity due to fast demand growth as end-users add more appliances and develop more productive uses of electricity. As a result, a major operational challenge can develop when different needs of multiple end-user groups need to be balanced in a manner that is objectively fair and, just as important, perceived as being fair by all end-user groups.

In order to understand these different end-users it is useful to categorize them based on the so-called 'A-B-C model' [19].

- Anchors (A) are large entities, often public or commercial, such as hospitals or cell-phone towers that require a reliable supply of electricity 24 hours per day, seven days per week.
- Businesses (B) form the second group, including small and micro enterprises in rural areas, which require electricity primarily during the day during normal business hours, such as small primary health clinics and local government offices, but also at night in the case of bars or video halls, for example.
- The community (C), i.e. households, require electricity largely at night for lighting and mobile charging, as well as potentially to power radios, fans or televisions.

Even if a mini-grid does not have a single anchor load, as is often the case, balancing the interests within and among these groups, and allocating limited amounts of electric power among them, can be very challenging. This challenge of balancing multiple interests and needs can be conceptualized and analysed using the framework presented in Figure 3, by constructing the analytical flow chart presented in Figure 7.

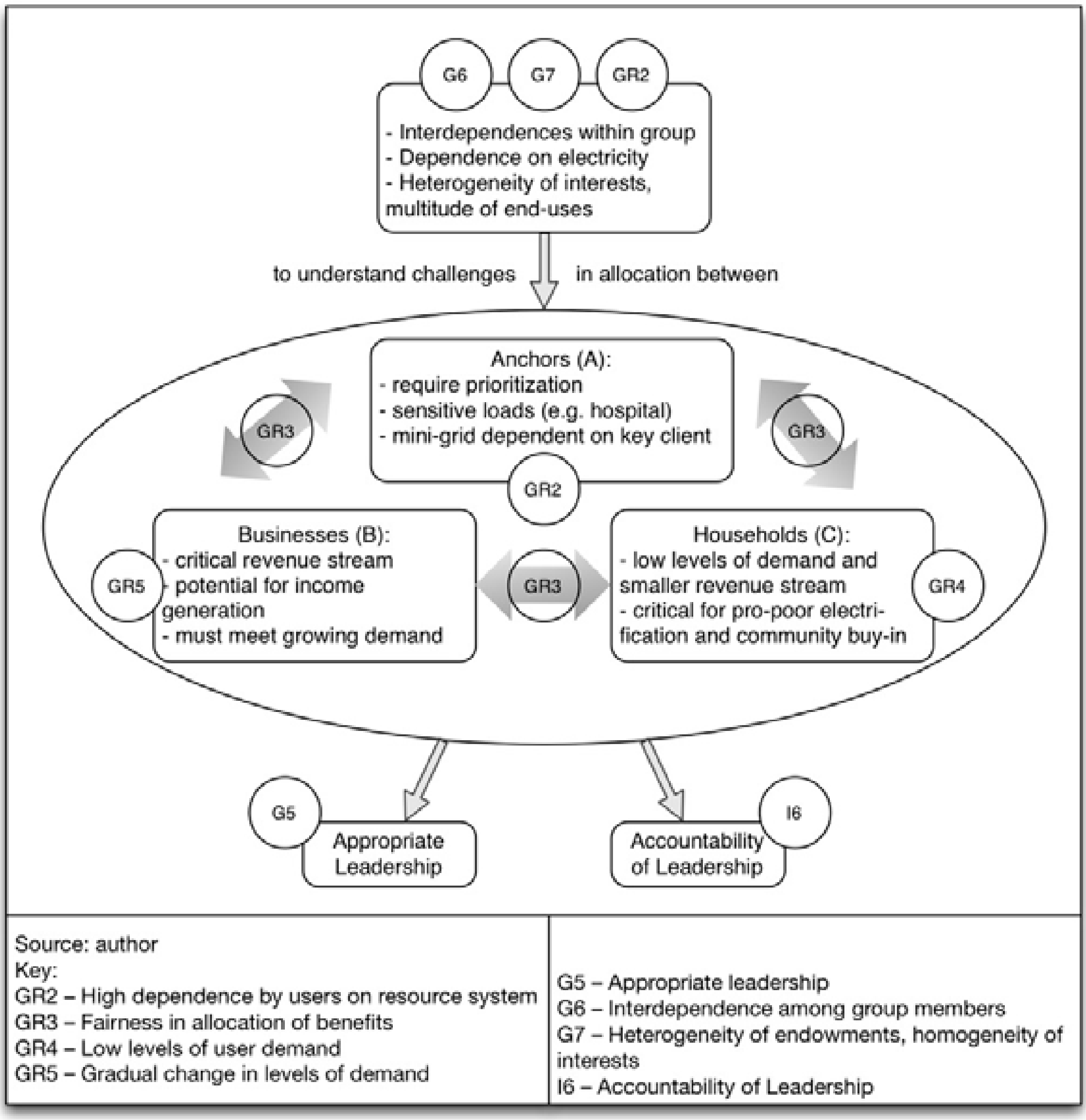

Figure 7 - Analytical Flow Chart for the Challenge of Serving Multiple End-user Groups

Anchor loads (A) require prioritisation during times of electricity shortages due to their high dependence on the resource system (condition GR2), i.e. the mini-grid. This may be due to (for example) being particularly sensitive to power outages, as is the case for hospitals or cell phone towers, where an interruption in the electricity supply can have considerable knock-on effects. However, they are not just dependent on the mini-grid; if an anchor load is present, the mini-grid is also dependent on the anchor load in return in terms of financial and electricity supply planning. This can have advantages as well, as the mini-grid operator may only need to find an arrangement with one customer in order to shift large amounts of demand to different times of day when necessary. However, this allocation schedule still must be perceived as fair by the anchor client itself, as well as the other customer groups.

Businesses (B), referring to micro and small businesses in this context, also exhibit a considerable dependence on electricity (condition GR2), but in addition have the potential to cause rapid and unpredictable changes in demand as they quickly develop more productive uses for electricity. This growing demand must be met in order to enable the small businesses to generate the additional income from the use of electricity that is required to pay for the electricity itself. Businesses in many ways are the backbone of the mini-grid, because they can earn additional income from the use of electricity. This income can be used in part to operate a financially sustainable mini-grid, by means of the business' payment for electricity. Thus there exists a reciprocal relationship between the mini-grid and the small businesses depending on it. Therefore, these small businesses must also perceive the allocation as being fair (GR3).

Finally, the community (C) also has its own demands. The households characteristically exhibit low levels of user demand (GR4) and thus represent a smaller revenue stream for the mini-grid. Their potential for demand growth is also much smaller than for A and B, because unlike the productive uses of those two user groups, household use of electricity is rarely productive and thus does not generate additional income to pay for itself. Instead, electricity supplements and partially replaces other energy sources, such as kerosene for lighting. Demand growth can only be easily afforded through efficiency improvements, so that a larger energy equivalent can be purchased for the same amount of money. Nevertheless, meeting the demands of the households is paramount to a long-term sustainable mini-grid not least because household electrification is critical for the goal of pro-poor, universal rural electrification. Therefore, naturally, the households in the community also must perceive the allocation of electricity as being fair.

The analysis of this challenge through the lens of enabling conditions for collective action and using a flow chart as an analytical tool leads to the conclusions that perceived fairness in allocation among these user groups thus requires the presence of conditions G5 (appropriate leadership) and G9 (dedicated operational management with technological capabilities and local presence), as well as mechanisms through which leadership and management can be held accountable for their actions (I6). This could take the form of a local management platform for mini-grid governance, where the needs of the different user groups are understood. That is, a platform that is rooted within the community, but that is also aware of the technical and financial limitations of the system. This platform would then be capable of developing electricity allocation schedules, when necessary, that take into account those limitations as well as the requirements of the different user groups. This is done in order to arrive at a system of simple and locally designed use rules (I1 and I2), which are perceived as fair by the majority, if not all, of the end users (GR3). The need for such a local management and governance platform forms the key lesson of this analysis and provides important guidance for practitioners.

6. Lessons for the Local Governance of Rural Mini-Grids

While 'sustainability' in the context of mini grids (as defined in Section 3) speaks independently about technical, financial, and governance systems, it is important to recognize that without functional local governance institutions, financial sustainability is almost certain to be jeopardized (unwillingness of individual end users to pay, inability to collect, etc.). This in turn affects technological sustainability (lack of resources to ensure regular maintenance and system upgradation) and as discussed earlier, this can cause a domino-effect leading rapidly to an unsustainable operational model. Based on experiences in the past (in particular the work of the Heinrich Böll Foundation and Development Alternatives on participatory village energy planning) and the analysis summarized in previous sections, certain lessons can be drawn.

Composition of management platforms

There is a need for a locally present, dedicated, specialised operator with appropriate social and technological capabilities, or a direct link to a technology partner for the community representatives. This entails the ability to operate, maintain, repair and upgrade the mini-grid system and source necessary spare parts and supplies. This operator forms one part of the management platform. The second part of the management platform is formed of representatives of the community, i.e. the end-users of the electricity. Involving the community in management can be extremely advantageous, particularly in finding solutions to the challenges around electricity allocation and the perception of that allocation. In such a community-based organization, it is also critical to ensure representation from other under-represented segments, especially women, the poorest and minority sectors. Finally, the management platform must have fiscal responsibilities or dedicated resources to manage collections and payments for electricity and the use of those repayments (for maintenance, repair and future upgradation). The creation of such a platform needs to be a vital part of future mini-grid policies and guidelines being formulated by governments and multilateral organizations.

Collaborations to gather experiences from operationalisation

Different scales of community energy intervention have been enabled by advances in technology and financial/economic models. Although there also is a developing research and practitioner literature on sociocultural and institutional factors (the 'human glue' binding energy project components into longer-term sustainability) how to operationalize that research effectively remains elusive. There is an urgent need to collate methodological and practical learning from a diverse range of energy stakeholders in the Global South and disseminate this learning widely and effectively as the decentralized energy imperative becomes more urgent daily, driven by access needs and climate change. Amalgamating the ongoing lessons from the solar nanogrid projects of the LCEDN with work of the Heinrich Böll Foundation and Development Alternatives can produce useful learning tools informed by direct experience, such as Table 2 below.

Increasing and Decreasing Risk

INCREASE	DECREASE
▪ Inappropriate cost recovery tariffs ▪ Technical services determined by scale-up/roll-out ▪ Provider acting as a financial services business ▪ Willingness to pay does not equal ability to pay ▪ Lack of ownership ⇒ theft, vandalism, refusal to pay ▪ Ignoring existing social structures/hierarchies ▪ Failure to understand gendering of social energy systems	▪ Reasonable tariffs ▪ Services tailored to community energy practices and needs ▪ User involvement and choice ▪ Close involvement of women (enablers of prior energy services) ▪ Ownership ▪ Making use of existing formal and informal relationship networks ▪ Transparent accounting ▪ Dispute resolution mechanism ▪ Remote pre-payment mechanism ▪ Community savings fund

Table 2 - Factors affecting sustainability of rural mini-grids

Because of technological advances, the substantial drop in costs of solar equipment and a prevailing ethos of dependency on novel financial and business models and practices, understanding and operationalizing the social aspects of community energy initiatives has not kept pace, and yet the need for hybridizing the three legs of a successful energy intervention - the technological; the financial/economic and the social – is greater than ever. Although there is an increasing quantity of general knowledge about each component in Table 2 above available, how each component works in a specific location and what to do about it need to be built into all aspects of decentralized energy planning.

In order to be truly pro-poor, energy intervention models also need to be adapted to support the infusion of patient capital or soft funds from social impact investors, donors and governments, taking cognisance of subsidies available to traditional electrification methods. To achieve this, these sources of funding have to be convinced by a clearly defined project methodology incorporating the elements above, explained and detailed in a way that is clearly understandable. Developing hybrid models, which combine operations managed by a private enterprise and a strong management platform with community involvement in decision making, demand estimation, tariff-setting and service quality standards, which would ensure that the benefits of both community-based and private sector approaches can accrue, requires building local community capacity to engage effectively and ensure democratic processes within the community.

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[i] Typically consisting of small PV panels charging a battery (or batteries) that powers light bulbs (CFL or LED), mobile chargers and other low power consumption appliances, such as a radio, television or fan , depending on the system's size and capacity.

[ii] Typically independent of the national grid, these systems draw power from one (or in a hybrid system two or more) small electric power generation source(s). Increasingly, solar PV, sometimes in combination with diesel generators are becoming common sources.

The Low Carbon Energy for Development Network (LCEDN) brings together researchers, policy-makers, practitioners and the private sector from across the United Kingdom (and indeed the rest of the world) to expand research capacity around low-carbon energy development in the Global South. The LCEDN was launched in January 2012 centred around hubs at the Durham Energy Institute and Loughborough University.

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