Creating enabling environment for affordable delivery of sustainable electricity services

Case studies of innovative techno-institutional models

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Abstract

Achieving universal electricity access has become a key policy objective for India as well for all other developing countries, especially after the launch of Sustainable Energy for All initiative of the United Nations. While governments have designed macro-scale policies and schemes for energy access; in recent year's entrepreneurs, NGOs, and user-groups have been introducing innovations in designing energy access projects at more localized levels with varying degrees of success. The key to achieve sustainability in such projects lies within the "one size does not fit all" framework, which essentially means that for different levels of access and for different socio-economic geographies, the design must be adapted to their socio-technical, institutional, and business perspectives. This article aims at highlighting some methods by which an enabling environment can be created for different stakeholders in the energy access space through case examples of three projects.

Introduction

The relationship between energy access and development is well established today and has led to a long-term interest in the development of energy access initiatives such as the declaration of 2014–2024 by United Nations (UN) as the Decade of Sustainable Energy for All (UN, 2012). Globally, 1.3 billion people lack access to electricity, 2.6 billion rely on traditional biomass fuels for cooking, and the epicenter of energy demand is shifting rapidly to emerging economies such as China, India, and the South-east Asian countries (IEA World Energy Outlook, 2013). The World Energy Outlook 2013 also estimates that by 2035, half the increase in the world's electricity access would be sourced from renewable energy, showcasing the need to focus on the business, institutional, and technical models for sustainable deployment of such technologies, especially in rural and remote locations.

The key question the authors want to introduce at this stage is with respect to: *how we understand an "enabling environment."* Significant information and literature is available today on the various factors that can contribute to the sustainable implementation and operation of programs dealing with energy access such as the need to integrate energy and productive activities (Chaurey et al., 2012), a focus on building institutional capacities (Balachandra, 2011), linkages with other developmental initiatives, restructuring of subsidies to smart subsidies and multi-stakeholder capacity building.

While many of these factors and solutions are well known today and debates are ongoing on the methods by which they should be implemented, it is important to note here that there is a great diversity within energy access programs and these solutions cannot be applied broadly to all of them. So how does one speak of an enabling environment for such a diverse and complex sector? One possible way to do this is from the point of view of the sustainability of all stakeholders involved — that the sustainability of no stakeholder in the process should be compromised as a result of the rigid nature of policies, which generally end up proposing blanket technological solutions which may not be applicable to the diverse range of stakeholders and situations in the energy access sector.

For example, while today there is an increased focus on private sector participation in the sector, the lack of data on when and whether the main grid will be extended to a village, hampers their participation even if strong business models are developed and incentivized by policies. Similarly, it is also observed that in many cases, subsidies tend to be linked to infrastructure development or capital cost of the power plants only, and they do not support the investor at the more critical junctures (e.g., for battery replacement in the case of off-grid solar photovoltaic (PV) power plants). As a third example, it is often observed that end-users in the case of renewable energy-based systems compare the cost of electricity from a mini-grid to that of the main grid and are therefore prone to believe that expensive power is being sold to them. Such examples demonstrate that how there are gaps still in the policy formulation for energy access, which create situations where the different stakeholders in the entire value chain are not adequately benefitted.

In other words, while evaluating these factors, it is crucial to note that the various stakeholders involved have very different expectations from a program and these expectations must be the guiding principle for deciding how an enabling environment is to be created. For three key stakeholders, the following may be classified as the expectations from an energy access program:

- End-users — Adequate and reliable electricity supply suited to their needs and paying capacities with standardized products and easy servicing.
- Project developers and implementers — Mostly would be concerned with evaluating the techno-economic viability of their projects and for adequate policy and financial support, provided at the right time to ensure external factors and ambiguity in laws do not hamper project sustainability.
- Government — Clear metrics for monitoring increase in access and efficient use of resources and methods by which the subsidy burden may be reduced.

Further, sustainability itself may be classified into financial sustainability, socio-economic sustainability, and environmental sustainability, all of which will be at different levels of priority for different stakeholders. The key message here is that while designing programs and enabling policies, it is important to consider that the success and sustainability of the program is defined differently for different actors and socio-economic geographies, and a "one size fits all" approach is not followed.

In the following sections, we showcase through case studies, examples of innovation in technical and business models that have taken place in recent years in the electricity access field, which aim to address some of these gaps in sustainability for different stakeholders, which can contribute to creation of enabling policies. The case studies being presented are from different projects executed and supported under an ongoing interdisciplinary research project, on off-grid delivery options titled "Decentralized off-grid electricity generation in developing countries: Business models for off-grid electricity supply," (in short Off-grid Access System in South Asia or OASYS), lasting from October 2009 to April 2015. The project aims to find appropriate local solutions, which are techno-economically viable, institutionally feasible, socio-politically acceptable, and environmentally sound, for sustainable electricity supply to off-grid areas.[1]

Electricity access for remote locations: a mini-grid project in Odisha, India

This project is located in the state of Odisha, India, where a community-managed and NGO-supported business model has been developed to set up five solar mini and pico-grids.[2] The village cluster, namely Rajanga village (and its Hamlet), Kanaka village, Chadoi village, and Baguli village, with a total population of 555 inhabitants, is in the Dhenkanal district. The district is identified as one of the backward districts in India by the Ministry of Panchayati Raj, Government of India (Ministry of Panchayati Raj, 2007). These villages are not electrified by any government program and are located within the Kandhara Reserve Forest, and as per forest regulations in India, taking electricity lines through the reserve forest is not permitted in India (MoEF, 2011). However, electricity grid may be drawn in the inhabited areas within the designated village.

In the case of this community, it was observed that being a tribal community living inside the forest, the village community was under considerable isolation from the local village-level governing body (called the Panchayat) with its headquarter in the nearest large village, about 5 km away from the tribal village cluster. However, a few NGOs (such as Wildlife Society of Odisha) had some presence at these sites owing to their development-related initiatives. This isolation over many years has led to a reduced focus on development initiatives targeted at that cluster of villages and therefore the lack of opportunities that can aid the locals break out of poverty traps or in finding new occupations and sources of income. Hence, the paying capacities and potential electrical loads in the households are low and expected to be low for a few years to come.

As per the design, each of the five sites has its own power plant, owing to the distance between sites. While the larger villages have received AC power plants which also support livelihood generation activities, the hamlets (with 12–15 households) have been provided with DC micro-grids to ensure cost optimization. However, considering that this is a community-based project and it is therefore important to maintain homogeneity, regardless of whether the village has an AC or DC system, the quality and quantity of services provided to each household has been kept exactly the same (Sharma et al., 2014). An analysis was also carried out to gauge the comparative costs and benefits of having five distributed power plants versus have a single large power plant with distribution lines running to all 5 villages (Sharma et al., 2014). While there are operational benefits from having a single power plant, for such small systems (total cumulative capacity of 15 kWp), the cost of distribution lines become prohibitively high. But with a good system design that ensures infrequent maintenance, even managing multiple power plants may not be difficult. Therefore, a strong case can be made in favor of distributed technical design of distributed systems. However, for ease of management of the system, a single institutional entity can be formed covering the group of villages.

While TERI approached a number of project developers with proposals for establishing a private investment led mini-grid model (with OASYS project contributing majorly for the capital cost), no developers were willing to work in this area owing to the high risk involved in operation and recovering revenue

[1] http://www.oasyssouthasia.dmu.ac.uk/ (Accessed on August 26, 2014).

[2] Solar Mini-grids are designed to generate electricity (AC or DC) centrally and distribute the same for various applications to households and small businesses spread within a particular area. They consists of (i) Solar PV array for generating electricity, (ii) a battery bank for storage of electricity, (iii) power conditioning unit consisting of charge controllers, inverters (for AC electricity), AC/DC distribution boards and necessary cabling, etc., and (iv) local power distribution network (AC or DC). They can also be referred to as micro-grid or pico-grid depending on capacity of the electricity generation system and number of households connected through the distribution network. While the AC mini, micro, or pico-grids supply 220 Volt 50 Hertz AC electricity the DC micro or pico-grids usually supply at 24 or 48 Volt through DC distribution network.

owing to the low-paying capacity of the community, a scattered population, and unpredictable load growth. With this in mind, it was decided that when working in such remote and isolated locations, a subsidy-driven model (the entire project cost was borne under the OASYS project with contribution in the way of land, some labor, and token connection cost from the community) might be more appropriate. What this is expected to do over a period of 2–3 years is aid the enhancement of income through the productive uses of electricity and enable users to purchase appliances therefore adding to the total demand. This then prepares the site for probable future private sector investment. The key lesson to be highlighted here is that while a privately owned and operated model certainly has some benefits, it might not be always applicable, as in the case of such remote locations. And hence, while there is a focus on moving away from subsidy-driven models, direct subsidies may still be applicable to a few locations which have specific characteristics that make them unviable business propositions for private investment.

A second crucial point that emerges from this is the need to develop more integrated projects in such areas, initiatives that integrate energy and livelihoods. If new business opportunities are created, it is likely that the incomes of electricity users will increase and therefore their paying capacities for electricity would increase as well. Through this project, numerous livelihood opportunities can now be enabled, which include activities that use applications such as grinders for spices, packaging, *Saal* leaf plate making, better irrigation facilities, functioning water purifiers, and installation of fans and street lamps in community areas/ institutions such as clinics and schools. From the policy perspective therefore, it is recommended that in such cases, the electrification schemes should be designed to focus not just on the delivery of electricity infrastructure, but other crucial development infrastructure and training as well and adequate funds must be allocated toward linking different activities, such as education (computers), health (vaccine refrigerators, potable water), and

Figure 1: A view of the solar mini grid in Rajanga village, Odisha, India

agriculture (water pumping), through appropriate institutional mechanism. While electricity and other developmental interventions are included in the domain of Panchayati Raj institutions in India to create the necessary convergence in rural areas, the required awareness and capacity building have never been provided to these local institutions to implement and operate projects at the local level through a more decentralized planning process.

The third critical point with respect to creating sustainable operational environment is to do with the institutional setup for system operation and management. Being remote, the costs of engaging regular service and maintenance from nearby towns is high and therefore local capacities are required to be created. The capacities of the local community must be built to a level where they are able to resolve minor technical issues by themselves and have the necessary information to reach out to experts for more critical technical problems. The local institution may or may not include the main project implementing agency, but it should include the local actors. Some of these actors include members from the local community, energy entrepreneurs selected from within or outside the village, local government representatives, utility company representatives, NGO and civil society organization representatives, and independent private operators of distributed generation power plant (Bhattacharyya, 2013).

A village-level group comprising of representatives from the village was constituted to hasten decision-making and better coordination of project implementation. And, since the community itself has no experience in managing electricity projects, representation from external agencies such as the local NGOs were included in the group. The committee is called a Village Energy Committee (VEC) and a constitution defining its regulatory role over the operations has been formulated. Further, while the power plants themselves are separate, a single VEC has been formed with representation from all villages in order to encourage collective management and decision-making which benefits all the villages equally, rather than just the larger villages which have received larger power plants. Members from any village have also access to the productive activities and self-help groups from all villages come to the main center (Rajanga) to engage in them. Often while working with VECs, comprehensive capacity building is missing in the case of many government-driven projects leading to mismanagement of projects by the VEC, upon exit of the implementing agency (Palit et al., 2013). Hence, training included the basics of record-keeping and banking, required for the long-term sustainability of the project.

While we have created the institution of VEC for this project, the suitability of the institutional setup must be gauged based on the specific features of the sites under consideration. Each institutional arrangement comes with its own pros and cons and associated costs. Literature indicates that such VECs have seen limited success in past projects (Chaurey et al., 2012). However, taking into consideration site-specific conditions in the Dhenkanal case, the VEC model emerged as the most feasible option. Therefore, an important focus of the project has been on the development of a clear exit strategy, with the potential for linkages with the local DISCOM, i.e., Central Electricity Supply Undertaking of Odisha, to facilitate transfer of the power plants to a technically competent authority in the future.

Finally, the nature of subsidies for such projects also needs to be reconsidered. Most subsidies available today support the capital cost or infrastructure development cost of mini-grids only. While this definitely aids in reducing the burden on the investor and the power cost for the consumer, such subsidies are unable to support the project during its period of operation (which for renewable energy power plants can be up to 15–20 years). For example, a solar PV mini-grid in an off-grid site would most likely include a large battery bank to cater to night time loads and traditional lead acid batteries require replacement every 5 years approximately and this amounts to a large cost for the project developer, the funds for which may or may not be available through the receipts of payments (tariff) owing to uncertain demands and low paying capacities.

An enabling policy would therefore attempt to provide some capital subsidy but also spread the remainder of the subsidy over the project lifetime, based on functioning of the plants, to assist in meeting such costs. Second, there are several instances where project developers have not shown an interest in operating plants in difficult locations and have closed operations after receiving the initial capital subsidy. In order to sustain their interests as well as lower the cost of power for the end-user, it is important to device subsidies linked to generation. An ideal model for such locations would include some capital subsidy, a generation linked incentive for the lifetime of the power plant and intermediate incentives in years where high costs such as battery replacement occurs to ensure that the cash flow of the developer are not negative. Further, mechanisms such as low-cost loans and an extended moratorium period (until the time all households take up connections and productive activities mature and start generating revenue) need to be included.

While the cost of such a scheme may be higher (TERI's preliminary calculations show that such a subsidy would amount to 1.3–1.5 times the capital cost of the power plant, over its lifetime), the benefits of long-term sustainable operation need to be factored in while taking a decision on whether the subsidy is feasible or not. Second, the feasibility of the subsidy must also be assessed from the point of view of the economic benefits that will accrue from the provision of energy beyond basic lighting, i.e., with respect to health, education, connectivity, and income-generating activities. Improvements in such indicators also help the government reduce its expenditure on these developmental activities in the long run and therefore if planned properly, the provision of subsidies in such regions could lead to an improved human developmental benefits. An ideal enabling environment in such cases would aid in enhancing the financial sustainability of the project implementer and at the same time, the socio-economic position of the end-users.

Community-owned model with support from financial institutions: solar pico-grids in West Bengal, India

The Solar Pico-grids have been implemented as a part of the OASYS project by Mlinda Foundation, which is a Paris based organization working on initiatives toward reversing environmental degradation. In India, they are working to promote cleaner means of transport and electrification projects to reduce GHG emissions in the state of West Bengal. Toward this overall objective of reversing environmental degradation, Mlinda launched a renewable energy-based solar electrification project in the rural region of West Bengal, especially in the Sunderbans region and Purulia district, where the central grid supply is not feasible.

The Solar Pico-grids program of Mlinda covers the households, schools, markets, and productive power segments. As compared to the sites in Odisha mentioned in the previous section, the paying capacities and future income-generating opportunities of the residents of these villages are relatively better, enabling the project implementer to create new types of business models which are less dependent on subsidies.

The project centers on a community-based model of solar pico-grid wherein Mlinda has partnered with the National Bank for Agriculture and Rural Development (NABARD) to provide people access to low-interest loans in order to avail the benefits of a shared solar pico-grid. In partnership with NABARD, Mlinda has made possible for people to avail loans to buy the solar installations instead of relying on pay-as-you-go schemes or subsidy schemes. Loans are available to a group of households known as Joint Liability Groups (JLGs). The end-user repays through easy and affordable installments over a period of 5 years from the direct savings accrued from non-usage of kerosene for lighting. The grids are owned by the JLG after repaying the banks.

These JLGs are linked to NABARD and the repayment is done by the group through monthly installments. The entire group is accountable for repayment of the loans, which reduces the chances of delayed payments and bad debts (TERI, 2014). Following are the two major models of Mlinda providing access to electricity through solar PV-based pico-grids in the state of West Bengal:

- Household segment model is a solar AC pico-grid system of 225 W/150 W consists of solar modules that are mounted on one of the houses in which the inverter and battery bank is also installed. This pico-grid is shared by 6–10 households and each system provides a household with three light points of 2 W LED bulbs and a point for mobile charging. On an average, the number of hours of lighting provided by this system is 5 hours.

- Market segment model is a solar AC pico-grid system which ranges between 500 Wp–3 kWp. The system consists of a solar module mounted on one of the shops or the diesel generator room with housing for the inverter and battery bank. Service cables are used to connect the rest of the shops. Each shop on an average receives 5 hours of lighting per day and is provided with one/two light points of 5 W or 10 W LED bulbs with a point for mobile charging along with internal wiring and switches. The market system is debt financed by the bank and is operated and maintained by a local market entrepreneur (who generally was the erstwhile diesel generator set operator) who repays off the loan in affordable installments within a period of 5 years.

The OASYS project has supported Mlinda Foundation for about 30% of the total project cost, which in this case includes infrastructure, training and capacity building, and other program costs. A formal bidding process was invited from over 20 private players in the off-grid electrification space who were asked to submit a proposal requesting for Viability Gap Funding (VGF) from the OASYS project. After an intensive process of evaluation, Mlinda Foundation and Mera Gaon Power (described in the next section) were selected and were recipients of the VGF. The remaining funds for the projects were raised through debt and equity. The key message here centers on the methods by which end-users also have the opportunity to own their power-generating system — through a combination of micro loans and subsidy. This is critical because individuals in rural areas who are engaged in farming or other activities in the informal sector often do not have the necessary credit history to avail loans from banks. The JLG model is an attempt to enhance the bankability of these individuals through collective applications for loans and repayment. From the point of view of the financing institution, such an arrangement reduces the risk for the bank by ensuring collective guarantees for repayments as well as scale.

Thus in such cases, the households provided electricity access through solar pico-grids in Sunderbans region, where the end-users do have some capacity to pay and financial institutions are willing to sanction loans, we see that a different set of enablers are required. From the point of view of the end-user, it is now possible to create a model where the end-user may own the system, rather than a community-based model in the case of community-owned project in Odisha. Second, from the government's point of view, the extent of subsidy can be reduced to only support administrative costs or some part of the capital investment required in this scheme. The OASYS project grant of around 30% for example, has been used for a variety of purposes, including for the placement of orders for power plants for which mobilization payments are required and the implementer may not be able to wait until the bank processes the loan. This is an example of how subsidies may be used innovatively to support the project-implementing agency at critical junctures of the project. To illustrate, the current subsidy scheme for solar PV systems in India is linked to output, that is, the subsidy is received upon completion of installation. Adequate cash flow however is required when orders for equipment are placed and payments to suppliers are to be made and hence the current schemes hamper the uptake of energy access by not supporting the end-user exactly at those junctures where cash-flow limitations exist for the end-user or implementing agency.

Hence in such cases, it is important to envision a more flexible subsidy scheme that is delinked from support for the capital cost only. Third, from the financer's point of view, it is important to work toward creating institutional arrangements and guarantees, which convince the bank of the viability of their investment, even if it is for the low-income group customers.

Privately owned and operated utility-style model: solar micro-grids in Uttar Pradesh, India

The third model is a privately operated model in which a cluster approach for implementing solar DC micro-grids is used by Mera Gao Micro Grid Power (MGP). MGP has been provided VGF of close to 50% of the project cost from OASYS project with the objective to enhance private sector participation in operating rural micro-grids and ensuring sustainable supply of electricity for basic lighting needs.

MGP has been working in Sitapur district of Uttar Pradesh for the last 3 years and has over time, developed their DC micro-grid model to provide basic electricity access to rural people for lighting and mobile phone charging. The model is low-cost (around INR 55,000 for 25–30 connections) and takes a day to install the system. Each connection entails two 1 W LED lights and one mobile charging point (total 4 W of load). Users may choose to pay extra for additional lights, however, a maximum of eight 1 W LED is provided per household. One house per grid is chosen as the system house where the panels are installed and batteries and charge controllers are kept in a secure wooden box with a lock arrangement.

MGP is responsible for all operations, maintenance, and management on its own using its human resource (HR). MGP's key focus is on strengthening operations and ensuring timely collection. They reportedly have collection efficiencies of over 90%. A JLG model, often used by MFIs has been developed, with all the users of a single micro-grid acting as one JLG.

A collection agent visits 7–8 sites per day, accompanied by a technician (one technician for 50 villages). Each user pays MGP the user fee and if any user is absent or unable to pay, the JLG has to pay on that user's behalf. Non-payment leads to immediate disconnection. As a technician accompanies the collection agent, fault rectification takes place immediately and the system is also inspected for performance. Any fault with the system is reportedly fixed within a 12 hours from the time a fault is reported via the helpline established by MGP. The connection charge is INR 50 and collections of INR 25 per week are made on a prepaid basis. Users may also choose to pay in advance for more than one week as well. In case of disconnected systems (due to non-payment), a reconnection charge of INR 40 is levied.

To strengthen staff operations, training, and reduce operations expenditure, MGP is adopting a cluster approach. For this, MGP establishes a cluster of offices catering to a block or a few blocks with all the staff and facilities for ensuring smooth operations. Each cluster then operates independently with monitoring at a central level. MGP now has a staff of over 75 field personnel and has a strong HR policy with promotions, incentives, and savings for employees.

In addition to the JLG approach already explained in the previous examples, the work being done by MGP showcases how innovations in service delivery can benefit different stakeholders. The first important enabler is with respect to the tariffs. While the per-unit (kWh) cost of generation from solar mini-grids is high, it needs to be packaged in an appropriate manner for the end-user so that payment becomes feasible while not impacting the revenues of the investor. In this case for example, a flat fee of INR 25 per week is charged per household. When converted to kWh for a load of 4 W, the tariff would appear to be prohibitively high compared to lifeline tariff of INR 2–3/kWh for grid-based electricity. However, what needs to be considered while designing tariffs for small-scale applications is not the comparative cost of grid electricity (which is cross-subsidized and does not factor in environmental costs) but rather the coping cost of the end-user. In other words, one must evaluate what the end-user is spending on similar levels (say, in lux output for lighting services) of service through existing options such as kerosene lamps. In this scenario, the cost of INR 25 per week is actually lower than the money being spent on kerosene lamps on a weekly basis or the minimum tariff (fixed and variable) that would have been charged by the distribution company, and hence from the end-users points of view, this is not an expensive alternative. Additionally, from the investor's point of view, it leads to an adequate return on investment in renewable energy technologies. Second, a small weekly payment is also more suited to the income profiles of rural consumers who do not often have the ability to save large sums of money to pay bills on a monthly or bi-monthly basis. This is however the case with billing for grid electricity and has been one cause of a large number of defaults on payment in rural areas and eventual loss to utility companies. A lesson from this model could be utilized even in the grid-connected areas.

The second point of interest is with respect to the use of subsidies. In the case of mini-grids in Odisha and the pico-grids set up by Mlinda Foundation, the models have not yet achieved a position of financial viability. MGP, on the other hand, is able to recover its investment in one micro-grid in a period of around 3 years. While MGP may not need subsidy support for the micro-grid installation itself, support can be extended in more innovative ways, with the objective of achieving scale. In the case of Mera Gaon Power, the OASYS project VGF supported the installation of micro-grids for 2,900 household initially, with the condition that an additional 1,500 households are to be given service connections over the next 2 years, by re-investing part of the revenue generated from the first 2,900 connections, thus reducing the overall subsidy from OASYS project to around 30%. If the objective of the governments is to reduce their subsidy burden while increasing the numbers of electrified households, this could also be a possible way to move forward.

Conclusion

The three examples showcased in this article demonstrate innovative ideas that can create enabling environments for different stakeholders working within the rural energy access space. Based on the specific characteristics of the socio-economic development of the user community, maturity of the business model, and the strengths and weaknesses of local institutions, the article aims to substantiate the point that a "one size fits all" approach is either not applicable or not required in every situation. Government subsidies should be continued in scenarios where the viability of business models is low, and restructured to enable scaling up of interventions in other scenarios. Tariff structures need to be assessed from the point of view of the end-user such that the high costs of electricity access are dissipated. And finally, the roles of different actors will vary, depending on the socio-economic characteristics and geographies. Where in some cases local governance is important, in others it may be more suitable to promote a micro utility-like model. To sum up, an enabling environment can be created if attempts are made to modify the rigid structure of existing policies, and allow for greater flexibility in pricing, tariff setting, subsidies, institutional linkages, and governance of energy access programs.

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