



OASYS South Asia Research Project



Towards Scaling Up of Electricity Access

Summary and Policy Recommendations from
OASYS South Asia Project

Subhes Bhattacharyya, Debajit Palit, and Gopal K Sarangi



OASYS SOUTH ASIA Research Project

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For more information:

For more information on this document and OASYS South Asia Project, please contact:

Prof. Subhes Bhattacharyya, De Montfort University (email: subhesb@dmu.ac.uk)

Debajit Palit, TERI (email: debajitp@teri.res.in)

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Abstract

This paper provides a summary of outputs from the research carried out under EPSRC/DFID funded research project on off-grid electrification in South Asia. The lessons from the studies are first presented, followed by a set of policy recommendations. Overall, the project finds and demonstrates that off-grid electrification can be an appropriate option for remote areas. However, no single solution fits all situations and a phased development process is more appropriate to take care of different levels of needs, local contexts, and resource availability. Given that mini-grid based local delivery systems can cater to household needs and productive loads, such an option can constitute an effective service delivery option for reliable and good quality electricity in rural areas. While lessons can be learnt from pilot projects, mass electrification requires scaling up of successful initiatives by providing a supportive environment. Ten policy recommendations distilled from various studies undertaken through OASYS South Asia project can guide us in the right direction.

Key words: Off-grid electrification, mini-grids, solar PV systems, business models, financing, regulatory issues, demonstration projects, and innovative policies.



Introduction



The Sustainable Energy for All initiative of the Secretary-General of the United Nations (UN) in 2012 has crystallized the global attention on the energy access challenge. It is estimated that about 1.3 billion people in the world in 2012 did not have access to electricity and 2.6 billion did not have access to clean cooking energies (WEO 2014). It was further suggested (IEA 2011) that the universal access to sustainable energy will not be achieved unless significant investment is targeted towards energy access provision.

Electricity has traditionally been supplied through a grid system which transported and delivered electricity from centralized power stations. However, with the emergence of new generation technologies, there has been a shift away from central stations leading to an alternative decentralized approach to delivering electricity. The decentralization can lead to grid-connected or off-grid (stand-alone) options. When a decentralized solution is not connected to the grid, it is known as an off-grid solution (see Fig. 1.1 for a pictorial view). An off-grid electricity supply can take two forms—individual product-based solutions and collective network-based solutions:

- ⚙ Individual solutions normally involve sale of a product or a service that enables individual users to produce or generate a small quantity of electrical energy (often at a low voltage) to meet some basic household needs of lighting or providing energy for running simple electrical appliances, such as a television, a radio, a fan, or such other items. Although the literature focuses mostly on renewable technology options [such as Solar Home Systems (SHS) or solar lanterns or battery systems], petroleum-fuel based small generating systems are widely used in many developing countries either as the principal source of electricity or as a backup system. The business activity depends on the product or service provided and the business arrangement/ contractual arrangement used in a particular case. For example, in the case of SHS systems, the business activity generally takes the form of an equipment sale, followed by a regular maintenance arrangement of the equipment when the purchaser takes the outright ownership. In a hiring

arrangement, the hirer pays a rental fee to the service provider for renting out an appliance. Small amounts of electricity generation takes place through the SHS or petroleum-fuel based small generators for self-use. In the case of solar PV-based battery/lantern charging systems, the charging station generates solar electricity and supplies stored energy.

- ⊗ Collective solutions, on the other hand, serve more than a single individual user and provide electricity to the users generally by producing electricity locally or by procuring electricity from other sources and distributing it amongst the consumers. The service provider in this case undertakes the business activities related to generation, procurement, distribution, and sale of electricity. In particular, the supplier invests in generating capacities, makes contractual arrangements for procuring electricity, invests in the distribution network, maintains the assets, and performs all relevant sales related functions (billing, revenue collection, and customer relationship management). The size of operation of such businesses can vary but no collective system is feasible below a minimum threshold of customers (say 20–30 households, although 50–400 households may be more common in practice).

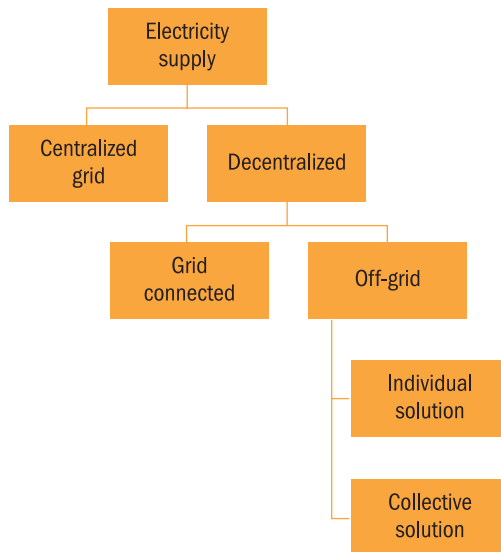


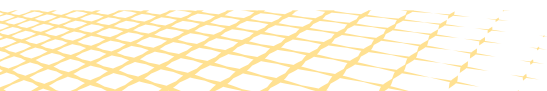
Fig. 1.1: Electricity supply options

As part of the research on off-grid electrification in South Asia, we have investigated the experience of rural electrification through an extensive research and have identified that electrification based on mini-grids can combine household electrification objectives with productive use of electricity through local livelihood generation activities. Accordingly, we have undertaken a systematic study and analysis of a number of successful and not-so-successful examples of mini- and micro-grids from across

South Asia. Simultaneously, we have also implemented and/facilitated demonstration project(s) in different clusters of villages in the states of Odisha, West Bengal, and Uttar Pradesh in India, thereby gaining practical insights about managing the entire process. We have also considered the scaling up and replication issues to enhance electrification and electricity access.

This paper draws on the above research and provides a number of policy recommendations to promote mini-grid-based electrification in South Asia and elsewhere. These recommendations flow from the multi-dimensional perspective that have been considered in our analysis and involve techno-economics, social aspects, environmental issues and governance. Our experience with the demonstration activities and our interactions with various stakeholders through the workshops and training events have enriched the policy outcomes reported here.

The paper is organized as follows: the second section presents the lessons from the global review of electrification experience. The third section presents the insights from the mini-grid related investigations. The fourth section presents a summary of insights from scaling up and replication analyses. Finally, the policy recommendations are presented in the last section.





Lessons from the Global Review of Electrification Experience

The project has undertaken an extensive review of literature on rural electrification experience from around the world. This review has also allowed the research team to look into issues, such as electrification—development linkages, regulatory issues, financing and investment challenges, and delivery options. This section presents a summary of the lessons from this review.

2.1 South Asian Experience

South Asia accounts for around 33 per cent of the global population without access to electricity (WEO 2014). Such a situation continues to exist despite several initiatives and policies to support electrification efforts by the respective country governments. The challenges to enhance electricity access are manifold including technical, financial, institutional, and governance barriers.

The current level of household electrification in the rural areas of the region is around 50 per cent, leaving some 479 million people without electricity in 2012 (WEO 2014). There also exists a wide disparity in Rural Electrification (RE) in South Asia. Sri Lanka has a RE rate of 88 per cent, which is higher than the global average (68 per cent), while only 22 per cent of the rural population in Afghanistan have access. Although the percentage of population with electricity access has increased during the last decade, there seems to be no significant decrease in the absolute number of people without electricity.

Of the total population without electricity access in the region, many reside in isolated communities, such as islands, forests fringes, and hilly settlements. These communities are generally small, consisting of low-income households—with characteristics that may be economically unattractive to electricity distribution companies or even government electrification programmes that usually prioritize the allocation of scarce resources. A substantial section of the un-served consumers are also found in mainstream rural and peri-urban areas, already connected to the grid, where the issue seems to be less of opportunity to get connected to the grid, but more

of the inability of households to take electricity connection due to financial constraints or the perception that electricity services (quantity and quality) will be inadequate.

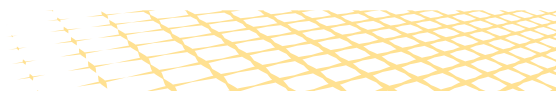
Across South Asia, a wide variety of RE models and technologies have been implemented. Grid extension remains the preferred mode of electrification and off-grid technologies have played a marginal role so far. Solar PV and mini-/micro-hydro systems are the most common technologies used in the region for off-grid electrification. Off-grid solutions (mini-grid or stand-alone) are usually preferred when accessibility is the central issue and cost of extension and servicing of central grid is high. A mini-grid based on locally available renewable energy sources is an attractive option if the village has the threshold number of households (for example, under the then, Village Energy Security Programme (VESP) in India, the threshold number of households was 100 and the required length of the distribution network was within two kilometre for system capacity of 10 kWe), optimal load (for example, the minimum threshold load for biomass gasifier power projects is 10 kWe as this is the commercially available minimum capacity) and lies in a geographically flat terrain. The main advantage of mini-grid is that it provides a better exploitation of the energy resources and utilization of the power generating equipment is higher (provided capacity is matched with the load while designing) than if stand-alone systems are used.

If it is difficult to reach consumers that live dispersed within the distribution lines (the rule of thumb is that if number of consumers is less than 50 in a village or number of connections per kilometre of distribution line is less than four) or in rough terrains, individual systems such as SHS or solar lanterns are better options. Such individual systems do not necessarily require a community organization, it only requires that there is sufficient willingness and ability to pay and that a robust product and spares supply chain exists. However, they suffer disadvantages, such as low capacity factor, excess battery costs, and a finite capacity to store electricity, forcing to throw away any extra energy that is generated.

Electrification in most of the region has relied on donor funding and state support but markets for solar lanterns and SHS have emerged in Bangladesh, Sri Lanka, and India. While the utility model has been generally used for grid extension, community-based models (such as village committees and electricity cooperatives) were prevalent for mini-grid based electrification. On the other hand, the private sector has been successful in delivering the individual product-based off-grid electrification.

Palit and Chaurey (2011) identify a number of interesting findings and lessons as summarized below:

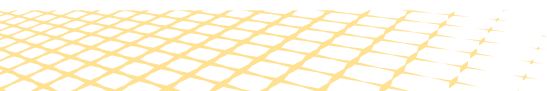
- ☀ Despite improving village level electrification, the household electrification rate remains comparatively low in many countries of the region. The key issues are 'how to improve the household level connection' and also 'how to ensure sustained electricity supply to rural areas in line with the demand'.



- ⚙ While grid-based electrification has adopted the top–down approach for extending the grid, off-grid electrification has been undertaken through community-centred projects or involving non-governmental organizations and thus lacking an organized delivery model. Off-grid options act more often as a pre-electrification option with communities continuing to aspire for grid connectivity because of the limited supply of power from off-grid projects.
- ⚙ Government’s commitment in creating an enabling environment strongly influenced the success rate of electrification. The review shows that clear policy framework and milestones, systems for defining and enforcing appropriate technical standards, standardized operational metrics, financial support mechanisms and support towards Research and Development (R&D) and training play a significant role.
- ⚙ SHS dissemination in Bangladesh and Sri Lanka shows that it is possible to successfully implement off-grid programmes in association with the private sector and micro-finance organizations. Improved access to capital, development of effective after-sales service, customer-centric market development, and regular stakeholder involvement assisted in scale-up.
- ⚙ Equality, commitment, and transparency in decision making are virtues behind the success of community-based or cooperative delivery options. However, appropriate checks and balances through an appropriate institutional environment, could create a highly favourable delivery mechanism for rural electrification.
- ⚙ The project viability has improved where it has also worked at improving the productive uses of electricity (to increase daytime demand) and the capacity of the consumers to procure electrical appliances. Revenue realization is comparatively better in projects where villagers are having cash income because of either existing income generation.

2.2 Review of Global Experience beyond South Asia

A global review (excluding South Asia) was reported in (Bhattacharyya 2013). The review considered China, Southeast Asia, Africa, and South America and observed varying degrees of progress in terms of electrification and use of off-grid options. For example, many countries, such as China, Brazil, South Africa, Thailand, and Vietnam have relied on grid extension as their preferred electrification approach. In most cases, top–down approach has been followed although China is a prominent exception where near universal electrification has been achieved despite its billion-plus population through a combination of top–down grid extension supplemented by a bottom–up local grid development, exploiting small-scale hydropower and local coal production, and integrating household electricity supply with productive use of energy in village and town industries. However, Sub-Saharan Africa lags behind significantly in terms

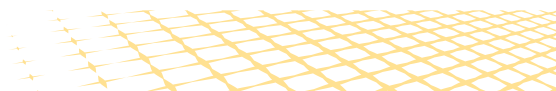


of electrification efforts and many countries of this region have very low electrification rates. In successful cases, the utility approach has been used for grid extension but weak organizational capacity and limited government commitment has led to weak performance in others. The state has borne the cost of infrastructure development and network extension in all cases but some contribution from the users has also been used in a number of cases.

For off-grid electrification, countries have largely relied on solar PV systems and micro-hydropower although use of diesel generators remains very common across a large number of countries (e.g., Philippines, Indonesia, Cambodia, and Brazil). Various organizational arrangements have been used for off-grid services: the private sector has been involved in diesel-based supply or in solar PV-based product sales; licensees or franchisees have been used in South America and in some African countries; cooperatives and other community organizations have also participated in local level off-grid electricity supply. Reliance on donor and grant funds remains chronic in most cases, but the huge investment needs for electrification in Sub-Saharan Africa requires greater attention.

This review brings out a number of interesting findings and lessons, which can be summarized as follows:

- ☀ Many countries have made a significant progress in terms of electrification but the rate of success has depended on the level of government commitment, will, and financial support to the process. In all cases, the electrification process has heavily relied on state subsidies for infrastructure development and in many cases for system operation. This leads to the issue of long-term viability and sustainability of such programmes.
- ☀ Grid extension has been used as the preferred mode of electrification in most of the cases. In some cases, it is noticed that the off-grid solutions are offered as an alternative 'temporary' solution, until grid extension becomes feasible. This is especially true in the case of South African approach but is evident in Brazil, Philippines, and elsewhere. Promoting off-grid solutions as 'inferior' or 'temporary' solutions creates concerns regarding the acceptability of these options and reduces their attractiveness. This also creates a sense of 'discrimination' or 'isolation' in the minds of the users and can adversely affect the success of programmes for access to electricity.
- ☀ The Chinese experience provides an alternative approach where rural development is integrated with the rural electrification programme. The decentralized decision-making process, reliance on local energies, development of local grid and supply network initially, followed by its upgrading and linkage to the national grid and a strong state commitment have produced a successful example of



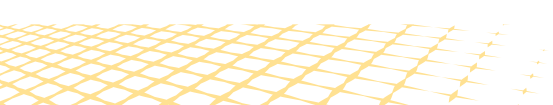
rural electrification and access. The phased network and supply development, reliance on local content, linkage with agriculture and local economic activity development, and high local participation in the process have created wider benefits that have sustained the programmes and made electricity accessible to all. However, the need for modernization arises once the system reaches maturity and through a strong state support, China has ensured such a transformation of the system. Whether the Chinese model can offer a replicable model for South Asia or Sub-Saharan Africa remains a moot issue.

- ☀ Where off-grid solutions are used, they appear to cater to limited needs of the consumers for lighting and some entertainment through radio/TV connections and very limited efforts have been found where these solutions have promoted productive use of energy for income generation. Similarly, very limited efforts have so far gone into hybrid off-grid solutions to provide a reliable and affordable solution. This feeds into the debate whether rural electrification is a pre-requisite for rural development or vice versa.
- ☀ The South African example of bundling lighting and cooking solutions through the same service provider offers an interesting solution. This addresses the main energy needs of rural communities but finding a viable, economic solution remains a challenge.
- ☀ While some private partners are participating in some off-grid supply activities, it is general experience that donor-assistance or state-support has been the catalyst for off-grid solutions. Better results have been achieved where the entire programme is well co-ordinated with adequate support services and clear assignment of responsibilities. The development of a local supply chain has also played a major role in the successful delivery of the systems.
- ☀ While a dedicated and effective implementation agency can support electrification, the experience from Sub-Saharan Africa shows that it is important to create adequate organizational capacity and sufficient funding for rural electrification. It is also important to have proper strategies, prioritization and planning for electrification. These aspects have not been adequately considered in many countries.

2.3 Electrification and Development Link

Rural electrification schemes have so far not provided universal access and have been unaffordable for most poor people. The solution to the question essentially involves three aspects [(Cook 2011) and (Cook 2013)]:

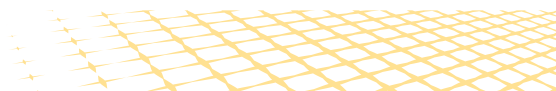
- ☀ First, instruments are required to ensure that service operators provide access (a service obligation).



- ⚙️ Second, instruments are required to reduce connection costs (through tariff design or direct subsidies built into payment plans to favour the poor).
- ⚙️ Third, instruments are required to increase the range of suppliers (to give choice to users to opt to choose lower quality service providers).

The achievements of these have often been difficult and slow and our understanding of the issues that act as constraints to the above is incomplete. Drawing on the experience with both grid-based expansion and off-grid applications in developing countries [(Cook 2011) and (Cook 2013)] identified the following issues that facilitate and constrain access and affordability of electricity services in rural areas:

- ⚙️ First, both connection charges and electricity charges continue to represent serious constraints for the poor and more innovative discount or subsidy schemes for connection and improved tariffs, that are compatible with poor people's incomes and resources, are required. For example, while income elasticities do not rule out cross-subsidization as a way of providing affordable services to lower income households, high income groups could be over-burdened, and as a result, may alter the quantity of electricity they consume. If appliance costs are subsidized, then electricity take up and use would increase for the poor. The earlier emphasis on cost recovery and reliance on the private sector to deliver electricity widely was misplaced. More recently, The World Bank, drawing on the experience with the 120 electrification projects it has supported since 1995, has moved away from a pure cost recovery approach to provide lessons that are more in keeping with meeting the needs of the poor, particularly in rural areas. These include firstly, justifying subsidies for capital as long as income covering operating and maintenance costs.
- ⚙️ Secondly, rural electrification programmes must be implemented with complementary infrastructure, including educational initiatives that influence change. As seen in our review, this enables the users of electricity to put energy to productive uses. These aspects are not normally part of rural electrification programmes provided by private or state-owned utilities. Even enterprise development programmes have not, as a rule, been designed to promote end-users of electricity (Cook 2006).
- ⚙️ Thirdly, more thought should be given to the prequalification criteria for selecting rural areas and the types of socio-economic facilities that are to be electrified. Again, the example of Kenya's experience with community group-based micro-grids to accelerate rural electrification, based on a mixture of energy sources including diesel, micro hydro, solar, wind, and biomass to serve dispersed areas, has provided a useful example of what can be achieved with careful selection.
- ⚙️ Fourthly, an autonomous and effective implementing agency is needed to ensure that plans for electrification can be delivered. An ingredient that works



in many spheres of local development is to involve the community closest to the targeted beneficiaries that can leverage local skills and resources and overcome local resistances.

2.4 Regulatory Weaknesses

Researchers observe that there is a need for regulation or some form of regulatory control of off-grid electrification (Sarangi *et al.* 2012). This emerges from several recent developments observed in the sector. One of the interesting developments is related to gradual increase in the participation of private players in the field, *albeit* in varying forms, i.e., pure privatization, and Public-Private Partnership (PPP) forms. This has been spurred by accommodative provisions introduced through changes in legal and legislative spheres governing the sector. However, private participation depends on developing proper regulatory arrangements for governing off-grid electrification or decentralized electrification. However, regulation of off-grid electrification has not received adequate attention in many countries.

Bhattacharyya (2013) analysed the regulatory issues of off-grid electrification and argues that in the case of individual solutions which are delivered through sale or renting of products, no distribution or transmission network is involved. In fact, electricity supply as a business is not carried out in these cases. Accordingly, this solution does not violate or interfere with the electricity acts or regulations and the problem of natural monopoly does not arise. Hence, the need for economic regulation does not arise here, although there is need to ensure compliance with technical, environmental and health and safety standards. On the other hand, a local mini-/micro-grid based service uses a distribution network and a set of decentralized generators. Here economic regulation becomes pertinent for two reasons: 1) to ensure that the activity complies with the law of the land and 2) to protect the interests of investors and consumers.

Three alternative forms of regulation can be identified (Bhattacharyya 2013):

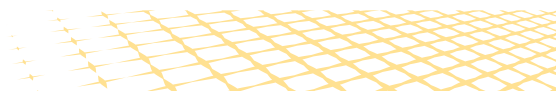
- ⊗ A generic waiver or exemption from the standard provisions applicable to the electricity supplier may constitute a simple solution. This can take different forms. For example, a blanket exemption for rural areas (as followed in India under the Electricity Act 2003) is a possibility. An exemption up to a given threshold (as in Mali, Senegal or Tanzania) or exemptions for specific organizations (e.g., cooperatives in Ethiopia) are other possibilities.
- ⊗ A simplified, standardized regulatory arrangement can offer a light-touch, practical approach. Such a regulation should specify the role and duties of the provider, set the information filing requirements and ensure consumer protection mechanisms. This reduces the compliance cost and imposes lesser burden on the regulators.
- ⊗ A full-fledged regulatory arrangement constitutes the most formal regulatory

approach. The licensing approach or a concession approach tends to conform to this idea. But this will be a costly option and should only be adopted where benefits from the regulation outweigh the costs.

Also, the issue of self-regulation and co-regulation emerged as a new trend (Sarangi *et al.* 2012), which could be traced in the operation and management of off-grid energy systems in India on the face of growing enthusiasm among private players in the field. While these entities operate within the broader mandate provided by central and provincial authorities, over time, a lot of self-regulatory practices and codes have evolved to regulate certain aspects of their business activity. For instance, mandatory training programmes for operators, routine maintenances, sharing knowledge about energy efficiency and energy conservation, and safety protocols are areas where evolving practices have emerged as self-regulatory practices in the absence of formalized regulatory schemes.

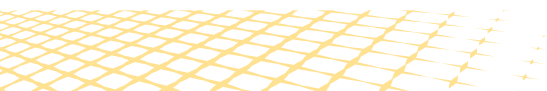
Bhattacharyya (2013) also indicates a number of regulatory challenges and issues:

- ☀ **Clarity about the service area:** The area where authority is to carry out the off-grid business is derived from a generic or specific licensing waiver, the off-grid area is not dedicated to the operator and the jurisdiction overlaps with the service area of the distribution and supply entity. In such a case, the most important challenge that any off-grid service provider faces is the threat of grid extension. Any grid extension soon after the installation of an off-grid system amounts to a loss of business opportunity and the risk of non-recovery of the costs. Therefore, a close co-ordination between the distribution utility and the off-grid service provider is essential. Aggressive grid expansion after launching off-grid services has been a common observation in many countries around the world. If the rural areas where the incumbent utility has failed to provide access are excluded from its area of service, and one or more off-grid service providers are granted exclusive rights for a fixed period, the business uncertainty can be mitigated. However, as such, a change often requires an amendment to the existing supplier's service area. This may not be easy and cannot be done without the consent of the incumbent utility. The off-grid service provider may however be appointed as a concessionaire of the grid company and can serve in remote areas as is practised in the Philippines under the Qualified Third Party Programme.
- ☀ **Quality of service:** Any off-grid service often aims to provide quality power for a limited period of time depending on the designed capacity of the power plant. Depending on the system used, the duration of supply and technical standards can be quite different from a grid-based supply and it often makes sense to prescribe different standards for the grid and off-grid services. Similarly, ensuring the reliability of supply is one of the issues faced by most off-grid systems. There are two levels of this problem: ensuring service reliability at present and maintaining a



reliable supply in the future as the demand increases. For day-to-day reliability, the system design, and operation and maintenance activities play an important role. The availability of technically qualified staff for repair and maintenance is also an essential requirement. For a reliable supply in the future, the supplier requires load forecasting, system planning, and demand management activities, absence of which may deteriorate the quality of supply in the future. While a performance standard for off-grid supply can specify these, it is generally ignored in most cases, thereby leaving the service provider to decide these issues.

- ☀ **Health and safety issues:** In addition, health and safety issues tend to receive less priority in a cost-conscious business environment. Compromises in technical standards and use of low quality materials are often attempted to reduce initial costs. However, this can increase accident risks and can make the activity unsafe. Technical quality and safety standards have to be carefully considered as part of the regulatory requirements.
- ☀ **System standardization:** As the mini-grid based supply systems develop in off-grid areas, the issue of inter-connection and integration will arise. If different local grids follow different standards, their integration will be difficult and significant capital investment for renovation and system upgrading will be required. Embedding very small systems to the distribution network can also pose technical stability challenges. However, connection to the central grid system can be facilitated through technical standardization and by allowing grid connectivity of decentralized generation at the distribution level. This calls for non-discriminatory third party access to the distribution system and an appropriate distribution code. Thus, it is important to consider quality of service and standardization of systems for cost effective outcomes.
- ☀ **Tariff issues:** Regulating tariffs remains a major challenge and the issues include appropriate pricing of off-grid supply, deciding the case for cross-subsidies depending on the demand or usage pattern, compatibility of tariffs with grid-based supply, and the need for and financing of subsidies for such services. Small consumer base, existence of subsidies for grid-based supply, and large cost variations by off-grid technologies make the issue more challenging. The regulatory challenge in respect of tariffs is to decide whether to intervene in the tariff matter or not, and how best the tariff can be regulated in this case without imposing too much regulatory burden on the service provider while ensuring that consumers are not unduly charged for the services they receive.
- ☀ **Regulatory capacity:** Depending on the regulatory approach chosen, the governance mechanism would require certain regulatory capacity to manage and monitor the developments in the off-grid sector. Most of these would be required in remote areas in countries with limited regulatory capacity in general. The issue



of a centralized regulatory agency versus decentralized regulatory arrangements will also need some consideration. Given the potential for a large number of regulated entities, the nature of regulation and the most appropriate organizational arrangement to manage this would have to be carefully considered. This assumes greater importance given the limited size and coverage of most of the entities, and the potential for an overwhelming amount of regulatory intervention in this newly developing activity. The challenge in this respect has not yet been fully recognized.

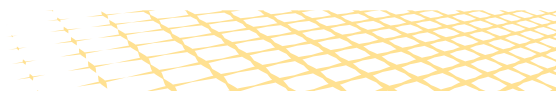
2.5 Financing and Investment Challenges

Since the launch of the Sustainable Energy for All initiative in 2011, countries lacking energy access are setting targets for achieving universal electrification by 2030. Consequently, it is becoming evident that an unprecedented level of investment will be required for financing electrification projects. The International Energy Agency estimates that an annual investment of \$48 billion over two decades will be required to meet the objective of universal energy access by 2030, and almost 90 per cent of this will go to electricity access. Additionally, it estimates that mini-grids and off-grid solutions will be deployed in 70 per cent of the rural areas and will require an annual investment of \$26 billion. About 60 per cent of the investment will go to Sub-Saharan Africa, where the electricity access is low at present. It is also reported that an estimated \$9.1 billion were invested in energy access in 2009 and that multi-lateral agencies contributed 34 per cent of the above investment, followed by 30 per cent from the developing country governments, 22 per cent from private sector, and 14 per cent of the above investment came from bilateral official development assistance.

Traditionally, investments in the electricity infrastructure are funded from internal sources, or through Foreign Direct Investment (FDI), Overseas Development Assistance (ODA), and multilateral funding support. FDI has benefited only a selected set of countries and FDI flow to Sub-Saharan Africa has remained insignificant and generally, large electricity supply projects have benefitted, making the funding less relevant for energy access purposes.

Similarly, although ODA generally benefits the developing countries, only a small share of it flows to the energy sector. Likewise, a small share of the energy access funding from multilateral agencies like The World Bank was directed to countries who need it the most and attention to energy access in Africa received attention only recently. Moreover, despite its significant growth, the carbon finance market has not really benefited the energy access agenda and it remains less accessible to small and poor developing countries.

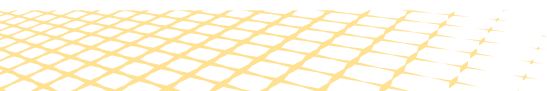
Based on the analysis of financial flows and investment needs for energy access, the magnitude of the challenge becomes quite clear. For least developed countries with a high level of energy access problem, even investing the entire amount of capital



now invested in the energy sector will not ensure universal energy access by 2030. The governments of budget-constrained developing countries may not be able to contribute much to finance such demands. International support will be required but the public finance may not be easily forthcoming and may not reach the countries that need it the most. The present support of multilateral finance organizations is biased towards large-scale energy projects and often disproportionately benefits large developing countries. Thus, if universal energy access has to be achieved, these trends need to change so that funds can flow to poorer countries at the right time, in right volume. Thus, a major change in the attitude of the funding agencies, development priorities of the states and the business strategies of the private sector will be required.

Off-grid electrification projects face a number of barriers. The initial barriers faced by an investor are classified as the 'first generation barriers' and include, among others, low returns on investment, high transaction costs, lack of experience with energy access financing, high cost of capital, and unsuitability of existing credit facilities for financing these projects. Large financial institutions do not get involved in financing activities below a certain threshold volume of funding and small-sized off-grid projects automatically get excluded. Even a few projects bundled together do not help much. Similarly, traditional financial institutions have relatively limited experience of dealing with off-grid electricity projects with specific features, such as low investment volume, low return, and high risk. Also, investors look for long maturity products that allow them to spread the costs over the lifetime of the project. However, such products are rarely available in the market. In addition, when the off-grid business is managed by a local entity (such as a community group or an NGO), their credit worthiness may be questionable and in some cases, even their legal status may be doubtful. Thus, unfamiliarity with the business segment, risk perceptions, and unsuitable products make the experience frustrating for the off-grid sector.

A second set of barriers arises from the absence of a level-playing field. The regulatory and political environment for off-grid business and undue competition from subsidies are the main barriers here. Off-grid electrification has not received adequate regulatory and legal attention and the electricity acts of many countries hardly acknowledge or refer to off-grid electrification as a separate business activity. Accordingly, there is some confusion about the status of these activities and as usual, the risk of grid extension at a later date remains one of the main investment risks. The prevalence of subsidised electricity rates for the poor in general and in rural areas in particular, acts as a further hindrance to off-grid investments. Unless the off-grid supplier receives state subsidies, it is practically impossible to ensure price parity with grid-based supply. The subsidized fossil fuel supply (such as kerosene), prevalent in some countries, also cause similar issues. Unless a level-playing field is created, investments in the off-grid electrification business will suffer.

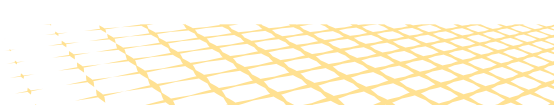


Finally, the country-level risks and investment environment also influence investment decisions. Political instability, weak or ineffective law-enforcement and currency-related risks are perceived as major threats to viable investments. There is thus an urgent need to remove major barriers that hinder large-scale mobilization and use of funds in the off-grid electrification business.

Any investor intending to enter the off-grid business would need the start-up capital and the ability to take risks in the new business. The seed capital is an early stage finance mechanism for this purpose that is used to convert an idea to a new business, particularly in the case of small and medium-sized businesses. Although venture capitalists play an important role in industrialized countries in taking risks of innovative businesses, the prospect of persistently low returns in the off-grid businesses restricts the potential of venture capital. The donor agencies could fill this gap instead.

Once a business starts operating, its operating capital needs to increase to meet the short- and long-term capital needs. Very few commercial lenders provide funds to off-grid electricity businesses and consequently, support mechanisms are required in the form of lines of credit, loans for credit enhancements, and capital funds for SME growth. If governments want to reach the poorest section of the population, subsidies perhaps cannot be avoided but these have to be well targeted and appropriately designed to avoid market distortions. There is still a huge affordability gap amongst rural poor and therefore subsidy plays an important role. But, the subsidies may be attracting new suppliers in the market and may not be creating a sustainable business model.

To become sustainable, an off-grid project has to be beneficial to all main stakeholders—consumers, service providers, financiers, and government. This needs to consider the government's intentions, subsidy commitment, and regulatory rules; promote productive and institutional energy use that generates income opportunities; and take the possibility of international co-financing into account. Designing an off-grid system is not an exact science—it is made more complex by a combination of factors including, among others, remote locations, high cost, poorer consumers, and new technologies. The question that requires investigation is how and when an off-grid investment complements grid expansion. Although a few off-grid operations are commercially viable (examples include PV in China and Kenya, some PV operations in India, pico-hydro in Laos and Vietnam, and micro-wind in China and Mongolia), most off-grid electrification may require subsidies. Therefore, enhancing affordability through subsidies, consumer financing, low-cost technology options, and policies and business practices are important. Further, financing arrangements can complement subsidies. International co-financing, through Global Environment Facility (GEF), Climate Investments Fund (CIF), and the Clean Development Mechanism (CDM) can help. By increasing the size of the consumer base through micro-finance, the affordability and viability of projects can be enhanced. Rationalization of duty or import



tax (e.g., waiver or reduction) and avoidance of multiple taxes are also important in this respect.

2.6 Delivery Options

The business model for delivering off-grid electrification tends to vary depending on, among others, the mode of delivery (product sale or local grid-based supply), financing mechanism, and ownership (see Fig. 2.1). For the stand-alone system delivery, four common delivery options are cash sales by retailers, rental fee-based service by an energy service company (ESCO), leasing arrangements by an ESCO, and a micro-finance based scheme. The South Asian region has experience with all these options, but some of the well-known cases include the following [See (Krithika & Palit 2013) for more details]:

- ☀ Grameen Shakti (GS), a non-profit company, has promoted SHS in Bangladesh through a micro-finance backed system developed by IDCOL. GS has created a rural network of decentralized branches all over Bangladesh and has developed a sales strategy linked with consumers' access to finance. Consumers make an initial down payment and repay the rest over a period of time, paying a low rate of interest on the loan. By 2012, GS had installed more than 1 million SHS in Bangladesh and recording an eight fold growth in sales between 2007 and 2012. The growth of the market has immensely benefited from IDCOL's leading role in providing soft loans, flexible financing and standardized financing models.
- ☀ SELCO, a private social enterprise in India, has used 'lease-to-own' approach to promote SHS in South India. Although it does not provide finance to its customers, SELCO supports its customers in securing loans through third-party finances [such as Renewable Energy and Energy Efficiency Partnership (REEP) funding to cover the down payment requirement for securing a loan] or loans from local banks and has been successful in installing 135,000 SHS since 1995.
- ☀ TERI's Lighting a Billion Lives (LaBL) campaign that uses a fee-based rental model using entrepreneurial model for service delivery for promoting solar lighting in India. The programme has impacted more than 2.5 million lives of people during the last six years.

In respect of local-grid based electricity supply in rural areas, the region has experimented with a number of alternative options as well. The supply of power from diesel generators by private entities is a commonly used option. These use temporary networks and either provide the service for a specific use (fair, market, etc.) or offer the service to a limited cluster of households. These operate on a fully commercial basis and usually charge much higher rates for their supply, commensurate with the small size of their generators (therefore poor technical efficiency) and high cost of diesel fuel used for the supply. In addition to this category of service, renewable energy-based rural

electricity supply has also emerged particularly in India, with the Husk Power System (HPS) being the most well-known case. HPS, a small start-up company based in Bihar, has electrified around 80 villages since 2007, affecting nearly 25,000 households. HPS builds village scale mini-grids using rice husk gasifiers, usually ranging between 30 and 200 kW systems. HPS usually works only in locations where at least 250 households agree to take connection and it charges a nominal installation charge as well as a regular fee for electricity, sometimes ₹45 per 15 W CFL. It charges a higher rate for commercial use than for residential use. The company has developed a franchisee-based business model to scale up their model of setting up mini-grids and follows the BOOM (build, own, operate, and maintain), BOM (build, own, and maintain) and BM (build and maintain) models for providing electricity services. Some of its plants have reportedly generated ₹40,000 monthly revenues from tariff, which is considerably greater than average expenses of ₹20–25,000/month (Krithika & Palit 2013).

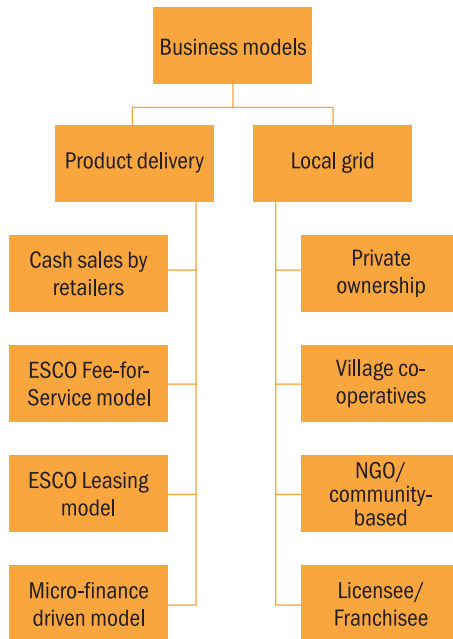


Fig. 2.1: Business models for off-grid electrification

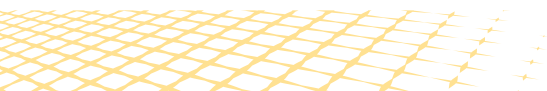
Community-managed systems have been widely used in the region. Microhydro-based developments in Sri Lanka and Nepal, considered to be successful initiatives, are run by the local communities using the locally available water resource to meet their energy needs. On the other hand, India has implemented solar PV-based projects which were successful but the biomass gasifier systems implemented under Village Energy Security Programme (VESP) in India met with very limited success. Generally, community involvement in a project brings a sense of ownership of the project and hence can enhance the acceptability of the project by the community. But a successful

implementation and operation of the system requires appropriate skills, clarity of roles and responsibilities, social cohesion, and strong commitment. Lack of technical skills in the community for system operation and financial management often impede with successful delivery of complex electrification projects.

Although the co-operative model has been widely used in Bangladesh, it was used for grid-based electricity supply and not for off-grid electrification as such. In India, the cooperative model has not been widely used but in the case of off-grid electrification in the Sunderbans, this model was used in some cases. As members of the cooperative consumers have a sense of ownership of the project and the management tends to take a formal approach than in the case of community-based systems. However, the issue of availability of skills and their retention remains a problem.

The franchisee model has been used in South America to engage private entities in rural electrification. In the case of grid-extension in India, a similar approach was used. Husk Power has been using this model in the case of off-grid supply.

The critical success factors from the business perspective, however, are not limited to financial factors alone. The organizational management of the entire business activity—starting from project inception, design, and implementation to project operation—is not an easy task. Good management of the local utility business with properly defined roles and responsibilities for each player, clear identification of risks and their mitigation and management of local aspirations are also essential. The issue of local income generation requires special mention here. In rural areas, where there exist limited regular monetary income flows, the ability to pay for electricity becomes limited. If the local electricity supply provides additional opportunities for income generation, this not only improves the living condition of the population but also enhances the viability of the mini-grid business.





Mini-grid-based Electrification as a Possible Solution

Mini-grids are receiving attention for a number of reasons (Bhattacharyya and Palit 2014):

- ⚙️ A properly designed system can offer a high quality and reliable supply;
- ⚙️ Such a system can cater to non-domestic demand, thereby offering income-generating opportunities for improving the quality of life;
- ⚙️ Green mini-grids using renewable energy technologies avoid greenhouse gas emissions and contribute to climate mitigation efforts; and
- ⚙️ Being independent of fossil fuels, they enhance energy supply security and reduce vulnerability of consumers in respect of fossil fuel price fluctuations.

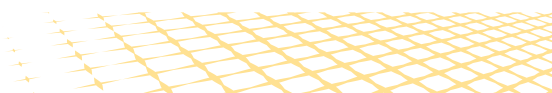
Our study has shown that mini-grid-based electrification has proved to be a feasible solution in the South Asian context. India has experimented with this since early 1990s but other countries in the region, namely Sri Lanka and Nepal have also implemented a number of initiatives while Bangladesh has joined the mini-grid-based supply more recently. The region has undertaken various pilot and demonstration projects to showcase alternative technologies as well as delivery mechanisms. For example, diesel generator-based local grids have played (and continue to play) a role in areas where people could afford this option. Micro or mini-hydro development has always relied on a local grid-based supply in South Asia. More recently, biomass gasification and solar PV-based systems have been used but solar PV has emerged as the leader in the technology front due to its modular size, efficient lighting systems, and falling cost of PV panels.

As a network-based service a mini-grid based service involves a local grid (mini or micro grid using alternating current AC or direct current DC), local generating plants and a service provider. This takes the form of a small-scale utility at a remote, rural location and clearly, the service provider approach requires undertaking a full-fledged generation, distribution, and retail supply activity. Electricity generation can come from a number of technologies: solar photovoltaic (PV) systems have been

widely used; small hydropower is also used where hydro potential exists; biomass-based technologies are also used; and diesel generators are also widely used. When the source of energy is intermittent (such as solar energy or wind), a backup system in the form of a storage system or a supplementary source is generally used. The generating system tends to be capital intensive but the operating cost is low for renewable energy driven systems, while for diesel powered generators the operating cost tends to be high. The local distribution system connects the load centres to the power plants. The system can be an alternating current (AC) or a direct current (DC) system, but AC systems are more commonly used. Wires and poles constitute the distribution system. This comes at a capital cost but has low operating expenses. Finally, the consumer premises require wiring and metres (or devices for service control) to allow supply of electricity and its measurement for billing purposes.

The service provider can take a number of alternative ownership forms and organizational arrangements, including private franchisees, co-operatives, community managed systems, or a state utility. Although electricity supply has traditionally remained a stronghold of state utilities in many developing countries, they have often focused on grid extensions. Very rarely, such utilities have ventured into local mini-grids or local supply arrangements. Consequently, various organizations, including local communities, non-governmental organizations and the private sector, have tried to fill the vacuum left by traditional electric utilities. These organizations pursue different objectives and bring different levels of skills and challenges. For example, a private investor will not be interested in any business unless it offers sufficient profits or returns on investment. Therefore, a privately owned and operated local off-grid based service will appear in niche areas, where the business has the potential for generating adequate profits, which could be in peri-urban areas or in larger, resourceful rural areas. On the other hand, a local community organization or an NGO may take a more social perspective to the business and a profit motive may not drive their activities. Similarly, a private investor entering into the rural energy business will either bring or acquire the required skills and expertise to run such businesses to support its profit motives. The same may not be true for socially-oriented organizations, who may try to rely on available expertise or resources rather than bringing professional skills for the utility business, thereby lacking innovation and professional management of the system. However, irrespective of the organizational arrangement, the transactions remain similar.

Further, as the developments in off-grid electrification have been dominated by donor and multilateral financial agency support, where a project-based approach has been pursued, such interventions have led to isolated developments. Although replication remains a possibility, yet a lack of integration amongst project-based intervention or with the grid leaves the possibility of developing local



electrified islands. This also has implications for the regulatory regime and overall electrification efforts.

A mini-grid based electrification of rural areas is however, not a simple activity. Often, a complex chain of processes is required to process the primary energy to deliver the usable form of secondary energy. Moreover, distribution networks and control systems are required to transport electricity to users and to manage the demand and supply. Moreover, being a resource constrained system, the supply and demand balancing is a greater challenge and where the primary energy comes from an intermittent source, energy storage becomes an important issue. It also requires cautious investment decisions, careful business planning, and watchful project management. The usual challenges of investment and business risks are compounded by additional barriers, such as locational disadvantage (rural areas in remote parts of a region), limited consumer base, weak paying capacity, poor business environment, and skill shortages. Moreover, mini-grids face competition from stand-alone systems, such as SHS as well as from the absence of a level playing field, due to subsidized supply of electricity and other fossil-fuels, such as kerosene and diesel. The business environment is also adversely affected by the rules of the game or lack of it and by institutional arrangements. Accordingly, the policy recommendations capture a range of issues facing the mini-grid-based electrification of rural areas.

The business model for delivering mini-grid electrification varies depending on, among others, the purpose and scope of service, organization, ownership, and financing mechanism (see Fig. 3.1). In terms of scope of service, three delivery options can be considered: lighting only micro utilities, lighting plus services catering to lighting and productive/community demand, and anchor loads where the service is designed according to the needs of a major user.

- ☀ The micro-utility systems are generally DC systems catering to small villages or hamlets with a concentrated population. They provide Light-emitting Diodes (LED) lights and a mobile charging point and electricity is locally generated through solar PV systems. Mera Gao Power (MGP), LaBL facilitated entrepreneurs, and Husk Power in India are some of the private sector service providers, whereas Chhattisgarh Renewable Energy Development Agency (CREDA) is a state agency operating in this area.
- ☀ The lighting plus service does not restrict its operation to the basic lighting provision, but extends the scope of electricity service to other household electricity demands as well as to productive and community electricity needs. Here, the service available to users can vary depending on their ability to pay. Some users may just receive a basic level of service for a low charge, whereas others, who are in a position to bear additional costs, can connect higher loads. Private entrepreneurs, often involved in local supply through diesel generators using temporary networks to provide the

service for a specific use (fair, market, etc.) or for the service to a limited cluster of households, can come under this category. Similarly, private renewable energy-based rural electricity supply has also emerged particularly in India, with HPS and DESI Power being the most well-known cases. These services operate on a fully commercial basis and usually charge much higher rates for their supply. Often they operate in niche areas and may not connect all households in a locality. On the other hand, the public sector that has adopted a social response approach does not focus on cost recovery. The solar PV-based mini-grids in the Sundarbans in West Bengal are prominent examples of this category. The cooperative approach or the community-based approach, widely used in Nepal for the mini-hydro power development, offers an intermediate option between private and public ownership, where the users themselves join together to own and operate the service. While community-based solar PV-based projects have succeeded in India, the biogas projects under the VESP have met with limited success. The sense of ownership and better acceptability of a community-based project have to be adequately supported by appropriate skills, clarity of roles, community commitment and appropriate technical skills to manage the process. The franchisee model has been used in India under the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme [has now become Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)], whereas the policy of Remote Area Power Supply System in Bangladesh allows for licensees to be used for mini-grid based electrification. The private entities in India, such as HPS, are also following the franchisee model to replicate their model more widely.

- ☀ The anchor load model is a variation of the lighting plus option where a major user (often a telecommunication tower, or a local industry) provides the base demand and the excess supply available on meeting the anchor load is distributed to the local community. The private sector has followed this approach as a risk mitigation option.

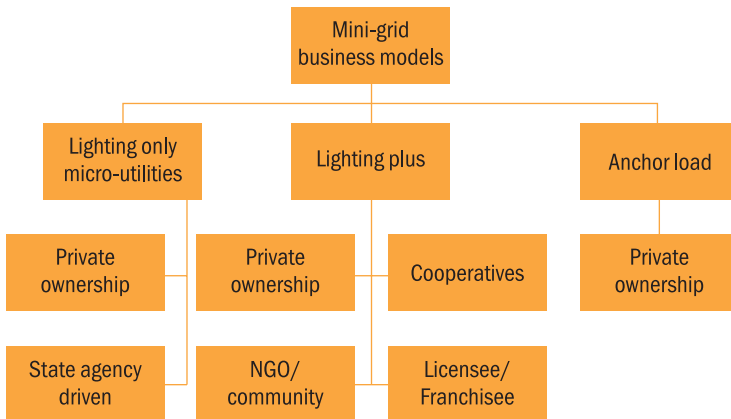


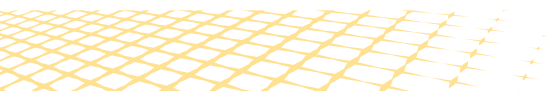
Fig. 3.1: Business models for mini-grid-based electrification

A number of commercial factors influence the financial viability of any mini-grid project. These include: capital cost of the project, capital structure, cost of capital, operating costs, tariff or charges, and collection efficiency. The financial attractiveness also depends on the price of alternative energies, availability of bankable contracts, credit worthiness of the project proponents, and the rate of plant utilization. For a given capital investment, the tariff will reduce as the capacity utilization rate improves and or the cost of capital is reasonably low. Similarly, the project proponent has an improved chance of securing debt funding if the project can enter into a selling contract with an anchor load, where the buyer is credible, thereby making the contract bankable. These factors are also influenced by commercial motives of the project proponents. For example, a private investor will look for cost recovering tariff or charges, whereas public sector entities with social motives are likely to charge a subsidized rate. The capital grant or subsidy funding from the government may be available for all players to encourage off-grid electrification through renewable energies. The project design, technology choice and cost management by any project developer contribute to the financial health of a project. Practically no fuel-related costs for solar PV, mini-hydro or wind power projects reduce their operating expenses whereas biomass-based projects or fossil-fuel based projects incur significant recurring expenses to ensure fuel supply.

3.1 Insights from the Field-level Study of Off-grid Electrification Projects

Mishra and Sarangi (2011) carried out a project-level analysis to understand the basic conditions that have largely shaped local grid-based off-grid project viability on a sustained basis. They found that the operational viability of off-grid projects is largely determined by policy support, social acceptance in the form of community participation, linkages with income-generating opportunities, and technological appropriateness. It was found that in 62.5 per cent of cases, there exists some kind of policy support to promote and develop off-grid energy development in the concerned state. This percentage figure goes up to 67 per cent if we consider only those projects which are currently operational; more interestingly, nearly 60 per cent of the projects currently non- or partially operational seem to have suffered because of lack of policy support.

The interactions with project developers revealed the critical role of policy support in determining the success of a project. The consensus is that macro-economic policy declaration must be strengthened and local mechanisms for continuous monitoring as well as accountability frameworks must be put in place, specifically for government owned and operated projects. These interactions further revealed that regulatory uncertainty and vacuum stifles the growth of off-grid projects and that the current paradigm of ad hoc and piecemeal dispensation to regulation produces sub-optimal outcomes in terms of resource use efficiency. Moreover, local level policies



often determine project outcomes and often developmental policies integrative of off-grid elements form the policy foundation for many of the off-grid energy systems. The flip side of this is that in-congruencies in the local governance structures act as impediments to project development.

Community participation in project activities, which in some cases is expected to culminate with community ownership of the project, is often highlighted as a critical factor. Such a premise, however, seems to be challenged in practice by the reality of capacity constraints among communities, local level conflicts, and 'elite capture'. Mishra and Sarangi (2011) found that only a fourth of the operational projects they investigated are characterized by community participation and the remaining are largely led by private enterprises.

The project-level analysis gives reason to link more definitively, a project's source of funding with the project's long-term viability. For operational projects as well as the other category of non- and partially-operational projects, government funding has clearly not been fortuitous in majority of the cases. The reason may be found in the soft-budget syndrome identified in the public finance literature. With guaranteed funding and lax monitoring, government funded projects are said to operate under soft budget constraint conditions, which inevitably leads to weak budgetary discipline by project developers and implementers. Moreover, a majority of public funded projects grossly fail on after sale service and poor maintenance structures.

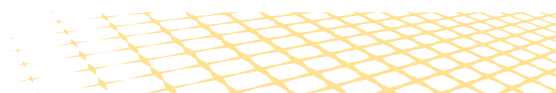
There are some serious handicaps that exist within the existing policy and legislative landscape governing the off-grid electricity sector (Sarangi *et al.* 2012). There is a realization within the policy circle that misplaced incentives like those available to mega power projects have yielded dampening effects on small scale decentralized energy projects. It is also contended that there exist several policy ambiguities and inadequacies to address the emerging challenges confronting the sector.

3.2 Lessons from Case Studies

A number of case studies were undertaken as part of the OASYS project, which also produced valuable lessons. This section provides a summary of such policy lessons from these studies.

3.2.1 Bangladesh Case Study

Bhattacharyya (2015) analysed the village-level electrification in Bangladesh, taking the case of a hybrid mini-grid system for a remote non-electrified village in the Dhaka division. The analysis developed alternative demand scenarios, considered local resources for electricity generation, conducted techno-economic analyses of all scenarios using Hybrid Optimization of Multiple Energy Resources (HOMER) and performed business analysis. The demand scenarios captured alternative development



pathways—starting from basic level supply for five hours per day to unrestricted, reliable supply consisting of residential, commercial, and productive loads. The techno-economic analysis suggested optimal configurations that consisted of diesel generators for the basic level of supply and hybrid PV-diesel solutions for more elaborate services. The renewable energy share in all configurations varies between zero per cent (in basic cases) to 60 per cent (for high PV cases) and the cost of electricity per kWh decreases as the system size increases. However, the hybrid systems require significant excess capacity due to intermittent nature of solar energy and consequently, the initial investment requirement increases. Moreover, during the project life, some assets (such as batteries and diesel generators) need to be replaced depending on their life and extent of use. This requires significant investment at regular intervals to keep the system going.

The analysis of business case of the investments revealed that the levelized cost of electricity (CoE) from off-grid options is much higher than the regulated tariff for various categories of consumers who receive grid electricity. However, the cost of off-grid supply is likely to be cheaper than the cost of owning a SHS. Low income consumers will pay almost one half of the cost of owning a SHS for a comparable level of energy use, while the high income users may be paying somewhat more for the restricted level of supply, although the monthly bill will not be too burdensome for low level of supplies. However, the problem arises when demand restrictions are removed, allowing consumers to use high volumes of energy. Their monthly bills will be burdensome, making higher consumption unattractive. This happens despite a reduction in cost of electricity per kWh due to high capacity-related costs and operating costs of the system.

The study also found that capital cost subsidy would not be sufficient to ensure grid price parity and significant amount of operating cost subsidy would be required. It showed that even if 100 per cent capital cost subsidy is provided, the cost of supply will remain higher than the retail tariff approved by the regulatory commission for different categories of consumers. As the operating cost subsidy will impose a recurring burden on government's finances, it is unlikely to be sustainable. This makes the energy access challenge significant. The analysis suggests that the basic electricity supply provision through a mini-grid is the most preferable business solution—it requires less capital, less subsidy volume, and moderate monthly bills for consumers. Such a business can be organized by local entrepreneurs, private investors, or local community organizations.

3.2.2 Nepal Case Study

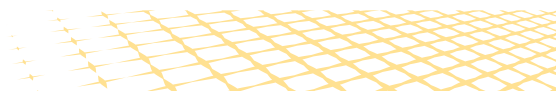
On investigating renewable energy-based off-grid electrification in Nepal, it was found that mini-grid has the potential to emerge as an effective alternative to the crisis ridden grid-based electricity system (Sarangi *et al.* 2014). Substantial progress in this front has

largely been made due to the presence of a strong and focused engagement of several key institutions and entities like AEPC, donor agencies, banks, private associations, and the presence of a strong market supported by private entrepreneurs. Financial assessment of a project revealed that there exists some potential of cost reduction by enhancing productive use of electricity. In addition, microhydro projects are found to be cost effective compared to similar sized solar energy projects. However, the sector is entangled by multitude of anomalies resulting in slow progress of the sector and underutilization and non-utilization of off-grid energy resources. Political instability and uncertainty has been a greater hindrance so far. Adhocism and changing focus of donor funded programmes are distorting the very foundation of the sector. On regulatory front, uncertainty about grid extension leads to sub-optimal utilization of private sector potential. In addition, poor access to credit and absence of formal financial institutions at the local scale debar the ability of private entrepreneurs to venture into the sector. Importantly, inadequate post installation evaluation produces only dry statistics about systems installed without any indication about sustainability of these projects. It is pertinent to address all these concerns to drive the sector on a sustainable trajectory and mainstream renewable energy electrification as an important ingredient in the overall economic development of the country.

One of the challenges encountered by the sector is the lack of adequate investment. Declaration of a long-term policy for the sector with accommodative provision of incentives and benefits could go a long way in attracting private investors into the field. In addition, sustainability of these projects requires mobilizing small-scale financing through micro-financing and micro-credit route. A related aspect is about policy and regulatory certainty regarding grid extension. Demarcation of off-grid villages/localities by the Government could address policy uncertainties about grid extension, as done in Sri Lanka recently.

Techno-economic assessment of solar energy based electrification is found to be relatively expensive compared to hydro based interventions. However, small scale microhydro systems would be cost effective only when optimally utilized. Though, subsidy schemes exist for better end use applications, what is required is to create income and employment opportunities to sustain the productive end uses and further lead to creation of additional productive end uses. Therefore, energy intervention should be combined with interventions having direct positive effect on income and employment at the local scale.

Institutionally, the sector requires better coordination and harmonization among various ministries, agencies, donor agencies, and other actors. AEPC by combining the entire donor funded programmes under one umbrella, i.e., National Rural and Renewable Energy Programme (NRREP) has able been able to better coordinate the programmes. However, there still exist legal entanglements across policies and acts, which require focused attention.



On the policy front, a long-term credit disbursement path should be declared with phased reduction of subsidies in order to develop sustainable off-grid energy sector. Pockets should be identified, where private entrepreneurs could take lead roles in promoting off-grid energy systems. In addition, in the name of quality control, private entrepreneurs should not be demotivated to introduce better and advanced technologies. Given limited strength of quality control authorities, ranges should be identified with flexibility to allow private entrepreneurs to innovate and introduce new technologies.

3.2.3 Sri Lanka Case Study

On analysing the case of off-grid electrification in Sri Lanka, it was found that of all South Asian countries, Sri Lanka has achieved the highest level of electrification—98 per cent of households are already electrified according to the statistics available in 2014 (Sarangi *et al.* 2015). Almost 95 per cent of the households are connected to the central grid system while the remaining three per cent are supplied with off-grid systems. The country has made a dramatic progress in electrification rate between 2001 (when only 53 per cent of households were electrified) and 2014. Strong political will and support, clear policy statements, active participation of donor agencies, and strategic intervention by government agencies and other players have resulted in such an improvement. Moreover, with grid reaching most of the country, the debate has moved to the next stage, grid-off-grid complementarity and grid connection of off-grid systems are dominating the policy discussions, which will be relevant for many other countries in the future.

The study reveals that the key leveraging points of success are robust community-centric interventions, well-designed credit systems, and well-structured capacity building initiatives. A comparative analysis between solar and micro hydro projects for rural electrification unfolds that microhydro systems are cost-effective compared to solar systems. The techno-economic analysis of existing microhydro project further reveals that there exist opportunities for more productive loads which could better the socio-economic profile of rural villages. The key set of challenges encountered by the off-grid sector are legal, social, as well as technical in nature.

Several policy recommendations could be drawn from the Sri Lanka case study, which could serve an effective lesson for other countries of South Asia and also for other regions of the world.

One of the key lessons is associated with the designing of off-grid programmes. It is important to conduct the exact needs assessment for designing of off-grid programmes. This is clearly evident in Sri Lanka case. The Energy Services Delivery (ESD) programme, the first major programme on off-grid electrification in Sri Lanka, was designed keeping in consideration that 300,000 off-grid households were using car

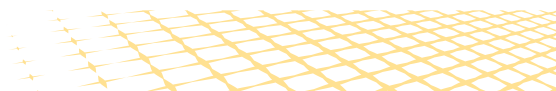
batteries for their basic electricity requirements. This indicates that the designing of a particular programme/project must be built upon the existing needs and requirements.

A second important lesson that emerged from the assessment of off-grid energy development in Sri Lanka is regarding policy and regulatory certainty for off-grid energy development, as spelt out in various policy statements. Specific reference must be made to the Sri Lanka Sustainable Energy Authority (SLSEA) Act which says that the national grid can be extended to cover 97 per cent of the population, and the remaining three per cent can be covered by off-grid systems. In the same vein, Ceylon Electricity Board (CEB) has come up with the list of villages for off-grid projects. This is also reflected in the approval process set for the operationalization of micro hydro projects. One of the initial approvals required for microhydro projects is to get certified by the CEB that the prospective area lacks access to grid and hence requires an off-grid solution. In addition, CEB was also required to certify that the village under consideration will not receive grid electricity in the next five years.

It also appears from the analysis of energy policies in Sri Lanka that some sort of policy learning has happened in the past. Policies are found to be modified on the basis of present challenges. For instance, the latest policy has emphasized the issue of tackling grid-interconnection matters—one of the burning issues worldwide, related to off-grid energy development. On the matter of subsidy disbursement, one can also discern similar policy learning. Recent policy statement on subsidies has the provision that the amount of subsidies disbursed should decline over the life of the project with the assumption that as the project moves closer to completion, systems providing electricity will also get cheaper.

3.2.4 Rice-husk as a Resource for Mini-grid-based Electricity Supply

Bhattacharyya (2014) has considered off-grid electrification through electricity generated from rice husk in South Asia. HPS has successfully used rice husks to provide decentralized electricity in rural areas of India and has so far installed 80 plants to electrify 300 villages. The success of HPS can be traced to their choice of technology, that is less capital intensive compared to other renewable energy options, their innovative approaches towards system cost reduction (e.g., using temporary structures made of bamboo poles for distribution network, local manufacturing of gasifiers) and additional income generation (e.g., use of carbon offsets and monetization of by-products), careful tariff design linked to Watts of demand instead of Watt-hours of energy used and careful siting of plants, where about 400 customers are willing to pay for the service. DESI Power on the other hand has placed emphasis on productive use of power and used husk-based systems to displace diesel-based electricity supply to micro-enterprises. It has also used anchor loads (such as supply to mobile telephone towers) to improve the financial viability of the business.



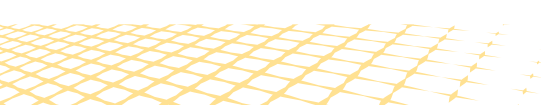
The financial analysis of rice husk-based power generation shows that the levelized cost remains high compared to supply from the centralized grid, when just the basic demand (of 30 W) of households is met. This is due to low plant utilization factor, but the tariff based on Watts helps generate the required revenue to run the system. As the system utilization improves, either due to higher electricity consumption by some or by integration of the supply system to the rice mill, the levelized cost of supply reduces. However, the benefits of such cost reduction are enjoyed by those who consume more when an inverted block tariff system is used. The integration of rice mill's electricity demand brings the costs down considerably due to extended use of the facility during off-peak hours. Such integration can ensure an anchor load and can be beneficial for the electricity supplier. The rice mill on the other hand, benefits from a reliable supply at a comparable price and reduces its cost arising out of electricity disruption. While the rice mill can develop a power plant for its own consumption, it is better to allow a specialized, separate entity to deal with the power generation business and develop contractual arrangements for fuel and power supply.

The extension of the analysis to include larger power plants for electricity distribution to a cluster of villages results in the cheapest cost of supply due to realization of economies of scale. The cost of supply in such a case can be very competitive even without any capital grants. This suggests that it makes economic and financial sense for a supply company to extend the business to cover larger areas as long as there are sufficient willing customers and adequate supply of rice husks from rice mills. This can also promote economic activities in rural areas and promote economic development urgently needed to reduce rural poverty. Yet, the regulatory uncertainty, limited access to financial resources and markets, increased complexity of the distribution network (i.e., it may require higher voltage permanent network systems to reduce losses), and higher dependence on a single or limited fuel supply source would have to be carefully considered. Such bigger systems would require careful system design to ensure adequate system reliability, appropriate maintenance, and limited line loss in distribution.

Being a major rice producing region, South Asia surely has a significant potential of utilizing a major agro-waste to produce electricity for rural supply and rural development. However, the barriers, mentioned above, need to be addressed to realize the potential. In addition, the potential for using rice straw alongside rice husk can also be considered for power generation.

3.2.5 Comparative Analysis of Solar PV Programmes in South Asia

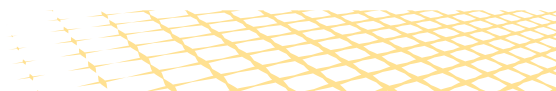
Palit (2013) examined the success stories in the dissemination of solar PV technologies in Bangladesh, Sri Lanka, Nepal, and India and found that improved access to capital, development of effective after-sales service, customer-centric market development, and regular stakeholder involvement assisted in scaling up of PV systems. Further,



output focused approach in Bangladesh and Sri Lanka offered the private companies and Microfinance institutions (MFIs)/Non-governmental Organizations (NGOs) incentives to enter new markets and deliver pre-defined products, while grants increased product affordability and covered a portion of the incremental costs of introducing clean energy products. Whereas subsidy mechanism in the case of India and Nepal did help to increase the penetration of decentralized solar applications, the institutional grant mechanism in case of Bangladesh (instead of a direct subsidy) helped in sales promotion as well as effective after sales service. A case in point here is from Chhattisgarh state, where ₹25 per household per month, provided by the government, was pooled by CREDA to create proper infrastructure facilities for proving the required maintenance of the SHS and Solar Mini Grids (SMGs). It is also observed that the delivery networks as well as the technological performance are comparatively better placed for solar PV than for other off-grid technologies, such as microhydro or biomass gasifiers in the region (Palit and Chaurey 2011).

The analysis also highlights financial innovation and private sector involvement, which are the two main factors that assisted in higher penetration of solar PV technology to enhance rural electricity access. However, since micro-credit is provided independent of income level, financial assistance from government programmes seems to have either not penetrated into the lower income households or the current financial mechanisms are not in line with their income level. Further, financial services have yet to reach everywhere in the region, and even though they exist in many areas, the relatively high interest rates still prevent economically challenged households to procure solar lighting solutions on the available financing options. The key issue which calls for immediate attention is rationalizing of the interest rate for micro-lending to cover poor households. Instead of direct subsidy by the government, flexible financial instruments, such as interest rate buydown, viability gap funding, output based aid, for both the end users and/or energy entrepreneurs and appropriate risk mitigation measures for the rural banking sector will be more effective in ensuring not only dissemination of solar products, but also their sustainability. There is need for creating a mechanism for easy access to credit and financing through simpler processes and better accountability mechanisms.

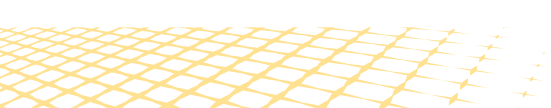
As off-grid projects are invariably smaller in capacity, concentrating energy loads in a given area or bundling projects can assist in increasing the market size. Off-grid solar projects could be identified in clusters, to ensure economies of scale and scope, which would help to manage them sustainably. For example, CREDA has been successfully running the projects in remote and densely forested areas, mainly because of the cluster approach followed for operation and maintenance. Financial institutions/banks would also be interested as project implementation and credit risks would be less. Bundling also can be helpful in minimizing the transaction costs associated to get carbon benefits.



Also, with more and more areas being connected through grid electrification, the market for solar PV systems in case of un-electrified areas is being pushed to more and more remote areas. The traditional market approach is being followed in most cases, but the available financing options may not be suitable to cover such remote areas with low disposable income. Such areas could be covered through the pro-poor public-private partnership (5P) model. The 5P approach can explicitly target the provision of services to poor communities, which are often ignored by traditional PPPs since supplying the poor can involve substantial business risk. Each of the stakeholders in the 5P model can play a different role with the common goal of promoting access: private sector participants can meet their corporate social responsibility obligations; utilities and energy companies can fulfil their obligation to deliver basic services; communities and members of civil society can expand access to basic services.

Also, the fee-for-service model for renting of lantern from a Solar Charging Station (SCS) or providing only lighting service from Solar DC Micro-grid (SDCMG) may be closer to the need of poor sections of population. Wong's (2012) research also corroborates the fact that without the support of any micro-credit systems and where poor people are expected to pay for the service by their own means, they prefer to pay for the 'service', rather than own the solar lighting systems since this exerts less financial pressure on the poor households. Simultaneously, it also fosters a sense of ownership that is essential for co-financing the technology. However, the amount required in setting up SCS or SDCMG grid is high when compared to equivalent number of individual lanterns/lamps with small panels. This is because of the poor reach of existing solar installers and unavailability of adequate technical capacity to install such systems in remote rural areas, thereby increasing their cost. These call for improved design efficiency, use of mobile telephony for fund transfer to reduce transaction cost, and economy of scale and development of local operations to foster a large pool of talent in remote areas for overall cost reduction.

A hybrid model of SCS with SDCMG can be an ideal enterprise based model for providing lighting and value added energy services. The SCS will provide lamp/lantern recharge to villagers who live away from the micro-grid station and cannot be connected by the SDCMG due to high costs of extension lines. On the other hand, the SDCMG will provide access to lighting the households, who do not wish to travel for collecting the lanterns. The cost structure of the micro-grid can be kept slightly higher in comparison and this customized model will benefit two levels of income within the Base of Pyramid (BoP) population. The modular design of the SCS and SDCMG also offer the advantage of demand-based capacity expansion. The capacity can be enhanced with additional PV module(s) and/or also in hybrid mode with any other renewable energy technology, such as wind-electric generator, biomass gasifier-based power-generating unit, etc., to provide power for productive applications in addition

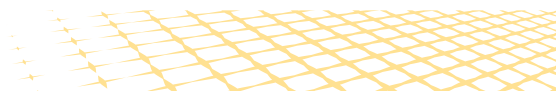


to lighting needs. They can thus function like a micro-utility in the village that can offer battery charging facilities as well as other applications such as mobile telephone charging, water purification, powering computers, television sets, etc. The enterprises can also have the option to sell solar lamps and energy efficient cook stoves to meet any demand in the villages, thereby acting as rural clean energy hub.

Added to this, developing necessary infrastructure and technical capacity at the local level for developing the last mile distribution channel and providing after-sales services is also critical. In many cases, villagers have had an experience with poor-quality products, or inadequate after-sales, which has brought about bad reputation to the solar solutions. There is thus a need for strict adherence to quality assurance and quality control of systems. This can be best achieved by the solar industry, who can pool their collective expertise in and develop the code of practice/standard operating practises for installation of off-grid systems as well as standards and quality parameters for the products. Added to this, technical feedback on product performance has to be regularly collected and effort should be made to develop customized suite of products best suited for rural areas.

Further, the capital cost of solar PV systems also need to be brought down through the use of upcoming technology such as LED lamps, instead of the Compact Fluorescent Lamps (CFLs) that are currently being used in most solar PV projects. The advantages of LEDs that make them suitable for solar lighting solutions are: reduced maintenance, ability to be dimmed, cold start capacity, and operability at low voltages, thereby reducing the size of battery and of PV module (Babu 2008). The capital cost can be brought down by 25–30 per cent, because of reduced panel size, freight, and storage cost. The Energy and Resources Institute (TERI) shifted to LED lanterns from CFL lanterns under LaBL, without compromising on the illumination level, and have achieved almost 30 per cent cost reduction in terms of lumen-hour for solar lanterns (Palit and Sarangi 2011). The shift to high efficiency LEDs with subsequent cost reduction will ensure that the economically challenged population takes advantage of the lower system cost, thereby improving the access to these deprived sections of society. The operating solar PV programmes in the region should target to introduce LED lamps, without compromising on the quality and level of illumination, to its existing technical model to cover the poorer households.

Another way to reduce the price of solar PV systems or meeting a part of the maintenance cost could be through the use of carbon funds. Solar PV systems directly replace kerosene or other fossil fuels used by households and thus offer an opportunity to the project proponents, system dealers, and customers to accrue carbon benefits by reducing the CO₂ emissions. However, as decentralized solar PV systems replace very small amount of kerosene or diesel, the challenge is to meaningfully bundle the number of systems operating in a country to make it a viable candidate for carbon financing.



The magnitude of reduction in Greenhouse Gas (GHG) emissions depends on the capacity of the systems being used in a country. Studies differ in their estimation on the quantum of carbon abated from a system such as SHS. For example, while Chaurey and Kandpal (2009) show that 50 Wp SHS have the potential to mitigate about 67.3 to 298.4 kg CO₂/year (depending on baselines used), another study (Wang et al., 2011) suggests that a standard SHS with 40–50 Wp capacity could reduce 76 kg CO₂/year. Chaurey and Kandpal (2009) further estimate that carbon finance mechanism could reduce about 15 per cent of the capital cost of 37 Wp system, considering that transaction cost of around 20 per cent of the revenue is involved in getting the carbon revenues. The author's estimates indicate that at the current Certified Emission Reduction (CER) price (around \$12/tCO₂), around one per cent of the cost of typical SHS can be recovered annually from CERs, which can probably be utilized for post-installation maintenance of the system to ensure technical sustainability. Although there is huge potential, current statistics reveal that very limited number of projects in South Asian region have received carbon benefits. Existing transaction cost barriers and current ways to bundle up small sized projects may be acting as key roadblocks to accrue the carbon benefits. A way to address the high transaction cost could be through Programme of Activities (PoA) route of availing carbon financing. The PoA offers the flexibility of one-time registration with its duration extending up to 28 years and addition of any number of CPAs during this duration, which have been developed using the same approved baseline and monitoring methodology for a particular technology. Further, the physical boundary of a PoA may extend to more than one country, indicating that the PoA can be developed at the regional level, thereby also getting benefits of economy of scale.

Lastly, for the solar sector to reach a significant scale, companies need to remove barriers to supply, demand, and scalability and at the same time adopt standard process and metrics, which will also help them to attract the necessary level of investment from financial institutions and venture capitalists supporting 'green' programmes. The strengthening of the finance, distribution, and after-sales service chain by facilitating the development of local capabilities to micro-finance, assemble, supply and service the systems will not only facilitate enterprise development on the supply side, but could also potentially enhance livelihood activities that can be linked to the provision of electricity services. The opportunities have to be seen not only from the rural electrification opportunities, but in the larger context of enhancing energy security of the nation.

3.2.6 Chhattisgarh Solar Mini-grid Study

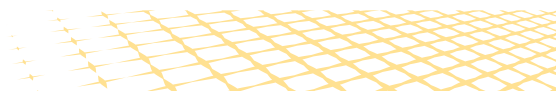
An attempt was made to present an analysis of the development and operation of the solar mini-grid model for enhancing electricity access in India, with special focus on the state of Chhattisgarh (Palit *et al.* 2014). From the study, it was observed that the

rate of success of mini-grids is directly dependent on the government's commitment to create an enabling environment, which includes having a clear cut policy framework and milestones, systems for defining and enforcing appropriate technical standards, financial support mechanisms both towards installation and operation, and support for capacity building. The Chhattisgarh state has developed a robust institutional framework not only for implementation, but also for ensuring responsive after-sales service and maintenance of the solar mini-grids in the state, paving the way for success of the programme.

While there may be a debate on what constitutes success, the model followed in Chhattisgarh is highly subsidized and the capacity of the power plants are designed to take care of only lighting load, there is no denying the fact that the provision of basic minimum electricity access to population who are at the extreme base of the pyramid is also important and requires innovative approach for success. While, many mini-grid projects fail in such remote areas because of lack of strong institutional framework and maintenance services, the implementing agency, CREDA, has been successfully operating and maintaining the power plants by utilizing the fund made available by the state government towards the operational subsidy.

The mini-grids have also proved to be a reliable solution for such remote areas in comparison to SHS. Technically, mini-grids were preferred over other modes like solar home-lighting systems and solar lamps, as they provide electricity services for lighting as well as running minor appliances, whereas solar home-lighting systems and solar lamps typically provide only lighting services. Organizationally, Chhattisgarh experience shows that managing mini-grids may be easier compared to individual systems due to their centralized operation in a village through a proper institutional structure. Further, the design also ensured that any future demand, in the form of new household connection or power for community load, can be catered to. The standardization of design and operation and maintenance model by local-level service providers also ensured that the solution was cost-effective at the local scale. The system also did not lock-in the community to a particular development path as the mini-grid capacity could easily be enhanced by addition of modular capacity in case of enhanced demand for any productive loads in the future, which otherwise would be a constraint in case of individual solar home systems. In fact, the study clearly brings out this fact of capacity enhancement which has been carried out in case of some villages using dismantled systems from other project villages where grid has reached over time.

Another key lesson from the mini-grid experience reveals that appropriate support systems should be a mixture of both 'participatory approach' and 'top-down approach'. While issues of a local nature could be better addressed through a participatory governance structure, technical, policy, and financing matters can be dealt with at the appropriate intermediary and/or higher level. It is important to design support

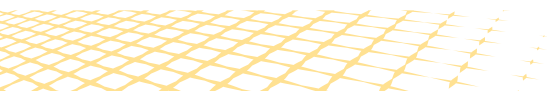


systems so as to ensure that plans and policies match the needs of all stakeholders—consumers, owners, and technology suppliers. Also, a divided ownership model, where operation and revenue collection have been kept independent of each other, is seen to bring better focus on generation and distribution. Lastly, the study recommends that for the renewable energy-based rural electrification sector to reach significant scale, implementation agencies need to work on overcoming the challenges of supply, demand, and scalability and at the same time adopt standard processes and metrics, which will also help them to attract the necessary level of investment from financial institutions in support of ‘energy access’ programmes.

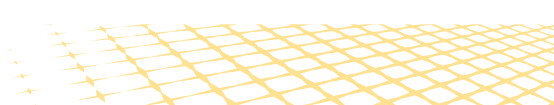
3.2.7 Isle of Eigg Study

Chmiel and Bhattacharyya (2015) analysed the Isle of Eigg off-grid electrification system which clearly shows that an off-grid system can support the electrical energy needs of a modern life style. The residents of the island are enjoying a reliable supply of electricity that meets their requirements effectively but more importantly, their carbon footprint has fallen considerably as about 90 per cent of their electricity comes from renewable sources of energy. It is reported that the CO₂ emission per household in the island is 20 per cent lower than the rest of the UK. Lessons from this experience are as follows:

- ☀ A suitably designed off-grid system can be an effective electrification option for any developing country. This experience confirms that reliable and modern lifestyle enabling supply can be ensured through an off-grid system and that such a system is not inferior to the supply obtained from the main grid. An off-grid supply need not be a temporary or a pre-electrification option. This is an important message given that policymakers and users are not always aware of successful examples and inaccurate or wrong impressions influence their decision-making.
- ☀ Yet, the cost of supply remains a major challenge. Based on simulations of the Isle of Eigg system, the study finds that the residents are paying a tariff that is equal to the operating cost of ensuring the supply without taking capital investment costs. Even this level of tariff is much higher than the tariff for a comparable supply from the central grid, elsewhere. This is still the case despite the high share of hydropower in the electricity supply mix in this island. Although the residents have reduced their expenses on diesel fuel and alternative energy supply options (such as batteries), there is no denying the fact that even the operating cost recovery makes the tariff high and unless the users are able to pay such high tariffs, an off-grid system cannot become operationally viable. In this example, islanders have accepted the cost and are able to pay, which remains an issue in many developing countries, particularly in rural areas where income may be limited and villagers may not be able to afford paying high charges. Thus the second lesson is to design



an effective tariff system to ensure the financial viability of an off-grid system, without which a sustainable supply cannot be ensured.

- ☀️ A related issue is the funding of the investment for developing the system. The initial investment for the off-grid system per resident was above £44,000. Clearly, mobilizing such investments is not a mean task. For this island, the funding came from various sources with residents contributing about six per cent of the cost. Unless such capital subsidy arrangements can be developed, poorer countries will find implementation of off-grid electrification projects very challenging. Thus the third lesson that the Isle of Eigg offers is that even in the context of a developed country, capital subsidy cannot be avoided for off-grid electrification and that the poor in developing countries cannot be expected to pay for their off-grid electricity supply systems. Sufficient grant fund has to be mobilized to create the electricity infrastructure in developing countries.
 - ☀️ This study also confirms that in order to ensure a reliable, round-the-clock supply from an off-grid system, demand assessment and demand management remains very crucial. There may be some periods of excess generation, while there are other periods when the supply will be constrained. An equitable and fair energy budget for all users and a smart energy monitoring system are essential to ensure effective user engagement in managing the supply-demand balance. The fourth lesson, therefore stresses the need for active user participation. The success of the system crucially depends on the active cooperation of the users who manage their demand effectively using the energy monitoring system. In a small system with limited diversity of demand, balancing supply and demand is always a crucial task and just relying on the supply-side management cannot ensure a reliable supply.
 - ☀️ The fifth lesson is that the simulation also highlights the importance of system design and component selection for a cost-effective outcome. As indicated earlier, the island system was over-designed to ensure high system reliability. In fact, the diesel generator capacity itself is much higher than the demand, although such a non-renewable option would lead to an excessive cost of supply (£1/kWh). The study finds that similar levels of reliability could have been achieved with 80 kW of diesel generator capacity (instead of 160 kW installed at present), but this would require using smaller generator sets that can be maintained and operated as required. Similarly, a better result would emerge if more wind turbines were installed instead of solar PV in this site. Direct feeding of AC load from AC sources could reduce the inverter and battery capacities requirement and could also enhance the reliability of supply (simply because the entire system does not depend on batteries in this case). The technical choice has significant cost implications, particularly for capital investment and a careful system design with innovative smart features can offer better value for money.
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This work provides a real example of a successful off-grid electrification system in a Scottish island and confirms that it is possible to supply electricity 24×7 from a hybrid off-grid system to support the electricity needs of a community leading modern lifestyles. It thus clears the misconception that off-grid electrification is just a temporary or an inferior solution for the developing world and shows that a properly designed off-grid system can be a viable alternative to grid extension in remote areas. With 90 per cent of electricity generated from renewable electricity and the backup system being used occasionally, the local grid has successfully reduced its carbon emission from electricity generation and can be a role model for many off-grid projects.

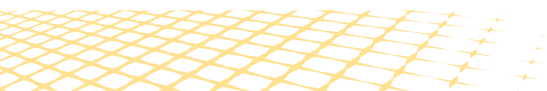
The study shows how important it is to carefully estimate the available renewable resources to design the system so that energy can be harnessed in the most efficient way. Demand management also plays an important role which requires active participation of the users. An enthusiastic user group that appreciates the challenges and plays the game for a cooperative solution has helped the island in sustaining its off-grid solution.

Developing countries that are in the process of enhancing electricity access can learn from this successful experience. Most communities to be electrified in these countries will have a much lower electricity demand than in this island, as users would often look for basic lighting, mobile charging, and some sort of micro-enterprising. This radically minimizes the cost of the micro-grid needed to fulfil these needs. In cases where continuous power is necessary, some sort of backup power is needed and usually a diesel generator serves the function. With careful initial planning, upsizing of the grid is totally possible in case of future development. Fulfilling higher demand also brings a lower cost per unit of electricity what can be crucial for poor developing communities.

3.2.8 Livelihood Linked Clean Energy Models from India

Mahajan and Fernandez (2014) have analysed two case studies (SHS and pico-hydro systems) supported under REEEP (Renewable Energy and Energy Efficiency Partnership) programme using a common framework of identifying need-based energy technology and suitably tailoring it to fit the pockets of the poor. They offer seven main conclusions for energy development practitioners and policymakers based on these case studies.

- ⚙️ Developing innovative and participatory energy delivery models for rural households is a time and resource intensive task and very few organizations would look at it as a profitable business. Hence, the initial grant support (such as from REEEP) plays a critical role by allowing project implementers the flexibility to innovate and experiment with different models and in absorbing the risk associated with piloting/demonstrating the project.
- ⚙️ However, the disadvantage with grant support is that if the organization

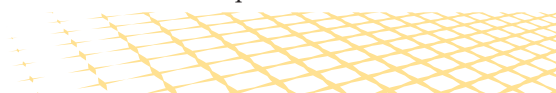


continues to exploit grant funding year after year, in the long run it could restrict entrepreneurial approach and make a project more dependent on external support. Therefore, grant support should be designed such that it is used to develop models and plans to guarantee long-term private sector investments and attain commercial viability.

- ☀ To measure the success of any business or financial model, extensive field survey is crucial, that includes all the parameters from resource availability, beneficiaries' portfolio mapping, and studying relevant demographic characteristics.
- ☀ For the people who have lived without electricity for decades, these technologies have provided them with luxuries that they never experienced. This impact cannot really be qualified, but we can certainly see the difference that good quality clean energy technology can bring about, especially for women, youth, and children by opening new possibilities, making them a part of decision making and possibly empowering them. These factors create a sense of belonging and dependence towards the technology, thereby improving its sustenance.
- ☀ The solar home lighting case study has proved that aspects, such as user capacity building, affordable and timely servicing, and maintenance play an important role in long-term sustainability and project replication. These help improve the reputation of the technology provider.
- ☀ The pico-hydro case study demonstrated importance of providing consistent good quality electricity supply in rural areas that have the capacity to match the grid supply, electricity that could be used not just for lighting but to run televisions and home appliances. But it failed to set-up a mechanism to improve the productive use of this supply using the electricity generated and thereby improve the capacity utilisation factors of the pico-hydro systems.
- ☀ Implementation models that catalyse strong linkages at the rural level between energy services, income generation, and appropriate financing may show better community acceptance. But these systems should be flexible enough, so that they could be expanded in case of higher demand and generation requirements.

3.2.9 Solar PV-based Lighting

Borah (2013) analysed solar PV-based lighting systems and found that one of the positive aspects of electrification is eradication of kerosene use for lighting. However, it was found that households having more than two rooms are still using kerosene to meet their lighting needs. For SHS, it was found that households still relied on kerosene for their lighting needs because of the provision of two CFLs with the system and the provision of four hours of backup for just two rooms. This was not sufficient to meet the lighting demand of the households. The SHS systems need to be replaced with LED lamps. The reason for these recommendations is that two CFL bulbs require a minimum



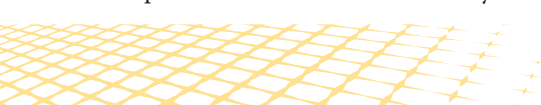
of 18 W (9 W each). However, when replaced by LEDs, a total of six LED lamps of 3W each can be supported by the same system capacity with a backup of 4–5 hours.

During this study, it was found that Solar PV programmes with strong management and monitoring mechanisms had shown a positive indication in the operation of the systems. With a good management structure, the users were satisfied with the support provided to them in maintaining the systems. Good management structure would help bring transparency to the flow of information between the Project Implementing Agency (PIA) and users, leading to faster and efficient addressing of issues in a programme. An institutional structure forms the main link between the PIA and the users and maintains the information flow in the hierarchy.

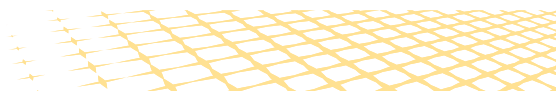
This study has also found that various institutional innovations can actually be a boon in the sustainability aspects of PV programmes. Innovative practices in delivery model ensure consumer satisfaction and sustainability of the projects. Entrepreneurs related to systems, such as SCS and SDCMG, play a vital role in the maintenance, operation, and management of the systems. A dedicated entrepreneur happens to be a key factor in the sustainability of such projects. Efforts to provide best service should be the prime aspect of an entrepreneur. Entrepreneur selection should not be done on its capability to pay for setting up the system, but should also possess good attitude towards the importance of maintaining user satisfaction and good health of the system to provide the best service to the users.

The study highlighted how the presence of strong technical assistance and proper training initiatives has been a key to the successful running of the PV programmes. Capacity building should be the key emphasis in such projects. Findings have revealed that users with good understanding of the system have shown a positive attitude towards the systems and service provided to them. Also, the level of sensitization in all stakeholders has shown benefits in the delivery model. Provision of after-sales technical support happens to be a major concern in maintenance of the systems. Programmes with good technical support from the technology provider have contributed to the system wellbeing. Most of the government funded projects lagged in the after sales service provision, but in case of the private and bank funded projects, it was found that the PIAs have involved local energy enterprises to provide the after-sales service to the systems. Since the energy entrepreneurs are directly involved with the technology providers for supply of parts, this removes the involvement of PIA and leads to faster acquisition of spares and speedy rectification. Technology provider should provide the best of after-sales service to their related projects. Insincerity on their part could lead to complete failure of the systems and the project.

The study reveals that users treat SHS differently, depending on how they have acquired them. Users showed less sincerity in maintenance of the systems which were provided free under the subsidy scheme. Involvement of user's money gives a sense



of ownership and make them responsible to look after the system, as the beneficiary knows the value of the money they have put in the system to acquire it. Lastly, for the sustainability of PV programmes in India, strong technical, institutional, and financial aspects are the key contributors. This paper, based on comparative analysis, highlighted how institutional aspects of a PV programme, irrespective of the technology, have been the main pillar for the viability of the programmes. With the presence of a strong institutional structure, there is a need of transparency in communication among the stakeholders of each programme. This study highlighted that the technology is not the only factor on which the sustainability of such programmes can be decided, but institutional and financial aspects are very important factors that contribute to the sustainability of the programmes. Developing a strong framework and institutional policies is the need of the hour for achieving higher success rates in PV programmes as revealed in this study.





Demonstration Project Experience: Enabling Environment

As part of the OASYS South Asia project, action research through demonstration activities was undertaken in India, which allowed a better appreciation of various issues related to off-grid electrification through mini-grids using different delivery options. Sharma and Palit (2014) present some thoughts about creating the enabling environment based on the above experience. They argue that various stakeholders are involved in an off-grid project and they have very different expectations from the project. These expectations must be the guiding principle for deciding how an enabling environment has to be created. For three key stakeholders, the following may be classified as the expectations from an energy access project:

- ☀ **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 that 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.

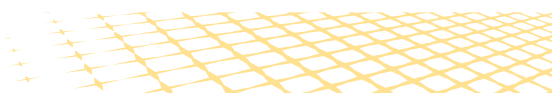
The key message here is that while designing programmes and enabling policies, it is important to keep in mind that the success and sustainability of a programme is defined differently for different actors and socio-economic geographies, and a 'one size fits all' approach does not work.

A second message relates to the readiness of the private sector in undertaking off-grid electrification. TERI approached a number of project developers with proposals for establishing a private investment led mini-grid model in Orissa demonstration site (with OASYS project contributing to the capital cost), but no developers were willing to work in this area due to perceived high investment risks arising from low-paying capacity of the community, a scattered population, and unpredictable load growth. A community-based delivery model with capital subsidy from the OASYS project

was chosen (with contribution in the way of land, some labour, and token connection cost from the community). It is expected that over a period of two to four years, the enhancement of income through the productive uses of electricity will enable users to purchase appliances which in turn will add 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. 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 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 the mini-grid project in Odisha, 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 agriculture (water pumping), through appropriate institutional mechanism. While electricity and other developmental interventions are included in the domain of Panchayati Raj Institutions (local level administration) in India, to create the necessary convergence in rural areas, the required awareness and capacity building has never been provided to these local institutions to implement and operate projects at the local level through a more decentralized planning process.

In addition, another 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

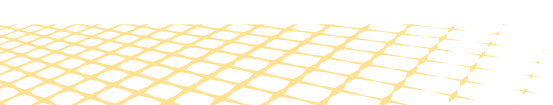


representatives, utility company representatives, NGOs, and civil society organization representatives, and independent private operators of distributed generation power plant. Further, the capacity development should be a continuous initiative and the length of such engagement with local actors may depend on the level of absorptive capacity of a particular community and or local institution.

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 five years approximately. 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 and also spread the remainder of the subsidy over the project lifetime, based on functioning of the plants, to assist in meeting such costs. 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 devise 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.

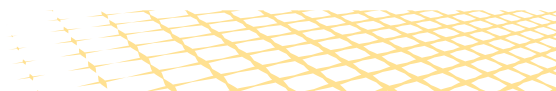
While the cost of such a scheme may be higher (TERI's preliminary calculations show that such a subsidy would amount to 1.3–1.5 times the capital cost of the power plant, over its lifetime), the benefits of long-term sustainable operation need to be factored in while taking a decision on whether the subsidy is feasible or not. In addition, 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 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.

The OASYS project has also supported private off-grid service providers such as Mlinda Foundation and MGP. A formal bidding process was invited from over 20 private players operating 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 MGP were selected and were recipients of the VGF. The remaining funds for the projects were raised through debt and equity. The key message here centres 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 Joint Liability Group (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.

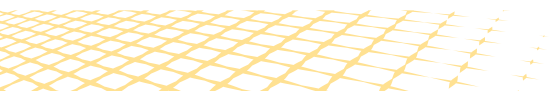
Thus in such cases, the households provided electricity access through solar pico-grids in the Sundarban region, where end users have the capacity to pay and financial institutions are willing to sanction loans, we see that a different set of enablers are required. From the point of view of the end user, 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. 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 per cent 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 now 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. 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 financier's point of view, it is important to work towards creating institutional



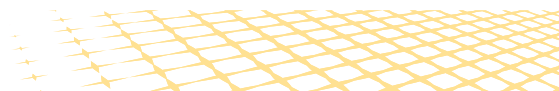
arrangements and guarantees, which convince the bank of the viability of their investment, even if it is for the low-income group customers.

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 ₹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 a lifeline tariff of about ₹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 ₹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 user's 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 often do not 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 a cause of large number of defaults on payment in rural areas and an 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 Minda 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 three 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 MGP, 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 two 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 per cent. 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.



The above examples 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, it can be said 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. While 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 programmes.





Scaling Up and Replication Studies



Off-grid electrification through local mini-grids or individual systems (such as solar home systems, solar lanterns, etc.) have emerged as an alternative option and over the past two decades, a significant level of experience has been gained through various experiments, pilot projects, and socially-oriented ventures around the world. However, in a majority of the cases, these initiatives were supported by international donor agencies or multilateral funding agencies and often involved pilot projects, or test experiments and many such initiatives ended, once the support was withdrawn at the end of the funding cycle. Similarly, there are other examples where a bundle of projects were supported under a programme, but the electrification activity as such did not continue along the programme lines, once the programme ended. Yet, in order to achieve the SE4ALL electrification objectives, there is a clear need for a step change, so that successful experiences can be replicated at a faster rate.

Bhattacharyya and Cook (2013) have highlighted the technical, financial, organizational, and regulatory governance issues related to replication and scaling up of off-grid electrification. They argue that if the S-curve of market development, with distinct three stages (namely preparation, take off, and scale-up) (see Fig. 5.1), is used, the status in most of the countries with respect to off-grid options will come under the preparation and market test phases and only a few will prepare for take-off in some areas.

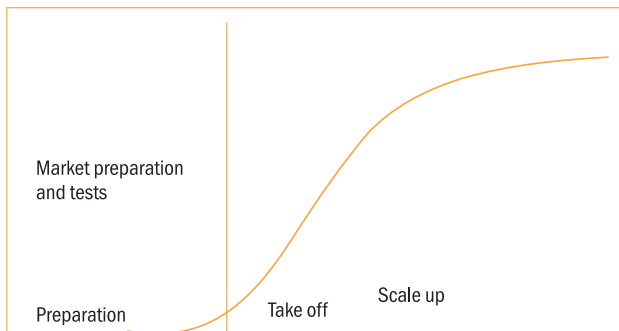
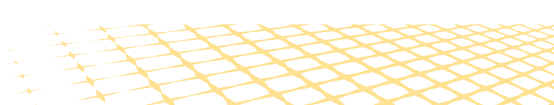


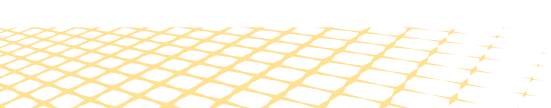
Fig. 5.1: Off-grid market development phases

They argue that:

- ⚙️ The technological options that can be used to provide electricity would be conditioned by the local resource availability, local demand conditions, and alternative combinations of technologies that can ensure the desired supply. To what extent a local grid system can be replicated and whether it is really amenable to duplication becomes an important issue.
 - ⚙️ Moreover, when a large number of isolated systems are created, they may involve different technologies, different system specifications, and operating standards. Some may use AC systems while others may be DC-based. Some may use over-ground temporary networks while others may rely on underground cables. The system voltage may vary as well. More importantly, each of them may or may not have the capability to connect to the central grid. There is a danger of creating island systems that do not talk to each other and such islands can prove to be costly in the long-run when the systems grow and they need to take advantage of networking for better reliability and system operation.
 - ⚙️ When a pilot project is scaled-up, the system configuration changes proportionately but the resource availability may not change in the same proportion. Therefore, the appropriate configuration that matches the resource availability and the demand may be different than the scaled-up configuration. Therefore, when a larger jurisdiction is considered for a mini-grid, the scaled-up prototype may not be the most appropriate solution.
 - ⚙️ Given that the grid is expanding in all countries and for political or other reasons, no government will say that the grid will not be expanded to particular areas, it is important to discuss whether future mini-grids should be completely off-grid or there can be interconnection of many mini-grids which can finally be connected to the grid at a later time or as and when the grid extends to such areas.
 - ⚙️ A further related challenge is to ensure appropriate management of the off-grid systems to deliver the desired services. For a mini-grid system, this not only involves managing the fuel supply system for generation but also other distribution and retail business activities including network maintenance, billing, and revenue collection. Moreover, technically-skilled human resources are required to operate and manage the local mini-grids. These systems can involve various degrees of sophistication and complexity and accordingly, the skill requirement varies. Finding sufficiently skilled workforce, training them for the job, and retaining them can be a challenge for any given project. The problem aggravates when the human resource has to be multiplied in association with the replication programme. Aligning the human resource development programme with the off-grid development programme remains a challenge.
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They also list a number of financial challenges that surround any rural electricity supply project in a remote area.

- ☀ First, the size of the investment is too small to be attractive to any financial institution, as their threshold transaction level tends to be \$20–25 million. Bundling of projects can avoid this problem if the promoter has a sound financial condition. It remains demanding to ascertain whether a promoter can support a few hundred of such small projects or not.
- ☀ Second, when the projects are managed locally, the village cooperatives or associations have limited borrowing capacity and do not have the required deposit or bank guarantees for availing any debt finance. Generally, commercial banks or local financial organizations who lend for such projects often require 100 per cent (or even more) guarantee for the credit provided, which proves to be difficult to comply with.
- ☀ Third, most of the projects sell their output to poor households and small commercial entities. Unlike power generators selling their power to the grid or to a large consumer through a bankable contract, the sale in these cases is highly distributed. Similarly, a community-based project is viewed as a non-commercial activity and so project finance is not extended by most financial institutions. In the absence of a bankable agreement, the project company cannot finance its projects through project financing.
- ☀ Fourth, given that the cost of off-grid supply is generally higher than the tariff charged for the grid-based supply, and because the paying capacity of the consumers tends to be low, cost recovering tariffs may discourage consumers to avail off-grid electricity. In such cases, subsidies to reduce the cost may be unavoidable. However, the sustainability of such subsidies in the long run is an issue, given the budget constraints of the governments in most countries.
- ☀ Fifth, many projects need component replacements during the project life and the revenue collected from the consumers may not be sufficient to take care of these capital needs.
- ☀ Sixth, the risks involved in doing business in remote areas can be perceived to be high, which in turn can lead to higher borrowing costs, thereby affecting the project viability and investor interest in the project. A related challenge comes in terms of financing logistics to set up plants in far flung remote villages. Private investors largely focus on ‘not-so-remote areas’ as a result. The question that thus arises: “Is there a need to split the entire off-grid energy market into different categories based on distance from grid?”
- ☀ Seventh, alternative streams of income have been considered by some projects from carbon credits or monetization of byproducts. However, their contribution



tends to be less and the funds flow at a later stage of the project operation in most cases, thereby not helping much with the financing challenge.

Finally, given that the donor and multilateral funding agencies have played an important role in providing capital support in this area in many countries, there remains a dependency on donor support. However, whether this can continue for long and whether donor support would be sufficient to meet the capital needs of off-grid electrification remain to be seen.

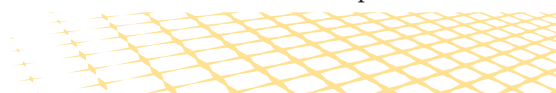
The regulatory challenges include the following:

- ⊗ As there can be numerous small, off-grid systems in a country, the regulatory burden on the regulatory agency as well as the regulated entity can be huge. Already, most of the developing countries are experiencing regulatory capacity constraints and the additional mandate can deteriorate their performance. On the other hand, if the business remains unregulated, consumers may not get a good deal.
- ⊗ The pricing issue comes as another challenge. As each supplier may rely on its own specific configuration of technology, the cost of supply can vary even when two mini-grids are located next to one another. Will each supplier charge its own tariff or will there be a common regulated tariff? How will this be different from the centralized grid tariff? Who sets them and how will they be modified? Will the tariff be remunerative for the operator? Will there be any subsidy? How will this be accounted for? All such questions can be raised.
- ⊗ The issue of quality control, monitoring of performance, reporting of incidents, and consumer protection will assume importance when diverse technologies, business models, and delivery options are used. Managing these require a strong regulatory capacity, which is missing in most developing countries.
- ⊗ Do these businesses need protection from competition? What happens when the grid is extended? How does the investor recover costs or how will his investment be protected? Will inter-connection of mini-grids to the national grid require a new set of electricity regulation?

As an introduction to the scale up and replication issues, (Bhattacharyya and Cook 2013) did not provide answers to these issues but these pertinent issues highlight the challenges that exist in scaling up and replication of off-grid electrification.

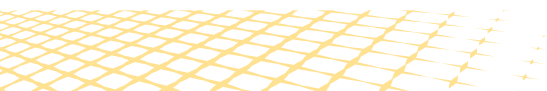
Another study analysed the scaling up and replication issues related to off-grid electrification (Krithika *et al.* 2015). The study carried out an extensive literature review and considered a number of off-grid projects/programmes. The main conclusions of the study include the following:

- ⊗ First, financial assistance/support for energy enterprises or project implementing entity emerges as a critical factor. The type of financial assistance should depend



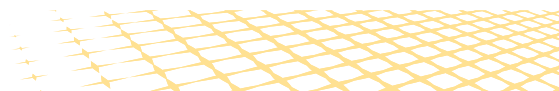
on the stage where the entity is, on its scaling up trajectory. Most of the times, for private energy enterprises, scale up finance to operate commercially is found lacking and it is here where these entities require support. Another critical requirement is the finance for working capital that is required to manage day-to-day operations. It is evident that grants have come to play a pivotal role in scaling up and if administered well can even propel an entity's growth (as seen in the case of Husk Power). The other key learning as far as financial assistance to energy enterprises is concerned is the need for 'flexibility'. Flexibility is required in loan repayment terms and in terms of the conditions that are tied to the debt provided by financiers.

- ☀ Performance milestones should incentivize the project developer to sustain a project and scale it up. For instance, capital subsidies which are provided to project developers only provide an incentive to build the micro-grid or solar power plant and do not incentivize long-term operation. Capital subsidies provided to project developers turn them to technology suppliers rather than serious investors seeking to scale up the project and earn a return on their investment. An effective alternative is performance-based subsidies. However, performance-based subsidies have not been much experimented with. It is argued that subsidies, wherever necessary, should be given related to the performance of the project implementing entity so that scaling up strategy is in-built in the design, or should be completely done away with as they have distortionary effects on the market.
- ☀ Monitoring and evaluation of projects is a must for developing a scaling up strategy or even evaluating whether a scale up is required. It is usually performed as a compliance requirement in most donor funded projects without a clear evaluation strategy. A set of KPIs should be clearly defined and realistically assessed before deciding the scale up strategy.
- ☀ Given all the elements of potentially scalable projects, a project/programme/enterprise can end up having very different scaling up trajectories given the entity or actor which is scaling it up, thereby underscoring the importance of an actor. Evidence shows that government and private sector on their own have a medium to high scalability potential, whereas NGOs because of their inherent structure are not designed for large scale ups. These entities get to scale through different agendas—mission, margin, and mandate as has been noted by a few researchers and a mutual partnership results in the formation of hybrid entities, such as social enterprises or Public–Private Partnerships. In the context of electricity access, it is found that, be it private or NGO-led initiative, government support through enabling policies, favourable regulatory regime, or a partnership with government for implementation is essential to achieve scale. Private or NGO-led initiatives cannot scale up on their own while excluding the government. At the same time,



partnerships amongst these actors (Government + NGO, Government + Private, Private + NGO) can also deliver good results.

- ☀ Depending on the level of scale, different actors come into the picture and often this may result in an increase in transaction costs. To put it more clearly, as a project scales up from a local to national to international levels, the number of entities it has to deal with multiplies and so do the transaction costs associated with each entity. It could in certain cases also lead to a conflict of regulations and laws. Many a times, energy enterprises which have traditionally operated at a smaller scale do not have a full overview of the applicable rules, policies, and challenges. In several developing countries, regulatory frameworks and legal frameworks are being defined (i.e., they are not in place), which could be detrimental to energy enterprise as getting licenses takes time, sometimes longer than the donor is prepared to wait. Even if the enterprise is working on getting the licenses and approvals before applying for donor funding, national authorities may not cooperate as they work on resolving these issues, only when there is an urgent need or inquiry. This may hinder the scaling up process, therefore, scaling up needs to be thought of with clear planning and pre-empting solutions.
- ☀ Finally, the question of when to scale up energy access project or programme remains debatable due to lack of sufficient evidence. While evidence shows that it is difficult for most energy access projects/programmes to scale up before five years, yet, it could take longer. It remains a moot point as to what is the best time to think of a large scale expansion. This clearly emerges as an area requiring further research.





Policy Recommendations

Based on the academic and action research carried out through the OASYS South Asia project, the following policy recommendations are made:

- ☀ **Recognize varying needs and multitude of solutions:** Local contexts vary from one location to another and solutions must adapt to the local contexts. There exists a continuum of options covering the basic needs and going up to the modern life styles. The local condition often influences the appropriate choice but a progressive development path over a period of time will ensure a transition from basic level of services to conditions suitable for modern living (see Fig. 6.1).

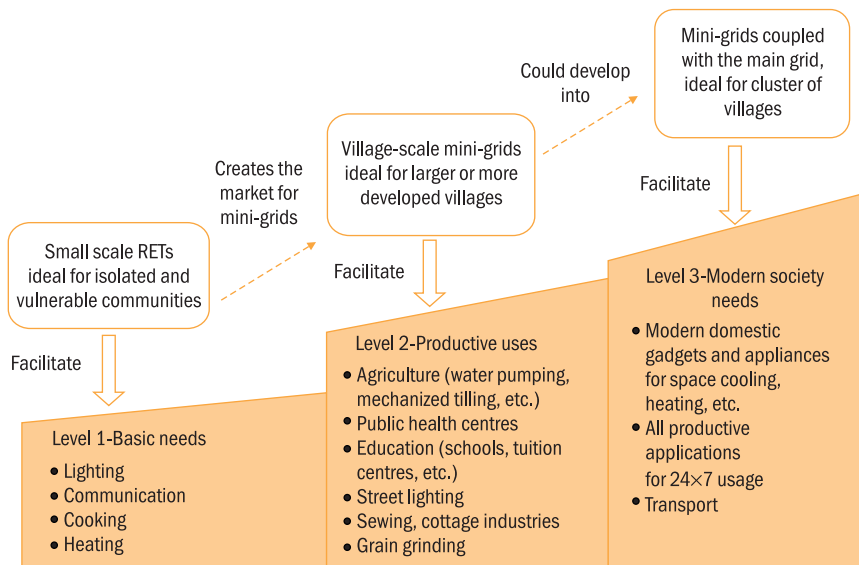


Fig. 6.1: Gradual development pathway for off-grid electrification (Source: TERI 2013)

- ☀ **Develop a supporting institutional arrangement:** As any off-grid electrification environment is influenced at different levels (e.g., global, national, and local), a cohesive institutional arrangement appropriately linking the different levels is

an essential pre-requisite for a successful promotion of off-grid electrification (Fig. 6.2). Depending on the stage of development, the institutional arrangement and linkages would have to cater to the varying needs of off-grid electrification. This not only requires a multi-tiered operational management system but also a robust organizational arrangement for any successful off-grid electrification. It is imperative that there must be appropriate (socio-politically acceptable) institutions in place with necessary skills and means to manage the systems on-site and collect revenue, and that the technical knowledge for ensuring sustainability must be available within a reasonable distance.

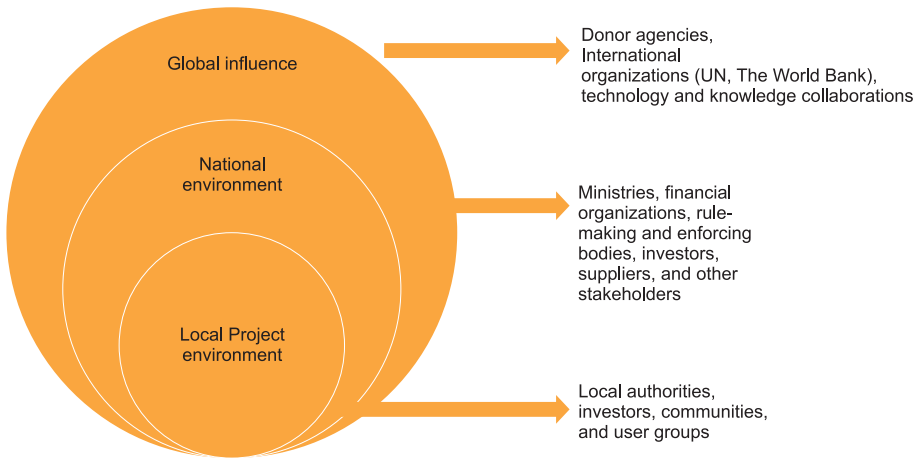


Fig. 6.2: Appropriate institutional arrangement

It is important to develop a support system at the intermediary level which provides an integrating link between the national and local levels, ensuring that plans and policies match the needs of consumers, owners, and suppliers. The intermediary can provide considerable help in explaining, facilitating, and planning a suitable choice of technology and delivery model.

- ☀ Create transparent rules of the game:** Unambiguous and transparent rules of the game are required to support off-grid electrification initiatives. Regulatory vacuum or weak regulatory arrangements adversely affect the off-grid sector and ambiguous rules increase investment risks. Off-grid electrification options, particularly those through local grids should be recognized in the electricity acts and a light-handed regulatory approach appropriate for the local country context should be considered for appropriate guidance of off-grid business development. A model off-grid regulation that imposes minimal regulatory supervision but allows for clarity in scope of service, puts in place appropriate service standards, and supports information collection, could be a suitable approach in this regard.

- Embed electrification within the overall rural development activities:** Electrification efforts stand a better chance of success when they are pursued as part of the overall rural development. Electricity could be used to generate opportunities for enhancing the local economy, which in turn can improve money flow to the rural households, so that they are willing and able to spend a part of the incremental income on purchasing the electricity. The institutional arrangement should cater to this aspect through cross linkage and policy support.
- Develop a supportive policy regime:** Although off-grid electrification activities mostly concern rural areas of a country, a complex web of interactions and inter-relationships influence the outcomes. These encompass policies related to: a) credits and financing for rural areas, b) access to donor funding, c) pricing, subsidies, and other support/control mechanisms for electricity and other agricultural produces, d) technology use and transfer, e) local business development, f) permissions and clearances from local authorities, g) labour and employment, h) land use and the like (see Fig. 6.3). For successful development of the off-grid electrification sector, an enabling policy environment is required that supports the overall activities by removing policy barriers and challenges. Removal of price distorting subsidies from fossil fuels, abolition of subsidy discrimination between grid and off-grid connections, promotion of low cost, micro-credit facilities, flexible and simplified procedures for business set-up, among others, can facilitate off-grid electrification.

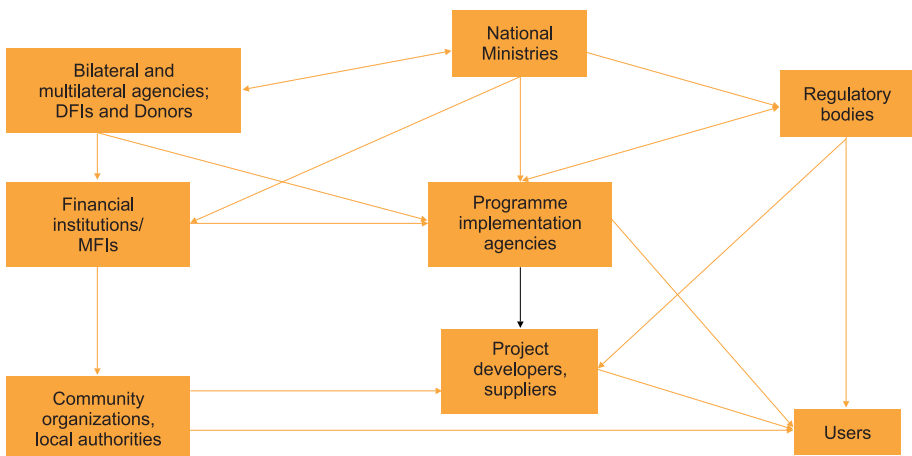
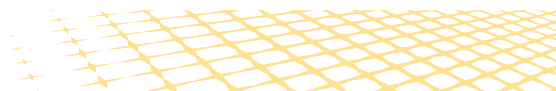


Fig. 6.3: Web of policy interactions

- Provide strategic and innovative support for long-term gains:** Off-grid electrification options would require support at least in its initial development phase and perhaps even in the subsequent phases before it becomes commercially viable. However, the support requirement varies by technology, location, local condition, and other factors. Strategic support has to be designed to ensure better

value for money and support for long-term benefits. Misplaced incentives that focus on high capital cost subsidies have to be replaced by a flexible support system that caters to demand creation, ensures viability gap funding as well as balances the lifecycle funding mismatches of projects.

- ☀ **Develop appropriate capacity across value chains:** Effective delivery of off-grid electrification depends on the availability of different skill set at various levels. These include, among others, regulatory and policy making capacity at the national level, business development and delivery at the sub-national and local level, finance-related skills at various levels, trained staff and technicians at the project level, and design and implementation capacity at the contractor level. There is an urgent need for building capacity at different levels to ensure successful implementation of off-grid electrification.
- ☀ **Create an eco-system for sustaining the off-grid electrification solutions:** For a successful implementation of off-grid electrification options, the entire supply chain has to be developed and properly supported so that the solutions can be sustained in the long-term. The development of local manufacturing and assembly capacity, building an ancillary after-sales service system, creating a pool of trained technicians, and a gradual evolution of demand creating services can effectively support off-grid electrification in the long-term.
- ☀ **Encourage bundling and clustering of initiatives:** As the off-grid projects are invariably smaller in capacity, concentrating energy loads in a given area or bundling projects can increase the market size. Off-grid projects could be identified, depending on the availability of local energy resources and implemented in clusters, to ensure economics of scale and scope and handed over to concessionaires. Private players may get attracted to become concessionaires for multiple areas, where grid connected distribution business could be bundled with off-grid areas, or bundling projects with different off-grid technologies to optimize costs. Financial institutions/banks would also be interested as project implementation and credit risks would be less.
- ☀ **Organized delivery for scaling up and replication:** Mass electrification from pilot projects requires an organized delivery approach through some sort of standardization and utility-like management. This requires attention to organizational absorptive capacity, as well as financial and technical capacity of the organization. Not all entities can take such responsibilities and successful mass electrification requires a strong element of top-down influence and the flexibility of a bottom-up delivery.





Conclusion

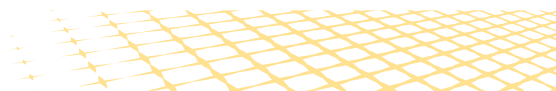


This paper provides a summary of research outputs from the OASYS South Asia project and presents a compilation of various lessons that this research has highlighted. Overall, the project finds and demonstrates that off-grid electrification can be an appropriate option for remote areas. However, no single solution fits all situations and a phased development process is more appropriate to take care of different levels of needs, local contexts, and resource availability. Given that mini-grid based local delivery systems can cater to household needs and productive loads, such an option can constitute an effective service delivery option for reliable and good quality electricity in rural areas. This can be effectively delivered if:

- ⚙️ The technical design of the project is carefully done ensuring: a) best utilization of available renewable resources, b) deployment of efficient technologies, such as LED lamps and efficient appliances for load management, c) low maintenance needs of systems in remote locations, d) grid readiness of the project to take care of the eventual arrival of central grid in the village, e) smart design features to reduce battery size and enhance system reliability;
- ⚙️ The economic case is managed innovatively through: a) flexible support systems that cater to initial capital needs, intermediate asset renewal, and even some operating cost support, b) locally contextualized tariff systems keeping consumer's income flows and ability to pay in mind, c) creation of income generating opportunities through productive use of energy, d) use of joint liability groups for risk sharing for credit purposes, e) monetization of co-benefits, such as carbon credits for carbon emission reductions or by product sale for income generation;
- ⚙️ The social impact is carefully managed through: a) user engagement from an early stage in designing and delivering the project, b) appropriate recognition of local knowledge and aspirations, c) responsive and effective communication and feedback mechanisms, d) mutual respect and trust for an effective partnership for local development; and
- ⚙️ A supportive governance mechanism is developed wherein: a) the rules of the

game are clear and unambiguous, b) a contextualized organizational arrangement is created for the delivery of the projects, c) an appropriate leadership is ensured for task implementation, and d) local capacity is built to ensure long-term effectiveness of the outcomes.

Our action research has demonstrated that it is possible to achieve the above conditions using a variety of arrangements—private sector participants, community organizations, and partnerships with local administrations. We have also found evidence of successful operations following the top-down as well as bottom-up approaches, where state agency driven initiatives as well as private sector, NGO, and community efforts have delivered off-grid electricity. Achieving universal electrification by the year 2030, however, will require learning from these and other similar examples and spreading the knowledge widely.





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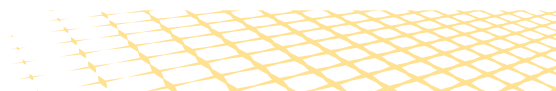
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ABOUT THE AUTHORS



Prof. Subhes Bhattacharyya of Institute of Energy and Sustainable Development of De Montfort University is an internationally renowned energy specialist with more than 25 years of experience. He was the project leader of the OASYS South Asia Project and has led a consortium of research organisations from the UK and India working on off-grid electricity access in South Asia as part of this project. He has written widely on energy issues in developing countries and particularly on energy access. He is the author of a best-selling book on energy economics and has edited books on rural electrification through decentralized off-grid systems and mini-grids for rural electrification of developing countries.



Mr Debajit Palit, Associate Director, Social Transformation at The Energy and Resources Institute has around 17 years of experience working in the field of clean energy access, rural electrification policy and regulation, distributed generation, solar photovoltaics, and biomass gasification. He has published widely on energy access and rural electrification issues, particularly related to South Asia, in several international peer reviewed journals and books. He has also authored a book on rural electricity distribution franchisees and has edited a book on mini-grids for rural electrification of developing countries. He has wide national and international experience, working in projects spread across Asia and Africa.



Dr Gopal K Sarangi, Assistant Professor, TERI University, is an economist by training. He has more than five years of experience in research and consulting in the areas of electricity sector regulation and competition, issues related to access to energy and socio-economic implications of rural energy interventions, and problems interfacing energy and climate change. He has published in several international peer-reviewed journals and books.

OASYS SOUTH ASIA PROJECT

The Off-grid Access Systems for South Asia (or OASYS South Asia) is a research project, which began in October 2009 and lasted up to April 2015. It was funded by the Engineering and Physical Sciences Research Council of UK and the Department for International Development, UK. The project has carried out a detailed review of the status of off-grid electrification in South Asian region and around the world from a multi-dimensional perspective, considering techno-economic, governance, socio-political, and environmental dimensions and implemented them through demonstration projects across different geographies in India in order to find appropriate local solutions for sustainable rural electricity supply. The project also looked at replication and scale-up challenges and options and came out with a set of lessons and policy recommendations based on the research.

A consortium of universities and research institutes led by De Montfort University (originally by University of Dundee until end of August 2012) carried out this research. The partner teams include Edinburgh Napier University, University of Manchester, The Energy and Resources Institute (TERI) and TERI University (India).

More details about the project and its outputs can be obtained from:

<<http://www.dmu.ac.uk/research/research-faculties-and-institutes/institute-of-energy-and-sustainable-development/research-projects/oasys/index.aspx>>
or <<https://dmu.academia.edu/OASYSSouthAsiaResearchProject>>



The Energy and Resources Institute
Darbari Seth Block, JHC Complex, Lodhi Road
New Delhi 110 003, INDIA
Email: mailbox@teri.res.in
Web: www.teriin.org

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