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Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required?

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HIGHLIGHTS

- The academic and action research activities undertaken through OASYS South Asia Project are reported.
- Evidence produced through a multi-dimensional participatory framework supplemented by four demonstration projects.
- Funding and regulatory challenges militate against universal electrification objectives by 2030.
- Innovative business approaches linking local mini-grids and livelihood opportunities exist.
- Enabling policies are suggested to exploit such options.

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ABSTRACT

With 1.2 billion people still lacking electricity access by 2013, electricity access remains a major global challenge. Although mini-grid based electrification has received attention in recent times, their full exploitation requires policy support covering a range of areas. Distilling the experience from a five year research project, OASYS South Asia, this paper presents the summary of research findings and shares the experience from four demonstration activities. It suggests that cost-effective universal electricity service remains a challenge and reaching the universal electrification target by 2030 will remain a challenge for the less developed countries. The financial, organisational and governance weaknesses hinder successful implementation of projects in many countries. The paper then provides 10 policy recommendations to promote mini-grids as a complementary route to grid extension to promote electricity access for successful outcomes.

1. Introduction

About 1.2 billion people in the world did not have access to electricity in 2013 (International Energy Agency, 2015) and achieving the universal access to sustainable energy even by 2030 remains a significant policy challenge. The visibility of the energy access challenge has improved since the launch of the Sustainable Energy for All (SE4ALL) initiative in 2012, attracting international and national players in a big way. It is now accepted that despite undue preference for grid extension, alternative approaches to electrification have to be pursued as well in order to meet the universal electrification objectives by 2030 due to the compressed timescale to achieve the target (Bazilian, et al., 2012), cost disadvantage of grid extension particularly in remote areas or for dispersed population (Moner-Girona et al., 2012), technological innovation for electricity generation and end-use technologies (such as LED lamps, efficient storage) and rapid price decline of some technologies (The World Bank and International Energy Agency, 2015).[1]

It is estimated that 135 million people have to be provided access to electricity every year in order to achieve the universal access by 2030 (The World Bank and International Energy Agency, 2015) and that grid extension will be feasible for only 40% of the population, and stand-alone and local grid options delivering electricity to 60% of the non-electrified rural areas (International Energy Agency and the World Bank, 2014). While the stand-alone individual solutions have traditionally received greater attention in the literature, mini-grid systems can offer a collective solution

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[1] While both standalone individual systems and mini-grid are considered as off-grid, this paper deals with mini-grids only and did not consider any stand-alone individual systems (such as solar home systems and/or solar lamps).

at a relatively lower cost to facilitate basic needs as well as productive use of electricity thereby promoting local economic development. However, being a more recent development for rural energy delivery, the mini-grid based electricity supply business faces a number of challenges including a risky business environment due to unknown consumer characteristics and unfamiliar business activities, weak institutional arrangements arising from non-supportive regulatory and policy frameworks, limited access to low cost finance and inadequacies in local skills and capacities.

The purpose of this paper is to share insights and lessons from a recently concluded research project on off-grid electrification in South Asia and to present a set of policy recommendations for mainstreaming and up-scaling of local mini-grid based systems in non-electrified areas of the developing world. Funded by Engineering and Physical Sciences Research Council (EPSRC) and Department for International Development (DFID, UK), the project, OASYS South Asia,[2] has investigated off-grid electrification using mini and micro-grids and undertook action research through demonstration activities. The knowledge gained through this project can contribute towards developing an enabling ecosystem for mini-grid based electricity service in the developing world.

The organisation of the paper is as follows: the second section presents the analytical framework followed in the project; Section 3 provides a summary of lessons from local and national level case studies and other desk-based research while Section 4 presents the insights from the demonstration activity; Section 5 offers ten policy recommendations distilled from the experience gained from implementing the OASYS project in order of preference, while Section 6 contains the concluding remarks.

2. Analytical framework

The basic premise of this research was that if any modern energy has to compete with traditional energies in rural areas, any credible off-grid electrification alternative has to ensure a reliable electricity supply to support income-generating activities for the poor on a regular basis. In other words, decentralised electricity solutions have to cater to productive activities in rural areas, but the existing stand-alone solutions offer limited potential for productive use of electricity. Therefore, this research, through an elimination process, focused essentially on mini-grid -based electrification.

The logical framework adopted in the project involved the following steps:

1) An in-depth multi-disciplinary review[3] of the existing off-grid electrification efforts in South Asia and elsewhere was undertaken to take stock of the present situation. It revealed that a database of off-grid projects is lacking and there is also a dearth of studies with integrated frameworks of analysis.[4]
2) To bridge the data gap, a database of off-grid projects in India[5] was developed from the documented experiences of a large number of off-grid projects supplemented by field visits to selected project sites. The database covers, among others a range of technologies, geographical locations, capacity of the plants, tariff structures, ownership and management arrangements.
3) An integrated framework for the analysis of the business case for off-grid projects in South Asia was developed, which was informed by the data available from the off-grid project database indicated above, supplemented by information obtained from the literature, field visits and stakeholder consultations.
4) An action research component was carried out where alternative delivery options were pilot tested on the ground. Four demonstration activities[6] provided practical insights about managing the entire process.

Fig. 1 presents an iterative process of decision hierarchy for off-grid energy projects consisting of six essential stages (namely, demand mapping, project scenario design, technology mapping, techno-economic analysis, business case analysis and financing mechanism).[7] At one extreme, the private-led business development will be feasible where users are willing to accept the services on a commercial basis. On the other extreme, where users cannot afford the services on a commercial basis, public and socially-driven funding would be required. In between these extremes, many combinations of contexts are possible, which would require a mixed form of financing.

The framework with adaptations for specific cases has been applied to various case studies undertaken in the project, namely for Bangladesh (Bhattacharyya, 2015), India,[8] Nepal (Sarangi, et al., 2014) and Sri Lanka (Sarangi, et al., 2015). The same framework has also been followed in the demonstration activities carried out in India: Dhenkanal and Kandhamal districts (Odisha), as Sunderbans (West Bengal) and Sitapur (Uttar Pradesh).

The next section presents the main findings from our case studies and analytical research while Section 4 presents the lessons from our action research activities.

3. Main findings from the research activity

A brief summary of notable findings and lessons is presented below based on a review of various publications and case studies from the project.

3.1. Electrification progressed but affordable universal electrification remains a dream

Our literature review found evidence of a significant progress in electrification around the world but the success has varied depending on the level of government commitment, and institutional and financial support to the process. Better performance was achieved with clear policy frameworks and milestones, enforcement of appropriate technical standards, standardised operational metrics, and support for finance, R&D and stakeholders'

[2] An international consortium of research organisations consisting of De Montfort University, Edinburgh Napier University, Manchester University, the Energy and Resources Institute (TERI) and TERI-University participated in the project activity. Initially, University of Dundee was involved as the lead institute but since September 2012, the project was transferred to De Montfort University when the PI moved there.

[3] The review considered the technical options, regional and national experiences, delivery models, electricity–development linkage, regulation and governance, funding as well as alternative approaches used to analyse off-grid problems.

[4] Most of the studies either are anecdotal, or focus on techno-economic assessments or present policy narratives without adequate attention to the local contexts and key determinants shaping the development trajectory of these projects.

[5] The dataset is available from here: https://www.academia.edu/15719978/Selected_Data_of_off-grid_projects_in_India.

[6] These are as follows: a community-managed micro-grid based solar PV electrification in a cluster of villages in Dhenkanal district of Odisha, a solar AC mini-grid in partnership with local administration in Kandhamal district, Odisha, a private developer managed solar DC micro-grid in Uttar Pradesh and a social foundation managed solar AC pico-grids for remote island villages in the Sunderban Islands.

[7] Further details on the analytical framework are available in and are not repeated here.

[8] A number of studies were done for India, which include among others the following: Borah et al. (2013), Mahajan and Fernandez (2014), Palit (2013), Sarangi et al. (2012), and Palit et al. (2014).