OASYS – South Asia Project

Workshop on Off-grid electrification: Experience, Approaches and Issues

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Brief Proceedings

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1.0 Introduction

As part of the research project on off-grid electricity access in South Asia (OASYS-South Asia), an international workshop was organised at Dundee on 6th July 2011. Professor Peter Cameron, Director of CEPMLP opened the workshop by welcoming all participants while Dr. Subhes Bhattacharyya, PI of the project provided an overview of the project (see Annex 1 for the slides). The workshop considered the international experience on off-grid electrification, discussed approaches being used towards off-grid electrification and highlighted the issues facing off-grid electrification. Eight presentations were made in two sessions by project team members as well as invited guest speakers in two sessions. This was followed by a panel discussion that considered the issues relating to off-grid electrification in the context of economic development agenda. About fifty participants attended the workshop from universities around Scotland (Aberdeen, Glasgow, Edinburgh and Dundee). Most of the attendees showed keen interest in the presentations and participated in the discussions.

The pre-lunch session considered the off-grid experience in various parts of the world, which was chaired by Dr. Arabinda Mishra of TERI University. The second session, chaired by Dr. Akanksha Chaurey of TERI was devoted to approaches to off-grid electrification and cross-learning opportunities from various initiatives. The Panel discussion was chaired by Prof. Paul Cook of Manchester University. This report provides a brief summary of the workshop presentations and panel discussions.

The report is organized as follows: Section 2 summarises the proceedings of the morning session while section 3 summarises the presentations in the post-lunch session. Section 4 presents the summary of the panel discussion and finally a concluding section summarises some final observations.
2.0 Summary of the proceedings of the morning session

Four presentations were made in the morning session spanning over a three hour period which was chaired by Dr. Arabinda Mishra (TERI University). Dr. Mishra opened the session with a brief remark on an off-grid project database development and analysis that he is undertaking. He informed that using the Indian project-level data, he is analysing an in-depth understanding of the factors affecting the success/ failure of off-grid projects. The insights will then be used to develop an analytical framework for off-grid project analysis. He informed that the initial work on this is being completed, and the analysis is likely to produce interesting insights.

Dr. Judith Cherni – Latin American Experience

Dr. Judith Cherni (Imperial College) presented the experience of three South American countries, Peru, Argentina and Cuba [See Annex 2 for the power point slides]. Although Latin America fares well in terms of electrification rates compared to other regions (with only 31 million lacking electricity access in 2009), the problem exists in remote rural areas. The gap in electricity access between urban and rural areas in Latin America is quite severe, even worse than that in South Asia. Consequently, the issue of off-grid electrification is related to extreme rural poverty and the promotion of off-grid electrification is to enhance rural livelihood. The sustainable livelihood aspect emphasises the role of renewable energy use for off-grid electrification, which is the second important feature of this region. The third issue relates to the investment requirement for off-grid electrification. Lack of investment, particularly foreign investment in electrification programmes acts as a main barrier to enhanced electrification in South American countries. The issue of extreme poverty and off-grid electrification is often linked in this region.

She presented three country cases briefly – that of Peru, Argentina and Cuba - and informed that these studies were carried out in the context of RURSUL project (Renewable Energy for Sustainable Rural Livelihoods) which adopted an integrated analytical framework that considered policy mapping, policy content analysis, analysis of regulation and law, and rural livelihood analysis. In 2006, after 15 years of electricity sector reform, 68% of the rural population in Peru
lacked electricity and the reform did not enhance or promote rural electrification. Although off-grid electrification was clearly a cost-effective option, it was not considered in the electrification policy and the grid-based electrification remained the main mode of electrification. In Argentina, the situation was quite different but the remote areas still lacked electricity access due to low load, limited ability to pay and engineering difficulties. The privatisated utilities essentially focused on urban and industrial areas and ignored the needs of rural areas. The private concession model, called PERMER, was introduced by the government. The private concessionaire who needed the least subsidy to provide electricity in rural areas, was chosen and the project was supported by the World Bank. In Cuba, only 15% of rural population lacked access to electricity. The country has a centralised system of electricity supply and the case study was done in a remote area, which provided a successful case study.

She highlighted that the case studies considered the physical resources, financial resources and the regulatory/ institutional arrangements. She remarked that the off-grid electrification projects have traditionally been a top-down approach, although the bottom-up approach provides an alternative option. From a business perspective, although off-grid projects may be cost-effective, the lessons have not been properly documented or analysed. Reliance on private sector alone may not always work. The government may have to take responsibility in cases where the private sector is not interested or not effective.

**Dr. Xavier Lemaire – the African Experience**

Dr. Xavier Lemaire (Warwick Business School) presented the status of electrification in Africa and then presented the case of off-grid electrification in South Africa using solar home systems. He remarked that the amount of electricity consumed in Sub-Saharan Africa excluding South Africa is about the same as consumed by New York city. Although solar energy has a good potential in rural areas of Africa and other developing countries, it is still quite expensive, compared to the per capita income of most African countries. But solar PV is entering an interesting phase with falling PV costs and increasing fossil fuel prices.
The first generation of projects aimed at technology transfer through donor agency support but the beneficiaries did not appreciate the systems and consequently, the projects did not produce the desired result. The new generation projects are aiming at providing a social service – not just a technology transfer. The activity is often market-based – not just donor-driven. These projects are trying to move away from technology demonstration to business, financial, institutional and social models. The new generation projects thus represent a paradigm shift.

Dr. Lemaire then considered two commonly-used models for solar home system dissemination – the unregulated competitive market model and the regulated “fee for service” model. He remarked that the competitive model has been widely used in some countries (including Kenya, and many Asian countries like Sri Lanka, India, China, Vietnam, etc.), but the quality issue has been a problem. The “fee-for-service” model on the other hand involves a service company (ESCO) to deliver the systems and collect monthly fees in turn from the consumers. The company receives government subsidy for each unit thus delivered. He then presented the Zambian case and the South African case as two contrasting examples – the Zambian case being a small-scale ESCO while the South African case representing a large-scale experience.

In Zambia, the regular issues licence to ESCOs. The activity has been supported by international organisations such as SIDA (Swedish International Development Agency) and SEI (Stockholm Environment Institute). ESCOs received government loans to buy the SHS and collect a monthly fee of USD 8-13 from the clients. Three ESCOs are successfully operating in the country and serving more than 400 clients. The collection rate is high and the theft is low. But the financial situation of the ESCOs is fragile due to limited customer base and also high dependence on government employees or organisations. The ESCO intervention can be considered as a pre-electrification experience.

In South Africa, a massive rural electrification effort has been initiated since 1994. Since 1999, a fee-for-service based concession system has been adopted to disseminate 300,000 SHS. Three concessions are active at present and the Nura concession is the largest and most successful of them. The concession covers a large area (10,000 km2) and offers multi-energy services (LPG and solar energy). The ESCO is using advanced technology (GPS, computer software) to ensure
customer satisfaction and manage resources. The main consumer complaints revolve around three issues: small-size of the system, high operating cost and ownership-related issues. In addition, lack of continued government support, lack of co-ordination with the grid authorities (leading to grid extension in the concession area) and differences in the interpretation of tariff rates affect the ESCO adversely. However, the potential for exploiting the economies of scale, advanced technologies and multiple fuels bring a contrasting experience.

**Mr. Marco Gaul – Bio-energy for off-grid electrification**

Mr. Marco Gaul of Technical University of Berlin presented a case study of bio-energy use for off-grid electrification where he analysed the case of Indonesia. He recalled that biomass-based electrification is often considered to offer a number of advantages – cost advantage, storability, adequate size for productive energy, income generation potential, etc. Biomass can be used in different ways – direct burning, anaerobic digestion, gasification and converting straight into vegetable oil. Gasification and oil conversion required complex technologies and their commercial application in small-scale is not yet available.

Marco then highlighted the differences in energy resources, conversion pathways and end-use demands for alternative bio-energy-based services. The main issue then is their appropriate comparison taking the entire supply chain into consideration. He presented the example of jatropha-based rural energy service pathways to find out if such a system is economically viable compared to the baseline or other renewable energy options. He used the life cycle costing and scenario analysis using GEMIS 4.6 and developed alternative scenarios for jatropha pathways and compared them against the baseline case. The analysis considered the net energy efficiency and cost efficiency.

His results show that the jatropha-based energy pathways represent very low net energy efficiency. This is because of high loss in the diesel motor pathway and high extraction and conversion losses in the biodiesel motor option. Bio-energy has long and inefficient conversion chain and the need for auxiliary energy is high as a consequence. He concluded that the net
energy efficiency can be improved by using residues or side crops. Similarly, the financial viability depends on local conditions and there is no single solution for all.

**Dr. William Arthur – Micro-hydro applications in rural areas**

Dr. William Arthur of Nottingham University presented small hydro power as a rural electrification option and provided case examples from various parts of the world. Many remote areas have good hydropower potential – either having high flow or good head – and can be used to provide reliable and inexpensive power supply. While hydropower comes in various sizes, small (mini or pico hydro) options are suitable for rural applications. Village-based mini-grids are becoming increasingly popular and depending on the head or flow available at a given site, alternative technical designs are possible (e.g. Pelton turbines for higher head, cross-flow or pump as turbine for medium heads and propeller turbines for low head). A World Bank study found that the pico-hydro option constitutes the least-cost option for small applications. These plants rely on simple civil works and can use locally manufactured turbines and parts to reduce the cost of supply.

The typical cost break down indicates that cable and wiring costs form a major part of the total project cost. Although the cost can be somewhat reduced by allowing higher voltage drop (i.e. by reducing the cable thickness), there is a limit to acceptable voltage drop. Modern software packages (e.g. ViPOR) can be used to design the mini-grid system and it is possible to connect a mini-grid to a grid extension system. Similarly, the choice of appropriate end-use technologies can enhance the benefits – for example, the use of LED lights in households can reduce the demand significantly, and thus provide access to a larger population. Various support schemes are available for local entrepreneurs to manufacture and manage the systems.
He concluded that mini-hydro offers a viable, cost-effective and reliable alternative. The village-based mini-grid systems can support rural energy needs and offer income generating/ rural development options.

3. Summary of proceedings of activities in the post-lunch session

The post-lunch session considered alternative approaches to off-grid electrification. The session was chaired by Dr. Akanksha Chaurey of TERI. This session regrouped the presentations of the second half of the day as two presenters could not join the workshop due to late receipt of entry visa. Dr. Chaurey remarked that the development of off-grid systems does not take place in vacuum – each country has its own policies, institutional arrangements and regulations. While most of the countries take a technocratic approach that flows from the top, the decentralised systems also have to be socially acceptable and compatible with the local practices and needs. Also, there are learning opportunities from one another. This session includes presentations that would throw lights into various approaches, practices and lessons from other projects.

Four presentations were made in this session.

Ms Krithika and Mr. Debajit Palit – Review of alternative participatory business models

Ms Krithika and Mr. Debajit Palit presented a review of literature on the alternative participatory business models being used in delivering off-grid electrification solutions. The study reviewed the literature to identify the strengths and weaknesses of each model and to prepare a comparative position of alternative options. From there, some key lessons are identified.
Five alternative models were considered, namely co-operatives, franchisees, Fee-for-service or ESCOs, community managed and private sector initiatives.

Cooperatives are owned and managed by its members, and take the obligation of offering universal electrification within its designated area. The Palli Bidyut Samiti (PBS) model in Bangladesh is the most cited example of this category. The PBS model has ensured a democratic governance system but such co-operatives have limited operational autonomy.

The franchisee model comes with different variations. In India, the distribution licensees have engaged franchisees as agents to manage the rural electricity distribution operation. These agents are responsible for metering, billing and revenue collection. This has resulted in improved performance through loss reduction and better customer service.

In the fee-for-service or ESCO model, a business entity installs, operates and provides the electricity service to the consumers and charges a fee. A variant of this where the entity charges a rental for leasing the equipment/appliance is also commonly used. This has been used in Zambia, Kenya and India successfully. The model generally ensures better quality service but the long cost recovery period increases business risk.

In the private sector model, a for-profit entity undertaken the supply activity and manages the entire operation. This has been successfully implemented in India by Husk Power and SELCO. They tend to provide a good service but the service does not reach the bottom of the pyramid due to profit motive of the supplier.

The alternative options were compared using a set of ten criteria covering various dimensions, including among others technology, ownership, financial viability, pricing, and suitability. The authors indicated that

a) the co-operative/community-based systems are appropriate in areas with progressive and cohesive social structures.

b) The franchisee model is suitable for grid-connected areas and not-so-remote areas.

c) The ESCO model is suitable for very remote areas, while
d) The private sector model suits areas with a good mix of productive load and domestic demand.

The presentation concluded that for any model to be sustainable, scalable and socially acceptable, the technological choice, financing of the initiative, appropriate electricity tariffs, service delivery issues and social benefits need to be considered. Each model has its own strength and weaknesses and depending on the local conditions, a proper selection has to be made.

**Ms Kirsten Ulsrud – the Solar Transition project**

Ms Kirsten Ulsrud, co-ordinator of the Solar Transitions project at the University of Oslo presented their research on geographical transfer of socio-technical change. The work focused on solar PV technology and considered how the experience of a successful development in one developing country can be transferred to another country. The project considered the successful example of solar mini-grid in the Sunderbans (India) and is working on how the lessons can be adapted and transferred to Kenya. Solar cell technology is widely known in Kenya but the challenge is to develop and replicate the village level mini-grid system using solar PV system.

The field study in India with the participation of Indian, Norwegian and Kenyan teams was the starting point. The field study showed how a mini-grid system can be successfully implemented. The process is not straightforward and cannot be easily understood. The implementing agency of the solar mini-grid system in the Sunderbans, WBREDA, has developed a web of institutions/organisations around the mini-grid project and distributed the responsibility across various actors. A complex system has been developed to manage and operate the system but it also depends on local participation to ensure better performance.

In Kenya, the task is action-oriented research. This involved identifying a village for the mini-grid project, mapping the resources and energy needs, designing the system technically and enlisting local co-operation and support for the project. The process is continuing but already the work offers a number of lessons/ experience. An interdisciplinary research group involving social
scientists and technologists, private sector players and community members is a good starting point. The project acted as a catalyst for extended effects wherein several innovative activities have been initiated and the government policy has been indirectly influenced. The knowledge transfer between countries is not straight forward – de-contextualisation and contextualisation is required. It not only involves knowledge transfer but requires knowledge creation. Working in a remote village is a challenging task. The work is an explorative activity that is driven by a practical research agenda. Pilot projects can influence the social structures and contribute to the creation of new institutions and continued change.

**Prof. Tariq Muneer – Co-operative experience in the UK**

Prof. Tariq Muneer of Edinburgh Napier University shared the co-operative experience of the UK and suggested that this can offer an effective and viable option for off-grid electrification in the developing countries. He informed that the idea of co-operation for the benefit of the community can be traced back in the 18\(^{\text{th}}\) century. The Fenwick Weavers Society in East Ayrshire was established in 1761 and since then many business activities including among others banking, insurance, health care, retail business, and energy services are being undertaken through co-operatives. He indicated that more than 800 million members are globally active in co-operative activities and such businesses are supporting about 3 billion population worldwide with a turnover of £4 billion.

Although co-operative business has become a global force, the public awareness is limited and the business principles are not always well understood. He informed that the co-operatives follow seven principles agreed by the International Co-operative Alliance – these are voluntary participation, democratic governance, equitable participation, self-help independent organisation, training for effective performance, working together to strengthen the movement and sustainable development of the communities.

In the renewable energy area three business models are common – co-operative consortium, employee-owned business and the community co-operative. A growing number of energy co-operatives are operating in Europe now and the prospect for such entities in the developing world
is also encouraging. Instead of buying individual units, a co-operative can take advantage of scale economies to reduce procurement costs. For example, instead of buying solar panels for individual household projects a bigger order covering a group of households can offer cost advantages. He suggested that as the business benefits the members, this model can be advantageous in the rural context as well.

**Dr. Anne Wheldon – the Ashden Awards for off-grid electrification**

Dr. Anne Wheldon, Senior Advisor of the Ashden awards, shared their experience of award-winning off-grid electrification projects and indicated their experience of success factors and challenges in such projects. The Ashden Awards champion practical, sustainable local energy solutions by identifying excellent examples, reward the winners and help them grow, and share practice-based information to others. Both mini-grids and solar home system projects have been awarded in the past – 8 mini-grid projects and 14 solar home system projects from Europe, Asia, Latin America and Africa. These projects have benefited 1.6 million households and businesses and have been developed by private, public or community-based organisations. For mini-grid systems, biomass gasification, mini hydro, pico-hydro, solar PV and hybrid technologies have been selected for awards. However, SHS remains the dominant category in the award-winning off-grid electrification projects and has provided electricity access to 1.5 million households.

The success factors perceived by Ashden Awards include user demand for the service, rugged technology choice, local expertise for operation and management, payment for the service and supportive government policies. The challenges perceived by them include maintenance and monitoring of technologies, managing user expectation, effective payment system and training and retention of staff.

She concluded by saying that innovative, practical solutions are being found on the ground and by sharing these experiences, the agenda of providing access to electricity can be taken forward.
Panel Discussion – Moderated by Prof. Paul Cook

The Panel discussion was the final element of the workshop. The discussion was initiated and moderated by Prof. Paul Cook of Manchester University. The panel consisted of Dr. Judith Cherni, Prof. Tariq Muneer, Dr. Anne Wheldon, Mr. Debajit Palit and Ms. Kirsten Ulsrud. Based on the presentations and discussions during the day, Prof. Cook remarked that the issue of off-grid electrification or rural electrification is linked to the issue rural development. In the 1970s and 1980s, the view was that the infrastructure is the missing link and by developing the required infrastructure, the rural development can be achieved. The assumption was that the development will follow once the critical infrastructure is available. But this did not happen in many places and despite electrification rural development did not follow. In the subsequent period, the focus shifted to the private sector for service provision. Given the huge challenge of electricity access, can private entrepreneurs be relied on particularly in Africa for off-grid electrification? What role can the government play to involve the private sector in the process?

Dr. Cherni opined that the initial investment and the cost recovery are the main barriers for private investors. What is important for the government is to focus on the development agenda and not just electrification or one such issue alone. If the government focuses on rural livelihood and overall development, it will serve the rural communities better.

Prof. Cook then remarked that the idea of integrated development is an old fashioned term which was tried in the past but never took off. He then asked whether countries like Cuba or China integrated the electrification objective better than others with the development agenda. The view of the panel was that each country works within its own institutional and regulatory frameworks and the performance is often constrained by the resources and human capital.

The discussion then moved to the issue of regulation and the role of the regulators. A member of the audience suggested that while regulation has a role in the development process, it is important to promote competition for the services. Prof. Cook remarked that regulation in the UK is supported by a strong social security network, which is missing in many developing countries. In that case the regulator has to take a more socially responsible role, which they have hardly taken.
The discussion then moved to reform and privatisation of the energy sector. The investment in infrastructure suffered during this period and electrification was neglected. Mr. Palit remarked that despite the failure of the reform process, developing countries have become aware of the electricity access issue and many of them have set targets to achieve electrification. But the issue is how to achieve them and what model to follow. The governments are undecided because there is no clear message from the policy analysts.

The discussion further moved to the subsidy issue that came up in the presentations and discussions. But to what extent subsidies are required for off-grid electrification? The view was that due to high initial costs, some support will be required. But Prof. Muneer remarked that consumers ultimately have to pay for the service – otherwise no project can run. He also suggested that a competitive process or auctioning can be used to identify the service providers to provide electricity services in rural areas with a cap on the maximum price and the subsidy. Mr. Palit remarked that such bid-based systems have not worked in India due to lack of investor interest due to poor cost recovery perception by the investors. Dr. Cherni remarked that the affordability aspect has to be considered as well. It was also remarked that the emphasis on off-grid or decentralised systems is a result of the failure of the grid system to provide the service.

Prof. Cook thanked the panel members and the participants for joining in the lively debate.

**Conclusions**

The well-attended workshop was successful in sharing the experiences of and approaches towards off-grid electrification. The workshop brought a range of relevant presentations and aroused interest in the ongoing work. The possibility of networking and learning from others was very helpful for the project team and the participants agreed to remain in touch and share experiences in the future. Through co-operation and collaboration we all aim to generate a greater impact in this challenging issue.