



# **OASYS SOUTH ASIA Research Project**

## **Papers presented at conferences/workshops/ Seminars**

### **An Actor Network Framing of Off-grid Electrification in South Asia**

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Presented at the *Green Asia Conference at Copenhagen Business School on 14-15 May, 2014.*



## Abstract

Being one of the least electrified regions of the world, South Asia faces one of the daunting challenges of providing access to energy to a large chunk of its population. The magnitude of challenge could be evident as about 470 million people in the region are deprived of any form of modern electricity (IEA, 2012). However, there exists heterogeneity in the approaches followed by the countries of the region to address this grave challenge. The paper applies an actor network framework to understand the constellation of actor networks, the role of relationships, interconnectedness and networks between actors and institutions in promotion and acceleration of renewable energy based off-grid energy system in the region. The study focuses on three countries of South Asia namely India, Nepal and Sri Lanka. Primary surveys are carried out in these countries to understand the existing as well as the evolving processes of actor networks. Primary surveys are supplemented by data gathered through secondary sources. Findings of the study suggest that actor constellations and the strength of their networks differ, both spatially and temporally, significantly across countries. The paper also suggests specific group of actors and their networks to be strengthened for each of the countries. While India needs to emphasize strengthening the networks between financial institutions and other actors on the one hand, there is also a need to give momentum to the networks connecting regulators and other actors. Sri Lanka should undertake similar efforts to strengthen regulators and the networks connecting regulators with other actors. While Nepal is relatively better placed in terms of strength of actor networks, it also has to introduce a whole range of new networks connecting the existing actors to a new actor ‘regulator’.

**Keywords:** off-grid energy sector, South Asia, actor-network theory, weak networks, and strong networks

**Acknowledgement:** The work reported in this paper is funded by an EPSRC/ DfID research grant (EP/G063826/2) from the RCUK Energy Programme. The Energy Programme is a RCUK cross-council initiative led by EPSRC and contributed to by ESRC, NERC, BBSRC and STFC. The author gratefully acknowledges the funding support.

**Disclaimers:** The views presented here are those of the authors and do not necessarily represent the views of the institutions they are affiliated with or that of the funding agencies. The authors are solely responsible for remaining errors or omissions, if any.

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## I. Introduction

South Asia<sup>1</sup> being one of the least electrified regions of the world faces the grave challenge of providing basic minimum energy services to its people. About 30 % of the total population of the region (which is about 470 million people) is deprived of access to any form of modern energy (IEA, 2012). The problem continues to prevail in spite of efforts undertaken by the countries of the region to boost the electrification coverage by designing appropriate policies, programmes and incentive frameworks (Palit and Chaurey, 2011). While at an aggregated level, this problem of access to energy is a common cause of concern, the magnitude and intensity of this challenge differs significantly across countries in the region. For instance, while on the one end, Sri Lanka stands out as a leading country in the region with an electrification rate of more than 90% - well beyond world average, on the other spectrum; Afghanistan has been able to provide electricity to a meager 30 % of its total population. The challenge also got a face of urban-rural divide, with visible differences in the electrification rates among urban and rural areas.

While traditional focus of electrification in the South Asian countries has centered around grid based centralized electrification processes, recent focus has been on renewable energy based off-grid/decentralized electrification options alongside grid based electrification (Narula et al, 2012). This recent focus on off-grid electrification options has been spurred by resurgence of debate on imminent perils of climate change, need and urgency of securing energy security, technological revolution in the field of renewable energy, and providing basic minimum energy services as an indication of economic development. Moreover, UN Secretary General's declaration of the year 2012 as the "International Year for Sustainable Energy for All" also acted as a driver for bringing decentralised energy into the mainstream of energy policy planning and designing in many countries of the world including countries of the South Asian region. Off-grid electrification as a cost-effective option to the grid based system is prioritized in the region as many areas of South Asian region are geographically difficult to access where off-grid solutions emerge as an appropriate solution to provide access to energy (Palit and Chaurey, 2011).

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<sup>1</sup> The region South Asia consists of eight countries i.e. Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

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Off-grid electrification option is also seen as an effective instrument to fill the void left by the grid electrification process in the countries of the region. A clear gap emerges when one compares household electrification rates with village electrification rates in these countries (Palit and Chaurey 2011). For example, in India while household electrification rate in 2011 was 67 %, village electrification statistics shows 95 % of villages are electrified. Therefore, households left in the mainstream electrification process are often targeted to be electrified through off-grid routes.

Varying forms of technologies such as biomass, solar, wind and micro-hydro have been tried out in the countries of the region with varying degrees of focus depending upon resource endowment of a country, technological maturity, prevailing policy and incentive frameworks, and prevailing socio-economic characteristics at the project level. For instance, Sri Lanka and Nepal have extensively used micro/mini-hydro systems (usually in the range of 50 kW to 3 MW) as off-grid electrification option, though India has also relied on micro-hydro systems to some extent as an off-grid technology option. Biomass gasifier based off-grid projects, within the range of 10 to 500 kW, have largely been confined to India, with very limited application in Sri Lanka. Of late, solar PV systems have emerged as prioritized options for all the countries of the region, due to its modularity, ease in use and relative cost effectiveness (Palit and Sarangi, 2011). Solar as a technological option has been used either as an individual household level electrification option, such as solar home systems (SHS) or solar lanterns or as community centric interventions like mini-grids. However, choice of off-grid solutions such as solar home systems (SHS) or village scale mini-grids is contingent upon factors like terrain of the locality, density of the households and a minimum threshold level of energy load (Palit and Chaurey, 2011). Deployment of off-grid energy systems have been done under different delivery models in countries of the region. As far as individual household level interventions like SHSs are concerned, a variety of delivery approaches like subsidy driven, fee-for-service based, leasing and consumer finance promoted, purely market driven models have been experimented in the countries of the region. While subsidy driven approach is the common approach in all the countries of the region, consumer financing models are limited in Bangladesh, India and to limited extent in Sri Lanka. Community centric interventions like mini-grids are promoted under different delivery models such as publicly supported and subsidized models, NGO/donor agency driven models, private sector managed models etc. While private sector promoted models

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are largely operational in India, Nepal and Sri Lanka have experienced donor agency/NGO led models. In order to propel off-grid energy sector and to bring the sector into the mainstream electrification process, there have been several policies and incentive schemes devised by countries in the region from time to time. Though, dedicated off-grid energy institutions or policies are conspicuous by their absence, agencies created to promote renewable energy in general have been assigned the task of developing off-grid energy sector in the countries of the region. For example, a majority of the countries in the region have set up dedicated renewable energy agencies to promote renewable energy in their respective countries. A snapshot of most recent acts and policies aimed at promoting renewable energy in the select countries of the region is presented in the Annexure I. Another interesting feature of this off-grid energy development in the countries of the region is the association of multiple actors at different layers of project development. This heterogeneous group of actors is discussed elsewhere in the paper.

However, review of scientific studies on off-grid electrification in South Asia reveals two major gaps in the existing approaches to analyse off-grid energy sector development. First, studies on off-grid energy sector in South Asia are largely limited to individual countries, though a few attempts (e.g. Palit and Sarangi, 2011; Narula et al, 2012; Palit and Chaurey, 2011) have been made to take stock of the off-grid electrification at the regional level on a comparative basis. Second, it is contended that development of off-grid energy sector in these countries, more particularly in India, has largely been technology centric, with disproportionate focus on non-technical considerations such as institutional, socio-political governance and environmental issues (Bhattacharyya, 2012; Cust et al, 2007; Kumar et al; 2009).

With this backdrop, the paper aims at understanding the off-grid energy sector development in South Asia on comparative basis by applying the theoretical lens of actors' network theory (ANT). Though, the notion of actors network theory has been applied in understanding the development of renewable energy development in some countries like France (Jolivet and Heiskanen, 2010), Germany (Galvin, 2009), and in India (Benecke, 2010), the theoretical tool of ANT has not been applied to understand the off-grid/decentralized energy sector till date. The paper is a novel attempt to apply this theoretical tool in the context of off-grid energy development. The understanding is built around the conception that off-grid energy sector is hybrid engineering problem, where both technological aspects are strategically interwoven with human elements. In

addition, the paper will contribute to the scant literature that exists at the regional scale to examine the off-grid energy development. With this understanding, the paper sets the following objectives;

- Identifies key actors and their heterogeneity across select countries of South Asia associated in the renewable energy based off-grid energy development
- Establishes networks among various actors and characterizes these networks based on their strengths and weaknesses

The structure of the paper is as follows. Section II dwells on actor network theory and its relevance for the study. Third section presents the methodological approaches followed in the study. Section IV identifies core group of actors and their heterogeneity. Fifth section highlights the actor networks and their interconnectedness. Final section concludes the paper.

### **II. The Actor Network Theory (ANT)**

Origins of Actors Network Theory (ANT) could be traced back to the writings of a group of sociologist such as Michael Callon, Bruno Latour and John Law around 1980s. However, the theory of ANT gained prominence during 2000 as scholars started applying the theoretical tenets of ANT in various other fields. While the initial focus of this theoretical framework was to understand the process of innovation and knowledge creation in the field of science and technology, later, ANT has been applied to understand the complex setting of human and non-human interactions that take shape through networks.

Actor network theory (ANT) upholds that an intervention is not a set of activities, strategies and objectives, but a process of negotiation created through interaction between actors ( Long and Vn Der Ploeg, 1989). It is also argued that non-human actors or technical artefacts also significantly contribute to the technological developments. Actor Network Theory (ANT) offers an explanation of complex composition of networks and explicates how the networks gains strength and how networks accomplish their scope (Murdoch, 2000). In ANT, networks are seen as power relations. The shape and content of these networks are not characterized by socio-economic components but by complex linkages between all the enrolled entities (Murdoch, 2000). ANT offers a framework to

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understand the constellation of actor networks, the role of relationships, interconnectedness and networks between actors and institutions in promotion and acceleration of a sector where both human and non-human elements are important for the sector's development. Actor network theory emphasizes that establishing strong networks with key actors becomes critical for achieving desired outcomes (Mahanty, 2002). ANT lays thrust on dynamic, evolutionary, flexible and unpredictable nature of networks (Ghose and Pettygrove, 2014). The theory also offers mechanisms to understand interactions between human actors and non-human actants, to design heterogeneous networks (Murdoch, 1998). ANT stresses emphasis on relationship between human and non-human elements. The theory also expounds that the process involves interaction between non-human artifacts, tools and rules which shape social relations, whereas these relations span across space and scales through networks (Dicken et al, 2001). ANT as a theory offers explanation of technological innovation in a socio-technical context ((Iskandarova, 2011).

The ANT theory offers an approach for structuring and explaining the interconnection that exist between technology and society. The theory posits that technology cannot be treated separately rather must be coalesced with social, cultural milieu of the society (Monteiro and Hanseth, 1996). It is argued that ANT as a theoretical approach serves in better understanding the intricacies of a sector development in a dynamic context where socio-technical issues are tightly interwoven and interrelated. ANT as a theoretical frame of analysis serves the purpose of understanding the dualism that emerges from technology and society as different aspects of development through networks and characterizing these networks. ANT offers explanations to resolve the duality that is often encountered in terms of 'technological' and 'social' aspects of development of a project. This approach provides solutions to the hybrid problems that are encountered in the current world where technological concerns are embedded with human centred concerns (Jolivet and Heiskanen, 2010).

In an actor network framing, four key aspects hold importance such as a) actors, b) their networks, c) how ANT develops its analysis, and d) how ANT is applied. Networks are reckoned in terms of nodes and links. In ANT, nodes are actors. Actors are entities which interact with other actors or serves as intermediaries for other actors. The ANT approach puts emphasis on determining interactions, connections and activities of actors involved.

The links between the actors are to be mapped in order to understand the networks and structures (Comber et al, 2003).

Though, ANT as a theoretical framework has not been applied to understand the growth of off-grid energy sector, however, there are studies where ANT as an analytical tool has aided in understanding various dimensions of renewable energy sector development. Development of German PV industry is examined through the lens of actor network, where human and non-human elements act upon each other to contribute to the development of German PV market (Galvin, 2009). Similarly, organizational dimensions of renewable energy projects have been explored by examining the alliances and networks formed by heterogeneous actors and entities (Iskandarova, 2011). The paper stresses emphasis on how organizational forms have been arranged and structured which could lead to contribute to the development of the sector. Jolivet and Heiskanen (2010) analyse local controversies and participation processes in the wind energy development by applying theoretical tenets of ANT. It is argued by the authors that ANT emphasizes on the process of creation of new technological artefacts, where the stress is laid on complex system of technical-natural and political environment that must be effectively embedded with the technological system in order to work properly.

Building on the theory of actor network, the present paper aims at understanding the renewable energy based off-grid energy sector from actor networks perspective in South Asia in a comparative basis. Since off-grid energy sector is considered to be a complex system where techno-economic considerations are strategically interwoven into the socio-cultural-institutional processes (Verbong et al, 2010), the sector requires an analytical tool, able to capture this multiplicity and complexity characteristics of the system. The next section details out the study methodology adopted in the paper.

### **III. Study Methodology**

The present study builds on a qualitative approach to understand the actors and their relationship and interconnectedness and the structures and processes of deployment of off-grid energy systems in select countries in South Asia. The theoretical framework of actor network contributes to the understanding of critical issues, relationship and processes by conducting an in-depth understanding of a specific case of off-grid energy development in select countries in South Asia. Since, ANT does not offer formal research approach, the study relies on both primary surveys and secondary information sources for

data and information. Primary surveys were conducted as part of the ongoing project activity i.e. OASYS project on a rotational basis during early 2013 to late 2013 in three select countries to gather information for understanding the growth of off-grid energy sector. For the present purpose of the study, three countries are chosen for the analysis i.e. India, Nepal and Sri Lanka. Various survey techniques such as key informant interviews, focused group discussions (FGDs), direct observations etc. were used for information and data gathering. Key informant interviews were held with organizations that are active in the field of decentralized energy development in the respective countries. Critical stakeholders analyses were also carried out to identify crucial aspects of off-grid energy sector development in the respective countries of the South Asia region. This is supplemented by content analysis of documentation from secondary sources. To fill the void that remained, a round of telephonic discussion was also held with several key stakeholders. The collated information was coded for analytical purposes. In addition select project sites were also visited to understand the ground level realities of off-grid energy development in these countries. The next section presents the core group of actors associated in the off-grid energy development in the study countries.

#### **IV. Core Group of Actors and their Heterogeneity**

Since, off-grid energy sector is conceived as a hybrid engineering problem, where technological aspects are strategically interwoven with human elements, understanding the sector and devising effective policy and planning for the sector needs an understanding of associated actors involved at various scales of project design, operation and management. Development of off-grid energy sector in the study countries has been characterized by spatially and temporally complex web of actors. This section presents a generic discussion on the key actors associated with the off-grid energy development in the three South Asian countries.

It emerged from the review and analysis of prevailing renewable energy based off-grid energy systems in these countries that organizationally each country has been able to set up a Centre/Authority at the national level for promotion of renewable energy, though the scope and thrust of these Centres/Authorities differ significantly from country to country. Interestingly, there do not exist dedicated Centre/Authority for promotion of decentralized energy systems in any of the study countries, however, development of renewable energy centric off-grid sector is considered as an integral part of the overall

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renewable energy development in the countries of the region. For instance, in India, Indian Renewable Energy Development Agency (IREDA) was set up in 1987 as a public limited company to provide financial assistance for the promotion of renewable energy in India. In Nepal, Alternative Energy Promotion Centre (AEPC) was set up in 1996 to develop and promote renewable energy resource in the country. Sri Lanka Sustainable Energy Authority (SLSEA) constituted in 2007 is serving as an apex institute to drive the country to a new level of sustainability by focusing on increasing indigenous renewable energy resources. In addition, at national level ministries are also been responsible for promotion of renewable energy based off-grid energy developments. However, there exist pronounced diversity in terms of their roles and responsibilities. While in India a dedicated ministry i.e. Ministry of New and Renewable Energy (MNRE) has been created to take care of the sector, in Nepal and Sri Lanka, renewable energy based off-grid energy sector has been developed by ministries which look after other issues alongwith renewable energy development. For instance, in Nepal, Ministry of Science, Technology and Environment (MoSTE) is entrusted to look into renewable energy development issues along with several other pertinent aspects such as sustainable development, climate change and environment etc. Similarly, in Sri Lanka, Ministry of Environment and Renewable Energy (MoERE) is responsible for developing several other aspects such as air resource management, climate change, natural resource management, sustainable development alongside renewable energy. However, while in India, MNRE is more active in promoting renewable energy based off-grid development, IREDA is on an extended wing of the ministry dealing with provision of financial assistance for renewable energy sector, in Nepal and Sri Lanka, while ministries are less active, national level Centres/Authorities such as AEPC and SLSEA are more active in the promotion of renewable energy based off-grid energy development in the respective countries.

Second important group of actors contributing to the sector development is the regulators. It is worthwhile to mention here that while off-grid energy sector in the study countries is largely an unregulated sector, however, there is an increasing realization among the policy makers and planners to bring this sector under the claws of regulation. Therefore, regulatory authorities designed to regulate the electricity sector in general are often tasked to look into regulatory aspects of off-grid energy sector. This has been tried out in Sri Lanka and also in India. In Sri Lanka, there has been an effort to introduce net metering by Public Utilities Commission of Sri Lanka (PUCSL) where erstwhile off-grid projects

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are being connected to the grid. Similarly, there is an effort by Central Electricity Authority of India (CERC) in India to introduce regulatory principles for the off-grid energy sector. However, in Nepal, AEPC acts as both as a centre for the promotion of renewable energy based off-grid energy in the country and also acts as a watchdog for the sector in its capacity of a regulator.

Another important group of actors is the financial institutions in these countries, banking communities in particular. In Nepal and Sri Lanka, banking communities have been instrumental in deployment of renewable energy based off-grid energy projects. However, in India, there appears to be a lukewarm response from bankers to finance off-grid energy projects. In recent past, efforts have been undertaken through specific programmes to sensitize bankers about the importance of this sector and the role banks can play in the promotion of this sector. In Nepal, Clean Energy Development Bank (CEDB), Laxmi Bank, Himalayan Bank are contributing to the off-grid energy development in the country through their involvement of various off-grid energy programmes in the country, largely supported by the donor agencies. Similarly, in Sri Lanka, Hatton National Bank (HNB), DFCC were important stakeholders in the World Bank funded off-grid energy development programmes such as Energy Service Delivery (ESD) programme and Renewable Energy for Rural Economic Development (RERED) programme. Nine participating credit institutes were involved in some form or other in the World Bank funded RERED programme in Sri Lanka. They had a great stake in the promotion of off-grid energy systems in Sri Lanka as these credit institutions assumed credit risks on sub-loans granted for the off-grid projects.

Associations and Forums also have played important role in the development of renewable energy based off-grid energy sector in the study countries. For instance, in Nepal, Nepal Micro-hydro Development Association (NMHDA), and Solar Electric Manufacturers Association of Nepal (SEMAN) have been instrumental in promoting micro-hydro and solar energy based off-grid interventions. Similarly, in Sri Lanka Solar Industries Association and Micro-hydro Developers Association have been created to look into the technology specific issues associated with off-grid energy development. Various forums and federations also have contributed substantially for the development of the sector. For instance, in Sri Lanka, Energy Forum has been created at the national level to represent the voice of off-grid energy consumers. Apart from these, several other actors like private manufacturers, NGOs – both national and local, private companies,

community associations at the local level, independent companies, equipment suppliers, consumer societies, moreover research institutions and universities are engaged in varying strengths and capacities in various aspects of off-grid project development in these countries.

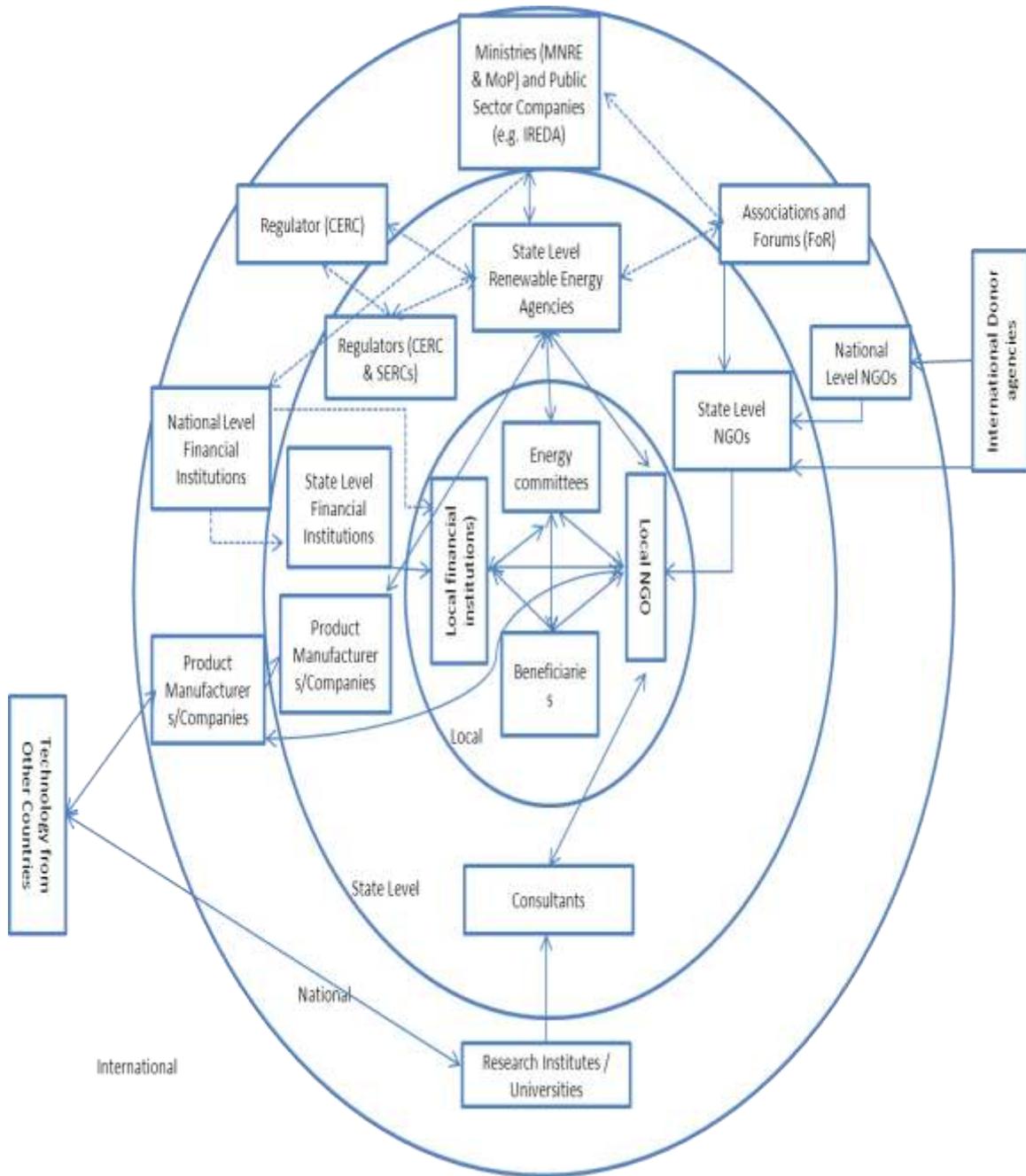
Having mentioned the key actors involved in the off-grid energy development three South Asian countries, next section presents how the networks are built among the key actors in a complex manner in the study countries.

### **V. Actor Networks and Interconnectedness**

This section brings out the networks of a heterogeneous group of actors contributing to the development of off-grid energy sector in three study countries of the South Asian region i.e. India, Nepal, and Sri Lanka. Since the socio-economic, political contexts differ across study countries, the strength of the networks, interconnectedness accordingly differ significantly. For instance, while in India, the responsibility of developing energy falls on both the Centre and states, this has not been the case with Nepal and Sri Lanka. In this section, we attempt to bring out this complexity of the networks that shape the renewable energy based off-grid energy sector in the study countries.

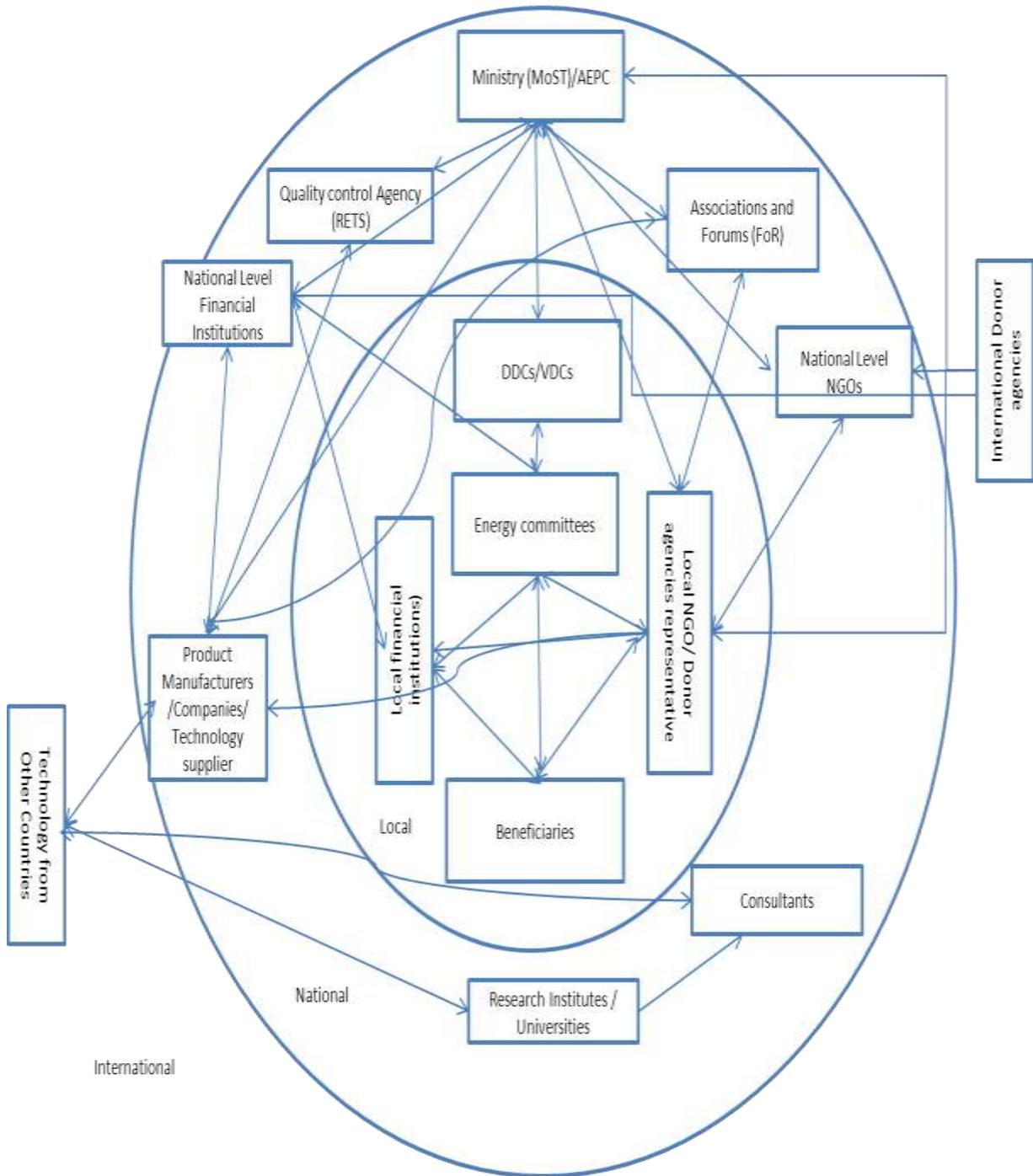
The deconstruction of interactions at various scales reveals some interesting phenomenon. One of the interesting phenomena is to look at these interactions from both spatially and temporally. Other important phenomenon is to examine the strength of the networks, which are characterized by either strong networks or weak networks. We present below the complex web of networks, relationships, and interconnectedness among various actors, spatially spread over from one scale to the other.

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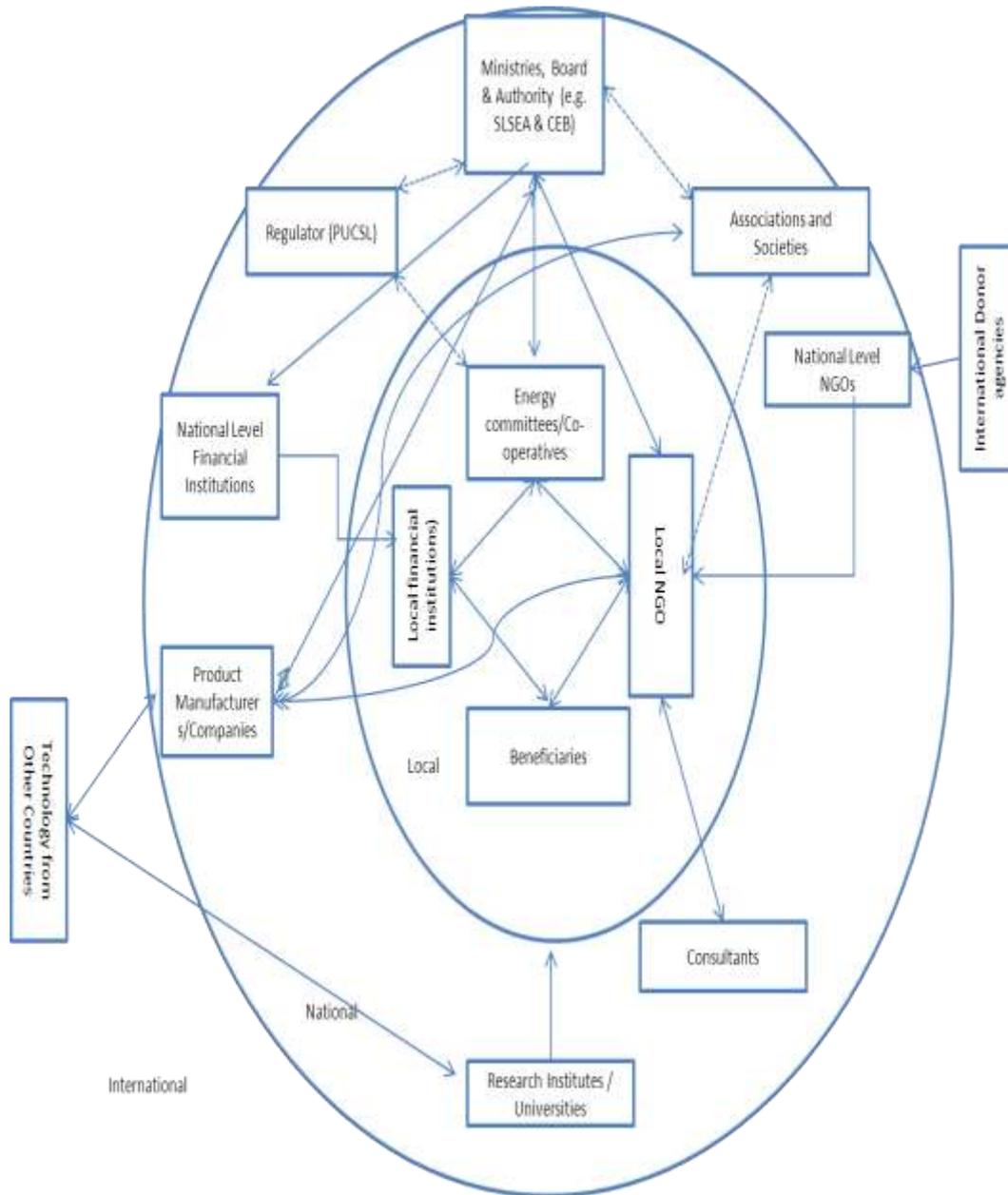


**Fig.1a: Actor networks and their interconnected promoting renewable energy based off-grid energy in India**

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**Fig.1b: Actor networks and their interconnected promoting renewable energy based off-grid energy in Nepal**



**Fig.1c: Actor networks and their interconnected promoting renewable energy based off-grid energy in Sri Lanka**

**Strong network:**  $\longleftrightarrow$

**Weak network:**  $\dashrightarrow$

Analysis of actor networks and their characteristics in three countries of the South Asia region as presented in the above figures (Fig 1a, 1b, and 1c) reveals several interesting

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findings. Let us first focus on the networks those take place at the local scale. This is the scale where interconnection between technology and society takes place in an intensive manner. Since, the project gets operationalized at the local scale, the frequency or depth of the networks among the actors is therefore very high, both spatially and temporally. All the upstream actors, either directly or indirectly are connected to the actors playing around the project at the local scale. The intensity of the spatial interactions between actors placed at different scales also changes over time. While actors positioned at higher scales either at the national level or international level are more active during the initial period of project development and operation, actors placed at the local scale keeps on interacting for the entire life period of the project. It could be gleaned from the figures and also emerged from our primary and secondary data analysis that the networks and interconnectedness exist at the local scale are more or less similar in all the study countries. Of course, there exist some variations depending on type of technology, mode of intervention and delivery model. The similarity of actor networks at the local scale is primarily due to the fact that a majority of delivery models for off-grid energy sector in the region are centered around community led models (Palit and Chaurey, 2011). The key actors at the local scale are beneficiaries, the village energy committee, local NGO and/or technology supplier, and local financial institutions. In some cases, local administrative units like Village Panchayats also play an important role.

Spatially, there also exist differences among countries in terms of actors located at different scales. For example, in India, there also exist a whole range of actors at the sub-national scale, which is not the case with other countries. Most important among them is the state renewable energy authorities, which acts as intermediaries between local scale actors and national level actors.

At the national scale, one can find varyingly different set of actors engaged in the sector development and interacting with varying degrees of intensity in different countries of the region. These differences are mapped by networks characterized either by weak networks or by strong networks. For instance, in case of India and Sri Lanka, the links that exist between various associations and forums with other actors are weak in nature. Associations and forums do not play important role in the promotion of off-grid energy development in these countries. Similarly, regulators in India and Sri Lanka are also weakly linked with the other actors in the promotion of off-grid energy sector, whereas in Nepal, regulators for the sector are conspicuous by their absence. Further, banking

communities as an important group of actors play instrumental role in Nepal and Sri Lanka and have strongly related to the sector development. However, in India, banking communities are weakly linked with other actors in the network. It also emerges from the analysis that temporally the networks connecting actors placed at macro and intermediate levels to the actors located at the micro-scales are strong during the initial period of project planning, designing, financing and operation and management. However, overtime these networks become weak and less relevant for the project.

The above analysis clearly brings out the existing gaps in the present system of networks that shape the renewable energy based off-grid sector in the study countries.

### **VI. Conclusion**

The paper is a novel attempt to understand the renewable energy based off-grid interventions in three South Asian countries from a new perspective by applying the theoretical lens of Actors Network Theory (ANT). The understanding is built around the conception that off-grid energy sector is a hybrid engineering problem, where technological aspects are strategically interwoven with human elements. The paper first identifies the key set of actors involved in the promotion of renewable energy off-grid energy interventions in the three countries of the region. It emerges from the discussion that there exist pronounced diversity among the actor types and actor groups engaged in the promotion of off-grid energy sector in the study countries. Then, the complex web of actor networks is captured graphically for each of the three countries separately. The results reveal that the strength of actor networks differs significantly both spatially as well as temporally. The paper also suggests specific group of actors and their networks to be strengthened for each of the countries. While India needs to emphasize strengthening the networks between financial institutions and other actors on the one hand, there is also a need to assign momentum to the networks connecting regulators and other actors. Sri Lanka should undertake similar efforts to strengthen regulators and the networks connecting regulators with other actors. While Nepal is relatively better placed in terms of strength of actor networks, it also has to introduce a whole range of new networks connecting the existing actors to a new actor ‘regulator’.

### **Acknowledgement**

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Authors acknowledge the financial support received through the EPSRC/DfiD research grant (EP/G063826/1) from the RCUK Energy Programme in preparing this manuscript. The Energy Programme is a RCUK cross-council initiative led by EPSRC and contributed to by ESRC, NERC, BBSRC and STFC. The views expressed here are those of authors and do not necessarily represent the views of the institutions they are affiliated to or the funding agencies.

## Annexure I

Country	Policy initiative(s)
India	India does not have a separate renewable energy policy per se. Various initiatives, however, such as Renewable Energy Portfolio Schemes (RPS), Renewable Energy Certificates (RECs) and National Green Funds have been introduced from time to time to mainstream renewable energy development. Renewable energy as a means of off-grid electrification has also been included as part of the Electricity Act, 2003, the National Electrification Policy 2005, and the Rural Electrification Policy(REP), 2006. The Jawaharlal Nehru National Solar Mission was launched in 2009 as one of the eight Missions under the National Action Plan on Climate Change (NAPCC), to boost the solar energy sector in the country.
Nepal	No comprehensive renewable energy policy, but several policy measures initiated to promote alternative energy technologies and systems.
Sri Lanka	The National Energy policy has sections devoted to development of renewable energy resources in the country.

## References

Benecke, G. 2010. 'Satkeholder Networks in Carbon Governanance: The Role of State Market Relations in the Indian Renewable Energy Sector'. *Governance of Clean Development Working Paper 007*, University of East Anglia.

Bhattacharyya, S.C. 2012. 'Review of Alternative Methodologies for Analysing Off-grid Electricity Supply'. *Renewable and Sustainable Energy Reviews* 16(1):677-694.

Callon, M. 1991. 'Techno-Economic Networks and Irreversibility', in John Law (ed.), *A Sociology of Monsterr: Essays on Power, Technology and Domination*, London: Routledge.

Comber, A., Fisher, p., and Wadsworth, R. 2003. 'Actor-Network Theory: A Suitable Framework to Understand How Land Cover Mapping Projects Develop'. *Land use Policy* 20: 299-309.

## **An Actor Network Framing of Off-grid Electrification in South Asia**

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- Cust, J., Singh, A., Neuhoff, K., 2007. 'Rural Electrification in India: Economic and Institutional Aspects of Renewables'. *EPRG 0730 and CWPE 0763*. < <http://www.eprg.group.cam.ac.uk/wp-content/uploads/2008/11/eprg0730.pdf> > (accessed on 5 October 2011).
- Dickens, P., Kelly, P.F., Olds, K., Yeung, H. W.C. 2001. 'Chains and Networks, Territories and Scales: Towards a Relational Framework for Analyzing the Global Economy'. *Global Networks* 1: 89-112.
- Galvin, R. 2009. 'Modifying Actor Network Theory to Analyse the German Project of Photovoltaic Electrical Energy Generation'. *CSERGE Working Paper EDM*, No.09-02.
- Ghose, R and M Pettygrove, 2014. 'Actors and Networks in Community Garden Development', *Geoforum* 53: 93-103.
- IEA. 2012. 'IEA Online Data Services'. Accessed @[data.iea.org/ieastore/statslisting.asp](http://data.iea.org/ieastore/statslisting.asp).
- Iskandarova, M. 2011 'Organisational Development of Renewable Energy: The Case of Wave Hub', Working Paper, University of Exeter Business School.
- Jolivet, E. and E. Heisknen. 2010. 'Blowing against the Wind – An Exploratory Application of Actor Network Theory to the Analysis of Local Controversies and Participation Processes in Wind Energy'. *Energy Policy* 38 (11) :6746-6754.
- Kumar, A., Mohanty, P., Palit, D., Chaurey, A. 2009. 'Approach for Standardization of Off-grid Electrification Projects'. *Renewable and Sustainable Energy Reviews* 13(8):1946-1556.
- Latour, B. 2005. *Reassembling the Social: An Introduction to Actor Network Theory*, Oxford: Oxford University Press.
- Long and Vn Der Ploeg, J. 1989. 'Demythologizing Planned Intervention: an Actor Perspective'. *Sociologia Ruralis* 29(3/4):226-249.
- Mahanty, S. 2002. 'Conservation and Development Interventions as Networks: the Case of the India Ecodevelopment Project, Karnataka'. *World Development* 30(8):1369-1386.
- Monteiro, E and Hanseth, O. 1996. 'Social Shaping of Information Infrastructure: On Being Specific about the Technology: In Orlikowski, W; Walsham, G; Jones, M.R., and De-Gross, J. (Eds) 'Information Technology and Changes in Organisation Work', Chapman and Hall, London.
- Murdoch, J.1998. 'The Spaces of Actor Network Theory'. *Geoforum* 29 (4):357-374
- Murdoch, j. 2000. 'Networks – a New Paradigm of Rural Development?'. *Journal of Rural Studies* 16 (4): 407-419.

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Narula, K., Y. Nagai, and S. Pachauri. 2012. 'The Role of Decentralised Distributed Generation in Achieving Universal Rural Electrification in South Asia by 2030'. *Energy Policy* 47:345-357.

Palit, D. and A. Chaurey 2011. 'Off-grid Rural Electrification Experiences from South Asia: Status and Best Practices'. *Energy for Sustainable Development* 15(3):266-276.

Palit, D. and G. Sarangi. 2011 'A Comparative Analysis of Solar Energy Programmes for Rural Electrification: Experiences and Lessons from South Asia', Pre-conference Proceedings of Third International Conference on Addressing Climate Change Sustainable Development through Up-scaling Renewable Energy Technologies', October 12-14, 2011, Kathmandu, Nepal.

Verbong, G., W. Christiaens, R. Raven, and A. Balkema. 2010. 'Strategic Niche Management in an Unstable Regime: Biomass Gasification in India'. *Environmental Science and Policy* 13 (4) : 272-281.



### OASYS South Asia project

The Off-grid Access Systems for South Asia (or OASYS South Asia) is a research project funded by the Engineering and Physical Sciences Research Council of UK and the Department for International Development, UK. This research is investigating off-grid electrification in South Asia from a multi-dimensional perspective, considering techno-economic, governance, socio-political and environmental dimensions. A consortium of universities and research institutes led by De Montfort University (originally by University of Dundee until end of August 2012) is carrying out this research. The partner teams include Edinburgh Napier University, University of Manchester, the Energy and Resources Institute (TERI) and TERI University (India).

The project has carried out a detailed review of status of off-grid electrification in the region and around the world. It has also considered the financial challenges, participatory models and governance issues. Based on these, an edited book titled “Rural Electrification through Decentralised Off-grid Systems in Developing Countries” was published in 2013 (Springer-Verlag, UK). As opposed to individual systems for off-grid electrification, such as solar home systems, the research under this project is focusing on enabling income generating activities through electrification and accordingly, investing decentralised mini-grids as a solution. Various local level solutions for the region have been looked into, including husk-based power, micro-hydro, solar PV-based mini-grids and hybrid systems. The project is also carrying out demonstration projects using alternative business models (community-based, private led and local government led) and technologies to develop a better understanding of the challenges. It is also looking at replication and scale-up challenges and options and will provide policy recommendations based on the research.

More details about the project and its outputs can be obtained from [www.oasyssouthasia.dmu.ac.uk](http://www.oasyssouthasia.dmu.ac.uk) or by contacting the principal investigator Prof. Subhes Bhattacharyya ([subhesb@dmu.ac.uk](mailto:subhesb@dmu.ac.uk)).

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