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Poverty amidst plenty: Case of renewable energy-based off-grid electrification in Nepal

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Abstract

Providing access to electricity to a large chunk of rural populace in Nepal has traditionally been a daunting exercise. This has been exacerbated by geographical variations, poor transportability; fragmented settlements, illusive energy development strategies, lack of sufficient financial capital and moreover by on-going energy crisis. The present study conducts an objective assessment of the renewable energy based off-grid energy sector in Nepal by applying a mixed method research design built on both qualitative and quantitative research techniques. While country experiences of developing micro-hydro and solar energy based interventions are captured by qualitative analysis, a case study evaluation is done by applying standard techno-economic analysis of renewable energy resources. Assessment of off-grid electrification options reveals that despite visible progresses achieved, there still exist multiple roadblocks to scale up. Absence of clearly spelt out policy goals, weak institutional designs, low load factors, poor financing base, and overall regulatory concerns stand as major obstacles for off-grid energy sector development in the country. In addition, project specific analyses reveal that solar loses out as a cost effective option compared to micro-hydro. But optimal use of micro hydro interventions requires creation of productive applications at the local scale on a sustainable manner.

Keywords: Nepal, micor-hydro, off-grid, mini-grid, solar PV;

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I. Introduction

Nepal, a land locked mountainous country of South Asia, is located between India and China. The country occupies a total land area of about 147,180 square kilometers with a population of 30. 5 million in 2011. About 40 % of the total land area of the country is covered by forests and shrubs. Country's socio-economic profile is not very encouraging as 44 % of country's population live below poverty line (UNDP, 2013). The economy of Nepal is ranked as one of the low income economies by the World Bank with per capita income of $ 742 and growth rate of 4. 5 % in 2011-12 (Ministry of Finance, 2012). Rural population of Nepal constitutes about 82 % of total population of the country, leaving rest as urban people. A large section (i.e. about 70 %) of population in Nepal is dependent on primary economic activities like forests and agriculture, whereas the rest are engaged in secondary and tertiary sector activities. On human development dimension the performance has also not been very encouraging. With the HDI scoring of 0.463, Nepal is outranked by 156 countries (UNDP, 2013). Presence of political uncertainty and disruptive political system is believed to have bred debilitating and inefficient governance system and culture pervaded in all spheres of socio-economic development in the country including the energy sector (Nepal and Jamasb, 2012).

Providing access to energy in Nepal has traditionally been a challenging exercise. While at the global scale, about 1.2 billion people do not have access to electricity and about 2.6 billion people do not have access to clean cooking facilities (IEA, 2012), Nepal, being located in one of the least electrified regions of the World i.e. in South Asia, has not been escaped from these hard realities. Precarious state of access to energy in Nepal is evident from the Nepal Living Standard Survey 2011. About 25 % of population do not have access to any form of modern lighting energy. Energy access challenges get exacerbated by geographical variations, poor transportability; fragmented settlements, illusive energy development strategies, lack of adequate capital (Parajuli et al, 2011) and moreover it gets manifested in the on-going energy crisis. Two pertinent aspects need further explanation. First, physiographic features of the country, as it has bearings on the state of energy system in the country and second, depth and intensity of on-going energy crisis, an outcome of multitude of factors like long persisting political instability, lack of adequate resources, and poorly crafted policy and regulatory framework.

Physiographic features of the country are characterized by rough physical terrain conjugated with a low, scattered and sparse population density. It is recognized at the policy sphere that providing grid electricity to all areas in Nepal seems to be a herculean task in the country in the foreseeable future (NEA, 2006). Grid based centralized electrification system is considered to be relatively expensive and time consuming to electrify scattered settlements located in difficult geographical terrains of the country (NPC, 2007; Bhandari and Stadler, 2011; Ghale, 2013). Studies indicate that about 10 million people (which constitute about 33 % of the total population of the country) live in such remote locations requiring 5 to 18 days of walk to reach (Zahnd, and Kimber, 2009). Marginal cost of grid expansion in Nepal is very high due to physical isolation, lower electricity loads and scattered low-income consumers (Mainali and Silveira, 2011).

It is pertinent to highlight the persistence and deepening energy shortages, the country has been experiencing since long, which has culminated into a ‘great energy crisis’. Economic Survey of Nepal 2011-12 acknowledges this on-going energy crisis in Nepal and states that “energy crisis has been the largest obstacle for country’s economic development” (Ministry of Finance, 2012). The crisis gets embodied in multiple dimensions of energy supply, energy production, energy consumption etc. It is posited that energy crisis in Nepal gets accentuated by rapid urbanization and growth of industries (Nepal, 2012) etc. Load shedding of about 12 -14 hours per day for almost all the on-grid households (about 2.4 million households) is a clear manifestation of the magnitude of such a crisis.

In the above backdrop, the paper focuses on two important mode of off-grid electrification options in Nepal such as micro-hydro and solar home systems (SHS). Though recently solar mini-grids as an option is decided upon for electrification in Nepal, it has not yet physically taken up, therefore we have not considered solar mini-grids in our analysis. The analysis dwells on the following set of research objectives.

- Assesses the state of renewable energy based off-grid electrification in Nepal.
- Presents a critical evaluation of policy and institutional landscape governing the renewable energy based off-grid electrification in Nepal.
- Carries out a critical assessment of a micro-hydro project including financial evaluation.
- Discusses key aspects of and identifies key anomalies and distortions for off-grid electrification in Nepal.

The paper organizes as follows. Section II spells out the study approach. Section III presents the macro energy scenario in Nepal. Fourth section highlights the renewable energy based off-grid interventions in Nepal with specific thrust on micro-hydro and solar energy based interventions. Section V spells out the policy and institutional contours governing off-grid electrification in Nepal. Section VI discusses the key ingredients of off-grid electrification in Nepal. Section VII presents a case study analysis of a micro-hydro project. Section VIII carries out a critical assessment of off-grid electrification by identifying the key anomalies and distortions. Section IX suggests the required policy changes to accelerate the process of off-grid electrification in the country and the final section concludes the paper.

II. Study Approach

A mixed method research design built on both qualitative and quantitative research techniques is employed for the analysis. The method prioritizes collecting, analyzing, and mixing both quantitative and qualitative data at different phases in the research process. While the emphasis of qualitative approach was to understand the critical nuances, actors and institutions associated and processes involved with the off-grid energy development in Nepal, quantitative assessment supplements the qualitative analysis by carrying out a critical analysis of gathered primary and secondary information.

A week-long visit was conducted to Nepal to carry out the survey and to gather information for the purpose of the study. The survey was divided into two parts. First, key informant interviews were conducted with different stakeholders to understand and assess the state of renewable energy based off-grid electrification system in the country. Second, a field visit to a micro-hydro site was carried out to gather information about the project operation, management and aspects of project sustainability and to validate the findings from key informant interviews.

A host of data collection techniques namely research interviews, field research, stakeholder's analysis and focus group discussions (FGDs) were used to elicit desired information. A semi-structured interview format with flexibility to accommodate changes was administered to conduct interviews with different stakeholders to obtain information. Interviews at the project site constituted transect walks, focus group discussion, and observational data gathering and semi-structured interviews with key local informants like system technician, president of the plant, village chief, school teachers, village shop keepers, productive end-users, and local health clinic staffs etc. In order to identify the prospective stakeholders, a non-probabilistic purposive sampling method was used to select interviewees having knowledge and wisdom of off-grid renewable energy in the country and having direct and/or indirect association with the sector. Key stakeholders interviewed were listed in the Annexure - I. The interview conducted consists of asking questions related to multiple crucial dimensions of off-grid energy sector development in Nepal such as growth and trend of renewable energy centric rural electrification, role of donor agencies, policy level supports and issues related to the subsidies and incentives, financial mechanisms, role of associations, NGOs etc. The gathered information from the multiple stakeholders was recorded and coded for further analysis. Information gathered from field visits are used to carry out a comparative financial assessment of various options for providing electricity in the locality.

III. Macro energy setting in Nepal : an overview

Nepal is one of the countries with lowest per capita electricity generation and consumption. Per capita energy consumption stands at 93 kWh in 2010. Total generation capacity of the country is about 714 MW (World Bank, 2013), largely drawn from hydro sources. The energy sector in the country is characterized by slow growth in all the critical dimensions. While the overall electrification rate in Nepal is about 75 %, there exist wide disparities in electrification rates between urban and rural areas. While 95 % of urban areas use electricity for lighting, rural areas in Nepal are limited only to about 60 %. This urban-rural disparity is worsened when it comes to access to modern energy for cooking. Use of traditional biomass for cooking between urban and rural reveals that while in urban areas, 27 % rely on fire wood and cow dung for their cooking, this goes up to 86 % in rural areas in Nepal (NLSS, 2011). Even at the global level, Nepal's performance in energy is not very exciting. International Energy Agency (IEA)'s Energy Development Index[1] (EDI) for Nepal ranks the country at 74 in 2012 with the EDI score of 0.08, echoing the poor state of energy in the country (IEA, 2012).

Despite Nepal being the second hydro resource rich country after Brazil and having enormous potential for solar energy, three decades of research and development has not produced visible progress. In terms of availability of water resources, the country is endowed with 6000 rivers with the theoretical potential of producing 85,000 MW. Similarly, Nepal is endowed with enormous solar resources with the radiation of 4.7 kWh/m2/day. However, available hydro and solar resources have not been exploited optimally. Meager exploitation of hydro potential in the country is often attributed to the lack of investments in the sector (Bhandari and Stadler, 2011). Contradictory legal and policy landscape governing the sector coupled with lack of market for the sector are the major inhibiting factors for private investors to venture into the sector (Thapa, 2013). On the other hand, rapid urbanization and industrialization has led the electricity demand to peak at 946 MW in 2011 and predicted to increase to 3679 MW in 2027-28 (NEA, 2011).

The country does not possess major reserves of coal, natural gas, or oil. Majority of petroleum product requirements are met through imports from other countries. Import profile of various petroleum products for the country is highlighted in Figure 1. It is evident from the figure below that while import of gas/diesel exhibits an increasing trend in the past,

[1] International Energy Agency has devised composite indicators to measure a country's progress towards the use of modern fuels and modern energy services, which on other hand aid in understanding the role that energy in human development (IEA, 2012).

there has been a drastic decline in import of kerosene oil. This could be attributed to the large-scale substitution of kerosene by diesel and gas.

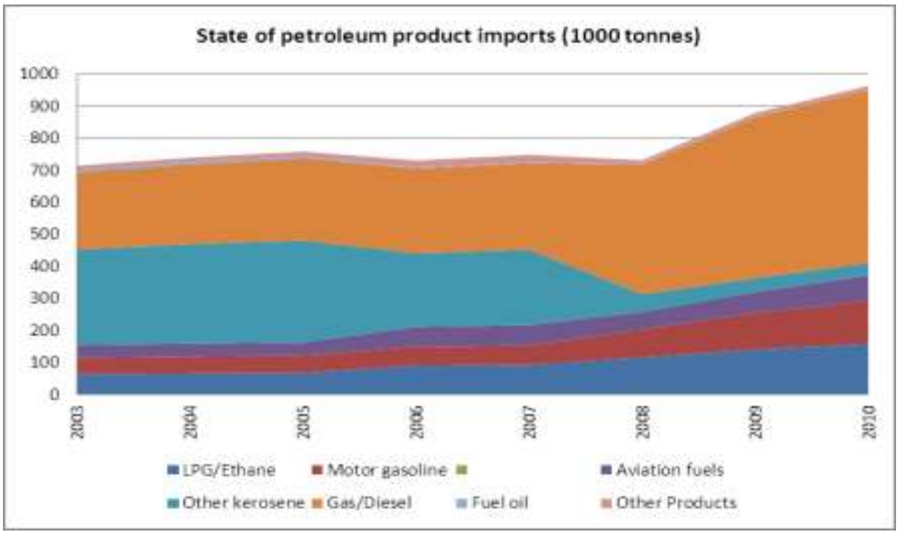

Fig. 1: Import profile of petroleum products in Nepal (Source: Energy Statistics for Non-OECD Countries (Different Volumes)

Energy consumption by sectors reveals that almost eighty percent of energy is being consumed by industrial and residential sector. However, in recent years relative share of commercial and public services sector has been showing an increasing trend. Agriculture and transport sector remain as low energy consuming sectors.

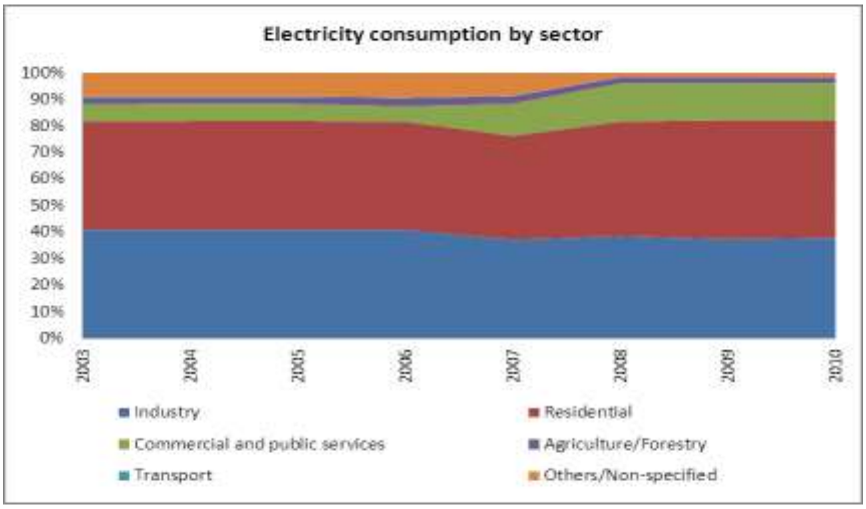

Fig. 2: Mapping of sector energy consumption in Nepal (Source: Energy Statistics for Non-OECD Countries (Different Volumes)

A segregation of sourcing of energy suggests that traditional forms of energy such as fuel wood, agricultural residues, and animal waste dominate the energy consumption basket in Nepal. Traditional energy sources meet about 86.5 % of energy requirements, followed by commercial energy, whose share is about 12.8 % of the total energy requirements and renewable sources only fulfill a meager energy requirement of 0.7 % (Ministry of Finance, 2011). It could be elicited from the figure that while traditional energy still dominates in the energy consumption portfolio, in recent years, commercial form of energy is increasingly substituting the traditional forms of energy. Though renewable energy has been prioritized very recently, its relative share still remains low.

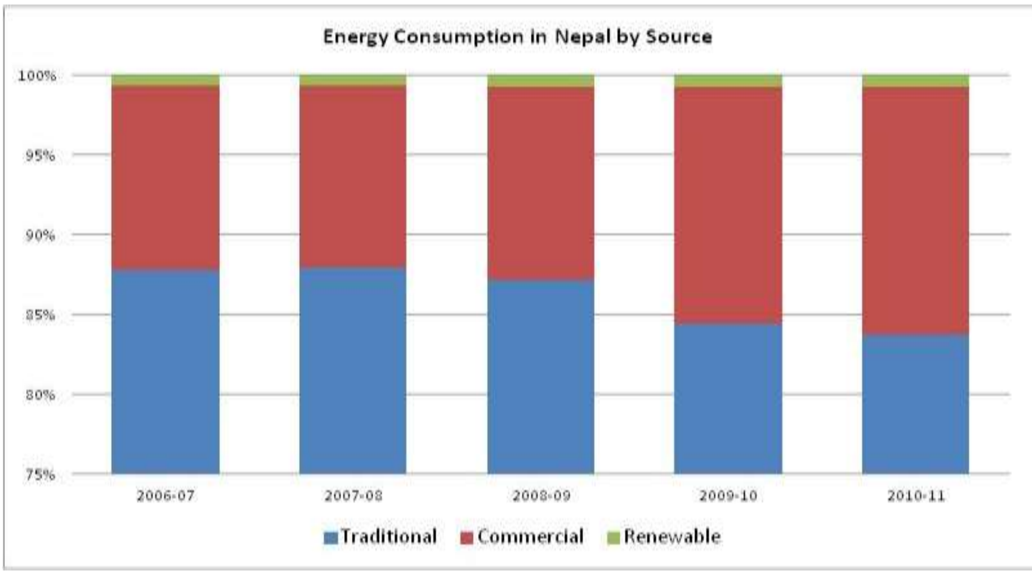

Fig. 3 Energy Consumption in Nepal by source (Source: Nepal Economic Survey, 2011)

State of energy access in Nepal exhibits the presence of heterogeneity in access to different forms of energy (Fig. 4). While LP gas serves around 70 % of the households cooking energy requirements in urban areas, it is limited only to 10 % of rural population. On the other hand, about 85 % of the rural households still rely on traditional biomass (e.g. wood/firewood and cow dung) as their prime source of fuel for cooking. In case of lighting, while about 94 % urban households use electricity, it is limited only to 60 % of the rural households. About 22 % of rural households in Nepal rely on kerosene as their source of lighting. In addition, solar, largely in the form of solar home lighting systems (SHSs), has been emerging as a potential alternative for lighting and about 9 % of the rural households are using solar as a source of lighting.

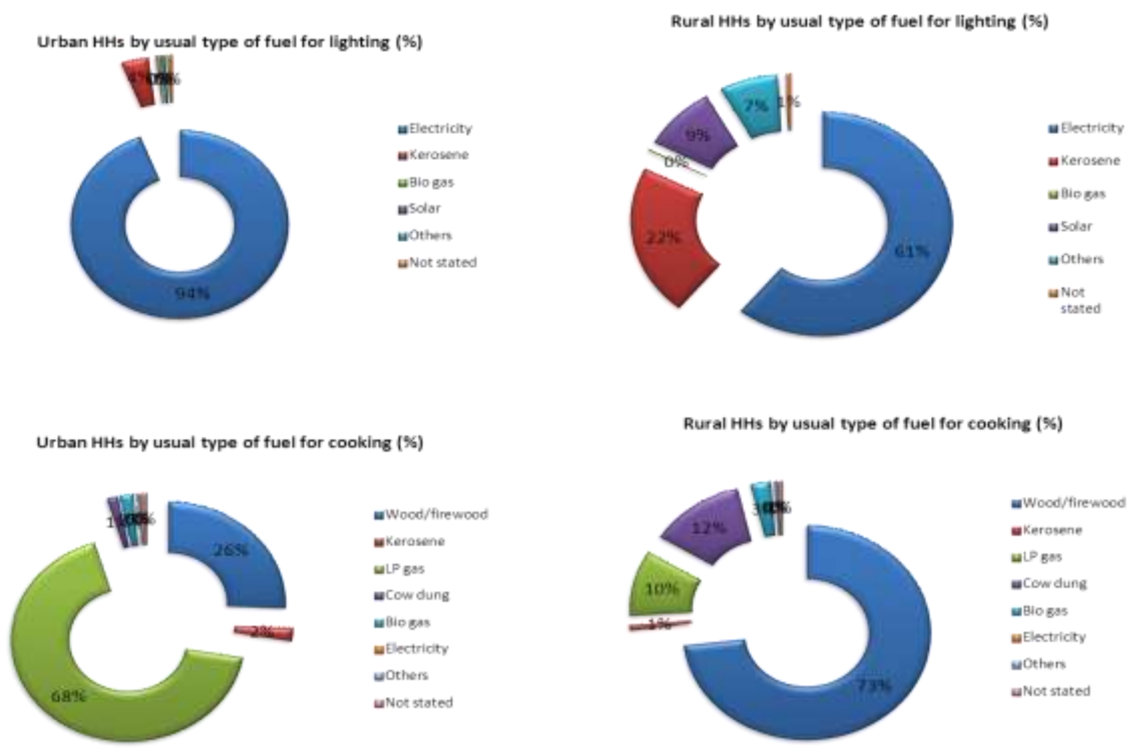

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Fig. 4: Cooking and lighting energy scenario in urban and rural conurbations in Nepal (Source: Nepal Living Standard Survey 2011)

In order to get a better picture of the state of energy scenario in Nepal, we present energy access indicator[2] for different districts in Nepal by combining access to electricity indicator and access to clean cooking fuel indicator as well as presenting both the indicators separately for all the 75 districts in Nepal. It could be gleaned from the figure that clusters could be identified where high access to electricity indicator values are followed by high access to clean cooking indicator values and vice-versa. However, there exist contrasting combinations suggesting specific policy thrusts on individual dimensions of access to energy.

[2] We largely follow the methodology advocated by IEA for constructing such an indicator. However, due to paucity of data, we have limited only to household level indicator of IEA. Variables are normalized by following the standard z –score normalization process. To find out the combined indicator, we have simply taken averages implying that we have assigned equal to weight to each individual indicators.

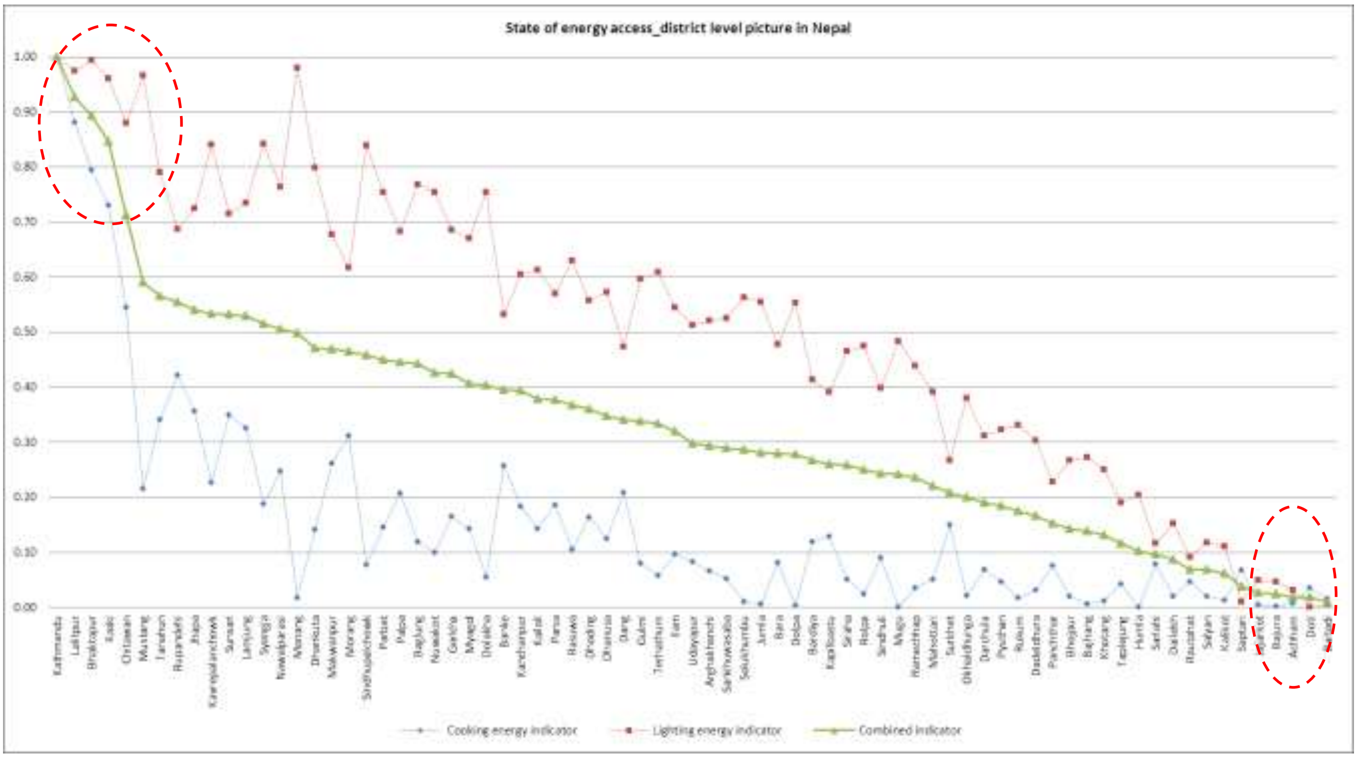


Fig. 5: State of energy access across districts in Nepal (Source: Nepal Living Standard Survey 2011)

The macro energy scenario in Nepal suggests the state of energy supply scenario is not very encouraging. There exist enormous challenges of access to modern lighting and cooking energy. More importantly, given the limitations of the grid electrification system in the country, large sections of the rural population are still devoid of any form of modern electrification. Renewable energy based off-grid electrification options have recently been prioritized as a supplementary route to the grid based system. The next section dwells on the off-grid electrification systems in the country.

IV. State of off-grid renewable electrification in Nepal

Development of alternative energy systems in Nepal could be traced back to the early Seventies. Off-grid renewable energy sector in Nepal has experienced a phased development process (Pokharel, 2013). The initial focus was on adaptive research and technology transfer, followed by focus on pilot programming and developing ad hoc policies for the promotion of renewable energy development during 1980s and 1990s. Next, emphasis was laid on setting targets, policy formulation, planning, resource allocation, capacity building, and institution strengthening during 1990-2010 and final phase was the period of scaling up, envisaging public-private-partnership (PPP) models, emphasizing sector development, increasing the share of renewable energy in energy portfolio, linking with economy, upgrading technology, making coherent policies, and linking with environment, etc. (Pokharel, 2013).

Off-grid electrification is mainly targeted at electrifying remote rural areas of the country characterized by low population density, low load factor and geographical remoteness. In addition, on-going energy crisis also gave impetus for the greater use and exploitation of off-grid renewable energy source (Gurung et al 2011; Sovacool et al, 2011). Micro-hydro, pico hydro, and solar home systems are the preferred mode of off-grid electrification in Nepal, though a small amount of electricity is generated through small-scale wind energy systems. There exist about 3 million off-grid households in Nepal, out of which 97 % are in rural areas. About 12 % of the total population are electrified through renewable energy based off-grid systems. While 22 MW generation capacities have been installed through micro-hydro and pico hydro schemes, 12 MW capacities have been installed through solar PV schemes. Besides, micro-hydro, pico-hydro and solar, about 20 kW is generated through wind energy systems as well. Development of off-grid electrification in Nepal has been largely supported by various donor agencies such as SDC, United Mission to Nepal, GTZ, GIZ, ITDG, DED, USAID, FAKT and SKAT, UNDP, DANIDA, SNV etc.

History of micro-hydro development in Nepal is the oldest and goes back to the early sixties and being constantly developed since then. Initial focus of micro-hydro projects was to create livelihood opportunities by utilizing the electricity for agro processing and other allied activities. Gradually micro-hydro systems became source of community electrification. These micro-hydro systems, during early days, were small in capacity ranging between 5 to 20 kW and largely supported by international donor agencies. These systems were providing lighting requirements with some productive activities like grinding, husking and oil-expelling. This was followed by installation of large-scale hydro-electric systems during mid-eighties. Development of micro-hydro systems was further accelerated through provision of loans and technical assistance and subsidies provided during early eighties. It was further boosted by financial and fiscal incentives such as subsidies; supports extended through several donor agencies and a host of other factors. As per the recent statistics, there are about 999 micro-hydro projects constituting about 19 MW and about 1480 numbers of pico-hydro projects totaling about 3.18 MW have been deployed by 2012. As far as the ownership of micro-hydro projects are concerned, 95 % of the projects are community owned; whereas about 5 % are privately owned and few are owned by NEA (Ghale, 2013). Two major programmes supporting the development of micro-hydro projects in the country are Energy Sector Assistance Programme (ESAP) supported by DANIDA, KfW, DFID, and Norwegian Government and Rural Energy Development Programme (REDP) supported by UNDP and World Bank. While under ESAP about 290 micro-hydro projects and about 402 pico-hydro projects have been installed, under REDP more than 300 micro-hydro projects ranging from 10 kw to 100 kw have been deployed so far (AEPC, 2012a; REDP, 2011). Figure 6 portrays cumulative number of HHs connected and kW capacity installed under the ESAP programme.

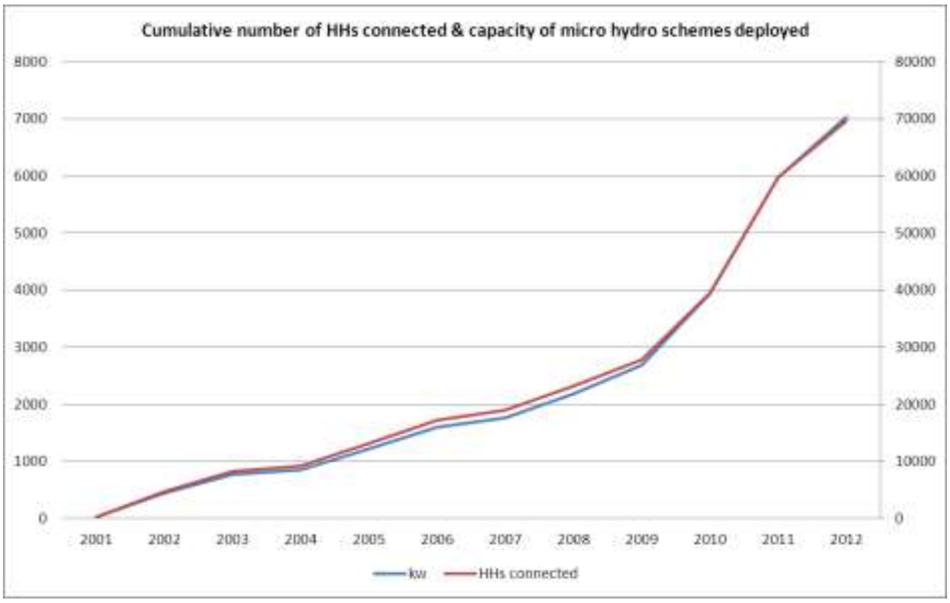


Fig.6: Cumulative number of HHs connected and capacity (kw) deployed under ESAP programme (AEPC, 2012a)

The second most important source of renewable energy based off-grid electrification in Nepal is the solar energy. Initiatives to develop solar energy in Nepal was undertaken as early as 1989 by National Electricity Authority (NEA) through support from French Government and streamlined after 1998. NEA installed three utility based mini-grids namely 30 kWp at Kodari, 50 kWp at Gamghadi, and 50 kWp at Simikot on experimental basis in 1989. This utility based mini-grid model was not very successful largely due to lack of sustainable financial model, lack of clarity in the role of private sector, tariffs, subsidies, capacity building etc. and absence of participatory approach in project planning (Dithal, 2013). The other important solar energy model promoted in Nepal is the Community Energy Service Provider (CESP) model operationalized by AEPC, European Union and REP. The model is primarily intended to promote institutional PV systems in rural areas to energize public institutions like schools, health posts etc. As per the implementation modalities of

CESP, ownership and management and annual maintenance lie with CESP. A monthly charge is imposed to recover O & M of the plant. However, CESP model has experienced several challenges such as difficulty in managing systems located in remote and difficult areas, poor payment structures of beneficiaries etc. Another model promoted by AEPC is the subsidized demand based vendor sales model, where long-term financing is provided with a subsidy component. Mainly three varieties of solar home systems (SHSs) are disseminated under government subsidy policy i.e. Solar Home Systems (SHSs), Small Solar Home Systems (SSHS), and Institutional and Pumping System. There are about 0. 3 million SHSs installed by 2012 with aggregated capacity of about 7 MW. In addition there are about 22,605 Small Solar Home Systems (SSHS) and 138 institutional and pumping systems with the total capacity around 1 MW has been deployed (AEPCb, 2012). Market based approaches to mainstream solar energy systems have emerged as a primary vehicle for the large scale dissemination of solar energy systems in Nepal. There are also a number of non-pre-qualified solar companies which install various solar application based systems solely on private entrepreneurial mode. In order to promote private entrepreneurial capacity in solar energy, Solar Electric Manufacturers Association in Nepal (SEMAN) has been created as an umbrella organization to protect and develop solar manufacturing companies in the country. There are about 100 companies who are members of SEMAN.

Growth of solar home systems in Nepal is graphed below (Fig. 7). It could be evident from the below that the growth of solar systems are very much sensitive to the provision of incentives like subsidies. For instance, unavailability of subsidies during 2004-05 led to fall in installed capacity of solar home system. However, resuming of subsidies in 2007 again led to sharp increase in the number of installation of solar home systems.

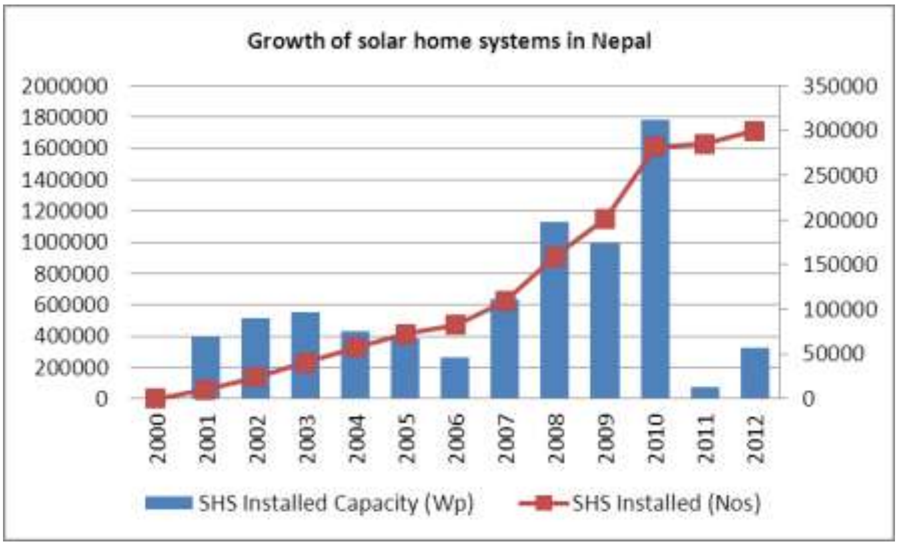


Fig.7: Growth of solar home systems (SHSs) in Nepal (AEPC, 2012b)

V. Policy, regulatory and institutional contours

The need and significance of policies and institutional considerations have been highlighted by several scholars and experts. It is emphatically posited that deployment of off-grid renewable energy technologies requires 'concrete, plausible policies (Nguyen, 2007). Potential to upscale renewable system largely hinges on the country's institutional characteristics and policy landscape governing the sector (Yadoo et al, 2011; Nepal, 2012). Present section highlights the existing policy and institutional landscape governing the off-grid renewable energy sector in Nepal.

Planned energy development in Nepal started with declaration of 7th Development Plan (1985-90) with focus on conservation of forest resources and upliftment of rural economies of the country. The Plan emphasized on promotion of biogas, solar thermal, wind energy, improved cook stoves, small water turbines and improved water mills. Specific thrust was laid on research and development and tapping of private sector potential in the field. It also laid emphasis on incentivizing the sector by giving grants and loans for large-scale dissemination of off-grid energy systems. The Eighth Plan (1992-97) continued its focus on renewable energy drawing from the experiences gained from the 7th Plan. Specific thrust was laid on developing technical manpower and gathering basic data for development of biogas, solar energy and wind energy. Increasing use of solar based systems like solar water heater, solar dryer, solar cooker, solar pump, solar generator, solar photovoltaic cells were prioritized. Emphasis was laid on attracting private investors. The plan proposed to develop a master plan for the diversification of use of solar energy. The Plan made a special provision for subsidies for PV household systems. Ninth Plan (1997-2002) reiterated the need to develop renewable energy as an important element of national development agenda by emphasizing creation of employment, enhancing better rural livelihood and prioritizing environmental sustainability. Research and development was also kept high on agenda to cut down the cost of generating power from alternative sources of energy. Tenth Plan (2002-2007) laid emphasis on using solar energy to meet the rising demand of energy. In addition, the need to electrify remote and rural areas through solar based interventions was also prioritized. The Plan envisaged setting up of Rural Energy Fund (REF) to manage and channelize grants and loans for development of alternative energy sources. 1st Three Year Interim Plan (2007-2010) focuses on developing a long-term alternative energy plan with specific focus on development of rural areas, creation of employment opportunities and sustainable development of the sector. 2nd Three Year Interim Plan (2007-2010) set an ambitious target of procuring 10 % of energy from alternative sources. In addition to the provision through planned development, several policy pronouncements are declared from time to time to accelerate the renewable energy based off-grid electrification in Nepal.

Policy pronouncements for off-grid energy development in Nepal could be traced back to the 1998 with declaration of Hydro Power Policy 1998, which again reformulated in 2001. Hydro Power Development Policy 2001 placed emphasis on development of rural economy through energisation and attracting private investors by devising favorable policies and incentive schemes. One of the important policy initiatives in the off-grid sector was undertaken with declaration of Rural Energy Policy (REP) 2006. This Policy prioritizes access to clean, reliable, and appropriate energy in rural areas. The Policy sets the objective of reducing dependency on traditional sources of energy, conserving environment, generating employment and creating productive activities through development of rural energy resources. Priority is also laid on creating capacities, human resource development, strengthening local institutions, and tapping private sector capabilities.

In addition to above policies, specific policies and mechanisms have been spelt out from time to time to disburse subsidies. First National Subsidy Policy 2000 envisaged providing subsidies to solar home systems, solar water pumps etc. Subsidy Policy 2009 broadened the scope by not only providing subsidies for solar home systems and solar water pumps, but also extending subsidies to institutional solar PV systems. The Policy aimed at maximizing service delivery and providing opportunities to the low income households in the rural areas, making use of grant assistance, and supporting and extending RET markets. The new subsidy policy i.e. Subsidy Policy 2013, inter alia, sets objectives like reducing cost of supply, encouraging productive use of energy, developing renewable energy market and contributing to the better health and education of people. In line with subsidy policies, there are subsidy mechanisms declared from time to time. For instance, while Subsidy Delivery Mechanism 2006 spells out the need for disbursing subsidies in a cost effective and easy access manner for the acceleration of renewable energy market, the Rural Energy Subsidy Delivery Mechanism 2010 emphasizes on setting subsidy criteria for various renewable energy resources and delivery mechanisms for disbursement of subsidies for different forms of renewable energy based off-grid energy sources.

Thrust on promoting alternative energy in Nepal is also recognized through several other legislative pronouncements. For instance, National Adaptation Programme of Action (NAPA) of Nepal, 2010 has identified a list of priority adaptation options for the energy sector. Specific thrust was assigned on the promotion of alternative energy technologies and strengthening the institutional aspect of promoting of alternative energy technologies (NAPA, 2010).

Apart from policies, promotion of off-grid renewable energy sector is also done through several other fiscal and financial incentives such as exemption of taxes, reduction of tax amounts etc. Import duties and value added tax (VAT) on green energy products have been waived off in order to accelerate the growth of renewable energy sector in the country. For instance, solar photovoltaic cells, modules/panels, LEDs enjoy zero import duty. 1 % duty is imposed on batteries and 10 % import duty is levied on readymade solar lanterns. Components used on SHS and SSHS (solar tukis) do not require to pay VAT.

While legal and policy systems of the country are designed to govern the sector, the state of institutional artifacts shape the system of governance of a country to great extent. Organisational contours for off-grid energy sector in Nepal reveal a complex web interrelationship between multitude of actors and entities consisting of several ministries like Ministry of Environment, Ministry of Energy, Ministry of Water Resources, multiple government originations and institutions like National Planning Commission, Water and Energy Commission Secretariat (WECS), Alternative Energy Promotion Centre (AEPC), Renewable Energy Test Station (RETS), several donor agencies e.g. Danish International Development Agency (DANIDA), European Union, UNDP, Norwegian Government, KfW, DFID, ADB, etc, a couple of associations like Nepal Micro-hydro Development Association (NMHDA), Solar Electric Manufacturers Association of Nepal (SEMAN), banking and credit institutions like Clean Energy Development Bank (CEDB), Himalayan Bank, Lakshmi Bank etc, and a number of manufacturing and installation companies, NGOs, micro-finance groups, local NGOs, village co-operatives, research institutes and many more.

At the ministerial level, the task is to formulate, implement, monitor, and evaluate policies, plans, programmes. It is also the duty of the Ministry to carry out R & D activities, promote private sector participation in the sector and to deal with multi-lateral agreements with other countries. At the institutional level, AEPC being at the helm of the affairs of off-grid energy development in the country, is responsible for mainstreaming renewable energy based interventions in the country and holds prime institutional responsibility. Created in 1996, AEPC is entrusted to carry out research and development for the promotion of renewable energy based off-grid energy in Nepal, to manage and administer subsidy policies, and to act as an umbrella organization for several other activities and initiatives such as UNDP led REDP, Danish and Norewegian Co-funded ESAP, and European Union funded Renewable Energy Project (REP) and Rural Energy Fund. The Centre has been responsible for the formulation of plans and policies, mobilize resources, monitor and co-ordinate activities, keep check on quality and execute all other necessary activities. AEPC also has local functionaries at the level of districts, namely District Energy and Environment Sections/Units and Regional Renewable Energy Service Centres (RRRSC) to execute activities at the district level. There are also affiliate institutions like Renewable Energy Test Station (RETS), which conducts various quality tests of renewable energy products and qualifies companies for eligible to get subsidies and get tax waivers.

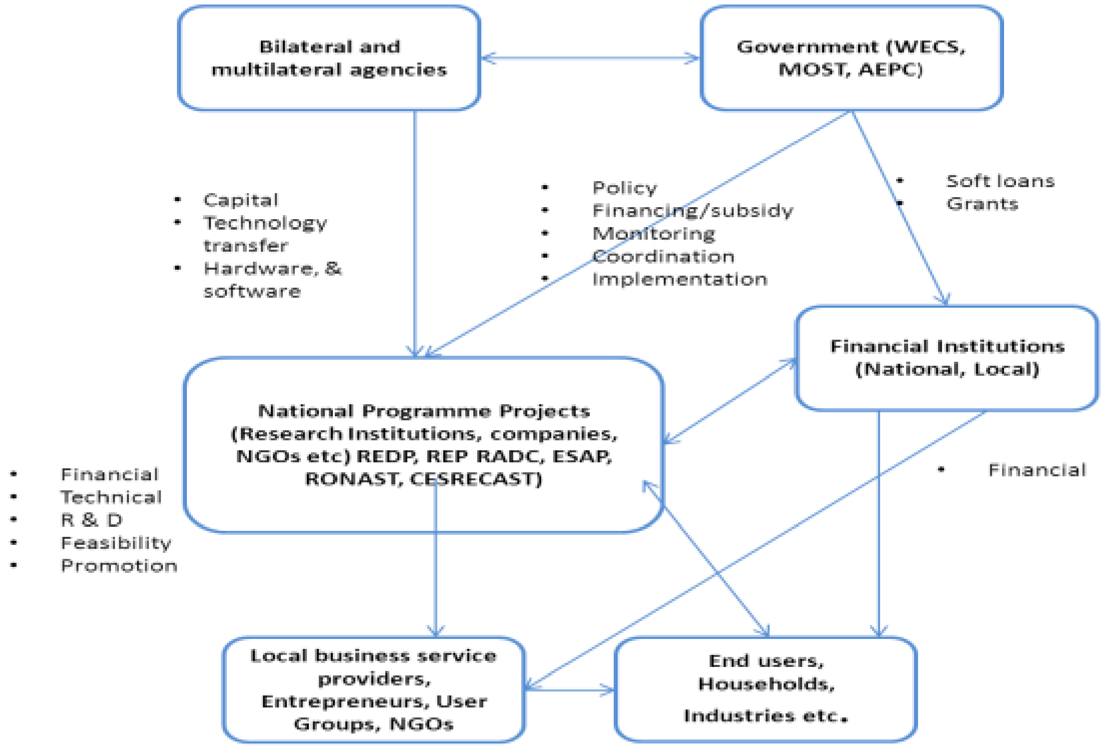
Various donor agencies and organizations have been playing instrumental role in Off-grid energy development in Nepal. A host of donor agencies have been supporting several off-grid renewable energy programmes in Nepal. These agencies have been playing pivotal role in driving the off-grid renewable electrification in Nepal through various programmes and schemes. Most of these donor funded programmes are anchored through AEPC. The focus and thrust of donor funded programmes differ and is largely driven by the Guidelines of donor countries. However, there seems to be lack of co-ordination and harmonization among these donor funded programmes thereby duplicating the efforts. Recently, efforts have been undertaken by AEPC to bring all the donor funded programmes under one umbrella through National Rural and Renewable Energy Programme (NRREP).

Off-late, private sector banks have emerged as effective channel to finance various off-grid renewable based interventions in Nepal through innovative financing schemes. While public sector banks like Agricultural Development Bank of Nepal has been involved in micro-hydro project financing as early as 1980, several private sector banks like Clean Energy Development Bank Limited, Himalayan Bank, and Lakshmi Bank are actively pursuing promotion of renewable energy in Nepal. Some of these banks have set up separate energy cells to finance the energy projects. Banks also have been entrusted responsibilities by donor agencies to manage special funds meant for promotion of off-grid energy sector in Nepal. For instance, Clean Energy Development Bank and Himalayan Bank have been tasked to manage Micro-hydro Debt Fund which is supported by GIZ and anchored through AEPC. Himalayan Bank has been able to finance six micro hydro projects[3] through Micro-hydro Debt Fund scheme. Banks also act as financing agents for private renewable energy developers and energy service companies. For instance, Clean Energy Development Bank has financed four hydro power contractors, 8 micro-hydro installer companies, 28 solar companies, 6 biogas construction companies.

Associations formed by private companies like Nepal Micro-hydro Development Association (NMHDA), Solar Electric Manufacturers Association of Nepal (SEMAN) also play a crucial role in driving the off-grid energy sector in the country by creating necessary skills, expertise and by protecting the welfare of these private companies. General concerns of manufacturers

[3] These micro-hydro projects are Khani Khoka (20 kW) in Karve dirtict, Chari Tola (80 kW), Ramechhap Dictrict, Thulo Khola, (50 kW), Okhaldhunga District , Swara Tap Khola (30 kW), Khotang District , Lumju Khola (20 kW), Khotang District, Midim Khola (100 kW), Lamjung District.

and companies are addressed through these associations. These associations also conduct periodic training and capacity building programmes on various issues of importance. Apart from all of the above, there exist a number of research institutes and universities, private companies, NGOs, micro-financing institutions, village co-operatives contributing to the development of off-grid renewable energy systems in the country. The complex web of interactions and interrelationships is shaped in the figure below (Fig. 8).



Source: Construed by authors

Fig.8: Institutional contour governing renewable energy based off-grid energy system in Nepal

VI. Salient features of off-grid energy sector in Nepal

This section analyses key features of renewable energy based off-grid electrification in Nepal.

a. Service delivery models

The dissemination of off-grid renewable electrification in Nepal is done through a variety of delivery models. In majority of cases, delivery models hinge upon the specific programme features and characteristics. Deployment of micro-hydro systems are largely done through community managed schemes, albeit, in some cases by private entrepreneurs. In addition, private entrepreneurs also play an important role even in community managed projects. Private manufacturing companies and private installer companies carry out the task of surveying, designing, installation of systems. These companies are pre-qualified by AEPC to channelize subsidies to the communities. Often deployment of projects largely follows programme protocols and guidelines. For instance, while Energy Sector Assistance Programme (ESAP) lays emphasis on improving the living conditions of the rural population through enhanced access to energy, Renewable Energy Development Programme (REDP) assigns primacy to community mobilization aspects. Apart from community managed micro-hydro schemes, other prevalent type is the private sector promoted micro-hydro schemes, which constitutes about 5 % of the total micro-hydro schemes deployed. In the field of solar, the predominant model is the subsidized vendor promoted solar home systems. Qualified vendors are responsible for installing systems and providing aftersales service for one year from the date of installation. Similar to private installers and manufacturers of micro-hydro projects, vendors which are pre-qualified by the AEPC are eligible to install solar systems and receive subsidies from the AEPC by carrying out certain procedural requirements like product tests. In most of the cases, the ownership lies with the individual households who own the SHS.

b. Operational modalities

Implementation of off-grid electrification projects in Nepal is carried out through a public-private-partnership model. While public sector performs several pertinent activities like capacity building, provides technical and financial assistances, and puts in place mechanisms for quality control, private sector spearheads through manufacturing, supply and installation, provides aftersales service and carries out internal quality check. In case of micro-hydro projects, the initial step is to carry out demand assessment for such a project in a locality. Demand assessment is followed by identification project sites, which is done through a scientific process of mapping by using the GIS tools and techniques. Next phase is the project approval phase, where the project gets approved at various stages through a well-designed approval system. The most immediate approval is required from DDC/RRECS, and then it gets approved by AEPC, where the project details are reviewed by a technical team known as Technical Review Committees. Once it gets approved by the Technical Review Committee, projects finally get in-principle approval for being eligible to receive subsidy. This is followed by installation and commissioning of the project. Once the project is installed and implemented, it goes through a quality control process. First level of quality control is in terms of monitoring and inspection of projects under construction. Next level of quality checking is done during testing and commissioning of the project. Final level of quality control is done through power output verification. As a process of quality check, one year guarantee is ensured by the project developer and consultant and 10 % of the project cost is kept as caution money.

Operationalisation of solar energy is done through demand driven approach. Vendors which are pre-qualified by the AEPC to carry out detailed feasibility study and install systems and receive subsidy from the AEPC by carrying out certain procedural requirements like product tests. Qualified vendors are responsible for installing systems and providing aftersales service for one year from the date of installation. After that, it is the responsibility of users to take care of maintenance and replacement of parts.

c. Financing schemes

Project financing structures reveal some interesting features. In case of micro-hydro projects, finance is mobilized through four major sources e.g. government subsidy, community equity, contribution from local government, contribution from other organizations.

In majority of cases, subsidies contribute more than one-third of the project cost. Community contribution comes in terms of cash, in terms kind and loans, which in majority of cases takes care of the largest share of the project cost. Rest of the amount comes through loan and contribution from local governments, VDCs and DDCs. Since, solar home systems are individual systems, cost of these systems are taken care through subsidies, private equity and loans/credits.

Subsidies have been playing instrumental role in mainstreaming the renewable energy dissemination and wide scale deployment of projects. Subsidy disbursement mechanisms are spelt out by the Government from time to time. Important aspect of this subsidy disbursement policy is the graded subsidy provisions based on the remoteness of the location. Table 1 details out the subsidy amounts for different forms of off-grid electrification options as spelt out in the latest subsidy policy.

Renewable energy type	**Subsidy amount (in NCR)**
Micro Hydro	*70,000 – 1,30,000 per kW*
	60,000 – 90,000 per kW
Pico Hydro	
Solar PV Home Systems (10 Wp)	*4500 – 5000 per HH per system*
	6000 – 7000 per HH per system
Solar PV Home Systems (20 Wp – 50 Wp)	*8000 – 10,000 HH per system*
Solar PV Home Systems (> 50 Wp)	

Table 1: Subsidy profile for different off-grid electrification sources, Source: AEPC (2013)

In order to enhance the access and instill a sense of commercialization among the users of the facility, innovative financing mechanisms have been devised by banks through support from multi-lateral and bilateral agencies and organizations. Micro-hydro Debt Fund – a dedicated fund to finance micro-hydro projects within the range of 10 to 100 kW has been operationalized by GIZ/AEPC. The funds have been routed through banks engaged in promotion of renewable energy in Nepal. GIZ/EnDev (German/Deutch collaboration) and NORAD has been supporting this initiative, Total fund of € 500,000 is available for soft loan for MHP. In addition, additional €42,000 (TA) is available for capacity building of local institutions, AEPC and rural communities. Funds are channeled through two banks, namely Clean Energy Development Bank (CEDB) and Himalayan Bank. Under this scheme, a maximum of 40 % debt financing is provided. The financing is based on pure project financing approach. Banks pay a nominal interest rate to AEPC (i.e. 3.5 to 5 %). The scheme aims at 416 kW of additional electricity generation. Financing structures and systems reveal that a maximum of 30 % of the project costs are financed by the banks. Priority is assigned to the term financing but limited to a maximum of five years. An interest rate of 10 % is charged on loans.

In majority of cases, decisions on tariff are made by user committees. There are four major varieties of tariffs structures prevailing in community scale micro-hydro projects. These are largely per household/per month basis, per bulb/per month basis, per watt per month, and per unit per month. Tariff rates are designed to meet the cost of O & M of the project.

Of late, thrust is also laid on carbon financing to enhance the financial viability of projects. There have been some efforts in this direction. About 650 micro-hydro projects have been bundled in order to procure carbon financing. These projects are expected to generate about 31875 tonnes of CO_2 emissions.

d. Quality control mechanisms

Another crucial dimension of renewable energy based off-grid energy development is the system of quality control in place. In order to ensure better quality of renewable energy products, Quality assurances are ensured through various quality control mechanisms. Renewable Energy Test Station (RETS) has been created as a quality control arm of AEPC to ensure quality of renewable energy products and equipments. Nepal Photovoltaic Quality Assurance (NEPQA) standard has been developed, adapted and revised by AEPC from time to time to address the quality concerns. NEPQA standard is used to test various components of solar home systems (SHSs) at Renewable Energy Test Station (RETS). In order to ensure the quality of solar energy products, two types of tests are conducted by RETS i.e. Product Introduction Test (PIT) and Random Sampling Test (RST). It is mandatory for renewable energy suppliers to test the products at RETS to be eligible to get the subsidy and VAT waiver. Quality control of micro-hydro projects in Nepal is largely carried out by AEPC. Recently, RETS has also been started checking the quality of micro-hydro equipments and products.

e. Capacity building efforts

Capacity building has been considered catalytic for the sustainability of off-grid energy interventions. Capacity building is done through various ways and for different stakeholders. An important aspect of this capacity building effort is technical assistance schemes provided under various donor funded programmes. Major donor supported programmes such as ESAP, REDP have technical assistance components, seeking to develop necessary knowledge and skill sets required for the operation and management of the systems. Technical support is provided through training, information, guidelines, quality assurance etc. In addition, enhancing the strength and ability of rural communities is also prioritized by several donor agencies. For instance, REDP programme gives emphasis on community mobilization and communities are placed at the centre of the project operation, management and sustainability. Community mobilization is considered pivotal and an important step in the project initiation process. Community mobilization under REDP consists of organization development, skill enhancement, capital formation, technology promotion, environment management, empowerment of vulnerable groups.

Capacity building activities are also carried out by private associations like Nepal Micro-hydro Development Association (NMHDA) and Solar Electric Manufacturers Association of Nepal (SEMAN). These associations conduct periodic training and capacity building programmes to produce skilled manpower for the acceleration of off-grid renewable energy programmes in Nepal in association with AEPC under various donor funded programmes. For instance, Nepal Micro-hydro Development Association has been conducting surveyors training, managers training, quality and management aspects of MHP for installers, auto cad training, output verification (POV) training, end use promotion training, operators training, advanced operators training and operators refresh training etc. for last ten years or so. NMHDA has conducted 42 training sessions till 2012. Importantly, these training and capacity building activities are supported by various donor funded programmes like REDP, ESAP, and RERL. Similar training and capacity building activities also have been undertaken by SEMAN for different technicians and field staffs in association with AEPC under various donor funded programmes. In addition to this, several orientation programmes have also been conducted by SEMAN for school teachers and company staffs.

VII. Case study analysis

In order to supplement the discussion above we present here a case study drawing from the information gathered from our field visits and stakeholder interviews. While assessing the case study, we largely follow the framework suggested by Mishra and Sarangi (2011) for mainstreaming renewable energy based off-grid systems in developing countries. The studied project is located in Mahadevstan VDC in the Dhading district of Nepal. The project serves about 265 households, out of which about 80 % of the HHs are poor, and about 13 % HHs are middle-income households and rest are rich households. About 75 % of cost of the project was taken care through government subsidies, whereas the rest amount was mobilized through private equity (both cash and kind), loans and contributions from local government i.e. VDC and DDC. It must be noted here that since the project was supported by UNDP and World Bank funded Renewable Energy Development Programme (REDP), implementation modalities of this project largely follow the REDP programme guidelines. The details of the studied project are given in the Table (Table.2).

Name of the project	Malekhu Khola
VDC	Mahadevstan
District	Dhading
Capacity	26 kW
Number of HHs	265
Year of commissioning	2007

Table 2: Salient features of the project

As suggested by Mishra and Sarangi (2011), the very first task towards deployment of off-grid system would be to carry out a needs assessment survey. As revealed from our discussion with various stakeholders, a proper demand assessment was conducted as an important initial activity for the project installation. However, since REDP emphasizes on mobilizing communities as a pre-requisite for deployment of micro-hydro projects, the very first step undertaken was to form users committees and strengthen the community capability for the effective operation and management of the project. Once the user committees were formed, application was submitted through proper channel to DDC/DEES, RRESC and finally to AEPC. Second most important step carried out was the project identification, where a potential project site was identified through a scientific process by applying the GIS tools/techniques. The GIS mapping and detailed feasibility study (DFS) suggested the possible size of the project, monthly flow of water, catchment area with its land use type, geo references position of major structures like intake, settling basin, fore bay, and power house, headrace canal, and penstock pipe length, and their head losses, the transmission lines and its segments and length. Next step was the project approval phase, where the project got approved through a well-designed approval system in place. The most immediate approval was received from DDC/RRECS, and then it got the approval from AEPC, where the project details were reviewed by a technical team known as Technical Review Committee. Finally, the project got in-principle approval for subsidy. Since, the resource mapping at the community scale were only limited to micro hydro schemes; it did not consider other potential resources. In order to get a comparative picture of micro-hydro vis-à-vis solar energy, we have estimated the LCOE[4] for the micro-hydro project under consideration and a similar size solar PV project. Our analysis suggests that for same capacity plant, while LCOE for micro hydro plant is coming out to be 0.07 USD, LCOE for solar plant is estimated to be 1.01 USD. Our findings are corroborated with the findings of the Mainali and Silveira (2011), where authors have estimated that LCOE ranges between 0.55 USD to 1.01 USD. The detailed parameters and estimated LCOE figures are presented in the table below (Table 3).

Fig. 9: OASYS project team members discussing with the president, members and plant technicians of Malekhu power plant

[4] For analyzing the levelized cost of electricity (LCOE) one has to consider the total life time cost of the project which includes the capital costs, operation and maintenance costs, replacement cost, fuel cost and the environmental externalities costs and total electricity produced by the plant during its lifetime. The formula for estimating LCOE is ,

$$LCOE = \frac{Total\ life\ time\ \cos t\ of\ the\ project}{Total\ life\ time\ useful\ electricity\ produced}$$.

Parameters	MHP	SPV
Rated power capacity (kW)	26	26
Annual power generation (kWh)	51496*	34164
Life span of the plant (years)	15	20
Escalation factor (%)	5	5
Loan interest rate (%)	12	12
Inflation rate (%)	5	5
Emission factors (g/kWh)	0.01 (No_x), 0.01 (So_x), 5.92 (Co_2)	0.193 (No_x), 0.322 (So_x), 83.43 (Co_2)
Marginal external/damage cost ($/kg)#	1.5312 (No_x), 5.8080 (So_x), 0.0277 (Co_2)	1.5312 (No_x), 5.8080 (So_x), 0.0277 (Co_2)
Capital cost of the plant ($)	53937.00*	93600.00
Annual O&M cost ($)	1300.00*	2100.00
LCOE ($/kWh)	**0.07**	**1.01**

Table 3: Parameters for LCOE for 26 kW MHP and SPV plant (* From field surveys, #Source: Mainali and Silveira (2011), Currency conversion rate: 1USD = 80 NCR)

In addition, we also attempted to compare and contrast the existing case (base case) with possible scenarios with increased productive loads to examine the possible extent of unit cost reduction. We have envisaged four different scenarios based on increased productive end uses. This has been done primarily on the basis of recent concerns about low capacity utilization of micro-hydro projects in Nepal due to poor productive end uses. Load profiles for different base case and different scenarios are presented in the Fig. 10.

It could be evident from the table below (Table 4) that in the scenario 1 as we increase the productive load from 14 to 17 kW; LCOE comes down from 0.07 USD to 0.066 USD. In case of scenario 2, further increase in the productive load by increasing the number of hours of productive end uses leads to further reduction in LCOE to 0.061 USD. Finally, in scenario 3, we have increased the productive load to 22 kW; this gives rise to further reduction in LCOE to 0.057 USD.

Items	Poor HH	Middle HH	Rich HH	Commercial load	Productive load
Base case	3x12 W lighting load for 5 Hrs (5 - 10 pm)	3x12 W lighting load for 5 hours (5-10 pm) and 1x80 W TV for 4 Hrs	3x12 W lighting load for 5 Hrs (5 – 10 pm), 1x80 W TV for 4 Hrs and 1x500 W Refrigerator for 6 Hrs (10am - 4 pm)	420 W lighting and fan load for 5 Hrs, 600 W computer for 1 Hr and 600 W refrigerator for 15 Hrs	Two flour mills of 5 kW each and one saw mill of 3 kW load for 3 Hrs and 1 kW poultry load for 6 Hrs
S1	3x12 W lighting load for 5 Hrs (5 - 10 pm)	3x12 W lighting load for 5 Hrs (5 - 10 pm) and 1x80 W TV for 4 Hrs	3x12 W lighting load for 5 Hrs (5 - 10 pm), 1x80 W TV for 4 Hrs and 1x500 W freezer for 6 hours (10am - 4pm)	420 W lighting and fan load for 5 Hrs, 600 W computer for 1 Hr and 600 W refrigerator for 15 Hrs	Two flour mills of 5 kW each and two saw mills of 3 kW each for 3 Hrs and 1 kW poultry load for 6 Hrs
S2	3x12 W lighting load for 5 Hrs (5 - 10 pm)	3x12 W lighting load for 5 Hrs (5 - 10 pm) and 1x80 W TV for 4 Hrs	3x12 W lighting load for 5 Hrs (5 - 10 pm), 1x80 W TV for 4 Hrs and 1x500 W freezer for 6 Hrs (10am - 4pm)	420 W lighting and fan load for 5 Hrs, 600 W computer for 1 Hr and 600 W refrigerator for 15 Hrs	One flour mill of 5 kW for 6 Hrs, and one flour mill of 5 kW and two saw mills of 3 kW each for 3 Hrs and 1 kW poultry load for 6 Hrs
S3	3x12 W lighting load for 5 Hrs (5 - 10 pm)	3x12 W lighting load for 5 Hrs (5 - 10 pm) and 1x80 W TV for 4 Hrs	3x12 W lighting load for 5 Hrs (5 - 10 pm), 1x80 W TV for 4 Hrs and 1x500 W freezer for 6 hours (10am - 4pm)	420 W lighting and fan load for 5 Hrs, 600 W computer for 1 Hr and 600 W refrigerator for 15 Hrs	One flour mill of 5 kW for 6 Hrs, and one flour mill of 5 kW and two saw mills of 3 kW each for 3 Hrs and 1 kW poultry load for 6 Hrs and 5 kW furniture udhyog for 3 Hrs

Table 4: Electricity demand constituents per HHs and scenarios

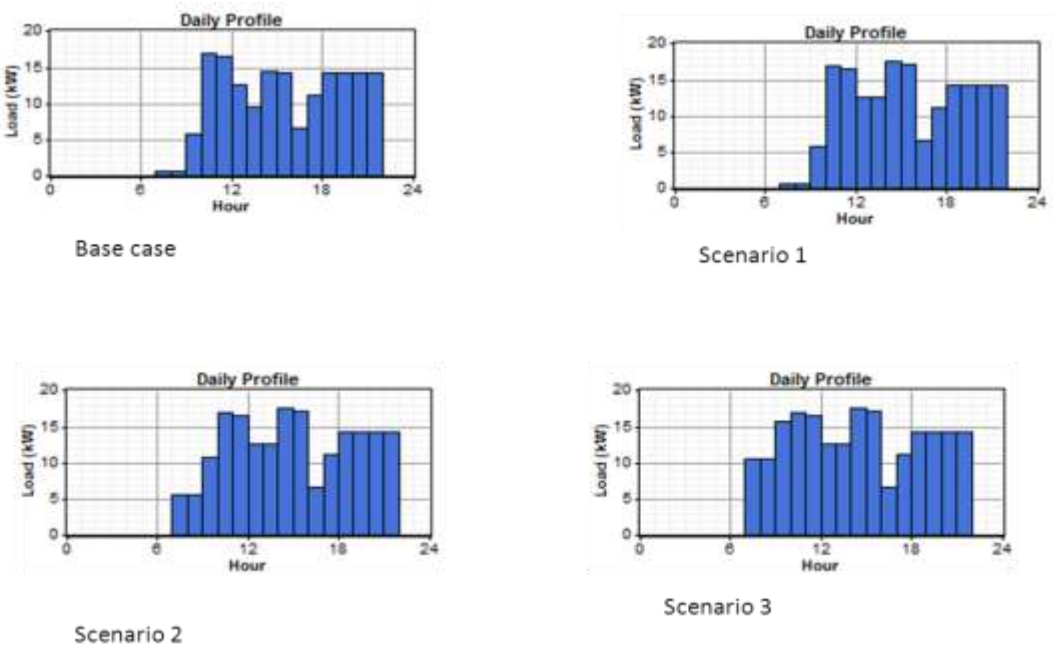


Fig. 10: Load profiles for different scenarios

We also attempted to assess the financial efficacy of the project by carrying out sensitivity analysis. Senisitivity analysis for the changing subsidies and its impact on LCOE is presented in the figure below (Fig.11). It could be evident from the figure below that with zero subsidy, LCOE is estimated to be very high. However, micro-hydro is still financially attractive compared to solar PV based project.

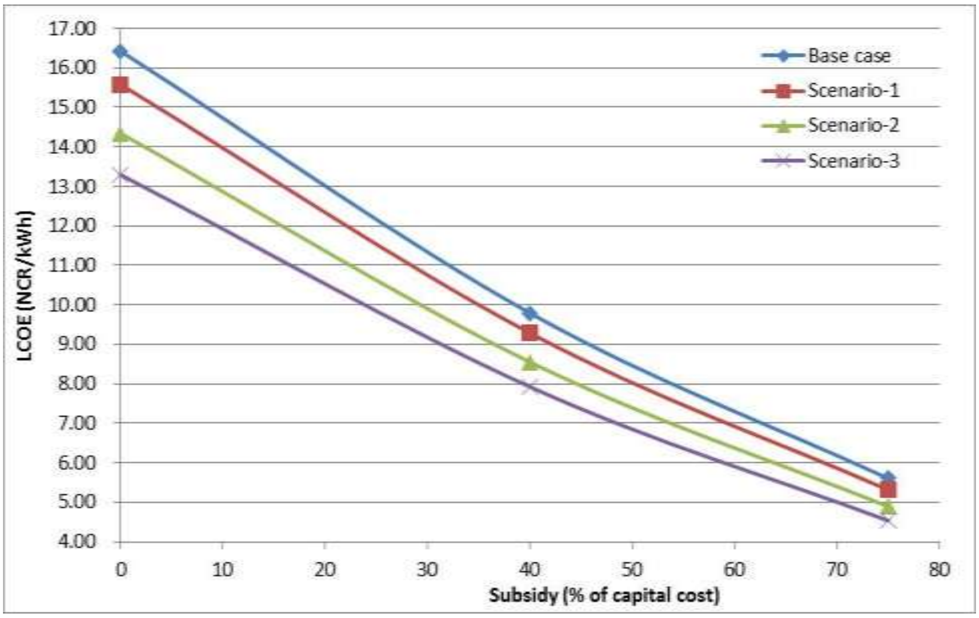


Fig.11: Subsidy and its impact on LUCE – sensitivity analysis

It is evident from the analysis above that though micro-hydro is cheaper option compared to solar; the challenge is to bring down the cost of supply by creating additional productive loads, which has been a concern in majority of off-grid micro hydro projects (Sovacool et al, 2011). At present, productive loads such as two flour mill, one saw mill and one poultry firm are energied through this project. However, there still exist additional potential to create productive loads. However, since the village economy is largely based on agriculture, productive loads of that nature could possibly be introduced. This needs designed policy thrusts, to create productive loads which would not only optimize the plant capacity, but also enable to generate income and employment at the local scale. Though specific subsidy schemes are put in place to enhance the end use applications, this has not been the case for every project.

In sum, it was found that the project has been running successfully with an average 9% downtime in a year and has been able to generate positive impacts in terms of bettering the social infrastructure in the village by energizing schools, health centres, bettering the socio-economic conditions of the local people by enhancing income and generating employment and empowering the women through provision of modern lighting system, and by reducing their drudgery. The formation of a co-operative in the village to manage the plant has also been able to create better social capital in the village. However, there exist a few challenges as far as sustainability of the project is concerned. Apart from the challenge of low load factor identified above, another related challenge is the lack of technical capacity at the local level to deal with unforeseen technical snags of the plants. Additional challenge emerged during the project installation. It was difficult for communities to mobilize finance through loans from formal credit institutions due to lack of collateral. The next section discusses in more detail the generic set of challenges being confronted by the off-grid sector.

VIII. Anomalies and distortions for up-scaling

Despite policy thrusts, renewable energy based off-grid electrification in Nepal confronts multiple challenges and barriers. There exist multiple economic, social, and institutional hindrances for up-scaling of renewable energy based off-grid electrification in the country. 1st Three Year Interim Plan (2007-10) of Government of Nepal recognizes this slow progress of the alternative energy sector in the country and attributes it to the existing economic, social and institutional roadblocks.

On the policy front, lack of strong legal framework in terms of an overarching act or policy, absence of clearly spelt out long-term realistic targets and moreover lack of integrated rural development plans retard the growth of renewable energy based off-grid electrification in the country. Most of these targets are ad-hoc in nature as spelt out only in annual budgets of the Government or by funds committed by donors. Subsidy policies declared from time to time are argued to have flawed design features thereby leaving scope for manipulation. For instance, subsidy schemes introduced in 1981-82 resulted in undesirable cost escalation (Nepal, 2012). It is contended that the existing subsidy policies are irrationally structured as far as fund allocations and their long-term impacts are concerned (Pokharel, 2003). In overall, subsidy policies in Nepal have not been able to deliver the desired outcomes due to inherent complexities in the delivery mechanisms (Pokharel, 2003; Mainali and Silveira, 2010). Subsidy mechanisms need to be made simpler and should have provisions of gradual phasing out.

The weak institutional structure is characterized by lack of centralized energy planning, duplication of efforts resulting from lack of co-ordination, and disputes between local and national institutions over energy decision making and cumbersome decision making processes (Sovacool et al, 2011, Nepal, 2012). Even renewable energy programmes implemented by donor agencies lack co-ordination and harmonization (Clean Start Asia, 2012). Multiple organisations continue to work on alternative energy sector and are often having overlapping mandates. Incongruent legal system adds further woes. For instance, while MHP and SHP systems are de-licensed on the one hand, stipulations of Local Self-governance Act 1998, assigns power to the local authorities to prioritize the use of water in their jurisdiction, generating potential conflict of interest among different stakeholders. In addition, local level institutions like village/community level institutions lack managerial capacity to manage micro-hydro systems, thereby posing threat to the sustainability of these projects. This necessitates the need for continuous community mobilization and capacity building.

Often technical and societal challenges are intertwined together and generate obstacles for the sector. Low load factors have been playing as a major hindrance for off-grid electrification process in rural areas of Nepal. It is posited that all community based micro-hydro projects have a maximum load of 20 to 25 % (Ghale, 2013). Because of this low load factor, private entrepreneurs do not consider this as a potential business avenue. There is a need to identify and assess potential energy based cottage industries in areas where these micro-hydro projects are installed. Since these off-grid energy facilities are located in remote areas of the country, maintenance becomes difficult, if these plants face problems.

Challenges associated with the financing of off-grid energy sources require targeted solution. Lack of adequate bank financing stands as a major hindrance for the sector. Poor access to credit by rural entrepreneurs is largely due to lengthy bureaucratic procedure, lack of collateral to access the credit and due to associated high transaction costs. In addition, financial institutions providing loans for the renewable energy sector in Nepal suffer from problems of bad debt (Mainali and Silveira, 2011). Thrust should also be laid on carbon financing to enhance the financial viability of mini-grids. Though some efforts have been undertaken in this direction, there still exist avenues to mobilize additional funds through carbon financing. Transaction costs of administering the financing of small projects are high, thereby deterring banks to venture into small sized projects. In addition, absence of collateral makes it difficult for the banks to provide loans for these small scale interventions. Access to credit has been found to be the major hindrances for promotion of renewable energy based rural electrification in the country (Poudel, 2013).

There has also been a host of regulatory hurdles encountered by renewable energy sector in the country. Though, AEPC is placed in the helm of affairs as far as renewable energy sector is concerned, it also in a way acts as a regulator for purposes like quality checking, disbursement of subsidies, waiving of taxes and duties etc. Regulatory power of AEPC is limited primarily because of dominance of Ministry. Regulatory uncertainty relating to grid extension has been acting as a major hindrance for the optimal exploitation of existing private sector potential in the field. For instance, with the construction of Prithvi highway, several MHP systems were closed down due to extension of grid (Pokharel, 2003). Studies point that almost 27 % MHP projects are within the vicinity of 5 km of grid electrification. This presents a great threat for MHP projects (Shakhya and Sharma, 2013). In addition, monopolized structure of NEA has also been putting additional constraints. NEA is unwilling to connect MHPs with grid largely because of small size of the projects, technical and managerial hurdles associated with connecting these small projects with the grid. Another major regulatory challenge emanates from the difficult project approval process. Developers have to fulfill several criteria to make the project successful. Developers have to get water source use licensee, get company registration, get tax registration etc. (Ghale, 2013).

Inadequate capacities have also been posing threats for the successful growth of the sector. At the macro level, limited testing capacities of renewable energy test station (RETS) creating sort of a 'technology lock in'. This has been primarily due to lack of adequate funds to equip the center with advanced testing equipment's combined with lack of adequate number of professionals to carry out the test.

IX. Policy recommendations

It emerges from the discussion above that renewable energy based off-grid systems like micro-hydro systems; solar home systems etc. are prime vehicles of electrification, especially in rural areas of the country. Though some laudable efforts have been undertaken by Government of Nepal through AEPC and by several associated actors and institutions, acceleration of the sector requires some specific policy thrusts and attention.

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 micro-hydro 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 co-ordination and harmonization among various ministries, agencies, and 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.

X. Conclusion

Renewable energy based off-grid electrification in Nepal has the potential to emerge as an effective alternative to the crisis ridden grid based electricity system. Substantial progress in this front has been made largely due to presence of a strong and focused engagement of several key institutions and entities like AEPC, donor agencies, banks, private associations and moreover by a presence of a strong market supported by private entrepreneurs. Financial assessment of a project reveals the existing potential of cost reduction by enhancing the productive uses. In addition, micro-hydro projects are found to be cost effective compared to similar sized solar energy projects. However, the sector is entangled by multitude of anomalies resulting slow progress of the sector and underutilized and unutilized 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 utilisation 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.

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Annexure - I

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Disclaimer

The views expressed in this report are those of the authors and do not necessarily represent the views of the institutions they are affiliated to or that of the funding agencies.

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 or by contacting the principal investigator Prof. Subhes Bhattacharyya (subhesb@dmu.ac.uk).

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