Alumni Workshop 2015

Addressing Resilience and Sustainability in Energy Management

EUROPA-UNIVERSITÄT FLENSBURG

January 30, 2016

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Alumni Workshop 2015

25 years of development oriented studies at the University of Flensburg

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Ensuring Sustainability of Decentralized Renewable Energy Systems through Creation of Rural Economic Zone (REZ)

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ABSTRACT

The extension of the national grid is, technically and financially, very challenging in Nepal where off-grid renewable energy seems to be the only viable solution. Over the last 30 years, Nepal has installed over 2,500 off-grid micro hydro plants benefitting over 300,000 rural households. The electricity produced is primarily used for lighting purposes and powering some low capacity equipment. Most such systems have issues of financial sustainability due to heavy under-utilization of available power. In this context, the concept of REZ has been developed with valuable experiences from similar activities in rural India. REZ is an entrepreneurship model which pivots around an assured power supply and creating rural enterprises. Around these, economic activities are encouraged based on traditional skills and value addition. REZ is owned and managed by private promoters under the public private partnership model. REZs overcome the twin barriers of promoting renewable energy and demonstrating sustainable growth.

KEYWORDS

Off-grid, renewable energy, financial sustainability, rural economic zone, entrepreneurship, rural enterprises, public private partnership

INTRODUCTION

Nepal is a land locked country located in South Asia between India and China. It contains 8 of the 10 highest mountains peaks in the world, although some of its low lying areas are near mean sea level. Thus there is an extreme spatial climate variation in Nepal, from tropical to arctic within a span of only 200 kms. Despite its natural beauty, Nepal is one of the poorest countries in the world with 25.16% of the population living below the poverty line[23] [1].

As compared to other under developed countries, "Energy Poverty" remains a major source of concern for development in Nepal. With a population growing towards 28 million [2], the total power demand of Nepal at present is around 1200 MW. With an annual increase of 10%, the power requirement will peak at 4500 MW by 2030. Compared to the per day demand, the installed capacity is only around 687.7 MW contributed mainly from hydro generations [3]. The situation turns grim in the winter season, when electricity of around 300 MW only is available, plunging the entire country into 12-16 hours of power cuts, especially in urban areas including the capital, Kathmandu. Thus,

[23] The Nepal Living Standard Survey (NLSS) measures poverty considering 2,200 calories per person per day consumption and access to basic non-food items as the threshold in Nepal

economic activities are badly affected, increasing the dependency on fossil fuel import from India thereby draining substantial foreign reserves.

Apart from electricity consumption, Nepal relies heavily on traditional energy resources in the overall national energy sector, as no significant deposits of fossil fuel are available. Out of the total energy consumption in Nepal in 2008/09, 89.1% was consumed by the residential sector while only 3.3% by the industrial sector. Based on the fuel type, biomass provided 87% of the total energy consumption, petroleum 8% (mainly consumed in urban areas), electricity only 2% and renewables less than 1% of the total energy consumption [4].

Nepal faces numerous challenges both similar and different to other developing countries. Its unique geography and culture provide a base for solutions for these challenges. Energy consumption in Nepal is increasing and critical component for development. A variety of rural renewable energy technologies are commonly being utilized and promoted in Nepal such as biogas, biomass, solar and micro hydro power (MHP). The promotion of these technologies has focused on rural Nepal where other source of modern energy is absent. Lighting has been primary use of the energy source and there has been a dire need to balance daily the use of the energy produced from these system and to generate income to ensure long term financial sustainability.

It is well established that Micro and Small Enterprises (MSEs) forms the backbone of any economy be it rural or urban. MSEs promote economic growth that is employment oriented. The one of the major barriers identified for growth of this sector are the availability of "reliable power supply", lack of clean energy efficient technologies for MSE production sector and marketing of these products; notably food processing, agro products, building materials, textiles, crafts, etc. Micro-enterprises gets lowest opportunity of grid based electricity supply, forcing production units to rely on diesel run generators.

CONTEXTUAL ANALYSIS

Over 80% of the people in Nepal live in rural areas with overwhelming dependence on traditional biomass for fuel. Despite huge hydropower potential, Nepal has one of the lowest per capita electricity consumptions in the world. Still about 40% of the population does not have access to electricity [5]. Considering the difficult terrain, subsequent cost involved and institutional barriers, extension of the national grid is very difficult to the remote rural areas. Off-grid renewable energy (RE) systems are essential to reach these areas still lacking electricity. Only about 15% of the rural population of Nepal has access to electricity from off-grid RE systems [6]. In this pursuit, Nepal has installed over 2,550 micro hydro plants (MHPs) over the past 30 years with a gross installed capacity of 36.8 MW utilizing variety of development aid and local matching funds benefitting over 300,000 households of rural Nepal [7]. However, electricity produced is primarily used for lighting purposes and powering low capacity equipment. According to very rough estimates by Alternative Energy Promotion Centre (AEPC), the national nodal agency for promotion of rural and renewable systems in Nepal, around 30% of the systems are no longer in operation for variety of reasons – technical, social, institutional, etc. Off-grid RE systems have issues of financial sustainability lacking enough revenues for operation and maintenance (O&M) and repair. The utilization of these systems is very low. Although some rural enterprises mainly agro-processing has come up in the vicinity of MHPs, it is estimated that the load factor of MHPs in Nepal is only about 19% [8]. Productive energy use, through the establishment of rural enterprises, to make

productive use of the power generated for income generating purposes is a way to increase utilization.

However, the notion of promoting rural enterprises is very challenging in Nepal considering that MSE sector is also at a very nascent stage. Considering that off-grid RE systems are based in remote rural areas of this mountainous country, the operational cost of setting up such enterprises as well as the operational cost is very high; thus, directly hampering the profitability of such an establishment. There is, then, a distinct lack of knowledge and skills required for establishing and operating such enterprises at the local level. Compounding the whole process is the fact that most previous individual efforts have resulted in poor quality products thereby restricting the market and profits, which directly acts as deterring factor for any potential investors and enthusiasts. Although many external actors have been playing an important part in developing the capacity in these aspects, there seems to be lack of post-project mentoring necessary to support the rural enterprises at the difficult initial stages of establishment and operation.

RATIONALE BEHIND PROMOTING RURAL ENTREPRISES

It is assumed that rural electrification in Nepal will generally serve for social and economic development of the beneficiaries with electricity access as the entry point. The past efforts in off-grid RE system promotion, to a large extent, have been able to impact positively on this development front. It was thought that increasing electricity access would inevitably boost economic development. However, past experiences have shown that although electricity is a pre-requisite condition for increased income and employment generation at the rural areas, it is not the only pre-condition. A well supported mechanism for promotion of productive use of electricity is necessary to foster the development. This generally helps to encourage private sector to participate in the productive use of electricity thereby increasing income and employment generation opportunities, reduction of drudgery, quality production at the comparatively lower prices that can be marketed at the local market, etc. This ultimately helps in positively impacting on the social and economic development of rural areas [9].

The energy consumption in Nepal is typically very low which shows both lack of demand and lack of access. Especially in the rural areas where the settlements are very much sparse and widely distributed, the cost of generation and distribution seems to be unviable in most areas. Even with provisions of subsidy from the Government and many development partners, the systems suffer from issues of long- and short-term financial sustainability. In many cases, the systems cannot even generate enough revenue for normal operation and maintenance of the systems primarily due to under-utilization of the plants and in some cases, due to tariffs being unaffordable to some users. On the other hand, there are experiences in Nepal where off-grid RE systems have been in operation for many years, primarily, in large load centres (local or regional market areas) where the demand for electricity is comparatively higher and revenue generation from the plants includes quite a few commercial and industrial loads. Based on these experiences, it is assumed that promoting rural enterprises increases productive uses thus improving the utilization of the systems thereby improving economic and financial sustainability of the systems. The whole rationale of promoting rural enterprises is adding commercial and industrial loads rather than only the domestic load as observed in majority of the rural areas at present.

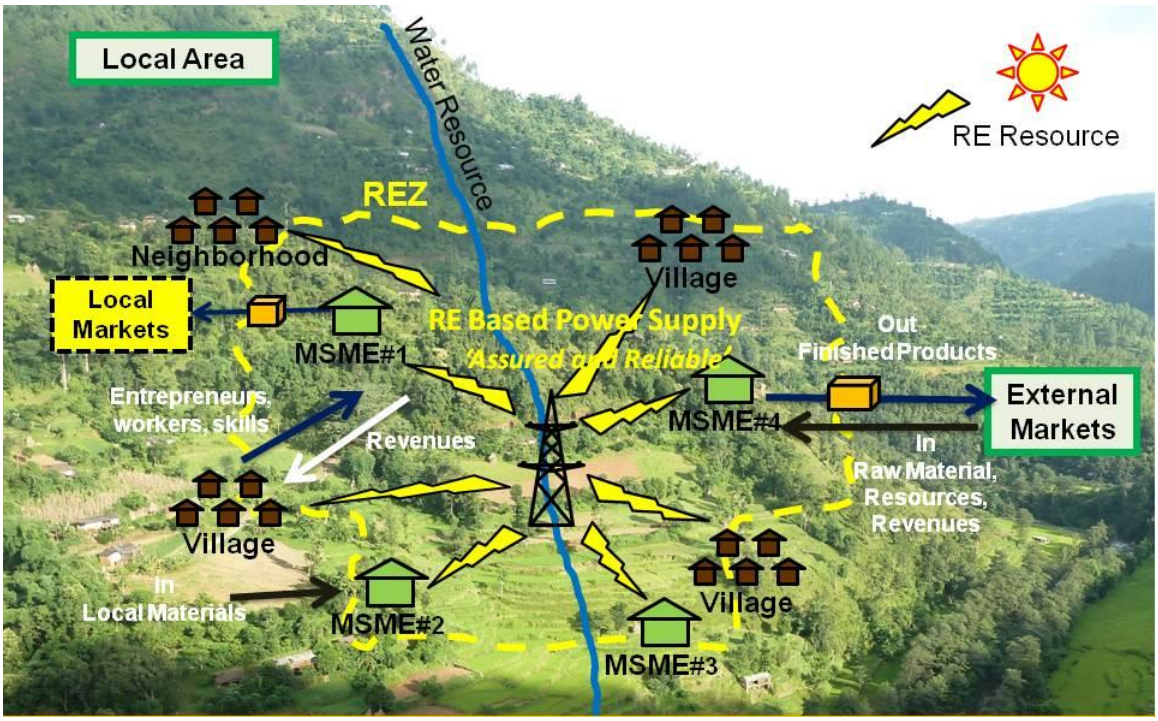
CONCEPT

The present concept aims to overcome the twin barriers by promoting green power and clean technologies and demonstrate sustainable growth through the concept of "Rural Economic Zones (REZ)." The concept of REZ revolves around renewable energy generation and distribution systems. In a REZ, a reliable RE source will allow energy-reliant businesses to flourish, and vice-versa, the businesses will provide the needed fees to pay for and maintain the energy operation, be it a business or cooperative.They are set up in energy starved areas or existing stand alone systems with potential for clustered industries. Around these assured power supply zones, economic activities are encouraged based on traditional skills, value addition and waste utilization.

The focus of the project is on stimulating viable economic activity based on local resources, local entrepreneurs, and local stakeholders with the addition of some outside knowledge, skills and examples. The MSEs consist of connected businesses that create a unique value proposition for the customer and provide assured services and green power to enterprises. Uninterrupted power supply to value adding enterprises is provided by RE generation systems at scales ranging from 10 kW to 1000 kW. The REZ thus acquire a brand value for quality products for various products and skills.

The proposed project envisages strong self-sufficiency and "Equal Opportunity Partnerships" between investors, users and management. Enabling policy and financial support is also sought for overall development. Land for setting up REZ is identified and transferred through Local Governments. Capital cost of the RE based power generation and distribution system is partially financed through financial institutions (FIs) and equity and incentives from government agencies. Commercial banks or apex body FIs is engaged in this process to leverage risk free loans.

Figure 1. Rural Economic Zone concept

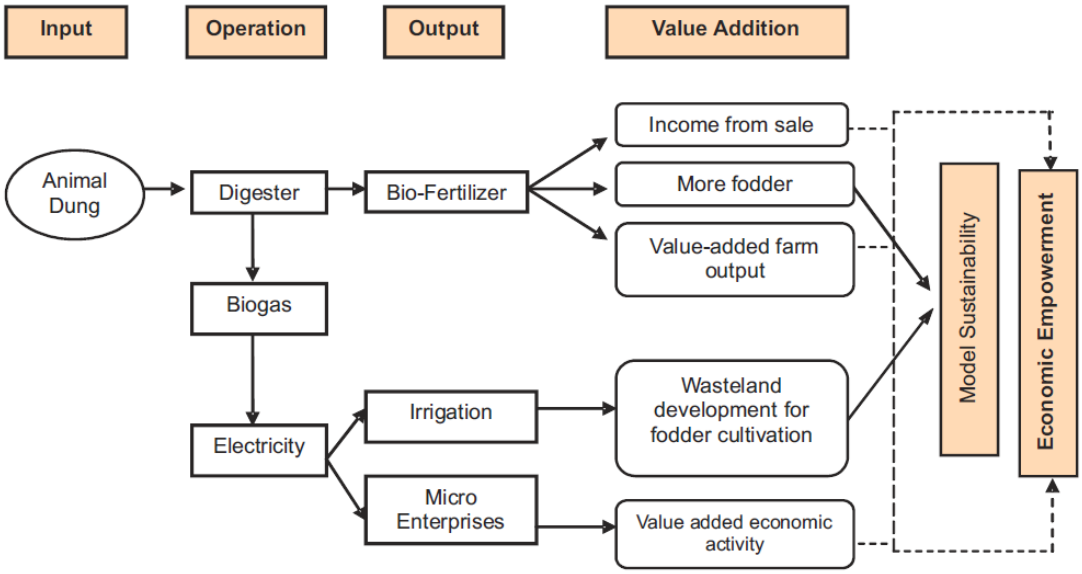


PAST EXPERIENCES – "GAUSHALA MODEL"

The concept of REZ is derived from previous similar experiences from neighbouring India, where Development Alternatives (DA), a national level NGO working at the community level, through its social enterprise, Technology and Action for Rural Advancement (TARA), has been successfully implementing the "Methane-Powered Energy Service Hub" in parts of Indian States of Uttar Pradesh (UP) and Madhya Pradesh (MP). The popularly known "*Gaushala Model*"[24] has been demonstrating the techno-commercial viability of the model through scientific disposal of dung or any biodegradable waste with high replication possibility in cattle-rich communities, in dairy/poultry farms and in *Gaushalas* (cowsheds). The model has been tested at three *Gaushalas* of Bundelkhand region in UP and MP namely, Lalitpur - UP, Orchha - MP and Mauranipur - UP.

Energy crisis in the rural areas has intricate linkages with the social, economic and environmental factors. With growing population, the demand for energy increased for various activities. Realizing this situation, DA sought to understand the need for energy in rural areas and undertook micro-level energy planning for several villages in Bundelkhand for fulfillment of basic needs and livelihood enhancement for sustainable development through the *Gaushala Model*.

Figure 2. "Gaushala Model" from India



The REZ Gaushala in Orchha was initiated in 2008 with the installation of a 7.5 kW biogas plant. The community management of this energy service model focuses on methane-capturing, using flammable gas for electricity generation, for irrigation, enterprise and domestic use. The *Gaushala* workers have been trained to operate the biogas plant, maintain the gas engine and to work on fodder management. The increased use of treated slurry as an organic manure is gradually reducing the use of chemical fertilizer to lower the input cost. Both these activities lead to climate change

[24] All information of the "*Gaushala Model*" has been derived based on field visits and information collected by Mr. Biraj Gautam, a one-year exchange participant from People Energy and Environment Development Association (PEEDA) to Development Alternative (DA), during May 2011 and March 2012.

mitigation. The use of energy services and enriched organic compost transformed the *Gaushala* at Orchha into a profit centre from their usual status as cost centre.

The detail of the model tested at Orchha in MP is tabulated below:

Table 1. Details of *Gaushala Model* tested at Orchha, MP

	Sri Ram Raja Gaushala, Orchha, MP
Power generating system	• 60 m^3 digester • 5-pit slurry tank • Gas engine 5 kVA single phase generator • Power controlling and distribution unit
Other infrastructure	• Vermi-compost bed • 2 submersible pumps of 2 & 5 horsepower capacity • Bore well • Spice grinding unit • De-husking unit • Expeller unit • Flour milling unit
Energy use	Water pumping, milling/grinding/expelling operations, lighting & fans, biogas for cooking
Products	Green fodder, organic vegetables, digested slurry, vermi-compost

The current financial performance of REZ Gaushala, without considering the secondary benefits to the community by the introduction of new enterprises, has not been as expected due to insufficient supply of cow dung and the plant is unable to produce enough biogas for energy. The daily energy required is 60 kWh to run all the electricity-based enterprises simultaneously for 8 hrs. But the biogas is able to produce only around half of that each day. The individual processing units – expeller, de-husking, flour milling and spice grinder – are running only for 2-3 hours per day thereby restricting revenue of the plant. The enterprises pay Rs. 9 per kWh as commercial tariff which is able to meet only the operating expenses of the plant.

Figure 3. Biogas plant and generator to produce electricity

The individual enterprises have been categorized into two units – service unit and production unit. The service unit basically provides services to the community and not focus on commercial production. The flour milling and groundnut de-husking units are considered as service-oriented for the community. Due to low service costs, the both service units are making losses. On the other hand, spice grinder and expeller units have been established as production units which are mainly used for commercial purposes. The produce from the production unit are processed, packaged and

marketed at the local markets and thus, making profits on the sales. The processed and packaged spices are marketed under the brand name of "*Shakti*" [11].

Presently Datia in Madhya Pradesh has a REZ based on building materials. The REZ Datia has gasifier for the generation energy which utilizes biomass of *Ipomea* plant. The energy generated is used for preparation of building and constructing materials such as cement bricks, fly ash blocks, micro concrete roofing tiles, interlocking pavers, hollow blocks, fiber concrete roofing tiles, mosaic tiles, etc. These days variety of alternative building materials are available which provide better, efficient, durable, cost effective construction and eco-friendly and also ensure judicious utilization of available limited resources with least possible degradation of environment. Some of the materials are manufactured by using various waste materials such as fly ash and stone dust as the raw material for their production.

Similarly, Radhapur village in Shivpuri district of Madhya Pradesh has a REZ based on rural micro agro-processing enterprises.

KEY CONSIDERATIONS

MSE development and growth are driven by both exogenous and endogenous factors, which together form the basis of an enabling condition. While some of the enabling attributes already exist prior to MSE development, others need to be nurtured and helped to grow in the local environment. At the same time, the drivers of an enterprise cluster are seen to be influenced by factors such as entrepreneurship development, business development support, assessing products and factor markets, technology, branding, etc. While the enabling conditions are more exogenous to any local cluster, the drivers are more endogenous and hence are influenced by local conditions.

More MSE friendly enabling conditions to rural people

There has been progress in creating enabling conditions for MSE growth in rural areas that are being served by MHPs. There is scope to strengthen both exogenous and endogenous factors to further make the enabling conditions more MSE-friendly to rural people. Among the exogenous factors, most challenging and essential is related to government/bureaucratic rules and procedures. Dealing with exogenous factors is always a challenge to rural people and could even discourage investments; hence, facilitating MSE growth and development should be made a part of helping these "infant industries" grow in rural areas.

Choice of RE system and modality

Among the endogenous factors, the growth of independent RE system, primarily mini/micro hydro, is the single most powerful driver in rural areas for MSE development. The choice of technology is governed by the availability of resources and willingness of the community to adopt it for electricity access. The development of MHP in Nepal has generally followed two approaches namely a cooperative led and an entrepreneurial led approaches. While both approaches have proved to be very successful in many places, there are also cases where it has been not-so-successful. The key aspect of the modality is maintaining the social capital within the user community that is attributed to binding the community together in Nepal [10].

Production for the local markets

Prompting MSEs that produce for the local market should be encouraged as it has greater change of generating income and employment in rural areas. This is not to say that MSEs with export potentials should be discouraged. The issue is to promote MSEs that produce for local consumption stand a better chance of survival and have larger local multiplier (employment and income) effect.

Access to finance

Access to finance and the availability of capital is another key aspect of the project. While access to commercial loans and financing is not constraints with genuine entrepreneurs, there is scope to shorten the procedures, which local people have to go through to obtain loans to venture into MSE establishment.

Continued training and skill development

Formal training to develop entrepreneurship, i.e., capacity and willingness to develop, organize and manage a business venture by taking necessary risk to make a profit, is needed. While many rural entrepreneurs have the knack to conduct business, the quality of training and skills is still inadequate. For MSEs to grow and sustain, it is therefore necessary that besides the provision of basic infrastructure like roads, electricity, and other goods and services, entrepreneurship development should also be given equal priority and must be a continuous process.

Prospective entrepreneurs in rural areas

Many potential rural entrepreneurs lack knowledge, skills, information but appear to have investment funds. How to identify these people needs to be facilitated as well. Three approaches could be followed namely, i) to capitalize on the trainees that have already been trained on entrepreneurship/business by different organizations in Nepal; ii) an apprenticeship approach to develop necessary required manpower and also a way to generate employment opportunities for the youths and iii) to identify interested youths on entrepreneurship.

Right technology

Prospective rural entrepreneurs may be unable to select the appropriate technologies and often 'low cost" approach seems to be the guiding principle for selection. While 'low cost' approach is also rational, efficiency of the technology from several angles (energy use, productivity, automation, etc) that help reduces unit cost also needs to be considered. Guidance is required in this aspect such that investments made become profitable to the rural entrepreneurs, or else can lead to investment failures. When mismatch occurs, the loan recovery can be problematic and can be a prime cause of the failure of new businesses, and the creditors' will have to find other means to pay back. This sends negative signals to prospective rural investors and a major setback for MSE development.

Branding

Branding is a way to give a unique identity to a product. Nepali community is familiar with branding, for example "Khukuri (Nepali knife) from Bhojpur district" and "Dhaka (local cotton) from Palpa district". Such quality products develop a market niche and command a higher premium in return. Branding has scope to give rural products a new place in consumers' mind and help make rural enterprises competitive too.

Infant Industry Protection

It needs to be emphasized that MSE development requires a great deal of nurturing. Without nurturing, there is no way the MSEs will survive. This has been an important strategy of all developed nations in the past. Small rural enterprises normally are unable to face competition when targeting larger markets. Given the uphill battle, some level of selective protection over a defined period of time and clear exist strategy of protection may be necessary.

Support Service Package

SME cluster development requires careful interventions in terms of support service package to help business grow, such that the entrepreneurs do not have to reach urban centers like Kathmandu for support. This could be achieved through strategically placed business support service center. The success of a SME cluster will very much depend on how effectively the needed services can be provided as per the needs of the entrepreneurs.

REZ governance

The governance of REZ is another very critical aspect. Since the concept is more of a business modality rather than a purely social venture, participation and interest protection of all stakeholders including the private sector, financial institutions and local community is paramount to the success of REZ. An appropriate institution needs to be set up to ultimately manage both the assured power supply system and the cluster of enterprises being served by the system.

EXPECTED IMPACTS

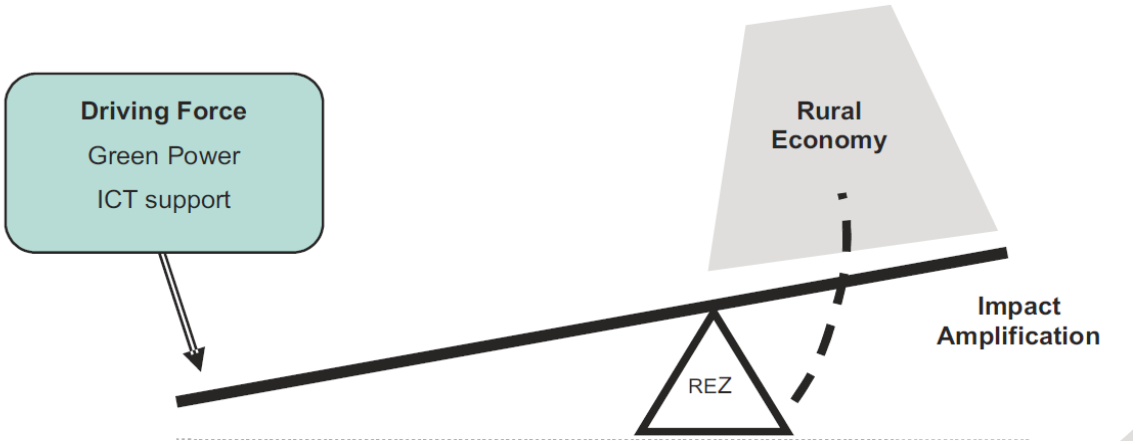


Figure 3. Impact illustration of REZ

The demonstration of successful operation of REZs will result in the sustainable economic growth of enterprise clusters in selected rural and semi-urban areas of Nepal. The REZ along with green power utilities will be managed to ensure growth of the enterprises and the economic viability of the energy provider. The revenues and cash flows will be substantially enhanced through the realization of carbon revenues. Value addition to products and clustered production will enhance market visibility and brand of the REZs. The project will focus on transforming the federation/cooperative into credible "energy service providers" managed with local participation.

The project will setup an example of facilitation of renewable energy based power generation and distribution systems reducing the dependency on fossil fuel energy. Coupled with service approach for supporting enterprises towards uptake of the power being generated, it will bring in an economic independency in rural areas. It will also significantly reduce emissions and promote economic independencies. Successful demonstration will create interest amongst Government agencies and policy makers to adopt and implement the systems thereby reducing energy demands.

Successful demonstrations of project objectives are expected to realize the following impacts in the regional and national scenario of the energy scenario of the country.

- Energy access and security
- Economic opportunities and benefits
- Environmental impacts
- Policy impacts
- Maintenance of cultural heritage

CONCLUSION

The development of entrepreneurship can be a major means of fighting economic inertia in rural areas that are located far from the main industrial center of a country. The notion of "rural entrepreneurship" is not limited to agriculture and related activities such as food processing, but rather it covers industrial development in general. In addition, the concept is not restricted to the villages but also is relevant to small towns and peri-urban areas. The concept aims at representing the strategies for spurring economic activity in underdeveloped areas. In this regards, access to modern forms of energy access is a major constraint to such a development initiative due to remoteness of the areas. Clubbing the provision of assured energy access with rural entrepreneurship, rural economy can positively be enhanced.

There have been concerted efforts from the Government and its development partners in enhancing access to modern forms of energy in the remote rural areas of Nepal through the promotion of off-grid RE systems. However, such off-grid systems are facing problems of long term financial sustainability due to under-utilization of energy generated. The promotion of rural enterprises through the energy generated from such off-grid RE systems helps to improve the utilization of energy generated thus improving the revenue generated from the systems thereby attaining long term financial sustainability of the systems.

The underlying approach of REZ, thus, should play a positive role in:

- Improve access to modern forms of energy
- Improve the utilization of off-grid RE systems thus impacting on ensuring financial sustainability of the systems
- Increase the number of enterprises and small businesses
- Increase employment generation opportunities
- Consolidate and expand already existing businesses, and
- Attract investment

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Promoting Energy Efficiency in Nepal: Issues, Challenges and Opportunities

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ABSTRACT

Despite a low level of per capita energy consumption, Nepal's energy intensity is one of the highest in South Asia and almost double of that of India or China. Relative to other countries in the Asian region, Nepal lags behind in offering a clear and forward looking energy efficiency policy direction. The main shortcomings of energy efficiency in Nepal have been the lack of policy, strategy, institution and a robust legal provision for developing, implementing and managing the energy efficiency agenda. The absence of legal, regulatory and institutional framework makes it challenging to find a consistent platform to evolve, build and deepen energy efficiency activities. The efficient use of energy has not yet been an integral part of national energy planning. Integrating energy efficiency into broader development goals might help Nepal in addressing its complex set of interrelated challenges of the energy sector on energy poverty, energy access, import dependence and low levels of embedded energy efficiency.

KEY WORDS: Energy Efficiency, Energy Intensity, Energy Security, Energy Audit

INTRODUCTION

Nepal has been experiencing an acute shortage of power for the past several years. In the past five years, country's demand has increased by 46%, whereas installed capacity has increased by only 16%. Country recorded 1,201 MW of electricity demand during the evening peak (on November 3, 2013); whereas the total supply was 791 MW and about 410 MW was deficit which was managed through load-shedding [1]. Power experts estimate, the actual electricity demand of Nepal could easily go over 2,000 MW provided there is enough supply in the system, but due to supply deficit, the demand is suppressed. It may be noted that high dependency on the run-off-river type hydropower plants is one of the major reasons for acute power deficit in dry and winter seasons. Nepal's rivers have high variation in their flow pattern. Currently, storage-type plant represents only 14% of the total hydro capacity. The electricity import from India is growing over the years, despite a good hydropower potential. It was contributing about 116 MW to the total national grid supply in 2013 AD.

Reliable and affordable power supply is essential for economic development. However, acute power shortage has forced many industries either to shut down or to run at under capacity. It is estimated that the industries are currently utilised only at about 40-50% of the capacity. Most of the industries have to rely on diesel generator, adding up to 25-40% in production cost. This makes hard for Nepalese industries to compete with the industries from India and abroad. Nepal's per capita electricity consumption is terribly low, which is only 108 kWh per year [2], the lowest in South Asia. The peak power and energy demand are growing at an average of 10% annually about 120 MW each year.

There is a need of a huge investment to develop necessary infrastructures for power generation and transmission. Government needs to explore alternative ways to reduce power shortages

besides increasing generation. In this backdrop, energy efficiency initiatives could play an important role to overcome the current energy crisis. Energy intensity in Nepal is almost 4 times higher than the world average and almost the double of India or China. International Energy Agency reports that Nepal's energy intensity in 2010 was 1.02 ton of oil equivalent (toe) per thousand dollars of GDP (at 2005 US dollar), whereas, India had 0.56 toe, China 0.60 toe and Asian average 0.47 [3]. Nepal currently spends more than the amount of all its foreign currency earnings from exports for the import the petroleum products. Import of petroleum product makes more than 40% of total national import, which is equivalent to about US$100 million/month; whereas, Nepal's total merchandise export is merely US$ 70 million/month [4]. Enhancing efficient use of energy would save the energy and reduce the foreign currency spending, energy saving is another way of increasing energy generation.

Recent technological innovations have demonstrated that it is possible to minimize the demand by 20-25% through various energy efficiency initiatives. It is estimated that, with the nationwide implementation of various energy efficiency initiatives, Nepal can reduce almost 260 MW of peak demand in the current use combined with energy savings of 430 GWh per year by 2020 [5]. This is sufficient to reduce the minimum of 6 hours of load shedding each day. These considerable benefits will enable the Nepal's electricity system to avoid generation capacity worth NRs 38 billion, with an investment by Nepal Electricity Authority of approximately NRs 3 billion. Clearly, these benefits greatly exceed the costs, while also assisting in meeting the future projected electricity system peak demand.

The electricity and thermal energy saving potential in industrial sector is estimated to be in the order of 160 GWh and 8 million gigajoules respectively through the implementation of different energy efficiency measures [6]. However, Nepal is yet to realize the importance of demand side management and the role of energy saving solutions, despite many other countries have been already investing a lot in managing the demand through the use of innovative approaches and technologies. Given the current energy crisis, it is important that Nepal pays immediate attention to energy efficiency initiatives in the process to overcome current energy crisis. Such initiatives includes real time energy management system, intelligent motor energy controller, air conditioner energy saver, capacitor banks, high efficiency LED lights, solar street lights etc.

OBJECTIVE

In the backdrop of the above context, the main objective of this paper is to offer a robust way forward of institutionalizing energy efficiency in Nepal. In this endeavour, this paper seeks to develop an overarching framework that offers recommendations on an institutional platform, policy vision, energy savings potential across measures, targets, implementation modalities, and monitoring

METHODOLOGY

In order to achieve the set objective, the following tools and methods were used:

- Review and analysis of energy supply/consumption, GDP and population data
- Use of bottom-up cost minimization energy system model -MARKAL
- Review of good practices of other countries
- Proposition of appropriate options of Nepal

RESULTS

Review of the energy, economic and demographic data has shown that traditional (or non-commercial) energy is by far the most dominant energy source, accounting for approximately 89% of the total final energy consumption in 1996-97 and 80% in 2010-11. Almost all of the traditional energy use occurs within the residential sector, largely in cooking, though trace amounts of it are also in the industrial and commercial sectors. Within commercial energy use, transport is the largest user of energy followed by residential sectors. Industrial, commercial, agriculture and other sectors collectively use less than the residential sector at 8,100 PJ against 9,300 PJ in residential sector in 2010. The low levels of energy use in the commercial, industrial and the agriculture sectors signify the low levels of mechanization and reinforce the fact that as a strategy, energy efficiency must enable the expansion of energy use. Although non-commercial energy use is the more dominant source being used, its growth is declining. There is an increasing shift from traditional energy to commercial energy use, along with the fact that economic growth is promoting the use of commercial energy. During the period of 1997 to 2010, the commercial energy consumption in Nepal grew from 30 PJ to 64 PJ (i.e. 5.5% annually) whereas non-commercial energy consumption grew from 267 PJ to 279 PJ (i.e. 0.3% annually). The growth in energy use is a function of three factors, i.e. economic growth (or GDP growth), the switch from traditional energy to commercial energy, and the changing energy intensity of the economy. These three factors are co-mingled and are simultaneously in play.

Energy use has a direct and strong correlation to GDP or economic growth. All else equal, higher economic activity will invariably require an expansion of energy use. The switch to commercial energy could be a function of many factors, like higher income induced by increased economic growth, urbanization, increased availability of commercial energy and increased reliability in supply of commercial energy. Economic growth, industrialization and the growing use of commercial energy also mean that there is a change in the energy intensity (i.e. amount of energy required per unit of GDP).

Modelling Outputs

The MARKAL model projects that the total primary energy supply will grow at an annual average growth rate of 1.8%, from 374 PJ in 2010 to 540 PJ in 2030. The total final energy consumption is forecasted to grow at 1.9% (i.e., from 369 PJ in 2010 to 536 PJ in 2030). The sector specific final energy consumption is projected to grow at 5.8%, 5.0%, 5.0% and 3.3% in the industrial, transport, commercial and agriculture sectors respectively (see Table 1).

Table 1: Final energy consumption with biomass in Nepal during 2010-2030 (PJ)

Sector	2010	2020	2030	Growth (2010-2030)
Transport	18.9	30.7	49.8	5.0%
Industrial	22.4	39.4	69.6	5.8%
Residential	304.7	328.9	357.9	0.8%
Commercial	19.4	28.6	51.1	5.0%
Agriculture	3.9	5.5	7.5	3.3%
Total	**369.2**	**433.1**	**535.9**	**1.9%**

The base-case results confirm the trend of higher growth in the commercial energy relative to non-commercial energy. The total residential sector energy consumption including traditional biomass (fuelwood, agriculture residue and animal dung) is expected to increase at the average growth rate of 0.8%, while the residential sector consumption of commercial energy increases by 4.2% annually. This is largely due to a switch from biomass to higher grade fuels (kerosene, LPG and electricity) for cooking as a result of increased urbanization. The annual total final energy consumption excluding traditional biomass is estimated to grow at 5.1% (i.e., from 61 PJ in 2010 to 167 PJ in 2030) as illustrated in Table 2.

Table 2: Final energy consumption without biomass in Nepal during 2010-2030 (PJ)

Sector	2010	2020	2030	Growth (2010-2030)
Transport	18.9	30.7	49.8	5.0%
Industrial	16.6	28.4	51.8	5.9%
Residential	16.5	25	37.7	4.2%
Commercial	5.4	9.8	20.4	6.9%
Agriculture	3.9	5.5	7.5	3.3%
Total	**61.3**	**99.5**	**167.2**	**5.1%**

Over the 2010 to 2030 period, the consumption of imported fossil fuel (consisting of petroleum products, LPG and coal) grow at an annual average growth rate of 4.1%. This indicates that the future energy supply will be increasingly more dependent on the imported fossil fuels.

The use of hydropower is projected to increase at the rate of 8.4% per annum; while biomass energy supply will increase at an average annual growth rate 0.8%. Power generation capacity, dominated by hydro, is estimated to nearly double between 2010 and 2030, while annual electricity generation is estimated to increase nearly triple over the same period. The share of hydropower (excluding micro-hydro) and other renewables in annual electricity generation will increase gradually from 75% of the total in 2010 to 98% of the total in 2030, while the share of thermal generation decreases during the study period.

PROPOSED ENERGY EFFICIENCY POLICY SCENARIO

Double the Rate of EE Penetration by 2030

According to UN's Sustainable Energy for All (SE4ALL) Rapid Assessment and Gap Analysis, the goal of SE4ALL was to double the rate of energy efficiency by 2030 [7]. In modelling the energy efficiency (EE) policy scenario, EE measures were selected so as to approximately double the levels of EE penetration, i.e. double the annual rate of decline in the energy intensity of total final energy consumption relative to the base case. In the base case, the average energy intensity of total final energy consumption between 2010 and 2030 for commercial energy would decline by approximately **0.84%** annually. The energy intensity of Nepal in 2010 AD is 1.02 toe per USD 1000 GDP [7])**.** The mix of EE proposed measures under the EE policy scenario were designed with the target rate of doubling the decline in energy intensity of total final energy consumption to **1.68%** between 2010 and 2030**.**

Proposed Measures

EE measures have been proposed across all five sectors, i.e. residential, commercial, industrial, agriculture and transport. Potential measures were designed for each sector based on similar measures being adopted in other countries and its expected applicability in Nepal. The selection of measures reflects two points of emphasis. First, the measures were selected based on the stage of energy market. For instance, EE measures that require a switch from other fuels to electricity, or would lead to increased electricity use in some way, have limited applicability in the stage where there is an energy deficit. It would be meaningless to promote technologies that switch demand from other fuel to electricity, where the supply of electricity itself is limited. The measures are then broadly staged to be consistent with the outlook on energy market as defined by the three stages. Second, the measures have been based on global trends and on the recognized reduction potential in certain sectors. The list of measures is not offered as the best solutions that exist in their respective sectors. It is presented as an indicative list of potential EE measures that can be undertaken with the target of achieving a doubling in the reduction of energy intensity relative to the base-case by 2030. The lighting measures for Nepal, for both residential and commercial sectors, encourage the switch from incandescent bulbs to CFLs and ultimately to LEDs.

The industrial sector also offers good potential for a reduction in energy intensity. However, energy consumption across sub-sectors varies widely as they reflect a range of different technologies and end-use. That is why the first stage for the industrial sector must begin with a period of data collection, analysis and measure design. Significant adoption of energy efficiency can then be anticipated in the subsequent stages. In the transport sector, an increased penetration of large buses could drastically reduce the total miles driven per capita, reducing the need for smaller vehicles. Near term plan includes a higher use of diesel buses, but electrical buses will gradually capture more industry shares as electricity might become more abundant. Other measures push for the use of higher efficiency technologies within the same fuel category. Such higher efficiency technologies are already available in the market and its use needs to be supported through awareness and fiscal incentives.

NEPAL'S ENERGY EFFICIENCY STRATEGY AND ITS IMPLEMENTATION

The energy efficiency strategy must be based on energy savings against a forward looking baseline energy use. Nepal has an aspirational goal of graduating from LDC by 2022 – a goal that is endorsed by the government and is recognized as a national target. Achievement of this goal implies that the economy must achieve an annual average GDP growth rate of 9.2%. Such a growth rate would require a cumulative investment of NPR 9,697 billion through 2022, which is 6.3 times the GDP of 2012/13. Clearly, if Nepal were to be on that trajectory, the bulk of economic activity is yet to occur, and when it does, it will easily be one of the most intense periods of economic activity in its history. Nepal's energy efficiency strategy must be consistent with the fact that most of the country's economic activity is yet to unfold. Energy efficiency programs, measures, incentives and technology choices must target upcoming choices rather than requiring retrofits or changes to the existing stock of technology.

Comprehensive and Broad-based Energy Efficiency Strategy

To be effective, Nepal's energy efficiency strategy must be broad-based and comprehensive that should facilitate implementation to overcome the barriers across many different dimensions, as illustrated in Figure 3 below.

Figure 3: Barriers to energy efficiency in Nepal

To overcome these barriers to energy efficiency, a strategy must include a legal framework that provides an institutional basis for promoting and implementing energy efficiency. It must also provide a legal definition and mechanism for creating and sustaining energy efficiency markets. The strategy must be supplemented by policies that incentivise fair pricing of energy and remove of price distortions. It must allow for participants to have access to technology that can help them reduce their energy intensity and allow them to manage their energy use more efficiently. It should help create a strong pool of expertise through proper information, education and training, and then can support implementation of the measures and policies. The strategy must also be built around partnerships that allow it use existing institutional mechanism and delivery channels, such as industry association or formal banking channels. Finally, a key component of an energy efficiency strategy is to ensure the availability of financing based on models that allows energy savings to be monetized.

Time-Frame

The proposed EE strategy is divided into three phases - evolution, transition and maturity - consistent with the evolution of the broader energy market as described in Figure 4 below.

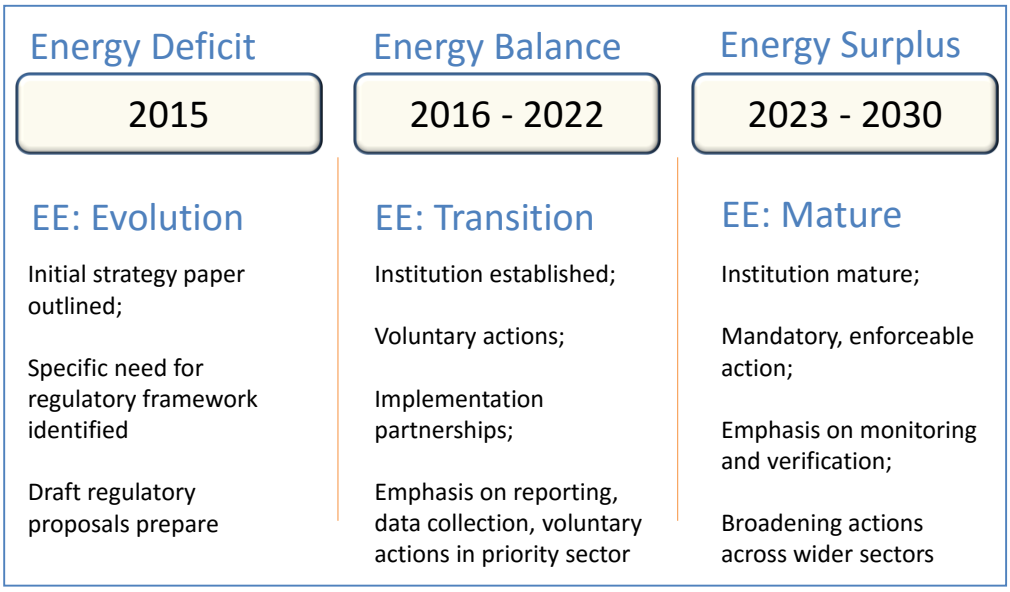

Figure 4: Proposed time line for an energy efficiency strategy

As described in an earlier section; 2015 AD, 2016 – 2022 AD and 2022 – 2030 AD have been associated with the three phases of energy deficit, balance and surplus respectively. The year range identified with each phase is not crucial to the analysis and simply offers one "hypothetical" view of when the transition between the energy phases will occur.

In the initial deficit period, policies and institutions will begin to be defined. In the next transition phase, the emphasis is on data collection and reporting, and almost of all the required actions is voluntary in nature. Beyond that, in the surplus phase, efficiency strategy moves into a mature stage. Institutional and legislative frameworks are well rooted by this time and required actions change from voluntary to mandatory requirements. There should be a greater emphasis on monitoring and evaluation. The energy strategy is pegged to the broader context of energy availability - deficit, balance and surplus - and not the specific years over which the phases occur.

Appropriate Regulatory Framework

No country has successfully implemented an energy efficiency strategy without a clear institutional structure. The prerequisite for an institutional structure is a legal framework, an act or executive order that clearly provides the legal basis for an energy efficiency strategy.

Ideally, the legal basis would create an institution, an Energy Efficiency Agency for example, that is charged with the objective of implementing the act. It must clearly define, for the institution, three of its key components: jurisdiction, regulatory authority and enforcement authority.

Practical Approach to the Implementation of EE Measures

As validated by the modelling results under the energy efficiency scenario, a large number of energy efficiency measures can be implemented. It will be impossible to implement all of them together. An important part of the strategy is, therefore, to offer a set of principles for how these measures could be implemented in a manner that is practical, achievable and meaningful. The analysis recommends for implementing EE measures in three broad time-horizon zones: short, medium and long term.

Short-term: Measures that offer a minimum accepted threshold of savings and are the easiest to implement are implemented in the short-term. The ease of implementation also depends on the instrument or approach being used to implement the measure. Command-and-control approaches, for example, are easier to implement than market based approaches.
Medium-term: Measures that require more capable systems of monitoring, evaluation and financial support are implemented in the mid-term. The environment and supporting framework should have been developed by then though it still may not have matured yet.
Long-term: All energy efficiency measures should be considered for implementation for the long-term.

The proposed implementation matrix based on an illustrative set of measures is outlined in Table 3.

Existing Gateways to End-users for Implementation

Despite endowing the energy efficiency agency with regulatory and enforcement authority, implementation of energy efficiency measures must use existing gateways to end-users to be effective. Having to build new implementation channels, even if its jurisdiction provides it the authority to do so, could mean significant duplication of effort and considerable inefficiency. This means that the implementation of energy efficiency must rely extensively on partnerships for implementation.

Broad-based Stakeholder Engagement

Energy efficiency is a cross-cutting issue puling across many different sectors, institutions and authorities. Stakeholder engagement is a crucial component of an overall energy efficiency strategy. It can also help build political consensus and ensures broad buy-in for policy implementation. Private sector co-operation during EE policy development and implementation ensures that policies take full advantage of the resources and commercial acumen of the private sector. EE issues are pervasive and the key target groups and/or stakeholders for EE intervention should be comprehensive. The primary stakeholders to energy efficiency in Nepal consist of government (including ministries and agencies), industry and business associations, civil society

organizations, consumer forums, development partners, universities and research institutions. Effective stakeholder engagement must include the following:

- Stakeholder diversity should be a goal of engagement;
- The legislative framework should make stakeholder engagement a mandatory requirement;
- Mechanisms that provide for ongoing stakeholder engagement are particularly useful;
- There is no single, best method for engaging stakeholders, the approach must be inclusive.

Table 3: Proposed energy efficiency measures

Priority	Sector	Measure Proposed	Rationale	Cost	Difficulty	Time Horizon
1	Industrial	Adoption of higher efficiency technologies	Holds strong reduction, as most potential industries are relying on low efficiency and low cost power solutions today. Even with the just limited penetration of high efficiency technologies, total reduction achieved will be significant	Moderate	Moderate	Mid/ Long term
2	Resident. & commerc.	Adoption of CFLs and LEDs	Global communities are rapidly moving away from low efficiency lighting source s As energy access increases in future, a large portion of future demand will come from lighting, reduction potential in the long run is big.	High	Easy	Short/Midterm
3	T&D losses	Reduce technical losses	Nepal has one of the highest level of losses The country is projected to rely heavily on locally generated electricity.	High	Moderate	Mid/Long term
4	Transport	Penetration of large diesel and electric buses	Large buses can dramatically reduce total miles driven per capita They can help reduce traffic congestion	High	Easy	Short/Mid term
5	Agricul.	Adoption of higher	Higher technologies already exists	Low	Easy	Short/Mid term

		efficient technologies with the same fuel	They have the highest reduction cost and fuel efficiency			
6	Resident. & commerc.	Adoption of higher efficiency technologies	Support a switch to a higher efficiency technology for future demand Several countries already have minimum efficiency requirement in place for certain appliances	Moderate	Easy	Short/Mid term

Enabling Pre-requisites for Implementation of EE Measures

In addition to an energy efficiency regulation and establishment of an agency, implementation of energy efficiency will require three key pre-requisites: human capital, testing facilities and enabling market.

Human Capital: Development and implementation of an energy efficiency strategy will require an industry of professionals with expertise in the sector. Essential among them are energy auditors and validators that work with companies, financial institutions, rating agencies and a range of other stakeholders to measure and monitor energy use and provide analysis of energy use and identify options for reductions. In addition, development of an energy efficiency industry also requires a critical mass of entrepreneurs who are willing to engage in the business of energy efficiency. Development of a critical mass of such experts requires training and certification facilities, which will enable these professionals to acquire these skills and have the supporting environment to grow with such careers.

Technical Testing Facilities: Implementation of energy efficiency programs requires a strong base of testing facilities that can provide independent reports on energy use of appliances and machinery. These facilities must be adequately resourced with current equipment that handle advances in consumer appliances, or must alternatively keep pace with international certification processes.

Enabling EE Market: Implementation of EE requires an enabling market that provides the base on which these activities can be built. An energy efficiency market consists of components which must come together within an integrated mechanism. Energy service companies (or ESCOs) are entities that help companies meet their energy efficiency objectives. They are effectively the delivery agents of the energy efficiency mission. Their business is, in turn, enabled by other factors, such as access to finance, contracting instruments and independent verification. One of the key challenges in developing an energy efficiency market is the legal contracting instrument. Many developing countries, including Nepal, lack the appropriate legal anchor for performance based contracts. A performance based contract is one where a service provider charges based on the realized performance. The challenge in implementing such contracts are that financial institutions

are typically not ready to project finance such contracts, in part because the independent monitoring and verification mechanism does not work.

A critical component for enabling an energy efficiency market is the readiness of financial institutions to invest in that sector. Financial institutions understand the energy dynamics but are still at an early stage of recognizing energy efficiency as a clear and distinct business opportunity. To support investments in that segment, however, they also need everything else to come together: such as contract sanctity, certainty of measurement and monitoring, availability of human and technical resources and companies that are in the business of delivering energy efficiency services. The ability to provide independent measurement, monitoring and verification (MM&V) is central to successful energy efficiency program. For this, there must be an agreement on the methods and protocols for conducting the MM &V. Such MM &V can only work if the users of the information have confidence in its independence and reliability. This is particularly important when financial contracts are involved.

CONCLUSION

Energy efficiency in Nepal can play a very meaningful role in supporting the country's development goals. In particular, if approached correctly, it could help enhance energy access and energy security. A wide range of potential measures are available to provide reductions on energy use. They can be implemented in a staggered, practical manner as the capacity for the design and implementation improves.

The biggest opportunities for Nepal's energy efficiency are yet to come. The energy efficiency strategy, therefore, must be prospective, rather than retrospective, in order to be consistent with future growth. The proposed energy efficiency measures and policy proposals for Nepal are based on **doubling the reduction in energy intensity by 2030 from what would otherwise have occurred in a business as usual case**. In order to implement these proposals, Nepal must also develop and put in place the necessary regulatory and institutional framework. Following this, the country must develop a draft action plan that outlines the sectors, measures, financing requirement and implementation strategy in greater detail.

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