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Overcoming Electrical Energy Efficiency Gap in Nepal's Residential Sector

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Abstract

The energy intensity of Nepal is economically not worthy, lacks eco-friendly and importantly not sustainable, and almost four times the average global energy intensity. Considerable efforts have been exercised to reduce the energy gap yet, it is still much to achieve. Nation priority on energy sector was envisaged with promulgation of investment friendly rules and law in hydropower and renewable technology even though, could not harness the sufficient energy. In amid of this acute energy crisis, the government launched the Nepal Energy Efficiency Programme (NEEP) with technical assistance from German International Cooperation (GIZ). Energy Efficiency (EE) practice is the most cost-effective method to reduce the supply and demand gap, reduce on greenhouse gases and pollution, and deter on import of petroleum products which finally improves on trade imbalance. This paper had proposed a framework of energy management team to promote energy efficient technologies in residential consumer. The energy management teams study the past records of energy use pattern of consumers and suggest appropriate technology for energy saving options. The paper provides some reviews of energy efficiency initiatives undertaken by the concern regulatory body which highlights the current status. The comprehensive knowledge acquired through exploratory research is implemented in this paper to identify the various barriers that domestic consumer is experiencing towards the active participation in energy efficiency program launched by the Government of Nepal.

Keywords Energy efficiency, Energy demand consumption, Nepal energy development, domestic consumer electrical appliances

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1. Introduction

The skyrocketing energy demand is due to rapid urbanization, industrialization and modernization of the global people. This use of excessive energy recklessly during third industrialization revolution resulted serious impact on global warming along with its adverse consequences. So the intuitive measures should be taken to reduce the energy intensity to an acceptable level. The most reliable and optimum energy use can be guaranteed only by adopting efficient technologies and practicing energy-friendly habits. Energy efficiency is the tool to meet the objective (desire product or services) with utilization of optimum energy (Nepal_GTZ_ Project). On the other way, energy efficiency is the most viable and environment-friendly solution which strengthen the energy security, this foster the competiveness and offers reasonable engagement of customers as well as generate the job opportunity in long run. So the horizon of energy efficiency should be expanded to all relevant sectors along with allocation to public fund where feasible. The consolidated monitoring should be focused over the complete energy chain i.e. from generation, via transmission and distribution to end user (European_Union, 2011). The growing global concern of the energy-related greenhouse gases could be offset through energy savings, efficient appliances and adopting solar generation technology in household. Solar roof-top technology significantly contributes in energy conservation and normalizes the green house emission which also reduces the losses incurred in the electrical grid. This is a sustainable approach which deters the expansion of grid infrastructure needs, increase competitiveness and build up consumer welfare. Energy efficiency would also reduce pollution emission in household. (Pokhrel, 2003)The objective of minimizing the conventional energy sources could be partially fulfilled by the renewable energy technologies which are being adopted in various countries. However the scale of implementation of this technology is limited mainly to individual household and small communities due to various implications which need to be resolving for promotional of renewable technologies extensively.

Cardenas (2017) conducted a study in resident sector of Colombia to demonstrate interlink of national energy policy and its impacts on the level of penetration of roof top-PV generation technologies and efficient electrical appliance along with adoption of energy friendly behavior of the resident consumer. With the higher penetration of the roof top-PV in consumer driven policies and pricing framework, the electricity demand is considerably decreased with simultaneous decrease in energy price while maintaining the energy security (Laura Cardenas, June 2017). The issue of energy sustainability could also be discussed from the grid and consumer perspectives where policy intervention is likely to superscribe both the Renewable Energy (RE) at generation side and Energy Efficiency (EE) at customer side. Though energy sector regulator has less direct

role in EE initiatives compared to RE initiatives but the electric utility and other agencies experiences a direct impact of EE on its financial cost. Because EE initiatives promote conservation of energy and better use of available energy efficiently and this reduces the grid loss, improvement in load factor, system security and reliability and better utilization of the grid capacity. The role of other agencies is to set appliances standard to comply with the EE program. Based on the impact on utility, an intervening role of sector regulator can promote EE initiatives or block some EE initiatives (Berg, October 2015). The policy also need to consider cost- effectiveness of RE and EE over the conventional generation technology and the long-term gain from the RE and EE technologies. These technologies offset the greenhouse emission and drives decarbonize economics. It is concluded that RE, EE and employment opportunity have positive interlink which adds the social value with potential trade-off in cost compared to conventional generation (Nicola Cantore, March 2017).

Most of the firm makes investment decision based on Pay-Back Time (PBT) and Internal Rate of Return (IRR) which is seems unjustifiable for adopting energy Efficiency (EE) technologies. If this decision is envisaged through a life-cycle cost perspective then it is more logical and cognitive decision for investment on EE technologies. Hence, concept of Levelized Energy Efficiency Cost (LEEC) indicator shall be the appropriate method for evaluation on investment decision in industrial EE technologies. This concept compares the energy saving with and without EE technology throughout the total life-cycle. The investment decision is made based on LEEC indicator which shows favorable investment decision if this indicator is less than total energy price incurred by the firm without initiatives of EE (Davide Chiaroni, June 2016). Surendra (2011) made a brief introduction of the various renewable energy technologies currently practiced in rural areas of Nepal and highlighted its current status and scenario. He highlighted on opportunity and barriers in adopting renewable technologies and finally researchers made a recommendation for enhancing and implementing of RETs in Nepal (Surendra K.C, October 2011).

Energy based national economy is often compared with the level of energy consumption and growth in Gross Domestic Product (GDP). Energy intensity which is the ratio between the net energy consumption to the gross domestic production offers better understanding of the national economic development and its tie-up with the energy consumption. The future needs of primary energy and electrical consumptions of Nepal are projected for year 2030 which revealed the demand for these types of energies significantly rises to 10-fold than the base scenario in the year 2009. The need of primary energy and electrical energy are dependent with the national GDP and population growth (Ranjan Parajuli, March 2014). To consume energy efficiently, it is equally important to have a good design and manufacturing practices in electrical appliances which considerably save the energy consumption along with fulfilling the international standards. A

research conducted on the ceiling fans of domestic consumer revealed flaws in design and manufacturing process to meet the international standards. A slight modification on induction motor design resulted with 35% improvement in energy consumption profile. The optimized technology incorporated in design will save the energy consumption and motivate the consumers to adopt this technology which in turn benefit the utility and consumer in developing nations (Tauseef Tauqeer, 2017).

The research conducted by (Samuel Gyamfi) has demonstrated that EE measures carried on CFL campaign over incandescent lamp has considerably offset of the national grid peak demand by 200-240 MW. Standard labeling of air conditioners has potential to offset another demand by 250 MW. The successful launch of EE program in Ghana is massively followed with nationwide educational campaign with schemes supported by the energy commission. This initiative has tremendously reduced the energy demand and offered saving opportunities to both customer and utility.

The report published by the UNDP for sustainable development of Viet Nam through the promotion of locally manufactured LED technology has focused on the various paradigms of social, economic, technology, institutional, policy and regulations to identify barriers. The study mainly focused on technology transfer and cost-effective and commercial production of LED lighting devices (UNDP, December 2014).

About 78% of primary energy for Nepal is extracted from the Biomass and the residential consumption of energy is about 84% of the total energy. The energy is mainly used for cooking, space heating and lighting in residential use. However, the inefficient use of energy imposed threat to deforestation in order to meet the energy requirements. At the same time, burning the fuel inefficiently creates pollution and health hazard. The aberrant energy use practice promulgated the country towards the energy crisis. The energy use behavior of Nepal is economically not worthy, lacks eco-friendly and importantly not sustainable. Considerable effort has been exercised to reduce the energy gap yet, it is still much to achieve. Nation priority on energy sector was envisaged with promulgation of investment friendly rules and law in hydropower and renewable technology even though, could not harness the sufficient energy. In amid of this acute energy crisis, the government launched the Nepal Energy Efficiency Programme (NEEP) with technical assistance from German International Cooperation (GIZ). Although, Demand Side Management (DSM) and Energy Efficiency programme are the tools to address the crisis but due to lack of comprehensive strategy and consolidated energy plan country is struggling on vicious energy crisis. Energy efficiency practice is the most cost-effective method to reduce the supply and demand gap, reduce on greenhouse gases and pollution, and deter on import of petroleum products which finally improves on trade imbalance. The energy efficiency program enhances towards energy independence and

hence improves on the national energy security. Alternatively, energy saving today is energy producing for future generation in reliable, efficient and environment friendly manner.

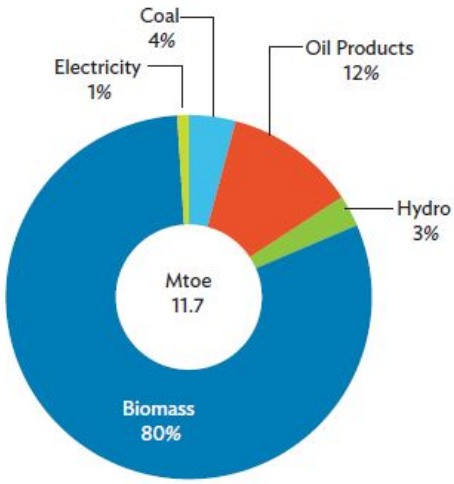
Domestic consumers in Nepal consist of significant population with 93.96% share on electrical consumption continue remained passive in energy efficiency program. This major group is the prime concern for the utility and stakeholders to back up with the quality of energy. The electrical energy consumption practices of the majority of the domestic consumers are not as per standard. Still majority of the consumers have installed energy inefficient appliances and systems for lighting, heating and entertaining purpose. This inefficient use of electrical energy not only hampered on the customer's electricity bills but also added the implication of the utility grid by under-utilization of grid capacity. The urge of customer shift towards the energy efficiency program is predominantly necessary to utilize available energy efficiently. Customer choices towards energy efficient appliances have shown a propitious sign but mass scaling in still could not achieve.

Ridah Sabouni, 2015 has presented three fundamental goals of Strategic Energy Management (SEM) and one of the goals was Value of Energy Efficiency which is achieved with continuous improvement in energy management system and sustainable saving from the energy management approach.

There is no dedicated institution in Nepal to implement and monitor energy efficiency measures for residential consumers. NEA is only responsible electrical service provider has less obligation to promote energy efficiency to residential consumer. The current structure of Energy Efficient Center and Energy Efficiency Unit (EEU) (Nepal_GTZ_Project) at national and district level provides services based on market approach targeted to industrial and municipal infrastructures. The paper is organized with Introduction of energy efficiency, current status of energy scenario of Nepal, present energy sector Institutional/policy status, India's institutional arrangement and EE&EC programs, analysis of various barriers experienced by household of Nepal and finally paper is concluded with discussion and conclusion.

2. Current Status of Energy Scenario of Nepal

Nepal lack the deposition of the fossil fuel, however the energy demand is meet by the primary energy sources like biomass, oil products, coal, grid electricity and renewables. With the last quarter century, the demand to the primary energy has increased from 5789 ktoe (kilotons of oil equivalent) in 1990 to 11,690 ktoe. Among the total energy mix, biomass shares highest percentage of total energy which is about 80% followed by the oil products, coal, grid electricity and renewables each with shares 12.3%, 3.9%, 2.8% and 1.2% respectively as shown in figure 1.



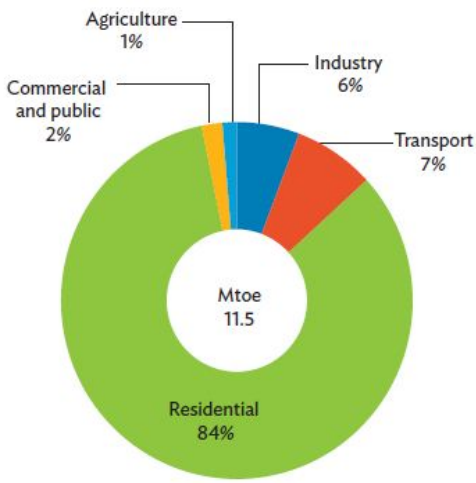


Figure 1(a) Primary Energy Supply Mix, 2014 **Figure 1(b)** Final Energy Consumption Mix, 2014

Source: International Energy Agency (IEA). http://www.iea.org/statistics

In the meantime, consumption has risen from 5761 ktoe to 11,534 ktoe in the same time frame. Residential, transport, industry, commercial/public services and agricultural/forestry are major energy consumer sector in Nepal. Among the various sources firewood, agricultural waste, animal manure is still dominant in the rural areas of the country because of lack of alternative source of energy and unavailability of the grid electricity. The largest share of energy still persisted by the domestic sector while other sectors uses very few percentage of the total energy consumption. The share of energy by industry and transport is very nominal but at recent years these sectors are rapidly growing. Among them, residential consumption is 83.80% followed by 7.4% transport, 5.8% industry, 2% energy is shared by the commercial/public services and 1% by agricultural/ forestry sector respectively (ADB). This figure shows that country's primary energy is mostly utilized by the residential sector with less output especially utilized in cooking, lighting and heating inefficiently while development sector utilizes the nominal share of energy. Hence, country like Nepal whose development economy is based on the energy shows it has scarce development activities (ADB, March 2017).

Nepal has huge commercial and feasible hydropower generation potential of 42000 MW. However, by the end of 2016, generation capacity has increased to 972.492 MW including 441.052MW generation added from 60 numbers of Independent Power Producer (IPPs) which is shown in table1 below. The national grid consists of mainly grid connected hydropower owned by the NEA and IPPs, thermal power plant and small fraction of solar. NEA own total generation of 531.44 MW including 53.410 MW of thermal power plant and 100 KW of solar plant. The IPP

sector owns 441.052 MW of generation totaling the install capacity of 972.492 MW nationwide while the national grid constitute about 967.856 MW of generation supplying the electrical demand at various load centers. The major generation is owned by the NEA consists of 55% share while remaining 45% generation is shared among the existing 60 IPPs.

Table 1 System Installed Capacity (kW)

Total Major Hydro NEA-Grid connected	473,394.00
Total Small Hydro NEA- Isolated	4,536.00
Total Hydro NEA	**477,930.00**
Total Hydro IPP	441,052.00
Total Hydro Capacity-Nepal	**918,982.00**
Total Thermal-NEA	53,410.00
Total Solar-NEA	100.00
Total Install Capacity	**972,492.00**

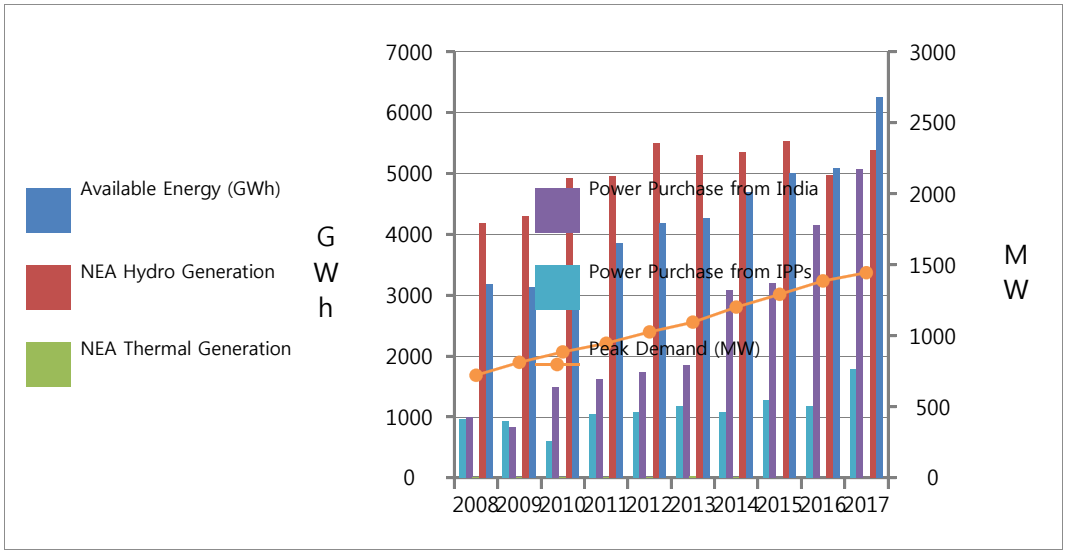


Figure 2 Generation and Demand growth pattern

Source: NEA Annual Report-2017

According to the annual report published by the NEA, the electrical demand is tied up with the customer intervention. The annual generation and demand growth pattern is depicted in figure 1 above. In the last decade residential consumers have increased from 1.45 million to 3.26 million which increased energy demand to drive residential loads. Residential consumer constitutes

93.96% out of total consumers have significant energy consumption of 41.85% of the total electrical energy. Most of the energy supplied to residential consumer is spent in lighting loads which constitutes major fraction of the residential loads including refrigerator, air conditioner, fans and fractional hp water pump. The electrical appliances and light bulbs used by the general consumer are not standardized and consume significant amount of energy. The cumulative impact of inefficient appliances is reflected on the grid systems which have direct consequences of increased demand at peak hours and low demand during off-peak hours.

The power grid of Nepal is under the critical stress because of speedy growth in demand but relatively crawling rise in generation and bottle neck capacity of existing transmission network and lossy distribution network. The rapid urbanization and fast economic growth demands electric energy but generation capacity deficits, high cost of new generations, expansion of existing network has imposed serious issue to match with economic growth. Hence this requires the increased effort to adopt some cost-effective measures to supply and manage the demand. From the perspective of demand side management, it offers the most viable and cost-effective solutions to minimize the supply and demand gap in energy. As per the annual report 2014 (NEA, 2014) published by the NEA, lighting loads consumes significant portion of the energy which constitute 44.29% of the NEA's total consumption. The domestic consumer spends significant revenue for the lighting purpose and this load impose stress to the national grid. Generally, simultaneously switching of domestic loads around the peak hours give rise to the system peak and this peak persists for few hours (18:00 hrs to 22:00 hrs). Hence, national grid is under stress for few hours while capacity remains unutilized for rest of the day. The gives the low use factor of the grid and generation capacity. The average plant factor of the NEA owned generation is at 49.97 which states that generation capacity is not fully utilized due to the poor load-factor of the overall consumers. Hence demand side management and energy efficiency and conservation program's importance has been realized to smooth out the system load curve in order to improve the load-factor and plant use factor of the power system.

3. Present Energy Sector Institutional Arrangements in Nepal

3.1 Energy Sector Player

There are many stakeholders in energy sector of Nepal but there is no leading agency to coordinate and manage the sector. There is also overlapping of roles and responsibilities between the stakeholders therefore it is difficult to map organizational network of energy sector of Nepal. Nevertheless, the major stakeholders of energy sector of Nepal are provided in figure 3 below. However Ministry of Energy (MoEn) is a leading institution which also formulates plans and

policies related to energysectors and implement those policies for through various agencies. MoEn generally looks after the broader aspects of energy related issues and coordinate among the various existing institutions involved in the field of energy. (Ministry of Energy, 2017).

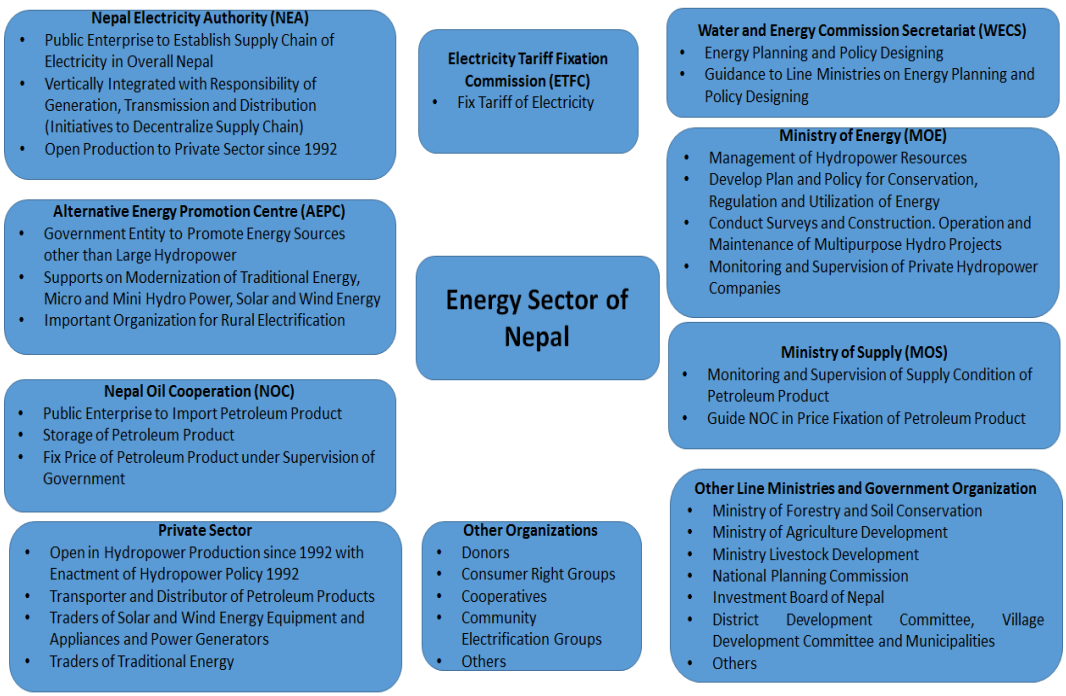


Figure 3 Various Energy Stakeholders

The Nepal Energy Efficiency Programme (NEEP) has been recently initiated under the Ministry of Energy and it is still in under the phase of study. After completion of first phase, the next phase aims to provide services to wider areas of energy market. The Energy Efficiency Centre (EEC) operating under FNCCI at central level and Energy Efficient Unit (EEU) at district level provides energy efficiencies services to industries and municipal infrastructures in collaboration with Nepal Electricity Authority (NEA) and Town Development Fund. EEC conducts awareness campaign and helps to identify possible energy saving opportunity through elaborated training on energy auditor and energy manager. This center also promotes the energy efficient technology adoption to their stakeholders by providing financial services in participation with local banks (Nepal_GTZ_Project).

3.2 Energy Efficiency regulations and various initiatives

For the sustainable development of the nation, government of Nepal bestowed with strong commitment to explore the renewable sources like hydropower, solar, wind and biomass. With the severe energy crisis jolt experienced by the nation, government has issued a "National Energy Crisis Mitigation and Electricity Development Decade Concept/Action Plan" in 2015 with an aim to eradicate energy crisis in an integrated approach. The concept paper has envisioned an action plan for short and long term for mitigation energy crisis. The first objective was to initiate necessary measures to minimize energy crisis to acceptable level within a one year i.e. by the end of 2016. Within a decade, target was to attain energy security via sustainable energy development which shall be bolstered with the development of hydropower projects along with the room for development of renewables to foster energy mix. The six topic based document has institutionalize the various administrative, technical, policy and legal reforms to deal with the crisis in an integrated approach. In order to minimize the electric demand and loss reduction the paper has envisioned to promote energy conservation program and time based tariff with implementation of Time-of-the Day (TOD) meters in Kathmandu Valley for pilot project (MoEn, November 2015).

With the continuity of previous energy crisis agenda, Ministry of Energy has published a white paper on "Energy Sector Current Status and Immediate Action Plan" with slogan of "Harness of Hydropower for Prosporous Nepal". Under this program government have pinned point the areas to address with top priorities and developed the action plan to meet the stated objectives (MoEn, July 2017).

Under the "Ujjyalo Nepal Abhiyaan- Nepal ko Paani Janta ko Lagaani" initiatives to eradicate load shedding, various activities were carried out along with the campaign on energy conservation and energy efficiency programme. As a result, last year was a historic triumph to mitigate load shedding, loss reduction and financial promotion by adding 121.5 MW of generation along with administrative and grid sectors reforms. The Ministry of Energy in coordination with the various energy sector stakeholders has launched a campaign on energy efficiency promotion. National Electricity Crisis Resolution Action Plan, 2008 has promoted the widespread adoption of energy efficiency measures for lighting to reduce the system peak through the nationwide replacement of inefficient filament lamps with the Compact fluorescent lamps. The program was launched by the NEA with financial support from GoN and ADB. The target was to promote energy efficient lighting by providing CFL to each consumer. The project was very popular and successful with 'buy one get one free' campaign. In order to encourage the efficient lighting government had exempted VAT and custom tax on efficient lighting sources like CFL, LED, and Slim tube light and electronic ballast. In the FY 2009/10, NEA distributed over 1,500,000 CFLs in various areas. The initiatives

taken by the NEA in demand side management with promotion of energy efficiency programme has gathered tumultuous applause from concern stakeholders. It is now focused to implement LED lamp and efficient fans campaign to save additional 240 MW of grid electricity by reducing grid peak and associated loss (NEA, August 2017).

With energy dearth, government has launched Nepal Energy Efficiency Programme (NEEP) lead by the Ministry of Energy since 2010 with the technical assistance from the GIZ until the end of first phase on June 2014. The second phase of the program scheduled for July 2014- June 2017 is focused on the energy efficiency market based approaches to promote energy efficiency program in collaboration with various energy stakeholders along with awareness campaign. In addition to energy market it assist in promoting quality improvements with setting up standards in biomass clean cooking and heating technology in rural households. Lastly, it provides the policy advice to the government to develop energy efficiency framework and action plan to deal with the sustainable and efficient energy use (NEEP, September 2015).

With a target to minimize the existing energy crisis and to supplement the GON campaign of "Bright Nepal, Prosperous Nepal" which was focused on energy generation with energy conservation through demand side management by promoting use of high efficiency Light Emitting Diode (LEDs) in place of Incandescent lamps. These programs are driven by the broader movement of the energy sector development toward reducing the energy usage, associated with lighting. However, the primary objective has been to address the peak power shortages and improve reliability of supply. Those programs involve the replacement of conventional, energy-intensive incandescent lamps (ILs) with more efficient, high-quality LEDLs (also referred to as “Energy Saver Lamps”) that provide savings of more than 80 percent compared to ILs for the equivalent lighting output (measured in lumens); the LEDL last 5-10 times longer than ILs. These energy-efficient lighting initiatives, based on large-scale deployment of LEDLs, have provided substantial operational experience, demonstrated peak load and energy reduction impacts on the grids, and have been able to showcase how demand-side, energy-efficiency measures can be implemented at a much lower cost and in a shorter time frame compared to the requirements for adding new generation capacities. Developing countries can benefit from the lessons learned by improving how they plan for and structure their large-scale, energy-efficient lighting programs. NEA has published Expression of Interest to purchase AC LED from the manufacturer, wholesaler and retailer (NEA, 2015).

Energy stakeholders were set to launch "Public Awareness Campaing" for efficient light sources and to promote energy efficiency programme through social media, TV, newspapers, Pamphelets at public places. The government webpage and websites are used to disseminate energy conservation and energy efficiency awareness related contents. These websites frequently updates

the various awareness activities conducted towards energy conservation program. The awareness program generally recommends on use of alternative energy sources, efficient and rated electric appliances and bulbs, and good energy practices on energy conservation. The extensive use of digital media, SMS and workshop on energy efficiency campaign has reached to large population in urban areas.

3.3 End-use appliances in Nepal

The large fraction of the appliances market in Nepal is made up of non-rated electrical appliances and luminaries which are very inefficient. All electrical appliances likes micro-ovens, fans, fridges, TVs, air conditioners and lighting devices demands significant portion of the electrical energy. The domestic consumers of about 3.06 million constitute 93.96% of the total energy consumption. Most of the domestic load consists of loads from above mentions appliances mostly used for cooking, heating and cooling and lighting purposes (NEA, August 2017). By introducing energy efficient appliances in households there is a significant opportunity to reduce the electrical demand, save the money and increase the economic growth while fulfilling the same purpose. The journal paper on Demand Side Management for Electricity in Nepal has depicted the fraction of energy uses by various consumer and run LEAP model for demand forecast. According to the data presented in this paper, with the increase in cost of fossil fuel, environmental concerns along with the reach of electricity, user preference will switch over electricity uses for sustainable use of energy. Residential sector will switch to electrical use by 2.47% in cooking, 0.41% in heating, 53.9% in lighting and 2.72% in water heating by year 2015. By 2030 these switch patterns reach 50% for cooking, 15% for heating, 60% in lighting and 50% in water heating respectively (Suman Shrestha, 2015). This result shows electrical growth pattern is residential sector and areas to focus energy efficiency program with action plan.

EE leaflets published by the National Energy Efficiency programme depicts that if the domestic consumers adopts energy star fridge then customer can make a saving of NRs 4410 per year. Similarly replacing lighting bulbs with Light Emitting Diode (LED) will results in saving NRs 2900 per year. The calculation is based on the electricity price of NPR 7.3/KWh (NEEP, 2013).

A survey study was conducted by the Shiva raj and Shree raj on status of energy efficiency and potential energy benefit from LED lighting in Kathmandu Valley. A survey conducted in 101 households showed that most of the respondents prefer CFL bulbs that comes to be 60% followed by 24% have a choice on tube light and 17% choose LED bulb while none of them choose incandescent bulbs. This result supports that people in Kathmandu Valley are aware of Energy Efficiency benefits. While examining on driving factors on their choice it was observed that 42%

buy a bulb based of efficiency performance, 37% focused on safety, 12% choice based on price, 7% choose bulb based on availability. From the survey it was recorded that 83% of lighting is fulfilled with CFL, 59% with tube light, 32% with incandescent, 7% with LED and 1% by other bulbs in general household under observations. This analysis showed that considerable energy saving can be achieved if customer switch from antique lighting to advance and efficient LED lighting. If same energy consumption of pattern of the sample size is reflected to the whole population of Kathmandu Valley then it is possible to save energy consumption by 60% if all existing lamps were replaced with LEDs and this in monetary term will be NRs 2.87 million per day calculated at tariff rate of Rs 7.30/unit (Shiva Raj Timilsina, 2014).

4. India's Experience in Energy Efficiency Programme

To match with the indispensable energy needs the government to India has undertaken long term vision to fulfill energy needs while ensuring low CO2 emission for sustainable environmental goal. In doing so two approaches has been undertaken first, promoting generation side with greater use of renewable energy mix while phase wise shifting or improving of thermal plants using supercritical technologies. Second effort is being focused on consumer side to promote efficient use of energy through various policy measures initiatives based on scope of Energy Conservation Act 2001. To facilitate and implement EC Act, a statutory body Bureau of Energy Efficiency (BEE) was set up at central level. The act provides energy conservation building codes for commercial buildings, mandate for standards and labeling of appliances, and energy consumption norms for energy intensive industries. The government of India followed the various schemes to promote energy conservation and energy efficiency practice (GOI, 2017).

4.1 Standard and Labeling

The Bureau of Energy Efficiency has initiated the standard and labeling of 19 equipment/appliances to provide consumers a choice of energy and cost saving options of the relevant marketed product. Appliances like Air conditioners, FTL, Frost Free Refrigerator and Distribution Transformer are notified under mandatory labeling form 7th January, 2010 while others are under voluntary labeling phase. The stringent labeling enforcement on refrigerator and air conditioner has replaced less-efficient equipment with more efficient product from the market (GOI, 2017).

The Indian labeling program has covered only few domestic appliances under mandatory labeling while still more appliances need to be covered under this program to tapped significant efficiency gap (Robert Harmsena, February 2014).

4.2 Energy Conservation Building Codes

The government of India had developed Energy Conservation Building Code on 27th May, 2007 which sets minimum energy standards for commercial building. Using the provision of EC act the central government has the flexibility to modify the code according to local states needs and notify them. Currently eight states are notified and adopted codes for their states (GOI, 2017).

4.3 Demand Side Management Scheme

It includes sectorial demand side management like Agricultural Demand Side Management, Municipal DSM, Capacity Building of DISCOMs and Energy Efficiency in SMEs sector (GOI, 2017).

4.4 Strengthening Institutional capacity of States

For implementation and enforcement of the provisions of energy conservation (EC) and energy efficiency (EE) stated in EC Act, State Designated Agency (SDA) is responsible in each state. To promote the effectiveness of EE and EC, government realized with strengthening of SDAs with building institutional capacities. To overcome the major barriers for implementation of energy efficiency programme a contributive fund called State Energy Conservation Fund (SECF) is established. The fund of Rs 40 million is released in two installments. The second installment is released only those state who provide matching contribution to the BEE's first installment (GOI, 2017).

5. Analysis on various barriers for Residential Consumers in EE promotion in Nepal

There are many stakeholders in energy sector of Nepal but there is no leading agency to coordinate and manage the sector. There is also overlapping of roles and responsibilities between the stakeholders therefore it is difficult to map organizational network of energy sector of Nepal. However, Ministry of Energy at current situation is playing the leading role in energy related plans and programs. Several initiatives have been undergoing to match with the objectives envisioned through "National Energy Crisis Mitigation and Electricity Development Decade Concept/Action Plan". Energy efficiency program with promotion of various standard rated electrical appliances along with LED lighting. However, domestic efficient appliances promotion is not as successful as expected. The various barriers experienced in adopting efficient technologies by the household in Nepal are as below:

5.1 Policy, Law and Regulatory barriers

Due to lack of Nepal Energy Conservation and Energy Efficiency Act, residential consumers have no obligatory to meet the energy standards and nor the electrical market appliances are regulated. Few consumers, who do not experience financial barriers, adopt the standard energy technology voluntarily. But from the Government side, residential consumers have not experienced strong initiatives measures to promote efficient technology. In absence of dedicated EE implementing agencies and conducive financial incentives to meet upfront cost of the technology, promotion of efficient technology seems challenging. However, Government is leading energy efficiency to program via CFL campaign, LED promotion for residential consumers. Recently NEA was assigned to promote the LED lighting but still what will be the approaches and framework to do execute the task is still perplexing.

Nepal market is flooded with imported non- standardized electrical appliances that are mostly manufactured in India or China. In absence of proper legislative regulatory framework to meet standard over the quality of electrical appliances in the market, customers are exposed to utilize sub-standard appliances for lighting, cooking, heating and cooling. So consumers do not experience promising energy and cost savings from the market products even though cost of appliances is comparatively high. Also due to lack of mandatory standards and regulations for domestic appliances and lamps, market is flooded with sub-graded quality of appliances which fails to meet the standards and have shorter life.

In addition, there is no mandatory provision to include energy saving specification in building code and energy audit in residential consumer is not mandatory. Hence, residential consumers are not obliged to implement energy saving appliances and measures. However, government offices and buildings following lead by example model to promote energy efficiency by implementing and integrating energy saving design with efficient appliances.

5.2 Institutional Capacity barrier

There is weak institutional arrangement for R&D and testing of electrical appliances in Nepal. Nepal Bureau of Standards and Metrology (NBSM) provide testing facilities and technical support in the field of SMQC but it lacks domestic appliances testing laboratory. The Renewable Energy Test Station is mainly runs quality assurance test on solar, Biomass and biogas, solar thermal and micro hydro components. It also lacks with sophisticated testing laboratory of LED lights. However the proposed institutional framework is not sufficient to address the energy efficiency issues that have been experienced by the household consumer of Nepal. The current institutional setup is responsible to provide advisory services related to energy efficiencies issue to the big

industries. FNCCI provides energy auditor trainings to meet the investment grade standard to open access to a pool of energy efficiency service providers. It also provides training to small and medium size business companies to encourage and trained in an energy efficiency operation. Through town development fund, municipal sectors are provided energy efficiency services to promote for adoption of energy efficient technologies. Figure below shows the incumbent institutional framework for Nepal Energy Efficiency Programme.

Due to the lack of coordination among various agencies in energy sector, it is hard to realize the successful launch of energy efficiency programme. Because energy efficiency program is concern with multilateral interconnected stakeholders like customer, service provider, financial institutions, Government agencies and so on. However integrated approach to conserve energy is big challenge in context to Nepal. Also Nepal has less institutional experience related to Energy Efficiency Program and limited expert manpower in this field.

Figure 4 Institutional framework for Energy Efficiency Program.

5.3 Economic Barrier

Most of the residential consumers are middle or low income based family. Most of the populations are out of reach of digital network either because of financial barrier or region beyond ICT coverage. Hence, enough information about the energy campaign has not been reached to

these populations with some exceptional case in urban areas. Due to high capital cost, lack of subsidies and fund, and market availability of non-standardized electrical appliances; the implementing agency is facing challenge to reach residential consumers. Also, upfront cost of energy efficient technology is comparatively high so, people simply refrain to adopt new technology due to financial barrier and continue rely on antique technology use which is not economical in long run. So economic barrier need to be addressed for the successful adoption of energy efficient appliances in household. The CFL project implemented by the NEA in 2009 with buy one get one free scheme was popular and successful to overcome financial restriction towards adoption of CFL lamps. NEA is at stage to promote LED lighting to residential consumers and without any promotional scheme, consumers are not interested to invest because of their financial affordability to replace all lighting with LEDs. The scenario is even worse because the market is flooded with poor quality of home appliances and consumer's perception to efficient technology is costly and also does not demonstrate committed life and quality.

5.4 Lack of Public Awareness

Despite of cost and energy saving opportunity through the energy efficient installation of home appliances, residential consumers are still lacks of awareness of efficient technologies. Some of the propitious sign have been observed through Energy Efficiency Programme and stakeholders integrated approaches to promote energy efficient appliances through public awareness campaign. The uses of modern ICT platform have been utilized to amplify the awareness program to reach every part of the nation. Mobile sms, government websites, TV, posters and pamphlets are the ways to disseminate campaign along with seminar, workshops and group discussion on benefit of energy efficiency technology. However, there is a gap in approach of government to promote energy efficient appliances and market demand of traditional appliances. Government does not undertake activities on rating and standardize verification of lighting and other electrical appliances right at the custom point. So the market is always found flooded with low efficient electrical appliances. In other perspective, there is not much R&D investment on energy efficient technologies suitable in context to Nepal.

6. Conclusion

Towards the implementation of the energy efficiency program in residential consumer, there is big challenges and opportunity related to policy/Law/regulations, institutional capacity limitation, lack of skilled energy managers, economic barrier and lack of awareness of energy efficiency programme. However, properly addressed various issues helps in solving the barriers of the sector.

In this paper, among various types of barriers major four types of barriers are discussed based on the past experience of the institution and practices. This helps in the understanding of different kinds of barrier towards adoption of energy efficient technologies in residential consumers. Understanding the barriers to EE provides important feedback for decision maker to choose appropriate measures at top level. Also, the overcoming the barriers with policy interventions and intensive sector targeted awareness and training campaign will helps consumers to switch energy use behavior in an effective and efficient way. The study is thus expected to provide analytical and theoretical background to various stakeholders for the better understanding of barriers to household for adoption of efficient technology.

There is an urgent need of energy conservation and energy efficiency law and regulation to address energy efficiency related dilemmas. There is a need of dedicated implementing agency responsible to carry all energy efficiency related measures to address various barriers. This institution should provide EE services to all categories of energy to every sector. The role of energy management team is to monitor the energy use pattern and provide energy advice to the various stakeholders including residential consumer. The use of ICT technology to integrate and analyze of energy use pattern helps to identify the areas requiring EE measures and energy management team should provide comparative energy use report to the stakeholders to realize the impact of EE measures. The policy should include some mandatory labeling of majorly use domestic electrical appliances for like lighting, cooking, heating and cooling. It is suggested that, Government should demonstrate lead by example role in promoting energy efficiency program. Because lead by example program demonstrates to the consumer that EE program is practical and economical. It boosts credibility of the EE program and consumer reaps benefit in terms of financial, environmental and energy security through efficient use of available energy.

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