IMPACT OF RURAL ELECTRIC COOPERATIVES IN REDUCING FINANCIAL LOSS OF DISTRIBUTION CENTER OF NEPAL ELECTRICITY AUTHORITY

A Research dissertation submitted to

Kathmandu University School of Management

in partial fulfilment requirement for the

Degree of Master of Philosophy (MPhil) in Management

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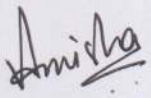
Kathmandu, Nepal

October, 2017

DECLARATION

I hereby declare this dissertation entitled *Impact of Rural Electric Cooperatives in Reducing Financial Loss* of *Distribution Center of Nepal Electricity Authority* embodies the original research work that I carried out in partial fulfillment of the requirements for the degree of Master of Philosophy (MPhil) in Finance of Kathmandu University of Management and that this dissertation has not been submitted for candidature for any other degree.

Amisha Rauniyar  October, 2017

RECOMMENDATION

This is to certify that *Amisha Rauniyar* has completed her research work on *Impact of Rural Electric Cooperatives in Reducing Financial Loss* of *Distribution Center of Nepal Electricity Authority* under our supervision and that her dissertation embodies the result of her investigation conducted during the period she worked as an MPhil candidate of the School of Management. The dissertation is of the standard expected of a candidate for the degree of MPhil in Management and has been prepared in the prescribed format of the School of Management. The dissertation is forwarded for evaluation.

Dissertation Advisory Committee

1. Chair Dr. Biswo Poudel

October, 2017

KATHMANDU UNIVERSITY
SCHOOL OF MANAGEMENT

APPROVAL

We have conducted the viva-voce examination of the dissertation *Impact of Rural Electric Cooperatives in Reducing Financial Loss of Distribution Center of Nepal Electricity Authority* by Amisha Rauniyar and found the dissertation to be original work of the candidate and written according to the prescribed format of the School of Management. We approve the dissertation as the partial fulfillment of the requirements for the degree of Master of Philosophy (MPhil) in Management.

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Amisha Rauniyar

October, 2017

ABSTRACT

Low electrification rate, huge financial loss of power providers and many hours of load shedding are found to be evident in developing and underdeveloped countries. Every year Government of Nepal set aside budget for funding Rural Electric Cooperatives (RECs). This study investigated impact of Rural Electric Cooperatives in reducing financial loss of distribution center of Nepal Electricity Authority (NEA). The empirical strategy used for this study is Fixed Effect Instrumental Variable method. The variable REC is suspected to have endogeneity so road length and total number of cooperatives in each district of Nepal have been used as instrumental variables. The control variables of this study are employee expenses, distribution line expenses, equipment repair expenses, meter repair expenses, transmission line expenses, per capita income, Gross Domestic Product (GDP), literacy rate, Human Poverty Index (HPI) and total repair and maintenance. Overall, the results suggest that the subsidies and budget for these RECs are justified on the ground of positive externalities. Hence, the estimates of this study suggest that the rural cooperatives of Nepal have lowered financial loss of distribution center of Nepal Electricity Authority.

Key Words: rural electric cooperative, financial loss, rural electrification

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ABBREVIATIONS

ADB	Agricultural Development Bank
BREB	Bangladesh Rural Electrification Board
CBM	Community Based Management
CREP	Community Rural Electrification Program
CRED	Community Rural Electrification Department
DEOC	Department of Co-operative
DOR	Department of Road
GoN	Government of Nepal
HPI	Human Poverty Index
FE	Fixed Effect
FL	Financial Loss
INPS	Integrated Nepal Power System
IV	Instrumental Variable
Kwh	Kilo Watt Hour
Mwh	Mega Watt Hour
NACEUN	National Association of Community Electricity Users Nepal
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organization
OLS	Ordinary Least Square
PBS	Palli Bidyut Samity
PPA	Purchasing Power Agreement
REC	Rural Electricity Cooperative
REP	Rural Electric Program
2SLS	Two-Stage Least Squares

CHAPTER I

INTRODUCTION

Energy poverty is evident in the developing and underdeveloped countries. It refers to a set of circumstances of large number of people in developing countries where energy consumption is very low and excessive time is spent in collecting fuel to meet the basic needs. The majority of rural population in developing countries has been utilizing natural resources around their settlement. According to the Energy Poverty Action initiative of the World Economic Forum (2016), access to energy is key to improving quality of life and for economic development. Therefore, an access to energy helps the well-being of a nation by promoting income generating activities. There is a wide body of literature which claims rural electrification is crucial for the welfare of rural people (e.g Barkat, Khan, Rahman, Zaman, Poddar, Halim, Ratna, Majid, Maksud, Karim & Islam 2002; Barnes & Binswanger, 1986; Chaurey, Ranganathan, & Mohanty, 2004; Khandker, Samad, Ali, & Barnes, 2012; Yadoo & Cruickshank, 2010).

Groups of individual have worked together forming cooperatives in pursuit of common goal and have also been successful in many ways. Policymakers in Nepal had initiated program supporting Nepal Electric Co-operatives (NECs) in the wake of different successful community based conservation efforts in preserving natural commons (Armitage, 2005; Kellert, Mehta, Ebbin, & Lichtenfeld, 2000; Spiteri & Nepal, 2008). Similarly, Rural Electric Cooperative (REC) program helps local stakeholder participation in planning, research, development, management and policy making for a community as a whole. There are almost 50 countries that have adopted

models of community based natural resource management (Gruber, 2010). Hence, many of these countries are also most likely to use REC program to electrify their villages and counter widerspread electricity losses.

Scaling up electricity access is an enormous responsibility of REC (Adhikari, Pahari, & Shrestha, 2014). Before 2003, 56.7 % of the total population had no access to electricity and 17 million people in rural areas were without electricity (Energypedia, 2016). In 2003, the Government of Nepal (GoN) came up with Community Rural Electrification Program (CREP), to expand the access of electricity services across the rural areas on the demand driven approach. Although rural electrification has been challenging and expensive due to topological situation, every year GoN allocates budget to expedite electrification process in the rural areas. Similarly, Community Rural Electrification Entities (CREE) were established by locals who have been seeking electrification in the village. In the beginning of this program the locals from rural areas used to assume 20% of the total capital cost but now it has been reduced to 10% (Pandey, 2005). And they are also provided subsidized electricity for sale which cost 50% less than other customers. The profit generated from it is used for different kind of micro financing activities in the rural areas. In policy discussions, these RECs are credited with reducing the electricity pilferage rate for example from 25% to 15% (Pandey, 2005). Moreover, they are also acknowledged for reducing monitoring and maintenance cost, mainly because the locals are responsible for the management of the whole system.

The financial loss of NEA is cumulating every year and is one of the loss making public enterprises. The annual report of NEA shows total system loss for the fiscal year 2008/09 was 28.6 % but it has come down to 24.44 % in the fiscal year 2014/15 (NEA, 2009; NEA, 2015). Although total system loss is in declining trend

but it is decreasing slowly as compared to other developing countries. According to Pangeni (2015), "By bringing down technical loss to around 18 percent, NEA can save around Rs 2.62 billion annually".

In 2015, NEA reported net loss of Rs 6.46 billion, and claimed it could have saved Rs 9.81 billion over the past four years by reducing technical loss to 18%. (NEA, 2015). However, the Nepal Energy Forum claimed that NEA financial loss has been doubled to Rs 11.57 billion in 2015/16 from Rs 6.46 billion in 2014/15 (World Economic, 2016) . If NEA is able to control and reduce financial loss then this loss can be converted into profit by being able to sell these lost unit of electricity. Finally, this financial loss relative to Nepal's economic value is much higher than mere electricity loss. According to Smith (2004), "Lost earnings can result in the lack of profits, shortage of funds for investment in power system capacity and improvement, and a necessity to expand generating capacity to cope with the power losses".

The goal of rural electrification is not only to provide rural household with affordable modern energy at cheaper price but also to improve the well-being of rural households. There are many studies which claim that rural electrification has greater contribution towards the welfare growth of rural households (Burgess & Pande, 2003, Barkat et al., 2002, Gruber, 2010, Kirubi, Jacobson, Kammen, & Mills, 2009). Moreover, above studies are based on correlation between rural electrification and development. Besides welfare gain , rural electrification also helps in reducing theft and non-technical loss since the local people continuously monitor their area, quickly perform repair and maintenance work and do bulk payment of electricity consumed. However, none of previous works have mentioned or studied whether the presence of RECs have helped in reducing financial losses of power providers. Therefore, this

study aims at evaluating whether the presence of REC in different distribution center of Nepal has helped in reducing financial loss of NEA.

Statement of Problem

NEA has the key role in the power sector of Nepal in generation, transmission and distribution of electricity in reliable and affordable manner. When the financial loss of NEA is compared to GDP of Nepal then this loss is extremely huge. Financial loss occurs because average earning per unit of electricity is less than the average cost of supply. The major contributors to financial loss are Purchasing Power Agreement (PPA) with independent power producers, pilferage of electricity including technical and non-technical losses, high interest loan taken from the government and non-adjustments of electricity tariff (The Himalayan Times, 2006). This is a serious issue since huge amount of electricity is being lost and financial loss is getting accumulated on yearly basis. Despite huge capital budget expenditure and operational expenditure, NEA hasn't been able to reduce its huge financial losses. Every year GoN funds the REC program and receives many applications from local community. But NEA hasn't done any policy evaluation whether the investment in rural electrification and presence of RECs have helped in reducing financial loss.

The RECs in respective distribution center of NEA is actively involved in various activities like repairs, maintenance, etc that help in reducing financial loss. For example, if NEA has to send its officials for repair and maintenance work in remote area, it will take few days depending upon the distance but with the help of local community it can be fixed quickly. And also NEA doesn't have to monitor theft which is a major issue in the remote areas. Although there is Electricity Theft Control Act 2058 and Electricity Theft Control Regulation 2059 which take action against electricity theft, there are only few of such incidences which are reported and

punished. The electricity theft control measures of NEA include confiscation of electric equipment's and taking legal action against culprits. In addition to it, extensive programs are implemented by NEA to prevent electricity theft manipulating meter and metering units (NEA, 2016).

Currently, there are 437 RECs which have been operating in different parts of Nepal (DEOC, 2016). Although this program has been able to meet its first objective of rural electrification process but second objective of financial loss reduction hasn't been investigated. This study evaluates the importance of Rural Electricity Cooperatives (RECs), which purchase bulk electricity in a predetermined and comparably lower rate from the state owned dominant utility firm. The investigation provides evidence on whether results from such efforts are transferrable to the electricity sector, which currently suffers from incidences of huge financial loss.

In this study, road length and total number of cooperatives of each district of Nepal have been used as instrumental variables. The control variables of this study are employee expenses, distribution line expenses, equipment repair expenses, meter repair expenses, transmission line expenses, per capita income, GDP, literacy rate, HPI and total repair and maintenance. The number of REC is a dependent variable and financial loss is an independent variable.

This study intended to answer the following question: Is there causal relationship between number of REC and financial loss of each distribution center of NEA?

This study is important because many poor countries in the world also have state utility firms which suffer from same scenario of financial loss. Over the time, this situation has been so persistent despite several policy experimentations to address such financial loss, there seems to be no known solution to it. In Nepal, access to

electricity is very low in rural areas and if this financial loss is reduced then more rural areas can be electrified and NEA can become profitable entity in public sector

The findings of this study will benefit Nepal by helping to unravel one of the benefits of RECs that is reduction of financial loss. Although in Nepal, this program has been in practice since 13 years but there has been no study about RECs and financial loss. This study will help NEA to evaluate the importance of RECs and GoN for funding these RECs. In addition to it, this study will be the first of its kind to uncover impact of RECs in reducing financial loss of distribution center of NEA. Thus, a new area of study may be arrived at. Since many underdeveloped and developing countries are facing similar situation, this study might be useful for researchers, policy makers, and government officials.

Objectives of the Study

The major objective of this study is to establish causal relationship between number of REC and financial loss of each distribution center of NEA. Under this study REC is the cause and financial loss reduction is the effect. The minor objective of the study is to examine the relationship between the financial loss and the control variables of the study.

Organization of the Study

This research is organized in five chapters.

Chapter one includes background, objective of the study, statement of problem and significance of the study. Chapter two includes the literature review on community based management, rural electrification and financial loss. It also incorporates related theories, the findings of the previous researcher and different perspectives proposed by various scholars.

Chapter three presents details of the research methodology. It includes detailed description of research design, secondary data, sample and instruments for REC. Chapter four deals with the result and findings obtained from the data analysis of the study. Chapter five provides summary of the findings and discussions, implication of the research and limitations of the study. A reference list and appendices have been kept at the end of this dissertation.

CHAPTER II

LITERATURE REVIEW

This chapter focuses on the theoretical concepts, empirical review and theoretical framework. The chapter begins with key concepts that are used in this study. It examines various concepts and theories that have been put forward in literature, and then moves to empirical literature. At the end of this chapter, theoretical framework is presented in which research idea is organized for achieving research objective.

Conceptual Review

Rural Electrification

During the 1930s United States of America was suffering from Great Depression. So President Franklin Delano Roosevelt saw the solution of this hardship as an opportunity to create new jobs, stimulate manufacturing and begin to pull the nation out of the despair and hopelessness (Engineering, 2016). On May 11, 1935, he signed an executive order establishing the Rural Electrification Administration (REA). Under this, REA would provide loans and other assistance so that rural cooperatives could build and run their own electrical distribution system. This program became the most successful venture of the government and within two years 1.5 million farms were electrified through 350 rural cooperatives in 45 of the 48 states (Engineering, 2016). Therefore, almost half of all farms were wired by 1942. By 1953, more than 90 % of the USA's farms had electricity (as cited by NRECA 2009 in Yadoo & Cruikshank, 2010). According to NRCEA, today there are 930 rural electric cooperatives which serve 42 million households in 47 states and own assets

worth US$ 12 billion and also employed 70,000 people (NRCEA, 2016). Thus, after successful implementation of this program, it was widely used in different countries of the world who wanted to accelerate the pace of electrification in rural areas.

Rural electrification is the process of providing electrical power to rural areas. In the rural areas electric power can not only be used for lighting but also for mechanizing farming operation such as reaping and hoisting grain, threshing, milking, refrigeration etc. Therefore, rural electrification has both social and economic benefits.

Mainali (2011) mentioned in his thesis that "the Government of Nepal considers the provision of electric light as electrification and, accordingly, policies to promote electrification focus on access to light at household level, despite of the multiple use of electricity". He also compared definition of electrification with Indian government in 2004 where the focus is on the community. According to him, " A village is only considered electrified if it has basic infrastructure such as transmission and distribution; if public institutions such as schools, health centers, and community centers are electrified; and at least 10% of households in the community are connected ". The positive impacts of electricity inputs in rural areas are basic activities such as lightning, powering small scale enterprise, agriculture modernization etc. According to Lahimer, Alghoul, Yousif, Razykov, Amin and Sopian (2013) benefits of rural electrification include poverty reduction, health improvement, securing environmental sustainability, education improvement and migration mitigation. Hence, rural electrification is directly or indirectly liked with rural development.

Community Based Management

According to Senyk (2005), Community-based management can be considered holistic and integrative because it is generally designed with multiple objectives, dealing with the numerous problems which the community in question may be facing and often adapting and changing over time. Under this community form a group for solving various problems that is encountered in daily lives. NGO, INGO and GoN also allocate budget and different kind of program for supporting community based program.

Financial Loss

Electricity system loss determines the efficiency and financial sustainability of the power sector. It is the difference between the amount of electricity generated and the amount that is delivered to end users. These losses also include the electricity that is used in generation, distribution and transmission and the electricity delivered but not billed which directly translates into financial losses. (Refer to Appendix 1 for the electric power and distribution losses percentage of Nepal for 42 year) However, lower electricity losses lead to increase in revenue, decrease in electricity tariffs for consumers and reduction in load shedding Nepal.

Figure 1 shows comparative rank of four countries China, India, Bangladesh and Nepal. In 2014, Nepal is in the bottom seven out of 186 countries in terms of system loss. It is ranked at 191 out of 219 countries in terms of electricity consumption per capita and has the highest system loss 31.49 % among four countries.

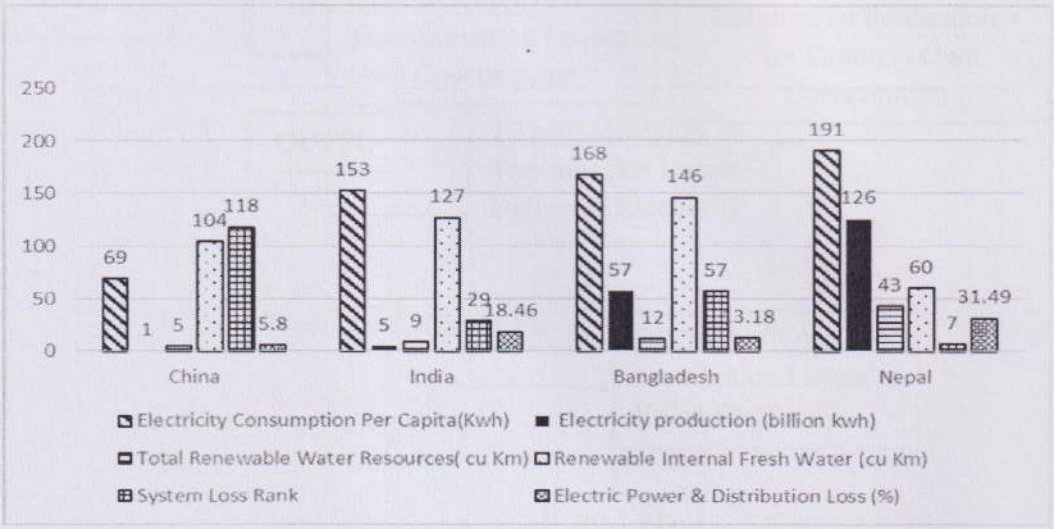


Figure 1. China, India, Bangladesh and Nepal Ranking
Source: IEA Statistics, 2014

Figure 2 and Figure 3 give the pictorial representation of losses in electricity flow and types of these losses. These figures are taken from the document "Power Lost" which was prepared by energy division (Jiménez, 2014). These show where the losses occur in electricity and types of electricity loss. In Figure 2, it shows that the input enters into the production process and leads to generation. Then output from generation is transmitted and delivered to customers. Then depending upon the units used residential and commercial customers is billed. In the process of input, output and delivery there are transformation, transmission and distribution losses.

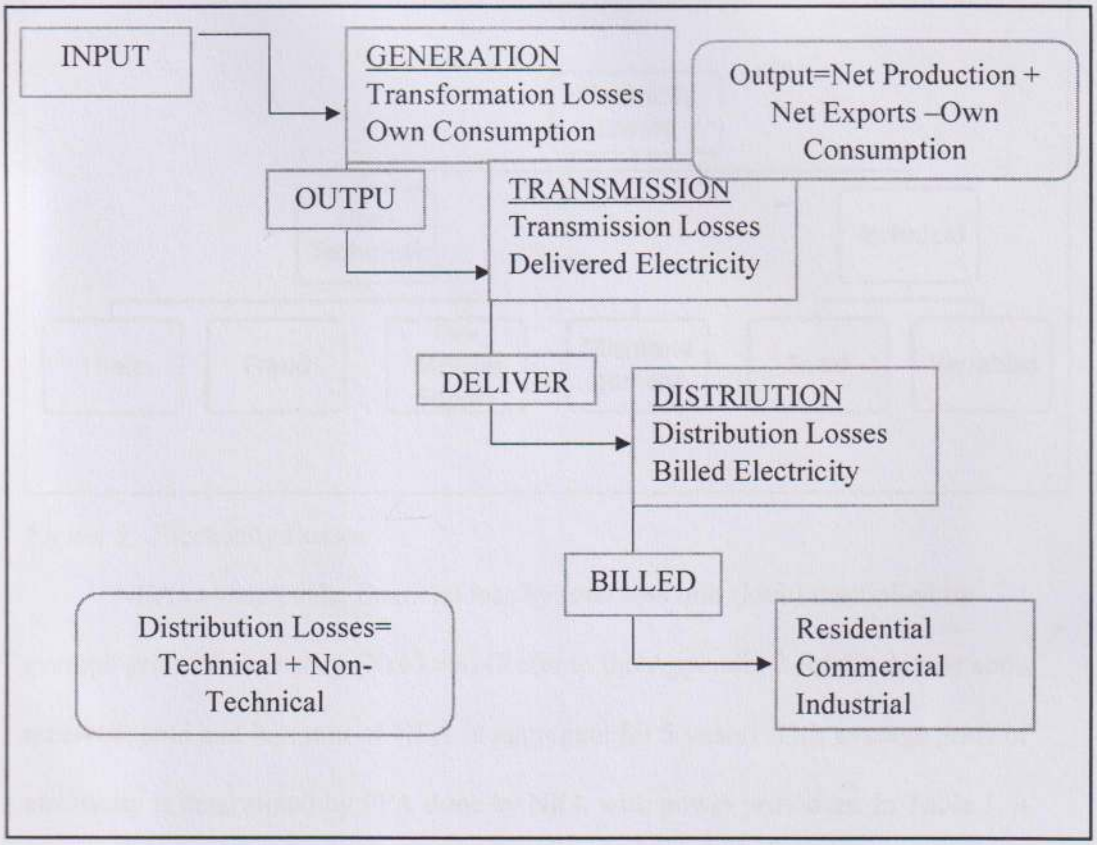


Figure 2. Losses in Electricity Flow
Source: Power Lost, 2014

According to NEA official, "System loss is the difference between received and sold unit of energy". Technical losses occur naturally due to electricity system components such as transmission and distribution lines, transformers, etc. Non-technical losses are caused by external action such as theft, non-payment of customers, errors in recording of the units used etc. These technical and non-technical losses are some of the components of financial loss of NEA. Furthermore, technical losses can be divided into fixed and variable technical losses. Fixed technical losses are caused by physical inefficiencies such as hysteresis but variable technical losses happen when power current flows through the lines, cables and transformers of the network (Jiménez, 2014).

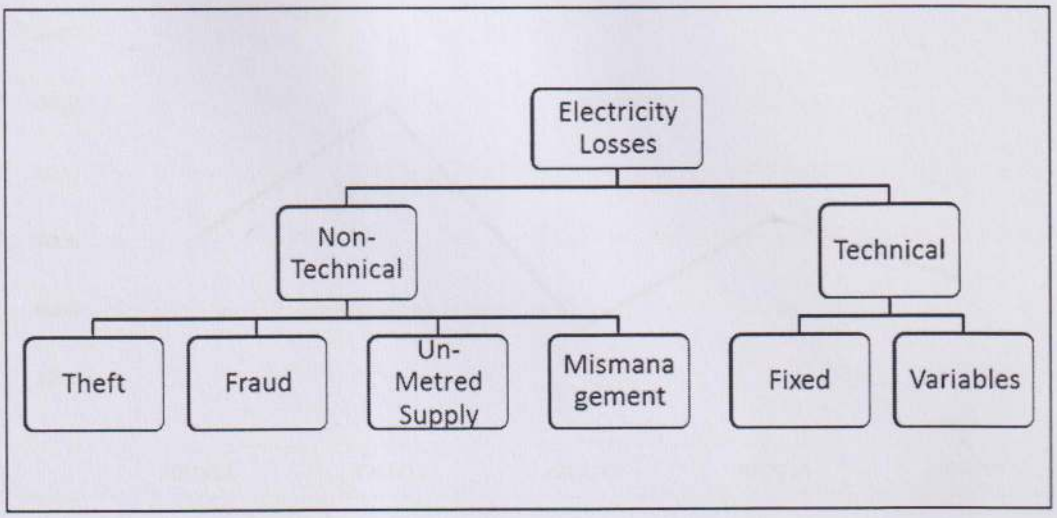


Figure 3. Electricity Losses

NEA calculates the financial loss by total loss unit (kwh) multiplied by average price of electricity (Nrs/kwh) (Refer to the Appendix 2 for the details about received, sold and loss unit of NEA in aggregate for 5 years) .This average price of electricity is determined by PPA done by NEA with power providers. In Table 1, it shows the average power purchase rate of NEA (Nrs/Kwh) for the fiscal year 2010 to 2015. These prices are in increasing rate which means NEA has to pay more for the purchase of electricity.

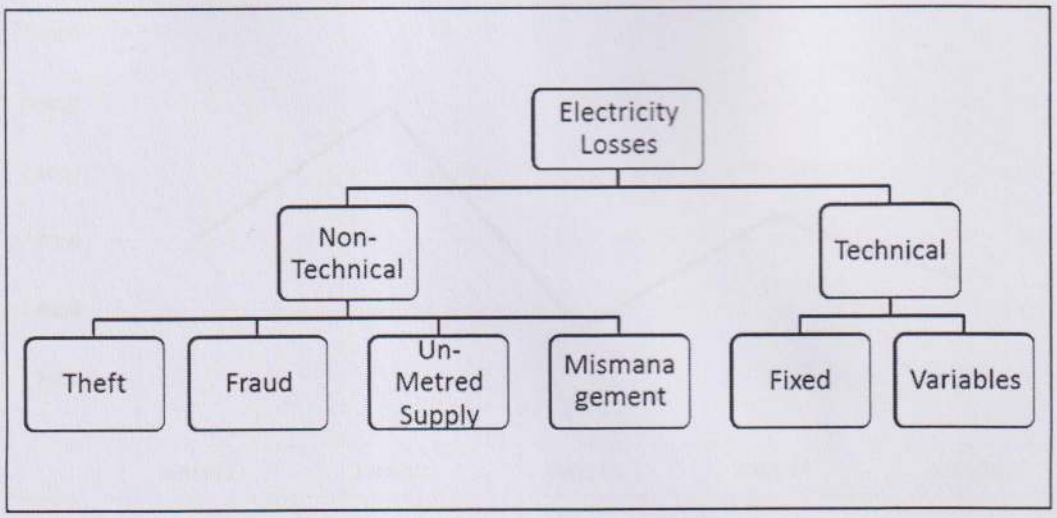
Table 1

Average Power Purchase Rate of NEA

Fiscal Year	Average Power Purchase Rate (Nrs/Kwh)
010/11	6.06
2011/12	6.90
2012/13	6.90
2013/14	7.03
2014/15	7.28

Source: NEA Annual Report, 2011,2012,2013,2014, & 2015

Figure 4 shows net loss of NEA for five years in million Nrs. Among 5 years, the highest loss was in the fiscal year 2011/12. Although it can been seen in declining trend but it is still high compared to other countries of the world as shown in Table 2.



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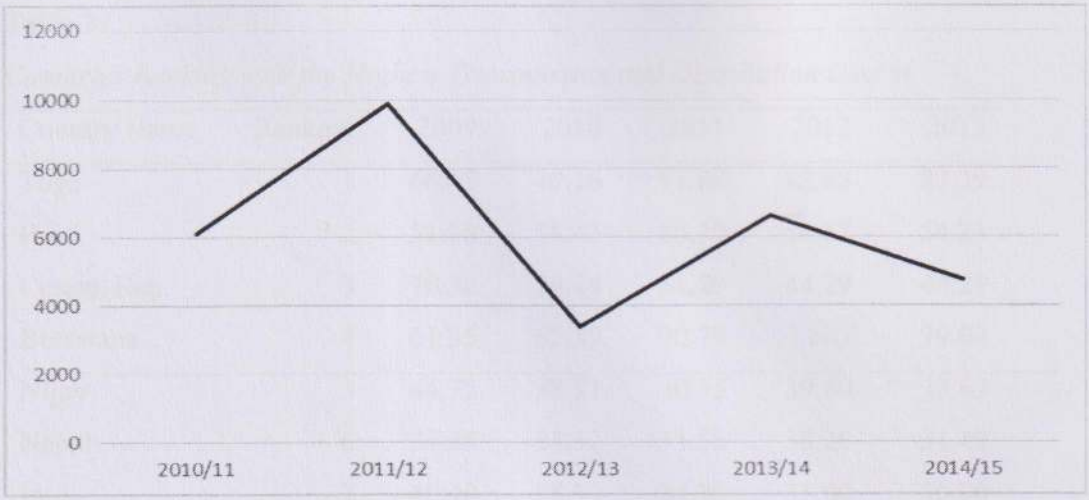

Figure 4. Net Loss of NEA for 5 Years
Source: NEA Annual Report 2011, 2012, 2013, 2014, & 2015

Table 2 shows the countries ranking with the highest transmission and distribution loss. Togo has the highest transmission and distribution loss of 87.39 % whereas Nepal is ranked 6th out of 264 countries. The table below has only taken the countries with the highest transmission and distribution loss in percentage.

Table 2

Countries Ranking with the Highest Transmission and Distribution Loss %

Country Name	Ranking	2009	2010	2011	2012	2013
Togo	1	66.45	49.16	71.88	82.88	87.39
Haiti	2	51.18	58.43	66.49	54.62	54.21
Congo, Rep.	3	70.32	59.44	51.89	44.29	44.29
Botswana	4	61.35	62.59	90.79	NG	39.04
Niger	5	44.75	38.91	40.35	39.60	33.63
Nepal	6	34.45	34.32	31.56	30.26	31.49
Iraq	7	40.40	38.99	34.76	35.00	30.00
Zimbabwe	8	16.92	19.32	14.94	16.32	28.12
Cambodia	9	14.17	28.77	28.11	18.27	28.07
Albania	10	23.56	12.64	25.13	23.68	27.99
Namibia	11	17.11	25.21	25.17	25.93	27.72
Myanmar	12	28.30	16.61	20.23	25.26	26.71
Jamaica	13	22.31	20.88	22.01	24.84	26.40
Yemen, Rep.	14	24.28	23.91	25.63	32.94	25.76
Moldova	15	23.48	23.56	21.05	21.66	25.23

Note. NG= Not Given

Source: IEA Statistics, 2014

Community Rural Electrification Program (CREP)

CREP is the grid extension program in the remote areas of Nepal. In the very beginning of this program, this was initiated by NEA as a pilot project. But this program was launched in the fiscal year 2003/2004 to increase the grid connection electrification in the remote areas. It was 20 % funded by community and 80 % funded by the government of Nepal. Since grid-extension to the remote areas is not commercially viable, NEA board of directors passed by-law in the same year, stipulating the model for CREP.

Current Situation of CREP in Nepal

According to the World Factbook 2015, Nepal is ranked 43nd richest country in water resources out of 172 countries of the world. However, the country still faces higher load shedding which ranges from 12 to 15 hours a day, with 585 MW load shedding per year. The data published in Trading Economics in 2014 show Nepal has rural population of 81.8 %. Therefore, the community based rural electrification has a wider scope. This program has been implemented in 55 district thorough 437 number of different communities entities. The main objective of CREP is to empower local people, rural electrification, alleviate poverty and system loss reduction.

In 2013, the cost of funding this program was revised, 90% of the rural electrification cost through NEA and 10 % of the cost of Rural Electric Community (REC). The revised cost was due to the increase in the involvement of community in the electrification program. Before 2013, any company can formulate and get into CREP but now there is more stringent policy and only the community can get into this program. Currently, Asian Development Bank (ADB) is interested to fund 5% of the cost paid by community.

The process of getting into this program is first the community should feel the need and forward the request to open REC in their respective district. The respective district then forwards an application to NEA and NEA forms a steering committee which makes estimation about the necessary for the funding of electrification. Finally, NEA approves the program and asks in writing for the 10% deposit from respective REC. After community makes the deposit, NEA calls tender and gives the fund for grid extension, transmission line, putting meter and transformer etc. In addition to this, NEA has appointed National Association of Community Electricity Users Nepal (NACEUN) which gives training to the REC members. There is a bulk meter installed

in the rural area and the co-operative has to make aggregate deposit of energy consumed by their community. The REC is given subsidized price for the unit of electricity sold by NEA. Then the REC sell the electricity to its community and the unit price applied to the community is 50 paisa lower than the prevailing rate of a unit of energy in urban areas. Thus, the REC can make profit from the sale of electricity to its community.

REC are formed not only to facilitate the process of electrification of the community but also to they work for the benefit of the community by financing factories, poultry farming, agricultural activities, husbandry, establishing cottage industry etc. Besides NEA, International and National Non-governmental Organization (INGO and NGO) also help REC. In the journey of 11 years, CREP has achieved a major success. It has provided electricity to more than 45,000 households of 55 districts through 480 different community entities (NEA, 2015). There has been a rapid increase in REC number from 2009 to 2013. But now the increase of REC has slowed down due to decreasing government funding. In 2015, Attariya distribution center has the highest number of REC (242) and Hetauda has the lowest number of REC (11). Figure 5 gives yearly statistics of number of REC from 2009 to 2015. According to the figure, in 2009 there were 250 RECs. There was a sharp increase to 400 RECs approximately in 2012. But in the later years the growth in the number of RECs was slow reaching approximately 450 in 2015.

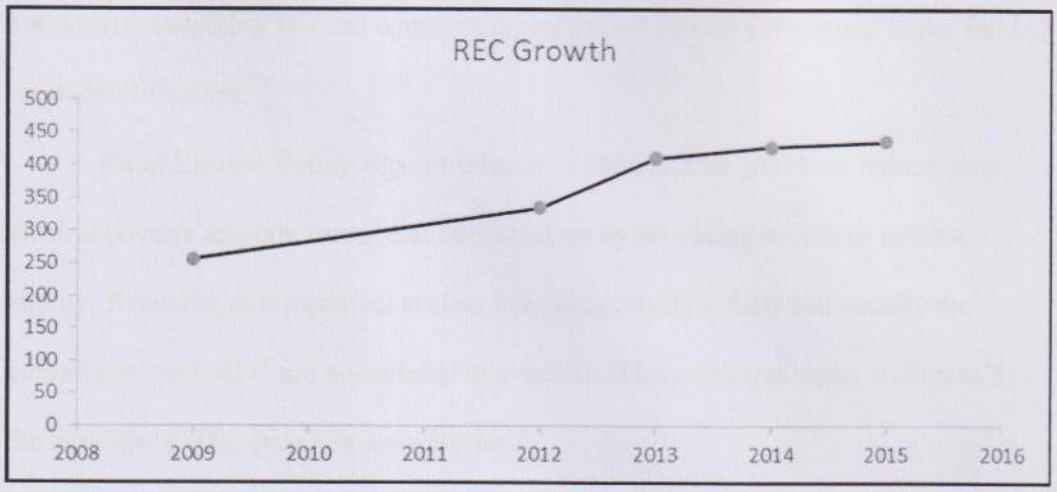

Figure 5. REC Yearly Statistics

The REC program has been executed by NEA through CRED. In 2010, CRED was dissolved as the process of restructuring NEA and its activities was carried out through regional offices. But later in July 2013, the CRED was formed again. This dissolution of CRED and lack of funding might be the result of slow growth in the number of REC from 2013 to 2015. The major activities of CRED involves addressing the problems experienced in community rural electrification program and operational activities, to strengthen the operating capacity of RECs, training for linemen and accountant, to bring uniformity in cost estimation of rural electrification work, extension of existing 11/0.4-0.23 kv distribution network and transformer upgrading etc. Hence, this program is very effective in the context of Nepal because within 2 or 3 years whole community gets electrified.

Rural Electrification Policy in Nepal and benefits of REC program

Community Electricity Distribution by Laws, 2060 (2003) promotes public participation in increasing effectiveness in the present distribution arrangement by reducing theft, conducting maintenance, protection and promotion of electricity distribution system (Adhikari et al., 2014). The objective of this law is to promote public participation, encourage community management, promote technical and

managerial capability of rural community and attract private investment in the field of rural electrification.

Rural Electric Policy was introduced in 2006 and its goal is to reduce rural electric poverty and environmental conservation by providing access to reliable energy. Reducing non-technical system loss by controlling theft and usually the community with REC are considered non-technical loss risk free zone. In Figure 5, the benefits of REC program are presented.

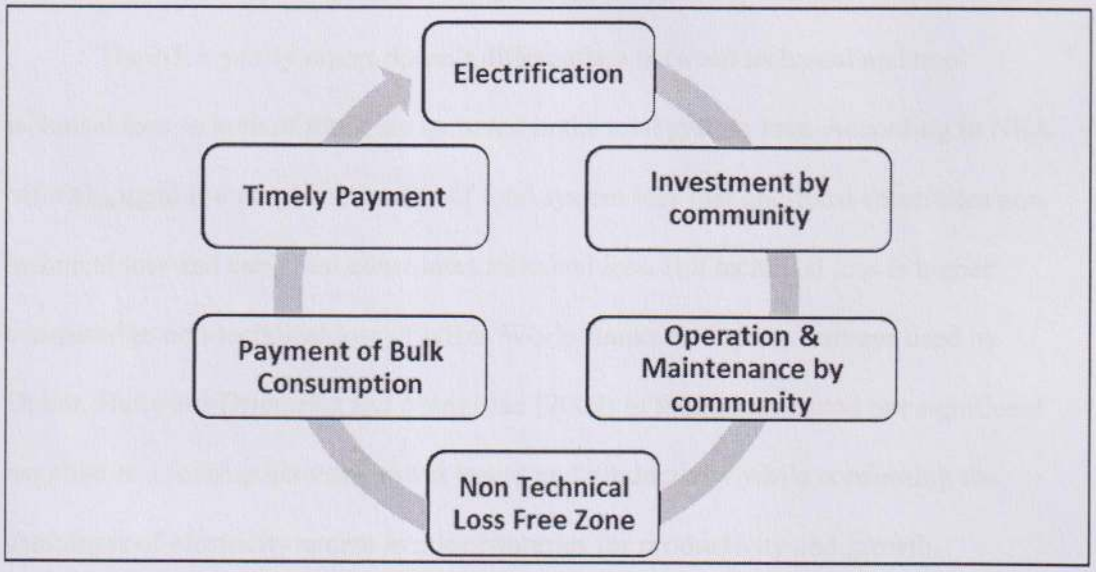

Figure 6. Benefits of REC Program in Nepal

Rural Electric Community

To apply for subsidy the community has to form a legal entity by registering as cooperative. According to NACEUN, there are 249 Community Rural Electric Entities (CREE) from 49 districts of Nepal. They help community to submit an application for getting into this program and also conduct awareness program. The government subsidy for this program is used for tender and construction of poles, transformers, grid etc. The last stage of metering device is borne by individual household. These meters are sold by NEA with after sales service. Once a month meter is read by CREE and NEA staff. CREE has to bear all the management, repair

and maintenance cost. So for becoming financially viable CREE has to have minimum of 200 households under it.

Developing countries all over the world are experiencing lower electrification rate and higher system loss. Kenny and Soreide (2008) mentioned in their study that "in the year 2000, roughly a fourth of all electricity produced in low-income countries was lost during transmission and distribution on average" (as cited in Pless, Bazilian & Fell, 2014). Although there has been an effort to reduce system loss but there is high economic, social and political risk (Smith, 2004).

The NEA yearly report doesn't differentiate between technical and non-technical loss so both of these are included in the total system loss. According to NEA officials, there is a rough estimation of total system loss that one-third constitutes non-technical loss and two-third constitutes technical loss. But technical loss is higher compared to non-technical loss of NEA. World Banks Enterprise Surveys used by Dollar, Hallward-Driemeier and Mengistae (2003) in their study found out significant negative relationship between power losses and productivity while confirming the usefulness of electricity access in poor countries for productivity and growth.

Venkatappaih (1971) preliminary study indicates that RECs have initiated different measure to reduce line losses. Along with the system improvement these measures include strengthening of the transmission system, incorporation of devices for correcting the factor, and the augmentation of interconnections. According to him," these not only help step up the technical efficiency of the systems, but also improve its economic outputs in terms of electrical energy and rural production". Therefore, RECs have to be actively involved in different activities for controlling system loss.

Proposed REC Electric Models for Nepal

According to Adhikari et.al (2014), the concept of REC in Nepal's rural electrification is suggested to be implemented and completed in three phases. They are as follows:

Phase I: Selling bulk power to registered cooperatives. NEA reserves the right of generation, transmission and distribution to itself but only sells it to registered REC at subsidized rate. RECs, in turn, provide membership to its villagers, and receive electricity in the discount rate than the direct customers. All the major work of maintenance is done by NEA.

In this phase, since the co-operatives lack the experience, they are devoid of looking into distribution network for which they need extensive training and technical knowledge. NEA treats these co-operatives as their bulk consumers. New service connection, metering, billing customers and revenue collection are the part of RECs job. Apart from these activities, along with the villagers these co-operatives are active in eliminating direct hooking and other types of electricity theft. As a result system loss is expected to reduce within their communities.

Phase II: Handling over LT lines and distribution system along with bulk power sale. For handling LT lines and distribution system, the RECs need huge money so it might require funding from NEA and other donors. This model allows them to sell electric power purchased only from NEA and to perform necessary works of maintenance regarding lines and transformers. The GoN provides funds for trainings of their employees and also nominate its representative for these co-operatives.

Phase III: Offering greater autonomy to electric co-operatives. Under this, RECs will be assigned the franchises of construction of new distribution line or

extension of existing one with prior approval from the concerned authority, maintenance of the electric network within their areas, purchase of grid power from the NEA or off-grid power directly from Independent Power Producer (IPP) and generate small scale electricity.

Bangladesh and Nepal Rural Electrification Program

Rural Electrification program in Bangladesh started in 1978. The government of Bangladesh established the Rural Electrification Board (REB) to carry out rural electrification programs (IC Net, 2009). In the beginning phase, it got technical assistance from National Rural Electric Cooperative Association (NRECA) United States of America with an objective of providing electricity in the rural areas. This program was based on the concept of member owned, *Palli Bidyut Samities* (PBS) similar to rural electric cooperatives. Initially, this REC program aimed at providing electrification to irrigation pumps, tube-wells, agro-based industries and serving domestic and commercial loads (Barkat et al., 2002). There are altogether eighty PBS till date in Bangladesh and these PBSes provide electricity for all purpose to enhance the living condition of rural people (BREB, 2016). Since 1978 there has been more than thousand fold increase in terms of number of services connected and also has realized an annual average electrification growth rate of 40% in Bangladesh (Barkat et al., 2002).

Bangladesh and Nepal have many similarities as both are South Asian developing countries. Although Bangladesh became independent in 1971 from Pakistan, it was able to increase electrification almost by 50 percent within a span of 41 years. Figure 7 shows that in 1971 electric power consumption of Bangladesh was 10.69 and Nepal was 6.05 Kwh per capita consumption. However, in 2013 for Bangladesh electricity per capita increase to 293.02 and for Nepal increased only to

128.15 Kwh per capita consumption. For Bangladesh there was huge increase but for Nepal it was comparatively lower. In 2012, Bangladesh was ranked 53 whereas Nepal was ranked 113 in 2011 electricity power consumption based on the world Factbook.

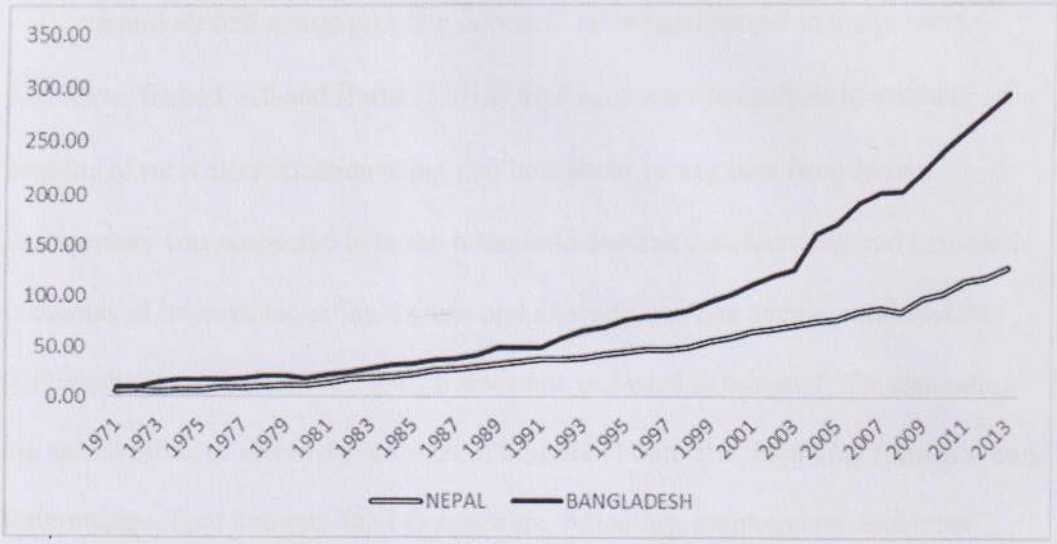

Figure 7. Electric Power Consumption (Kwh Per Capita) for 42 Years
Source: Factbook, 2015

According to Barnes (2005), one of the challenges for rural electrification in Bangladesh is that it is one of the world's poorest and densely populated countries with an estimated total population of nearly 130 million people. In Bangladesh, electricity in rural areas is used widely for pumping water in regions that have access to service and agriculture. When this program was started only 10 % households of the country land had access to electricity and 80 % lived in the rural areas. But looking at the data of World Bank 2012, 59.6 % of its population has access to electricity. It can be inferred from this data that rural electrification program has been successful. Japan has been supporting such rural electrification programs of Bangladesh through ODA loan projects including the Rural Electrification Project (Phase IV-C) and the Distribution Network Expansion and Efficiency Improvement Project (IC Net, 2009). *Palli Bidyut Samity* (PBS) of Bangladesh is similar to Rural Electric Community (REC) of Nepal. They promote the electrification of rural areas

by establishing and refurbishing the distribution network and also constructing substations in Khulna and Jhalakati located in southern part of Bangladesh

Empirical Review of Previous Studies

Rural electrification program is beneficial to rural people in many ways. Khandker, Samad, Ali and Barnes (2012) used econometric analysis to estimate benefits of rural electrification using rich household survey data from India. Endogeneity was suspected between household demand for electricity and household outcomes of interest, including income and expenditure. The instrumental variable (IV) method in a fixed effects (FE) framework was used in this study for estimating the causal effect of electricity on a set of household outcome, including farm and non-farm income, food and non-food expenditure, schooling, employment, and other indicators of household welfare. This study also performed some robustness checks like Endogeneity test, Hansen J test for over identification restriction and Kleibergen-Paap LM test for under identification and weak instrument. The result of the study showed that rural electrification helps in reducing time spent in collecting fuel woods and poverty. Similarly, it helped in increasing time to study for boys and girls and also increasing household per capita income and expenditure. However, the largest benefits to the wealthier rural households because they can use electricity for wider purpose than poorer ones who have limited use of electricity.

Haanyika (2006) pointed out the problem that rural electrification in developing countries are facing problem due to inadequate policies, weak institutional frameworks and limited financing. Even though governments in developing countries have been making efforts and coming up with market based reform, there is a need to establish a measure to evaluate the extent to which these reforms have increased access and affordability of electricity in rural areas. Similarly, the government should

also develop appropriate policy and structure to align rural electrification with reformed power sectors. According to Haanyika (2006), "It is cardinal to establish how privatized and commercialized power companies in a reformed power sector could contribute to rural electrification and the role of governments and government agents in facilitating expanded access to electricity in rural areas". In the context of Nepal, NEA is the sole power buyer but currently it's been on discussion to unbundle the company in three separate entities which will be in the form of grid, power purchase and distribution company.

Barnes and Binswanger (1986) empirically examined "what agricultural impact electricity and other infrastructure improvements have had on 108 villages in three states of India". They used Ordinary Regression (OLS) and Principal Components (PC) regression with fixed village characteristics and cross sectional data. In the PC and OLS regression, they used village demographics such as the level of literacy, years since rural electrification, population, number of diesel engines and the number of electric pump sets as independent variables to analyze the impact of rural electrification on agriculture. They concluded in their study that rural electrification had a direct impact on agricultural productivity through private investment in electric pumps but farmers also have to make substantial investment in diesel pumps.

In the study conducted by Bautista and Valderrama (2012), the efficiency analysis of 118 Electric Cooperative (EC) was done in remote areas of Philippines using Data Envelopment Analysis (DEA). The average financial and operating data from 2001 to 2006 were taken for computing the efficiency scores and Malmquist Index. The variables used under empirical analysis were sales volume, number of customers or connections, peak demand, customer structure, length of distribution

line, number of employees, transformer capacity, supply and metering cost, operation and maintenance cost, administration cost, sales density, customer density and system loss. The study showed the efficiency of ECs rise with size but levels of efficiency are inversely related to system losses. In addition to these findings, the study also concluded that structural and operational factors significantly affect the efficiency of grid-connected EC. These structural and operational factors were sales and customer density, customer structure, size, system loss and number of customers per employee. However, these ECs were inefficient in non-technical component of their distribution which included distribution cost in relation to their line operation and maintenance cost.

Many studies have linked rural electrification to rural development. Kirubi et al. (2008) study claimed that community based electric micro-grid can contribute to rural development. This study was done in rural Kenya where access to electricity enabled small and micro enterprises (SMEs) the use of electric equipment and tools. As a result there was significant improvement in the productivity and income levels of the workers. This study used both quantitative and qualitative data for establishing the fact that rural electrification leads to rural development. The primary data were collected through a combination of surveys of SMEs, interviews with key informants and direct observation of electricity uses. The secondary data were collected about electricity users, units generated and sold, systems losses and income and expenditure. This study concluded that access to electricity along with infrastructures such as markets, roads and communications, can have significant impact on productivity in rural livelihoods of small and micro-enterprise (SMEs) and agriculture. Another study conducted by Chaurey, Ranganathan and Mohanty (2004) pointed out positive

contribution of electricity to Human Development Index, reflecting that the poorest are most likely to benefit from even minimal electricity inputs.

Ranganathan (2005) in his study addressed that one of the key component of power sector reforms is reducing transmission and distribution losses. He also mentioned that "non-technical loss is likely to occur more at the distribution level than the transmission level, and a high transmission loss figure gives an impression to the regulator that most of the high losses are of a technical nature. Transmission and Distribution losses are divided into three parts- technical losses, theft from unofficial meters and theft by hooking or making the meter run slow by using a magnet. The method used in the study was a case study among different state of India. It outlined the problems in measurement of system losses and information asymmetry between the regulator and license on this account and concluded with the broader issue of distribution privatization and prerequisite for it.

In the developing countries, there is high system loss but these system losses constitute both technical and non-technical loss. According to World Bank paper (2009)

> Technical losses occur naturally and consist mainly of power dissipation in electricity system components such as transmission and distribution lines, transformers, and measurement systems and non-technical losses are caused by actions external to the power system and consist primarily of electricity theft, non-payment by customers, and errors in accounting and record-keeping (p. 5).

Electricity theft is non-technical loss which is quite evident in the rural areas. The causes of electricity theft are meter tampering, illegal connection, billing irregularities and unpaid bills. The study took sample of 102 countries from 1980 to

2000. The empirical findings of this study suggested that electricity theft is closely related to governance indicators, political instability, high corruption, low accountability and low government effectiveness.

According to Reciche, Covarrubias and Martinot (2000), lack of access to energy in rural areas is of same order of magnitude as lack of access to other types of infrastructures. This means that when there is lack of energy then the people are also devoid of other facilities like road, modern telecommunication, clean water, schools, health services etc. In the World Bank policy research working paper of Transport Infrastructure and Welfare, this paper proposed an approach to analyze differential development impacts of alternative road construction using a case study of Nigeria. But the measure of road transport was considered potentially endogenous because road infrastructure is nonrandom. "Road construction costs are a function of segment length, and land topography, the natural path route is therefore highly correlated with the most cost effective place to construct a road network, if economic benefits were ignored" (Ali, Barra, Berg, Damania, Nash & Russ, 2015). In this paper the author used natural path and topography of the land has been used as IV between the origin (household) and the destination (markets). The findings of the study suggested that reduction of the transportation cost in Nigeria will increase crop revenue, non-agriculture income, the wealth index and local GDP. Finally, the author also suggested that by analyzing small segments of each road separately, infrastructure projects can be further prioritized by comparing the expected development impacts.

In Nepal, mostly REC are established in the areas where roads are not well developed and there is no grid for electricity distribution. Lahimer, Alghoul, Yousif, Razykov, Amin and Sopian (2013) mentioned that connection to the mainland national power is impossible when the transportation cost is expensive and when road

and other infrastructures are insufficient such as for small, scattered, and isolated islands or forests, hill areas, and deserts. The authors gave an example of Bhutan which exports 75% of its total generation to India but 75% of its population do not have access to electricity due to its geography. So for rural electrification process, road and topography play a very important role.

Theoretical Framework

The conceptual, literature and emprical review have helped in developing theoretical framework for the study. The variables considered for the study are number of REC, financial loss, employees expenses, distribution line expenses, equipment repair expenses, meter expenses, transmissin line expenses, per capital income, GDP at market price, literacy rate, capital expenditure, HPI and total repair and maintenance.

Figure 8 is the diagrammatic representation of study. In this figure, it can been seen that the financial loss is the dependent variable and number of REC is the explanatory variable along with other control variables. The central interest of this study is to establish causal relationship between financial loss and number of REC. There should be negative relationship between number of RECs and financial loss because one of the benefits of having RECs in rural areas is reducing financial loss. This REC keeps an eye on theft and leakage of electricity by taking different measures to control theft and doing quick repair and maintenance. However, there is reverse causality between financial loss and number of REC. This means when number of REC establishment increases then it helps to reduce financial loss so this leads to omitted variable bias. Since the variable REC is endogenous, road length and number of co-cooperatives in each district of Nepal are considered as instrumental variables.

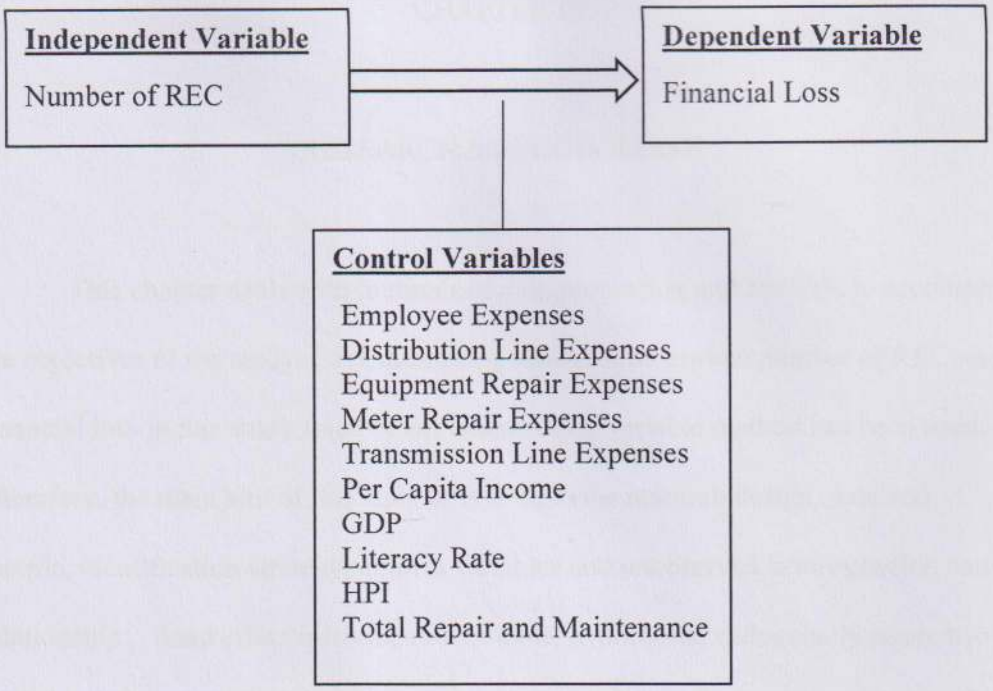

Figure 8. Conceptual framework of the study

CHAPTER III

RESEARCH METHODOLOGY

This chapter deals with methods of data processing and analysis to accomplish the objectives of the study. For establishing causal link between number of REC and financial loss in this study fixed effect instrumental variable method has been used. Therefore, the main aim of this chapter is to describe research design, data and sample, identification strategy, control variables and unobserved heterogeneity, causal relationship , fixed effect instrumental variable, hypothesis, endogeneity issue, two stage least square method and robustness checks of this study.

Research Design

Bautista and Valderrama (2012) have used DEA and Malmquist index for measuring technical efficiency of ECs. But for impact study of rural electrification and infrastructure on agriculture Barnes and Binswanger (1986) used OLS and Principal Component Regressions. It is a quantitative based analysis using regression which allows causal link study. However, for the policy analysis Difference-in-difference (DID) estimate is used by different researchers in their study. But in this study DID can't be used since data is not available for differential effect on a treatment and control group.

Instrumental Variable method in fixed effect framework is used to obtain unbiased estimates of the impact of rural electrification. This study also analyzed whether individual distribution center's repair and maintenance expenses, PCI, GDP at market price, HPI capital expenditure, literacy rates and salary of employees of distribution center helped in reducing financial loss.

Data and Sample Selection

The panel data from fiscal year 2010/11 to 2014/15 has been used for this study. The fiscal year in Nepal starts from the month of Shrawan (around 15th July) of each year and ends in the month of Asadh (mid July). The sample is drawn based on the availability of data from NEA. The numbers of RECs are taken from soft copy provided by NEA officials but NEA doesn't have the systematic record of establishment and operation of each of REC in their regional offices. An additional data of REC was collected from the Department of Cooperatives (DOC) of Nepal. Each year NEA allocates budget and monitors the expenses of distribution center. The data from annual budget of NEA has been used to collect each distribution center expenses in the form of transmission, distribution, meter, equipment repair, staff salaries and capital expenditure. The distribution center literacy rates, PCI and GDP at market price have been taken from the website of Central Bureau of Statistics (CBS) of Nepal.

In Table 3, it can be seen there are 8 regional offices of NEA, 99 distribution centers and number of REC for respective years (Refer to Appendix 3,4 and 5 for more details about current situation, the sample and REC for regional offices and distribution center). But for this study, sample of 78 distribution centers have been used. The data is also segregated between the distribution center with and without RECs. In the sample there were 21 distribution centers that didn't have any RECs in their location. The distribution centers are very heterogeneous because the number of RECs under them varies and so does the size of customers they serve. There were missing data on the record of NEA about each distribution center. Hence, extrapolation was done for some data where it was possible.

Table 3

Sample of REC and Non-REC for the Year 2008 to 2015

Regional Office	Total Distribution Center	Sample	Distribution Center with REC	Distribution Center without REC
Kathmandu	19	17	13	4
Janakpur	12	10	7	3
Biratnagar	15	12	8	4
Hetauda	9	8	7	1
Pokhara	11	7	6	1
Butwal	10	9	6	3
Nepalgunj	14	10	5	5
Attariya	9	5	5	0
Total	99	78	57	21

Identification Strategy

Under this study, region year effects have been considered by taking 8 regional offices of NEA and 5 year data. So OLS estimates with region year effects on financial loss are unlikely to be consistent because the distribution center located at rural areas will have more number of REC and also the urban areas will be able to control financial loss. The identification strategy lies on region year differences in number of REC in reducing financial loss of distribution center.

Control Variables and Unobserved Heterogeneity

A control variable is the variable that is not changed or held constant throughout an experiment. These variables are the factors that influence the outcome, but often are not the variable of interest. If these variables are not controlled then it may distort our causal inference of dependent and independent variables. However, it helps in establishing causal inference between our variable of interest. Controlling this variable is widely known in economics as *ceteris paribus.*

In Fixed Effect Instrumental Variable setting controls for region and year level heterogeneity by introducing region year dummies. There is a distribution center level control that takes good care of distribution center heterogeneity. The study follows Burgess and Pande (2003) to address this heterogeneity. Hence, region year dummies have provided efficient and unbiased control for the effects of regional level heterogeneity.

Causal Relationship

A correlation between variables doesn't mean that the change in one variable is the cause of change in the values of the other variables. Whereas causation indicates that one event is the result of the occurrence of other event, this means that there is causal relationship between the two events. Therefore, correlation and causation are two different terms.

According to the economist Heckman (2000), what distinguishes econometrics from statistics is that econometrics focuses on establishing causation, while statistics is content with correlation. "Most econometric theory adapts methods originally developed in statistics. The major exception to this rule is the econometric analysis of the identification problem and the companion analyses of structural equations, causality, and economic policy evaluation" (Heckman 2000, p. 45, emphasis added.). The major contributions of twentieth century econometrics to knowledge were the definition of causal parameters . . . the analysis of what is required to recover causal parameters from data . . . and clarification of the role of causal parameters in policy evaluation . . . (Heckman 2000, p. 45, abstract, emphasis added.).

The causal relationship between number of REC and financial loss can be defined as the functional relationship that describes what percentage of financial loss a given distribution center would reduce if it would have different number of REC.

Fixed Effect Instrumental Variable

Fixed Effect (FE) model represents the observed quantities in terms of explanatory variables in which observed quantities are non-random. This model helps in controlling for unobserved heterogeneity which is constant over time. Likewise for each distribution center there is an individual specific effect which is constant over time. One of the assumptions of FE is that an individual specific effect is correlated with the independent variables. As noted above that the placement of RECs are endogenous. The identification method under endogeneity is to use fixed effect instrumental variable for endogenous variable. The main model for this study is

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \lambda REC_{it} + \mu_{it} \ldots \text{(i)}$$

where, Ω is region year dummy for each distribution center which includes region and year effects respectively. FL_{it} is financial loss of distribution center i time t with their regional office at time t with i=1...N; t=1…5 and μ_{it} is usual iid (Independent and Identically Distributed) normal error term. There are 8 Regional offices, 78 distribution center and 5 year data. Financial loss is dependent variable, REC is explanatory variable and others are control variables of this study. X variables includes all control variables that are listed in Table 4. Over the period, RECs have increased in the distribution center so β_2 coefficient increases with the time. The variables, abbreviations and its measurement for this study are presented in Table 4.

The region year dummies allow us to control for time- invariant characteristics that affect the number of REC in the region. NEA has divided the country into eight regions. However, regions are very important because there is significant intra-regional in terms of numbers of RECs operating under each region (Refer to Appendix 5 for the number of REC by regions for 5 years). Since each region has

several distribution centers, by including region year dummies, intra-regional variation in policies and other socioeconomic intervention are controlled.

Table 4

Summary of the Variables Used for this Study

Variables	Abbreviations	Measurement	Unit	Source
Dependent Variable				
Financial Loss	FL	Natural logarithm of Net Loss	Nrs	NEA
Control Variable				
Employee Expenses	EMPEXP	Natural logarithm of employee expenses	Nrs	NEA
Distribution Line Expenses	DISTEXP	Natural logarithm of distribution line expenses	Nrs	NEA
Equipment Repair Expenses	EQEXP	Natural logarithm of equipment repair expenses	Nrs	NEA
Meter Repair Expenses	METEXP	Natural logarithm of meter repair expenses	Nrs	NEA
Transmission Line Expenses	TRANSEXP	Natural logarithm of transmission line	Nrs	NEA
Human Poverty Index	HPI	Index	Number	CBS
Capital Expenditure	CBEXP	Natural logarithm of capital expenditure	Nrs	NEA
Total Repair & Maintenance	TRM	Natural log of total repair and maintenance	Nrs	NEA
Literacy Rate	LIT	Percentage of Literacy Rate	Nrs	CBS
Per Capita Income	PCI	Natural logarithm of PCI	%	CBS

GDP at Market Price	GDPMP	Natural logarithm of GDP at market price	Nrs	CBS
Independent Variable				
Number of REC	REC	Total number of REC located in each distribution center of NEA.	Number	DEOC
Instrumental Variable				
ROAD	ROAD	Road length of each district of Nepal.	Km	DOR
Number of Co-operative	COOP	Total number of co-operative located in each distribution center.	Number	DEOC

Distribution Center Specific Variables

Financial loss. Financial loss of each distribution center is calculated using by total loss unit (kwh) multiplied by average price of electricity (Nrs/kwh).

Employee expenses. Employee expenses include salary and wages paid to employess of each distribution center. Although NEA pays for employee wealfare activities such as loan facility for purchase, contruction and maintenance of house or land, accidental insurance , medical facility , pension etc but these were not included in the employee expenses under this study.

Transmission and distribution line expenses. Transmission line is a specialized cable designed to carry electricity or an electrical signal over larger distance. Whereas distribution line carries the medium volatage power to distribution transformers located near the customer's home. Rural electrification system uses

higher volatges because distribiton lines have to cover longer distance (Malone, 2008). Each year NEA allocates the budget for transmission and distribution line expenses.

Repair and maintenance expenses. Distribution center of NEA spends huge amount of money on repair and maintenance activities on diversion gates, alignment of turbines , rectification of SF6 breaker, transformer leakage control, distribution transformer of head tank, oil pressure pump, control power pump connector, blower system motor, power house, etc (NEA, 2015). Under this study, total repair and maintenance expenses exclude meter expenses, transformer repair expense, trasnmission line and distribution line expenses. However, it includes equipment and machinery, civil , customer service and other expenses.

Meter expenses. Meter Expenses include replacement of electro mechanical meters with automatic meter reading system and internet-facilitated billing system, installation of static energy meter, bulk supply meter, tamper proof meter, monitoring and repair expenses of meter, meter testing, rehabilitation of meter cubicles etc. Lack of proper meter, metering equipments, tamper proof meter, regular monitoring etc can lead to increase in non-technical loss (NEA, 2015).

Transformer repair expenses. A transformer is an electrical device which transmits electrical energy between two or more circuits through electromagnetic indiction. Transformer repair expenses include transformer upgrading, replacement , repair and restoration etc for reducing non-technical loss (NEA, 2015).

Capital expenditure. Capital expenditure includes the money spent by each distribution center of NEA on acquring or maintaning fixed assets such as land, buildings, and equipments.

District Specific Variables

Literacy rate. According to the present and pervious census," A literate person is defined as a person (aged 6 years and above) who can read and write and perform single mathematical calculations independently" (ICIMOD, 2001). In Nepal, the literacy rate is the ratio of the literate population to the total population and is expressed as a percentage.

Per capita income. Per capita income measures the average income earned per person in each district.

GDP at market price. Gross Domestic Product is the monetary value of finished goods and services produced within a country's border which is calculated yearly at market price. For this study, GDP is taken for each district and measured in Nepalese Rupees.

Road length. Nepal's total road length includes Strategic Road Network (SRN), Local Road Network (LRN) and rural roads. Access to road plays a vital role for economic development. The Economic Survey for 2014-15 published by the Ministry of Finance showed that Nepal has total road network of 80,078 km (Economic Survey, 2015). In this study, the road length is measured in kilometers.

Co-operatives. According to the International Co-operative Alliance (ICA), a cooperative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise. This study includes the number of all types of co-operatives in each distribution center for example agricultural co-operatives, rural electric co-operatives, etc in the respective distribution center of NEA.

Hypothesis

To meet the research objective, the following research hypothesis is formulated.

H1: The presence of REC reduces the financial loss of each distribution center of NEA.

Endogeneity Issue

In simple words, a regressor is called endogenous if it is correlated with the error term. Moreover, OLS estimator is biased because of finite sampling property. Endogeneity issue is suspected in this model due to reverse causality in the regression model. Formation and utilization of RECs are characterized by two way endogeneity. On the one hand, in most of the cases an entire village is served by a REC and only those villages form a group and apply for RECs where each villager deems behavior of other villagers to be sufficiently responsible for him to be a part of the group. Furthermore, whenever NEA has to make a decision about expanding grid then first priority is given to existing REC because it is easier for NEA to monitor them and low cost for various activities since NEA has already made huge investment for the establishment of those REC and trained local people for carrying out maintenance work. For example if NEA has to send its official in rural areas for fixing any equipment then it will take few days and labor cost is high but with the help of personnel's from RECs it can be fixed quickly and at cheaper price. On the other hand, NEA feels hesitant to go to new areas where there is no RECs because in those areas NEA has to do feasibility study and create structure for power transmission. Furthermore, this whole process will be expensive and time consuming for NEA. Therefore, formation of RECs is not exogenous in nature and any evaluation of RECs on financial loss needs careful experimental design.

In this study, Fixed Effect (FE) instrumental variable approach has been used to achieve this precisely. Since the explanatory variable REC might be correlated with μ_{it} in equation (i) and there is endogeneity issue with the number of RECs. Durbin and Wu-Hausman is used for checking endogeneity. From, the available data also it can be seen that the distribution center where there are higher number of RECs, the financial loss is low. Therefore, this issue is addressed using instrumental variable.

Instrumental Variable

In econometrics, there is a major complication about the possibility of inconsistent parameter estimation due to endogenous regressor. The regression estimates measure only the magnitude and direction of impact although estimates may be biased and inconsistent. One of the possible solutions for this kind of problem is the use of instrumental variable. This method is widely used in the research study where econometrics is used. It is mostly popular whenever correlation between error term and explanatory variable is suspected. In a pioneer study where IV was a major issue, Angrist and Krueger (1991) used quarters of birth as an instrument. But it is always difficult to find legitimate instrument for an endogenous variable. After referring to different literature, two possible instruments were chosen for the study that are road length and number of co-operatives in each distribution center.

Like mentioned earlier, ROAD and COOP are used as IV for potentially endogenous explanatory variables REC. But if the IV candidate is weakly correlated with endogenous variable then the instruments are considered weak. So, in this situation IV instruments will produce estimates with large standard errors and the errors can lead to a large inconsistency. The 2SLS estimators will be most biased when instruments are weak and there may be over-identifying restrictions. And also

2SLS estimator is biased towards the probability limit of the corresponding OLS estimate. The biasness in 2SLS estimate is due to the randomness in the endogenous variable since the first-stage coefficients are obtained from the endogenous variables on the instruments. Angrist and Pischke (2008) mentioned in their book that "If the population first-stage is zero then this randomness turns into finite-sample correlation in first-stage fitted values and the second-stage errors, since the endogenous variable is correlated with the second-stage errors".

The strength of the instruments can be tested from endogenous covariates and instruments. For testing the endogeneity, Durbin and Wu-Hausman test has been used. This test is useful determining if the model has endogenity and if not then the model selected for the study isn't appropriate.

It is very important to check whether the instrument used for the study is strong or weak. The problem with weak instrument is that it produces biased IV estimator. Besides it, this produces hypothesis test with large distortion (Stock & Yogo, 2005). The strength of the instrument is measured by correlation it has with the endogenous explanatory variable. To be a strong instrument, in first stage the F-Statistics has to be greater than 10 then only 2SLS can be carried out. According to Burgess, Thompson and CRP CHD Genetics Collaboration (2011), "When F is 10, this means that the bias of the IV estimator, leading to the rule of thumb that the F-Statistic should be at least 10 to avoid bias". If F-Statistics is less than 10 then the instruments is considered weak. In this scenario we have to look for another instrument. Finally, the first stage regression will show whether the instruments used for this study is strong or weak.

Two Stage Least Squares (2SLS)

The 2SLS method provides a general solution to the problem of endogenous variable and omitted variable bias. It is used when the dependent variable's error terms are correlated with the independent variables. To address these concern 2SLS strategy is proposed with multiple instrumental variables, these variables are road length and number of cooperatives of 75 district of Nepal. Road length is measured in square kilometer and is less likely to directly affect financial loss conditional on other explanatory variables and distribution center fixed effects. Due to topography, infrastructure, availability of funds etc it is difficult to expedite the process of electrification in the rural areas. An idea of instrumental variable is that the variable road has to be correlated with number of REC but uncorrelated with any other determinants of the dependent variables.

First condition of IV is ROAD and COOP must be uncorrelated with ε_{it} :

$$\text{Cov}(ROAD_{it}, \varepsilon_{it}) = 0 \ldots \text{(ii)}$$

$$\text{Cov}(COOP_{it}, \varepsilon_{it}) = 0 \ldots \text{(iii)}$$

This means that all other explanatory variables except REC are exogenous in equation (i). Then linear projection of REC onto ROAD and COOP are

$$REC_{it} = \Omega_{rt} + \delta ROAD_{it} + \beta' X_{it} + \varepsilon_{it} \ldots \text{(iv)}$$

$$REC_{it} = \Omega_{rt} + \theta COOP_{it} + \beta' X_{it} + \omega_{it} \ldots \text{(v)}$$

Where, by definition $E(\omega_{it}) = 0$ and ω_{it} must be uncorrelated with all the exogenous variable $ROAD_{it}$. The key assumption on this linear projection is that the coefficient on ROAD is nonzero:

$$\Psi_1 \neq 0$$

$$or, \ \text{Cov}(ROAD_{it}, REC_{it}) \neq 0 \ldots \text{(vi)}$$

$$or, \ \text{Cov}(COOP_{it}, REC_{it}) \neq 0 \ldots \text{(vii)}$$

The second condition means that $ROAD_{it}$ and $COOP_{it}$ are partially correlated with REC_{it}. So the correlation and R-Squared is checked by running OLS. When $ROAD_{it}$ and $COOP_{it}$ satisfy the condition (ii), (iii), (v) and (vi) then they are said to be IV candidate for REC_{it}. In simple words, $ROAD_{it}$ is called an instrument for REC_{it}. The coefficient of REC_{it} from equation (iv) and (v) is used to estimate FL_{it} which is the second stage equation.

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \lambda \widehat{REC}_{it} + \gamma_{it} \quad \text{... (vi)}$$

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \theta \widehat{COOP}_{it} + \eta_{it} \quad \text{... (vii)}$$

Robustness Check

There are two methods used in this study for checking robustness of the result. The first method used is dividing the observation into REC located into Terai and Non-Terai region. Most of the REC in the study is located in Terai region.

Another robustness check is used to examine whether identification strategy is reasonable and that the number of REC of current year only affect the financial loss of current year. In particular, the future REC and COOP are used as REC_{t+1} and $COOP_{t+1}$ should not affect current financial loss. The equations used for testing the robustness are as follows:

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \phi REC_{i,t+1} + \Psi_{it} \quad \text{... (viii)}$$

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \phi COOP_{i,t+1} + \xi_{it} \quad \text{... (ix)}$$

Ω is region year dummy for each distribution center which includes region and year effects respectively. FL_{it} is financial loss of distribution center i with their respective regional office and time t with i=1...N; t=1…6 .We should have ϕ=0.

CHAPTER IV

RESULTS

This chapter aims to present the outcomes from the proposed methods and proposed relationship of the variables of interest. This section analyzes the results of the empirical research.

Descriptive Analysis of Variables

Descriptive statistics gives the summary of the variables used for this study. It is a form of univariate analysis which shows the number of observations, mean, standard deviation, minimum and maximum values of the variables.

Table 5

Descriptive Analysis

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
FL	376	17.39	1.52	11.08	20.18
CB	369	8.68	1.03	2.64	14.11
EMPEXP	386	9.87	0.74	8.01	11.46
DISTEXP	385	8.47	0.82	3.76	10.51
TRANSEXP	385	5.89	0.96	2.08	8.89
EQEXP	303	6.16	0.94	2.89	8.44
METEXP	372	4.78	1.16	0.69	7.40
PCI	390	6.65	0.39	5.72	7.74
GDPMP	390	10.11	1.00	7.32	12.72
FINANEXP	322	2.32	1.42	0.00	6.17
LIT	390	61.21	12.96	33.75	86.24
HPI	390	30.50	7.82	14.58	47.80
REC	390	6.33	23.95	0.00	160.00
COOP	390	709	870.94	39	3728
ROAD	390	185.85	72.65	0.00	375.87

Relationship of Variables

Pearson Correlation Analysis was used to analyze nature and strength of relationship among the variables. Table 6 provides a simple correlation matrix.

Table 6

Correlation

	FL	CB	EMPEXP	DISTEXP	TRANSEXP	EQEXP	METEXP	TRANEXP	PCI	GDPMP	FINANEXP	LIT	REC	COOP	ROAD
FL	1.00														
CB	0.36*	1.00													
EMPEXP	0.73*	0.35	1.00												
DISTEXP	0.54*	0.36*	0.71*	1.00											
TRANSEXP	0.29*	0.26*	0.39*	0.36*	1.00										
EQEXP	0.04	-0.02	0.11	0.04	0.12	1.00									
METEXP	0.45*	0.23*	0.51*	0.38*	0.22*	0.09	1.00								
PCI	0.25*	0.13	0.61*	0.51*	0.28*	-0.10	0.22*	-0.02	1.00						
GDPMP	0.51*	0.34*	0.65*	0.52*	0.25*	-0.13	0.36*	-0.19*	0.70*	1.00					
LIT	0.04	0.06	0.30*	0.25*	0.15*	-0.30*	0.08	0.06	0.69*	0.47*	-0.23*	1.00			
HPI	-0.20*	-0.13*	-0.38*	-0.31*	-0.21*	0.24*	-0.16*	-0.05	-0.65*	-0.48*	0.15*	-0.92*	1.00		
REC	-0.01	-0.06	-0.02	-0.05	0.08	0.03	-0.07	0.09	-0.08	0.06	-0.05	-0.01	1.00		
COOP	0.22*	0.19*	0.51*	0.45*	0.18*	-0.23*	0.19*	-0.26*	0.73*	0.81*	-0.13*	0.53*	-0.05	1.00	
ROAD	0.13	0.08	0.14*	0.13*	-0.06	0.03	0.14*	0.06	0.16*	0.47*	0.15*	0.14*	0.25*	0.22*	1.00

Note. *Correlation is significant at the 0.01 level (2-tailed).

Figure 9 is a graphic representation of relationship between road and financial loss. The scatter plots are everywhere and the line doesn't have any observation. The correlation matrix and scatter plot together justify the decision to exclude road from the list of control variables included in the reduced form equation. However, road is correlated with the number of REC in each distribution center.

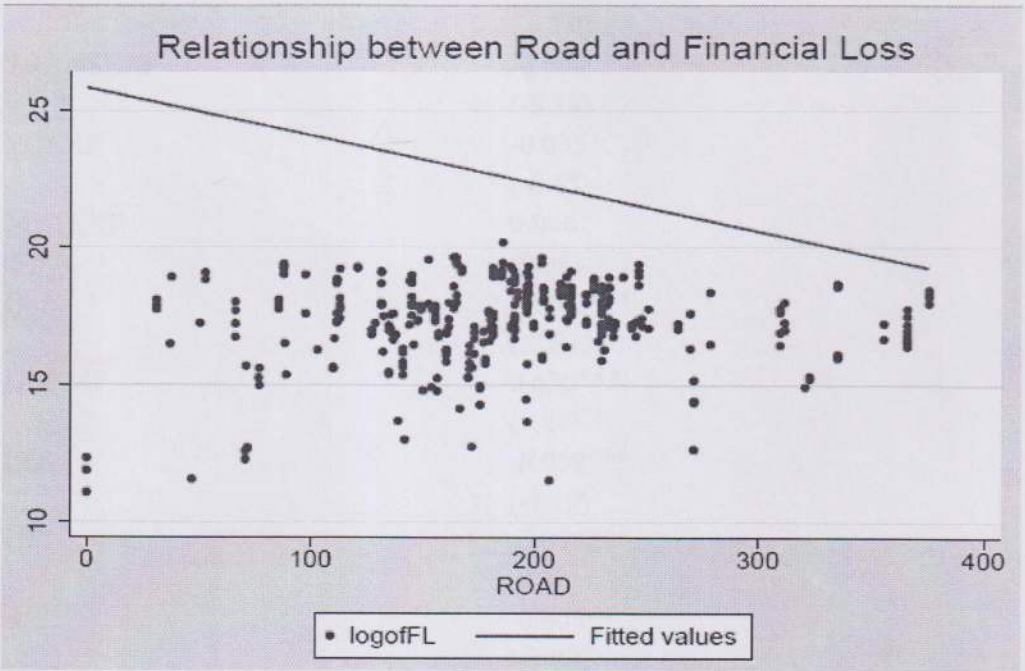

Figure 9. Scatter Plot

Ordinary Regression Results

It is useful to start with the OLS result for establishment of relationship between number of REC and financial loss. Table 7 presents the result of pooled OLS which estimates the effect of number of REC on the financial loss of each distribution center. The result shows that there is negative relationship between the number of REC and financial loss. The employee expenses, PCI, GDPMP, HPI, literacy rate and number of REC are the explanatory variables that are significant for this model. The adjusted R^2 for the OLS model is 0.56. The variable REC is statistically significant at 0.05 level of significance and has negative relationship with financial loss.

Table 7

OLS Model

	1 FL
CB	0.067
	(1.13)
EMEXP	1.136***
	(8.74)
DISTEXP	-0.062
	(-0.70)
TRANSEXP	-0.008
	(-0.14)
EQEXP	-0.035
	(-0.65)
METEXP	0.046
	(0.94)
PCI	-0.762***
	(-2.91)
GDPMP	0.430***
	(5.21)
LIT	-0.058***
	(-5.19)
HPI	-0.077***
	-4.34
REC	-0.005**
	(-2.89)
Other Controls	No
REGYR Dummy	No
N	271
R^2	0.5740
Adjusted R^2	0.5559
F-Stat	31.72
F-Value	0

Note. The control variables are used along with the region year dummies. The t -statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

In Table 8, control variables have been used for running OLS. The OLS estimates suggest that there is a negative relationship between financial loss and REC. This means that the presence of REC has caused the reduction of financial loss of distribution center of NEA. The only difference between the results of two columns is that the first column consists of total repair and maintenance expense whereas the

second consists of repair and maintenance consisting transmission line expenses, meter repair expenses, distribution line expenses and transformer repair expenses. The adjusted R^2 for the OLS model is 66% and 55 %. Similarly, the independent variable REC is statistically significant at p value 0.05.

Table 8

OLS Model with Total Repair and Maintenance

	1	2
	FL	FL
REC	-0.005**	-0.006**
	(-2.16)	(-2.54)
Other Controls	Yes	Yes
REGYR Dummy	No	No
N	297	227
R^2	0.67	0.57
Adjusted R^2	0.66	0.55
F-Stat	74.26	23.89
F-Value	0	0

Note. The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

Testing Endogeneity

Durbin and Wu-Hausman test is used for testing endogeneity and by default this tests the endogenous regressor namely REC. If the endogenous regressor is exogenous the OLS is more efficient but in this study instrumental variable is used for potentially endogenous variable. The null hypothesis under this test is that the variable under consideration can be treated as exogenous. This test of endogeneity was performed after 2SLS.

Null Hypothesis

Ho: variables are exogenous

Durbin (score) chi2(1) = *8.18411* *(p = 0.0042)*

Wu-Hausman F(1,213) = *7.96658 (p = 0.0052)*

Since both test statistics are highly significant, the null hypothesis of exogeneity is rejected and the variable REC is treated as endogenous variable. The difference between these two test score is Durbin test uses an estimate of the error term's variance based on the model assuming the variables being tested are exogenous whereas Wu-Hausman test uses an estimate of the error variance based on the model assuming the variables being tested are endogenous.

First Stage Regression Output

In the first stage, each explanatory variable which has an endogenous covariates in the equation of interest is regressed on all the exogenous variables. Table 9 shows ROAD and COOP as instruments for REC, they are regressed along with the control variables and region year fixed effect. The first stage regression depicts that ROAD as an instrument is statistically significant at p-value 0.001. Similarly, the first stage result suggests that the instruments are strong since the F-Statistics is above ten. And also from Table 9, it can be seen that the correlation of ROAD and REC is 0.25 and is statistically significant at 99%. Therefore, the instrument ROAD is said to have a strong first stage. But COOP has a weak correlation with REC and may provide misleading inferences about parameter estimates and standard error. COOP as an instrument in first stage has F-Statistics of 9.29 which is near to 10. All the three columns have Adjusted R^2 above 60 %. Finally, all these combination of instruments has been used in the second stage.

Table 9

First Stage Regression Output

	1 REC	2 REC	3 REC
ROAD	0.13***		
	(-5.62)		
COOP		-0.01**	
		(-3.21)	
ROAD			0.12***
&			(4.87)
COOP			-0.01*
			(1.80)
Instrument	ROAD	COOP	ROAD & COOP
Other Controls	Yes	Yes	Yes
REGYR Dummy	Yes	Yes	Yes
N	271	271	271
R^2	0.71	0.68	0.71
Adjusted R^2	0.64	0.61	0.64
F-Stat	10.55	9.29	10.52
F-Value	0.00	0.00	0.00

Note. The table reports the result for the regression mentioned below:

$$REC_{it} = \Omega_{rt} + \delta ROAD_{it} + \beta' X_{it} + \varepsilon_{it} \ldots \text{(iv)}$$

$$REC_{it} = \Omega_{rt} + \theta COOP_{it} + \beta' X_{it} + \omega_{it} \ldots \text{(v)}$$

The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

2SLS Regression Output

In 2SLS, the regression of interest is estimated in the second stage but in this stage each endogenous covariate is replaced with the predicted values from the first stage. From Table 10, three columns were used for ROAD, COOP and both of it as instruments. Column (1) has REC as significant variable at p value 0.10 and the exact p-value at which it is significant is at 0.067. But Column (2) and Column (3) do not have REC as significant variable when COOP is used as an instrument. In this case,

we can say that ROAD is the only instrument that is significant and can be used as an instrument for REC. Since one instrument is used in the final model so there is no problem of over identification of instrument. Due to this reason, Column (1) is considered as the final model and it if the number of REC increases by 1 then financial loss decreases by 1% remaining other things constant in each distribution center of NEA. The Adjusted R^2 for the model is 66.79% with F-Statistics 9.72. Finally, the F-value is significant and it can be said that REC and FL variables have negative relationship.

Table 10

Two Stage Least Squares Output

	1 FL	2 FL	3 FL
REC	-0.01*	0.01	-0.01
	(-1.83)	(-0.62)	(-1.45)
Instrument	ROAD	COOP	ROAD & COOP
Other Controls	Yes	Yes	Yes
REGYR Dummy	Yes	Yes	Yes
N	271	271	271
R^2	0.67	0.73	0.69
Adjusted R^2	0.59	0.66	0.62
F-Stat	9.72	11.79	10.46
F-Value	0.00	0.00	0.00

Note. The regression for 2SLS is mentioned below:

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \lambda \widehat{REC}_{it} + \gamma_{it} \text{ ... (vi)}$$

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \theta \widehat{COOP}_{it} + \eta_{it} \text{ ... (vii)}$$

The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01

Robustness Check

Table 11 shows that for Terai region ROAD is a strong instrument for REC but for non-Terai region ROAD is a weak instrument. Similarly, Table 12 shows that

REC in Terai region has helped in reducing financial loss. Although the result is not significant when only non-Terai district data is used but significance of the earlier result remains if nonlinear and higher ordered control variables are included.

Table 11

REC in Terai region and Non-Terai First Stage Regression

	REC in Terai Region First Stage	REC in Non-Terai Region First Stage
	1 REC	1 REC
ROAD	0.07***	0.21***
	3.69	2.59
Instrument	ROAD	ROAD
Other Controls	Yes	Yes
REGYR Dummy	Yes	Yes
N	168	97
R^2	0.88	0.79
Adjusted R^2	0.86	0.65
F-Stat	27.66	5.50
F-Value	0.00	0.00

Note. The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

Table 13

Robustness Check using OLS

	FL
RECPLUSONE	0.07
	(1.21)
Other Controls	Yes
REGYR Dummy	Yes
N	227
R^2	0.75
Adjusted R^2	0.68
F-Stat	10.58
F-Value	0.00

Note. The table reports the result of the robustness check using OLS regression mentioned below.

$$FL_{it} = \Omega_{rt} + \beta' X_{it} + \phi REC_{i,t-1} + \Psi_{it} \ldots \text{(viii)}$$

The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

Table 14

Robustness Check Using IV

	First Stage
	1
	RECPLUSONE
ROAD	0.08***
	3.26
Instrument	ROAD
Other Controls	Yes
REGYR Dummy	Yes
N	270
R2	0.64
Adjusted R2	0.56
F-Stat	7.85
F-Value	0

Note. The control variables are used along with the region year dummies. The t statistics in parentheses * p<0.10, ** p<0.05 and *** p<0.01.

CHAPTER V

SUMMARY, DISCUSSIONS, AND IMPLICATIONS

This chapter is divided into four sections. It includes major findings, practical and research implications and discussion of this study. Along with this critique of the study will be presented at the end which will include the limitations and possibility of improvements.

Major Findings

The major findings of the present empirical study are summarized as follows. The result of descriptive statistics shows the number of observation, mean, standard deviation, minimum and maximum for the variables used in this study. The mean value of FL is 17.39 with standard deviation of 1.52, REC is 6.33 with standard deviation of 23.95 and ROAD is 185.85 with standard deviation of 72.65.

The result of pooled OLS with FL as dependent variable shows if the number of REC increases then financial loss decreases in each distribution center of NEA. The result indicates that if number of REC increases by one then the financial loss of each distribution center of NEA decreases by 0.5%. Similarly other variables PCI, GDPMP and literacy rate are found to have negative and statistically significant relationship with FL. The employee expenses are found to have positive and statistically significant relationship with FL. The result of first stage regression shows that ROAD as an instrument is statistically significant at 99 percent level of confidence with F-value 10.55. But COOP as an instrument in first stage has F-Statistics is 9.29 which is near to 10 and is considered as a strong instrument. The result also shows ROAD and COOP together as an instrument are also significant with F-value 10.52.

The 2SLS result shows REC has negative and significant relationship with FL. The result shows if number of RECs increases by 1 then financial loss decreases by 1% other things remaining constant. The findings of this study suggest increase in the number of REC leads to the reduction of financial loss. There may be other factors like repairs and maintenance cost, investment in plant and machinery, etc that jointly help in reducing financial loss. NEA annual reports mention that the activities conducted for reducing loss are meter change, resealing, conductor and transformer upgrading, etc (NEA, 2016).

The first robustness check used under this study is done by dividing the sample of distribution located in Terai region and non-Terai region. The result shows that REC in Terai region has helped in reducing financial loss whereas the result of REC in non- Terai region isn't significant. Another robustness check result shows the future REC doesn't affect the current financial loss of each distribution center of NEA.

Discussion

There are many nations who have suffered from low electrification rate and huge financial loss of power providers since 1935 (World, 2009). It was Franklin Delano Roosevelt who signed an executive order establishing the Rural Electrification Administration (REA) in 1935. After this, it is widely used all over the world for due to its benefits. The benefits of having REC in any location are it helps in reduction of theft, timely payment and prompt repair and maintenance. This also helps directly in reducing financial loss otherwise huge amount of money will be spent for monitoring theft in rural areas, collection of unpaid bills and sending an official for maintenance

work. It seems that promoting REC is one of the important programs of NEA for reducing financial loss of its distribution center.

The findings of this study have suggested that RECs have reduced the incidence of the financial loss. This result has local interpretation (of being LATE). According to Waldinger (1991), "The intuition of LATE generalizes to most cases where we have continuous endogenous variables and instruments, and additional control variables". However, in the short run NEA is unable to readjust monitoring expense and other resources such as manpower. Since the data is limited, empirical investigation is speculative about precisely how it happens: our claim that RECs are positive externality for reducing financial loss is yet to be proven.

Causal research helps to observe variation in the variable assumed to cause change in the other variables and measures the changes in the other variables. However, the other confounding effects must be controlled for so they don't distort the results. This type of research is very complex and researcher is not completely certain that there are no other factors influencing the causal relationship. But there are many international studies which have documented the causal relationship between different programs and economic policy outcomes. It is very important to evaluate the effectiveness of any program after it has been implemented because evaluation provides the snapshot of outcomes. In addition to it, this helps in improving the effectiveness of such programs. Since this study is new so similar studies were used for developing theoretical framework of this study.

There are many empirical studies that have focused on economic and social aspects of rural electrification program (e.g Barkat et al., 2002; Barnes & Binswanger, 1986; Chaurey et al., 2004; Khandker, Samad, Ali, & Barnes, 2012; Yadoo & Cruickshank, 2010). These studies mainly foucused on the impact of rural

electrification on the well-being of rural people in various ways such as establishment of SME, use of advanced agricultural equipment, improvement in education, increased income etc.

After going through many literatures, there are few studies which mentioned several ways to reducing different kind of power loss (Aguero, 2012 and Ranganathan, 2005). But these literatures have not established direct link between RECs and the financial loss reduction. Aguero (2012) evaluates technologies, methodologies and operation of power distribution systems with an emphasis of improving efficiency and reduction of technical and non-technical power and energy losses. Ranganathan (2005) mentions that "non-technical loss is likely to occur more at the distribution level than the transmission level, and a high transmission loss figure gives an impression to the regulator that most of the high losses are of a technical nature".

There was only one study that mentioned about the financial impact of electricity theft. Smith (2004) in his study mentioned that the financial impacts of theft are reduced income from sale of electricity and necessity to charge more to customers. Electricity theft is closely related to poor governance, political instability, low government effectiveness and high corruption. Therefore, this can be reduced by technical solutions such as tamper proof meters, managerial methods such as inspection and monitoring and restructuring power system ownership and regulation.

This research has found out ROAD is the instrument that can be used for endogenous explanatory variable REC. RECs are established in the rural areas where road is not developed. After reviewing many empirical literature where ROAD has been used as an instrument for endogenous explanatory variables. In our country, it is very difficult to get the data of other instruments like number of villages, altitude of

each distribution center, etc and if these data were available then it would have been used as potential instrument for this study

This study has documented the evidence about the impact of number of REC in reducing financial loss of each distribution center of NEA. The findings suggest that there is negative causal relationship between financial loss and number of REC. In Nepal, the number of REC is huge compared to Bangladesh which has only 80 RECS but has low financial loss. So, NEA must try to establish more REC in the rural areas where financial loss is high.

Practical and Research Implications

The main purpose of this study is to examine the causal link between the number of REC and financial loss of distribution center of NEA. This study has revealed that the presence of REC reduce the incidence of financial loss in the respective distribution center of NEA. Most of the variables were controlled due to the inability to readjust monitoring expenses and other resources (such as manpower) in the short run. This study is the first to document the impact rural electric cooperatives in reducing financial loss. The evidence is of theoretical and practical significance as the study employs robust method to ensure causality between the variables and data was collected by visiting NEA.

The findings of this study can be useful for policy makers. If RECs in Nepal are very effective in reducing financial loss then the GoN should promote establishment of REC, allocate more budget for funding REC and encourage local communities of various distribution center. NEA has various loss reduction programs, and along with this program, it can achieve its electrification and loss reduction objectives. There are several possible explanation about how the structure of REC affiliates affect the outcomes of parent organization NEA. One of the reasons is added

supervision made possible by not having to spend resources in monitoring certain areas. Hence, this reduces the monitoring cost to a fraction of total annual budget and the resources saved from this will be used in areas where RECs are absent. However, such impacts must be short run and dissipate over time.

Another reason is peer monitoring where people living in urban or dense areas are usually in proximity with several people and incidence of theft is close to zero. But in the rural areas where people income level is low and there is probability of higher incidence of theft. However, the RECs in rural areas act as a positive externality of such behavior which induces better behavior among the citizens living in cooperative run areas. These citizens are more likely to report any incidence of theft in their area.

This study can be useful for academic researchers, developing countries with REC program and those countries with high financial loss. CBM is widely in practice all over the world so the theme of this study can be related with various programs where CBM is in use like forestry, fishery, agriculture etc. This study can shed new light on the proposed topic.

Finally, the Government should promote the expansion of REC along with the other measures of loss reduction process. As mentioned above, Bangladesh and USA were highly successful in increasing electrification rate and electricity consumption per capita by adopting rural electrification program. Nepal should also try to learn from these countries about what they have done differently and how our country can reduce financial loss.

Positive externality effect of cooperatives hasn't been studied in the literature and the investigation of this as a possible next direction for research in more general setting. For example microfinance agencies may also affect the behavior of banking

and financial institution which lends money to them. So, understanding this feedback is very important in getting a clear picture of economic ecosystem in which these cooperatives operate

Critique of the Study

This study has limitations which need to be addressed. First, few data were not available for the study since NEA doesn't have proper system of data management. Although it has CRED (Community Rural Electrification Department) it doesn't keep the record properly. It has only the data for RECs which has applied for this program and the RECs which are under construction. Second, this study would have been very effective if the data were available from when the REC started. A large sample size would have given more accurate result. However, if those data were available then it might have been possible to use DID estimates. Finally, the body of literature related to this study is limited. There have been no prior studies that have focused on the impact of rural electrification in reducing financial loss. However, there are many works which focus on benefits of rural electrification rather than on policy evaluation. To fill the gap of literature review in this study System loss literatures were referred.

To sum up, as a researcher it is very difficult to research about a topic that has been there but no one has done any research on it. And also there are many policies that have been there in practice but no evaluation has been done so far. So as a researcher opening up new avenues of research and working consistently on them is all that matters.

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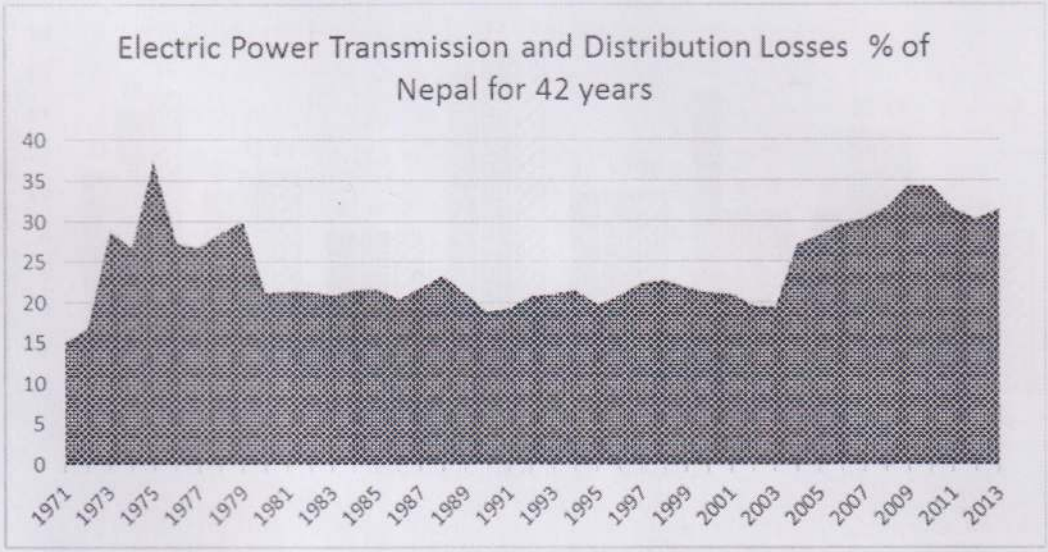
APPENDIX I

Electric Power Transmission and Distribution Losses % of Nepal for 42 years



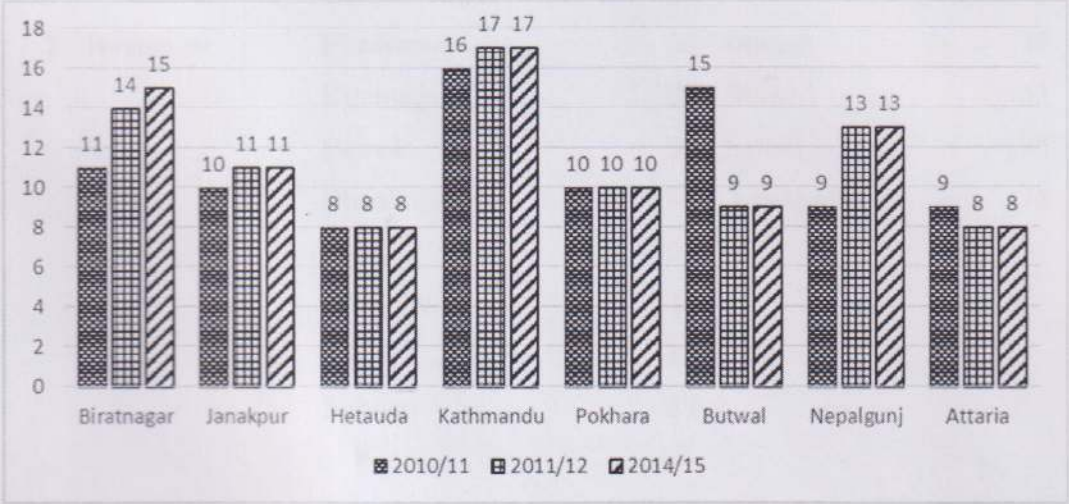
APPENDIX II

Received, Sold and Loss Unit of NEA

S. No	Fiscal Year	Received Unit	Sold Unit	Loss Unit
1	2010//11	3,545,888,904.02	2,683,963,272.39	861,925,631.64
2	2011/12	3,861,709,447.74	3,030,766,989.84	830,942,457.90
3	2012/13	4,022,950,876.53	3,255,475,063.52	767,475,813.01
4	2013/14	4,292,120,321.41	3,492,107,910.72	800,012,410.69
5	2014/15	4,204,007,095.63	3,260,850,302.19	748,899,633.32

APPENDIX III

Regional Offices and Distribution Center of NEA



APPENDIX IV

Sample and Code of Distribution Center

S.N	Regional Office	DC with REC	Code	DC without REC	Code
1	Kathmandu	Dhadhing	2	Bhaktapur	1
		Baneshwore	3	Helambu	5
		Dolkha	4	Kirtipur	8
		Jorpati	6	Thimi	11
		Kavre	7		
		Pulchowk	9		
		Rasuwa	10		
		Sindhu	12		
		Kuleshwore	13		
		Lagankhel	14		
		Maharagunj	15		
		Ramechap	16		
		Ratnapark	17		
2	Janakpur	Diktel	18	Jaleshwore	19
		Janakpur	20	Lahan	21
		Malangwa	22	Rajbiraj	23

		Sindhuli	24	Siraha	24
		Udayapur	26		
		Okhaldhunga	27		
3	Biratnagar	Bhadrapur	28	Dharan	32
		Biratnagar	29	Duhabi	33
		Damak	30	Itahari	35
		Dhankuta	31	Anarmani	38
		Illam	34		
		Khandbari	36		
		Ragel	37		
		Belwari	39		

S.N.	Regional office	DC with REC	Code	DC without REC	Code
4	Hetauda	Baharatpur	40	Gaur	42
		Birgunj	41		
		Hetauda	43		
		Kalaiya	44		
		Palung	45		
		Simara	46		
		Thadi	47		
5	Butwal	Bhairawa	49	Argakhachi	48
		Gulmi	50	Taulihawa	52
		Kawasoti	51	Krishnagar	53
		Palpa	54		
		Parasi	55		
		Butwal	56		
6	Attariya	Dadeldhura	57		
		Dhangadi	58		
		Mahendranagar	59		
		Tikapur	60		
		Acham	61		
7	Pokhara	Parbat	63	Pokhara	62
		Syanja	64		

		Gorkha	65		
		Baglung	66		
		Myagdi	67		
		Tanahu	68		
8	Nepalgunj	Ghorahi	70	Dailekh	69
		Gulariya	71	Pyuthan	72
		Surkhet	75	Rolpa	73
		Tulsipur	76	Salyan	74
		Nepalgunj	77	Dolpa	78

APPENDIX V

Distribution Center of REC by Regions