YANGON UNIVERSITY OF ECONOMICS

DEPARTMENT OF ECONOMICS

MASTER OF ECONOMICS

A STUDY ON THE CAPACITY OF HYDRO ELECTRIC POWER GENERATION IN MYANMAR

WAI PHYO OO

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Supervised By:

Dr. Thin Thin Oo

Associate Professor

Department of Economics

Yangon University of Economics

Submitted By:

Wai Phyo Oo

Roll No. 5

MEcon(Eco)

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ABSTRACT

Increasing the electric power facilities of a country is the general expansion of the economy and it is one of the principle elements of the development programs. This study is focused on the fundamental source of electricity such as generation, consumption , transmission and unit losses over the period of 1988-2016 and based on secondary data. The objective of the study is to examine the production, consumption and distribution of Myanmar Electric Power Sector. Much more electricity is needed for transmission and distribution upgrade. Immediate investment in combined cycle gas generators are needed to boost output. Hydropower installed capacities are increased year by year. It is also found that the strength is high relevance for agricultural sector, weakness is trainings for hydropower professionals are not available, opportunity is international investment interest in Myanmar and threat is hydropower generation reduce in dry seasons. Although the government is trying to decreases the unit losses, are still high in Myanmar.

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Lists of Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
ASEAN	Associations of South East Asia Nations
BOT	Built- Operate Transfer
BTL	Biomass to Liquid
CT scan	“Cat Scan” or “Computed Tomography”
DC	Direct Current
DEPP	Department of Electric Power Planning
DHPP	Department of Hydropower Planning
DICA	Directorate of Investment and Company
ECG	Electrocardiogram
EPC	Electric Power Corporation
EPGE	Electric Power Generation Enterprise
ESB	Electricity Supply Board
ESE	Electric Supply Enterprise
EU	European Union
HPGE	Hydropower Generation Enterprise
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
JICA	Japan International Corporation Agency
JV	Joint Venture
KV	Kilo-Vott
kW	Kilowatt
kWh	Kilowatt Per Hour
MEPE	Myanmar Electric Power Enterprise
MESB	Mandalay Electric Supply Board
MESC	Mandalay Electric Supply Corporation
MOA	Memorandum of Agreement
MOEE	Ministry of Electricity and Energy
MOU	Memorandum of understanding
MPA	Master of Public Administration

MW	Mega Watt
MWh	Mega Watt Per Hour
NEMC	National Energy Management Committee
SPDC	State Peace and Development Council
UN	United Nation
W	Watt
X-ray	Beam ray
YESB	Yangon Electricity Supply Board
YESC	Yangon Electric Supply Corporation

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Chapter 1

INTRODUCTION

1.1 Rationale of the Study

Increasing the electric power facilities of a country is the major expansion of the economy and it is one of the principle elements of the development programs. For human development and increase living standards, electricity is very important for every country. Since electricity is so central to our modern economy and lifestyle, it is a key determinant of the development of the nation (Tun Tun Swe, 2015).

Hydropower is one of the pivotal components of socio- economic development in every country. Among electricity production, hydropower production is the cheapest way to produce electricity. Hydropower is still the most efficient and effective way to generate electricity. Additionally, Hydropower is an major source to generate electricity in all over the world and especially main produce in the developing countries (Aye Pearl Hlaing , 2011).

One of the most fundamental essential for the nation's development is to improve the infrastructure like roads, bridges, electricity and so on. To construct the modern industrial country, electricity is an essential to develop industrial sectors. Infrastructure is critical to achieving economic growth and reducing poverty in developing countries. The benefits of improved infrastructure range from increased industrial productivity, higher economic growth and competitiveness to higher living standards as a result of better access to electricity, communication, transportation, etc. Electricity is critical for eradication of poverty and improvement of living standard of human beings and welfare (Soe Paing Myint, 2012).

Electricity is basic needs for economic development of a nation. Electricity is now an essential part of our human society. When the society evolved and developed steadily, the electricity consumption increases with time. Electricity is also extensively used and produced all over the countries of the world. Modern life style cannot be constructed without electricity. Component of electricity are generation,

transmission and distribution. Electricity can generate for education sector, electricity is essential in many aspects (Phyu Win Ei ,2002).

For health sector, electricity is also needed in a wide range. Modernized hospital appliances, such as Ultrasound machine, CT scan machine, X-ray and etc; cannot be used without electricity. Hydropower is one of the oldest power sources on the planet, and generating power among sources when flowing water spins a wheel or turbine. Hydropower plants capture the energy of falling water to generate and produce electricity. A turbine converts the kinetic energy of falling water into mechanical energy and a generator converts the mechanical energy from the turbine into electrical energy. Besides, it is renewable energy source. Hydropower is the cheapest way to generate electricity in the world today. In Myanmar, around 22 percent of households off-grid electricity schemes, which typically high cost, low-reliability services for a few hour per day (Dobozi, I, 2016).

In Myanmar, the role of electric power plays in an essential role to improve living standard of citizens and for sustainable development of industries (Phone Myint ,2012). There are 70% of public electricity production and 30 % of private electricity production in Myanmar. Restructuring and corporatization and cooperation have been initiated in the power distribution sector. To improve performance and overall efficiency in power distribution, the government corporatized the former States and Regions and should update the distribution lines in the rest of the country.

In 2016, the consumption of household's electricity consumption is 3.69 MW and improved 4.05 MW in 2017. In 2018, the generation of Myanmar's electricity is 1,888.130 kWh. The ratio of energy in electricity production of Myanmar, there are 54.54% of hydroelectric power energy, 42.19 % of natural gas and 3.27 % of heat and energy in 2017. Economic development is accordingly a priority of hydroelectric power energy. As parts of its development efforts are needed to upgrade the country's basic infrastructure, including, roads, bridges, communication system and the electrical grid (MEPE Magazines, 2016-2017).

In particular, boosting electrification is a key driver for the economic development and industrialization of Myanmar. Myanmar has the lowest electrification rate among the ASEAN countries. Upgrading its electricity infrastructure and updating legislation, governing the electricity sector and

maintaining the generators are central to Myanmar's economic development for alleviating rural poverty. The major obstacle sector in Myanmar is the shortage of electricity supply. To fulfill the gap between the supply and demand for electricity, government should support an effective ways to get the sufficient electricity. The development of power sector is the major sector for the development of country especially manufacturing, industrial and social development. Therefore, this study was to study how Ministry of Electrical and Energy operate to increase electricity production, transmission and distribution in Myanmar.

1.2 Objective of the Study

The objective of the study is to examine the production, consumption and distribution of electricity that is fundamental source of the development of Myanmar.

1.3 Method of Study

The method of the study is descriptive method based on secondary data from the Ministry of Electric Power, magazines, other department, library and internet websites.

1.4 Scope and limitation of the Study

This thesis is emphasized on the Hydropower generation in Myanmar from 1988 to 2018.This study focus on the electric power generation and consumption of Myanmar's Electric Power Sector.

1.5 Organization of the Study

This study is organized into five chapters. Chapter (1) (introductory chapter) presents rationale, objectives, method, scope and limitation and organization of the study. Chapter (2) presents Literature Review. Chapter (3) describes Electric Power Sector in Myanmar. Chapter (4) mentions Hydro Electricity Generation in Myanmar. Chapter (5) is about conclusion with findings and suggestion.

Chapter 2

LITERATURE REVIEW

2.1 Basic of Hydropower

Electricity is one of the necessity goods in a modern economy. The nature of electricity is such that supply and demand must be in an equilibrium. The system breaks down occur in short time if demand exceeds supply and vice versa. The electricity can use water, fossil fuels, bio fuels, wind and geothermal energy as primary energy sources to run turbines producing electricity (Naung San Lin , 2016).

Among the sources of power generation, hydropower is renewable and clean energy which use the flow of water into kinetic energy and can generate and produce the electricity by rotating the turbine and generators. The use of water in hydropower is not only to consume and it flows to the river course after running the turbine for generating the electricity .Some other sources of generation can emit at least Carbon di oxide into the world atmosphere and caused pollution into the air and can cause health problem but hydropower generation does not emit Carbon di oxide (Phone Myint, 2012).

Hydropower is based on water driving the turbines. The Primary energy is provided by gravity and the height the water falls down on the turbine. The potential energy of the stored water is the product of the mass of the water and the gravity factor and the head defined as the difference between the dam level and the tail water level. Hydropower can be based on unregulated river flows, or dams and reservoirs with limited storage capacity above the natural flow, and on water drawn from reservoirs that may contain up to several year worth of inflow.

There are four broad hydropower such as Run-of-river hydropower, Storage hydropower, Pumped-storage hydropower and off-shored hydropower. Hydropower projects are often diversified into a size by means of its installed capacity. Up to 5KW

as Pico-hydro, 5KW to 100 KW as Micro-hydro, 100 KW to 1 MW as Mini-hydro, 1 MW to 20MW as Small-hydro, 20MW to 100 MW as Medium-hydro, and 100MW or more as Large-hydro (Naung San Lin, 2016).

2.2 The Importance of Electricity

Electricity is the form of energy. Electric energy can't be stored economically or in any Large scale. It has to be generated and utilized and consumed at the same time. There is at all time, there must be the balance between supply and consumption of electric power. Components of electricity are generation, transmission and distribution (Aung Myint Naing, 2007).

Electricity power is a secondary energy resource obtained from the conversion of the primary energy sources such as fossil fuels (natural oil, coal) and wind energy Coal has been the fuel mostly used in electricity and natural gas in electricity consumption has increased in recent years, but the use of oil in electricity generation has decreased since the late 1970, due to sharp increases in oil prices.

Electricity is the most versatile and easily controlled form of energy. At the point of use, it is practically loss-free and essentially non-polluting the air. At the point of generation it can be produced clean with entirely renewable methods, such as wind, water, tide and sunlight. Electricity is weightless, easier to transport and distribute, and it represents the most efficient way of consuming (Aprial Hlaing, 2011).

Electrical energy is used throughout the world to power devices, appliances and methods of transportation utilized in daily life. To make elements operate, electrical energy must be emitted from energy sources such as power plants to enable an object to consume the power it need to function .As a result, the electrical energy permits people to watch television in the home, or purchase soda from a vending machine because the electrical power is available (Phyu Win Ei, 2002).

Electricity is one of the most important goods that science has given to mankind .It has also become a part of modern life and one cannot think of a world without electricity. Electricity has many useful in our day life. It is used for lightning rooms, working farms and domestic appliances like using electric stoves, and more all these provide comfort to people and improve living standards. In factories, large

machines and equipments are worked with the help of electricity. Essential items like food, cloth, paper and many other things and machines are the product of electricity.

About 70% population of Myanmar lives in rural areas where average electrification rate is 16%. Out of total 64,917 villages, about 57,557 villages are in remote areas, far away from the national grid. Myanmar is bless with an abundance of energy potential and extensive renewable resources, including large amount of agricultural biomass waste (Pode, R, Pode, G., & Diouf, B, 2016).

Increased cooperation with an expending domestic civil society this established activist community is stimulating improved governance of hydropower development and simultaneously assisting in the creation of a more open and democratic Myanmar (Simpson, 2013).

Modern means of transportation and communication have been revolutionized and industrialized by it. Electric trains and battery cars can travel quickly. Electricity also provides means of amusement, radio, television, and cinema, which are the most popular forms of entertainment and they are the result of electricity. Modern equipment like computers and robots, televisions and electronic devices had also been developed because of electricity. Electricity plays a vital role in the fields of medicines and surgery too- such as X- ray, ECG. The useful of electricity is increasing day by day. Electric power provides electricity to all commercial and industrial private sectors of our society (Phyu Win Ei, Oct 2002).

2.3 Energy Sources for Electricity

There are nine main energy sources using in electricity generation in the world today. These energy sources can be diversified into two broad groups nonrenewable and renewable. Nonrenewable energy sources include coal, natural gas, and uranium. All these sources are used to generate electricity, to heat our homes, to move our cars and to manufacture products and to produce electronic devices. These energy sources are called nonrenewable because they cannot be replenished in a short time period. Petroleum, for example, was formed millions of years ago from the remains of ancient sea life, so can't produce more quickly (Simpson, 2015).Nonrenewable resources can be running out and replenished someday. Renewable energy sources include biomass, geothermal, hydropower, solar and wind because their supplies are replenished in a

short time. Day after day, the sun shines, the wind blows, and the river flow. The renewable energy is suitable and efficient for electricity generation in the long run (David Dapice,2015). A renewable resource is a natural resource which replenishes of time.

Renewable resources are a part of Earth's natural environment and the larges shares of its ecosphere. A positive life cycle assessment is a major indicator of resources sustainability.

(i) Biomass

Biomass is an industry things for getting energy by burning wood and other organic matter. Burning biomass releases, but has been classed as a renewable energy in the EU and UN legal framework, because plants stocks can be replaced with new growth. It has become more popular among coal power stations, which switched from coal to biomass from convert to renewable energy generation. Biomass most often refers to plants or plants-based materials that are not use for food or feed, and are especially called lignocelluloses biomass. As an energy source, biomass can either be used directly combustion to produce heat or indirectly after converting it to variety forms of bio-fuel. Conversion of biomass into bio-fuel can be achieved by different methods. Biomass can be transformed into other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel.

(ii) Geothermal

Geothermal thermal energy is thermal energy that generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the formation of the planet and from radioactive decay of materials. The geothermal gradient, which is the difference in temperature between the major of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.

Geothermal power is cost effective, reliable, sustainable, efficient and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological improved have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal energy releases greenhouse gases

trapped deep within the earth, but these emissions are much lower per energy unit than that of fossil fuels. The International Geothermal Association has reported that 10,715 megawatts (MW) of geothermal power in 24 countries is online which was expected to generate 67,246 GWh of electricity in 2010.

(iii) Hydropower

Hydropower or water power is power derived from the energy of falling water or fast running water, which may be used for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation system can be applied and the operation of various mechanical devices, such as gristmills, saw mills, textile mills, trip hammers, domestic lifts, and ore mills.

In the late 19th century, hydropower became a major source for generating electricity. Since the early 20th century, the hydropower has been used almost exclusively in conjunction with the modern development and popular of hydroelectric power. International institutions such as the World Bank described that hydropower is the major elements for economic development without adding substantial amounts of carbon to the atmosphere, but dams can have significant negative social and environmental impacts.

At the beginning of the Industrial Revolution in Britain, water was the main source of power for new inventions in the country. Although the use of water power gave way to steam power in many of the larger mills and factories, it was still used and applied during the 18th and 19th centuries for many smaller operations, such as driving the bellows in small blast furnaces (Aung Myint Naing, 2007).

(iv) Solar Energy

Solar power captures the energy of the sun through using collector panels to create conditions that can be turned into a kind of power. Large solar panel fields are often used in desert to gather enough power to charge small substations, and many homes and industries use solar systems to provide for hot water, cooling and supplement their electricity. This issue with solar is that when there is many amounts of sun available, only certain geographical ranges of the world get enough of the direct power of the sun for long enough to generate usable power from this source.

(v) Wind Energy

Wind power is becoming more and more common and useful. The new innovations that are allowing wind farms to appear are making them a more common sight. By using electricity large turbines to take available wind as the power to turn, the turbine can operate a generator to produce electricity.

(vi) Hydrogen Energy

Hydrogen is available with water and is most common goods available on earth. Water contains two-thirds **o**f hydrogen and oxygen can be found in combination with other elements. Once it is separated, it can be used as a fuel for operating electricity. Hydrogen is a major source of energy and can be used as a source of fuel to power ships, vehicles, homes, industries and rockets. It is completely renewable energy and can be produce on demand and does not leave any toxic emissions in the atmosphere.

(vii) Tidal Energy

Tidal energy uses rise and fall of tides to convert kinetic energy of incoming and outgoing tides into electrical energy. The generation of energy through tidal power is mostly prevalent in coastal areas. Huge investment and limited availability of sites are few of the drawbacks of tidal energy. When there is increased height of water levels in the ocean, tides are produced which rush back and forth in the ocean. Tidal energy is one of the renewable sources of energy and produce large energy even when the tides are at low speed.

(viii) Wave energy

Wave energy is produced from the waves that are produces in the ocean. Wave energy is renewable energy, and causes no harmful to atmosphere. It can be harnessed along coastal regions of many countries and can help a country to reduce the dependence on foreign countries on fuel. Producing wave energy can damage marine ecosystem and can also be a source of destroyed to private and commercial sector. It is highly dependent on wavelength and can also be a source of visual and noise pollution.

(ix) Nuclear power

Nuclear power is the use of nuclear reactions that release nuclear energy to generate heat, that most frequently used in steam turbines to produce electricity in a

nuclear power plant. Nuclear power can be gained from nuclear fission, nuclear decay and nuclear Fusion. Presently the popular majority of electricity from nuclear power is produced by nuclear fission of Uranium.

Nuclear power is one of the leading low carbon power generation methods of producing electricity. In terms of total life-cycle greenhouse gas emissions per unit of energy generated, nuclear power has emission values comparable or lower than renewable energy. From the beginnings of its commercialization in the 1070s, nuclear power prevented and recused about 1.84 million air pollution- related deaths (Phone Myint, 2012).

2.4 Power Generation

Power generation is the process of producing electric energy or the amount of electric energy that produce by transforming the other forms of energy into the electrical energy, and commonly described in kilowatt-hours (kWh) or Megawatt-hours (MWh). The major different types of electricity generation are

- Heat (thermal) energy that generated from fossil fuels, coal, petroleum, natural gas, solar thermal energy, geothermal energy, and nuclear energy.
- Potential energy from falling the water in a hydroelectric facility
- Wind energy
- Solar electric from solar(photovoltaic) cells
- Chemical energy from : fuel cells, and batteries

(i) Electricity Generation

Electricity generation is the process of generating electric power sources among the primary energy. For electric utilities in the electric power industry, generation is the major first stage in the delivery of electricity to end users, the other stages are generation, transmission and distribution. There are many various different types of electric power generation. A generation plant is a facility that designed to produce electric energy from another form of energy, such as heat thermal energy generated from fossil fuels, (coal, petroleum, natural gas) solar thermal energy, geothermal energy ,nuclear energy, potential energy from falling water in a hydroelectric facility, wind energy, solar electric from solar cells, chemical energy from: fuel cells, batteries (Phyu Win Ei, 2002)

(ii) Electricity Transmission

Electric power transmission is the second process in the delivery of electricity to the consumers. Electricity is transmitted from the electricity generation power plants and sold to the final consumers by retailer and electric power transmission and electricity distribution. After electricity is produce at power plants, consumers get and use the electricity. Our cities, towns, states and the entire countries are cross and installed with power lines that carry electricity. The electricity first goes to the transformer at the power plants and that boosts the voltage up to desired level. When the electricity travels long distances it is better to have it has higher voltages.

Another way is that electricity can be transferred more effectively at high voltages. High voltage transmission lines carry electricity long distances to a substations. The power lines goes into substation near businesses, factory and homes. Transformers change the very high voltage electricity back into lower voltage electricity. From these substations, electricity in different power levels is used to run factories, street lights and terrific light (Phyu Win Ei, 2002).

(iii) Power Distribution System

A Distribution System originates at a distribution substation lines and includes lines, poles, transformers and other equipments needed to deliver electric power to the consumer at the required voltages. Customers are classified as: Industrial Customers, Commercial Customers and Transportation Customers.

A Distribution System consists of all the facilities and equipment sans machines that connecting a transmission system to the customer's equipment. A typical distribution system can involve of Substation, Distribution Feeder Circuits and Switches, Protective equipment, Primary Circuits and Distribution Transformers (Phone Myint, 2012).

(iv) Power generation Plant

A power generation plant is a facility equipments that designed to produce electric energy from another form of energy. The major types of generating electric power today are

- Hydroelectric plants
- Thermal power plants
- Solar power plants
- Wind power plants (Naung San Lin, 2016).

2.5 Electricity Development and Economic Growth

Electricity is so essential to the economic development of every nations because it brings about investment opportunities for the country. In a country with a fair share of electricity, investors come in because the cost of production in a country is minimal compare to where there is no electricity. Without electric light, school cannot open and students cannot study at home. Villages without any electricity can struggle to attract teachers. Farmers have to use costly diesel pumps for irrigation and cannot communicate with markets or food- processing factories without cellphones. Electricity helps to decreases mortality rate in the country because the hospitals will be effectively powered and such is a major key factor in service delivery at hospitals. Also access to affordable electricity is a necessary for the new business to emerge, induce investment and increase productivity. In countries with better electricity, good production and preservation are bigger. In such environment, agricultural productivity is increase because, the electricity can help in power irrigation, food preservation, and seed preservations. They bring about the country to have fewer damages to agricultural products they can be kept in storage facilities to avoid wasting them.

Since electricity is so central to our modern economy and lifestyle, it is a key determinant of the development. This is very important for the economic improvement of the country. If the people live in better conditions, it has bigger effects on every aspect of the country. For those who have it, it opens a world of possibilities, new opportunities to improve their quality of life, income, education, health and their freedom. Keeping electricity cheap, at least initially, help to ensure a level playing field (San Win, 2012).

The level of a society's electricity consumption is generally seen as a reflection of its economic development. Consequently, growth in consumption is often view as a vital for economic progress itself, and increasing a country's electric power supply is treated as a major activity in economic development policies and plans. In many cases, has been carried to an extreme by regarding the development of

the power sector, without regard to its impact on the output of other sectors of the economy or on the welfare of the society. Electricity is high quality carrier- more productive and flexible and control than other energy. Electricity is far more effective than any alternative technology in application such as lighting. There are high range applications such as computing and telecommunication. In the nineteenth century, electric motors proved much more flexible than steams engines and allowed the reorganization of work in factories, providing productivity gains (Kander, Malanima, and Warde, 2014).

Communication, lighting and industrial power are likely to still be the first applications when the electricity is introduced in previously unsupplied regions today. According to ADB, as a key of infrastructure component, electricity is a key to social and economic development. Its support of wide-ranging activities and services increase quality of life, increases labor productivity, and encourages entrepreneurial activity. Its stable power supply allows households and industries to improve living conditions, helping to meet heating, lightning and cooking needs across income level. And it is a key goods in economic production, making goods and services such as education, health care, clean water supply, and sanitation. As such, access to affordable electricity can help developing countries meet the United Nation Millennium Development goals Total electricity from natural gas in Myanmar 2011 was less than 6 million kWh or only 33% of the account that could be operate from a modern combine cycle generator using an equal amount of the gas (Dapice, D, 2012).

At the national level, there is also a higher share of electricity in energy use as income per captia increases (Burke, 2013). The close connection between electricity and economic activity the major improvement of the measurement of economic growth. Providing a reliable supply of electricity require costly investment such as skilled control of the electricity network. Electricity supply and demand must be generally balanced at all times in order to prevent network collapse. Due to the complexity and cost of electricity sector management and investment, power supply is often less reliable and less efficient in developing countries than developed countries.

Methods of providing small-scale electricity, such as diesel generators, are generally costly. Oil-fired generation is the dominant source of electricity among small countries : particularly island developing countries (World Bank, 2016).

2.6 SWOT Analysis of Hydro Electric Power Generation

A SWOT analysis is the evaluation of strengths, weaknesses, opportunities and Threats. The analysis group key pieces of information into two major categories:

1. Internal factors- the strengths and weakness internal to the technology and its characteristics
2. External factors- the opportunities and threats presented by the environmental external to the mini-grids (markets, regulations, competing technologies). Table 2.1 shows the SWOT framework.

Table2.1 SWOT framework

Strength Internal + Helpful	Weaknesses Internal + Harmful
Opportunities External + Helpful	Threats External + Harmful

SWOT= Strengths, Weaknesses, Opportunities and Threats

2.7 Reviews on Previous Studies

San Win (2012), in his thesis "A study on production and consumption of Electricity in Myanmar" mainly analyzed in thesis based on the changes and progress in electric sector from 2000-2001 to 2011-2012.This study based on the secondary data from the Ministry of Electricity and other sources. He stated that the production, consumption has increased but losses is larger which is affecting the electric power sector and he pointed out that in order to induce FDI, there is need for efficient supply of electricity.

Phyu Win Ei (2001), in her thesis "The development of Electric sector in Myanmar" , mainly analyzed in thesis based on electricity supply and demand needed in Myanmar from 1988-1989 to 2000-2001. Secondary data were used in this study. She mentioned that the electricity supply and demand may be balanced in the near future and then electric power sector in Myanmar will be developed. She pointed that national economic resources must be allocated efficiently, not only among different sectors of the economy, but also within the electric power sector.

Aye Peral Hlaing (2011), in her thesis, "An analysis on hydroelectric Power development in Kayah State", in this thesis based on the progress of hydroelectric

power generation by Balachung hydroelectric power plants 1 and 2 in Kayah State. She expressed that for the longterm power generation, it is important to have sufficient resources, machines, funds for maintenance and repair and water. Her paper is used descriptive method based on secondary data from the electrical department and other sources. She recommended that it is need to make short-term and medium term policy reform priorities and to lay down the strategies for sustainable development of the power sector.

Soe Paing Myint (2005), in his thesis, “Hydroelectric Power generation in Myanmar”, mainly analyzed on the accelerating importance of hydroelectric power generation in Myanmar. Secondary data were used in his thesis. He stated that in order to have full utilization of the generated Electricity, it is necessary to take effective and control measure to reduce power losses. He highlighted that in Myanmar, electric power installation is undertaken not only by the Ministry of Electric Power but also by other state organizations.

Khin Thi Aye 2017, (Planning and Statistic Branch, Minister’s office) in her paper, “The Role of Hydropower in Myanmar”, used primary data and mainly expressed hydropower resources in Myanmar, hydropower development strategy, existing hydropower stations, current status of hydropower and future plan are mainly described.

Chapter 3

ELECTRIC POWER SECTOR IN MYANMAR

3.1 Historical Background of Myanmar Electric Power

The use of electric power had been begun in Myanmar by hydropower generation since at very late 19th century. The Rangoon Electric-Tramway and Supply company had been started traffic lightening along of Sule Pagoda road in Yangon in 1905. In the period of the independence of Myanmar, the national leaders set programs and plan for the development of the country: to improve and expend the agricultural sector with advanced technology, to exploit the natural resources effectively by cooperation with local countries (Aung Kaung Set, 2018).

According to the policy strategies by the Ministry of Industry, the main duty of Electricity Supply Board was to economically supply the electricity to where it was needed then. The service men got salary, travel allowance and they had the right to get provision fund. Then the government nationalized the 51 private enterprises. On 1st November 1953, the Rangoon Electric Tramway & Supply company was dissolved and gave compensation and then nationalized the whole country. In electric supply board, there was consisted 21 divisions, 41 districts and 335 towns (Phone Myint, 2012).

Electric Supply Board exerted force to get water resource generate hydroelectric power, they produced hydroelectric development scheme. In the means time, to get lighting for the re-establishing of the country, they used the diesel engines to produce electric power. In thermal electrification scheme, the board managed to use steam power to heat the turbine. To fulfill the requirement of electricity the government built the Baluchaung hydroelectric power plant. Later Japan paid the construction cost as a war reparation. In 1960, the hydroelectric power plants generated electricity to Yangon with 230KV power line. To Mandalay, it conducted through 130 KV power line.

Before the hydroelectricity, the generator from Ahlone with the capacity of 10 MW distributed the electricity efficiently. The industrial development corporations need to expend its industrial complex comprising foundry, Pharmaceutical Factory and Textile Mill. To developed the electricity is essential (Phyu Win Ei, 2002).

On 16 March 1972, it was changed as Electric Power Corporation (EPC). In 1972 the Revolutionary Council established Electric Power Corporation and came under the administration of the Ministry of Industry (2).

On October 1975, the Ministry of Industry was organized as No 1 and N02, the EPC was composed under the Ministry of No 2 Industry. On 12 April 1985, the Ministry of No 2 Industry was changed as Ministry of Energy, so the EPC was composed under it. On 1 April 1989, the EPC was changed into Myanmar Electric power Enterprise(MEPE). After the present government assumed state power in late 1988, MEPE was still under the Ministry of Energy and only in 1997, did the government established an independent organization known as the Ministry of Electric Power. Under this ministry, there were three departments, namely, Myanmar Electric Power Department (MEPE), Department of Electrical Power, Department of Hydropower. When the State Peace and Development Council (SPDC) assumed the state authority established the Ministry of Electric Power on 15 November, 1997. The office of the Minister of Electric Power is composed with 35 employees including senior officials and others.

On 15 May 2006, the Ministry was divided into No 1 and No 2. On 5 September 2012, they were composed as one Ministry as Ministry of Electrical Power (MOEP). The Ministry of Electrical Power (MOEP), is responsible for generation, transmission and distribution of electricity (Phone Myint, 2012).

Electric power department is at the vicinity of the office of the Minister of Electric Power. Its main object is to do program for long term and short term plans. It has to make progress report and submit it to the Minister of Electric Power. Myanmar Electric Power Enterprise emphasized on lighting, distribution of electric power to the industrial plants and factories. The hydroelectric power department examines how to use water resources systematically. When there is a water resource, it plans to construct a hydroelectric power plant (Naung San Lin, 2016).

Before 1988, 14 hydroelectric power plants were already completed and hydroelectricity that amounted to 228.226 mega-watts. After 1988, the newly built hydroelectric power plants are altogether 30 in numbers and total power generation is 517.346 mega-watts. There are over 30 hydroelectric power projects at presents, some planned and some are still under construction and total installed capacity is 5390 MW in 2016-2017 (MEPE Magazines, 2016-2017).

3.2 Legal framework of Myanmar Electric Power

When the State Peace and Development Council (SPDC) assumed the state authority established the Ministry of Electric Power on 15 November, 1997. The office of the Ministry of Electric Power is composed with 35 employees including senior officials and others.

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The objectives of Electric Power Sector are:

1. In order to transmit the generated power, through National Grid System to Regions and States by implementing the Transmission Lines and Primary Substations and by carrying out the distribution Plans for Electricity supply to the Industry and Public.
2. To provide the technical know-how and policy support for using renewable energy such as bio-mass with cooperation and participation of the local people in rural areas, remotely located from the National Grid.
3. In order to be reliable the quality of the National Grid System for generation, transmission, distribution and consumption of Electricity at the standard voltage level with the least of power interruption and losses, to be carried out by carried out by skilled staffs and by getting technical know-how from abroad.
4. In order to fulfill the electricity demand of Myanmar, to encourage the power generation not only hydro and also natural gas and coal, and to be widely and commercially operated by Wind and Solar Plants.

5. To generate more electricity from the renewable energy resources (Soe Paing Myint, 2009).

The power production sector in Myanmar had been historically governed by was passed in 2014.

The old electricity law distinguishes between generation, transmission, distribution and the use of electricity. It generally set forth the principle that permission is required by the relevant authorities for installation, generation, transmission, distribution and inspection activities.

The old law established the role of the electricity inspector and its responsibilities, which includes the settlement of the disputes between the producers vans users of electricity.

A new electricity law was enacted on 27 October 2014. The new electricity law lists which Government bodies and reforms are involved and it states a number of general principles and concepts. One of the core new achievements is the establishment of a new department within the MOEE, an electricity regulatory commission, to formulate policy, prepare tariffs, advise the MOEE, set standards and form inspection bodies.

The new law divides projects into “small” (up to 10 MW), “medium”(between 10MW to 30MW) and “large” (upwards of 3OMW). States and regions can issue permits for small and medium power plants, while the MOEE will approve permits for large scale power plants.

The new electricity rules have not been public yet, therefore, the old Electricity Rules (1985) are still in effect as long as they do not contradict the new law.

There are eight departments in electrical power sector in Myanmar. They are department of hydropower planning (DHPP), Hydropower Generation Enterprise (HPGE), Department of Electric Power Planning (DEPP), Electric Power Generation Enterprises (EPGE), Electric Supply Enterprise (ESE), Yangon Electric Supply Corporation (YESC) and Mandalay Electric Supply Cooperation (MESC).

Electricity, a basic part of nature and it is one of the most widely used forms the flows of electrical power or charge. It is a secondary energy source from conversion of other sources of energy which are called primary sources. Power Policy in Myanmar is driven by centralized government decisions making. The Myanmar's domestic energy market is influenced both by regional and international investment flows from major regional states looking for energy resources (Tun Tun Swe, 2015).

Myanmar is a natural resource rich country including abundance of gas and oil reserves and high hydro power potential are being exploited. Investors from the regions including Thailand, China, South Asia Countries, South Korean are all involved in extractive industries within the country (Than Win Swe, 2005).

Though the government of Myanmar claims that the energy sector development is vital for meeting the population's basic needs and overall development strategy, Myanmar electrification rate is very low, even after years of resource exploitation. During 2019-2020, Myanmar energy sector plans, to continue oil and gas pipeline construction, oil and gas extraction plans, hydroelectric power development and transmission line construction both for domestic use and for regional interconnection plans. Myanmar's Power Planning is based on in order to achieve its economic and social development plans of 12 % annual GDP growth, Five Year Plan was formulated to meet stated target. One of the power related objectives in the five year Plan is " To develop electric power and energy sector to be conformity with developing trend industries. In addition, specific long-term policy for the Energy Sector is as follow:

Sustainable use of natural resources to support economic growth in a sustainable manner,

1. Efficient utilization of available energy resources,
2. Smooth and reliable energy supplies for building a modern agroindustrial-based nation;
3. A well balance use of energy sources by creation of an equal distribution of the share of various primary energy sources for conversation;
4. Promoting the development and utilization of all available renewable energy resources;
5. Creating an attractive base for further investment in energy and energy related ventures.

Some apparently still relevant laws and policies related to electric power generation, distribution and consumption are;

1. Myanmar Electricity Law (1984)
2. Electricity Act 1948 (as amended in 1967)
3. Electricity Rules (1985)
4. The Petroleum Act(1934) and
5. Petroleum Rules of 1937 (as amended in 1946)

Myanmar Oil and Gas Enterprises (MOGE), the Myanmar Petroleum products Enterprises (MPPE) and the Myanmar Petrochemical Enterprises (MPE) are 100%state owned enterprises that run the secure power sector in the country. In off-grid areas, there might be providers of electricity or household electricity production technologies (eg. Diesel, pico -hydropower) (Phone Myint, Februaray, 2012).

3.3 Electrification and Power Sector Reform

In recent years, the government has initiated several reforms to improve the institutional and policy environment in the energy sector. After the lifting of many US and European Union sanction s in 2012, private sector participation has significantly increase in Myanmar generation. In 2013, the National Energy Management Committee was established to improve coordination and policy making among multiple agencies responsible for energy at the time. The Ministry of Energy prepared an Energy Master Plan and a National Energy Policy, which has adopted in 2014 to provide a broad framework and strategic directions for sector development including electrification electrification. Other major goals of the policy include energy mix diversification, higher energy efficiency and energy pricing policies that reflects costs for both suppliers and users in the energy market (San Win, 2012).

In 2014, a new Electricity Law was adopted, which established the legal basis and provided for introducing an Electricity Regulatory Commission that would catalyzed further sectors reforms and much needed private sector participation. Due to the relative freedom on the border and in Thailand this community has developed expertise and international network that have proved crucial in communicating the social and environmental impact of hydropower development in Myanmar to the international community (Simpson, A, 2013).

Short-term concessions for distribution grid in urban areas have been piloted to reduce distribution losses through private sector participation in billing and collections. As a result, distribution losses has been significantly reduced. However, continuing the lost reduction program will required substantial investments in expansion and modernization of overloaded and outdated distribution networks (Ross, R. P, 2015).

3.3.1 Policies for Electric Power Sector

Ministry not only issued the objectives for electric power sector but also laid down the following policies for power sector to get more and more improvement and to become efficient electricity utilities.

1. For sufficient electricity supply throughout the country, to expend the national power grid for effective utilization of generated power from the available energy resources such as hydro, wind, solar, thermal and other alternatives ones.
2. To conduct the electricity generation and distribution accordance with the advance technologies and to uplift and enhance the private participation in regional distribution activities.
3. To conduct Environmental and Social Impact Assessments for power generation and transmission in order to minimize these impacts.
4. To restore the power sector with corporation, boards, privates companies and regional Organization for more participation of local and foreign investment and formation of competitive power utilities.
5. To formulate the electricity acts and regulations with the assistances of the local and international experts in order to align with the open economic era.

3.4 Generation System

In Myanmar, there are three major ways to generate electricity such as hydropower, gas-fired power and fuel-fired power. Hydropower projects are the most reliable one for the country. In generating electricity, from hydropower projects, there was only Lawpita hydropower project in the past decade, but now new hydropower projects have been implemented for supply of more electricity (Aye Pearl Hlaing, 2011).

For those hydropower projects, the engines, the turbines and equipment that cannot be produced locally. All the machines imported must be cleared from the custom through special system. Then, the Government should involve into the system in order to get an active and quick movement.

The hydropower projects being implemented at top priority are Kabaung, Shweli, Phyuchaung, Shwekyin, and Yeywa hydropower projects. Kabaung and Phyuchaung hydropower projects are being implemented by joint efforts of the Ministry of Electric Power No (1) and The Ministry of Agriculture and Irrigation (MOEE Magazines, 2017-2018).

Myanmar has many abundant natural resources of energy such as hydropower, wind, solar, biomass, natural gas and geothermal. In particular, hydropower and natural gas are abundant resources for power development of Myanmar. The estimated potential hydropower is more than 100,000 MW from the country's four major river basins of Ayeyarwady, Chindwin, Sittaung and Thanlwin. The Ministry of Electric Power has identified 92 potential large hydropower projects with at least 10 MW of capacity with total potential installed capacity of 46,101 MW. According to ADB, country's proven gas reserves were estimated at 20.11 trillion cubic feet in 2012 with very large potential for exploration but most of the gas exploration are exported to Thailand and China.

In Myanmar, the another main ways of generating electricity was generation from steam power. First steam turbine was built and run in Ahlone since colonial days. After 1988, combined cycle power plant was built and it can run without furnace oil. Combine cycle power plants were built in Ahlone, Hlawga, Ywama, and Mawlayine. Myanmar has an population about 51 million people according to 2014 census. Among them only 32% of population can access electricity remaining 69% of population have no access.

From 1988 to 2011, there were 14 large hydropower plants and 29 small hydropower plants are implemented and on going plants are 23 plants in Myanmar. In government hydropower plants, the total installed capacity are 2226 MWh in 1988 and improved in 7360 MWh in 2011. Therefore, the total installed capacities are improved 3.3%. But the rare of electrification is very low comparing with other countries in region (MOEE Magazines, 2017-2018). About 70% of population of

Myanmar lives in Rural areas where average electrification rate is mere 16% (Pode, 2016). Myanmar should keep in mind that carbon di oxide for non-carbon power may make the electricity even more available in the future (Dapice, D, 2012).

Currently, there are 27 large public hydropower plants, 32 small hydropower plants, 17 gas-fired steam power plants, 1 coal- fired power plants, 11 natural gas power plants, 11 private natural gas power plants and the total installed capacity is 5437 MW. In 2016, the total household electricity consumers are 3.69 million and increased 4.05 million, thus the consumption were increased 0.36 million in Myanmar. In 2018, 31728 villages got electricity and then the overall villages in country were received 49.6% in Myanmar (MOEE magazines, 2017-2018).

Electricity Supply from hydropower is a vital role of electricity supply in Myanmar for several years till now. Due to abundant water resources, government emphasized on hydropower supply from recent years to now. The generation from hydropower is very large share of total generation of electricity. Due to very small share of available gas supply for power generation and decreases in efficiency of outdated turbines and generators, gas power stations are generated under full capacity. As March of 2018, 27 hydropower stations with installed capacity of 5390 MW and the electricity generation for hydropower deliver through 230kV and 132 kV transmission lines of National Grid system to the whole system (Soe Paing Myint, 2009).

The electric power projects are being completed and implemented with greater momentum. The Government is trying to meet the electricity need of the nation and people for the best. It is cost-effective to produce hydroelectric power among other sources. Rivers and creeks and dams are abundant in Myanmar and so it is possible to produce hydroelectric power in Myanmar. In an attempt to fulfill the need of electricity, priority is given the implementation of hydropower projects (San Win, 2012).

The hydropower projects which can supply and generate power to the national grid and other projects which will benefit 42 regions have been implemented and these projects generate nearly 2000 MW of electricity. It is estimated that throughout the country, there were 268 small, medium and large sites which have a total capacity to produce about 40000 MW of electricity. The government is building hydropower

plants in the entire nation with added momentum to increase electricity (Khin Thi Aye, 2017).

Chindwin basin project including Htamanthi project, Maykha project, Shweli project, Tarhsan projects are not imaginary ones but they are being constructed in practically. Table 3.1 shows the Electric Power Generation increase in Myanmar from 1988 to 2016.

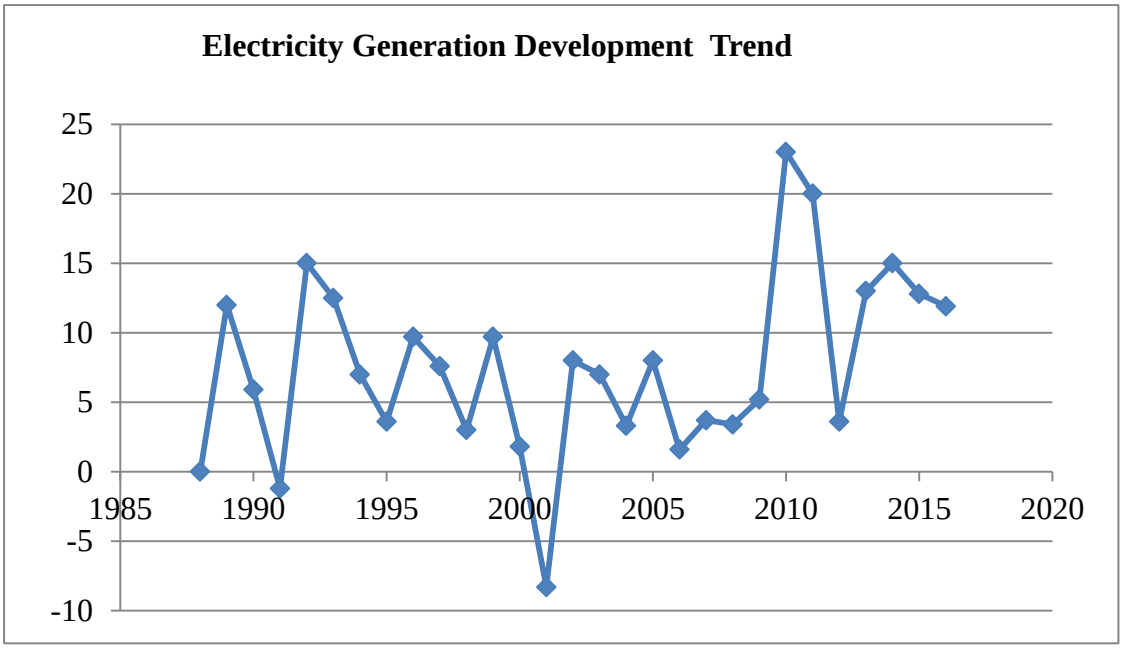
Table 3.1 Electric Power Generation Development (1988-2016)

Year	Installed Capacity (MW)	% Change in Installed Capacity
1988	2226.45	0
1989	2493.71	12
1990	2643.05	5.9
1991	2611.00	-1.2
1992	3006.60	15
1993	3386.79	12.6
1994	3631.48	7
1995	3762.33	3.6
1996	4130.31	9.7
1997	4445.38	7.6
1998	4579.29	3
1999	5024.35	9.7
2000	5117.64	1.8
2001	4688.98	-8.3
2002	5067.95	8
2003	5425.88	7
2004	5608.24	3.3
2005	6064.16	8
2006	6164.15	1.6
2007	6398.02	3.7
2008	6621.76	3.4
2009	6964.27	5.2
2010	8625.11	23
2011	10425.03	20
2012	10800.90	3.6
2013	12247.12	13
2014	14156.30	15
2015	15964.75	12.8
2016	17866.99	11.9

Source: Ministry of Electricity and Energy, 2016

According to Table 3.1, Starting from 1988, electric power generation (kW) is continuously increased when installed capacity are increased. The generation of electricity was increase almost 8.5 times from 2226.45 KW in 1988 to 17866.99 in 2016. The installed capacity is slightly decrease from5117.64 in 2000 to 4688.98 in 2001. But, the installed capacity is significantly increase from 2002 to 2016.

Figure 3.1 Electric Power Generation Development Trend (1988-2016)



Source: Ministry of Electricity and Energy

According to Figure 3.1, electricity generation trend from 1988 to 2016 shows upward trend due to the hydropower projects are implemented with momentum by government. On average, total generation improved 6.8% in annual. Hydropower's power generation in total generation increased from 42% in1988 to 62% in 2016.

Myanmar's government tries to increase electricity production with many electricity production power plan projects. Table 3.2 express Power development plan projects.

Table 3.2 Power Development Plan projects

No	Project Name	2018	2019	2200	2021	2022
1	Thaketa Gas Turbine & Combined Cyale Power Project	106				
2	Thatone Gas Turbine & Combined Cycle Power Project	108				
3	Myingyan Gas Turbine & Combined Cycle Power Project	225				
4	Minbu Solar Power Project		40	40	40	50
5	Yangon (HFO) Rental		300			
6	Yangon Karpower Rental		300			
7	Belin Gas Engine Project Rental		110			
8	Myanaung Gas Engine Project			20		
9	Ywarma Gas Turbine & Combined Cycle Power Project				150	75
10	Alone Gas Turbine & Combined Cycle Power Project			200		
11	Gas Turbine & Combined Cycle Power Project				450	600
12	Upper Kaung Taung Hydro- Power Project				51	
13	Upper Yeywa Hydro- Power Project				280	
14	Middle Paung Long Hydro- Power Project					100
15	Deedoke Hydro- Power Project					66
Total		439	750	260	971	891

Source: MOEE, 2018

For The electricity production increase, need the power development plan projects. According to Table 3.2, the government target to get 891 power projects in 2022.

3.5 Distribution System

In Myanmar, there are two major types of distribution systems:

1. Distribution within National Grid system Area (In -Grid)
2. Distribution outside National Grid System Area (off –Grid)

Distribution lines used for electricity distribution in Myanmar are (1) Overhead lines and (2) Underground Cable Lines. There are four major types of distribution lines as 33KV, 11KV, 6.6KV and 0.4KV in both overhead and underground system are used to distribute the electricity to the customers. The Overhead distribution lines are constructed generally with concrete poles and open wire system. There are many elements in distribution lines and most of the distribution structures and distribution lines are outdated and substations are shown in Table 3.3. and 3.4.

Table 3.3 Existing Distribution lines and Substations (2013)

Voltage	Length(miles)	Capacity (MWh)
33	4,543.14	4,630.55
11	9930.56	5,079.79
6.6	838.83	1,503.17
0.4	12,908.28	-
Total	28220.81	11,213.51

Source: MOEP(2013)

Table 3.4 Distribution lines

Sr. No	Line	2014-2015	2015-2016	2016-2017
1.	230KV	297.74	297.74	297.74
2.	66KV	127.31	127.31	129.52
3.	33KV	845.12	855.64	861.90
4.	11KV	1293.94	1381.28	1511.05
5.	6.6KV	670.28	670.38	670.38
6.	3.3KV	2.00	2.00	2.00
7.	0.4Kv	3454.12	3528.76	3637.21

Source: YESC (2014, 2015, 2016, 2017**)**

According to Table 3.4, the distribution lines(66 KV, 33 KV, 11 KV, 6.6 KV,0.4 KV) are increase installed in 2015, 2016,2017,2018 but (230 KV and 3.3KV) are remain unchanged. Due to outdated system structure and technology resulting in high losses and ultimately burnout and failure of the equipment on the system. Even though, MOEP is trying to improve the electricity losses on both transmission and distribution lines, losses remain high.

At present, hydropower comprises two thirds of the country's energy mix, with 3255MW of installed capacity. Hydropower is still high potential through the country. According to the Asian Development Bank (ADB), the country has hydropower potential of more than 100,000 can gain from the four main rivers: Ayeyarwady, Chindwin, Thanlwin and Sittaung.

3.6 Transmission System

The electric power is transmitted through transmission lines from main power station to substations from which the power is in turn transmitted through overhead cables, with the potential of 230 KV, 132 KV and 66KV to respective station. The erred electricity is transferred from transmission lines to distribution lines and distributed into the whole country. The Ministry of Electric power No.1 operates the National Grid System and isolated system (Phyu Win Ei, 2007).

Before 1988, there are 568.98 miles of 230 KV lines, 706.67 miles of 132 KV and 482.37 miles of 66 KV line, totally 1758.03 are connected to Main power stations of 7, 10 and 17 respectively. In 2011-12, there are 1856.30 miles of 230 KV line, 1480.70 miles of 132 KV and 2264.14 miles of 66 KV lines, totally 5601.14 are connected to Main power stations of 26, 25 and 96 respectively. In 2017-2018, totally 56699 miles are connected to Main power stations (MOEE Magazines, 2026-2017).

In order to facilitate the power transmission and distribution to the various area of Myanmar, the National Grid has been constructed since 1974. The national Grid System consists of 230 KV, 132 KV and 66 KV transmission lines are connected into a mesh. In Myanmar, National Grid system include Southern transmission lines, Northern transmission lines and Pyay transmission lines.

Table 3.5 Current Transmission Lines (2013)

Voltage(KV)	Number of lines	Length (miles)
230	47	1983.33
132	40	1406.19
66	163	2859.67
Total	250	6249.18

Source: MOEP (2013)

Myanmar has about 250 transmission lines extending 6,249 miles and among them over 60% are 66KV line system. Cross border connections have been constructed to export power from Shweli-1 (600 MW) hydropower plant and Dapein hydropower plant (240MW) to China. As electricity demand increases around 15% annually, new power plants are needed to construct and at the same time transmission lines are necessary to extend the supply and decrease the electricity losses and high voltage fluctuation.

3.7 Electricity Consumption and Electrification

Today, Myanmar has one of the lowest electrification rate and electricity consumption rate in the ASEAN region. According to census 2014, total population in Myanmar is about 51 million people and 32.4% of household using electricity for lighting and 16.45 using for cooking. According to MOEP estimation, the ratio of electrification is 32% and other 68% who living in rural areas has no access to grid electricity. The rate of electrification, consumption and economic development are the major relationship and it is necessary to increase the electrification rate for the poverty reduction.

The country's average electrification has increased from about 16% in 2006 to 26% in 2011to 34% in 2015. Yangon city has the highest electrification ratio of approximately 78% follow by Kayar (46%), Mandalay (40%) and Nay Pyi Taw (39%). The remaining rural areas are still poorly electrified, averaging less than 20%. In Kayin and Tanithari states it still remains under 10%. Under the national target of universal access by 2030, the government tried the National Electrification Plan(NEP) in September in 2014, which proposes an aggressive grid electrification rollout plan and ambitious off-grid program. The State and Regional governments are permitted to

construct small-scale hydropower plants up to 30MW according to new electricity law of 2014 (Naung San Lin, 2016).

Myanmar's national grid reaches only a minority of the country's 51 million people, electrification is mainly emphasized and constructed in large cities such as Yangon, the capital Nay Pyi Taw and Mandalay. The government estimates about 40,000 rural villages without access to government supported electricity services, through programs are proceeding to extend the national grid system and delay renewables of off-grid communities (Naung San Lin, 2016). Table 3.6 shows electric power installed, consumption and generation.

Table 3.6 Electric Power Installed, Consumption and Generation

Period	Installed Capacity (MW)	Generation (Million kWh)	Consumption (Million kWh)
2000-2001	1,171	5,117.64	3,267.94
2001-2002	1,160	4,688.98	3,040.90
2002-2003	1,190	5,067.95	3,484.09
2003-2004	1,191	5,425.88	3,849.66
2004-2005	1,562	5,608.24	3,909.18
2005-2006	1,690	6,064.16	4,352.66
2006-2007	1,684	6,164.15	4,354.99
2007-2008	1,717	6,398.02	4,438.09
2008-2009	1,848	6,621.76	4,701.26
2009-2010	2,544	6,964.27	4,993.36
2010-2011	3,413	8625.11	6,312.08
2011-2012	3,588	10,425.03	7,876.72
2012-2013	3,726	10,964.90	8,441.04
2013-2014	4,146	12,247.12	9,795.09
2014-2015	4,805	14,156.30	11,406.76
2015-2016	5,125	1569.77	13,550.81

Source: Statistical Year Book, 2015, 2016

According to Table 3.6, electric installed capacity is increase from 1171 MW in 2000-2001 to 5125 MW in 2015-2016 because of the government emphasize implementing electrification projects. The consumption were increased from 3267.94 million (kWh) in 200-2001 to 13550.81 million kWh in 2015-2016. Thus, generation was also increased year by year because of installed capacity were increased.

To increase the electrification rate and electricity consumption per capita , Myanmar government implement the country electrification plan with assistance of international organization and donors such as World Bank, ADB, JICA and other countries. With international assistances and technical transfer, the installation and generation of hydropower capacity can increase significantly year by year. Table 3.7 shows the conditions of electric power consumption in Myanmar by population.

Table (3.7) Electric Power Consumption in Myanmar (1990-2016)

Year	Share % of Total Population	Share % of Urban Population	Share % of Rural Population
1990	31	82	20
1991	31	83	20
1992	32	83	20
1993	33	83	21
1994	33	83	21
1995	34	84	22
1996	34	84	23
1997	34	84	23
1998	35	84	25
1999	36	85	25
2000	36	85	25
2001	36	85	26
2002	37	85	28
2003	37	85	28
2004	38	86	29
2005	38	86	30
2006	39	86	31
2007	38	86	30
2008	38	87	30
2009	39	87	31
2010	40	89	31
2011	39	87	32
2012	39	88	32
2013	39	88	33
2014	40	85	35
2015	41	90	38
2016	41	89	38

Source: World Bank, 2017

In electricity consumption in Myanmar, by sector, residential contributes 20%, industrial 40% and commercial 40% respectively according to Table 3.7. Increase in domestic consumption of electricity is due to increase in living standard, improved in industrial sector and increase utilization of modern devices such as refrigerators, television, air con, computer, watching machines and so on. This is because of Myanmar government has planned and applied industrial improve projects to increase the overall sectors.

Electric Power Consumption measure the ability of electricity from not only national grid but also operated small scale plants and solar and wind. According to World Bank data, 41 % of total population has access to use electricity in 2016, 89% of urban population and 38% of rural population. Rural citizens rely mainly on alternative sources, often powered by diesel-powered mini-grids.

The Asian development Bank (ADB) recently released an excellent report on Myanmar's energy sector. They show demand doubling from 12,459 million kWh in 2012-2013 to 25,683 million kWh in 2017-2018, a compound growth rate of 13% per annually. Due to rapid economic growth and urbanization, more electricity is needed to meet the growing demand and more power stations needed to be constructed to meet the annual demand increases. Myanmar export practices have left insufficient energy supplies for meeting domestic demand, and this gap will widen as demand growth is projected to exceed supply expansion by double or triple the rate per year. Old equipment lacking new investments mean power generation facilities operate below peak load capacity. The International Energy Agency (IEA) estimates the efficiency of fossil-fuel power plants in Myanmar is 28 percent, the lowest in the region. Also, the Myanmar government estimate 20% of power is lost during transmission and distribution. The Myanmar government is also planning to construct a number of new gas-fired power stations and retrofit old gas-fired turbines to improve efficiency and productivity (Phone Myint, 2012).

Electricity consumption is growing fast, and electricity shortage remain high, peaking at about 30% of power demand in 2012-2013 in Myanmar (Chauvet, Lisa, and Alexa Tiemann).The government of the Union of Myanmar try to continues to build, operate, manage and construct the small hydropower plants to provide off-grid power. Previous times, 32 mini hydropower plants under MOEE with total generating

capacity of 33.1 MW supply electricity to village and small industries are not connected to the national grid (Rachel Posner Ross, 2015).Currently, 64% of total power generation is consumed in Yangon and all other areas in the country are using the remaining 36% in Myanmar. This is the reason that ministry of electric power classified into two distribution departments and YESC is taking authority of power distribution in Yangon region and ESE is taking the other areas.

3.7.1 Electricity Consumption of States, Regions, Towns and Villages in Myanmar

The condition of electricity consumption of States and Regions of Myanmar, the consumption increased due to MEPE promote generation. Electricity consumption in Yangon Division high annually which is the highest consumption of all because Yangon Division consists of a capital City with a large population, greater number of residential building , extension of industrial zones, factories, workshops, government offices, other institution , cooperation and establishment (Naung San Lin, 2016).

The second highest is Magway Division, where total consumption in this division has increased doubled. Mandalay division is the third highest consumption which consume 13% of total population within 11 years. States and Divisions with least consumption are Chin, Kachin, Kayah, Rakhine States and Tanathari Divisions. Because of low level of the development, low level of living standards, difficulties in transportation, long distance from National Grid System and with traditional agricultural system, such as farming and fisheries, consumption was only 0.3% to 0.4% of the total consumption (Naung San Lin, 2016). Table 3.8 shows Electricity consumption by type.

Table 3.8 Electricity Consumption By Type

So. No	Year	Total	Domestic Power	Industrial Power	Bulk	Other
1	1988-1989	1428.21	500.1	737.74	1496.68	40.69
2	1989-1990	1600.56	570.39	804.87	183.15	42.24
3	1990-1991	1675.2	628.91	787.5	214.03	44.76
4	1991-1992	1879.86	690.17	923.56	217.6	48.53
5	1992-1993	1831.46	770.59	768.93	238.36	53.58
6	1993-1994	2059.17	887.89	850.89	263.03	57.36
7	1994-1995	2218.01	982.36	862.9	302.35	69.9
8	1995-1996	2262.37	972.29	875.67	340.21	74.2
9	1996-1997	2433.8	1089.24	875.65	392.51	76.4
10	1997-1998	2676.08	1206.46	914.02	472.9	82.7
11	1998-1999	2848.02	1277.11	962.58	520.19	88.14
12	1999-2000	3140.78	1459.82	1014.76	572.21	93.99
13	2000-2001	3267.94	1361.02	1295.43	526.52	84.98
14	2001-2002	3040.9	1244.72	1147.01	563.51	84.81
15	2002-2003	3484.09	1430.88	1417.01	552.22	83.98
16	2003-2004	3849.66	1611.9	1576.82	578.31	82.63
17	2004-2005	3909.18	1662.3	1549.09	613.08	84.71
18	2005-2006	4352.66	1811.97	1756.42	695.41	88.86
19	2006-2007	4354.99	1614.04	1853.62	826.69	60.64
20	2007-2008	4438.09	1646.92	1871.83	863.96	55.38
21	2008-2009	4701.26	1798.51	1904.44	944.98	53.33
22	2009-2010	4993.36	2015.13	1849.74	1071.07	57.42
23	2010-2011	6312.08	2653.33	2286.77	1306.38	65.6
24	2011-2012	7716.86	3380.97	2727.37	1531.71	76.81
25	2012-2013	8255.19	3655.18	2676.57	1642.81	280.63
26	2013-2014	9612.64	3764	2699	1692.12	1457.52
27	2014-2015	11254.95	4112.83	2984.6	1754.58	2402.94
28	2015-2016	13396.55	3567.15	2144.85	1463.75	6220.8

Source: Statistical Year Book, 2015, 2016

According to Table 3.8, the electricity consumption of domestic power is 500.10 in 1988-89 and increased 3567.15 in 1015-2016 and also industrial power is 777.74 in 2015-2016. The increased in domestic purpose is higher than industrial power because of the shortage of electric supply, load shedding made mostly in industrial zones.

3.7.2 Electrified Towns and Villages in States and Divisions

Since 1988-89, there was only 287 electrified towns. But now it has increased to 323 towns in 1996-97 which express that within 9 years, 36 townships now had access to electricity. There was no improve in the number of electrified township from 1996-97 to 2001-02, as there was no improvement of electricity distribution because of difficult communication and long distance from National Grid System (Phone Myint, 2012).

Of the townships and villages in State and Divisions, most of the townships and villages in Kayin, Chin, Mon, Rakhin States and Sagaing, Ayeyarwady, Tannitharayi , Bago, Magway, Yangon Divisions gained electricity and the rest of the States and Divisions gained 83% to 98% of total of 1621 villages, 749 villages have now access to electricity in 1988-89 and 1098 villages in 2000-01. Therefore, only 10% of villages are electrified.Thus, rural electrification should be increased.

In villages, forest products, such as firewood, coal, are used for instead of electricity and caused deforestation. In the long-term, rural electrification will decrease from the use of firewood and decrease deforestation. Thus, there is a large gap of development between city and villages (Phyu Win Ei, 2002).

At around 160 kWh, Myanmar's annual electricity consumption per capita is twenty times lower than the world average. At about 30 percentage, the overall electricity rate is low compared with the Myanmar's regional peers. Two-thirds of population and 84% of rural household are not connected to the national electricity grid.

As a result, electricity consumption is growing significantly fast. Due to heavy reliance on extremely seasonal hydropower with low firm capacity, the existing power generation system cannot meet the peek demand during the dry season. Electricity shortages and supply disruptions are widespread during the dry seasons (Phone Myint, 2012).The number of electrified towns and villages by government grid in Myanmar has improved slightly. Under the national target of universal access by 2030, the government try to implement the National Electrification Plan in September 2014,

providing for an aggressive grid electrification systems an ambitious of off-grid programs. Between 1990 and 2016, the electrified towns and villages were arisen from 380 towns and 466 villages to 564 towns and 24531 villages respectively.

The government of the Union of Myanmar continues to build, operate and manage and construct the small hydropower plants to provide off-grid power. Previous times, 32 mini hydropower plants under MOEE with total generating capacity of 33.1 MW supply electricity to village and small industries not connected to the national grid .

Currently, 64% of total power generation is consumed in Yangon and all other areas in the country are using the remaining 36%.This is the reason that ministry of electric power divided two distribution departments and YESC is taking authority of the power distribution in Yangon region .Table 3.9 shows Electrification of Towns and Villages in Myanmar.

Table (3.9) Electrification of Towns and Villages in Myanmar, 2016

No	Region/State	Total Towns	Electrified Towns	Total Villages	Electrified Villages
1	Yangon	-	-	2128	577
2	Kachin	10	10	2579	40
3	Kayar	5	5	511	104
4	Kayin	5	5	2063	64
5	Chin	1	1	1346	-
6	Mon	11	11	1182	327
7	Rakhine	9	9	3860	43
8	Tanarthari	-	-	1230	-
9	Shan (South)	28	28	4965	524
10	Shan (North)	14	14	5893	199
11	Shan (East)	-	-	3501	-
12	Sagaing	28	28	6003	1010
13	Mandalay	33	33	4780	1055
14	Magway	21	21	4795	499
15	Nay PyiTaw	8	8	799	216
16	Bago (East)	18	18	2941	449
17	Bago (West)	15	15	3623	629
18	Ayrewarday	345	34	11935	532
	Total	377	240	64134	6268

Source: Ministry of Electricity and Energy, 2016

According to Table 3.9, the number of electrified villages are increased every Region and State. Because of government is trying to increase electrified both rural and urban areas. Hydropower projects are implemented momentum with sole by Ministry of Electrical Power Energy and local entrepreneurs and foreign company.

Regarding users condition, in 1988, there are 0.6 million households out of 5.59 million households (out of 5.59 million households) have accessed to electricity with home-used meters which accounted for 10.7% household. In 2016, there are 2.1 million households have access to electricity with home use meters. These data are shown in Table 3.10.

Table 3.10 Households and number of installed meters for the Union (2016)

Particular	Unit	1988	2016
Population	Million	39	53.58
Household Total	Million	5.59	8.3
Installed Household	Million	0.6	2.1
Percentage of Installed Household	Percent	10.7	25.3

Source: Ministry of Electricity and Energy, 2016

According to Table 3.10, when the total household increase, the population was increase from 39 million in 1988 to 8.3 million in 2016. Therefore, the percentage of installed meters of household was increased from 10.75 in 1988 to 25.3 % in 2016. Average annual per capita electricity consumption is 160 kWh, one-twentieth the world average. Installed capacities are express in Table 3.11.

Table 3.11 Installed Capacity

Types of generation	**Grid system (MW)**	**Isolated (MW)**	**Total(MW)**	**(%)**
Installed capacity	5,254.9	135.069	5,389.97	100%
Hydroelectric	3.221	34,174	3,255.174	60.39%
Gas	1,913.9	6.60	1,920.50	35.63%
Coal	120	-	120	2.23%
Diesel	-	94.295	94.295	1.75%

Source: MOEE data

The installed capacity (2015-2016) is shown in Table 3.11. According to the table, most of the generation bases on hydropower which is 60.39% of the total installation. The second is 35.63% coal power although Myanmar is rich in natural gas. Coal is 2.23% and diesel engines supply only 1.75.

3.8 Investment Opportunities in Power Sector

Myanmar needs additional electricity as soon as possible in order to improve economic development, there are many opportunities to invest in power generation, transmission and distribution in Myanmar.

3.8.1 Oil and Gas

The government has plan to use Liquefied Petroleum Gas (LPG) to meet the rapid growth of domestic power demand by 2020. The Myanmar Oil and Gas Enterprise (MOGE) under the Ministry of Electricity and Energy plans to improve the oil and gas sector and engaged in three joint ventures with international service companies in 2017. The joint venture emphasized on onshore seismic acquisition services, onshore drilling services and onshore pipeline construction and maintenance services.

By the end of December 2017, the oil and gas sector induced over US $ 22.4 billion foreign direct investment from 154 permitted foreign enterprises and organization. In order to Myanmar oil and gas sector will continue to grow, there were opportunities to use cost-effective solutions to local oil and services companies. The oil and gas sector plays a key vital role in driving the sustainable economic growth and boosting and improvement of the country's GDP.

3.8.2 Solar

Solar energy has the potential aspect in Myanmar, and it can solve power shortage problems in rural communities, especially in Central Myanmar and the Dry Zone. In October 2015, Black and Veatch company was appointed to implement by Thailand Green Earth Power (GEP) to support design for a 220 MW PV power plant to be built in Minbu, Magway Region. There are the major six solar power plans to generate 1,460 MW in Central Myanmar. The projects locations involved: Sagaing and Mandalay (880 MW), Minbu (220MW), Thapyaysan (100MW), Myingyan

(150MW), Wundwin (Meikgtila) (150 MW) and Shwemyo (10MW) . In addition, floating pilot projects are also planned to construct for Kun Chaung Dam (30MW), Zaung Tu Dam (30MW) and Shwe Gyin Dam (30 MW). Myanmar need efficient and effective electricity supply as soon as possible and there are several opportunities for foreign investment in the power sector, such as hydropower, coal, gas and solar energy as well as wind power and tidal power. The Ministry also tries to have responsible electricity price per unit, efficient electricity generation and the least impact on society and environment and update technology.

3.8.3 Hydropower

According to the Ministry of Electricity and Energy (MOEE)'s long term plan, power generation from hydropower is a major components to fulfill increasing for electricity. Myanmar has only developed 3GW out of Potential of more than 100GW of hydropower throughout the country. In order to develop hydropower energy, another 46 GW of technically potential has been planned to improve. Major hydropower resources can be found in Kayin State, Shan State, and Kayah State, which is constructed along the Salween river. These starts have many potential power for those who are interested to invest in hydropower in Myanmar.

Chapter 4

HYDRO ELECTRIC GENERATION IN MYANMAR

4.1 Back ground of Hydro Electric Power Plants in Myanmar

Energy utilization in Myanmar mainly depend upon traditional energy such as fuel wood, charcoal and biomass. During 1999-2000, 35 percent of the total energy consumption is contributed by commercial energy such as oil, natural gas, coal and hydropower. The balance utilization of different energy type have all along been emphasized and increased production of commercial energy has been prioritized in order to replace traditional energy types and at the same time to meet the requirement of industrial development plan.

Baluchaung hydropower project is the first sources of hydroelectric power in Myanmar and it's located in Loikaw township , Kayah State. There are seven States and seven Regions in Union of Myanmar and kayah state is the smallest in the 14 States and Regions. There are two districts in Kayah States , Bawlake and Loikaw which are divided into seven townships ,the State capatial is Loikaw. Majory economy of this State are irrigated agriculture, the hydropower and mining sectors. The Baluchaung hydropower is the serving as one of the major hydropower source for Myanmar. It produced about 200 Mw and about 10% of electrical power of the whole country.

The Balachaung project is the first hydroelectric project selected by the Government of the Union of Myanmar for implementation, it has the ultimate total installed capacity of 240 MW with total energy output of about 1,700 million kilowatt hours. The implementation of the first power station known as Baluchaung power station with installed capacity of 168 MW has been carried out in two stages. The commissioning of the first three generators was started in April in 1960 and the second three generators started in March 1974. Myanmar Electric Power

Enterprise has identified more than 200 potential hydropower sites throughout the country which has a total capacity is only 360.32 MW, constituting about 31 percent of total installed capacity. The generation of electricity from hydropower plants during 1999-2000 have been approximately 959.46 million kWh constituting about 21 percent of the total power generation. There have been delay in the exploitation of hydropower reserves because of the high capacity investment requirement. In the past several years, the contribution of hydroelectricity is about 3 percent of the country's total energy consumption. MEPE has developed 26 mini and 9 medium size hydropower projects who capacities are between 24 kW and 5,000 kW mostly in remote border areas.

It is estimated that the hydropower installed capacity of 1,171.8 MW will increase to 2,67.5 MW in Year 2005-2006. In order to meet increasing demand in electricity consumption , mini and medium scale hydropower projects are to be implemented in addition to major hydropower for domestic supply that are planned to be constructed for export to neighboring countries (Aye Pearl Hlaing, 2011).

4.2 Hydropower Resources in Myanmar

Myanmar's hydropower sector has been developed since 1990s. The contribution of hydropower to electricity production has improved and the hydroelectric power supply has become the priority of all the electricity consumes in Myanmar. At present, 27 hydropower stations with the total install capacity of 3221 MW generate the electricity and these stations have connected to the national grid for electricity power supply. Moreover, about 8 hydropower projects are under implementation and constructed several more are under planning. In Myanmar, Ministry of Electricity and Energy responsible for the most national energy and electricity activities under one umbrella and supported the framework for a comprehensive and balanced energy and electricity plan and programs.

But 92 potential medium and large hydropower projects (between 10 MW and 50 MW are 32 numbers more than 50 MW are 60 numbers) with the total potential improved capacity about 46099 MW and 210 potential small hydropower projects with the total potential installed capacity of about 231 MW have been classified (Khin Thi Aye, 2017). The total number of classified size for hydropower production for Myanmar is 266. The largest electricity potential is located in Kayin, Shan and

Kayah States as they have the optimal topographic and climate conditions (Kattelus, 2015). Hydropower potentials in major River Basin is shown in Table 4.1.

Table 4.1 Hydropower Potential River Basin

Sr No.	River Basins	Number of hydropower Projects	Installed capacity (MW)
1	Ayeyarwaddy	34	21821
2	Chindwin	8	3015
3	Sittaung	11	1128
4	ThanLwin	21	17641
5	Mekong	4	720
6	Others	14	1776
	Total	92	46101

Source: Ministry of Electricity and Energy, 2016

According to Table 4.1, Ayeyarwady river basin has the highest hydropower projectd and installed capacity are the maximized other basins. ThanLwin, Sittaung, and others river basins are second highest projects and Chindwin and Mekong river basins are the small project number. Therefore, more hydropower projects and hydropower plants are constructed, the installed capacity are more higher.

4.3 Current Hydropower Stations in Myanmar

In Myanmar, the government is trying to increase electricity supply to meet demand of consumes and installed capacity and update the transmission and distribution lines. Therefore, the government plan to built and construct new hydropower plants and on going many hydropower projects are undertaking with momentum.

At present, total 27 number of hydropower stations with the total installed capacity of 3221 MW have been connected to the national grid system. Among them, 22 numbers of hydropower stations with the total installed capacity of 2110 MW have been constructed with solely invested by Ministry, 2 numbers of hydropower stations with the total installed capacity of 172 MW has been constructed by local entrepreneurs on BOT basis and the rest two hydropower stations with the total

installed capacity of 939 MW has been constructed by foreign companies on JV/BOT basis (MEPE Magizines, 2017-2018).

4.3.1 Current Hydropower System

In the current power system, consists of four major components, namely hydropower, natural gas, coal –fired power and diesel power generation. Currently, hydropower condition is the largest share in the power system. As a share of total installed capacity (5409 MW) on the grid, hydropower in power system currently account for 60% (3221 MW), natural gas account for 36% (1967 MW), diesel engine generation account for 2% (101) MW and coal-fired power plant accounts for the remaining 25 (120MW) in Myanmar (Khin Thi Aye, 2017). The development of hydropower projects can decrease poverty elevation by means of increases in electrification rate and income. On the other way, country gross domestic product can increase by implementing and investing expenditure in small, medium and large hydropower projects and capital inflows by international organizations, cooperations and donors. The potential source of 92 large hydropower in the States and Regions are describes in Table 4.2.

Table 4.2 Hydropower Potential of Myanmar By Region

State/Region	No. of Sites	Potential (MW)
Kachin	19	18,744.50
Kayah	5	954
Kayin	9	7,064
Sagaing	6	2,830
Tanintharyi	6	711
Bago	8	538
Magway	5	359
Mandalay	9	1,555
Mon	2	290
Rakhine	6	764.5
Shan	17	12,289.30
Total	92	46,099.30

Source: MOEP, 2012

According to the Table 4.2, northern part and eastern part of Myanmar has much hydropower potential 19 sites with the potential of 18,744.5 MW in Kachin

State and 17 sites with the potential of 12,289.3 MW in Shan State. It is found that the most hydropower projects constructing sites are far away from the area of Yangon. The development of Current hydropower stations in Myanmar are shown in Table 4.3.

Table4.3 Current Hydropower Stations in Myanmar

No	Stations	Installed Capacity(MW)	Annual generation (MWh)
1	Balauchaung(1)	28	200
2	Balauchaung(2)	168	1190
3	Kinda	56	165
4	Sedawgyi	25	134
5	Zawgyi(1)	18	35
6	Zawgyi(2)	12	30
7	Zaungtu	20	76
8	Thaphanseik	30	117.2
9	MoneChaung	75	330
10	Paunglaung	280	911
11	Yenwe	25	123
12	Kabaung	30	120
13	KengTaung	54	377.6
14	Yeywa	790	3550
15	Shwekyin	75	262
16	Kun Chaung	60	190
17	Kyeewa	74	370
18	Nancho	40	152
19	PhyuChaung	40	120
20	Upper PaungLaung	140	454
21	Myogyi	30	135.7
22	Myittha	40	170
23	Thaukyegat(2)	120	604
24	Balachaung(3)	52	334
25	Shweli(1)	600	4022
26	Dapein(1)	240	1065
27	ChipweNge	99	433
	Total installed capacity	3221	

Source: Ministry of Electricity and Energy, 2016

According to Table 4.3, there are 27 hydro power stations in Myanmar. Among them, Balachaung(2), Yeywa, Shweli (1) hydro power plants are greater

annual generation (MWh) than the other plants. The annual generation are 40222MWh in Shweli(1), 3550MWh in Yeywa and 1190 MWh in Balauchaung. Therefore, Shweli (1) power plants is produce the highest hydro electric power in Myanmar.

4.3.2 Hydropower Generation in Myanmar

At present, eight hydropower projects with total installed capacity of 1691.6 MW are under implementation in Myanmar (Khin Thi Aye, 2017).Hydropower projects are described in Table 4.4.

Table 4.4 Hydropower Projects in under Implementation

Project Name	Location (State/Region)	Capacity (MW)	Start Year	Remark
Middle Paunglaung	Naypyitaw (Union Region)	100	2014	MOEE
Deedoke	Mandalay Region	66	2015	MOEE
Upper Nattrum	Kachin State	3.2	2014	MOEE
Thahtay	Rakhine stage	111	2008	MOEE
Shweli(3)	Shan Stage(N)	1050	2010	MOEE
Upper Yeywa	Shan Stage(N)	280	2010	MOEE
Upper Kengtawn	Shan Stage(S)	51	2008	MOEE
Upper Baiuchaung	Shan Stage(S)	30.4	2010	BOT
	Total	169.6		

Source: Ministry of Electricity and Energy, 2014, 2015

According to Table 4.4, there are eight hydropower projects are under implementation, among them, seven hydropower projects are implemented by sole

investment and by Ministry and the rest one is implemented by local entrepreneurs on BOT basic.

4.3.3 Ongoing Hydropower Projects By MOEP

At present, hydropower includes two thirds of the country energy mix, with 3,255 MW of Installed Capacity. Hydropower still has the largest potential throughout the country. According to the Asian Development Bank (ADB), the country has hydropower potential of more than 100,000 MW, from the four main rivers: Ayeyarwady, Chindwin, Thanlwin and Sittaung.

According to the Ministry of Electricity and Energy (MOEE)'s long term plan, power generation from hydropower is a major components to fulfill increasing for electricity. Myanmar has only developed 3GW out of Potential of more than 100GW of hydropower in the country. In order to develop hydropower energy, another 46 GW of technically potential has been implemented in Myanmar. Major hydropower resources can be found in Kayin State, Shan State, and Kayah State, which is located on the Salween river. These starts have many potential for those who are interested to invest in hydropower in Myanmar. Table 4.5 shows ongoing hydropower projects by MOEP.

Table 4.5 Ongoing Hydropower Projects by MOEP, (March, 2015)

Sr. No	Project Name	Location	Installed Capacity (MW)	Annual Generation (Million KWh)
1.	Upper Paunglaung	Shan (South)	140	454
2.	Shweli (3)	Mandalay	1,050	3,300
3.	Upper Yeywa	Shan (North)	280	1,409
4.	Thahtay	Rakhine	111	386
5.	Ann	Rakhine	10	44
6.	Upper NamHtum	Kachin	3.2	14.13
	Total		1,655.2	5,874.13

Source: MOEP, 2015

According to Table 4.5, Shweli (3) hydropower project and Upper Yeywa project are higher installed capacity and annual generation .Total installed capacity of six hydropower projects under implementation by MOEP is about 1650 MW and annual generation about 5,874 million KW.

Table 4.6 Summary of Hydropower Projects (2015)

Description	No. of Projects	Total Installed Capacity (MW)
MOEP Implementation	7	1,655.2
BOT Projects	3	195
JV/ BOT Projects	4	13,800
-MOA Stage	19	16,970
-MOU Stage	9	8001
Total	42	40,621.2

Source: MOEP, 2015

According to Table 4.6, it is found that MOA stage and MOU stage of hydropower projects are higher than other BOT, and MOEP projects. In the MOA stage, many process are necessary to prepare such as financial analysis, environmental and social impact accessment, approval from relevant Ministry and approval of government office. Thus, many projects are implementing under MOA stage.

4.4 International Assistance for Future Hydropower Projects

From early 2000, Myanmar government emphasized to improve the hydropower to supply the increasing country's electricity demand. Some of the projects are implemented and completed by foreign loan and some are by state own budget. Hydropower technology is very specific technology and have to consider many alternative based on meterohydrological condition, water discharge, geological condition, economic profit and environmental and social impacts. The successful implementation and construction of the hydropower projects are technical and experience are most important other than budget.

After 2011, international organization like World Bank, ADB and JICA also give support to MOEP for power sector progress. Some other countries support technical assistance to MOEP with specific technical sector. The electricity development in Myanmar, World Bank Plan the National Electrification Plan based on geospatical approach to electrify 100% in Year 2030. According to the JICA Master Plan, the total installed capacity will get to 23,594 MW where 8,896 MW from hydro, 4758 MW from gas, 7940 MW from coal and 2000 MW from other renewable energy in Myanmar (Naung San Lin, 2016).With international assistance and technical transfer, the installation and generation of hydropower capacity improved significantly year by year as shown in Table 4.7. Hydroelectric power installed capacity from 1990 to 2016 is shown in the following Table 4.7.

Table 4.7 Hydropower Installation (1990 to 2016)

Year	Hydropower Installed Capacity (MW)	Percent Change in Hydropower Installed Capacity
1990-1991	226	33
1991-1992	258	32
1992-1993	289	36
1993-1994	291	36
1994-1995	299	36
1995-1996	317	32
1996-1997	327	32
1997-1998	328	31
1998-1999	340	32
1999-2000	360	30
2000-2001	360	31
2001-2002	360	31
2002-2003	391	33
2003-2004	391	33
2004-2005	746	48
2005-2006	746	44
2006-2007	771	46
2007-2008	803	47
2008-2009	947	44
2009-2010	1,654	34
2010-2011	2,522	54
2011-2012	2,693	56
2012-2013	2,813	59
2013-2014	3,005	56
2014-2015	3,185	59
2015-2016	5,125	60

Source: Statistical Year book, 2015, 2016

According to Table 4.7, the installed capacity of hydropower supply sharply increased from 226 MW in 1985-1986 to 5125MW in 2015-2016 in which isolated hydropower generation from hydropower stations are added. In general, hydropower development should be implemented in order to prioritizing the Hydropower Master plan.

Among Myanmar electricity generation, hydropower generation contribute largest share in Myanmar electricity generation. As the government strive to increase hydropower projects implementation, the hydropower installed capacity is increase . consumption and generation are increase year by year. Table 4.8 shows the electricity generation in Myanmar and hydropower installed capacity and generation.

Table 4.8 Electricity Generation in Myanmar and Hydropower Installed Capacity and Generation (2000-2001 to 2015-2016)

Period	Installed Capacity (MW)	Generation (Million kWh)	Hydropower Installed Capacity (MW)	Hydropower Generation (Million kWh)
2000-2001	1,171	5,117.64	360	1,891.93
2001-2002	1,160	4,688.98	360	2,008.25
2002-2003	1,190	5,067.95	391	2,111.02
2003-2004	1,191	5,425.88	391	2,074.81
2004-2005	1,562	5,608.24	746	2,407.75
2005-2006	1,690	6,064.16	746	3000.80
2006-2007	1,684	6,164.15	771	3,324.63
2007-2008	1,717	6,398.02	803	3,681.51
2008-2009	1,848	6,621.76	947	4,071.08
2009-2010	2,544	6,964.27	1,654	5,256.36
2010-2011	3,413	8625.11	2,522	5,105.43
2011-2012	3,588	10,425.03	2,693	7,517.99
2012-2013	3,726	10,964.90	2,813	7,766.24
2013-2014	4,146	12,247.12	3,005	8,823.14
2014-2015	4,805	14,156.30	3,185	8,828.84
2015-2016	5,125	15969.77	5,125	9,398.98

Source: Statistical Year Book, 2015, 2016

According to Table 4.8, among electricity generation 5117.64 MW in Myanmar, the hydropower generation include 1891.93 MW in 2000-2001. When the electricity generation increased 15969.77 MW in Myanmar, the hydropower generation contributed 9,398.98 MW in 2015-2016. Therefore, the whole electricity generation increase year by year and the contribution of hydroelectric power generation was also increased and the hydropower generation is the major sector of Myanmar electricity generation. At present, hydropower comprise two thirds of the country energy mix, with 3,255 MW of Installed Capacity. Hydropower still has high

potential throughout the country. According to the Asian Development Bank (ADB), the country has hydropower potential of more than 100,000 MW, with comes four main rivers: Ayeyarwady, Chindwin, Thanlwin and Sittaung.

4.5 Inadequate Investment in Power

Influenced by national economic infrastructure reform, power consumption hasimproved. During 1990-91, investment in power supply accounted for 8.0 % of total public investments, MOEP is mainly dependence on high levels of foreign assistance to get financial aid and/ or self- investment in the electrical sector. Based on these facts, the expectation of micro-economic development and power demand are much lower than reality. Some expect suggest that many existing investments in electricity generation facilities could become imperiled. If the value of production from an existing investment falls below its costs of production, the invested capital becomes stranded. Some or all of the invested capital may be lost. Therefore, investments are becoming more active in this field.

(I) Huge-Power- Consuming Industries' Development

Industrial development is considered one of the most vital driving forces in the overall economic growth and development. After being transformed to market economy, the industrial use of electricity has increased. Industrial consumption compromises the electricity used for that of State owned and private mills and factories. To improve the potential of industrialization and industrial know- how, the government has established (19) industrial zones at specific major areas and regions.

The demand for electricity increased significantly and dramatically and subsequently power shortages were faced. Most of private firms have to use their own generators to ensure continuous supply.

(II) Hot and Dry Weather

The long lasting high temperatures and droughts are major reasons for greater demand and loss power supply. And the inadequate administration system is the major situation of inadequate power in Myanmar.

Using simple logic, droughts led to less water in the reservoirs and more water demand for agricultural irrigation which impacted hydropower production and supply.

Most of the hydropower projects are small facilities which were not designed to utilize peak river flows. Many of these small facilities spill significant amount of water in normal year.

Unit Losses of Myanmar Electric Power

Losses in electricity are often become between suppliers and consumers. Although it can be acceptable within in a limited range, reduction of unit losses is important. In Unit Myanmar losses Electric sector, loss reduction measure are being implemented by using standard equipments in electricity generation, transmission and distribution, preventing overload, and applying appropriate engineering techniques. In order to meet increasing electricity demand and supply in today society, the supply authorities have to conduct the continuous monitoring system through the developing annual planning for generation, transmission and distribution functions (Soe Paing Myint, 2009).Unit losses can occur at three sites:

i. Losses in the power plants Losses in transmission lines
ii. Losses in distribution areas

Concerned with unit losses, it is important to know how the system works in general. An electric power system consists of three principal components that are (1) generation stations, (2) transmission lines and (3) distribution systems.

(1) Transmission and distribution lines
(2) Transformers and.
(3) Measurement systems
(1) Non- technical Losses are caused by actions external to the power systems and consist of primarly of
    (a) Electricity Theft
    (b) Non-payment by consumers and
(c) quality of conductors and electrical equipments used because electrical energy is transformed easily to heat energy during their transmission process. Table 4.7 shows Unit Losses of Electricity Generation In Myanmar. The electricity losses are occur both in transmission and in distribution line not only technical losses but also by human losses like illegal usage of electricity. Due to the long distance of transmitting electricity from power station are high demand area, the transmission losses are occurred. According to MOEP, distribution losses are more bigger than transmission losses.

Table 4.9 Unit Losses of Electricity Generation in Myanmar (1988-2016)

Year	Total Production (KW)	Unit Losses (KW)	Average % of Unit Losses in Total Production
1988	2226.45	712.46	32
1989	2493.71	847.86	34
1990	2643.05	687.19	26
1991	2611.00	939.96	36
1992	3006.60	1112.44	37
1993	3386.79	1185.37	35
1994	3631.48	1234.70	34
1995	3762.33	1429.68	38
1996	4130.31	1445.60	35
1997	4445.38	1511.42	34
1998	4579.29	1282.20	28
1999	5024.35	1607.79	32
2000	5117.64	1586.46	31
2001	4688.98	1453.58	31
2002	5067.95	1571.06	31
2003	5425.88	1573.50	29
2004	5068.24	1682.47	30
2005	6064.16	2365.02	39
2006	6164.15	1787.60	29
2007	6398.02	1919.46	30
2008	6621.76	1920.31	29
2009	6964.27	1949.99	28
2010	8625.11	1380.01	16
2011	10425.03	2085.00	20
2012	10800.9	2741.22	25
2013	12247.12	2571.89	21
2014	14156.3	2831.26	20
2015	15964.75	2413.90	15
2016	17866.99	2384.9	13

Source: World Bank Data Base, 2018

As shown in Table 4.9, the electricity losses are still higher but electricity production is increase annually. In country with tremendous natural rich, only 39.08% is electrified up to September 2016. The unit losses occur not only transformers, distribution lines and transmission lines but also the illegal uses of electricity by household.

4.6 SWOT Analysis of Hydro Electric Power Generation

Different approaches in understanding a SWOT analysis can be found in literatures. Some studies have got information from expect through such collective exercises as papers and websites (Markovska, Taseska, 2009). Table 4.10 shows Myanmar Hydroelectric power of SWOT analysis summary.

Table 4.10 Myanmar Hydroelectric Power of SWOT analysis summary

	Positive	**Negative**
Internal	**Strengths** • Favorable cost • Available potential to be developed • Public support for solar energy and opposition to coal and large-scale hydro • Can grow with increasing demand • High relevance for agricultural sector	**Weaknesses** • Uncertainty in the establishment of an independent regulatory commission • Low electricity tariff • Not supporting policy for the development of renewable • Trainings for hydropower professionals are not available
	Opportunities • Regional power trade • Seasonal complementary with other sources such as solar, natural gas • International investment interest in Myanmar • Support from international donors • Technical assistance available • Many existing mini-grids in Myanmar	**Threats** • High level of perceived corruption • Regulatory frame work missing • Uncertainty concerning grid expansion • Hydropower generation reduce in dry seasons

Source: Based on Secondary data

(I) Strengths

Micro hydropower mini-grids have favorable initial capital costs and favorable levelized energy costs in cases where consumption levels are low even if the grid-extension costs are low or moderate.

Myanmar has amongst the highest potential for hydropower potential about 100,000 MW from main four rivers. More than half of the country (about 60%) is suitable for hydroelectricity generation (Oxford Business Group, 2016).

In many cases, mini-grid generation technology can start out small and new equipments and machines, can be added as village load grow. For example: a mini-grid may add solar panel, wind turbines, larger diesels, or micro hydropower generators, expanding as the community's demand for electricity improvement. When the dam more construct, the electricity can produce and thus the near villages can get water from the dam in the irrigation system.

(II) Weakness

To induce the appropriate investment, there should be plan and program in place to resource potential conflict and secure transparency in the regulatory process. Myanmar power sector is under the control of the state-owned government , vertically integrated utility Electric Power Generation Enterprise (EPGE) and has a small partly private energy generation component consisting of independent power producers (ADB 2016, OECD, 2014). The electricity Law of 2014 replaces the previous legislation law dating back 1954 and introduce some major changes. Decision Making become major from decentralized when the state government were allowed to approved off-grid project smaller than 30MW (Oxford Business Group, 2016, Ross, 2015). However, the conditions of having commissions remain unclear.

Electricity tariff is highly provided in Myanmar. It is responsible of the MOEE department and its own power generation products or sign power purchase agreement with private developers. Electricity produced by hydropower and coal-fired power stations (owned by MOEP) was sold to MEPE at a constant price of 20 kyats/kWh. In addition, all generation by gas-fired power plants is provided to MEPE. Generation costs of combined cycle gas turbines has been estimated about 130 kyats/kWh. As of January 2012, YESB and ESE have two major categories for their electricity tariffs.

i. 35 kyats/kWh for general purpose (households), street, lighting, government offices.

ii. 75 kyats/kWh for domestic power, small power, bulk and high-voltage temporary users.

Myanmar has not adopted any specific policy to induce investment into renewable energy. The Regulatory Indicator for Sustainable Energy, developed by the Energy Sector Management Assistance Program of the World Bank, support a global comparison of the energy situation in different countries. In sustainable energy, Myanmar offers only fiscal incentives in the form of reduce import taxes and reduce sale taxes and other taxes (World Bank, 2016). Trainings for hydropower professional are not available because of technical system is not improved in Myanmar related to other countries.

(III) Opportunities

Hydropower share is around 60% of Myanmar's power supply although the contribution of the natural gas is increasing. Power generation capacity is sufficient and efficient during the rainy season but becomes restricted and limited during dry seasons. The Energy Master Plan, which was developed with support from the ADB, the good seasonal complementary between hydropower and solar energy (Emmeerton et al, 2015). Minimum hydropower occurs between January and May, which is the time of minimum output for hydropower, the situation is reversed from July to November. During the dry season, when the power supply is restricted and limited, solar energy can be complemented with the solar chances of electricity increasing.

In Myanmar, its democratic transition and opening up to the world have induced the interest of many international investors and donors organizations. In 2014, Myanmar Government announced the development of special economic zones. Four special economic zones (SEZs) have been identified: Thilawa, Tawei, Kyauk Phyu, and Sittwe (Khandelwal and Teachout, 2016). The Thilawa Special Economic Zone, provided by Japan is the only one in cooperation, it has induced about US$ 700 Million from over 70 companies by 2016 (Hunter et al, 2018). Considering the rising electricity demand connected to Myanmar's economic growth, the power sector itself can become another business opportunities for the investor, transparent framework is developed (Matsui, 2017).

Development partners active in Myanmar, including Germany's GIZ, UK's DFID have experience with mini-grids. Countries in the region including Nepal, Sri, lanka, Indonesia, India and the philippines have many experience with the renewable energy mini-grid. Development partners in these countries involved in mini-grid have been started sharing expertise with Myanmar in international forums in Myanmar and neighboring countries.

Community, organizations and local private companies in Myanmar, have developed experience with mini-grids. While some are old and operating at low level of efficiency, many of these sites can be replaced to use modern efficient, effective and reliable equipment considerably less cost than building greenfield projects.

(IV) Threats

In 2012-2017, Myanmar was ranked of corruption 130th out of 180 countries. Likewise, corruption is recognized as an obstacle for businesses (Ferrie, 2014). An Anti-Corruption law and Commission were conducted in 2013 and 2014, respectively, but had little effect (Soe, 2018). The NLD-led government has implemented the fight against rampant corruption a key objectives and improvement has been seen in recent years (Control Risks, 2017, Naing, 2017).

Components of needed regulatory framework are involve safety, quality of services and tariffs. Basic registration function such as registration of micro-hydro power projects sites to avoid competition of water resources can be accomplished through local offices.

Under the National Electricity Plan (NEP), the national hydroelectric grids are expending constructed quickly in some areas, but other will not receive national grid electricity for 15 years. To ensure that investment in mini-grid is made in the right places and not made in the wrong places, NEP must be updated and improved to reflect the best, most recent estimates. Among the electricity generation, the hydroelectric power generation is the major source of Myanmar, the electricity generation is reduce in dry seasons in Myanmar.

Chapter 5

CONCLUSION

5.1 Findings

The electric power industry has played an important role in the dramatic economics development in Myanmar and Electricity has become a critical factor sustaining the well-being of the Myanmar People. The sufficient supply of electricity can assist in the development of all sectors such as economics, industrial, education, communication, health, transport and so on.

There is a repaid growth in population, urbanization and use of electrical appliances in Myanmar, demand for electricity is increasing year by year. According to the practice of the market economic system in Myanmar, industrial sector has become to play an important role. In order to receive more foreign direct investment, there is a need for electric supply of electricity. According to SWOT analysis, the strengths, weakness, opportunities and threats of hydroelectric power is found in Myanmar. The market oriented economic system has been practiced since 1988 in the country, thus demand for electricity increased more than before 1988. This is because of new industrial zones, housing projects and more used of electric power goods.

In Myanmar the shortage of power is a major obstacle in the development for establishment of manufacturing industries. The Government is implementing the large-scale hydropower projects throughout the country to meet the demand for electricity, instructing transmission power lines to connect the hydropower plants within the National Grid System. The generation of electric power by various power plants can be variable according to the supply resources of power.

In the rainy season, the hydro power plants can operate and generate electric power efficiently 24 hours daily. In Myanmar, the electricity is produce 70 percent by public (government), and 30 percent in private sector. In electricity production, the government is trying to produce natural-gas plants, steam turbines plants, and

hydroelectric power plants are built with momentum. Therefore, electricity production and consumption are increase average in annually. There can be some relationship between the hydropower generation and electricity consumption per capita because Myanmar's electricity generation heavily relied on the hydropower generation.

Currently, there are 27 large public hydro power plants, 32 small hydro power plants, 17 gas-fired steam power plants, 1 coal-fired power plants, 11 natural gas power plants, 11 private natural gas power plants and the total installed capacity is 5437 MW. In 2016, the total households electricity consumers are 3.69 million, thus the consumption were increased 0.36 million in Myanmar. In 2018, 31728 villages got electrified and then the overall villages in country were received 49.6% in Myanmar. Electricity Supply from hydro power is important role of electricity supply in Myanmar several years till now. Due to abundant water resources, government emphasizes on hydropower based on load of power supply up to recent years. The generation from hydropower is very large share of total generation.

The electric power projects are being implemented with greater momentum. The government is trying to meet the electricity need of the nation and people.It is cost-effective to produce hydro electric power. Before 1988, there are 568.98 miles of 230KV lines, 706.67 miles of 66 KV line, totally 1758.03 are connected to Main power stations of 7, 10 and 17 respectively. In 2017-2018, totally 56699 miles are connected to Main power stations.

According to MOEP data, the total installed capacity (MW) increased about 11% in average over the period from 2000 to 2015. The total installed capacity from hydropower is more significantly increased around 21% in average and gas around 8% and thermal and diesel about 3% respectively during the period from 2000-2001 to 2014-2015.The private electricity production in Myanmar is 2226 (kWh) in 1988 and increased 7360 (kWh) in 2011. Therefore, the electricity production increased 3.3 times. Electricity is need not only to increase industrialize but also to improve human life style, therefore, public electricity production is need to systematics.It is need to save between producers and consumers of electricity.

Although the electricity tariffs are 35 kyats (kWh) for general purposes (households), street lighting, government office and low-voltage temporary users and 75 kyats(kWh) for domestic power , small power, bulk , the private's tariffs are from

100 kyats to 560 kyats in Myanmar (especially chin state). The annual average rate of electricity is 16% in Myanmar. In household's consumption, the consumption is increased in morning at once and evening at once because of cooking in that times, the peak load is maximize. The electricity plants are faced this maximum peace load a twice in every one day.

Not only for the public can consume electricity sufficiently but also for international investments, the electricity is importance in vital role. Every Myanmar's Ministry departments are plan systematically to produce electricity for international investors. Although hydropower plants are constructed in Myanmar, there were completely do not produce of hydro power plants are 6 no of plants.They are ZaungTu, Mone, Kyue, Myittha, YazaKyo and Tarpain hydropower plants. Electricity losses are classified into technical losses and non-technical losses. Only YESC department is decrease unit losses, but other departments of Electricity are still high unit losses although government is trying to reduce unit losses.

In 2016, 31728 villages are electrified and improve electrification are increased (49.6) % in overall averages. With JICA loans, Thilawar (50 MW) plant is implemented with Sumitomo Corporation. MOEE department is plan to construct Solar power project with BOT system. Much more electricity supply is needed as well as transmission and distribution upgrades.

5.2 Suggestions

Myanmar face serious power shortage however, the country which has rich in water resources, possesses great potential for the development of the sector. With successful cooperation with the ASEAN neighbors in development of the hydropower sector, it is recommended that Myanmar should seek more foreign direct investment and cooperation with international investors to receive more benefits.

It is also need to have the awareness of conserving power generation and utilization such that there would be the most effective and efficient use of the power generated. In accordance with the market-oriented system, the YESC is trying to decrease power losses and increase sales of electric power to the consumers in Yangon city. Although the government is trying to reduce electricity losses, among the electricity departments, some departments are still increase losses. For decreasing

of power losses, the Yangon Electricity Supply Cooperation (YESC) should arrange the modern technology and the outdated transmission and distribution lines are replace with the update electricity cabal lines. Besides, the YESC should emphasizes to safe the electricity department workers and consumers. Extension of various kinds of power lines should use to increase the electricity consumption, production and transmission.

Although hydropower projects are more implemented in Myanmar, the access to electricity is lower than other countries. Lower access to electricity might not only be one of the causes of the underdevelopment of the country's private sector but also be leading existing firms to become worse performances. Enormous budget will require for power development and transmission expansion plans proposed by JICA. It is necessary to establish a more practical plan especially high priority rural electrification plans. To make efficient power supply to un-electrified villages, the promotion of medium and large hydropower development as one measure to boost capacity to supply the rural grid needed area.

Hydropower development can reduce poverty elevation by means of increases in electrification rate and income. If a country is surplus in electricity production, it will export to the other countries, therefore, this country will economic growth and improve living standard. Thus, the government should try to construct new practice hydropower plants in Myanmar. Although hydropower plants among other sources are cheap, hydropower plants are less efficient in dry season, thus not only new hydropower projects should implement bit also plan to produce other electricity production sources like steam turbines, gas-fired power plants, wind, diesel and biomass power plants. Immediate investment in combined cycle gas generator is needed to boost output, lower costs and to get more electricity from a limited gas supply.