YANGON UNIVERSITY OF ECONOMICS
MASTER OF DEVELOPMENT STUDIES PROGRAMME

A STUDY ON ELECTRICITY DISTRIBUTION SYSTEM IN NAY PYI TAW COUNCIL

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ABSTRACT

This study focuses on the Distribution of Electricity in Nay Pyi Taw (2016-2017 to 2019-2020). The aim of the study is to expose the distribution of electric power sector in Nay Pyi Taw Council and evaluate the condition of consumption and power supply services to Nay Pyi Taw Council (2016-2017 to 2019-2020). This study based on descriptive method by using secondary data and Key Informant Interview. In Nay Pyi Taw Council, Electricity Supply Enterprise (ESE) is taking charge of electricity generation and distribution for households. It is found that ESE is facing the major problem such as shortage of power supply and losses of electricity, and is trying to reduce these barriers during this period.

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LIST OF ABBREVATIONS

AC	Alternating current
BOT	Built Operate Transfer
CT	Current Transformer
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
IPP	Independent Power Plant
JC	Joint Venture
KV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Per Hour
MEPE	Myanmar Electric Power Enterprise
MESB	Mandalay Electric Supply Board
MESC	Mandalay Electric Supply Corporation
MOEE	Ministry of Electricity and Energy
MW	Mega Watt
MWh	Mega Watt Per Hour
NEP	National electrification plan
PT	Potential Transformer
SI	System Improvement
W	Watt
YESB	Yangon Electricity Supply Board
YESC	Yangon Electric Supply Corporation

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

Electricity is one of the most important blessings that science has given to mankind. It has also a part of modern life and one cannot think of a world without it. Electricity has many uses in our day to day life. It is used for lighting rooms, working fans and domestic appliances like using electric stoves, alternating current and more. All these provide comfort to people. In factories, large machines are worked with the help of electricity. Essential items like food, cloth, paper and many other things are the product of electricity.

Modern system of transportation and communication have been revolutionized by it. Electric trains and battery cars are quick mechanisms of travel. Electricity also provides means of amusement, radio, television, cinema and mobiles phones, which are the most popular forms of entertainment are the result of electricity. Modern equipment like computers and robots have also been developed because of electricity. Electricity plays a critical role in the fields of medicines and surgery too — such as X-ray, ECG. The use of electricity is increasing day by day.

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 update the distribution lines in the rest of the country.

Myanmar has increased Electricity production rate of over 470 megawatts more within a month, raising the total to 3,430 megawatts, according to Ministry of Electricity and Energy. Myanmar produced maximum amount of 3,431 megawatts on November 25 while it produced only 2,956 megawatts as of October 25. Electricity consumption rate in Yangon Region currently demands up to 1,242 megawatts, more than 36 per cent of overall electricity consumption rate. Mandalay Region uses 500 megawatts and is about 14.6 per cent of total electricity consumption rate. Nay Pyi Taw requires 130 megawatts and is at about 3.8 per cent. By comparing the other regions, Nay Pyi Taw has lower population but the consumption of electricity is 3.8 % from overall consumption. Nay Pyi Taw is the capital city of Union of Myanmar, as the seat of Government of Myanmar, there are the site of Union Parliament, the Supreme Court, the Presidential Palace, the official residences of the Cabinet of Myanmar and Headquarters of Government Ministries and Military. So, the adequate infrastructure in the form of road and railway transport system, ports, power, airports and their efficient working is also needed. Among them, Electric power and the source of its production such as coal and oil, is the most fundamental needs. By getting the adequate electricity, other infrastructure are also improved firstly. The Electricity Supply Enterprise is responsible for planning, implementation of new distribution substations and distribution lines and looking after the existing electricity distribution system only in Nay Pyi Taw Council and contribute the electricity to end users in Nay Pyi Taw Council area. Therefore, in Nay Pyi Taw Council, the electricity generation and distribution is controlled by the ESE and in this, this thesis is made an effort to examine the current status of ESE's performance in the electricity distribution, how is dealing with power supply to meet the adequate demand of this Nay Pyi Taw Council area.

1.2 Objectives of the Study

The objectives of the study are as follows:

- To expose the generation and distribution of electricity in Nay Pyi Taw Council
- To evaluate the electricity supply and administration of Electricity Supply Enterprise (ESE) in Nay Pyi Taw Council.

1.3 Method of Study

Descriptive method was used in order to analyze the electricity distribution in Nay Pyi Taw Council by using secondary data from World Bank, Ministry of Electric and Energy, various reports and researches and various websites.

A survey is conducted with interviews on Electricity Supply Enterprise officials from eight townships for the administration of ESE to provide the adequate supply of electricity in Nay Pyi Taw Council. This Key Informant interviews are done to explore the condition of electricity supply service in Nay Pyi Taw Council.

1.4 Scope and Limitation of the Study

The scope of the study is the functions of Electricity Supply Enterprise from 2015-2016 to 2018 -2019 and this study is mainly focus on distribution and power supply service of ESE in Nay Pyi Taw.

1.5 Organization of the Study

This study is organized into five chapter. Chapter (1) presents rationale, objectives, methods, scope and limitations of the study. Chapter (2) deals with the literature review concerning with history of electricity, forms of energy and importance of electricity Chapter (3) includes the overview of Electric Power sector in Myanmar Chapter (4) emphasizes on the function of ESE in Nay Pyi Taw Council Chapter (5) is the conclusion consists of findings and suggestions.

CHAPTER II
LITERATURE REVIEW

2.1 Concept of Electric Power

Electric power is energy generated through the conversion of other forms of energy, such as mechanical, thermal, or chemical energy. Electric energy is unrivaled for many uses, as for lighting, computer operation, motive power, and entertainment applications

Electric power is characterized by current or the flow of electric charge and voltage or the potential of charge to deliver energy. A given value of power can be produced by any combination of current and voltage values. If the current is direct, electronic charge progresses always in the same direction through the device receiving power. If the current is alternating, electronic charge moves back and forth in the device and in the wires connected to it. For many applications either type of current is suitable but alternating current (AC) is most widely available because of the greater efficiency with which it can be generated and distributed. A direct current (DC) is required for certain industrial applications, such as electroplating and electrometallurgical processes and for most electronic devices (Encyclopaedia Britannica, 2019)

The wide-scale production and distribution of electric power was made possible by the development of the electric generator, a device that operates on the basis of the induction principle formulated in 1831 by the English scientist Michael Faraday and independently by the American scientist Joseph Henry. There are two primary sources for driving generators—hydro and thermal. Hydroelectric power is derived from generators and turbines driven by falling water (Encyclopaedia Britannica, 2019). Most other electric energy is obtained from generators coupled to turbines driven by steam produced either by a nuclear reactor or by burning fossil fuels—namely, coal, oil, and natural gas.

Electric energy generated at a central power station is transmitted to bulk delivery points, or substations, from which it is distributed to consumers.

Transmission is accomplished by an extensive network of high-voltage power lines, including overhead wires and underground and submarine cables. Voltages higher than those suitable for power plant generators are required when transmitting alternating current over long distances in order to reduce the power losses that result from the resistance of transmission lines. Step-up transformers are employed at the generating station to increase the transmission voltage. At the substations other transformers step down the voltage to levels suitable for distribution systems (Encyclopaedia Britannica, 2019).

2.2 Environmental Impacts of the Electricity System

All forms of electricity generation have an environmental impact on our air, water and land, but it varies. Producing and using electricity more efficiently reduces both the amount of fuel needed to generate electricity and the amount of greenhouse gases and other air pollution emitted as a result. Electricity from renewable resources such as solar, geothermal, and wind generally does not contribute to climate change or local air pollution since no fuels are combusted (United States Environmental Protection Agency , 2017)

Nearly all parts of the electricity system can affect the environment, and the size of these impacts will depend on how and where the electricity is generated and delivered. In general, the environmental effects can include:

a) Emissions of greenhouse gases and other air pollutants, especially when a fuel is burned.
b) Use of water resources to produce steam, provide cooling, and serve other functions.
c) Discharges of pollution into water bodies, including thermal pollution (water that is hotter than the original temperature of the water body).
d) Generation of solid waste, which may include hazardous waste.
e) Land use for fuel production, power generation, and transmission and distribution lines.
f) Effects on plants, animals, and ecosystems that result from the air, water, waste, and land impacts above.

Some of these environmental effects can also potentially affect human health, particularly if they result in people being exposed to pollutants in air, water, or soil.

The environmental effects of the electricity we use will depend on the sources of generation available in our area. We can reduce the environmental effects of our electricity use by buying green power and by becoming more energy-efficient (Myanmar Statistical Year Book 2019, 2019) (United States Environmental Protection Agency, 2017)

More broadly, several solutions can help reduce the negative environmental impacts associated with generating electricity, including:

i. **Energy efficiency.** End-users can meet some of their needs by adopting energy-efficient technologies and practices. In this respect, energy efficiency is a resource that reduces the need to generate electricity.

ii. **Clean centralized generation.** New and existing power plants can reduce environmental impacts by increasing generation efficiency, installing pollution controls, and leveraging cleaner energy supply resources.

iii. **Clean distributed generation.** Some distributed generation, such as distributed renewable energy, can help support delivery of clean, reliable power to customers and reduce electricity losses along transmission and distribution lines.

iv. **Combined heat and power (CHP).** Also known as cogeneration, CHP produces electricity and heat simultaneously from the same fuel source. By using heat that would otherwise be wasted, CHP is both distributed generation and a form of energy efficiency (United States Environmental Protection Agency , 2017).

2.3 Sources of Electricity

Sources of electricity are everywhere in the world. Worldwide, there is a range of energy resources available to generate electricity. These energy resources fall into two main categories, often called renewable and non-renewable energy resources. Each of these resources can be used as a source to generate electricity, which is a very useful way of transferring energy from one place to another such as to the home or to industry.

The numerous existing energy types can be classified in different ways. Primary types can be used directly from coal, oil, natural gas and wood, nuclear fuels (uranium), the sun, the wind, tides, mountain lakes, the rivers (from which hydroelectric power can be obtained) and the Earth heat that supplies geothermal energy .Secondary types come from the transformation of primary energy: for example petrol, that derives from the treatment of crude oil and electrical power, obtained from the conversion of mechanical energy (hydroelectric plants, Aeolian plants), chemical plants (thermoelectric), or nuclear (nuclear plants). Electric energy is produced by electric plants, i.e. suitable installations that can transform primary energy (non-transformed) into electric energy (Electricity Forum, 2017).

2.3.1 Renewable Energy

Renewable energy derived from replaceable sources such as the Sun (solar energy), wind (wind power), rivers (hydroelectric power), hot springs (geothermal energy), tides (tidal power), and biomass (biofuels).

(I) Solar Energy

Sun is the primary source of energy. Sunlight is a clean, renewable source of energy. It is a sustainable resource, meaning it doesn't run out, but can be maintained because the sun shines almost every day. It lights our houses by day, dries our clothes and agricultural produce, keeps us warm and lots more. Its potential is however much larger. Solar energy is a perennial, natural source and free, it is available in plenty and non- pollution and does not emit any greenhouse gases. But it depends on changes in seasons/ weather – they must not be always used, requires a high initial investment for productive use, and solar energy storage technology has not reached its potential yet (Wset, 2019)

The International Energy Agency projected in 2014 that under its "high renewable" scenario, by 2050, solar photovoltaic and concentrated solar power would contribute about 16 and 11 percent, respectively, of the worldwide electricity consumption, and solar would be the world's largest source of electricity. Most solar installations would be in China and India (Wset, 2019).

(ii) Wind Energy

Wind is the movement of air that occurs when warm air rises and cooler air rushes in to replace it. The energy of the wind has been used for centuries to sail ships and drive windmills that grind grain. Today, wind energy is captured by wind turbines and used to generate electricity. Issues periodically arise about where turbines are installed, as they can be problematic for migrating birds and bats (Wset, 2019).

The wind is an intermittent energy source, which cannot make electricity nor be dispatched on demand. It also gives variable power, which is consistent from year to year but varies greatly over shorter time scales. Therefore, it must be used together with other electric power sources or storage to give a reliable supply (Wset, 2019). As the proportion of wind power in a region increases, more conventional power sources are needed to back it up (such as fossil fuel power and nuclear power), and the grid may need to be upgraded. At least 83 other countries are using wind power to supply their electric power grids.

(iii) Hydroelectricity

Water flowing downstream is a powerful force. Water is a renewable resource, constantly recharged by the global cycle of evaporation and precipitation. The heat of the sun causes water in lakes and oceans to evaporate and form clouds. The water then falls back to Earth as rain or snow and drains into rivers and streams that flow back to the ocean. Flowing water can be used to power water wheels that drive mechanical processes. And captured by turbines and generators, like those housed at many dams around the world, the energy of flowing water can be used to generate electricity. Tiny turbines can even be used to power single homes. While it is renewable, large-scale hydroelectricity can have a large ecological footprint (Wset, 2019).

(iv) Biomass and Geothermal

Biomass has been an important source of energy ever since people first began burning wood to cook food and warm themselves against the winter chill. Wood is still the most common source of biomass energy, but other sources of biomass energy include food crops, grasses and other plants, agricultural and forestry waste and residue, organic components from municipal and industrial wastes, even methane gas harvested from community landfills. Biomass can be used to produce electricity and as fuel for transportation, or to manufacture products that would otherwise require the use of non-renewable fossil fuels (Wset, 2019). The heat inside the Earth produces steam and hot water that can be used to power generators and produce electricity, or for other applications such as home heating and power generation for industry. Geothermal energy can be drawn from deep underground reservoirs by drilling, or from other geothermal reservoirs closer to the surface. This application is increasingly used to offset heating and cooling costs in residential and commercial buildings (Wset, 2019).

2.3.2 Non-renewable Energy

Non-renewable sources of energy powers can be divided into two types: fossil fuels and nuclear fuel.

The numerous existing energy types can be classified in different ways. Primary types can be used directly, as they appear in the natural environment: coal, oil, natural gas and wood, nuclear fuels (uranium), the sun, the wind, tides, mountain lakes, the rivers (from which hydroelectric power can be obtained) and the Earth heat that supplies geothermal energy (Electricity Forum, 2017)

Secondary types come from the transformation of primary energy: for example, petrol, that derives from the treatment of crude oil and electrical power, obtained from the conversion of mechanical energy (hydroelectric plants, Aeolian plants), chemical plants (thermoelectric), or nuclear (nuclear plants). Electric energy is produced by electric plants, i.e. suitable installations that can transform primary energy (non-transformed) into electric energy (Electricity Forum, 2017)

(I) Fossil Fuels

Fossil fuels include coal, petroleum, natural gas, oil shales, bitumen, tar sand, and heavy oils. All contain carbon and were formed as a result of geologic processes acting on the remains of organic matter produced by photosynthesis, a process that began in the Archean Eon (4.0 billion to 2.5 billion years ago). Most carbonaceous material occurring before the Devonian Period (419.2 million to 358.9 million years ago) was derived from algae and bacteria, whereas most carbonaceous material occurring during and after that interval was derived from plants (OttoC.Kopp, n.d.)

All fossil fuels can be burned in air or with oxygen derived from air to provide heat. This heat may be employed directly, as in the case of home furnaces, or used to produce steam to drive generators that can supply electricity. In still other cases—for example, gas turbines used in jet aircraft—the heat yielded by burning a fossil fuel serves to increase both the pressure and the temperature of the combustion products to furnish motive power (OttoC.Kopp, n.d.).

Since the beginning of the Industrial Revolution in Great Britain in the second half of the 18th century, fossil fuels have been consumed at an ever-increasing rate. Today they supply more than 80 percent of all the energy consumed by the industrially developed countries of the world. Although new deposits continue to be discovered, the reserves of the principal fossil fuels remaining on Earth are limited.

The amounts of fossil fuels that can be recovered economically are difficult to estimate, largely because of changing rates of consumption and future value as well as technological developments. Advanced in technology have made it possible to extract smaller and difficult-to-obtain deposits of fossil fuels at a reasonable cost, thereby increasing the amount of recoverable material (OttoC.Kopp, n.d.). In addition, as recoverable supplies of conventional (light-to-medium) oil became depleted, some petroleum-producing companies shifted to extracting heavy oil, as well as liquid petroleum pulled from tar sands and oil shales.

(ii) Nuclear Fuel

These fuels are fissile, and the most common nuclear fuels are the radioactive metals uranium-235 and plutonium-239. All processes involved in obtaining, refining, and using this fuel make up a cycle known as the nuclear fuel cycle.

Uranium-235 is used as a fuel in different concentrations. Some reactors, such as the CANDU reactor, can use natural uranium with uranium-235 concentrations of only 0.7%, while other reactors require the uranium to be slightly enriched to levels of 3% to 5%. Plutonium-239 is produced and used in reactors (specifically fast breeder reactors) that contain significant amounts of uranium-238. It can also be recycled and used as a fuel in thermal reactors. (al, 2018)

While nuclear fuel is not renewable, it is sustainable since there is so much of it. It will run out eventually, but not for centuries. Unlike fossil fuels, using nuclear fuels to produce energy does not directly produce carbon dioxide or sulfur dioxide. It should be mentioned that the processes of mining, transporting, and refining the fuel have carbon emissions associated with them, comparable to those of wind and solar power (al, 2018). Although the carbon footprint of using nuclear fuels is smaller, there are still disadvantages of using nuclear fuel. The waste, while a much lower volume must be handled very carefully because of its radioactivity. Nuclear fuels require far more complicated systems to extract their energy, which calls for greater regulation. These complex systems and regulation make for very long build times. In addition, public opinions on nuclear energy tend to be more negative than with other energy sources. The over-estimation of the dangers associated with releases of radioactive material is a significant issue, as large-scale nuclear incidents are rare (al, 2018).

2.4 Economic Benefits of Renewable Energy Development

The benefits of renewable energy development and production are significant and numerous. In addition to the key economic benefits detailed in this report, energy produced from renewable sources also helps protect our shared environment and preserve other ecosystem services, including reducing greenhouse gas emissions which helps address the threat of climate change. Sustainable sources of energy, such as those from solar, wind, and geothermal resources, help stabilize the economy by reducing uncertainty in future energy prices and help to ensure the nation has a sufficient supply of energy for future generations. Increasing renewable energy development decreases our country's dependence on foreign oil, which helps support national security and eases foreign relations (Nikki Springer, 2020).

Renewable energy development also supports a strong domestic economy and creates jobs with competitive wages, often in rural or economically depressed areas, and further, helps sustain local economies via capital investments, taxes, and related economic activities. The development of large renewable energy projects can also prompt other infrastructure investments that provide additional benefits to local communities, such as roads and data communication infrastructure. It is important to note that some communities whose economies are currently closely tied to fossil fuels, such as communities with many jobs in coal mines or at coal-fired power plants, are facing economic uncertainty (Nikki Springer, 2020). Renewable energy provides some important opportunities — for example, imagine a community facing a loss of jobs from a coal-fired power plant. If solar energy were developed nearby to take advantage of the existing transmission lines running from the coal-fired power plant, some solar construction and operations and maintenance jobs would be created. However, as a nation, we must ensure we are developing comprehensive plans to assist these communities as they diversify their economies. Given the differences in staffing requirements between the fossil fuel energy sector and the renewable energy sector, especially for long-term operations and maintenance jobs, truly comprehensive transition plans will likely require job training and investment in sectors beyond renewable energy alone (Nikki Springer, 2020).

2.5 Electricity Distribution System

Electricity distribution is the final stage in the delivery of electricity to end users. A distribution system's network carries electricity from the transmission system and delivers it to consumers. Typically, the network would include medium-voltage (less than 50 kV) power lines, substations and pole-mounted transformers, low-voltage (less than 1 kV) distribution wiring and sometimes meters. The modern distribution system begins as the primary circuit leaves the sub-station and ends as the secondary service enters the customer's meter socket. Distribution circuits serve many customers. The voltage used is appropriate for the shorter distance and varies from 2,300 to about 35,000 volts depending on utility standard practice, distance, and load to be served. Distribution circuits are fed from a transformer located in an electrical substation, where the voltage is reduced from the high values used for power transmission.

Conductors for distribution may be carried on overhead pole lines, or in densely populated areas where they are buried underground. Urban and suburban distribution is done with three-phase systems to serve both residential, commercial, and industrial loads. Distribution in rural areas may be only single-phase if it is not economical to install three-phase power for relatively few and small customers.

Only large consumers are fed directly from distribution voltages; most utility customers are connected to a transformer, which reduces the distribution voltage to the relatively low voltage used by lighting and interior wiring systems. The transformer may be pole-mounted or set on the ground in a protective enclosure. In rural areas a pole-mount transformer may serve only one customer, but in more built-up areas multiple customers may be connected. In very dense city areas, a secondary network may be formed with many transformers feeding into a common bus at the utilization voltage. Each customer has an "electrical service" or "service drop" connection and a meter for billing.

2.6 Energy and Economic Growth

Physical laws describe the operating constraints of economic systems (Boulding, 1966; Ayres and Kneese, 1969). Production requires energy to carry out work to convert materials into desired products and to transport raw materials, goods, and people. The second law of thermodynamics (the entropy law) implies that energy cannot be reused and there are limits to how much energy efficiency can be improved.

These limits can be approximated by a production function with an elasticity of substitution significantly below one (Stern, 1997). A meta-analysis of the existing empirical literature found that the elasticity of substitution between capital and energy is indeed less than one (Koetse, de Groot, and Florax, 2008).1 As a result, energy is an essential factor of production and continuous supplies of energy are needed to maintain existing levels of economic activity as well as to grow and develop the economy (Stern, 1997). There may also be macroeconomic limits to substitution of other inputs for energy. The construction, operation, and maintenance of tools, machines, and factories require a flow of materials and energy. Similarly, the humans that direct manufactured capital consume energy and materials. Thus, producing more of the substitutes for energy requires more of the thing that it is supposed to substitute for. This again limits potential substitutability (Cleveland et al., 1984). While there are limits to substituting energy for other inputs, meta-analysis of existing studies suggests inter-fuel substitution possibilities are good (Stern, 2012). Transitions between different energy sources have taken place in the past and can take place in the future. (David I. Stern, Paul J Burke, Stephan B. Bruns, 2016).

Before the Industrial Revolution, economies depended on energy from agricultural crops and wood as well as smaller amounts of wind and waterpower, all of which are directly dependent on the sun. This is still largely the case in rural areas of low-income countries. While solar energy is abundant and inexhaustible, it is diffuse compared to fossil fuels, and plants only capture about 1% of the energy in sunlight. Therefore, the maximum energy supply in a biomass-dependent economy is low, as is the "energy return on investment" for the human-directed energy expended to extract energy. This is why the shift to fossil fuels in the Industrial Revolution was so important in releasing constraints on energy supply and, therefore, on production and economic growth (Wrigley 2010).

In spite of this, core mainstream economic growth models disregard energy or other resources (Aghion and Howitt, 2009), and energy does not feature strongly in research on economic development (Toman and Jemelkova, 2003). For example, a search for "energy" in titles and abstracts of the Journal of Economic Growth yields no results. The mainstream empirical literature on the determinants of economic growth also usually ignores the role of energy (e.g. Barro, 2003; Moral-Benito, 2012). There are many models where resources are an input to production in the sub-field of environmental and resource economics (Stern, 2011), but most assume good substitutability between resources and other inputs (i.e. a Cobb Douglas production function where the elasticity of substitution is one) and do not focus on the potential role of energy in enabling growth.

By contrast, a prominent tradition in heterodox ecological economics, known as the biophysical economics approach, is based on thermodynamics (Georgescu-Roegen, 1971; Cleveland et al., 1984; Hall et al., 2001; Ayres and Warr, 2009; Murphy and Hall, 2010). Ecological economists usually argue that substitution between capital and resources, such as energy, can only play a limited role in mitigating the scarcity of resources (Stern, 1997). Furthermore, some ecological economists argue that when we account for the role of energy, there is little role left for technological change in driving economic growth (Hall et al., 2001). These researchers argue for a model where energy use is the main or only driver of economic growth. However, because the quality of resources and technology do affect the amount of energy needed to produce goods and services, and because energy intensity has declined in the long term in leading economies such as the United States (US) and United Kingdom (UK) (Csereklyei, Rubio, and Stern, 2016), we find it difficult to argue for such a model (Stern, 2011).

In order to better integrate the biophysical and mainstream economics approaches, Stern and Kander (2012) modify Solow's neoclassical growth model (Solow, 1956) by adding an energy input that has low substitutability with capital and labour, while allowing the elasticity of substitution between capital and labour to remain one. This is a so-called nested constant elasticity of substitution (CES) production function. The model also breaks down technological change into innovations that directly increase the productivity of energy (energy-augmenting technological change) and those that increase the productivity of labor (labour-augmenting technological change). 6 Depending on the scarcity of energy, the model displays either neoclassical or energy constrained behavior (Stern and Kander, 2012). When energy is superabundant the level of the capital stock and output are determined by the same factors as in the Solow model.2 But when energy is relatively scarce, the size of the capital stock and the level of output depend on the level of energy supply and the level of energy-augmenting technology. In the preindustrial era when energy was scarce, the model suggests that increases in energy availability and energy-augmenting technology had much larger effects on economic growth than they do in developed economies today. Until the Industrial Revolution, output per capita was generally low and economic growth was not sustained (Maddison, 2001). After the Industrial Revolution, as energy became more and more abundant, the long-run behavior of the model economy becomes more like the mainstream Solow growth model (David I. Stern, Paul J Burke, Stephan B. Bruns, 2016)

2.7 Reviews on Previous Studies

Electricity is one of the most important blessings that science has given to mankind. It has also become a part of modern life and one cannot think of a world without it. Electricity has many uses in our day to day life. So, there are many researchers who had written about the Electric Power Sector which provide electricity.

Kyaw Swar Tun (2010) studied Trend of Electric Power Generation and Consumption in Myanmar (1988-89 to 2007-2008), he presented the status of Myanmar Electric Power Production and assumed on that- although rotation system of electricity distribution is practice now in Myanmar, to be continue the trend of electricity production as – the electricity production is increasing around national wide in Myanmar. According to the data analysis the estimate portion of annual electricity unit loss lies between 32% and 36% of total electricity generation. The estimated annual electricity consumption also lies between about 63% and 67% of total electricity generation. To promote private investment in electricity generation, the MOEP should launch two programmes: (1) Small power producers (SPPs) and (2) Independent Power Producers (IPPs). The pricing reform aimed at lowering electricity prices, should be made for electricity supplied to grids in the future. As a state monopoly, electricity subsidies have benefited for the largest and wealthiest power consumers (Kyaw, 2010).

Soe Paing Myint (2012) studied the Hydro Electric Power Generation in Myanmar (1999-00 to 2001-07), presented the status of Myanmar Electric Power Production has become one of the important tasks to fulfill the power demand of the rapid growth of population for various uses also to the development of state economies. The power installed capacity in Myanmar has increased from 1171 megawatts in 1999-2000 to 1679 megawatts in 2006-2007. In the installation power sources, the hydro power generation is the main capital for Myanmar and all developing countries, Mini Hydro Plants are also established to fulfill the needs of those who lived in border areas. For the, author amend the Hydro has become the main sources of power where electric power can be generated and which has potential for further power supply (Soe P. M., 2010).

Phone Myint (2012) studies on Electricity Distribution Development in Myanmar (1988-89 to 2010-11) has also shown that the area of installation of transmission line and the area of power generation were increased over two-decade period (from 1988-89 to 2010-11) in several developments. But that cannot make projection over the electricity demand, and pay more attention on both of electricity power production and reducing unit losses (Phone, 2012).

Soe Naing (2013) examined the Electricity Consumption and Electric Power Sufficiency In Myanmar (2002-2011), he presented assess the current status of distribution of electricity and analyze the utilities of electricity in Myanmar between 2001- 02 and 2010-2011 (Soe N. , 2013).

Tun Tun Swe (2015) studied about "A Study on Electricity Distribution of Electricity Supply Board (YESB)", this analyzed the generation and distribution of Electricity in Yangon region and studied the current consumption of electric power in Yangon Region by using both primary and secondary data. She stated that reducing of electricity losses increased the supply of electric power (Tun, 2015)

Philip Kofi Adom (2011) studied the direction of causality between electricity consumption and economic growth using the Toda and Yomamoto Granger Causality test from 1971 to 2008. The ARDL Bounds test of cointegration revealed that there exists a long-run relationship between electricity consumption and real per capita GDP and that real per capita GDP can be treated as the 'long-run forcing' variable explaining electricity consumption. The results herein imply that electricity conservation measures are a viable option for Ghana. As a result, there would be the need to develop and intensify appropriate electricity conservation measures in the Ghanaian economy since this will not retard growth in the economy (Adom, 2011).

Chi Zang, Kalie Zhou, Shanlin Yang, Zhen Shao (2017) had studies a comprehensive overview of relationship between electricity consumption and economic growth and summarizes findings spanning from 1978 to 2016.the invention and wide application of electricity are important symbols of the second industrial revolution. With the rapid growth of population, expanding of urbans scale and acceleration of industrialization, electric power has become one of the main driving forces to promote the economic and social development of China. However, with large consumption of energy, resource depletion and environmental pollution problems have become increasingly severe. So, China has to take effective measures and policies to speed up the adjustment of the electricity supply structure (Chi Zhang, Zhen Shao, Kaile Zhou, Shanlin Yang, 2017)

CHAPTER III
OVERVIEW OF ELECTRIC POWER SECTOR IN MYANMAR

3.1 Reform of Energy Sector in Myanmar

Myanmar's successful transformation into a democratic nation in 2010, opened the new development horizons in political arena and economic arena of the country. Since then, Myanmar is performing proactively and moving forward with the ultimate goal of achieving an "All-inclusive Sustainable Development". Under the effective reform processes undertaken by the Government of the Republic of the Union of Myanmar, positive improvements have been evident in the economic performance of the country during the last five year. The country is also achieving the rapid economic growth and it is now a priority to sustain this development state by enabling access to sustainable and reliable energy supply (JICA, 2015).

(i) Institutional Restructuring of MOEE

Therefore, the Government of the Republic of the Union of Myanmar instituted the Ministry of Electricity and Energy (MOEE) has not been restructured after MOEP (1) and MOEP (2) were consolidated into one ministry in September 2012.Four departments (DEPP, OGPD, DPTSC, DHPI), five enterprises (EPGE, ESE, MOGE, MPE, MPPE) and two corporations (YESC, MESC) exist under the MOEE. After April 2016, institutional restructuring is being undertaken. But MOEE doesn't have a section to study a structure of electric power sector. Though DEPP simply plans to increase employees in the present departments and enterprises of MOEE, they need a new organization and specialized persons for new tasks. Support of experts and capacity building to the power sector are essential. (JICA, 2015)

The current movement of sector reform undertaken by MOEE advances in the right direction. But more reform is required to solve significant issues such as financial deficit of MOEE and power development to meet more demand increase. The approach of corporatization and privatization in power sector is expected to let the power sector work effectively and efficiently. Bid solicitation initiated by

Government of Myanmar is suggested to manage the IPP projects like on-going Myingyan Gas Power Plant. On the other hand, the internal human resources are shortage in the present departments and enterprises in MOEE. (JICA, 2015) They need new organization and specialized personnel for extra tasks. Donors support of experts and capacity building to the power sector are essential. MOEE plays a role of the single buyer similar to the power sector of Thailand and Indonesia, in Asia each country selects his own power sector model. Deliberate reform seems desirable for MOEE so that the government of Myanmar should avoid the confusion against the fast movement to unbundle generation, transmission and distribution, or accelerate private competitiveness.

(ii) Establishment of an appropriate pricing policy

An appropriate pricing policy on power tariff for retail and wholesale is necessary to improve financial situation of state-owned enterprises in the power sector. In the case that Government of Myanmar develops most of new power projects through IPP scheme due to shortage of project finance, financial burdens of Myanmar will increase as studied in the previous Master Plan. Thus, introduction of IPP projects, setting of power tariff, and injection of governmental subsidy should be implemented appropriately (JICA, 2015).

(iii) Biding Power Purchase Agreement (PPA) procedures based on international standards

In Myanmar, MOEE started to negotiate PPA (Power Purchase Agreement) mostly after completion of the construction in the past projects. This PPA negotiation takes time and IPP plants cannot start operation just after completion. According to MOEE, effective PPA period for hydropower IPPs is one year and renewal negotiation is necessary every year, but PPA period for gas-fired and coal-fired IPPs differs from project to project. MOPFI (Ministry of Planning, Finance and Industry) doesn't give Myanmar governmental guarantees for IPP projects. (JICA, 2015) .This could be hard situation in project finance for foreign investors to participate in IPP projects at present. It is required that international standard or procedure for bidding and IPP contract has applied to project implementation. (JICA, 2015).

3.2 Electric Power Sector Policies and Objectives

As the electric power sector is playing vital role in the process for the development of the country, the Ministry of Electricity and Energy set up national electric power policies are as follow:

1. For enough electricity supply throughout the country, to expand the national power grid for effective utilization of generated power from the available energy resources such as hydro, wind, solar, thermal and other alternative ones.
2. To conduct the electricity generation and distribution in accordance with the advanced 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 restructure the power sector with cooperation, boards, private companies and regional organizations for more participation of local and foreign investments 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.
6. To encourage the expansion of power transmission and distribution throughout the country and the Public- Private Partnership in each sector.
7. To get millennium achievement, besides of construction of thermal power plants, must construct more hydropower plants yearly by the least of EIA and SIA, whereas hydro power is the clean and renewable energy.

The objectives of Ministry of Electricity and Energy 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 Industries and Public.
2. To provide the technical know-how and policy support for using renewable energy such as biomass with cooperation and participation of the local people in rural areas, remotely located from the National Grid.
3. To meet the electricity demand for the inaccessible areas to National Grid, to be supplied by Mini Hydro and Diesel Generators.

4. In order to be reliable, the quality of 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 our skilled staffs and by getting technical know-how from abroad.
5. In order to fulfill the electricity demand of Myanmar, to encourage the Power Generation not only Hydro and Natural Gas and Coal, and to be widely and commercially operated by Wind and Solar Power Plants.
6. To generate more electricity from the renewable energy resources.
7. To get a greater number of electrified villages with great effort.
8. To carry out distribution of electricity to regions and states in the whole nation by connection with national grid.
9. To carry out the under constructed projects will be finished in time.
10. To generate and distribute electricity from the existing power station with full capacity.

3.3 Power Development Plan of Myanmar

MOEE should update a long-term Power Development Plan in Myanmar based on the previous master plan. It would be necessary to study a development plan against peak demand in dry season in consideration of plant utilization factors of hydropower stations in dry season and types of hydropower stations such as run-of-river, regulation-pond and reservoir types. Moreover, most hydropower projects are located in the north area and the present main transmission lines of 230kV running from north to south does not have enough capacity to transmit full electricity from north to south. Therefore, the long-term Power Development Plan should correspond with an expansion plan of bulk transmission lines (JICA, 2015).

Though MOEE makes every effort to forward new IPP projects such as gas engines and gas fired thermal plants around the existing thermal power plants in Yangon Area as short-term countermeasures for power supply, MOEE needs to make a middle-long term gas-fired development plan considering gas procurement for power generation. MOEE also needs to study new coal-fired thermal power projects utilizing domestic coal and/or imported coal in view of diversity power sources, future stable power supply, future gas supply amount, etc. (JICA, 2015).

MOEE will have more than 50 plans to be constructed by BOT (Build Operate and Transfer) scheme and JV/BOT in addition to about 10 hydropower and a few thermal power projects to be newly developed by MOEE own investment. This development plan presents that the IPP projects will generate power of more than 80% of the total installed capacity in 2030-31. As described in the previous master plan, financial burdens of Myanmar will increase, provided that the installed capacity ratio of IPP to the total capacity is substantial. MOEE should study this situation focusing on appropriateness of planned annual supply and demand balance, agreement of the transmission line expansion plan, and effects to power tariff. (JICA, 2015). Power supply in rainy season is usually 1.4 times as large as that in dry season. Power supply of gas-fired and coal-fired plants can be reduced by the increase of hydropower generation in rainy season to minimize power generation cost of the national grid. Though most of gas-fired and coal-fired thermal power plants are planned to be developed though BOT and JV/BOT schemes, MOEE should study various sources for procurement of electricity in dry season, including development of thermal power plants own by MOEE and import of electricity from surrounding countries, so that MOEP can ensure capacity of electricity supply corresponding to the demand and minimize the generation cost of the national grid (JICA, 2015).

In short term Power Development Plan, it is necessary to consider the capacity increased by rehabilitation of the existing power plants with completion time of the projects. (JICA, 2015).To secure the design installed capacity of the existing power plants, MOEE reinforce organizations, arrange rules and manuals to implement proper operation & maintenance, and secure sufficient consumables to keep good condition of the existing facilities.

3.3.1 Establishment of procedures for Power Development in Myanmar

By 2014, evaluation sequences of EIA (Environmental Impact Assessment) for the ongoing projects were unclear without applicable rule and enacting EIA for electricity power development. At present proponents should implement due EIA on the environmental guideline and receive approval from MONREC (Ministry of Natural Resources and Environmental Conservation) before construction start. At present, regulatory ministry on water right of rivers is unclear. MOALI (Ministry of Agriculture, Livestock and Irrigation) controls water rights for irrigation and agriculture, and the City Development Committees in local governments control water rights for clean water. A regulatory ministry would be necessary to control water right of rivers for development of hydropower, irrigation and agriculture, water supply, etc. (JICA, 2015). Though attention to renewable energy such as solar and wind power is increasing for future power resources, there is no circumstance to introduce them by promoting measures against relatively high generation cost.

According to the Census Report Volume 2, the 2014 Myanmar population and housing census, May 2015, a sizeable proportion of households in Myanmar use electricity (32.4%) as the main source of energy for lighting, followed by candle (20.7%). However, there is a huge difference between urban (77.5%) and rural areas (14.9%) in the use of electricity as the main source of lighting. The proportion of households using battery, generator and solar systems as the main source of lighting is considerable. It is also evident that, four out of five households in Myanmar use wood or charcoal as main sources of energy for cooking. In urban areas, over half of households use wood or charcoal, while in rural areas up to 80 percent use wood or charcoal for cooking. Overall, only 17 percent of households use energy such as electricity and liquefied petroleum gas for cooking. The proportion is higher in urban areas (46%) but very low in rural areas (6%). An expansion plan of the national grid should be coordinated with the NEP (National Electrification Plan) on Rural Electrification presently supported by WB (World Bank). DRD (Department of Rural Development) of MOALI and ESE are in charge of making the Master Plan on Rural Electrification, showing the future electrification plan until 2030 (JICA, 2015). Government of Myanmar including MOEE and other relevant organizations cooperate and implement rural electrification effectively with assistance of international donors.

3.4 Energy and Nation's Economics

The real GDP of Myanmar increased at an average rate of 10.1% per year from 2000 to 2016. GDP, measured in constant 2010 US dollars, increased from around $49billion in 2010 to $74 billion in 2016. The services sector – mainly wholesale and retail trade, mining and quarrying, agriculture (planting), and electricity – drove Myanmar's economic growth. (David I .Stern, Paul J. Burke and Stephan B. Bruns, 2017). The population grew by 0.9% per year on average, from 46 million to 53 million over the same period. Table 3.1 show, the TPES/capita indicator increased at an average annual growth of 2.8% from 0.28 to 0.35 toe/person whilst the TPES/GDP declined from 0.29 to 0.25 toe/ thousand dollars (at constant 2010 US dollars) over 2010–2016.

Table (3.1) Energy and Economic Indicators

Year	TPES	GDP	Population	TPES/GDP	TPES/POP
	ktoe	million $	thousand persons	toe/thousand$	toe/capita
2010	14275	49541	50156	0.29	0.28
2011	15065	52311	50553	0.29	0.30
2012	15430	56147	50987	0.27	0.30
2013	15516	60878	51448	0.25	0.30
2014	17720	65742	51924	0.27	0.34
2015	18873	70340	52404	0.27	0.36
2016	18484	74470	52885	0.25	0.35
AAGR	4.48	7.1	0.86	-2.26	3.88

Source: Myanmar Energy Statistics 2019

As shown, the energy per capita changes in the same way as the TPES but at a slower rate of growth. The increase in the energy consumption per capita is common for emerging economies in line with the growth in GDP/capita, electrification, and similar development programmes. The energy intensity (TPES/GDP) declined from 2010 to 2016. The intensity in 2016 was 62% lower than it was in 2010. The growth in the TPES was significantly smaller compared to GDP, which drastically decreased the energy intensity (David I .Stern, Paul J. Burke and Stephan B. Bruns, 2017).

3.5 Sources of Electricity Generation in Myanmar

Myanmar's main sources of electricity generation are hydro, gas and coal power plant. Starting from 1988, electric power generation (MW) is continuously increased in installed capacity. The government has set a target to generate power from a mix of sources – 38 percent from hydropower, 20 percent from gas-fired power plants, 33 percent from coal-fired power plants and 9 percent from renewable energy sources, according to the electricity master plan.

(i) Coal Power Plants

The government's stance towards coal has changed significantly in the past years. Various plans call for a large portion of generation to come from coal power in the future, though recently there has been little progress in this area. The former government signed at least 11 early-stage agreements for coal-fired power plants around the country with several international and regional companies. Most of these projects have since stalled due to widespread public opposition, including from local residents and environmental groups. There is further concern that domestic coal extraction may not meet the demand of all 11 planned plants, leading to a situation where Myanmar must import the resource. Although Myanmar has estimated domestic coal resources of 540 million tons, coal extraction has remained slow due to low investment and the remoteness of most of the country's 565 identified coal sites. In April 2016, Huagaung Electric Power Engineering was selected as the winner for a tender to upgrade and operate the existing Tigyit plant in southern Shan State, the only coal-fired power plant in the country (Myanmar, 2019) (JICA, 2015). Since this agreement, the current government has not signed any new major agreement for a coal power plant, though some regional and state level agreements have been reached, such as for the 1,280 MW Toyo Thai project in Kayin State.

(ii) Gas Power Plants

In the past, gas-fired power plants in Myanmar used existing domestic gas, which is cheaper and more environmentally-friendly than liquid fuel. Nevertheless, gas power is limited by declining domestic production and export contracts with Thailand and China, limiting the amount available for Myanmar's use. Nonetheless, there is considerable interest in gas-fired power plants. Three significant gas plants are completed / nearly so, including the Thilawa project at Yangon, Myingyan in Mandalay Region, and Thaton in Mon State, with a total combined capacity of 380MW. In terms of adding new production, a major step was taken on 31 January 2018, when four gas-to-power projects received the first "Notices to Proceed". The four projects total over 3,000MW, representing a large increase to national capacity if they are built. The projects include Total and Siemen's 1,230MW LNG-to-power plant in Tanintharyi Region, Supreme and Zhefu's 1,390MW LNG-to-power plant in Ayeyarwady Region, Toyo Thai's 356MW LNG-to-power plant in Yangon Region, and Supreme and Sinohydro's 135MW combined-cycle plant in Rakhine State (Myanmar, 2019). The four Notices to Proceed (NTP) are not final Power Purchase

Agreement, which are in the process of being negotiated. Nonetheless, the NTPs indicate a clear direction for medium-term power production in Myanmar.

(iii) Hydropower

Myanmar has a rich endowment of potential hydropower sites, given its strong river system and favorable geography. Altogether, 28 hydropower plants with a minimum capacity of 10MW have been built. Another six have been listed as under construction, and another 69 with potential capacity of 43,848MW have been proposed/ identified. Under previous governments, much of the proposed FDI into hydropower was from Chinese companies. However, beginning with the 2011 democratic transition, and further under the current government, there has been increasing interest particularly from European countries. This culminated in 2018 with Électricité de France receiving a Notice to Proceed for the 1,050MW Shweli-3 plant on 10 September, and a consortium including Austrian firm Andritz receiving a Notice to Proceed for a small plant at Deedoke in Mandalay Region in August (Myanmar, 2019) .

(iv) Bioenergy

Biomass is the main energy source for cooking, particularly in rural areas. The 2014 census, the first conducted in decades, showed 86.2% of rural households relied on firewood for cooking food. Other sources used in the country include sugarcane bagasse, palm leaves, cotton stalk, sesame stalk, rice husk, sawdust and bamboo. Biomass is traditionally a local, decentralized energy source, though this is changing. A few experiments are being conducted with electricity generation from rice husk, with local firm MAPCO opening a 0.5MW, USD4.7 million facility with a foreign partner in May 2018xv. There were previously attempts to build a biofuel industry based on jatropha. However, the attempt has essentially been abandoned due to problems including pests and diseases in the plants (Myanmar, 2019)

(v) Wind Power

Myanmar has a technical potential for the development of 4,032 MW of wind energy, mostly in Shan State, Chin State, and along the Rakhine coast. The following new projects are planned according to the Ministry of Electricity and Energy:

Table (3.2) Renewable Energy Projects

Region	Numbers of Projects	Capacity (MW)
Rakhine	10	1484
Chin	10	1472
Ayeyarwady	5	478
Yangon	2	274

Source: ADB sectors assessment: Energy 2015-2017

An MOU for the first wind-power project was signed between the Ministry and China's Three Gorges Corporation in March 2016. This agreement paves the way for construction of a wind turbine project in the Chaung Tha area of Ayeyarwady Region which is expected to generate 30MW of electricity. In April 2017, InfraCo Asia Development signed an MoU looking at wind potential in Magwe Region (Myanmar, 2019).

(vi) Solar Energy

The overall potential for solar power is estimated to be 51,973 terawatt-hours per year, with the highest potential in the central dry zones of the country. Although several MOUs have been signed, only two firm Power Purchase Agreements have been reached for large-scale solar. US-based ACO Investment Group plans to invest USD480 million to build two 150MW solar plants near Mandalay. Thailand's Green Earth Power will spend USD350 million on a 220MW A/C plant in Magway Region's Minbu township. As of 2018, the first 40MW phase of the Green Earth Power project is moving forward (Myanmar, 2019).

3.6 Electricity Generation System in Myanmar

Before 1960, the generation system consisted mainly of isolated grids supplied by diesel generators and mini-hydropower. The first stage of the first medium-scale hydropower plant, Baluchaung-2 in central-east Myanmar about 420 km north of Yangon, was commissioned in 1960 with an installed capacity of 84 MW. The plant was designed for an annual generation of 595 gigawatt-hours (GWh) to supply Yangon and, in 1963, Mandalay. The second stage was commissioned in 1974, also with 84 MW capacity and providing an additional 595 GWh (Inn, 2012). During the subsequent 30 years, another eight hydropower plants were built, ranging from 12

MW to 75 MW and totaling 264 MW. In 2005, the 280 MW Paunglaung Hydropower Plant, about 20 km east of the new capital, Nay Pyi Taw, was commissioned. From 2005 to 2019, eight power plants, totaling 3221 MW, were built. Two large-scale hydropower plants, one partly for export to the PRC (Shewli-1,600 MW) and the other for domestic supply (Yeywa,29 790 MW), were commissioned in2008 and 2010, respectively (Inn, 2012).

With regards to the Shweli 1 hydropower plant, the agreement with the PRC investor is that three of its six generation units will provide the power to the Myanmar grid. Of the will be provided at cost. MOEP records indicate that 49% of the electricity generated by the power plant since 2008, operating at about 75% of its potential capacity, has been transmitted to the Myanmar grid. For the Dapein-1 hydropower plant (240 MW), also being developed by Chinese investors, 10% of the generated electricity will be made available to the Myanmar central grid. In combination, the two plants will augment domestic supply by 324 MW. The 120 MW Tigyit power plant in central Myanmar was completed in 2002 in central Myanmar and was the first coal-fired power plant. It generates between 217 GWh/year and 389 GWh/year, corresponding to an average capacity factor of 31%; to be efficient, it should operate at 75%–80% capacity (Inn, 2012). Off-grid power supply is provided for by ESE, local communities, and district authorities. There are 32 mini-hydropower plants with a combined generating capacity of 33.1 MW. A sub-department of ESE plans, builds, and operates the mini-hydropower plants. An exception is the 10.5 MW Buga hydropower plant at Myitkyina, Kachin State, which is a private sector arrangement. The company pays a royalty to ESE and is contracted to generate and distribute the power to villages and small industries in the surrounding project area. However, off-grid power supply is intermittent and electricity is only provided up to two hours a day in remote areas (Inn, 2012).

Kyunchaung in central-western Myanmar, was commissioned in 1974 with an installed capacity of 54.3 MW. During the following 30 years up to 2004, another nine gas-fired power plants were commissioned with a total capacity of 714.9 MW. Ywama, the first gas-fired power plant close to Yangon, was commissioned in1980 with an installed capacity of 36.9 MW. In 2004, two units of 33.4 MW capacity were added (Inn, 2012). Subsequently, another three gas-fired steam turbine power plants were built in stages surrounding Yangon: Hlawga (154 MW), Tharkaytha (106 MW), Ywama (180) and Ahlone (154 MW). The total installed capacity is now 594 MW. Output has not been as high as expected due to the low calorific value of Myanmar gas30 and low pressure without gas compression. According to MOEP, the energy potential of these power plants is 7537 GWh/year, representing an average capacity factor of 70% (Inn, 2012).

The existing generation comprises 30 power stations with a combined installed capacity of 3,495 MW as of August 2012.Due to scheduled maintenance and various operational limitations at a number of the stations, the actual firm capacity as of August 2012 is 1,957 MW. During the wet season (June to September), the hydropower stations are able to generate at optimum capacity. However, during the dry season, their capacity drops off due to insufficient water storage. In 1995, 49% of electricity generation to the national grid was provided by thermal units, primarily gas-fired turbines, with the remainder provided by hydropower sources (Inn, 2012). Since then, there has been less dependency on gas-fired generating plant with hydropower providing 74% of the annual production in 2018. Nevertheless, with generation being unable to sustain demand, the gas-fired plants are supplying base load and running almost continuously at 100% of available capacity. Similar to the lack of demand projections, there is a lack of comprehensive planning for power generation, on a least-cost, efficiency basis. MOEE make future plans for hydropower development based on assessments of hydropower potential (Inn, 2012).

3.7 Electricity Transmission System of Myanmar

The MEPE transmission system currently comprises an interconnected overhead grid of 230 kV,132 kV, and 66 kV, which interconnects with all generation stations. There are plans to introduce 500 kV in the near future in order to connect the majority of the country's generation, which is predominately in the north with the main load centers in the south. The existing transmission lines are shown in Table (3.3).

Table (3.3) Existing Transmission Lines (2019)

Voltage (kV)	Numbers of Lines	Length (miles)
500	16	1392
230	51	2983
132	40	2289

66	137	3614
33	12	114
Total	**229**	**10392**

Source: Ministry of Electricity and Energy (2018-2019)

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 (Inn, 2012).

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 (Inn, 2012).

Myanmar has about 229 transmission lines spread 10392 miles and among them over 30 % 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 powerplants 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 (Inn, 2012).

3.8 Electricity Distribution System of Myanmar

Distribution in Myanmar comprises a network of 33 kV, 11 kV, and 6.6 kV emanating from the grid and zone substations to connect to the distribution transformers to supply single and three phase 400/230 V to the customers. The existing distribution lines are shown in Table (3.4).

Table (3.4) Existing Distribution Lines, 2019

Sr. No	Line	Length (km)
1.	230KV	297.74
2.	66KV	129.52
3.	33KV	861.90

4.	11KV	1511.05
5.	6.6KV	670.38
6.	2.00KV	2.00
7.	0.4KV	3637.21

Source: MOEE (2019)

The 33 kV is used to connect 33/11 kV zone substations, but it could be used in the future to directly supply 33/0.4 kV distribution transformers. The 6.6 kV, mostly in Yangon, is a relic voltage and needs to be phased out as soon as practical in order to improve the efficiency of the distribution network and reduce losses. It is noted that some of the more recent distribution transformers purchased for the 6.6 kV system also have a 11kV winding to facilitate the future changeover to 11 kV. Sizes of the distribution transformer vary from 100 kilovolt amperes (kVA) up to 1,000 kVA and are mostly in reasonable condition, although oil leaks were not uncommon. In urban areas, some transformers are installed indoors in substation buildings; otherwise most are either ground mounted or on single or two pole structures (Inn, 2012).

The low voltage network comprises a 400/230 V three-phase four-wire system with the neutral solidly grounded. Frequency is nominally 50 hertz (Hz). Construction is generally overhead, base, open-wire construction using concrete poles. There is also some underground distribution in Yangon City area. Much of the construction is old and of insufficient cross-section for present-day loads. Some construction designs are outmoded; for example, conductor guards for road and railway crossings (this practice has been superseded in most countries now as modern protection systems prove more reliable). Myanmar has not yet introduced aerial bundled conductor. It was observed that many service connections just used twisted connections instead of connectors—this is a bad practice as it will lead to high resistance connection with high losses and ultimately burning and failure of conductor (Inn, 2012).

3.9 Electric Power Supply and Consumption in Myanmar

Myanmar's sources for power generation were mainly natural gas and hydro resources. In 2000, total electricity production was 5,118 gigawatt-hours (GWh) and 62% of this total was generated from natural gas power plants. The remaining shares were hydro (37%) and oil (1%). By 2016, total electricity production reached 20,258 GWh where 60% was production from hydro plants and 39.7% from gas plants. The share of oil power plants declined to 0.3% in 2016. Other renewables such as solar and wind (9 GWh) and coal plants (10 GWh) also generated electricity. Some of the electricity generated was used internally by the power plants (own use). Electricity for own use by the power plants was estimated by applying an appropriate rate for the existing power plants. The remaining generated electricity (net production) was available to the market. Myanmar was not an electricity-importing country and it has been exporting electricity to China since 2013 (Kimura, 2019). (Ministry of Electricity and Energy, n.d.) Table 3.4 shows the electricity supply of Myanmar in 2010 to 2016.

Table (3.5) Electricity Supply in Myanmar (GWh)

Year	**Electricity Supply**	**Gross product-ion**	**Coal**	**Oil**	**Gas**	**Hydro**	**Others**	**Export**
2010	8505	8625	391	33	2012	6189	0	0
2011	10322	10455	312	38	2556	7544	4	0
2012	10773	10969	265	51	1883	7766	4	0
2013	12032	14739	136	61	3228	11310	4	2532
2014	14024	15639	70	65	5193	10298	14	1463
2015	15830	17223	0	55	6518	10639	11	1239
2016	11749	20258	10	61	8052	12125	9	2381
AAGR	12.8	15.6	-22	11.6	26.8	13.1	35.2	5.8

AAGR = average annual growth rate, GWh = gigawatt-hour

Source: Myanmar Energy Statistic 2019

Table (3.5) show, the Electricity supply increased from 8505 GWh in 2010 to 17,749 GWh in 2016 at an average rate of 12.8 per year. The transmission and distribution losses must be subtracted from the total electricity supply before the final users can consume electricity. The estimated transmission and distribution losses were around 26% of the total electricity produced in 2010. Most of the losses were due to the poor distribution system and illegal electricity use. Transmission losses were around 5%–10%. Upgrading the system and increasing the electrification ratio had reduced the transmission and distribution losses to 12% by 2016 (Kimura, 2019).

In Table (3.6), Total electricity consumption was 6312 GWh in 2010. Of this total consumption, the industry sector's consumption of electricity accounted for 36.2%whereas that of the residential sector was 42%. The remaining 21.7% was the share of the services sector (20.7%) and that of the other sectors (1.1%). By 2016, total electricity consumption increased to 15,365 GWh at an average rate of 16.0% per year. Industry sector consumption increased at a slower rate of 14.5% per year compared with that of the residential sector at 22% per year. As a result, the share of the industry sector to total consumption declined to 30% whilst that of the residential sector increased to 49%.

Table (3.6) Electricity Consumption in Myanmar (GWh)

Year	Domestic Electricity Consumption	Industry	Service	Residential	Other	Estimated Distribution Loss	Electricity Supply
2010	6312	2287	1306	2653	66	2193	8505
2011	7701	2177	1531	3378	81	2777	10322
2012	8258	3848	1643	2618	86	2515	10773
2013	9617	1061	1692	3764	100	2416	12032
2014	11275	5276	1755	4113	131	2750	14024
2015	13408	4121	1250	6675	107	2422	15830
2016	15365	4651	3023	7573	118	238516	11749
AAGR	16	14.5	25.1	22	20.5	21.7	12.8

Source: Myanmar Energy Statistics 2019

Electricity consumption of the services sector increased the fastest at an average rate of 25.1% as more commercial buildings, especially hotels and offices, were constructed. The share of the services sector increased to almost 20% in 2016. That of the other sectors decreased to 1% since consumption grew the most slowly at 2.1% per year.

CHAPTER IV
THE SITUATION OF ELECTRICITY DISTRIBUTION BY ESE IN NAY PYI TAW COUNCIL

4.1 Future Power Development Plan to Fulfill Electricity Supply in Nay Pyi Taw Council

Myanmar has one of the lowest rates of electrification in Southeast Asia. Less than 30 percent of households in Myanmar have access to electricity, and electricity consumption per capita is among the lowest in the world. The urban-rural divide in access to electricity is huge – while the electrification rate in urban areas is about 75% (e.g. Yangon and Mandalay), the rural areas have an extremely low electrification rate of only 16 percent. In fact, most of rural communities in border areas have no access to the grid-based electricity at all, and some regions and states with a high share of rural population (e.g. Ayeyarwady and Magway Regions and Rakhine State) have access to grid-based electricity below 10 percent. Therefore, the access to electricity provides a clear indication of relative and absolute poverty levels in Myanmar. (Ministry of Electricity and Energy, n.d.). Energy poverty also affects population with access to electricity due to shortages and poor reliability of power supply. Delays in investments in power infrastructure, over-reliance on seasonal hydropower production (which accounts for about 70 percent of power generation), and a rapid increase in electricity demand, which tripled over the last decade, resulted in large electricity shortages which are estimated at about 30 percent of power demand during the dry season. Access to modern energy service has direct bearing on poverty reduction and rural development. Universal access to electricity in Myanmar by 2030 is achievable and affordable Goal. With help from the global Sustainable Energy for All initiative, led by the World Bank and the UN, the Government (through the Ministry of Electric Power and the Ministry of Livestock, Fisheries and Rural Development) is preparing a National Electrification Plan (NEP) which includes recommended geospatial, least cost grid rollout plan for achieving universal access to electricity by 2030, According to this Master Plan, the development of electricity supply in Nay Pyi Taw Council is shown in Table (4.1) and (4.2).

Table (4.1) Electrified Households in Nay Pyi Taw After Completion in Financial Year 2018-2019

Sr. No	Name of District	No. of Household	Electrified Household	Unelectrified Household	Electrified Household (%)
1.	Dekkhinathiri	143426	93816	49610	65.41%
2.	Ottarathiri	118827	62184	56643	52.33%
	Total	262253	156000	106253	59.48%

Source: Ministry of Electricity and Energy (2018-2019)

The Government of Myanmar adopted the National Electrification Plan in 2014 to achieve universal access to sustainable electricity services by 2030, drawing on World Bank analytical support provided through the National Electrification Project (NEP). After the Financial Year 2018-2019 by the NEP plan, the electrified households in Nay Pyi Taw council was increased about 65.41% in Dekkhinathiri District and 52.33 % in Ottarathiri District. Total electrified households were 156000 out of 262253 and only 106253 households were still unelectrified.

Table (4.2) Electrified Households in Nay Pyi Taw After the Completion of NEP Plan

Sr. No	Name of District	No. of Household	Electrified Household	Unelectrified Household	Electrified Household (%)
1	Dekkhinathiri	143426	126309	17117	88.06%
2	Ottarathiri	118827	83032	35795	69.88%

	Total	**262253**	**209341**	**52912**	**79.82%**

Source: Ministry of Electricity and Energy (MOEE)

According to the table (4.1), (4.2), after the completion of the projects under the NEP plan, 79.82% or 209341 out of 262553 households will be electrified and only 20% or 52921 households still unelectrified. By getting more electricity, it increased the living standard and total income of households. Because electrification in the 21thcentury dramatically improved productivity and increased the well-being of the industrialized world. The NEP has delivered electricity access to 2 million people and to schools, rural health clinics and community centers by extending the public grid in over 5,000 rural villages and delivering Solar Home Systems and renewable energy mini-grids in 7,200 villages throughout the country.

4.2 Manpower Management and Risk Management Under ESE

(i) Manpower Management

The Electricity Supply Enterprise is 24 hours emergency maintenance sections are opened in every township to reduce the outage times and to receive the regular electric power as soon as possible. Moreover, system upgrading has been implementing regularly to get the safety, secure, stability and reliable electric supply system. Complaint sessions are also opened in four districts and head office. Twenty-Four Hour emergency maintenance sections are always stand-by to repair in-time for power outage case. Moreover, overhead department and 24-hour customer call center are cooperating 24 hours to maintenance for emergency cases. The Electricity Supply Enterprise (ESE) also facilitate the one stop for the installation of meter.

Measuring Load, changing and filling transformer oil, annual check, schedule maintenance and substation round check have been implementing regularly from respective departments for distribution lines, transformers and substations to get good conditions. Replacing and extending producers for existing system are hard for aging not modernizing occurring full load and over land condition, poor of capital capes for system upgrade. Therefore, only maintenance producers are applied more.

Investment, Technical Assistance, Financial Assistance and capacity building training would be needed to upgrade the existing system. In addition, motivation must carry out to improve the civil service mindset.

(ii) Risks Management

Due to the use of electric power by illegal means, loss of electric power, system breakdown, electrical danger, fire danger occurs the whole areas. Another may be disturbance for state and people.

The following expressions, the use of electric power by illegal means are.

i Stealing the use of electric power dishonestly,

ii Allowing the use of electric power by way of distributing to any other person.

iii Using the electric power not allowed to be used for commercial purpose from general purpose meter or domestic power meter.

iv Consumption of electric power exceeding the power load limit of the industrial power meter.

v Stealing the use of electric power to meter repairing.

vi Using the electric power at restricted period (time).

vii Using the electric power at load shed hours due to not enough power supply.

viii Transmitting the more than power line 2 at above.

ix The use of electric power in General Purpose meter, domestic power meter, small power meter by illegally tampered means.

x Making tampered the current Transformer, Voltage Transformer, Electric Circuit.

4.3 Electric Power Generation in Myanmar (from 2010 to 2018)

The generation of electricity in Myanmar from 2010 to 2018 can be seen as increasing trend. In 2010, the generation of electricity was 8625.11 Million kwh which then gradually increased from 14156.30 Million kwh in 2014-15 and in 2017-18, the generation was almost three times greater than 2010.The rising trend of electricity is shown in table (4.3).

Table (4.3) The Rising Trend of Electricity Generation Capacity in Myanmar (Million Kilowatts)

No	Year	Generation (Million Kilowatt)
1	2010-2011	8625.11
2	2011-2012	10425.03
3	2012-2013	10964.90

4	2013-2014	12247.12
5	2014-2015	14156.30
6	2015-2016	15971.96
7	2016-2017	17866.99
8	2017-2018	20055.32

Source: Myanmar Statistical Year Book 2019

In the area of power generation, total power generated is increased from 8625.11 to 20055.32 million kwh comprising Hydel power from 6188.95 Mkwh or 72% in 2010-2011 to 11190.81 Mkwh or 56% in 2017-2018, and thermal power from 631.91 Mkwh or 7.3% in 2010- 2011 to 1217.70 Mkwh or 6% in 2017-2018. The amount of Gas used is increased from 1763.46 Mkwh or 20.4% in 2010-2011 to 7577.94 Mkwh or 37.7 % in 2017-2018. Power manufactured from Diesel was slightly increased amount from 32.66 Mkwh or 0.3% in 2010-2011 to 68.67Mkwh or 0.4% in 2017-2018. Power Generation by various types is shown in table (4.4).

Table (4.4) Power Generation by Various Types and Location (million kwh)

Year	By Type				Total	By Location		
	Thermal	Diesel	Hydel	Gas		Yangon	Lawpita	Other
2010-2011	630.04	32.66	6188.95	176.46	8625.11	1605.22	631.91	6387.98
2011-2012	749.75	38.21	7517.99	2119.08	10425.03	2076.57	1085.78	7262.68
2012-2013	770.64	50.63	7766.24	2377.39	10964.90	2177.32	1294.69	7492.89
2013-2014	568.91	60.76	8823.14	2794.31	12247.12	2486.98	1192.64	8567.50
2014-2015	285.98	64.898	8828.84	4977.03	14156.30	3775.57	1439.69	8941.04
2015-2016	284.98	55.23	9398.98	6225.56	15964.75	3490.04	1130.84	11343.87
2016-2017	524.23	61.12	9743.85	7537.79	17866.99	3701.48	1233.30	12932.21
2017-2018	1217.70	68.87	11190.81	7577.94	20055.32	4230.54	1592.12	14227.66

Source: Myanmar Statistical Year Book 2019

This table showed the electric power generation by various types of power generating methods. This described the generation types of thermal generation, hydropower generation, diesel generation and gas turbine power generation. In

Myanmar, thermal power generation has started to generated at 1997-1998, Thermal such as fossil oil or coal or other related tinder produced power from steam or heating power generator of heated. The coal burning power plants set Tharketa, near by the former capital, Yangon and today, there are 32 coal power plants all around the country. Natural gas turbines produced electric power in Myanmar and they are trying to maintain to enhance the turbines up to more sufficient condition. At the present year, the government is trying to generated the electric power from renewable energy source which reduced the negative impact for environment by producing electricity.

4.4 Distribution of Electricity in Nay Pyi Taw Council

Nay Pyi Taw is the capital and third-largest city of Myanmar. The city is located at the center of the Naypyidaw Union Territory. It is unusual among Myanmar's cities, as it is an entirely planned city outside of any state or region. As the seat of the government of Myanmar, Naypyidaw is the site of the Union Parliament, the Supreme Court, the Presidential Palace, the official residences of the Cabinet of Myanmar and the headquarters of government ministries and military. Nay Pyi Taw is notable for its unusual combination of large size and very low population density.

The required electric power to be distributed in Nay Pyi Taw Council is transferred from the National Grid transmitted via four 230KV primary substations, namely Nay Pyi Taw (1), Pyinmana, Shwe Myo and Nay Pyi Taw (2) which are located in Nay Pyi Taw Council. Table 4.5 showed the 230 KV primary substation's installed capacity and location.

Table (4.5) 230 KV Primary Substation in Nay Pyi Taw

No	Substation	Voltage Ratio	Capacity (MVA)	Location
1	Nay Pyi Taw (1)	230/33/11	100	Nay Pyi Taw
2	Pyinmana	230/33/11	100	Kinmontan, Pyinmana
		230/33/11	60	
3	Shwemyo	230/33/11	100	Tatkone Township
4	Nay Pyi Taw (2)	230/33/11	100	Ottayathiyi

Source: Ministry of Electric and Energy

In table (4.5), 230KV Nay Pyi Taw (1) Primary substation was located in Oaktayathiri Township, Oaktayathiri district, it's installed capacity was 100MVA. It has two transmission lines_ Pyinmana Line and Taungdwingyi line and eight 33KV distribution feeders_ (1) substation 6 feeder, (2) Substation 2 feeder, (3) MWD Audiovisual feeder, (4) Min-gone Brick Factory Feeder, (5) Hluttaw feeder, (6) Wana-theik-deed feeder, (7) Government guest feeder, (8) Taung Nyo feeder.230KV Pyinmana Primary Substation located in Pyinmana ,Datkhina District, Union

Territory. It's total installed capacity is 160 MVA and has five 230 KV transmission lines _ Nay Pyi Taw 1 line, Shwemyo line, Paunglaung 1 line, Paunglaung 2 line and Thaephyu line. It has two types of distribution feeders (1) 33 KV feeders distributed by 100 MVA transformer__ Phwint Phyo Yae 1 feeder, Phwint Phyo Yae2 feeder, Pin Laung 1 feeder, Pin Laung 2 feeder, A lar feeder and 33 KV feeders distributed by 60 MVA Transformer _ Yae Zin feeder, Pyinmana feeder, A lar Airport feeder, Taung Nyo Feeder, Paung Laung extension feeder, Nay Pyi Taw Airport feeder. This primary substation distributed the electricity to Datkhinathiri Township, Zabuthiri Township, Pobbathiri Township, Zayarthiri Township, Oaktarathiri Township, General Headquarters, Pin-laung Military Regions, Taung-nyo Military Regions, Pyinmana Township, Yae-zin, A-lar Township, Thar-witt-hti Township and Lae-way Township.

230 KV Shwemyo Substation was set in Tatkone township, Nay Pyi Taw District on 20 April 2009 and total installed capacity was 100 MVA. Four 230 KV Transmission lines _ Thazin line, Pyinmana line, Nay Pyi Taw (2) line and Blue Chaung (2) line and five 33 KV distribution feeder _ MRTV -1 feeder, MRTV-2 feeder, Pinlong 1 feeder, Medical research feeder and Tatkone feeder was possessed by Shwemyo Substation. MRTV, NPE PPE, Zoology Zone, President Garden, Sugar Factory, Tatkone,Bedstead (300), B.E.H.S(20),Pob-ba-thiri(6) Quarters were distributed the electricity by Shwemyo Primary Substation. The last 230 KV Nay Pyi Taw (2) Primary Substation was plant in Pobbathiri Township, Oaktarathiri District, Union Territoiy on 30 September 2013.It's total installed capacity was 100 MVA and has only 230 KV distribution line _ Shwemyo line but has six 33 kV distribution feeders_ Substation 10 feeder, Militarily Community feeder, Tatkone feeder, Taung Nyo feeder, No-8 feeder and No-11 feeder. It:s distributed regions are Pobbathiri Township and Oaktarathiri Township .

Unlike the other regions, in Nay Pyi Taw Council, the Electricity is distributed by the Electricity Supply Enterprise (ESE). The ESE's distribution of electricity in households from 2016-17 to 2019-20 is shown in Table (4.6).

Table (4.6) Distribution of Electricity in Nay Pyi Taw Council (2016-17 to 2019-20)

Particular		2016-2017	2017-2018	2018-2019	2019-2020
Number of households		232048	232048	232048	232048
Number of Electrified households	Residentials	120622	128552	143407	167157
	Non-Residential	8577	8822	11332	11587
	Total	129199	143575	154739	178744
Access to Electricity		55.6%	61.8%	66.7%	77%

Source: Electricity Supply Enterprise (2019-2020)

According to this table, residentials include households and government official's residences and other electricity users are non-residentials. It is found out that the access of electricity in Nay Pyi Taw is steadily increased from 55.6% in 2016-2017 to 77% in 2019-2020. The government is trying to fulfill the every household to get the electricity. With the ambitious goal of 100% electrification in 2030, the ESE has giving out operation and maintenance contracts to private players with intention of achieving more efficient power distribution.

4.5 Current Situation of Electricity Distribution in Nay Pyi Taw Council

Electricity Distribution services across the country are undertaken through the nation electricity systems. Towns and villages electrified till 2020 is shown in Table (4.7). Distribution lines used for electricity distribution in Nay Pyi Taw has only overhead Lines. There are three major types of distribution lines as 33KV,11KV,0.4KV in overhead system are used to distribute the electricity to customers. The total overhead distribution lines are shown in Table (4.8).

Table (4.7) Electrification of Towns and Villages in Nay Pyi Taw (2016-17 to 2019-20)

Year	Total Towns	Electrified Towns	Total Villages	Electrified Villages	Access to Electricity % (villages)
2016-2017	8	8	796	164	20%
2017-2018	8	8	796	175	22%
2018-2019	8	8	796	257	32.5%
2019-2020	8	8	796	524	65.8%

Source: Electricity Supply Enterprise (ESE)

According to table (4.7), the numbers of towns be all towns and 524 villages out of 796 villages (65.8%) are electrified. Most of towns are getting electricity at the time of construction the capital city but most of villages are getting electricity in 2019-2020 by NEP plan. In Nay Pyi Taw, most of rural population is greater than urban population so it is important to distribute electricity to rural areas that can increase the per capital income and living standards because electricity is the fundamental infrastructure for economic growth.

Table (4.8) Total Over Head Distribution Lines (2016-2017 to 2019-2020)

Year	33KV (miles)	11KV (miles)	0.4KV (miles)
2016-2017	388.000	743.346	550.995
2017-2018	555.340	795.636	571.385
2018-2019	556.445	835.861	598.844
2019-2020	570.045	965.918	663.994
Total	**1513.385**	**3340.761**	**2385.218**

Source: Electricity Supply Enterprise (ESE)

According to table (4.8), the distribution lines (11KV, 0.4KV) are significantly increased installed in 2018, 2019, 2020 but 33KV is slightly increased. The increased of 11 KV and 0.4 KV distribution lines means the households are getting electricity simultaneously because 11 KV and 0.4 KV lines are used to distributed electricity to household meters.

4.6 Consumption of Electricity in Nay Pyi Taw Council

The public use of electricity is classified into four groups namely, General Purpose Use (households), Industrial Use, Small Power, Bulk Use (Institution, school and hospital) and other Use (streetlight, Temporary Use). Current status of Electricity consumption by types are shown in table (4.9).

Table (4.9) Current Status of Electricity Consumption by Types (by Units)

No.	Types	6/2020	
		No. of Users	Units
1.	General purpose	166675	27670124
2.	Commercial	783	13007736
3.	Small power	2349	2671627
4.	Bulk	1183	29726208
5.	Streetlight	944	1093442
6.	Temporary	110	88724
Total		**172044**	**74257861**

Source: Electricity Supply Enterprise (ESE)

The largest end-use of electricity in the Nay Pyi Taw is for bulk representing institutions and hospital, accounting for approximately 40% of total end-use in 2019-2020, followed by general purpose representing households at 37% and commercial at 17.5%. Temporary uses and street lighting account for less than 2%. Nay Pyi Taw is accounts for around 32% of total electricity drawn from the grid, fourth behind the Yangon, Mandalay and Magway regions.

4.7 New Extensions in Power Supply of Electricity Supply Enterprise in Nay Pyi Taw

In order to meet the increasing demand for electricity in various township, the Electricity Supply Enterprise has arranged to be established new extensions in power supply such as construction of new power lines which include new sky power lines. In Nay Pyi Taw, there is no land power line (underground line), it has only sky power lines.

4.7.1 Construction of Power Line in Nay Pyi Taw Council

The power lines by Electricity Supply Enterprise carried out the drawing of a new line from 2016-2017 to 2019-2020 is shown in Table (4.10). The ESE is trying to get electricity fluently to all areas within the Council.

Table (4.10) Construction of New Over-head Lines (miles)

Year	33KV	11KV	0.4KV
2016-2017	27.559 (miles)	88.425 (miles)	60.456 (miles)
2017-2018	167.340 (miles)	52.290 (miles)	20.390 (miles)
2018-2019	1.105 (miles)	40.225 (miles)	27.459 (miles)
2019-2020	13.600 (miles)	27.143 (miles)	15.110 (miles)

Source: Electricity Supply Enterprise (2019-2020)

According to the table (4.10) the 33 kV and 11 kV lines are most constructed in 2017-2018 and 0.4 kV lines are more contributed in 2016-2017. By constructing the more power line, the households having the electricity more easily. In 2019-2020, the over-headlines are less constructing than 2017-2018 because in this recent years, ESE is using the existing power lines in the distribution of electricity in Nay Pyi Taw Council, ESE set up the new transformers in the whole regions in the recent year than constructed over-headlines.

4.7.2 Existence of Main Transformer in Nay Pyi Taw Council

In Nay Pyi Taw, there are total of 102 transformers, which generate 759.60 MVA. But only 25 transformers are owned by Electricity Supply Enterprise. Table (4.11) shows the main transformers owned by ESE.

Table (4.11) Existing Main Transformers Owned by ESE

No.	Name of Townships	Voltage Ratio	Total number of	
			Transformers	MVA
1.	Zebuthiri	33/11	12	120
2.	Dekkhinathiri	33/11	8	100
3.	Pyinmana	33/11	5	40
4.	Lewe	33/11	2	20
5.	Ottarathiri	33/11	6	60
6.	Pobbathiri	33/11	5	50
7.	Zeyarthiri	33/11	2	20
8.	Tatkon	33/11	4	12.5

Source: Electricity Supply Enterprise

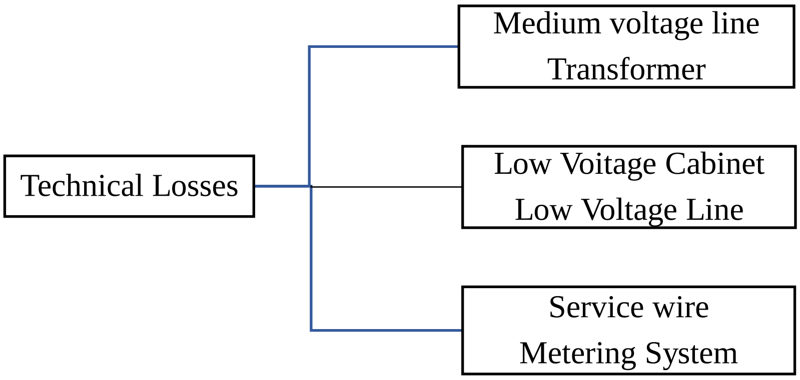
According to table (4.9), Zebuthiri township and Dekkhinathiri township have many transformers and consumed most of electricity rather than other township because most of government ministry office are in that township. Tatkon and Lewe township are less used in electricity because most of villages in Nay Pyi Taw Council are located in these townships.

4.8 Electricity Loss Management by Electricity Supply Enterprise

There are two main factors that lead to electricity losses. They are (1) Technical losses and (2) Non-Technical losses.

(1) Technical losses may occur because of the quality of electrical equipment, lack of knowledge and lack of standard in power generation, distribution, utilization. The technical losses that may occur in the distribution system include Medium voltage lines, transformers, low voltage line, service wire, and metering system.

Figure (4.1) Electricity Losses (Technical)



Source: Ministry of Electricity and Energy (2019)

The following points are needed to reduce the technical losses found in medium voltage lines. Cable terminations are required to firm and contact. If it is losses, termination will occur, and the heat may cause losses. The appropriate conductors are needed to be chosen to fit with load. If undersized conductors are used that is not compatible if needed.

If line length is longer than the specified space for its load, losses may occur at the end of the line. So, transformers are needed to be installed at the load center instead of extending distribution lines and distributing by using Multi Transformer System with the shortest line. By doing this, good voltage and power will be stable, and losses may be reduced.

(i) To reduce the losses appeared on the transformers, it is needed to check and follow the fact of the described diagram. In addition, good quality type transformer is required to choose to avoid the transformer losses.

(ii) To reduce the losses occurred at the low voltage cabinet of the transformer output, it is needed to have a firm connection at the termination and connection and quality cables are needed to be chosen to withstand the load.

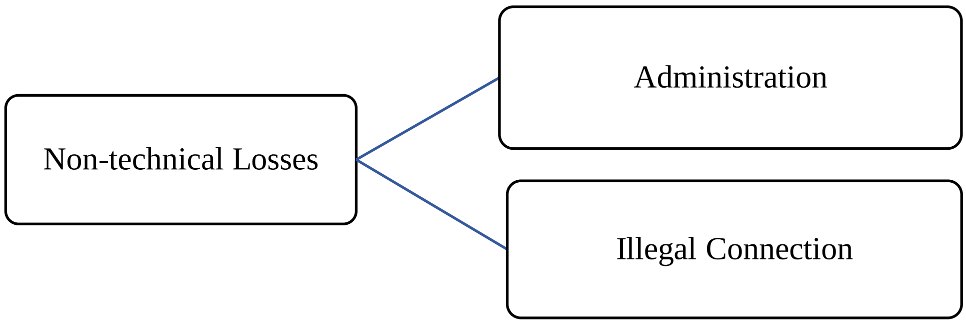
(iii) To reduce the losses in the service wire, it is needed to use standard size wire appropriate load. Ad it must avoid using long and confused service wire.

Losses may occur depending in the quality of CT, PT of wiring system and accuracy of the meters of the metering system. So, all the meters must be fixed accurately, and quality meters must be used. ESE have been implementing to replace the analog meter with digital meters. In addition, the measuring and balancing the transformer load are conducted to cover the losses occurred by load unbalancing of the transformers.

(2) Non-Technical Losses

Non-technical losses are due to the actions external to the power system and consist primarily of electricity theft, non-payment by consumers and environmental factors (overhead tree).

Figure (4.2) Electricity Losses (Non-Technical)



Source: Ministry of Electricity and Energy (2019)

To reduce the non-technical losses caused by environment, it is required to clear the branches of the trees contact with overhead lines regularly. By doing this activity, temporary power outage and accident of cable cut off will be reduced.

Regular meter inspection and surprise checks to the consumers are needed to stop the illegal users. Digital Meters needed to replace to aging meters and non-operating meters. All the meters should be set up at the poles to protect illegal users from connecting households' services wires to these poles. In addition, replacing modernize electrical equipment and related materials for aging materials used in old substations. Step by Step strategic plans must be executed to fulfill the voltage for rapid development of demand by constructing new high voltage lines.

Table (4.12) shows the electric power losses in Nay Pyi Taw Council from (2014-2015 to 2019-2020).

Table (4.12) Electric Power Losses in Nay Pyi Taw (2012-2013 to 2019-2020)

Year	Purchased Unit (MV)	Unit Sold (MV)	Losses (MV)	
			Unit	%
2014-2015	660.120	626.200	31.0174	4.72%
2015-2016	687.964	641.462	43.755	6.36%
2016-2017	720.168	669.263	50.012	6.94%
2017-2018	798.344	741.935	55.983	7.01%
2018-2019	834.544	772.095	62.016	7.43%

Source: Electricity Supply Enterprise (ESE)

The electricity losses in Nay Pyi Taw, is seen as 4.72% in 2015-2013 but 2019-2020, it was 7.43%. These losses are needed to be reduced and authorities concerned is putting much effort by replacing old meters with digital meters and partnering with private companies I the collection of meters bill and distribution of electric power to Nay Pyi Taw Council.

4.9 Using Key Informants Interviews (KIIs) Technique: A Current Status and Management of ESE on Electricity Distribution in Nay Pyi Taw Council

To highlights the current status and management of the ESE in the distribution of electricity in Nay Pyi Taw council. This informant interview is participated by the ESE's administrators and members of township administrators. The questionnaire for the interview had already built up and this was delivered to the respondents. The rest of the key informants were made contact through phone calls and briefed on the purpose of the study. After this process, 15 respondents gave stamp of approval to participate and meeting times were set with them for purpose. The following answers are interacted conservation by phone with the respective township administrators and members. A total of 15 respondents, eight of the participants are lived in urban areas and the rest are stayed in rural areas.

All the township officials have stated that electricity volume distributed to the representative townships are insufficient, about 156000 out of 262253 households are electrified. The distribution of electricity in Nay Pyi Taw Council is about 756.90 MVA in 2019-2020. From overall electricity distribution, about 80.5% of electricity is consumed by households and commercial and only a few19.5 % is used for industrial. Most of the electric power is consumed by urban area, because all townships are already electrified since 2006-2007 period. Rural areas are getting electricity only a few percentages, because there have over 60% of villages which do not have the electricity.

Distribution of Electricity

There is four 230 KV Primary Substation in Nay Pyi Taw, their total capacity is 460 MVA.MOEE planned new projects to supply more electricity, by implementation hydro power stations, extend the power transmission lines and power transformers. In Oaktayathiri district, the electricity is distributed by230 KV2 Nay Pyi Taw (1) primary substation and 230 KV Nay Pyi Taw (2) primary substation and they contributed electricity to Oaktayathiri township, Pobbathiri township and Nay Pyi Taw Union Territory. For Dekkhinathiri District, 230 KV Pyinmana primary substation distributed electricity to Zayarthiri township, Dekkhinathiri township, Zabuthiri township and Pobbathiri township. There has electricity master plan, called NEP plan to fulfil the electricity supply for the annually increased demand and to gain more electricity in rural area in Nay Pyi Taw Council. After the completion of NEP Plan, there are about 80% of electrified households in Nay Pyi Taw council but 20% of rural area are still unelectrified.

Power Supply Service

ESE opened the 24 hours emergency maintenance sections in every township to reduce the outage time and to access the regular electric power as soon as possible. The electric power supply cannot full load in every township because there has a losses in the time of transmission and distribution of electricity deliver from primary substation to transmission lines and distribution feeders. Because there has a low quality and old products in the distribution of electricity. To reduce the technical losses, SI being conducted. To reduce non-technical losses, checking meters, cutting down trees, replacing small electric cable lines with large cable lines and examining illegal cases. To operate full load in the townships, need to exclude the barriers, like electricity losses. When there is less power generation in the dry season and if IPP system is practiced and enough gas can receive from IPP, GTT, and if electricity power plants can operate with full capacity, there would be many benefits. In order to eliminate power losses, it is required to upgrade the meters by using digital meters rather than analog meters. With local and international and private assistance, the need for electric power can be fulfilled. Table (4.13) describes the finding of both improvement and weakness of ESE's function in the distribution of electricity as indicated by the respondents.

Table (4.13) The Improvements and Weakness of ESE in the distribution of Electricity in Nay Pyi Taw Council

Improvement	Weakness
- ESE set up new the Primary Substations in four townships to distribute electricity to rural areas. - About 65.8% of rural households getting electricity in 2019-2020 by constructing new overhead lines and setting up many distribution feeders. - ESE opened the 24 hours emergency call center to solve the customers complains and to access the customers feedback. Also, 24 hours maintenance section are always stand by to repair in- time for power outage case. - Facilitated the one-stop service for the installation of meter, everyone can get electricity more easily than the earlier years. - Replacing and extending procedures for existing system which are hard for aging and cannot supply full load and causes the losses of electricity. - Also reducing the technical losses by making system improvement conducted and for non-technical losses, by checking meters and cutting down trees and examining illegal cases. - Planning the electricity master plan(NEP) to fulfill the increased electricity demand of households. There are about 80% of households will electrified after the	- Only the urban areas are getting electricity sufficiently, most of the rural households are still unelectrified. - Power Supply Cannot full load in every township and losses from electricity distribution and transmission are still occur. - Less power generation in the dry season and electric power plants cannot full with full capacity. - Using the old function meters which are low quality and causes the electricity losses and reduce the government revenue.

completion of NEP plan.	

Source: Survey data, 2020

CHAPTER V
CONCLUSION

5.1 Findings

In Myanmar, the shortage of power supply is a major obstacle in the development for establishment of manufacturing industries. The Government is implementing large scale hydropower projects throughout the country to meet the demand for electricity; constructing transmission power lines to connect the hydropower plants within the National Grid System. The generation of electric power by various kinds of power plants can be variable according to the supply resources of power. During the hot season, the inflow of water for storage dams, reservoirs is very spares and the water level becomes very low that hydropower station cannot generate electric power round the clock efficiently. During that period, the gas Turbines generates more electric power to fill the requirement of power demand. In the rainy season the hydropower plants can operate and generate electric power efficiently 24 hours daily.

The ESE efficiently maintain transmission and distribution lines and replace old lines with new ones. Constructing the new power lines and substations within Nay Pyi Taw Council, especially villages which haven't access the electricity. And facilitated the 24 hours call center for public, to solve the problems e.g. power breakdown, electricity shock, etc. The public also has the responsibilities to slow down wastage of electricity as much as possible so that the dramatic rise in demand for electricity is manageable. The ESE is trying to enhance the efficiency of electric power distribution and consumption in Nay Pyi Taw council and to reduce the losses of electricity which affected the revenue for power unit sold.

5.2 Suggestions

It is also needed 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 market- oriented system, the ESE is trying to decrease power losses and increase sales of electric power to consumers in Nay Pyi Taw Council. The required electric power to be distributed in Nay Pyi Taw Council is transferred from the national grid transmitted via four 230 KV primary substations. From those substations, ESE supply the electricity to the consumers. If yearly demands of electricity may be increased in electricity demand up to 772 MW during 2020. For the fulfilment of increased demand of electricity during the coming years the time has come to extend 230 KV,66KV, and 33KV main supplies to cope the Nay Pyi Taw Council electricity demand.

As compare to Yangon Region, the commercial city of Myanmar, Nay Pyi Taw has only a little use electricity for industrial usage. There have no industrial zones in Nay Pyi Taw Council, most of the electricity users are households and Government Ministry Offices. The capital city is needed the future to seek the foreign and local companies to establish their businesses in there.

In Nay Pyi Taw, the main power supply sources have 780 MW and indirect power supply is about 950 MW. So, there is no doubt that these power sources can cope with the present demand of power supply. However, most of the electrical power lines and transformers have the danger of natural disasters, such as tightening, thunderstorms and decline of insulation due to abrupt change of cold and that during the early rainy seasons.

The ESE is arranging for development of electric power works and safety from electrical danger by making use of modern and advanced technology. For decreasing the power losses, it is essential to avoid illegal joining of power supply. To generate the electricity efficiently, all the plants may be maintained in running condition. Line clearance of overhead lines is important for decreasing of power losses and safety use of power. Extension for various kinds of power lines are needed to construct and transformers to install at the required sited to balance the power needs.

The ESE is supervising the collection of electric power fees from the consumer of electric power. The fees collected from the unit sold is revenue of the State, and revenue can be increased by means of decreasing losses and collecting power fees fully. Action should be taken against any consumer who commits the use of power by illegal means intentionally. The meter bill unit should be read exactly, and the fees be paid during the prescribed period, and if there is failure to pay electric power fees during prescribed period, the supply of electric power must be cut off.

The ESE is distributing electricity to supply enough electric power to the consumers of electric power in Nay Pyi Taw Council. Every citizen must avoid the illegal uses, unnecessary or needless use, and waste of power.

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APPENDIX

Questionnaire for Key Informant Interview

1. It is enough the electric power supply based on the receiving to the household?
2. What are the types of transformers, quality and amount of electric power supply?
3. Is there any transformer? If not, which transformer get from?
4. Are there any plan to supply the annually electric power demand increase?
5. If the power supply to the customers is on 24 hours in the township?
6. Can the electric power supply operate full load in the township?
7. If the electric power supply will reduce, can it operate full load?
8. Which kinds of matter can cause the electricity losses?
9. How many types of electricity loss?
10. Households, commercial and industrial uses, which uses have greater power loss?
11. How to reduce the power loss in the township?
12. If the power loss can reduce, how many households can be received electric power?
13. How to solve the power loss by the meters?