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A STUDY ON ELECTRICITY GENERATION DEVELOPMENT IN MYANMAR

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A STUDY ON ELECTRICITY GENERATION DEVELOPMENT IN MYANMAR

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Development Studies (MDevS)

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ABSTRACT

A study on electric sector in Myanmar was conducted with the aim to examine the electricity generation development in Myanmar form 1988 to 2016. For a developing country, a cheap power supply for industries is needed to be industrialized. The trends about electricity installation, generation, consumption pattern and unit losses were described by using secondary data obtained from government official reports and World Bank. From 1988 to 2016, progressive trends were founded in the generation and consumption of electricity. A downward trend has been occurred in unit loss of electricity transmission and distribution systems. But this is not enough to fulfill the demand for electricity. Power pricing system is still weak to encourage for industrial sector development because of high price for industrial and commercial use. It is necessary to focus on alternative generation systems to reduce reliance on hydro power and be more paid attention in reducing unit losses.

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LIST OF ABBREVIATIONS

ADB	= Asian Development Bank
ASEAN	=Association of Southeast Asian Nations
DEPP	= Department of Electric Power and Planning
DHPI	= Department of Hydropower Implementation
DPTSC	= Department of Power Transmission and System Control
EPC	= Electric Power Corporation
EPGE	= Electric Power Generation Enterprise
ESB	= Electricity Supply Board
ESE	= Electric Supply Enterprise
GDP	= Gross Domestic Product
ICT	= Information and Communications Technology
IHLCA	= Integrated Household Living Conditions Assessment
IMF	= International Monetary Fund
KV	= Kilovolt
KWh	= Kilowatt Hour
MESC	= Mandalay Electricity Supply Corporation
MOA	= Memorandum of Agreement
MOEE	= Ministry of Electricity and Energy
MOEP	= Ministry of Electrical Power
MOGS	= Myanma Oil and Gas Enterprise
MOU	= Memorandum of Understanding
MPE	= Myanma Petrochemical enterprise
MPEE	= Myanma Petroleum Product Enterprise
MW	= Megawatt
OGPD	= Oil and Gas Planning Department
PPP	= Public Private Partnership
R&D	= Research and Development
RET & S	= Rangoon Electric-Tramway and Supply
RGDP	= Real GDP
SMEs	= Small and Medium-sized Enterprises
YESC	= Yangon Electricity Supply Corporation

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

Increasing the electric power facilities of a country is to stimulate and keep pace with the general expansion of the economy and it is one of the principle elements of the development program. One of the indicators of the general trend of economic activity is power consumption. Sufficient and continuous supply of electricity is a basic need for not only heavy industrial development but also SMEs. Electricity is also a basic need for households, construction, transportation, commerce and etc. Without electricity, modernized equipment such as internet can't be used. In Myanmar, role of electric power plays an important infrastructure for higher level of quality lives of human beings and for sustainable development of their communities. The development of the electric power sector plays a contribution of socioeconomic development.

Myanmar was riddled with deep economic sanctions for nearly three decades as the international community reacted to oppression of democratic liberties in the economy. With restriction on foreign investment and lack of assistance from multilateral organizations, Myanmar' economy lagged behind its potential. With a new government taking office in 2011, Myanmar's foreign relations have started to be improved again once more. Sanctions are increasingly being lifted and assistance has started pouring in from ADB and World Bank.

As Myanmar suffers upon reversing the damage and realizing its potential, availability of electricity is crucial in all spheres - economic, health-related and education. However, nowhere is the immensely of the task at hand more apparent than in the electricity sector. Less than 30% of households are connected to the electric grid. Per capita consumption of power is lowest in ASEAN.

There is over-reliance on hydropower and unsteady demand-side management and shortage in supply-side especially in summer months. Current supply is almost 30% below demand, manifested in sweeping load-shedding. Planning is centralized, unsystematic and seemingly untouched by market dynamics. Power plants have numerous breakdowns and lack of efficiency. Transmission and distribution networks are out of date and fail large expanses. Current installed capacity, unit generation and consumption by consumers in both urban and rural area of Myanmar is also studied to assess how much of those are feasible with the needs of the people domestically and their communities for modernization and catching up in the world of globalization. Insufficient electricity supply still threat to foreign investment in industrial sector.

The phases of electric power sector in Myanmar especially can be divided into generation, distribution, and consumption since these phases have links to each other harmoniously participating by different ways in which each sub-sector works. Many kinds of production ways, as example, are hydro base, gas base, coal base, solar base, wind base and nuclear base. But Myanmar is experiencing a limit access to wind base and solar base energy and no use of nuclear energy. Means of production of electric power in Myanmar are especially by hydro, gas and coal base. Similarly in distribution sub-sector, the system of the national power grid area as a main arena and out-reach of it in rural area is needed to view clearly. Therefore, this study was intended to examine how Myanmar electric power sector works and what pattern of development are being occurred in these areas.

1.2 Objective of the Study

The objective of the study is to examine the trend of the electricity generation development in Myanmar.

1.3 Method of the Study

Descriptive method was used in order to analyze the electricity production of Myanmar by using secondary data. These data were collected from World Bank, Ministry of Electricity and Energy, various reports and researches and various websites.

1.4 Scope and Limitations of the Study

The study is based on the secondary data regarding changes and progress in electric sector from 1988 to 2016. The study is limited and focused on only the electricity production of Ministry of Electricity and Energy.

1.5 Organization of the Study

The study is composed of five chapters. Chapter (1) is an introduction. Chapter (2) deals with literature review concerning with forms of energy and sources of electricity. Chapter (3) is about historical background of Myanmar electric sector and main sources of Myanmar electricity generation sector. Chapter (4) focuses on current electricity production, consumption, electricity distribution system, power pricing and unit losses in Myanmar Electric power sector. Chapter (5) is about conclusion which also encompasses findings and suggestions.

CHAPTER II
LITERATURE REVIEW

In the history of electricity, no single defining moment exists. The way we produce, distribute, install, and use electricity and the devices powered by electricity is the culmination of nearly 200 years of research and development. Efforts to understand, capture electricity began in the 18^{th} century. For the next 150 years, dozens of “natural scientists” in England, Europe, colonial America and later the United States analyzed the electricity in nature, but producing it outside of nature was another matter.

Edison, Westinghouse, and other investors and builders of electrical equipment competed to show that the wonders of their new inventions. In 1881, Lucien Gaulard of France and John Gibbs of England arranged the first successful alternating current electrical demonstration in London.

People have always used energy to do work for them. Thousands of years ago, early humans burned wood to provide light, heat their living spaces, and cook their food. Later, people used the wind to move their boats from place to place. A hundred years ago, people began using falling water to make electricity.

Today, people use more energy than ever from a variety of sources for a multitude of tasks and our lives are undoubtedly better for it. Homes are comfortable and full of useful and entertaining electrical devices. People communicate instantaneously in many ways. People can live longer, healthier lives. People travel the world, or at least see it on television and the internet.

There is a question electricity is a renewable or nonrenewable source of energy. Electricity is different from the other energy sources because it is a secondary source of energy. That means people have to use another energy source to make it. In Myanmar, Hydro power is number one source for electricity generation.

2.1 Forms of Energy

Energy does things for human beings. It moves cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights homes at night so that people can read books and watch the television. There are many forms of energy, but all fall into two categories-potential or kinetic.

2.1.1 Potential Energy

Potential Energy is stored energy and the energy of position, or gravitational energy. These are several forms of potential energy, including.

(a) Chemical Energy is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy. During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are later broken down, the stored chemical energy is released as heat, light, motion and sound.

(b) Stored Mechanical Energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

(c) Nuclear Energy is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of hydrogen atoms into helium atoms in a process called fusion. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, E$= mc^2$.

(d) Gravitational Energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

2.1.2 Kinetic Energy

Kinetic energy is motion- the motion of waves, electrons, atoms, molecules, substances, and objects.

(a) Electrical Energy is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called electricity. Lightning is another example of electrical energy.

(b) Radiant Energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

(c) Thermal Energy, or heat, is the internal energy in substances—the vibration and movement of atoms and molecules within substances. The faster molecules and atoms vibrate and move within substances, the more energy they possess and the hotter they become. Geothermal energy is an example of thermal energy.

(d) Motion Energy is the movement of objects and substances from one place to another. According to Newton’s Laws of Motion, objects and substances move when a force is applied. Wind is an example of motion energy.

(e) Sound Energy is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave.

2.2 Energy Sources for electricity

There are eight major energy sources using in electricity generation in the world today. These energy sources can be classified into two broad groups- nonrenewable and renewable. Nonrenewable energy sources include coal, natural gas, and uranium. All these sources are used to generate electricity, to heat our homes, to move our cars, and to manufacture products from candy bars to MP3 players. These energy sources are called nonrenewable because they cannot be replenished in a short period of time. Petroleum, for example, was formed millions of years ago from the remains of ancient sea life, so can't make more quickly. Nonrenewable resources can be running out someday. Renewable energy sources include biomass, geothermal, hydropower, solar, and wind because their supplies are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. So, renewable energy is suitable for electricity generation in the long run.

A renewable resource is a natural resource which replenishes to overcome resource depletion caused by usage and consumption, either through biological reproduction or other naturally recurring processes in a finite amount of time. Renewable resources are a part of Earth's natural environment and the largest components of its ecosphere. A positive life cycle assessment is a key indicator of a resource's sustainability.

Definitions of renewable resources may also include agricultural production, as in sustainable agriculture and to extent water resources. Paul Alfred Weiss defined Renewable Resources as: "The total range of living organisms providing man with food, fibers, etc..." Another type of renewable resources is renewable energy resources. Common sources of renewable energy include solar, geothermal and wind power, which are all categorized as renewable resources.

A non-renewable resource is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically-derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas. Earth minerals and metal ores, fossil fuels (coal, petroleum, natural gas) and groundwater in certain aquifers are all considered non-renewable resources, though individual elements are almost always conserved. In contrast, resources such as timber (when harvested sustainably) and wind (used to power energy conversion systems) are considered renewable resources, largely because their localized replenishment can occur within time frames meaningful to humans.

2.2.1 Biomass

Biomass is an industry term for getting energy by burning wood, and other organic matter. Burning biomass releases carbon emissions, but has been classed as a renewable energy source in the EU and UN legal frameworks, because plant stocks can be replaced with new growth. It has become popular among coal power stations, which switch from coal to biomass in order to convert to renewable energy generation. Biomass most often refers to plants or plant-based materials that are not used for food or feed, and are specifically called lignocelluloses biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of bio-fuel. Conversion of biomass to bio-fuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical. Some chemical constituents of plant biomass include lignin, cellulose, and hemicelluloses.

Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas, also called landfill gas or biogas. Crops such as corn and sugarcane can be fermented to produce the transportation fuel ethanol. Biodiesel, another transportation fuel, can be produced from leftover food products like vegetable oils and animal fats. Several biodiesel companies simply collect used restaurant cooking oil and convert it into biodiesel. Also, biomass-to-liquids called BTL and cellulosic ethanol are still under research.

The biomass used for electricity generation varies by region. Forest by-products, such as wood residues, are common in the US. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (rice husks). Animal husbandry residues, such as poultry litter, are common in the UK.

2.2.2 Geothermal

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

Geothermal power is cost-effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels.

The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive. Forecasts for the future of geothermal power depend on assumptions about technology, energy prices, subsidies, plate boundary movement and interest rates. Pilot programs like EWEB's customer opt in Green Power Program show that customers would be willing to pay a little more for a renewable energy source like geothermal. But as a result of government assisted research and industry experience, the cost of generating geothermal power has decreased by 25% over the past two decades. In 2001, geothermal energy costs between two and ten US cents per kWh.

The International Geothermal Association (IGA) has reported that 10,715 megawatts (MW) of geothermal power in 24 countries is online, which was expected to generate 67,246 GWH of electricity in 2010. This represents a 20% increase in online capacity since 2005. IGA projects growth to 18,500 MW by 2015, due to the projects presently under consideration, often in areas previously assumed to have little exploitable resources.

In 2016, Indonesia set in third with 1,647 MW online behind USA at 3,450 MW and the Philippines at 1,870 MW, but Indonesia will become second due to an additional online 130 MW at the end of 2016 and 255 MW in 2017. Indonesia's 28,994 MW are the largest geothermal reserves in the world, and it is predicted to overtake the USA in the next decade.

2.2.3 Hydropower

Hydropower or water power is power derived from the energy of falling water or fast running water, which may be harnessed for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. A tromped, which produces compressed air from falling water, is sometimes used to power other machinery at a distance.

In the late 19th century, hydropower became a source for generating electricity. Crag side in Northumberland was the first house powered by hydroelectricity in 1878 and the first commercial hydroelectric power plant was built at Niagara Falls in 1879. In 1881, street lamps in the city of Niagara Falls were powered by hydropower.

Since the early 20th century, the term has been used almost exclusively in conjunction with the modern development of hydroelectric power. International institutions such as the World Bank view hydropower as a means for economic development without adding substantial amounts of carbon to the atmosphere, but dams can have significant negative social and environmental impacts.

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

2.2.4 Solar

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect.

Photovoltaic were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. Commercial concentrated solar power plants were first developed in the 1980s. The 392 MW installations is the largest concentrating solar power plant in the world, located in the Mojave Desert of California.

As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. The current largest photovoltaic power station in the world is the 850 MW Solar Park, in Qinghai, China.

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. In 2017, solar power provided 1.7% of total worldwide electricity production, growing at 35% per annum.

2.2.5 Wind

Wind is the flow of gases on a large scale. Wind energy is the kinetic energy of the air in motion. In human civilization, the concept of wind has been explored in mythology, influenced the events of history, expanded the range of transport and warfare, and provided a power source for mechanical work, electricity and recreation.

Wind powers the voyages of sailing ships across Earth's oceans. Hot air balloons use the wind to take short trips, and powered flight uses it to increase lift and reduce fuel consumption. Areas of wind shear caused by various weather phenomena can lead to dangerous situations for aircraft. When winds become strong, trees and human-made structures are damaged or destroyed.

Nowadays, a yardstick used to determine the best locations for wind energy development is referred to as wind power density (WPD). It is a calculation relating to the effective force of the wind at a particular location, frequently expressed in terms of the elevation above ground level over a period of time. It takes into account wind velocity and mass. Color coded maps are prepared for a particular area are described as, for example, "Mean annual power density at 50 meters". The results of the above calculation are included in an index developed by the National Renewable Energy Lab and referred to as "NREL CLASS". The larger the WPD calculation, the higher it is rated by class. At the end of 2008, worldwide nameplate capacity of wind-powered generators was 120.8 GWH. Although wind produced only about 1.5% of worldwide electricity use in 2009, it is growing rapidly, having doubled in the three years between 2005 and 2008.

In several countries it has achieved relatively high levels of penetration, accounting for approximately 19% of electricity production in Denmark, 10% in Spain and Portugal, and 7% in Germany and the Republic of Ireland in 2008. One study indicates that an entirely renewable energy supply based on 70% wind is attainable at today's power prices by linking wind farms with an HVDC. Wind power has expanded quickly its share of worldwide electricity usage at the end of 2014 was 3.1%. In 2011 wind energy was also used to power the longest journey in a wind powered car which travelled a distance of 5,000 km (3,100 miles) from Perth to Melbourne in Australia.

2.2.6 Coal

Throughout human history, coal has been used as an energy resource, primarily burned for the production of electricity and heat, and is also used for industrial purposes, such as refining metals. Coal is the largest source of energy for the generation of electricity worldwide, as well as one of the largest worldwide anthropogenic sources of carbon dioxide releases. The extraction of coal, its use in energy production and its byproducts are all associated with environmental and health effects including climate change.

Coal is extracted from the ground by coal mining. Since 1983, the world's top coal producer has been China. In 2015 China produced 3.747 billion tons of coal – 48% of 7.861 billion tons world coal production. In 2015 other large producers were United States (813 million tons), India (678), European Union (539) and Australia (503). In 2010 the largest exporters were Australia with 328 million tons (27% of world coal export) and Indonesia with 316 million tons (26%), while the largest importers were Japan with 207 million tons (18% of world coal import), China with 195 million tons (17%) and South Korea with 126 million tons (11%).

For every megawatt-hour generated, coal-fired electric power generation emits around 2,000 pounds of carbon dioxide, which is almost double the approximately 1100 pounds of carbon dioxide released by a natural gas-fired electric plant. Because of this higher carbon efficiency of natural gas generation, as the market in the United States has changed to reduce coal and increase natural gas generation, carbon dioxide emissions may have fallen.

2.2.7 Natural gas

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkenes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is also used as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals.

Natural gas is a major source of electricity generation through the use of cogeneration, gas turbines and steam turbines. Natural gas is also well suited for a combined use in association with renewable energy sources such as wind or solar and for alimenting peak-load power stations functioning in tandem with hydroelectric plants. Most grid peaking power plants and some off-grid engine-generators use natural gas. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns more cleanly than other fuels, such as oil and coal. Because burning natural gas produces both water and carbon dioxide, it produces less carbon dioxide per unit of energy released than coal, which produces mostly carbon dioxide. Burning natural gas produces only about half the carbon dioxide per kilowatt-hour (KWH) that coal does. For transportation, burning natural gas produces about 30% less carbon dioxide than burning petroleum. The US Energy Information Administration reports the following emissions in million metric tons of carbon dioxide in the world for 2012.

Natural gas is often described as the cleanest fossil fuel. It produces 25%–30% and 40%–45% less carbon dioxide per joule delivered than oil and coal respectively, and potentially fewer pollutants than other hydrocarbon fuels. However, in absolute terms, it comprises a substantial percentage of human carbon emissions, and this contribution is projected to grow. According to the IPCC Fourth Assessment Report, in 2004, natural gas produced about 5.3 billion tons a year of CO_2 emissions, while coal and oil produced 10.6 and 10.2 billion tons respectively. According to an updated version of the Special Report on Emissions Scenario by 2030, natural gas would be the source of 11 billion tons a year, with coal and oil now 8.4 and 17.2 billion respectively because demand is increasing 1.9% a year.

2.2.8 Nuclear power

Nuclear power is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant. Nuclear power can be obtained from nuclear fission, nuclear decay and nuclear fusion. Presently, the vast majority of electricity from nuclear power is produced by nuclear fission of Uranium.

Nuclear power is one of the leading low carbon power generation methods of producing electricity. In terms of total life-cycle greenhouse gas emissions per unit of energy generated, nuclear power has emission values comparable or lower than renewable energy. From the beginning of its commercialization in the 1970s, nuclear power prevented about 1.84 million air pollution-related deaths and the emission of about 64 billion tons of carbon dioxide equivalent that would have otherwise resulted from the burning of fossil fuels in thermal power stations.

Civilian nuclear power from fission-electric generating stations, supplied 2,488 terawatt hours (TWH) of electricity in 2017, equivalent to about 10% of global electricity generation. As of April 2018, there are 449 grid connected fission-electric reactors in the world, with a combined electrical capacity of 394 GW. Additionally, there are 58 reactors under construction and 154 reactors planned, with a combined capacity of 63 GW and 157 GW, respectively. Over 300 more reactors are proposed. Most of reactors under construction are of generation III reactor design, with the majority in Asia.

Nuclear power is a sustainable energy source that reduces carbon emissions and increases energy security by decreasing dependence on imported energy sources. Nuclear power produces virtually no conventional air pollution, such as greenhouse gases and smog, in contrast to the main alternative of fossil-fuel power stations. Nuclear power can produce base-load power unlike many renewable which are intermittent energy sources lacking large-scale and cheap ways of storing energy. When other nonrenewable sources run out some day, nuclear energy will be as a replacement energy source. The risks of storing waste are small and can be further reduced by using the latest technology in newer reactors, and the operational safety record in the Western world is excellent when compared to the other major kinds of power plants.

On the other hand, Nuclear power poses many threats to people and the environment. These threats include the problems of processing, transport and storage of radioactive nuclear waste, the risk of nuclear weapons proliferation and terrorism, as well as health risks and environmental damage from uranium mining. The reactors themselves are enormously complex machines where many things can and do go wrong; and there have been serious nuclear accidents. Critics do not believe that the risks of using nuclear fission as a power source can be fully offset through the development of new technology. In years past, there were many arguments about that when all the energy-intensive stages of the nuclear fuel chain are considered; from uranium mining to nuclear decommissioning, nuclear power is neither a low-carbon nor an economical electricity source.

CHAPTER III
OVERVIEW OF MYANMAR ELECTRIC SECTOR

3.1 Historical Background of Myanmar Electricity Sector

The use of electric power had been started in Myanmar by hydro power generation since at very late 19th century. The *Rangoon* Electric-Tramway and supply (RET & S) company had been started traffic lightening alongside of *Sule* pagoda road in Yangon in 1905. In the period approached to independence of Myanmar, the national leaders set strategies and plans for the development of the country: to promote and expand the agricultural sector with advanced technologies; to exploit the natural resources effectively by cooperation with local industries. The leaders also realized that electricity played a vital role to implement above strategies. Therefore, in June 1947, they decided to implement the hydropower projects which were enormous resources in Myanmar, and could be implemented by suitable budgets as a first priority. They put those plans in two years plan for Economic Development of the Union of Myanmar (1947).

In early post-independence time, Electricity Supply Board (ESB) was organized under the Ministry of Industry on 1st October 1951 complied with the Electricity Act of 1948. On 16th March 1972, it was changed as Electric Power Corporation (EPC). On 1st April 1975, the Ministry of Industry was divided into the Ministry of Industry (1) and the Ministry of Industry (2) and so the Electric Power Corporation (EPC) was composed under the Ministry of Industry(2). On 12th April 1985, the Ministry of Industry (2) was expanded with the Ministry of Energy and the EPC was composed under the Ministry of Energy. On 1st April 1989, the EPC was changed into the November 1997, the Ministry of Electrical Power was organized, and there were three departments under it: the Department of Electrical Power, the Myanmar Electric Power Enterprise and the Department of Hydropower.

After 1988, a great momentum was occurred in nation development as in expansion of industrial zones, construction of modern housing, developing the status of living, using electrical power in agriculture, and advancing in technology in health and education sectors. Therefore, electrical consumption was dramatically increased. Therefore, government has implemented the new gas stations as well as new hydropower plants and coals based were constructed.

On 15th May 2006, the ministry was divided into No 1 and No 2, and on 5th September 2012, they were composed again into one Ministry as the Ministry of Electrical Power (MOEP) under which there were three departments, two enterprises and two corporations. On 1st April 2016, the MOEP was composed with the Ministry of Energy to form the Ministry of Electricity and Energy (MOEE), under which there were four departments, five enterprises and two corporations.

3.1.1 Organizational Structure of Myanmar Electric Power Sector

The regulatory framework is laid down by the Electricity Act of 1948, the Myanmar Electricity Law (1984), and the Electricity Rules (1985). The power sector is centralized and is primarily under the control and management of government enterprises.

1st April 2016, under the Ministry of Electricity and Energy, there are four departments, five enterprises and two corporations.

(a) Department of Electric power and planning (DEPP)
(b) Oil and Gas planning Department (OGPD)
(c) Department of Electric power Transmission and system control (DPTSC)
(d) Department of Hydropower implementation (DHPI)
(e) Electric power generation enterprise (EPGE)
(f) Electric Supply Enterprise (ESE)
(g) Myanma oil and gas enterprise (MOGE)
(h) Myanma petrochemical enterprise (MPE)
(i) Myanma petroleum product enterprise (MPPE)
(j) Yangon Electricity supply corporation (YESC)
(k) Mandalay Electricity supply corporation (MESC)

Power Policy in Myanmar is driven by centralized government decision-making. The Myanmar' domestic energy market is influenced both by regional and international investment flows form major regional states looking for energy resources.

Though the government of Myanmar claims that energy sector development is vital for meeting the population's basic needs and overall development strategy, Myanmar electrification rate is very low, even after years of resources exploitation. In 2014, 36 Million of Myanmar 54 Million population lived without electricity. During 2010-2020, Myanmar energy sector plans to continue oil and gas pipeline construction, oil and gas extraction plans, hydroelectric power development, and transmission line construction both for domestic use and for regional interconnection plans.

Myanmar's power planning is based in order to achieve its economic and social development plans of 9% annual GDP Growth, Fourth Short-Term, Five-Year Plan (2016-2020) was formulated to meet this stated target. One of the power-related objectives in the five year plan is to develop electric power and energy sector to be in conformity with developing trend industries.

PROMEEC (Promotion of Energy Efficiency and Conservation) is a program coordinated on by ASEAN to facilitate capacity building and exchange of information between the ASEAN countries. PROMEEC proposes a new institutional set up for energy efficiency and conservation measures. Since 2015, Myanmar and Thailand signed an MOU on cooperation in renewable energy and energy saving sectors.

According to power demand forecast, in 2030, due to Power Development Plans and Transmission Interconnection Projects of the country Myanmar will have a peak demand of about 20000 MW in 2020. During 2010-2020, several projects will be developed. At present, 18 hydropower projects are under construction. Furthermore, 18 cross border hydropower projects are currently being planned through investments by companies and state owned enterprises from China, Thailand and India. If these projects are completed, their total installed capacity will rise to 19413 MW. To facilitate power transmission system, during 2010-2020, the government plans to construct 62 transmission lines throughout Myanmar.

Myanma Oil and Gas Enterprise (MOGE), the Myanma Petroleum Products Enterprise (MPEE) and the Myanma Petrochemical Enterprise (MPE) are 100% state owned enterprises that run the secure power sector in the country. It can safely be assumed that the electricity production and distribution is also state owned, although no documentation could be found no competition is expected in the power generation sector. In off-grid areas, there might be providers of electricity or household electricity production technologies (e.g. Biomass, Solar and Pico-hydropower)

Myanmar Electric Power Enterprise (MEPE), a state-owned enterprise, has been distribution electricity generated by major hydropower and gas turbine stations. The national grid supplies 94% of the nation's power needs while another 6% comes from off-grid isolated energy sources. MOEE's objectives for the country's development are as follows:

(a) Developing Hydropower for base load and gas turbine for peak load
(b) In order to optimize the use of natural gas by gas turbine, combined cycle power plants are implemented
(c) To expand the national gird
(d) To revive the study of alternative production of electricity by using waste products including rice husks (Biomass).
(e) To reduce unit losses of electricity incurred form transmission and distribution
(f) In remote areas where electricity from hydropower through the national gird cannot be utilized, the generation and distribution of electricity will be performed by diesel generation sets, wind and solar facilities.

The way form the origins of generation to end-users, the generated electricity first goes to a transformer at the power plant that boosts the voltage up to desired level. High voltage transmission lines carry electricity long distances to a substation. Transformers change the very high voltage electricity back into lower voltage electricity before reaching in the hand of end-users. Power system may by broadly define as a network of conductors and associated equipment over which energy is transmitted form the generation stations to the load centers.

3.2 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.

3.2.1 Hydro Electric Power

Sources of electricity refer to the inputs used to generate electricity. Hydropower refers to electricity produced by hydroelectric power plants. The cost of hydroelectricity is relatively low, making it a competitive source of renewable electricity. The hydro station consumes no water, unlike coal or gas plants. The average cost of electricity form a hydro station larger than 10 megawatts is 30 to 50 kyats per kilowatt-hour. And hydroelectric stations have long economic lives, with some plants still in service after 50-100 years. Operation labor cost is also usually low, as plants are automated and have few personnel on site during normal operation.

Myanmar has the potential for more than 100000MW of hydropower. Myanmar has currently developed 25 grid-connected hydropower plants: all operated by EPGE. According to world-bank, their installed capacity was 3337 MW in 2014. Off-grid supply form mini-hydropower is provided by ESE, but it is miniscule at just 33 MW.

Small hydroelectric plants are fairly common, being actively manufactured and installed in more than 100 countries. The smaller size plants include micro-hydro and mini-hydro. Typically plants less than 100 KW can use and induction generator to generate the electricity. Plants larger than 100KW can use either induction or synchronous generators depending on design and cost analysis. Many of these smaller plants do not include a dam, but they are run by a flowing river or stream. They are then dependent on the variation of water flow in the river than those with storage reservoir. As type of hydro power plants, there are three types of hydropower plants, such as small hydropower plant (which can produce less than 1 MW and 1 MW); medium hydropower plant (1MW to 10MW); and large hydro power plant (10MW and above). The numbers of large hydro power plants which are currently run are shown in Table (3.1).

Table (3.1) Current Large Hydro Power Plants in Myanmar, 2016

Sr. no	Hydropower Plants	Capacity (MW)
1	Baluchaung 1	28
2	Baluchaung 2	168
3	Kinda	56
4	Sedawgyi	25
5	Zawgyi Dam 2	32
6	Thapanzeik	35
7	Mone	75
8	Lower Pang Laung	280
9	Yenwe	28
10	Kabaung	34
11	Kengtawng	55
12	Shweli 1	600
13	Yeyma	790
14	Dapein 1	240
15	Shwe Gyi	75
16	Kyeeankyeewa	74
17	Kun	64
18	Thauktegat 2	130
19	Nancho	44
20	Chinweage	102
21	Phyu	46
22	Upper Paung Laung	247
23	Baluchaung	63
24	Zaungtu	26
25	Zawgyi Dam	20

Source: Ministry of Electricity and Energy, 2017

MOEE is developing 18 hydropower projects, 14 of which involve investments from China and Japan. The China Power Investment Corporation (CPI) has invested USD 25.6 billion to build 7 stations in the upper reaches of Irrawaddy. Loans with USD 17 billion have been agreed form the Export-Import Bank of China and China Development Bank.

Table (3.2) Upcoming Hydropower Plants (2017-2025)

Sr. no	Hydropower Plants	Capacity (MW)
1	Shweli 3	1050
2	Upper Yeywa	280
3	Tha Htay	111
4	Upper Keng Tawng	51
5	Middle Paung Laung	100
6	Dee Doke	66
7	Mong Wa	50
8	Ngot Chaung	20.6
9	Upper Bu	150
10	Kaing Kan	16
11	Upper Baluchaung	30.4
12	Middle Yeywa	320
13	Bawgata	160
14	Upper Thanlwin	1400
15	Naopha	1200
16	Mantong	225
17	Dapein 2	140
18	Shweli 2	520

Source: Ministry of Electricity and Energy, 2017

After completion of these upcoming projects, an estimated installed capacity of 6026 MW could be produced in Myanmar. Furthermore, investments from foreign countries are welcomed and thus a total of 32 hydro power plants projects are implementing under research throughout the country.

3.2.2 Gas-Fired Power

Myanmar has abundant natural resources and thus role of gas power in electricity production is become crucial. Air pollution from natural gas is considerably lowered than other types of fuels and waste from this source is very little. Besides, it can build within short time and initial cost for investment is also low. The size of plant is small and it has the least complication and easy to control. On the other hand, the efficiency is very low in compared with hydro source. Although natural gas is one of abundant natural resource, it is a type of non-renewable natural resources. Sources of electricity refer to the inputs used to generate electricity. Gas refers to natural gas but excludes natural gas liquids.

Currently Myanmar has 14 gas fired power plants, all operated by MPGE. Their installed capacity of 1595 MW account for 8.9% of national grid capacity in 2016. Kanpauk is the biggest plant with 531.6 MW capacities. It was to supply to Dawei Special Economic Zone.

Table (3.3) Gas-Fired Electric Power Plants in Myanmar (2016)

Sr.no	Name of Plants	Installed Capacity (MW)
1	Myinchan	103.04
2	Kyaukse	110.62
3	Mann	36.9
4	Kyanchaung	54.3
5	Kyauk Phyu	49.92
6	Shwedaung	55.35
7	Myan Aung	34.7
8	Thanton	50.95
9	MyawLaMyaing	230
10	Hlawga 2	54.55
11	Ywama	70.3
12	Ahlone	121
13	Tharketa2	92
14	Kanpawk	531.6

Source: Ministry of Electricity and Energy, 2017

MOEE intend to focus on gas-power to reduce reliance on hydropower. In its official five-year-plans, MOEE has set an ambitious target to add about 3000 MW capacity in 2019-2020. The World Bank lent USD 140 million in September 2014 to upgrade and add 125 MW capacities to Thanton Station. And there are 9 upcoming gas-fired-power plants. Some of them are operated by private sector.

Table (3.4) Upcoming Gas-Fired Power Plants (2017-2025)

Sr. no	Power Station	State/Region	Installed Capacity (MW)
1	Kyauk Phyu (with loan from China)	Rakhine	50
2	Thilawa (with loan from JICA)	Yangon	50
3	Sembcorp (Myinchan)	Mandalay	225
4	Be One Energy Co. ltd (Hlaing Thar Yar)	Yangon	400
5	Hydrolacang Energy Co. ltd (Hlawga)	Yangon	486
6	UREC Energy (Tharketa)	Yangon	513
7	Thanton (with loan form World Bank)	Mon	120
8	Busan Korea Bio Technology Co. ltd (Tharketa)	Yangon	560
9	Andamnan Power and Utility (Dawei)	Thanintharyi	200

Source: Ministry of Electricity and Energy, 2017

3.2.3 Coal-Fired Power

Currently, Myanmar has three coal-fired power plants- Takyit, Mai Khot and Launglon with total installed capacity of 357.32 MW. According to World Bank, it was about 2.02% of national grid capacity in 2014. All new planned coal-fired power projects were likely to be delayed beyond the general election, which is set to be held on November 8 2015. A memorandum of understanding (MOU) for 11 coal-fired power plants was signed between the Ministry of Electric Power (MOEP) and local and international private companies in 2010, and other new coal power projects are also in the planning stage. MOUs has been signed for four coal-fired power plants in Yangon Region, three in Tanintharyi Region and one each in Shan state, Mon state and Ayeyarwaddy and Sagaing regions.

Only projects in Shan and Mon states have progressed to the next step- investors signed a memorandum of agreement (MOA) early 2016 under new government. But in order to start construction, developers need to sign a final joint venture agreement, with total consent from the people living nearby, according to Ministry of Electricity and Energy.

Other major coal-fired power plant projects in the pipeline include a 1280MW plant in Ye Township in Mon State by Toyo-Thai Group, a 660 MW plant in Nganyoutkaung Township in Ayeyarwaddy Region by Indian Tata Power, a 500MW plant in Kyineton, Shan State, by Lumpoondum from Thailand, and a 270 MW plant in Kalaywa in Sagaing Region by Singapore – based ISDN[1] Holding and Tun Thwin Mining from Myanmar.

3.2.4 Non Hydro Renewable Sources

Renewable sources can give renewable energy which is naturally replenished on a human timescale, such as sunlight, wind, rain, and geothermal heat. Using non-hydro renewable sources for power generation is still in its infancy in Myanmar and constitutes a small percentage of total installed and generation. While Myanmar is rich in renewable resources, development remains severely hampered by limited availability of funds to support R&D; lack of a clear renewable energy policy; and lack of talented manpower.

(a) **Geothermal:** Close to 90 geothermal locations have been identified to date. Of these, 43 are being tested by MOEE along with Electrical Power Development Company of Japan and others with Union Oil Company of California.

(b) **Wind Energy:** Wind-power projects are either in experimental phase or undergoing feasibility determination. There are some very small operational projects off the grid (Dattaw Mountain, and Government Technical High School in Ahmar, Ayeyarwaddy). Gunkul Engineering Public Company Limited and China Three Gorges Corporation, both foreign, singed a MOU with MOEP in 2010 to conduct feasibility studies for the development of 4032MW of wind energy in Myanmar.

1 ISDN was founded on its engineering capabilities in 1986. ISDN Holdings limited is a fast growing multi-industry corporation focusing in the motion control segment.

(c) Solar Energy:

The solar electric power can be improved the quality of life for people living in isolated areas. The most important thing is to keep the power system simple and dependable. Here, power and light supplied with solar system are now available for studying, working and for just playing around in rural areas.

As Myanmar is situated in the southeastern part of the Asian Continent, it enjoys abundant sunshine all year around, especially in the Central Myanmar Dry Zone Area; potential available solar energy of Myanmar is around 51973.8 Watt-hour per year. Use of solar energy in Myanmar is in the very initial stages. Due to the expensive initial cost the solar energy is presently in the research and development phase.

Some pilot PV cell projects financed by MOEP and university research departments are underway in rural areas: being used to charge batteries and pump water for irrigation. Another example is the installation of 3MW PV systems in remote schools by Mandalay Technological University. At current costs, solar energy is unaffordable. If Myanmar produce solar cells as a home-made, the prices will be cheaper than expected. If so, everywhere away from Nation Grids can enjoy the electricity generated by solar energy. Solar energy is presently in the research and development due to cost.

(d) Biogas

Biogas is produced in a digester where organic material is fermented to produce electricity, and the residue from the digester can be used as fertilizer. Since 1980 biogas generation is being implemented in order to substitute fuel wood scarcity in Central Myanmar region. There are seven bio-fuel electrical power plants, three in Yangon Region and four plants in Rakhine State. Of which, one from Yangon Region is still under completion and others have completed. All after completion, a total of 2120 Kilowatt hours will be utilized. The biogas system is environment-friendly. It is inexpensive, clean, produces hardly any pollution and provides employment for the local people. If there is enough demand for the electricity, it is also economically viable project.

(e) Biomass

Myanmar as an agricultural base country, rice husks are available across the rural areas. Most of unelectrified areas in Myanmar are rural areas. Thus, Biomass is a reasonable solution for the electrified of villages in rural areas. Under the MOEE, first biomass gasification power plant was developed in Nay Pyi Taw with the help by a Japanese consortium. The US$4.7 million undertaking is one part of the integrated rice complex project being developed throughout the country. Under the project, about 5 plants are under research in different regions and states across the country.

CHAPTER IV

ELECTRICITY GENERATION IN MYANMAR

4.1 Electric power generation in Myanmar (From 1988 to 2016)

Starting from 1988, electric power generation (kWh) is continuously increased as well as installed capacity. The generation of electricity was arisen almost 8.5 times which reflected for 2226.45 million kWh in 1988 to 17866.99 million kWh in 2016. However, exception was occurred in 2001. The generation capacity was slightly reduced from 5117.64 MW in 2000 to 4688.98 MW in 2001. After that, generation capacity was increased again. Table (4.1) illustrates the information regarding the electric power generation in Myanmar from 1988 to 2016.

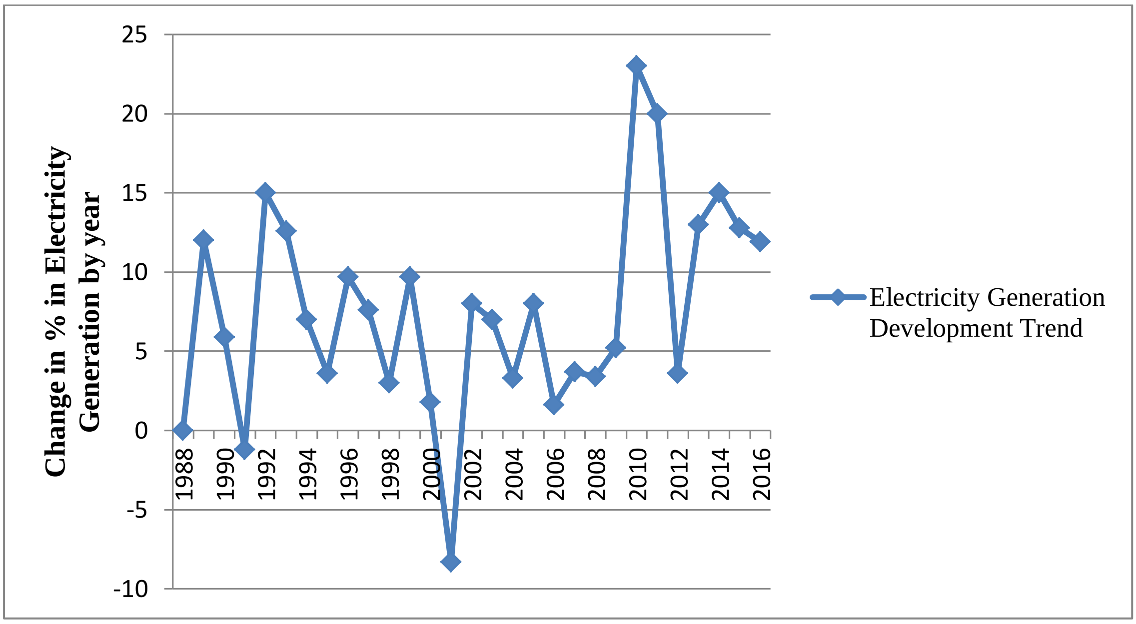
On average, total generation increased annually by 6.8% over the period. Hydropower's share in total generation grew from 42% in 1988 to 62% in 2016. Gas contributed 35% and coal 3% in 2016. The production trend of electricity by year is shown in Figure (4.1).

Table (4.1) Electric Power Generation Development (1988-2016)

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

Source: Ministry of Electricity and Energy, 2017

Figure (4.1) Electricity Generation Development Trend (1988-2016)



Source: From table (4.1)

4.2 Consumption of Electricity in Myanmar

Since the British colonial authorities allowed private operators to supply electricity to urban areas, electricity usage in Myanmar started only recently in 1908. Some local private businesses were able to generate and supply electricity to towns and cities due to very small population in those times. Rural electrification was almost unknown. After Myanmar attained independence in 1948, the government started "Electricity Supply Board" in 1951 and thus began the government monopoly on utilities.

Electric power consumption measures the ability of electricity form not only national gird but also own operated small scale plants and solar and wind. According to World Bank data, 41% of total population had access to use electricity in 2016, 89% of urban population and 38% of rural population. Rural citizens rely mainly on alternatives sources, often powered by diesel-powered mini-girds. Table (4.2) shows the conditions of electric power consumption in Myanmar by population.

Table (4.2) Electric Power Consumption in Myanmar (1990-2016)

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

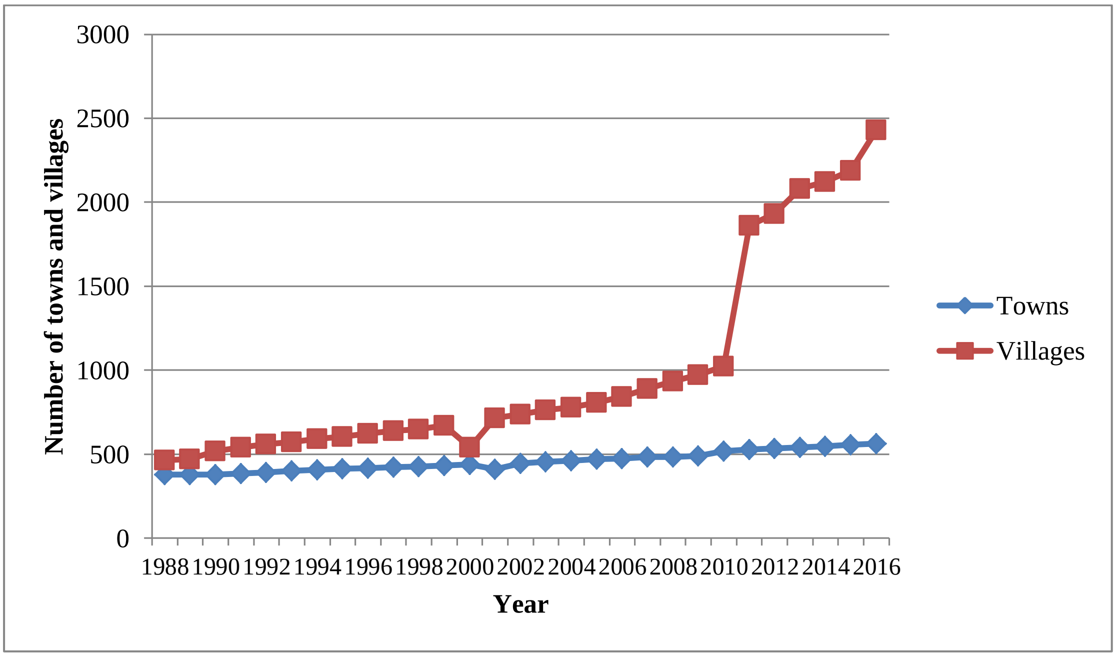
Source: World Bank, 2018

Note:* Data for 1988 and 1989 is not available.

In electricity consumption in Myanmar by sector, residential contributes 20%, industrial 40% and commercial 40% respectively in 2014 according to 2014 census data. Increase in domestic consumption of electricity is due to increase in living standard of people, increase in utilization of modern electronic gadgets such as computer, refrigerators, and satellites receiver, washing machines etc. in the today modern world. Similarly electricity consumption was also increased in industrial sectors. This is because of government of Myanmar has implemented the development of industrial sector by developing several industrial zones throughout the country. Until recently, however there is insufficient electricity supply was one of the major problems in impeding industrial sector development in Myanmar. During 2000-2014, the commercial sector grew most, at 8.6% annual average, followed by the industrial (3.6%) and residential sectors (1.6%). Consumption in the agriculture and transport sectors contracted 3.6% and 0.7% respectively, during the same period.

The number of electrified towns and villages by government grid in Myanmar has increased slightly, but electrification remained low overall at around 34% as of 2014. Yangon region has the highest electrification (78%), with Kayah State (46%), Mandalay (40%), and Nay Pyi Taw (39%). Extremely low rural electrification in several divisions or states is a particular concern, such as in Rakhine State and areas east of Yangon and in the Ayeyarwaddy Delta. Under the national target of universal access by 2030, the government approved the National Electrification Plan in September 2014, providing for an aggressive grid electrification rollout program and an ambitious off-grid program. Between 1990 and 2016, the electrified towns and villages were arisen form 380 towns and 466 villages to 564 towns and 2431 villages respectively. Figure (4.2) presents the number of electrified towns and villages in Myanmar from 1988 to 2016.

Figure (4.2) Electrified towns and villages in Myanmar (1988-2016)



Source: Ministry of Electricity and Energy, 2017

Regarding users condition, in 1988, there are 0.6 million households (out of 5.59 million households) have accessed to electricity with home-use meter which accounted for 10.7% of household. In 2016, there are 2.1 million households (out of 8.3 million households) have access to electricity with home-use meter. These data are shown in Table (4.3).

Table (4.3) Households and number of installed meters for the Union (2016)

Particular	Unit	1988	2016
Population	Million	39.0	53.58
Household Total	Million	5.59	8.3
Installed Household	Million	0.6	2.1
Percent of installed household	Percent	**10.7**	**25.3**

Source: Ministry of Electricity and Energy, 2017

4.3 Electricity Transmission and Distribution System

The transmission network is the responsibility of DPTSC with the purpose of delivering generated electricity – usually over long distance- to the distribution grid located in populated areas. Since power plants are most often located outside of populated areas, the transmission system must be fairly large. Major power stations feed electricity into the national grid using 500 KV, 230 KV, 132 KV, 66 KV and 33

KV overhead transmission lines. These lines are very high voltage and do the majority of long distance transmission. And these lines must be high voltage in order to minimize power losses. These lines are predominantly single, with very few double lines. As of 2106, the total active net worth length was almost 10392 km.

Table (4.4) Existing Transmission Line (2016)

Voltage (kV)	Numbers of Lines	Length
500	16	1392
230	51	2,983
132	40	2,289
66	137	3,614
33	12	114
Total	229	10,392

Source: Ministry of Electricity and Energy, 2017

Over long distance, 230 KV transmission systems suffer from high voltage drops, sometimes exceeding 10%. To remedy this situation, MOEP planned to build a 500KV system under its five year plan from 2011 to 2016. Under the MOEE after 2016, there are 4 extra 500 KV lines to build for new hydropower plants. This new system aimed to connect Myanmar’s power generation plants in the north to main load centers in the north. Additional to other capacity lines are also being planned to improve the electrification ratio.

Table (4.5) Planned Expansion-Transmission Lines (2016-2020)

Voltages (kV)	Numbers of Lines	Length (km)
500	4	468
230	13	1340
132	8	230
66	54	2214
Total	79	4252

Source: Ministry of Electricity and Energy, 2017

The distribution network is primarily controlled by YESB and ESE. YESB supplies to all customers in Yangon. ESE supplies electricity (including that production in off-grid generation) to rest of Myanmar.

The distribution system consists of low-voltage levels like 33KV, 11KV, 6.6KV and 0.4KV. Lines connect to distribution transformers that supply both single-phase and three-phase 400/230V power. Running low on available funds, the government is actively soliciting private sector participation in these upgrading exercises for transmission and distribution networks.

4.4 Power Pricing

The price of electricity appears to be lower in Myanmar for users compared to other countries in the region, mainly because of the government controlled pricing policy, which does not reflect the true cost of generation. YESB and ESE purchase grid-electricity from MOEE and supply it to end-customers.

Table (4.6) Electricity Prices by ASEAN Countries (US cents/KW)

Country	Residential	Commercial	Industrial
Indonesia	4.60 – 11.74	5.93 – 12.19	5.38 – 10.14
Malaysia	7.26 – 11.96	9.67 – 11.10	7.83 – 10.88
Myanmar	3.09 – 7.5	6.17 - 15	6.17 - 15
Singapore	19.76	10.95 – 18.05	10.95 – 18.05
Thailand	5.98 – 9.40	5.55 – 5.75	8.67 – 9.43
Vietnam	2.91 – 9.17	4.38 – 15.49	2.30 – 8.32

Source: Asian Development Bank Report, December 2014

Power is being provided at highly subsidized price (lower than average cost which is estimated at 125 kyats/kWh in 2013). MOEP estimates the size of annual subsidy at 185 billion kyats (~USD 170 million). With MOEP making loses, available public funds to expand power generation and distribution infrastructure. Consequently, increase in power generation capacity has not been able to keep up with increasing demand.

On 1st April, 2016, MOEE announced price for both households and business farms. MOEE explained that the decision was made to better cover rising costs of electricity production, to encourage private investment and to fund an expansion of the national grid. Under the revised structure:

a. Though households will still pay K35 per unit up to 100 units, they will pay K40 per unit up to 200 units, and K50 for any units used above that.
b. Industrial users will pay K75 per unit up to 100 units, K100 from 501 to 10000 units, K125 from 10001 to 50000 units and K150 from 50001 to 300000 units. Above 300000 units, the price will drop to K100.

But according to the new pricing system, there are still a gap of price for residential use and industrial use. The price for industrial use is almost double compared with residential use.

4.5 Unit Losses in Myanmar Electric Power Sector

Power generated in power stations pass through large and complex networks like transformers, overhead lines, cables and other equipment and reaches at the end users. It is fact that the unit of electric energy generated by power station does not match with the units distributed to the consumers. Some percentage of the units is lost in the transmission and distribution network.

Unit losses in electricity are often occurred between supplier and consumers. If it is acceptable within a limited range, reduction of unit losses is reasonable. In Myanmar electrical sector, loss reduction measures are implemented by using standard equipment in electricity generation, transmission and distribution. In order to meet increasing electricity demand in today society, the supply authorities have to perform the continuous monitoring system through developing annual planning for generation, transmission, and distribution systems. Unit losses occur at three sites- a. Losses in the power plants- b. Losses in transmission lines, c. Losses in distribution areas.

Table (4.7) Summary of Unit Losses in Electricity Generation in Myanmar

Year	Total Production (KW)	Unit Losses (KW)	Average % of Unit Losses in Total Production
1988	2226.45	712.46	32
1989	2493.71	847.86	34
1990	2643.05	687.19	26
1991	2611.00	939.96	36
1992	3006.60	1112.44	37
1993	3386.79	1185.37	35
1994	3631.48	1234.70	34
1995	3762.33	1429.68	38
1996	4130.31	1445.60	35
1997	4445.38	1511.42	34
1998	4579.29	1282.20	28
1999	5024.35	1607.79	32
2000	5117.64	1586.46	31
2001	4688.98	1453.58	31
2002	5067.95	1571.06	31
2003	5425.88	1573.50	29
2004	5608.24	1682.47	30
2005	6064.16	2365.02	39
2006	6164.15	1787.60	29
2007	6398.02	1919.46	30
2008	6621.76	1920.31	29
2009	6964.27	1949.99	28
2010	8625.11	1380.01	16
2011	10425.03	2085.00	20
2012	10800.90	2741.22	25
2013	12247.12	2571.89	21
2014	14156.30	2831.26	20
2015	15964.75	2413.90	15
2016	17866.99	2384.90	13

Source: World Bank Data Base, 2018

While distribution losses have been reduced recently, losses incurred are still high due to outdated and dilapidated infrastructures, its insufficient cross-section for present day loads. In view of this, ESE is planning infrastructure upgrades:

a. Several 6.6kV systems are to be converted to 11kV systems to reduce losses and improve efficiency.
b. Over 2013-2014, ESE plans to expand the 33kV network by 400km, 11kV network by 360km, and 6.6kV network by 250km.

After 2016 general election, for the new government, Asian Development Bank (ADB) offered a cheap long-term loan of USD 60 million to build new transmission infrastructure outside Yangon and Mandalay, which should significantly reduce electricity losses.

CHAPTER V
CONCLUSION

5.1 Findings

Myanmar’s electricity sector has experienced significant growth in demand in the recent past putting pressure on aging and inadequate infrastructure. This has resulted in the deployment of stop gap measures in the form of investment in small gas engine technologies and distribution system rehabilitation programs. As the country’s economy has been undergoing a process of economic reform, the outlook and prospects for economic growth in the near future are optimistic. Key to economic growth in the country will be a continuous supply of energy to enable the country to prosper. The ongoing enhancement and expansion of Myanmar’s electricity industry is an important part of enabling economic growth to occur. Strategies for enhancing access to electricity include the approach of investing heavily in transmission and distribution equipment to expand the national grid or giving advances in distributed technologies.

In the area of power generation, total power generated is increased form 2226.45MW to 17866.99MW. Power generation form hydro plants and gas plants increased annually. But the ratio of gas fired power started decrease slowly since 1998 till today. There is no new coal fired plants since before 1988. After the completing the developing hydro, gas and coal plants at about 2027, the production capacity of electricity will increase about two times.

The transmission and distribution systems are also under upgrade in both quantity and quality. ADB provided a US$ 75 million loan for power transmission and distribution. In addition, ADB is supporting off-grid development in the rural areas of Myanmar. Furthermore, because of Public-Private-Partnership (PPP), the transmission lines and distribution lines are expected to get efficiency and effectiveness. When efficiency and effectiveness are got, the problem of unit losses in transmission and distribution process will be solved automatically.

In electricity consumption by sector, residential contributes 20%, industrial 40% and commercial 40% respectively. About 41% of total population had access to use electricity in 2016, 89% of urban population and 38% of rural population from national grids some source of their owned generation. But it can be assumed that the population that get electricity form national grid only will be still low in total population across the country. Unit loss of electricity in 2016 was about 13% of total generation capacity compared with about 32% in 1988. Which mean it can be reduced about half in unit loss volume.

However, the average current electricity price in Myanmar is 35 kyats per unit for household use and 75 kyats per unit for industrial use. As the supply site, the average cost per unit is 125 kyats (the cost are calculated at exchange rate of 1US$=1100 kyats in 2014), and therefore, electrical sector in Myanmar is no profited for supplier site and runs as a social welfare and government subsidy program.

In general, the rising trends or positive trend were occurred in electricity installation, generation, and consumption. By contrast, decreasing trend in unit loss of electricity is also a good result. In the late 2016, the World Bank approved a US$ 400 million interest-free credit from the International Development Association to provide financing and technical assistance for Myanmar's NEP.

5.2 Suggestions

Over a couple of decades from 1988 to 2016, there is a progressive trend, i.e., generation, installation and consumption on electric power sector. Especially the number of electrified household consumers increases annually. Government will have been tried to fulfill the electricity supply to all population as a basic need for quality of life, whatever in cost and benefit ratio. Nuclear power will be a part of the solution to the energy crisis. It produces large-scale electricity with low carbon emissions - although mining and enriching uranium is very intensive. If Nuclear power is not suitable for a developing country with lack of advanced technology, Biomass energy will be suitable because Myanmar is an agricultural base country and enough raw materials for biomass are available for across the country.

The centralized management system by state own sector should release more freedom for privatizing choices and private participation in off-grid area expansion should be given some subsidy by government for examples technology and capital. In the in-Grid area, it is also demanding to replace old lines with more powerful (higher capacity facilities, i.e. 500KV lines instead of 230KV), transmission lines from the origin of northern places of generation to a half way of transmission_ the region of central Myanmar. Myanmar's grid is concentrated primarily in urban areas, leaving those who live in rural environment largely without gird access. So, government should emphasize more in rural areas.

To reduce the reliance on hydro power, Conventional Generation system should be paid more attention, also same interest on newer source of power like solar based, although heavier set-up cost has to be paid, considering for starting wider based combined powers (hydro, gas, coal, wind, biomass and solar etc.) for alternative generations or conventional set of generations in both in-Grid and off-Grid.

About industrialization and electricity, industrialization and electricity are closed linked because industrialization is based on cheap energy supply. Electricity price should be cheaper for industrial sector than for social sector-household uses. And the electricity price for day-time use electric power should be more charged than night-time use electric power. On the other hand, basic rate of unit price of electricity in industrial sector need to be less than that in social sector. By doing so, mutual benefits and satisfaction will be got between the supplier and consumers of electricity and good for industrialization and economic growth.

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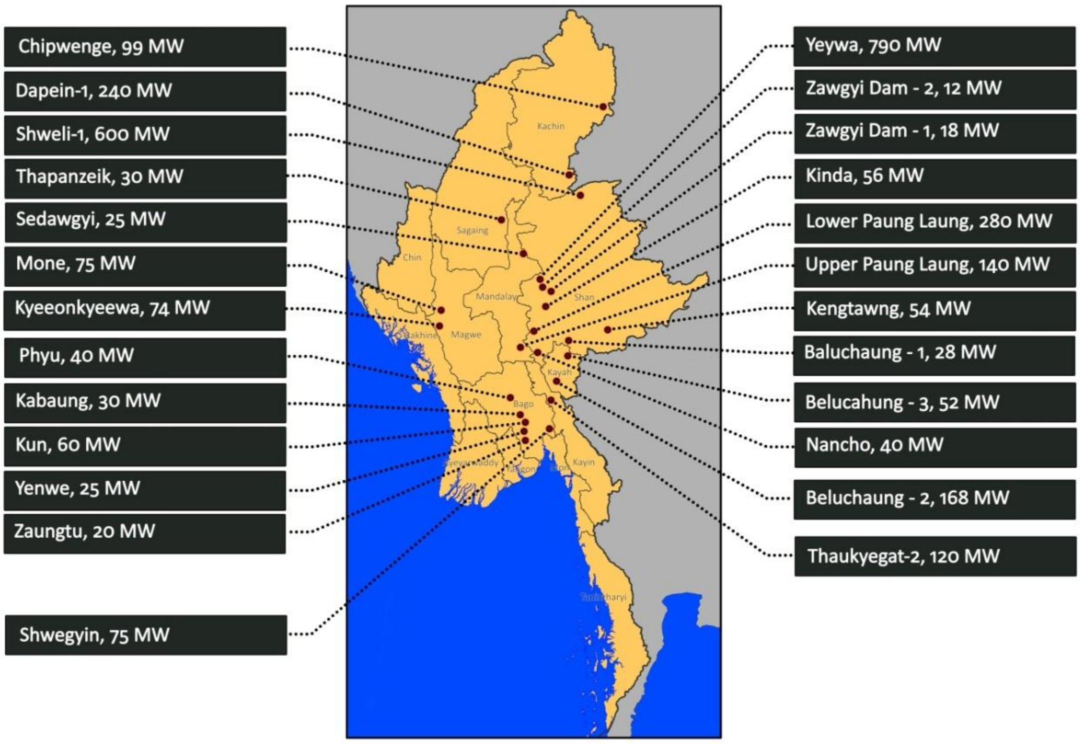
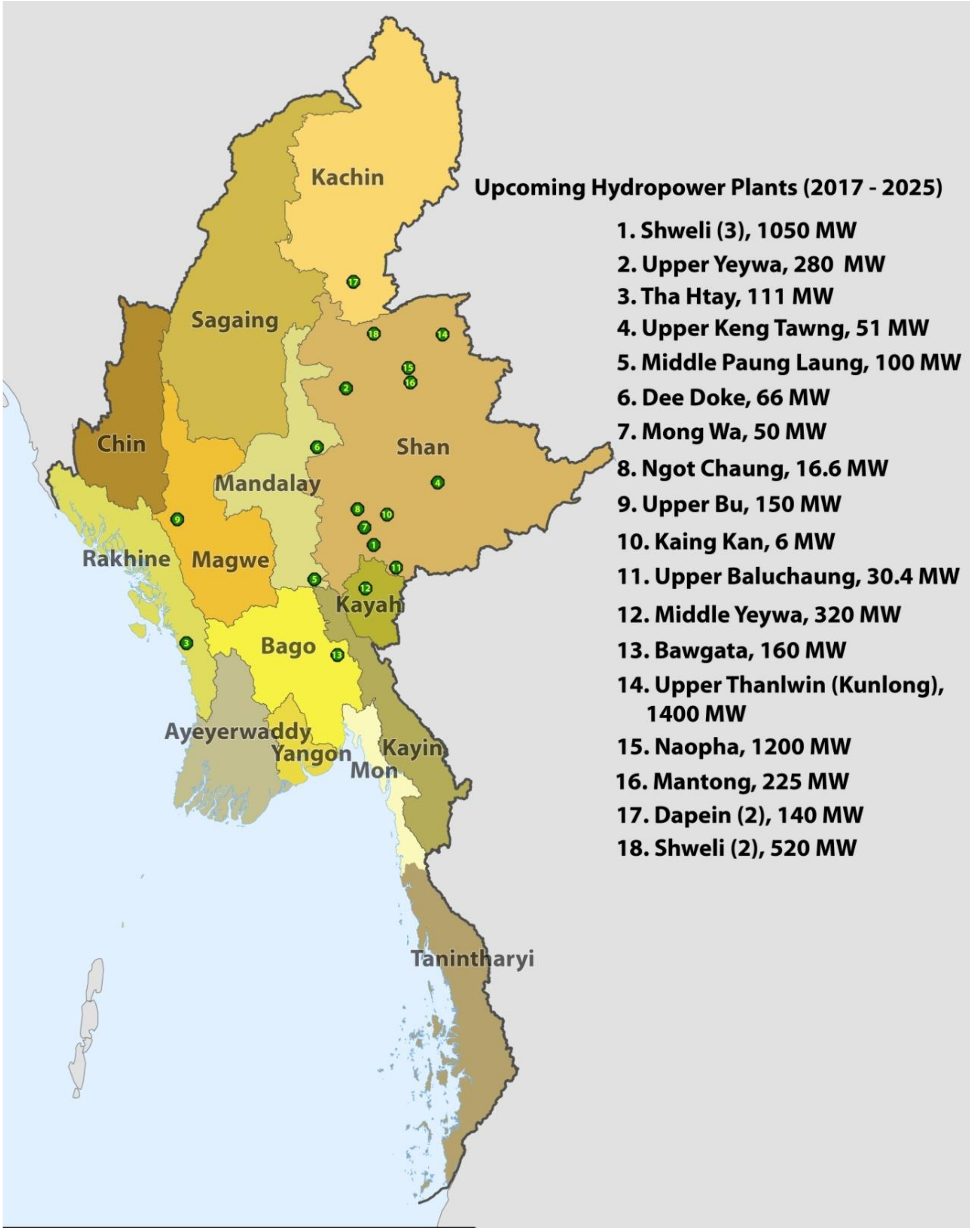
APPENDICES

APPENDIX-A: Existing Hydro Power Plants



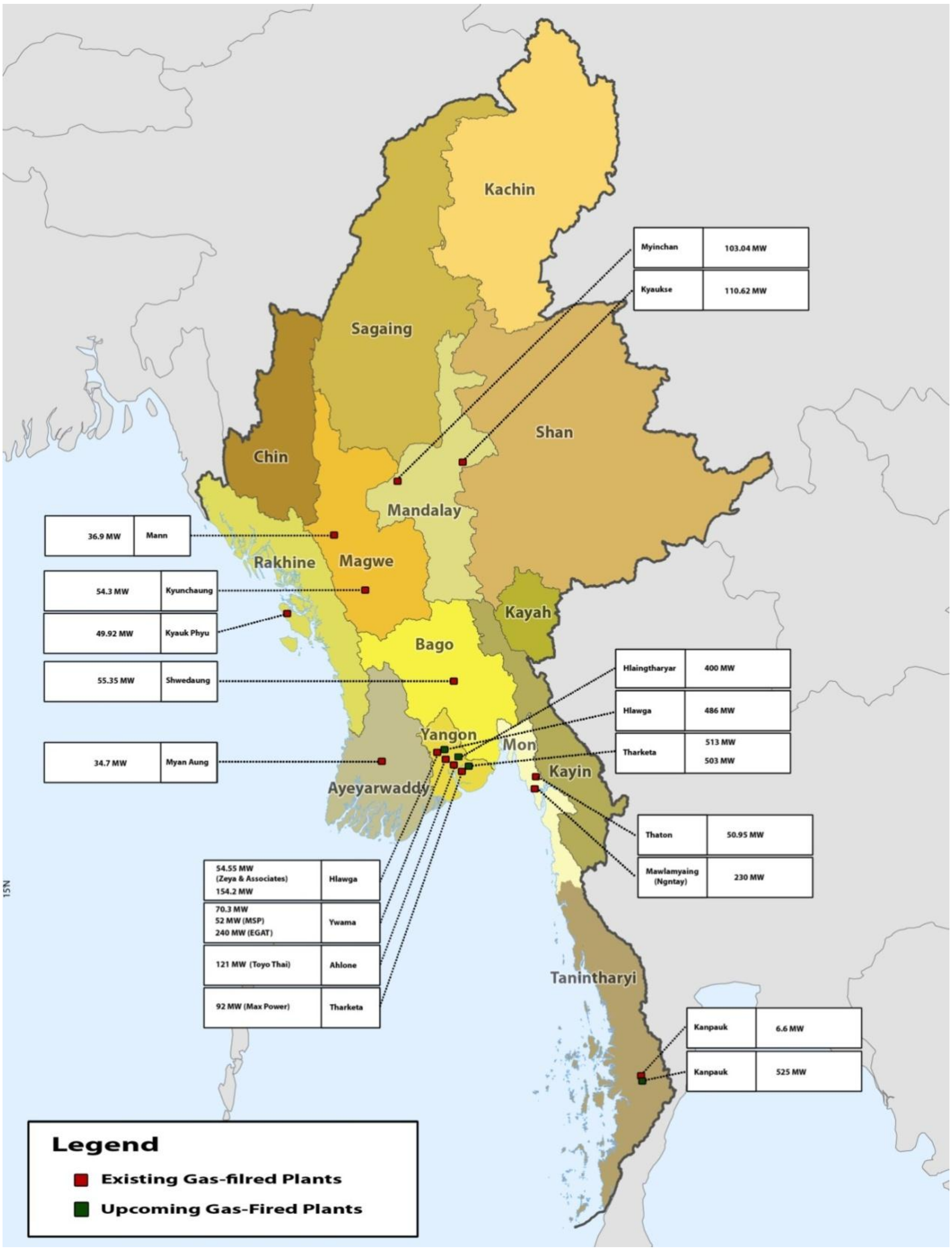
Source: MOEE, 2017

APPENDIX-B: Upcoming Hydropower Plants (2017-2025)



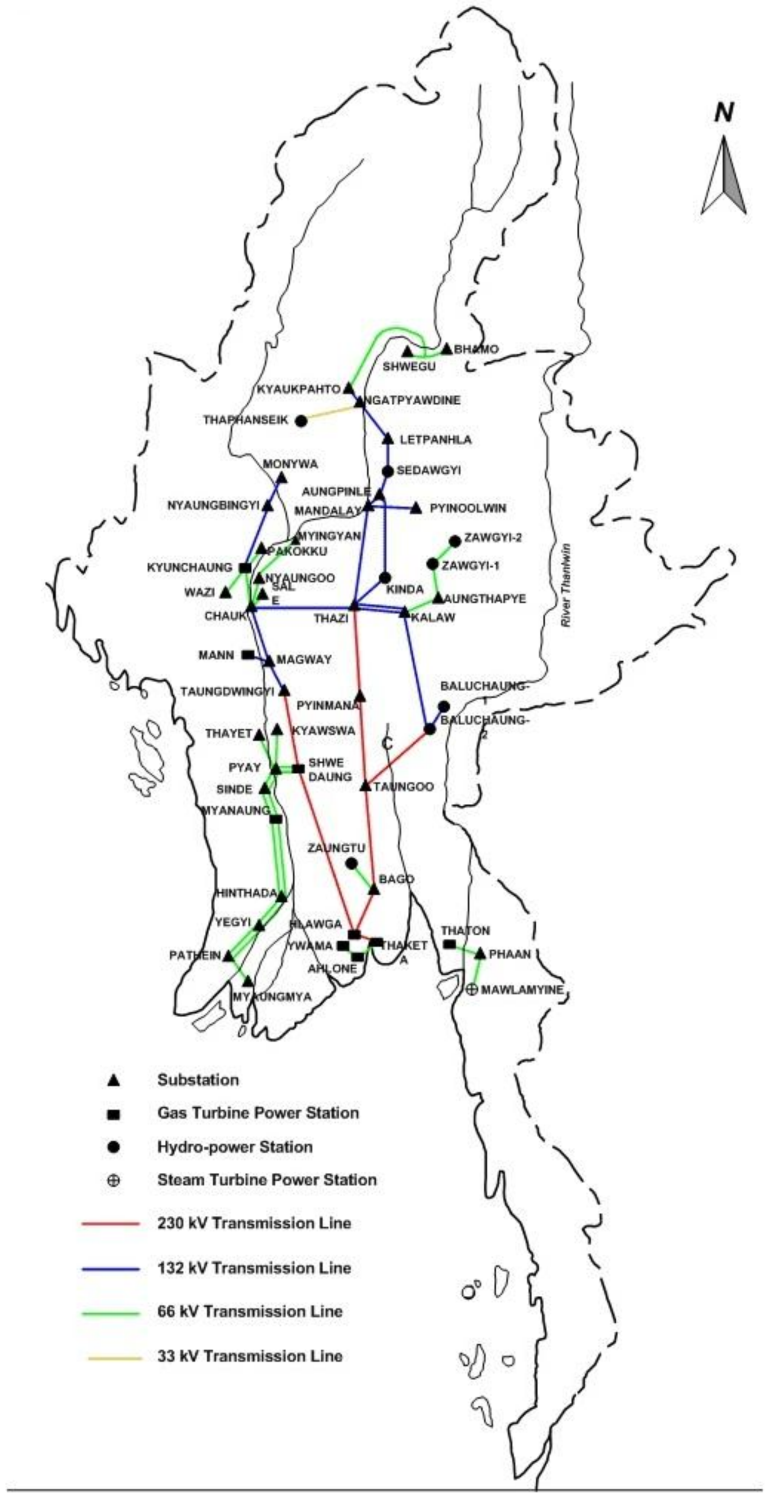
Source: MOEE, 2017

APPENDIX-C: Existing and Upcoming Gas-Fired Plants



Source: MOEE, 2017

APPENDIX-D: Myanmar's National Grid for Transmission System



Source: Asian Development Bank, 2017