YANGON UNIVERSITY OF ECONOMICS

MASTER OF DEVELOPMENT STUDIES PROGRAMME

A STUDY OF HYDROPOWER GENERATION AND GAS-FIRED POWER GENERATION IN MYANMAR

KO KO SOE

EMDevS – 10 (15th BATCH)

DECEMBER, 2019

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A STUDY OF HYDROPOWER GENERATION AND GAS-FIRED POWER GENERATION IN MYANMAR

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

Supervised by

Dr. Cho Cho Thein
Professor and Head of Department
Department of Economics
Yangon University of Economics

Submitted by

Ko Ko Soe
EMDevS - 10
EMDevS 15th Batch
2017-2019

December, 2019

YANGON UNIVERSITY OF ECONOMICS
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This is to certify that this thesis entitled **"A Study of Hydropower Generation and Gas-fired Power Generation in Myanmar"** submitted as a partial fulfillment of the requirements for the degree of Master of Development Studies, has been accepted by Board of Examiners.

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ABSTRACT

Electricity is strategically importance of human beings and correlated with economic developments. Power generation is a root of electrification. The objectives of the study are to examine the current status of hydropower generation and gas-fired power generation in Myanmar, to examine the difficulties and challenges of power generation management and to identify on transmission and distribution losses. The study used descriptive method based on secondary data. Qualitative approach is conducted by key informant interviews with (25) personnel. The study found that the Ministry of Electricity and Energy needs to increase more power generations, electric power security. In addition, it has to renovate or replace the old infrastructures and manage on non-technical transmission and distribution losses to get the affordable price for consumers. Myanmar has highly opportunity for power export to neighboring countries especially by hydropower generations.

ACKNOWLEDGEMENTS

I wish to show my gratitude to Professor Dr. Tin Win, Rector of Yangon University of Economics and Professor Dr. Ni Lar Myint Htoo, Pro-Rector of Yangon University of Economics for their permissions and giving me the opportunity to undertake this study.

I would like to pay my respect and regards to Professor Dr. Kyaw Min Htun, Pro-Rector (retired), Yangon University of Economics and all of the visiting honorable professors who taught and guided me in EMDevS (15^{th} Batch) academic years 2017-2019.

I wish to express my deepest gratitude to my thesis supervisorDr. Cho ChoThein, Professor and Head of Department, Department of Economics, and Programme Director for Executive Master of Development Studies, Yangon University of Economics. She consistently allowed this thesis to be my won work, but steered me in the right the direction whenever be thought I needed it.

I would also like to thank the senior management and advisors from Ministry of Electricity and Energy, respectful retired persons and independent private operators who were involved in the informant survey for this thesis. I wish to thank all the people whose assistance was a milestone in the completion of this thesis.

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LIST OF ABBREVIATIONS

°C	Degree Celsius
ADB	Asia Development Bank
AEC	ASEAN Economic Community
ASEAN	Association of South East Asian Nations
BOC	Burma Oil Company
BOT	Build Operate and Transfer
CCGT	Combined Cycle Gas Turbines
CCPP	Combined Cycle Power Plants
CCT	Clean Coal Technology
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
DEPP	Department of Electric Power Planning
DHPI	Department of Hydropower Implementation
EDC	Energy Development Committee
EIA	Environmental Impact Assessment
EMBA	Executive Master of Business Administration
EMPA	Executive Master of Public Administration
EOR	Enhance Oil Recovery
EPC	Electric Power Corporation
EPD	Energy Planning Department
EPGE	Electric Power Generation Enterprise
EPTSC	Department of Power Transmission and System Control
ESB	Electricity Supply Board
ESE	Electricity Supply Enterprise
FDI	Foreign Direct Investment
FY	Fiscal Year
GMS	Greater Mekong Sub-region
GoM	Government of Myanmar
GWh	Giga Watt Hour
HSE	Health, Safety and Environment
I.C	Internal Combustion

IDA	International development Association
IOR	Improved Oil Recovery
JICA	Japanese International Cooperation Agency
JV	Joint Venture
KII	Key Information Interviews
kWh	Kilo Watt Hour
LNG	Liquefied Natural Gas
MDGs	Millennium Development Goals
MEMP	Myanmar Energy Master Plan
MEPE	Myanma Electric Power Enterprise
MES	Myanmar Engineering Society
MESC	Mandalay Electricity Supply Corporation
MMBBL	Millions of Barrel
MMSCFD	Millions of Standard Cubic Feet Per Day
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOC	Myanma Oil Corporation
MOE	Ministry of Education
MOE	Ministry of Energy
MOEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power
MOGE	Myanma Oil and Gas Enterprise
MOI	Ministry of Industry
MONREC	Ministry of Natural Resources and Environmental Conservation
MPE	Myanmar Petrochemical Enterprise
MPPE	Myanma Petroleum Product Enterprise
MSDP	Myanmar Sustainable Development Plan
MW	Mega Watt
MWh	Mega Watt Hour
NEMC	National Energy Management Committee
NEMP	National Electricity Master Plan
NEP	National Electrification Plan
NEP	National Energy Policy
O_2	Oxygen
OGPD	Oil and Gas Planning Department

PBG	Performance Bank Guarantee
PCC	Performance Compensation Contract
PPA	Power Purchased Agreement
PPP	Public Private Partnership
PSC	Production Sharing Contract
PV	Photovoltaic
REAM	Renewable Energy Association Myanmar
ROR	Run-Off-River
RSF	Reactivation of Suspended Fields
SDG's	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SIA	Social Impact Assessment
SOEs	State Own Enterprises
TSCF	Trillion Standard Cubic Feet
TWh	Tera Watt Hour (Trillion Watt Hour)
UN	United Nations
USD	United States Dollar
WB	World Bank
YESC	Yangon Electricity Supply Corporation

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

The Electric Power is one of the energy types, an essential for development and electricity generation is a root of the electricity supplies to every end-users. Electricity improves the standard of living of the people in the country. Electric power sector is the most important role of the country's development process, the economic advancement of a country and it improves the security of the county and helps to create job opportunities for the entire country because the indirect sectors use the electricity to power their businesses. The strong economic growth also accompanied by an increase in energy consumption in all sectors.

This demand for electricity is never ending, always increasing therefore human beings are striving very hard to promote the power generation. The countries are always seeking the reliable resources of electric power generation. The power generation is the back bone of every country. All of the developed countries had had strong national electricity plan, price competitiveness, electricity quality, electricity security, strategy, supporting laws and relevant rules, price policy and high-quality management practices. Some of the countries did not own the electricity resources for power generation but well managed on their electricity sector with their suitably strong nation's plan, strategy, management, etc. In the electric power sector, always looking base on each energy resources for power generation and its advantages and disadvantages, energy mixing ratio, transmission problems and losses, affordable price, etc.

Universal access together with a substantial increase of the share of renewable energy and the improvement of energy efficiency are the core elements of the "Sustainable Energy For All" initiative, which has been launched by the UN General Secretary Ban Ki Moon. The availability of basic energy services is also essential for reaching the Millennium Development Goals (MDGs). The number 7^{th} goal in SDG's highlighted on "Affordable and Clean Energy": between 2000 and 2016, the number

of people with electricity increased from 78 to 87 percent and the numbers without electricity dipped to just below one billion. Yet as the population continues to grow, so will the demand for cheap energy, and an economy reliant on fossil fuels is creating drastic changes to our climate, investing in solar, wind and thermal power, improving energy productivity, and ensuring energy for all is vital if we are to achieve SDG-7 by 2030, expanding infrastructure and upgrading technology to provide clean and more efficient energy in all countries will encourage growth and help the environment (UNDP, 2016).

MOEE plans to fulfill that annual electricity demand with energy mix by hydropower, gas-fired power (thermal power), LNG to natural gas power, coal power, solar power, wind power and diesel/heavy fuel oil power.

According to the National Electricity Master Plan (NEMP) targeted 100% electrification to the households with demand focus 14,542 MW in year 2030.According to the policies set by MOEE, electricity generation from hydropower is still a key part of the long term plan for the country's energy needs while gas-fired power generation is a key to the short term plan. Hydropower generation and gas-fired power generation are leading power sources and contribute 95% in current generation mix for Myanmar. Myanmar has abundant energy resources for hydropower and natural gas. Especially, hydropower has been an important source of flexible, low cost, and emissions friendly renewable energy. Myanmar has 4 main river basins such Ayeyarwaddy, Chindwin, Sittaung and Thanlwin. It rivers estimated the hydropower potential is more than 108,000 megawatts (MW) for Myanmar. International third party approved16.6 trillion cubic feet (TCF) of natural gas reserved in Myanmar offshore area.

The per capita electricity consumption was around 180 kWh per year and 30% of total households have electricity access in 2015. In December 2019, per capita electricity consumption is 370 kWh per year and 50% of total households have electricity access in Myanmar. According to the press released by ministry of electricity and energy, the annual demand for power consumption is increasing from 12 percent to 17 percent in previous years and electricity consumption will be increased up to 19 percent starting from 2019 to 2021 which calculated by MOEE.

Today, Myanmar needs more power generations for fulfillment of National Electricity Master Plan.

1.2 Objectives of the Study

This study aims to examine the current status of hydropower generation (renewable source) and gas-fired power generation (non-renewable source) in Myanmar, to identify the challenges of power generation management and to examine on transmission and distribution losses.

1.3 Method of Study

The study used descriptive method and based on secondary data from Ministry of Electricity and Energy and its departments, joint study reports, related articles, documents, international organizations, websites, seminars, conferences, etc. To obtain vital information, key informant interview was conducted with total 25 of senior management personnel, government departmental officials, retired persons and current operators from electricity and energy sectors.

1.4 Scope and Limitation of the Study

The scope of the study is mainly focused on hydropower generation and gas-fired power generation from FY 2013-14 to FY 2017-2018.The limitation of the study only focus on power generations by government owned projects.

1.5 Organization of the Study

This thesis is organized by five chapters. Chapter I describes the introduction including the rationale, objectives, and method of study, scope and limitations of the study and organization of the study by 5 sub-chapters. Chapter II studies literature review on related study areas. Chapter III describes about the historical background of electricity and energy in Myanmar. Chapter IV is the study analysis. Chapter V is conclusions based on the findings and suggestions.

CHAPTER II
LITERATURE REVIEW

2.1 Natural Resources and Economic Development

There are 3 major types of natural resources such power, mineral and forest resources. Natural resources are not only founder for economic development but also initial push to the raising of production in all sectors of the economy. The existence of natural resources in abundance is essential for economic growth. Natural resource management is very important. Natural resources can contributes to the country's development base on increasing production and manufacturing, secure energy supply, increasing export revenues and reducing imports, promote local businesses and households.

Water Resource: Staying alive is most important for human beings. Human needs 3 essentials such food, clothing and shelter. It's an essential component for not only social development but also economic development.

Water is a key driver of sustainable growth and development, water is quite literally a source of life and prosperity. Water is complex economic good. Water permeates all aspects of life on Earth. Like the air we breathe, water sustains human, animal and plant life. It provides vital services for human health, livelihoods and well-being and contributes to economic growth and sustainability of ecosystems. Water is an essential component of our economics and is at the centre of economic and social development. It is vital to maintain health, grow food, manage the environment, cheapest transportation, cheapest power, and create jobs. It is impossible to overstate our dependence on water. Water, because it has so many different uses in everyday's life is hard to analyze in terms of economic development. Yet there are some lessons to drawn on the role of water in economics of every type. Health has shown to be dependent on a good supply of clean water. It is needed for almost all industries, for agriculture, for animal rearing and for much service activities. Managing water as an economic good is an important way of achieving efficient and equitable economic

growth of economy. Better access to clean water, sanitation services and water management creates tremendous strategy for economic growth of country. There is a close link between water and economic growth of country. Good management of water resources brings more certainty and efficiency in productivity across economic sectors and contributes to the health of nation. Water is a critical part of most environmental services on which our ecosystems depend. Water requires optimal management to control scarcity and competition for use due to population growth, increasing demand, climate change and declining water supplies. (Goswami & Bisht, 2017)

Natural Gas: The sustainable access to affordable energy is essential for the functioning of modern economies. However, the distribution of energy supplies among countries is uneven, prompting increased competition over different energy sources. Fossil fuels account for approximately 83 per cent of global energy consumption; however, in the future, their contribution to the global energy mix will depend on policies designed to mitigate climate change, enhance energy security and address energy poverty. Natural gas is one of the most widely utilized fossil fuels because of its environmental characteristics: (a) low carbon dioxide emission (half as much carbon dioxide emitted in natural gas than in coal when burned); (b) efficiency in power production; (c) growing demand from the industrial sector; and (c) a wide geographical distribution of reserves across regions. As such, natural gas is widely considered as the fuel of choice both from an environmental and economic point of view. For many developing countries, natural gas also offers opportunities for industrial development which could launch their economies on a sustained growth path of rising income and poverty reduction. Ensuring sustainable and reliable supply of gas to many developing countries remains a major constraint. The Special Unit on Commodities special event on Natural Gas as an Engine of Growth represents a timely contribution to the global initiative Sustainable Energy for All (UNCTAD, 2012).

2.2 The Role of Electricity and its Generations

Electricity is one of the energy sources which essential for human beings that not a luxurious. Electricity needs in everywhere at our daily life. The development statuses of economy, education, health, social, politics all these are affected on how electricity sufficient and how used by affordable prices at the respective countries.

Electricity is a part of our daily life and one cannot think of a world without electricity. Electricity is the most adaptable and easily controlled form of energy and the point of use it is practically loss-free and essentially non-polluting. Electrification is the strategically importance of major needs for human beings consequently that electricity use and access are strongly correlated with economic development. Electricity generation is a root.

2.2.1 Definition of Electricity, Electricity Generation and its General Information

Electricity is a form of energy. Electricity is the flow of electrons. The nucleus of an atom is surrounded by negatively charged particles called electrons. The negative charge of an electron is equal to the positive charge of a proton, and the number of electrons in an atom is usually equal to the number of protons.

In 1878, Thomas Edison began serious research into developing a practical incandescent lamp and on October 14, 1878, Edison filed his first patent application for "Improvement in Electric Lights".

On September 30, 1882, the world's first hydroelectric power plant began operation on the dam across Fox River in Appleton, Wisconsin. The plant, later named the Appleton Edison Light Company, was initiated by Appleton paper manufacturer H.J. Rogers, who had been inspired by Thomas Edison's plans for an electricity-producing station in New York (National Geographic) .

Electricity has also become a part of modern life and one cannot think of a world without electricity. The process of producing electric energy or the amount of electric energy produced by transforming other forms of energy into electrical energy called electricity generation.

There are various methods of electricity generation dependent on types of energy. Among resource energies, coal, oil and natural gas are used to generate electricity by combustion (thermal power), Uranium by nuclear fission (nuclear power), to utilize their heat for boiling water and rotating steam turbine. Among renewable energies, sunlight is directly converted into electricity (photovoltaic), rotation energy by wind is converted into electricity (wind power), rotating water wheel by running water to generate (hydro). Magnetic heat boils underground water to rotate steam turbine to generate (geothermal). Continuous technology development for them is proceeding to convert resource energies or renewable energies into

electricity with less loss. It is also important for the operation of power plant to do maintenance or training of operators.

2.2.2 Various Types of Power Generations and Its Sources

There are generally 2 types of resources for power generation such non-renewable (fossil fuel and mineral) sources and renewable sources.

Thermal power generation (coal, oil and natural gas) and nuclear power generation are under the source of non-renewable and hydropower generation, solar power generation, wind power generation, geothermal power generation , biomass power generation, waste water and biogas power generation and ocean tidal power generation are under renewable source.

1. Non-renewable Power Generations

Non-renewable power sources are mostly base on fossil such crude oil, natural gas, liquefied natural gas, coal seam gas, coal and uranium.

Thermal Power Generation (Fossil Fuel): Thermal power generation consists of using steam power created by burning oil, natural gas, liquefied natural gas (LNG), coal, coal seam gas and other substances to rotate generators and create electricity. A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. Such organisms and their resulting fossil fuels typically have an age of millions of years, and sometimes more than 650 million years. A natural fuel such as oil, gas or coal formed in the geological from the remains of living organisms. The gas turbine is the engine at the heart of the power plant that produces electric current. A gas turbine is a combustion engine that can convert natural gas or other liquid fuels to mechanical energy. This energy then drives a generator that produces electrical energy.

The following table 2.1 is evolution of thermal power generation up to 20^{th} Century. Ferdinand Verbiest invented a carriage model which relied on a steam jet power in 17^{th} century (Year 1678). John Barber invented the first true gas turbine and it leads modern gas turbine technologies in 18^{th} century (Year 1791). In the 19th Century the concept of the gas turbine became known to many engineers and the efforts of all the pioneers are well documented. There were more technology developments such centrifugal compressor, constant volume combustion and the

world first industrial gas turbine set during 20th century. The world's first gas turbine for power generation invented by Brown Boveri Company, Neuchatel, Switzerland in 1939, in first part of 20th century.

Table 2.1 Evolution of Thermal Power Generation

Year	Name	Type of Power
1678	Ferdinand Verbiest	Steam Jet for Power
1791	John Barber	Gas Turbine
1904	Franz Stolze	Unsuccessful Gas Turbine Projects
1906	Armengaud Lemale	Gas Turbine
1910	Holzwarth	First featuring intermittent Gas TurbineCombustion.
1939	Broun Boveri Company	World first gas turbine for power generation

Source: Early Gas Turbine History, MIT Gas Turbine Laboratory

Early on it was recognized that this was a technological concept with huge potential being limited only by the state of art of associated technologies and the materials available at that time. Early gas turbine concepts are basic. Invented Combined-Cycle Gas-Fired turbine (CCGT) in end of 20th Century and it can increase plant efficiency more and more up to 61% in 21st Century.

At 5,597MW installed capacity, Surgutskaya GRES-2 (Sugrut-2), a combined cycle power plant located in the Russian city of Surgut, is the world's biggest gas-fired power station. (Source: Early Gas Turbine History, MIT Gas Turbine Laboratory)

Nuclear Power Generation (Mineral): Nuclear energy is classified as non-renewable. The fuel used for nuclear energy is generally uranium, which is in a limited supply. So we classify it as non-renewable. Production of electricity from nuclear energy does not release carbon dioxide. Thus, use of nuclear energy is safe for the environment. 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 reactions. Nuclear energy is the energy that holds together the nucleus of atoms. Atoms are the simplest blocks that make up matter. Every atom has in its center a very small nucleus. Nuclear fusion is the combining of two light atoms into a heavier one and nuclear fission is the splitting

of a heavy atom. Nuclear energy originates from the splitting of uranium atoms – a process called fission. This generates heat to produce steam, which is used by a turbine generator to generate electricity. Because nuclear power plants do not burn fuel, they do not produce green house gas emissions.

The world's largest nuclear power plant is in Japan named Kashiwazaki-Kariwa plant, capacity of 7,965 MW approximately.

2. Renewable Power Generations

Available renewable power generation sources in Myanmar are hydro, solar, wind, geothermal, biomass, waste to energy and ocean tide.

Hydropower Generation: Water is important natural resources. All living organisms need water to live. Humans need water for many purposes such as drinking, cleaning, cooking and growing crops. Water flowing into the river or water stored in a dam is sources of hydro energy. The Simple method to use hydro energy is to convert it into electrical energy.A hydropower station converts the kinetic, or movement, energy in flowing or falling water into electrical energy that can be used in homes and businesses. Hydropower can be generated with a 'run-of-river' installation, which uses naturally flowing river water to turn one or more turbines, and a large scale with a hydropower dam.A hydropower dam straddles a river, blocking the water's progress downstream and the water on the upstream side of the dam, forming an artificial lake known as a reservoir. Damming the river converts the water's kinetic energy into potential energy: the reservoir becomes a sort of battery, storing energy that can be released a little at a time. As well as being a source of energy, some reservoirs are used as boating lakes or drinking water supplies.

The reservoir's potential energy is converted back into kinetic energy by opening underwater gates, or intakes, in the dam. When an intake opens, the immense weight of the reservoir forces water through a channel called the penstock towards a turbine. The water rushes past the turbine, hitting its blades and causing it to spin, converting some of the water's kinetic energy into mechanical energy. The water then finally flows out of the dam and continues its journey downstream. A shaft connects the turbine to a generator, so when the turbine spins, so does the generator. The generator uses an electromagnetic field to convert this mechanical energy into electrical energy.

As long as there is plenty of water in the reservoir, a hydroelectric dam can respond quickly to changes in demand for electricity. Opening and closing the intakes directly controls the amount of water flowing through the penstock, which determines the amount of electricity the dam is generating.

The turbine and generator are located in the dam's power house, which also houses a transformer. The transformer converts the electrical energy from the generator to a high voltage. The national grid uses high voltages to transmit electricity efficiently through the power lines to the homes and businesses that need it. Here, other transformers reduce the voltage back down to a usable level.

A dam is a barrier that stops or restricts the flow of water or underground streams. Reservoirs created by dams not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aquaculture, and navigability. Hydropower is often used in conjunction with dams to generate electricity. A dam can also be used to collect water or for storage of water which can be evenly distributed between locations. Dams generally serve the primary purpose of retaining water, while other structures such as floodgates or levees are used to manage or prevent water flow into specific land regions. The earliest known dam is the Jawa Dam in Jordan, dating to 3,000 BC.

Run-Off-River hydroelectricity (ROR) or Run-Off-the-River hydroelectricity is a type of hydroelectric generation plant. No need to store water and reservoir. ROR do not require any water storage capability. The power is only generated on how water is available from the river. Conventional hydro uses reservoirs, which regulate water for flood control and dispatchable electrical power. Dispatchablegeneration refers to sources of electricity that can be used on demand and dispatched at the request of power grid operators, according to market needs. Dispatchable generators can be turned on or off, or can adjust their power output according to an order.

The Three Gorges Dam in China, which holds back the Yangtze River, is the largest hydroelectric dam in the world, in terms of electricity production. The dam is 2,335 meters (7,660 feet) long and 185 meters (607 feet) tall, and has enough generators to produce 22,500 megawatts of power. (Source: National Geographic,)

Solar Power Generation: Sun is a big source of energy. The energy that we get from the Sun is called solar energy. 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.

The world's largest solar power generation plant located at Abu Dhabi in mid 2019 named Noor Abu Dhabi, production capacity 1,177 MW approximately.

Wind Power Generation: Winds are constantly being created in nature. The windmill is a source of electrical energy. These windmills are generally established only at places where most of the days in a year experience strong winds. The energy from this wind is used for grinding grains, pumping water and to produce electricity. Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity. Mechanical power can also be utilized directly for specific tasks such as pumping water.

World largest onshore windfarm is in Gansu Province, China. Currently installed capacity is 7,965 MW. A grand total of 20,000 MW will be installed in 2020. China is a top 1 country which installed 221 GW in the world by wind energy (EvWind).

Geothermal Power Generation: Geothermal power is power generated by geothermal energy. Technologies in use include dry steam power stations, flash steam power stations and binary cycle power stations. Geothermal electricity generation is currently used in 26 countries, while geothermal heating is in use in 70 countries.

Geothermal power plants use hydrothermal resources that have both water (hydro) and heat (thermal). Geothermal power plants require high-temperature (300°F to 700°F) hydrothermal resources that come from either dry steam wells or from hot water wells. People use these resources by drilling wells into the earth and then piping steam or hot water to the surface. The hot water or steam powers a turbine that generates electricity. Some geothermal wells are as much as two miles deep (EIA, 2019).

The world's largest geothermal power plant is located at United States of America named Geyser Complex its capacity of 1,520 MW.

Biomass Power Generation: Biomass power is carbon neutral electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as fodder for forest fires. When burned, the energy

in biomass is released as heat.Most biomass power plants use direct-fired combustion systems. They burn biomass directly to produce high-pressure steam that drives a turbine generator to make electricity in some biomass industries, the extracted or spent steam from the power plant is also used for manufacturing processes or to heat buildings. The world's biggest biomass power generation plant named Ironbridge located at United Kingdom that capacity is 740 MW.

Waste to Power Generation: A waste-to–energy plants is a waste management facility that combusts wastes to produce electricity. This type of power plant is sometimes called a trash-to-energy, municipal waste incineration, energy recovery, or resource recovery plant. Modern waste-to-energy plants are very different from the trash incinerators that were commonly used until a few decades ago. Unlike modern ones, those plants usually did not remove hazardous our recyclable materials before burning. These incinerators endangered the health of the plant workers and the nearby residents, and most of them did not generate electricity. Waste-to-energy generation is being increasingly looked at as a potential energy diversification strategy, especially by Sweden, which has been a leader in waste-to-energy production over the past 20 years. The typical range of net electrical energy that can be produced is about 500 to 600 kWh of electricity per ton of waste incinerated. Thus, the incineration of about 2,200 tons per day of waste will produce about 1200 MWh of electrical energy.

The world's largest waste-to-energy plant will be open at Shenzhen, China and handle capacity 5,000 tons of waste per day.

Ocean Tide to Power Generation: Tidal energy or tidal power can be defined as the energy that is the result of the moon and the sun's gravitational influence on the ocean. Height differences between high and low tide create tidal currents in coastal areas, and these currents can be strong enough to drive turbines. Basic principle of tidal power plant is constructed in such a way that a basin gets separated from the sea and a difference in the water level is obtained between the basin and sea. These large underwater turbines are placed in areas with high tidal movements, and are designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity.

The world's biggest tidal power station is Sihwa Lake Tidal Power Station which transited at South Korea and generates capacity 254 MW.

2.3 Advantages and Disadvantages of Power Generations and impacts

2.3.1 Advantages and Disadvantages of Hydropower Generation and Gas-Fired Power Generation

There are 2 major technical advantages during the operation period which not compare with other source of power generation methods are manage the necessary generation such increase the capacity, decrease the capacity and stop or running in shortly period and easy to change pump storage turbine and manage options such stores low-cost off-peak, excess or unusable electrical energy.

Table 2.2 Advantages and Disadvantages of Hydropower Generation and Gas-Fired Power Generation

Hydropower Generation	
Advantages	**Disadvantages**
Sustainable renewably water resource. Lowest production cost for long run. Low maintenance costs. Technology has been established Correlated benefits such as flood control, soil conservation, irrigation and water supply. Average hydropower facility has been operating for 64 years and up to more than 100 years. Currently, lowest price compare than other generating power sources except nuclear source. Generating electricity with hydro energy is not polluting (no greenhouse gas) itself. Generate power to the grid immediately. Essential back-up power during major electricity outages or disruptions. It is prime renewable power source for Myanmar	High cost of investment than other source of generations except nuclear power generation. Cause environmental and social threats, such damaged wildlife habitat, decrease forest areas, displacements, food insecurity, health concerns, harmed water quality, obstructed fish migration, and diminished recreational benefits of rivers. Facilities can affect land use, homes and natural habitats in the dam area
Gas-Fired Power Generation	
Advantages	**Disadvantages**
Can built in shorter time (within 24 months) Can operate during storm Low emission of green gas than other fuels Low initial investment Easy to control Require less space than other generations	Using fossil fuel (non-renewable) Cause of fire or explosion Itself is extremely toxic Produces Carbon dioxide and Sulphur dioxide

Source: GetRevising, 2019 & Conserve Energy Future, 2019

According to the above table 2.2 is an advantages and disadvantages of hydropower generation and gas-fired power generation.

2.3.2 Environmental Impacts of Hydropower Generation

Dam reservoirs will inundate these biologically rich areas while the resulting human displacement will impact remaining habitats. The rivers themselves are also repositories of immense biodiversity; Large dams destroy ecosystem integrity, fragment riverbank ecosystems, isolate populations of species living up and downstream of the dam, cutting off migrations which can contribute to inbreeding from smaller genetic pools. Dams inundate riverbank habitats upstream and alter seasonal flow regimes and natural sedimentation processes downstream. In addition, dams can have direct impacts on fish migration routes and access to spawning grounds.(Source: Burma Rivers Network, burmariversnetwork.org)

Forests: In addition to inundation, the road building and displacement put further pressures on forests by increasing logging activity and human habitation in previously untouched forest areas.

Fisheries: In addition to blocking migration routes so that fish cannot reach upstream areas to spawn, the downstream impacts of dams on fisheries are also severe. The number of fish species decline due to dams

2.3.3 Social Impacts of Hydropower Generation

According to the World Commission on Dams, physical and livelihood displacement leads to “landlessness, joblessness, homelessness, marginalization, food insecurity, increased morbidity, loss of common resources, and loss of social and cultural resilience” resulting in an “often irreversible decline in living standards”.

Displacement: The flood zones created by dams that will displace estimated thousands of people depend on the area how required. They will be left without their land, homes, or livelihoods. As populations near dam sites are mostly living at subsistence levels, it is highly likely that the displaced will be forced to migrate, most probably to other countries, to find work. **Food Insecurity:** Dams trap sediment from the river and keep it from reaching downstream areas. This decreases floodplain and delta agricultural productivity and decreases nutrients for fish and aquatic plants. Dams located in tremendously biodiversity areas will flood rich lowland areas where hundreds of unique cultivated species could be lost to the world forever. People

displaced by dams and those that lose their farmlands or forest foraging areas to dam reservoirs also face food insecurity. The impact of dams to fisheries and the loss of rich river bank farms also decrease food security.

Health Concerns: Toxic releases from reservoirs: As water sits behind a dam in a reservoir, bacteria transform any mercury in the water into methyl mercury, a central nervous system toxin. When the water is released, it sends this toxin downstream. Scientists have become increasingly aware of the accumulation of high blood mercury levels of people living downstream of dams. Toxic releases are of particular concern with dams nearby mining sites. As methyl mercury passes up the food chain, it becomes increasingly concentrated. Methyl mercury exposure in the womb, which can result from a mother's consumption of contaminated fish, can adversely affect a baby's growing brain and nervous system, impacting cognitive thinking, memory, attention, language, and fine motor and visual spatial skills.

2.4 Reviews on Previous Studies

As per previous studies, scholars conduct the research on electricity generation and distribution sector such a study of hydroelectric power projects in Myanmar by Hla Myint (2007), a study of electricity power generated by gas turbine system and its consumption by Kyaw Moe Hlaing (2013), a study of project management of Hlawga gas-fired power plant project by Aung Thu Htoon (2015) and a study of electricity distribution of Yangon electricity supply board (YESB) by Tun Tun Swe (2015).

Among of them, Hla Myint (2007) studied of 'hydroelectric power projects in Myanmar' by descriptive method and scope of limitations up to August, 2007 from pre-war. Installed capacity of various power generations was 1,571.90 MW and actual generated electric power was 885.58 MW to transmit to national grid. The maximum productivity was 37,725.60 MWh but actual generated electric power to national grid was 19,386.19 MWh. The actual production rate was only 51.39 % highlighted. Suggested for full load, to complete the ongoing hydropower projects timely and initiate a real future energy plan.

In additions, Kyaw Moe Hlaing (2013) studied of 'electricity power generated by gas turbine system and its consumption' by mainly based on descriptive analysis and highlighted the gas-fired power generation and demand of electricity as well as losses of electricity. Oil and Gas sector plays an important role for infrastructure development by providing reliable and affordable energy to industries and

households, also instrument in the economic and social development of a nation. Found table 4.9 which Production, Sale and Loss from 1988-89 to 2010-2011. That table clearly shows the transmission and distribution losses percentages. The highest transmission loss 38.70% in 1996-1997 and the lowest transmission loss was 26.67% in 2008-2009.

Moreover, Aung Thu Htoon (2015) studied of 'project management of Hlawga gas-fired power plant project' by descriptive research method and based on primary and secondary data. It's highlighted the project management and analysis on time, cost and earned values. This study covered the project planning, implementation, project management, evaluation practices for whole project except technology details and legal factors.

Furthermore, Tun Tun Swe (2015) studied of' electricity distribution of Yangon electricity supply board (YESB)' by descriptive method based on secondary data of Yangon electricity supply board (YESB) between 2011 and 2015. In Yangon, electricity supplied to 1,286,061 households around 2011-2012 and up to 1,383,004 households in 2014-2015. YESB found that non-technical losses was the major problem facing, was about 18% of losses each year. YESB changed the name to YESC.

CHAPTER III
OVERVIEW ON MYAMAR POWER GENERATION SECTOR

3.1 Historical Background of Electricity and Energy in Myanmar

Electricity: Ruby Mining Company installed hydropower plant in 1893 at Yeni Creek, Mogok area that very first power generation in Myanmar. Built capacity was 460 kilowatts by hydropower generator. The Rangoon Electric Tramway & Supply Company built electric power generating plants in 1905 at Ahlone Township and Pazundaung Township for the purpose of Rangoon-Tarmway transportation. Sule Pagoda road was the first electric lighting road in Rangoon. Myanmar adopted Indian Electricity Law on 18th March, 1910. Most of the records were destroyed during Second World War.

In the period approached to independence of Myanmar, the national leaders drew strategies and plans for the development of the country to promote and expand the agricultural sector with advanced technologies and exploit the natural resources effectively by cooperating with local industries. The leaders also realized that electricity played a vital role to implement above strategies. Therefore, in June 1947, authorities decided to implement the hydropower projects which were enormous resources in Myanmar, and could be implemented by suitable budgets as a first priority. There was 2 years plan for Economic Development of the Union of Myanmar in 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 to the Ministry of Industry (1) and the Ministry of Industry (2). 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 Myanma Electric Power Enterprise (MEPE). On 15th 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. On 15th May 2006, the ministry was divided into Ministry of Electric Power (1) and Ministry of Electric Power (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.

Energy: During the British colonial period and from after getting the independence to 31st December 1962, Burma Oil Company (B.O.C) controlled the Myanma Oil Industry including production, refining and distribution of oil. On 1st January 1963, all the above operations in Myanmar were carried out by the Public Oil Enterprise, which was state owned, under the Ministry of Mine, and changed as Myanma Oil Corporation (MOC) by the notification letter (1/70) of the Ministry of Mine dated on 28th February 1970. MOC conducted oil exploration, drilling , production, refining and distribution of petroleum products, and on 1st April 1975, the refineries and petroleum products distribution industries were composed under the Ministry of Industry (2) by the agreement of the 26th Meeting of State Council hold on 28th February 1975 .Then starting from 1st August 1977, the whole corporation was composed under the Ministry of Industry (2) by the notification letter (10/77) of the cabinet's letter No. 87 WaPha 77 (4) dated on 29th July 1977.

The Ministry of Energy was organized by the notification letter (41/85) of the State Council of the Socialist Republic of the Union of Burma dated on 12th April 1985 and the notification letter (5/85) of the cabinet dated on 12th April 1985.

By the notification letter (2/89) of the cabinet of the Union of Myanmar dated on 31st March 1989, it was declared to change the name of the state owned enterprises.

By the letter No. 40/97 Ah PhaYa 97 (3) of the cabinet of the Union of Myanmar dated on 16th November 1997, Myanma Electric Power Enterprise was changed and organized as the Ministry of Electric Power.

Table 3.1 Contribution of the Energy and Electric Power Sector in GDP and Annual Growth Rate

Year	GDP Contribution		Annual Growth Rate	
	Energy	Electric Power	Energy	Electric Power
2005-2006	0.16%	0.23%	19.4%	19.2%
2010-2011	0.17%	1.06%	-6.0%	28%
2013-2014	5.03%	1.20%	3.0%	14%
2014-2015	6.15%	1.42%	36.1%	14.8%
2015-2016	5.07%	1.42%	-0.5%	13.1
2016-2017	3.35%	1.39%	-7.1%	8.0
2017-2018	3.78%	1.33%	12.9%	6.3

Source: Myanmar Statistical Year Book, 2018

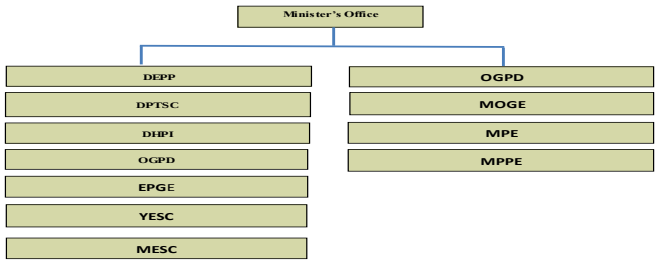
According the table 3.1 isGDP Contribution and Annual Growth Rate of the energy and electric power sectors. The year 2014-2015 energy data are extremely increased than previous years in GDP contribution and annual growth rate. Ministry of Energy floatedthe PSC blocks for onshore and offshore in 2014 and selected operators. The awarded onshore and offshore company's remittance their signature bonuses to MOEE when they entered to exploration stage in fiscal years 2014-2015 and 2015-2016. That is why, the GDP contribution and annual growth rate were high at those years.

3.1.1 Ministry of Electricity and Energy

Ministry of Electric Power (MOEP) and Ministry of Energy (MOE) were composed into one Ministry in 1st April 2016. The Ministry of Electricity and Energy (MOEE) under which there were four Departments, five Enterprises and two Corporations shown at (figure 3.1). According to the departments such Department of Electric Power Planning (DEPP), Department of Power Transmission and System Control (DPTSC), Department of Hydropower Implementation (DHPI), Oil and Gas Planning Department (OGPD), Electric Power Generation Enterprise (EPGE), Electricity Supply Enterprise (ESE), Myanma Oil and Gas Enterprise (MOGE), Myanma Petrochemical Enterprise (MPE), Myanma Petroleum Product Enterprise (MPPE), Yangon Electricity Supply Corporation (YESC) and Mandalay Electricity

Supply Corporation (MESC) are administered by the minister, deputy minister (electric power) and deputy minister (energy).

Figure 3.1 Ministry of Electricity and Energy (Management Structure)



Source: MOEE

3.2 Plans, Policies, Strategies and Frameworks by the Government of Myanmar

The Government of the Republic of the Union of Myanmar instituted the National Energy Management Committee (NEMC) and formed the Energy Development Committee (EDC) in 9th January, 2013. NEMC takes the leading role and the committee is implementing its priority duties and functions to ensure the development of energy sector, including the power subsector.Japan International Cooperation Agency (JICA) conducted the project for formulation on the National Electricity Master Plan (NEMP) to support the preparation of the Myanmar Energy Master Plan since 2013.National Electricity Master Plan had been conducted by the assistance of JICA. Its plans, policies, strategies and frameworks can be seen in Appendix (2).

National Energy Policy was successfully adopted on 6th January, 2015 when after closed cooperation with relevant stakeholders. The Myanmar Energy Master Plan (MEMP) prepared by Ministry of Energy (MOE) and its partners such Asia Development Bank (ADB), Intelligent Energy Systems (IES) and Myanmar International Consultants (MMiC) in December, 2015 which under guidance by NEMC. Myanmar is performing proactively and moving forward with the ultimate goal of achieving an "All-inclusive Sustainable Development". Ministry of Electricity and Energy (MOEE) has a long term National Electric Master Plan (NEMP) and short term plans for electricity sector and its National Energy Policy (NEP) highlighted to invite the local and foreign investments for the extraction and utilization of natural

resources in order to fulfill the nation's energy needs by minimizing the environmental impacts and practicing the Health, Safety and Environment (HSE) and Corporate Social Responsibility (CSR) measuring activities. NEMP targeted on 50% of households to be electrified in 2020, 75% households to be electrified in 2025 and 100% households to be electrified in 2030, 99% will electrify by national grid and 1% will electrify by off grid. Government of Myanmar (GoM) continues to reform and extend the energy infrastructure to support the country's sustainable economic growth.

The Myanmar Sustainable Development Plan (MSDP) is the expression of national development vision which published by the Government of the Republic of the Union of Myanmar in August, 2018. The MSDP delivers this strategy, providing an overall framework for coordination and cooperation across all Ministries, and all States and Regions to forge a common path towards the emergence of a prosperous, peaceful and democratic Myanmar. The MSDP has been developed to ensure full alignment with the Economic Policy of the Union of Myanmar (2016).

According to the policies set by MOEE, electricity generation from hydropower is still a key part of the long term plan for the country's energy needs and gas-fired power generation is a key to the short term plan.

Energy is the GoM's top priority sector and the government is committed to constantly increasing the electricity access for the Myanmar people. Leading sub-sectors are hydropower, gas-fired power, coal-fired power and renewable solar power.

3.3 Hydropower Generation Sector

Myanmar owns the water renewable resources; the rivers name Ayeyarwaddy, Chindwin, Thanlwin and Sittaung. Myanmar has significant hydropower potentials more than 100,000 MW of installed capacity stated by Asia Development Bank (ADB). ADB focused on 7.7% of the hydropower resources in Asia, Government of Myanmar has a plan to being built to increase the hydropower generation capacity up to 29,000 MW by 2031. There are ongoing two additional hydropower schemes, Upper Kyaing Taung and Upper Yeywa at Shan State with 51MW and 280 MW respectively in 2021.There are numerous hydropower mini-grids and hybrid solar and diesel mini grids across Myanmar. Magway and Sagaing divisions are transited at dry zones and further mini-grids could solve the power shortage problems in rural

communities. The potential for mini-grid development is higher than other areas. The government is committing sizable resources for off-grid renewable there.

The following table 3.2 is existing generation mix in Myanmar. There are grand total 5,798 MW (97% of national grid 5,628 MW and 3% of off-grid 170 MW) at existing generation mix. Hydropower provides 3,262 MW and ongoing constructions capacity is 1355.4 MW in various areas in Myanmar. On the existing generation mix, hydropower account for (3,225 MW), natural gas-fired power account for (2,283 MW) and coal-fired power generation account for (120 MW) are under national grid and small hydropower (37 MW), gas-fired power (16 MW), and diesel power (117 MW) are under off-grid system. Currently, there are 61 numbers of hydropower generation projects, 1 number of coal-fired power plant and 23 numbers of gas-fired power generation projects operating in Myanmar.

Table 3.2 Existing Generation Mix (March, 2019)

Types of Power Plants	No. of Stations	Installed Capacity (MW)
Hydropower Plants	28	3,225
Coal-fired Thermal Plant	1	120
Gas-fired Power Plant	29	2,283
Installed Capacity Connected to National Grid		5,628 MW
Small Hydropower plants (off grid)	33	37
Gas-fired Power Plants (off grid)	1	16
Diesel (off grid)		117
	Grand Total	**5,798 MW**

Source: MOEE

National Electricity Master Plan targeted generation is 23,594 MW at fiscal year 2030-2031. The generation mix ratios are 38% on hydropower (8,896 MW), 33% on coal power (7,940 MW), 20% on gas-fired power (4,758 MW) and 9% on solar power (2,000 MW).MOEE has 3 ways for power generation such sole investment by MOEE, investment by local entrepreneurs on B.O.T basis and investment by foreign companies on J.V/B.O.T/P.P.P basis.

Myanmar is a second top country with the highest number of mini grids. A mini-grid is an electric power generation and distribution system that provides electricity to a localized community (World Bank Blogs, 2019).

Under the National Electrification Project (NEP), an estimated 1.2 million people living in 4,000 remote villages nationwide have new access to electricity from 228,000 solar home system and 24,000 solar powered street lights. All schools, rural health clinics and community centers of these villages have also been electrified. NEP is also planning to bring electricity to an additional 2.2 million people in 2019 through grid extension and off-grid electrification. This covers additional 5,000 villages through the national power grid and 2,300 remote villages from off-grid solar systems. Myanmar is one of the world's most disaster-prone countries, exposed to multiple hazards including floods, cyclones, earthquakes, landslides and droughts. Myanmar is one of the most affected countries by climate change in the last 20 years, ranking third out of 184 countries in the 2019 Global Climate Risk.

(Source: The World Bank in Myanmar – World Bank April, 2019)

The Myanmar water resources possess 12% of Asia and 16% on ASEAN countries and more than 7% of Asia's hydropower potential. MOEE, related ministries and organizations studied on the potential energy resources for Myanmar are as following table.Today, electrification reached to 50% of households and more generation capacity around 904 MW during three years and 9 months period (4/2016 to 12/2019).

Table 3.3 Potential and Type of Various Power Resources (March, 2019)

Types of Resources	Potential
Hydropower	100,800 MW
Solar Power	51973.8 TWh per year
Wind Power	365.1 TWh per year
Biomass Power	Annual yield of wood fuel 19.12 million metric ton base on 52.5 % covered with forest in the country.
Coal	711 million metric tons
Natural Gas (Offshore & Onshore) (Proved + Probable)	122.5391 TSCF including 16.6 TSCF proved offshore reserved.
Crude Oil (Offshore & Onshore) (Proved + Probable)	648.59 MMBBL

Source: MOEE

According to the above table 3.3 is potential and type of various power resources. Potential energy resources such as hydropower 100,800 MW, solar power 51,973.8 TWh/year, wind power 365.1 TWh/year, biomass power by wood 19.12 million metric tons, coal 711 million metric tons, natural gas 122.5391 TSCF

(probable reserved) and 648.59 MMBBL (probable reserved) are available in Myanmar.

The following table 3.4 is existing hydropower generation plants around Myanmar. Serial 1 to 23 (subtotal installed capacity 2,114 MW) was sole invested by MOEE. Serial 24 and 25 (subtotal installed capacity 172 MW) was invested with BOT basis by local entrepreneurs. Serial 26 to 28 (subtotal installed capacity 939 MW) was invested with JV and BOT basis by Foreign Direct Investment (FDI).

Table 3.4 Existing Hydropower Generation Plants (March, 2019)

No.	Stations	Installed Capacity (MW)	Annual Generation GWh
1.	Beluchaung (1)	28	200
2.	Beluchaung (2)	168	1,190
3.	Kinda	56	165
4.	Sedawgyi	25	134
5.	Zawgyi (1)	18	35
6.	Zawgyi (2)	12	30
7.	Zaungtu	20	76
8	Thaphanseik	30	1,172
9.	MoneChaung	75	330
10.	Paunglaung	280	911
11.	Yenwe	25	123
12.	Kabaung	30	120
13.	KengTaung	54	3,776
14.	Yeywa	790	3,550
15.	Shwekyin	75	262
16.	Kun Chaung	60	190
17.	KyeeOhnKyeeWa	74	370
18.	Nancho	40	152
19.	PhyuChaung	40	120
20.	Upper PaungLaung	140	454
21.	Myogyi	30	135.7
22.	Myittha	40	170
23.	Yezagyo	4	96
24.	Thaukyegat (2)	120	604
25.	Beluchaung (3)	52	334
26.	Shweli (1)	600	4022
27.	Dapein (1)	240	1065
28.	ChipweNge	99	433
	Total Capacity	**3,225**	**20,219.7**

Source: MOEE

There are not listed existing (33) small hydropower generation stations which under off grid and total installed capacity was 37,374 kW around Myanmar. The largest station name Nam Kham Kha generates 5,000 kW at Kachin state that not listed above table. The smallest station which installed capacity was 50 kW at Palettwa, Chin State. Upper Nam Htun hydropower project is a small scale (3.2 MW) and project completion in early this year.

Currently, government owned Yeywa (790 MW) is a biggest hydropower generation plant and Ywama (240 MW) is a biggest gas-fired power plant in Myanmar. The river Thanlwin, the water flowing rate is faster than other rivers in Myanmar. In the previous studied found that possible projects in Thanlwin River were Kun Long (Shan North), Nong Pa (Shan North), Tasang (Shan North), Ywathit (Kayar), Weigyi (Kayin State at Thai border), Dagwin (Kayin State at Thai border) and Hatgyi (Upper Myaing Gyi Ngu at Kayin State).

Finally, looking Run-Of-River type at the Thanlwin River hydropower projects which more reduces the impacts than dam type if disaster populated. Kun long and Nong Pa are already feasibility studied. The following table 3.5 shows the hydropower projects under feasibility study.

Table 3.5 Study for Hydropower Projects (March, 2019)

Sr. No.	Projects Under Feasibility Study	Installed Capacity MW
1.	Middle Yeywa	600
2.	Shweli-2	520
3.	Upper Thanlwin	1,400
	Total	**2,520**

Source: MOEE

All three projects seem to be feasible for hydropower generation; however, they are still under contract negotiation process between MOEE and Independent Power Producers.

The following table 3.6 is detail hydropower resources potential in Myanmar. MOEE investigated the hydropower resource potentials. When after the investigation for 302 potentials, the power generation availability such 60 numbers of big scale projects (more than 50 MW) will be generated subtotal 45,293 MW, 32 numbers of

medium scale projects (10 MW to 50 MW) will be generated subtotal 806.30 MW and 210 numbers of small scale projects (less than 10 MW) will be generated subtotal 231.25 MW respectively.

Table 3.6 Potentiality of Hydropower Resources in Myanmar (March, 2019)

Hydropower Resources	108,000 MW
Total Investigated Potentials	46,330.55 MW from 302 numbers
<10 MW	231.25 MW from 210 numbers
10 MW to 50 MW	806.3 MW from 32 numbers
>50 MW	45,293 MW from 60 numbers
Existing Installed Capacity	3,262 MW in Hydropower sector

Source: MOEE

The following table 3.7 is under planning and investigation statuses for hydropower. Currently, MOEE has signed 22 hydropower projects total installed capacity for 6,807 MW MOU with foreign companies under JV/BOT, 12 hydropower projects total installed capacity for 16,030 MW MOA with foreign companies under JV/BOT, 7 hydropower projects total installed capacity for 13,259 MW JVA with foreign companies under JV/BOT, 3 hydropower projects total installed capacity for 116.4 MW MOA with local companies under BOT and 2 hydropower projects total installed capacity for 731 MW PPP foreign companies under JV/BOT. Altogether 46 contracts were signed for total capacity 36,943.4 MW.

Table 3.7 Under Planning and Investigation Statuses for Hydropower (2019)

Status	Total Number	Installed Capacity MW	Type of Investment
MOU	22	6,807	JV/BOT (Foreign Company)
MOA	12	16,030	JV/BOT (Foreign Company)
JVA	7	13,259	JV/BOT (Foreign Company)
MOA	3	116.4	BOT (Local)
PPP Notice to Proceed	2	731	JV/BOT (Foreign Company)
Total	**46**	**36,943.4**	

Source: MOEE

The following table 3.8 shows MOEE owned ongoing construction for hydropower generation projects such Upper Kengtawng, Upper Yeywa, Middle Paunglaung, Deedoke, Shwerli-3, Thahtay Chaung and Upper Beluchaung projects. The constructions will be completed between 2020 and 2025 and getting more installed capacity 1,355.4 MW for the country.

Table 3.8 State Owned Ongoing Hydropower Generation Plants (3/2019)

Sr. No.	Project Name	Location (State/Division)	Capacity MW	Completion Period
1.	Upper Kengtawng	Shan State (South)	51	2020-2021
2.	Upper Yeywa	Shan State (North)	280	2020-2021
3.	Middle Paunglaung	Naypyitaw	152	2020-2021
4.	Deedoke	Mandalay Division	60	2021-2022
5.	Shweli-3	Shan State (North)	671	2022-2023
6.	ThahtayChaung	Rakhine State	111	2024-2025
7.	Upper Beluchaung	Shan State (South)	30.4	-
		Total	**1,355.4**	

Source: MOEE

3.4 Gas-fired Power Generation Sector

Natural gas resource development is important for gas-fired power generation. Myanmar has 14 geological basins transited in onshore and 3 geological basins transited in offshore. Myanmar Oil and Gas Enterprise (MOGE) discovered the oil and gas fields and still production operations at Kyaukkwet-Letpando-Ayardaw oil and gas field, Thargyitaung-Sabei oil field, Chauk-Lanywar oil field, Yenanchaung oil field, Mann oil field, Htaukshabin-Kanni-Petpe oil field, Htankaing-Dahatpin-Yenanma oil field, Pyay oil field, Myanaung oil field, Shwepyithar oil and gas field, Ahpyauk gas field, Nyaungdon-Maubin oil and gas field (Yenanchaung and Chauk discovered from British Oil Company). Average daily production was 6,300 barrels of crude oil and 54.21 millions of standard cubic feet (MMSCF) of natural gas up to December, 2018 from Myanmar onshore operations. There are local owns hand dug wells produces crude oil, permitted by regional authorities in several areas but all

those crude oils direct used by respective areas. No data but observers expects that productions are more than government production.

There are 53 onshore blocks and 51 offshore blocks under various types of production sharing contracts such 22 onshore blocks and 34 offshore blocks were under Production Sharing Contracts (PSC), 3 onshore blocks were under Improved Oil Recovery contracts (IOR) and 1 onshore oil field under Performance Compensation Contract (PCC) that responsible for enhancing production.

The following table 3.9 is companies and onshore blocks and their contract statuses. Currently, (15) onshore PSC Blocks are operating and one block under official suspension out of (25) PSC Blocks in Q3 of 2019. (10) Onshore Blocks are ongoing termination processes.

Table 3.9 Companies and Onshore Blocks (September, 2019)

Operator	Onshore Blocks	Status
Asia Orient International	PSC-E	Termination process
Bashneft	EP-4	Active
CAOG	MOGE-4	Active
ENI	PSC-K and RSF-5	Active
Geopetrol	RSF-9	Termination process
Goldpetrol	MOGE-1 and IOR-2	Active
PSCI/Jubilant/ Parami Energy	PSC-I	Notice to termination
MPRL E&P Pte., Ltd	MOGE-2	Active
NOBEL Oil	PSC-A (Temp. suspension) and PSC-B1	PSC–B1 is ongoing termination process
NPCC	PSC-F	Termination process
ONGC	PSC-B2 and EP-3	Active
Pacific Hunt	PSC-C1 and PSC-H	PSC-H will terminate if fail to deposit PBG
Petroleum Brunei	EP-1	Termination process
PT Istech	EP-5	Active
PTTEP South Asia Limited.	MOGE-3, EP-2 and PSC-G	EP-2 and PSC-G are ongoing termination process
PCML	IOR-5 andIOR-7	Active
SNOG	PSC-R	Termination process

Source: MOEE

Table 3.10 Companies and Offshore Blocks (September, 2019)

Operator	Offshore Blocks	Status
Berlanga	M-8	Active
Transcontinental Group (TRG)/CFG	M-15	Active
Chevron	A-5	Active
CNPC	AD-1, AD-6 and AD-8	Active
ENI Myanmar B.V.	MD-2 and MD-4	Active
MPRL E&P Pte., Ltd.	A-6	Active
Ophir	AD-3	Active
Petrovietnam	M-2	Termination process.
PCML (UK)	M-12, M-13 and M-14	Active
POSCO-DAEWOO	A-1, A-3 and AD-7	Active
PTTEPI	M-3, M-9, M-11	Active
PTTEP South Asia Limited	MD-7	Active
Relaince	M-17 and M-18	Termination process.
SHELL Myanmar Energy Pte., Ltd.	A-4, AD-2, AD-9, AD-11, MD-5	MD-5, AD-9 and AD-11 are ongoing termination process.
Tap Oil and Smart Co., Ltd.	M-7	Termination process
TOTAL E&P	M-5, M-6 and YWB	Active
Woodside	A-7 and AD-5	Active

Source: MOEE

The table 3.10 presents companies and onshore blocks and their contract statuses. At present, (27) offshore PSC Blocks are operating out of 34 PSC Blocks in Q3 of 2019. (7) Offshore Blocks are ongoing termination processes.

International oil and gas prices crushed in 2014 from above USD 100/BBL to dropped under USD 30/BBL. Today, the crude oil price is increasing up to USD 60/BBL.

Table 3.11 Offshore Daily Gas Production (December, 2019)

Offshore Oil Field	Daily Production	Export gas	Domestic Consumption
Yadana	890	665	225
Yetagun	90	90	0
Shwe	530	400	130
Zawtika	325	250	75
Total	**1,835**	**1,405**	**430**

Source: MOEE

According to the table 3.11 is export gas and domestic consumption of offshore daily gas production in December, 2019.

There are (4) existing offshore projects such Yadana, Yetagun, Shwe and Zawtika. Yadana project produces 890 MMSCFD (Export 665 MMSCFD and Domestic 225 MMSCFD) of natural gas. The share ratios for Yadana project are operator TOTAL E&P owns 31.24%, UNOCAL 28.26%, PTTEP 25.50% and MOGE 15%. Yetagun project produces 90 MMSCFD of natural gas exporting to Thailand and 2,850 bbls of condensate sold-out by situation. The share ratios for Yetagun project are operator Petronas 40.75%, Nippon Oil 19.40%, PTTEP 19.40% and MOGE 20.45%. Shwe project produces total 530 MMSCFD of natural gas (export 400 and domestic 130 MMSCFD). The share ratios for Shwe project are operator DAEWOO 51%, ONGC 17%, GAIL 8.5%, KOGAS 8.50% and MOGE 15%. Zawtika project produces total 325 MMSCFD of natural gas (export 250 MMSCFD and domestic 75 MMSCFD). The share ratios for Zawtika project are operator PTTEP 80% and MOGE 20%. 2,850 barrels of condensate and 1,820 MMSCFD of natural gas (export 1,835 MMSCFD and domestic consumption 430 MMSCFD) produced up to December, 2018 from Myanmar offshore operations.

The following table 3.12 is MOEE owned gas-fired power plants in Myanmar. Total installed capacity is 942 MW but most of them were installed over 20 years and low efficiency.

Table 3.12 MOEE Owned Gas-Fired Power Generation Plants (June, 2019)

No.	Plant	Install capacity(MW)	Commercial operation date
1	Kyung Chaung	54	1974
2	MyanAung	35	1975
3	Ywama (CCPP)	70	1980
4	Mann	37	1980
5	ShweTaung	55	1982
6	Thahton	51	1975
7	Thaketa (CCPP)	92	1990
8	Ahlone (CCPP)	154	1995
9	Hlawga (CCPP)	154	1996
10	Ywama	240	2014
	Subtotal	**942**	

Source: Energize Myanmar, 2019

The following table 3.13 is IPP owned gas-fired plants. Independent power producers operating eight numbers of gas-fired power plants which total installed capacity is 792 MW.

Table 3.13 IPP Owned Gas-Fired Power Plants (June, 2019)

No.	Plant	Install capacity(MW)	Commercial operation date
1	Toyo Thai (Ahlone)	121	2013
2	MCP (HlawGa)	54	2013
3	Max Power (Thaketa)	50	2013
4	UPP (Ywama)	52	2014
5	Myanmar Lighting (Mawlamyaing)	230	2014
6	Kanbauk	6	2015
7	Thaketa CIC	54	2015
8	Sembcorp	225	2018
	Subtotal	**792**	

Source: Energize Myanmar, 2019

Table 3.14 Rental Gas Fired Power Generation Plants (June, 2019)

No.	Plant	Install capacity(MW)	Commercial operation date
1	APR (Kyauk Se)	110.6	2014
2	V-Power (MyinGyan)	90	2015
3	Aggreko (MyinGyan)	103	2015
4	V-Power (MyinGyan)	65	2016
5	PowergenKyaukse	145	2019
	Subtotal	**523.6**	

Source: Energize Myanmar, 2019

According to the above table 3.14 shows rental gas-fired power generation plants. There are 5 rental gas-fired power generation plants around MyinGyan and Kyaukse areas total installed capacity 523.6 MW.

The following table 3.15 is salient features of ongoing gas-fired power construction projects. Gas-fired power generation capacity is increasing year by year and existing gas-fired power generation is 2,299 MW in first quarter of 2019. Estimating gas-fired power generation installed capacities are 2,409 MW in year 2019, 2,932 MW in year 2020, 5,292 MW in year 2021 and 5,777 MW in year 2022 respectively.

Table 3.15 Salient Features of Ongoing Gas-Fired Power Construction Projects

No.	Gas-Fired Power Generation Projects	2019	2020	2021	2022
1	Baelin Gas Engine (Rental)	110			
2	Myanaung Gas Engine (Japan Grant)		20		
3	Pahtolon CCGT (JICA)		12		
4	Ahlone LNG to Power (Toyo Thai)		356		
5	KyaukPru CCGT (Sinohydro)		135		
6	Mielonggyaint LNG to Power (Zhefu)			1,390	
7	Kanbauk LNG to Power (TOTAL &Seimens)			820	410
8	Ywar Ma (World Bank)			150	75
		110	523	2,360	485

Source: MOEE

5.46% of natural gas production increased in 2017-2018 and 13.41% of crude oil production decreased in fiscal year 2017-2018 by Central Statistics Organization's Report.MOEE issued 'Notice to Proceed' certificates for total installed capacity 3,111 MW to 4 energy developers such TOTAL & SIEMENS A.G. for LNG to power-Kanbauk (1,230 MW), Zhefu& Supreme for LNG to power-Mee Laung Gyaing (1,390 MW), TTCL Public Company Limited for LNG to power-Ahlone (356 MW) and Sinohydro & Supreme for combined cycle gas turbine (CCGT)-Kyauk Phyu (135 MW) at 30th January, 2018. The term "Notice to Proceed" was not an international practice in Public Private Partnership (PPP) before.

3.5 Electricity Demand Forecasts

MOEE and Japan International Cooperation Agency (JICA) joint studied on electricity demand forecast for 20 years period (2011-2030).

Table 3.16 Electricity Demand Forecast for 20 Years Period (2011-2030)

Year	Low Case Demand MW	High Case Demand MW	Generated MW
2011	1,600	1,600	-
2012	1,850	1,850	1,796
2013	2,055	2,055	1,969
2014	2,157	2,248	2,232
2015	2,376	2,527	2,497
2016	2,617	2,840	2,802
2017	2,884	3,192	3,189
2018	3,178	3,587	3,586
2019	3,503	4,032	4,268
2020	3,862	4,531	-
2021	4,208	5,092	-
2022	4,585	5,723	-
2023	4,996	6,431	-
2024	5,443	7,227	-
2025	5,930	8,121	-
2026	6,461	9,125	-
2027	7,039	10,253	-
2028	7,668	11,520	-
2029	8,353	12,944	-
2030	9,100	14,542	-

Source: MOEE

The above table 3.16 is electricity demand forecast for 20 years period.Demand forecasts based on low case and high case (cooking time and lighting time). Yearly forecasts are not constant. It's mainly depends on the future industrial development plan which directly linked with electricity consumption.

The following table 3.17 is consumption increase between 2012 and 2018 and focusing for year 2019 up to year 2021. Consumption increased year by year such as 9.63% in 2013, 13.36% in 2014, 11.87% in 2015, 12.21% in 2016, 13.81% in 2017 and 12.45% in 2018, MOEE calculated forecasts shall be yearly 19% increased from 2019 up to 2021 depends on industrial development plans.

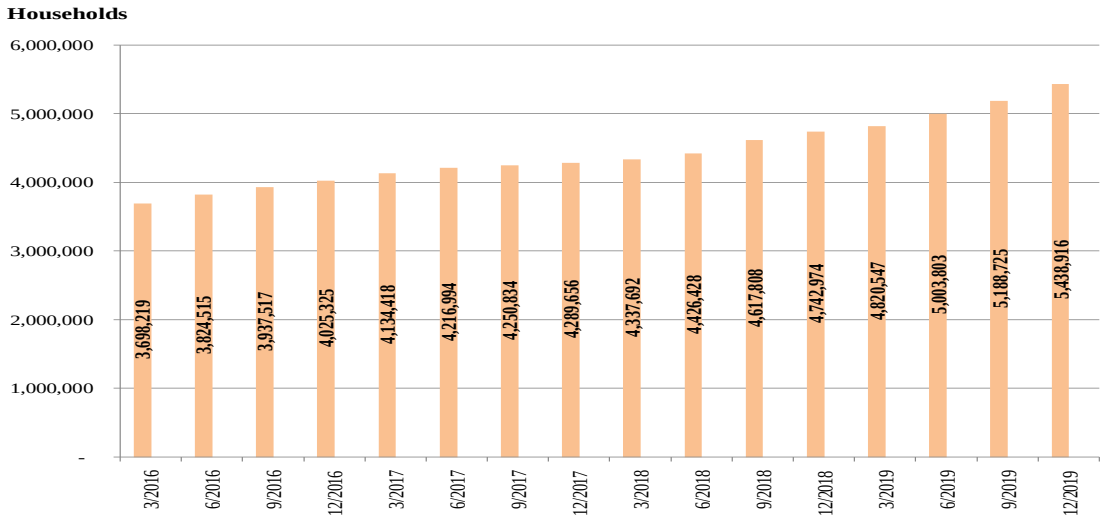
Table 3.17 Consumption Increase between 2012 and 2018 and focused (%)

Year	Generation MW	Increased Consumption %	Calculated Focus%
2012	1796	-	-
2013	1969	9.63 **%**	-
2014	2232	13.36 **%**	-
2015	2497	11.87 **%**	-
2016	2802	12.21 **%**	-
2017	3189	13.81 **%**	-
2018	3586	12.45 **%**	-
2019	4268	-	19 **%**
2020	5079	-	19 **%**
2021	6044	-	19 **%**

Source: MOEE

The following Figure 3.2 shows electricity consumption by households from 3/2016 to 12/2019. Total households in Myanmar up to March, 2019 was 10,877,832. Electrified household ratio was 50% in December, 2019.Electricity consumption rate is higher and higher in Myanmar and today there are 370 kilo watt hour per person. The figure 3.2 shows electricity consumption by households.

Figure 3.2 Electricity Consumption by Households (Quarterly) June/2019



Source: MOEE

The following table 3.18 is power generation by types from 2014 to 2018. Hydropower generation contribution ratio is always more than gas-fired power generation. Total generation increasing rate are 10.63% in 2015, 11.46% in 2016 and 11.02% in 2017. 2018 data is in completed. That data was collected up to mid-November, 2018.

Table 3.18 Power Generation by Type (2014 to 2018)

Year	**Hydropower MW**	Ratio %	**Thermal-power MW**	Ratio %	**Total Generation MW**	**Yearly Increased %**
2014	8,799,564	64	4,872,808	36	13,672,372	-
2015	9,173,547	58	6,125,472	42	15,299,019	10.63
2016	9,733,185	56	7,545,794	44	17,278,979	11.46
2017	10,901,813	56	8,516,947	44	19,418,760	11.02
2018	10,840,652	57	8,076,019	43	18,916,671	-2.64

Sources: MOEE

*2018 data is from January to 15th of November.

3.6 Electricity Unit losses

Unit losses mean the differences between generating station/sub-station to end users. There are 2 types of unit losses such technical losses and Non-technical losses. MOEE has a planned for reducing technical line loss by the loan USD 60 million from ADB at Yangon, Mandalay, Magway and Sagaind divisions. The project was completed in December, 2016.

Today, MOEE maintaining the national grid transmission loss decreases to 4%. That is acceptable for international standard. But transmission and distribution losses in urban areas are still high. MOEE is tracking the line loss cases and try to reduce down to 10% targeted. The line loss percentages of the neighboring countries are Thailand 6%, China 6.6%, India 21.4% and Laos 14.42%.

The following table 3.19 is transmission and distribution losses from year 1988-1989 to year 2017-2018. A transmission and distribution Line loss is one of the major factors for electricity sector. In fiscal year 1998-1999, transmission decreased from 4,550.46 GWh to 4,139.44 GWh and total line losses showed 31.00%. In fiscal year 2001-2002, transmission decreased from 5117.64 GWh to 4688.98 GWh and total transmission losses showed 33.05%.

Table 3.19 Transmission and Distribution Losses from 1988-1989 to 2017-2018

Fiscal Year	Generation Yearly Total GWh	Transmission Line Loss GWh	Transmission Line Loss differences for closed years %	Generation vs. Transmission Line Loss %
1988-1989	2,226.54	765.09	-	34.36 %
1989-1990	2,494.44	871.00	12.16 %	34.92 %
1990-1991	2,643.05	934.28	6.77 %	35.35 %
1991-1992	2,675.92	953.95	2.06 %	35.65 %
1992-1993	3,006.60	1,125.23	15.22 %	37.42 %
1993-1994	3,386.79	1,271.40	11.50 %	37.54 %
1994-1995	3,631.84	1,354.57	6.14 %	37.30 %
1995-1996	3,762.33	1,437.21	5.75 %	38.20 %
1996-1997	4,130.31	1,598.43	10.09 %	38.70 %
1997-1998	4,550.46	1,735.52	7.90 %	38.14 %
1998-1999	4,139.44	1,283.13	-35.25 %	31.00 %
1999-2000	4,639.11	1,627.86	21.18 %	35.09 %
2000-2001	5,117.64	1,747.84	6.86 %	34.15 %
2001-2002	4,688.98	1,549.57	-12.80 %	33.05 %
2002-2003	5,067.95	1,491.60	-3.89 %	29.43 %
2003-2004	5,425.88	1,498.88	0.49 %	27.62 %
2004-2005	5,608.24	1,618.68	7.40 %	28.86 %
2005-2006	6,064.16	1,630.29	0.71 %	26.88 %
2006-2007	6,164.15	1,727.16	5.61 %	28.02 %
2007-2008	6,398.02	1,821.73	5.19 %	28.47 %
2008-2009	6,621.76	1,767.14	-3.09 %	26.69 %
2009-2010	6,964.27	1,855.93	4.78 %	26.65 %
2010-2011	7,543.06	2,165.05	14.28 %	28.70 %
2011-2012	10,450.19	2,776.62	22.03 %	26.57 %
2012-2013	10,964.90	2,514.60	-10.42 %	22.93 %
2013-2014	12,247.12	2,452.03	-2.55 %	20.02%
2014-2015	14,156.30	2,749.54	10.82 %	19.42 %
2015-2016	15,964.75	2,413.94	-13.90 %	15.12 %
2016-2017	17,866.99	2,384.90	-1.22 %	13.35 %
2017-2018	20055.32	2,803.41	14.93 %	12.71 %

Source: MOEE and Myanmar Statistical Year Book 2018

Transmission line losses were gradually decreased from 22.93% in 2012-2013 to 12.71% in 2017-2018. MOEE measured on line losses by USD 60 million loans from Asia Development Bank during that period. Replacing old cable and transformers to new project was completed for entire ADB loans in 2016. That why the year 2015 to 2018 data were shown transmission and distribution losses decrease to 12.71%.

The following table 3.20 is average cost for 1 unit power generation in December, 2019. Power generation mix is important for the price control. There are 5 different generations and their respective generation prices. Average generation price was 80.98 in December, 2019.

Table 3.20 Average Cost for 1 Unit Power Generation (December, 2018)

Type of Generations	**Per Unit Costs Kyats**
Government Hydropower Generation	9.20
IPP Owned Hydropower Generation	71.24
JV Owned Hydropower Generation	45.49
Government Owned Gas-fired Power Generation	147.24
IPP Owned Gas-fired Power Generation	131.69
Total	404.68
Average Cost for 1 Unit Power Generation	**80.98**

Source: MOEE

MOEE calculated the average estimated cost for generation, transmission and distribution was Kyats 101.19/unit. MOEE collected rate was Kyats 69.30/unit. MOEE subsidized Kyats 552.936 billion in fiscal year 2017-2018 (under old tariff). Government owned gas-fired power generation cost is higher than IPP owned gas-fired power generation costs. Most of the government owned plants were installed more than 20 years. Gas consumptions were not compared with IPP new plants and MOEE owned plants.

CHAPTER IV
ANALYSIS ON SURVEY RESULTS

4.1 Profile of the Ministry of Electricity and Energy

Ministry of Electricity and Energy mainly manages and operates on energy sector development for The Republic of the Union of Myanmar. There are one union minister, two deputy ministers, four departments, five enterprises and two corporations. MOEE plans and manages on electricity generation, transmission, distribution for electric power sector and upstream, midstream and downstream for energy sector. MOEE cooperates with regional organizations Ayeyarwady-Chao Phraya-Mekong Economic Cooperation Strategy (ACMECS), the Association of South East Asian Nations (ASEAN), Bay of Bangal Initiative for Multi Sectorial Technical and Economic Cooperation (BIMSTEC) and Greater Mekong Sub-region (GMS) to promote its policies and frameworks for balanced development in the region.

Electric Power Generation Enterprise (EPGE) is fully authorized on power purchasing agreements on respective JV/BOT/PPP with foreign and local investors (independent power producers).

4.2 Survey Design

In this thesis, the method of study is descriptive and based on secondary data which collected from ministry and its departments from MOEE, joint study reports, related articles, documents, international organizations, conferences, seminars, websites, Wikipedia, etc.

Key Informant Interviews with 25 persons from electricity and energy sectors.

4.2.1 Sampling Design

For this thesis, in-depth interview, meetings and telephoning interviews with total (25) officials of electric and energy industries were conducted. All these people

have experienced in electricity and Oil & Gas sectoral management, planning and operations.

Table 4.1 Informant Interview List

Participants	Number
Senior Management	4
Advisor	5
Director	6
Chief Engineer	2
General Manager	2
Project Director	2
Assistant Director	2
Manager	2
Total	**25**

Vital information, key informant interview and discussion surveys with (4) senior managements, (5) advisors, (6) directors, (2) chief engineers,(2) general managers, (2) project directors, (2) assistance directors, (2) manager altogether (25).

4.2.2 Questionnaire Design

The research used qualitative data analysis and data was collected through a structured questionnaire as a main tool for the study. The survey questionnaire contained six parts with (22) questions related to hydropower and gas-fired power generations. Part I contained Question No. 1 to No. 5 which covered power generation, transmission, distribution and related transmission, and distribution losses controls. Part II consisted of Question No. 6 to No. 9 which was related to corporate social responsibilities, dam failures and impacts of environmental and social. Part III included Question No. 10, a lesson learned. Part IV contained Question No. 11 and No. 12 which was related to power purchasing rates and comparison of affordable or not for the Myanmar people. Part V consisted of Question No. 13 to No. 16 which was related to export opportunities, required investment volume, development process and suffering transmission and distribution losses. Part VI was composed of Question No. 17 to No. 22 which covered existing power fulfillment, future Myanmar, major

difficulties, major challenges, sustainable development strategy and challenges for MOEE.

The questions in the Questionnaire are as follows:

1. What are the basic operations in electric power?
2. What is electric power generation mix?
3. What objectives are major priorities for power generation?
4. How to resolve technical transmission and distribution losses?
5. How to resolve non-technical transmission and distribution losses?
6. How to support corporate social responsibility activities to relocated villagers?
7. What are the main causes of dam failures?
8. What are the environmental and social impacts in hydropower generation areas?
9. What are the environmental and social impacts in gas-fired power generation areas?
10. Are there any losses on postponement of the Myitsone hydropower projects and suspension of coal-fired power projects?
11. How about the price in PPA of hydropower generation?
12. How about the price in PPA of gas-fired power generation?
13. Has Myanmar an opportunities for electric power export?
14. How much investment required for power development up to 2030?
15. How to get required finance for power projects?
16. How do transmission and distribution losses affect economy?
17. Are existing power generations meeting the country's needs?
18. How to fulfill electric power requirement in future Myanmar?
19. What are the major difficulties for power sector in Myanmar?
20. What are the major challenges for GoM in IPP involvement projects?
21. What are the priorities on sustainable development strategy?
22. What are the challenges for MOEE?

4.3 Identify Challenges and Difficulties from KII

1. **What are the basic operations in electric power?**

Regarding this question, six informants gave suggestions. There are three basic operations, such as generation, transmission and distribution of electric power. Operational balances of above basic operations are very important and its operations base on budget, time frame, technology, management, etc.

2. **What is electric power generation mix?**

Regarding this question, eight informants gave suggestions. The power planners mainly consider the factors such as sustainability, renewability, energy security, and commercial viability with how to fulfill yearly demand and how to increase generations. The generation mix is a group of different generation sources based on primary and secondary resources. Electricity generation mix is sensitive to policies, plans and electricity price. Single source generation is not secure for the country. All the nations plan the generation mix mostly based on their owned resources such nuclear power, hydropower, gas-fired power, LNG to power, diesel power, coal power and renewable power. Currently, nuclear power is impossible for Myanmar. Myanmar chose prime generation with hydropower for long term, secondary in gas-fired power, and small ratio with other generations such coal, diesel and solar. The economic and social benefits will be wasted if the water flows into the ocean without generating hydropower. Example: Yeywa hydropower plant consumed 104.82 feet of water and generated approximately 1,035 GWh during 6 months from 1st of January to 30th of June, 2019. Equivalent income was Kyats 87 billions.

3. **What objectives are major priorities for power generation?**

Regarding this question, six informants gave suggestions: There are two major elements such as resource guarantee for power generation and generation price. All the interview results are the same as Myanmar generated less than 7% on proven exploitable potentials of hydropower resources and 3% on potential hydropower resources. Hydropower generation and its resources are grant and first priority for generation they recommended. Hydropower is the cheapest electric price in renewable energy resources. Myanmar can be generated more than 46,000 MW in 10 years if financial supports are available.

4. **How to resolve technical transmission and distribution losses?**

Regarding this question, seven informants gave suggestions. Current national grid transmission loss, which is under 4%, is acceptable. There is 12% to 18% transmission loss in urban areas. It is necessary to upgrade loads for national grid and substations. It is necessary to construct new grids of 500 KV lines and substations. It is necessary to replace the new distribution insulated cables and gas insulated substations with old distribution lines and transformers in urban areas.

5. **How to resolve non-technical transmission and distribution losses?**

Regarding this question, nine informants gave suggestions. Non-technical power losses are only base on human factor both government staff and private users. The governmental staffs fail to inspect on their respective townships. They know well which household or business is untrustworthy. They received some profits from those power theft users. Strongly suggest, carrying out township-by-township inspection thoroughly and systematically, and take appropriate legal action and penalty on the power theft and against the government staffs if involved. Some households and industries are not willing to pay their actual costs. The management is mainly responsible for the power theft control.

To be summarized of Part I for power generation, transmission and distribution, operational balances are important in electric power sector. Myanmar generation mix is a group of different generation sources and it plans considering on the factors of sustainability, renewability, energy security and commercial viability, demand forecasts and generations. It is a sensitive issue, to policies, plans and prices. Hydropower ratio is a prime and mix generations with gas-fired power, coal power, diesel power and solar power in Myanmar. Hydropower is an appropriate resource which guarantee for power generation and its price is affordable for the country's people. Myanmar has more than 46,000 MW proved hydropower potentials. The transmission and distribution line losses are still high the government authorities said. Technical losses are accepted. MOEE operated line losses reduction measures which received USD 60 million loans from ADB. Project areas mainly concentrated in Yangon, Mandalay, Sagaing, Magwe and completed in 2016. Non technical losses are mainly based on power theft and failure to inspect and action against such activities.

6. **How to support corporate social responsibility activities to the relocated villagers?**

Regarding this question, twenty informants gave suggestions. CSR refers to the voluntary on mainly social actions with environmental and economic undertaken by who develops hydropower generation or gas-fired power generation around there. In Myanmar, the developers mostly build roads, schools, medical care or hospital, playing ground, etc. for their CSR activities. Some developers also consider the local people's daily life and support their home businesses. CSR development is very important for the local people. The government has responsibility to find out the way how to get more CSR fund. Some suggest putting fixed percentage on the profit of the entire projects by both sides for CSR fund.

7. **What are the main causes of dam failures?**

Regarding this question, nine informants gave suggestions. There are major causes of dam failures, such as material and techniques, error of spill way design, slow spill way flows, poor survey data affects on geological instability, landslides into reservoir, poor maintenance, extreme inflow, human error on control or computer or design, internal erosion in earthen dam and earthquakes. Spill way was broken at Swar Creek Dam in Myanmar in 2018. 85 villages were submerged, more than 60,000 people rescued and one dead. In Myanmar, MOEE and MOALI operate dam reservoirs for electric power generation and irrigation. There are two types of hydropower generation such reservoir type hydropower generation and run-off-river (ROR) type hydropower generation. ROR has less impact if dam failure occurs because reservoir is not necessary. Government must need to find out the ways how to reduce impact of each project and their rescue plan.

8. **What are the environmental and social impacts in hydropower generation areas?**

Regarding this question, ten informants gave suggestions. Destruction of the nature and ecosystem at the dam reservoir area is the main reason. Reservoir stores water and provide renewable power and prevent for floods but flood can destroy or displace different organisms for plants and wildlife. Reservoir area replaces the forest and farmland areas at reservoir site. Forests directly support the conversion of CO_2 to

O_2 and farmland produces food for the people. Currently, the government establishes new villages, new farmlands to relocate people and pay compensation for their loss of properties, transports, etc. Sedimentation is one of the problems for rivers when building dams. Myanmar needs to formulate effective plan. EIA and SIA assessment evaluations are important. MONREC needs to emphasize more on issuing EIA and SIA approval to investors.

9. **What are the environmental and social impacts in gas-fired power generation areas?**

Regarding this question, four informants gave suggestions: Gas-fired power plants release carbon dioxide and green house gases. Air pollution caused by them is less than coal and oil. Excessive noise when operating but the noise barriers reduce the noises. Today, technologies are improving and improved designs resolve the noise issue.

To be summarized of Part II for corporate social responsibilities, dam failures and impacts of environmental and social, CSR practices are developing in Myanmar but not covering the local people's requirements. CSR supports are one of the ways out for the local peoples. The government and developers need to co-study the local peoples' needs and find out the way how to get fund for CSR activities. Corporate social responsibility activities are not only providing social needs for relocated people but also for their motivation. Run-Off-River hydropower generation has less impact if dam failure occurs. There are man-made causes and natural causes. Could not predict in advance on the natural causes but prevent man-made causes for dam failures. Establish the active management team and inspect when project planning and continuously monitor the operations phase by phase. Waste management and noise absorbing systems are essential at gas-fired power generation areas.

10. **Are there any losses on postponement of the Myitsone hydropower projects and suspension of coal-fired power projects?**

Regarding this question, eight informants gave suggestions. The Government of Myanmar suspended the Myitsone hydropower dam schemes by the reason of social conflicts in November, 2011. Also suspension as the same reason on the clean coal technology base coal-fired power generation schemes. Postponed projects took

many years for studies and multi millions of dollar expenses both government and investors in each project. Those projects highlighted on the major weaknesses of overall plans by both parties. Dam series are very dangerous for the country if dam failure occurs. It causes immense damage and loss of life when dam failure occurs. There are over 8,000 hydropower dams which generates 1 MW and above in the world. 200 dam failures between 10 years.

One of the informants pointed out the environment against profits about Yeywa hydropower generation and its profits. More than 7,445,000 hectares of forest were lost in Myanmar between 1990 and 2010. Trees absorb the carbon dioxide and release oxygen, and water into the atmosphere for contributing the global warming. The biggest hydropower generation project Yeywa Dam took the surface area of 14,580 acres (5,832 hectares) and produces 790 MW of electricity. The advantages are much more than deforested and that area of deforestation is 0.078% of deforested areas by cutting trees in Myanmar. Yeywa hydropower project construction took 7 years from 2004 to 2011. Between 1-1-2019 and 30-6-2019, Yeywa generated approximately 1,035,726,730 kWh during the 6 months that equivalent income Kyats 87 billion.

To be summarized of Part III for lesson learnt, Myitsone dam project and coal-fired power project both suspended by social conflicts. Myanmar lost not only economically but also trusts from the foreign investors. Myanmar government and peoples decide on one which development profits or unseen impacts.

11. How about the price in PPA of hydropower generations?

Regarding this question, five informants gave suggestions. Power purchasing prices are between USD 0.04/kWh to USD 0.06/kWh in power purchasing agreements. It depends on the receiving locations. The Government receive 10% free electricity of generation capacity in every contract.

12. How about the price in PPA of gas-fired power generation?

Regarding this question, six informants gave suggestions. Power purchasing price are around USD 0.12/kWh in power purchasing agreements. LNG to power will be more than USD 0.12/kWh. In solar power, power purchasing price is USD 0.1275 kWh. Solar power price and gas-fired power price are likely the same.

To be summarized of Part IV for power purchasing price, hydropower generation price is between USD 0.04/kWh and USD 0.06 /kWh. But, Gas-fired power price is around USD 0.12/kWh that higher than today power distribution price Kyats 125/kWh. It will hurt Myanmar people in the long run.

13. Have Myanmar an opportunities for electric power export?

Regarding this question, seven informants gave suggestions. Myanmar has a two way chance that electricity trading with neighboring countries and ASEAN countries. Power demand is very high in neighboring countries such China, India, Thailand and Bangladesh. Myanmar is exporting gas to Thailand and China for their gas-fired power plants and industrial purposes. Also, ASEAN has a plan for Inter ASEAN Power Grid. Myanmar is exporting electricity to China and Thailand. The electric power export business can contribute to Myanmar's economic development.

14. How much investment requires for power development up to 2030?

Regarding this question, nine informants gave suggestions. MOEE and its department implementing based on national electricity master plan's objectives such as 100% electrification as demand forecasts 14,542 MW at fiscal year 2030-31. USD 35 billion to USD 40 billion required for power generation, transmission and distribution by NEMP. International organizations were forecast on investment for Myanmar that at least USD 2.0 billion per year investment required for power sector development.

15. How to get require finance for power projects?

Regarding this question, eight informants gave suggestions. Myanmar is poor as its status of least developed country. Government has no capability for mega investment by itself, but electricity demand increases every year. GoM has invited foreign investors and local entrepreneurs to invest especially in infrastructure development including power sector. It will develop the transmission network through public finance, considering economies of scale and the capacity to enable open access to generating sources. Also, the government has started corporatizing the large distribution utilities to encourage their financial autonomy. The Myanmar Investment Law has attractions that are acceptable to investors. But, it is necessary to balance and update the aligned laws, rules, regulations and frameworks time by time.

16. How do transmission and distribution losses affect economy?

Regarding this question, nine informants gave suggestions. Transmission and distribution losses were extremely high in the country around 30 years. Technical loss can be resolved if the ministry has enough budget for changing the cable and replace transformers. Non-technical losses mainly based on power theft. There are some staffs, households and business involved in power theft. MOEE must be able to prevent power theft.

To be summarized of Part Vfor export opportunities, required investment volume, development process and suffering transmission and distribution losses**,** Myanmar has great opportunities on export electricity because electricity demands are very high in neighboring countries such as Thailand, China, Bangladesh and India. USD 2.0 billion/year investments required for all round electric power sector development up to the fiscal year 2030-2031. It will develop the transmission network through public finance, considering economies of scale and the capacity to enable open access to generating sources. Also, the government has started corporatizing the large distribution utilities to encourage their financial autonomy. The Myanmar Investment Law has attractions that are acceptable to investors. But, it is necessary to balance and update the aligned laws, rules, regulations and frameworks time by time. Technical losses can be resolved but non-technical losses stem from lack of discipline and business ethic. Management failed to complete measures on power theft.

Example: Commercial lost for FY 2017-2018 from transmission and distribution losses. All calculations base on old tariff.

Average unit price collected by MOEE Kyats 69.30/Unit

Total Line Losses GWh (12.71%)

Acceptable line loss percentage 8 %

Line loss in 2017-2018 12.71 %

Unacceptable line loss percentage = current line loss – acceptable line loss

= 12.71 – 8.00

= 4.71 %

$$\text{Total Unacceptable Line Loss (GWh)} = \frac{\text{Total Line Loss} \times \text{Unacceptable Line loss \%}}{\text{Total Line Loss \%}}$$

$$= \frac{2{,}803.41 \text{ GWh} \times 4.71\%}{12.71\%}$$

= 1038.871,841 GWh

1GWh is equivalent with 1,000,000 kWh

1kWh is equivalent with 1Unit

Un-acceptable Power Losses = 1038.871,841 x 1,000,000

= 1,038,871,841 kWh

(A) Actual generation cost for 1 unit was 101.19 Kyats

(B) MOEE collected average for 1 unit was 69.30 Kyats

MOEE suffered amount base on (A) and (B) are as follows:

Transmission Losses Amount for (A)= Unacceptable Power Losses x Average Generation Cost

= 1,038,871,841 Unit x 101.19 Kyats

= 105,123,441,590 Kyats (105.12 Billion)

Transmission Losses Amount for (B)= Unacceptable Power Losses x Average Tariff

= 1,038,871,841 Unit x 69.30 Kyats

= 71,993,818,581 Kyats (71.99 Billion)

In the fiscal year 2017-2018, MOEE lost between Kyats 71.99 billion (equivalent to USD 48 million) and Kyats 105.12 billion (equivalent to USD 70.08 million) on the transmission and distribution sub sector.

17. Are existing power generations meeting the country's needs?

Regarding this question, six informants gave suggestions. Not enough for the whole especially in dry seasons from February to before monsoon around early June every year. Existing installed capacity of generation mix are 5,798 MW. Daily generated capacity is less than 4,000 MW in 2019. Demand focus for 2019 is 4,268 MW. Increase solar power generation up to 10% ratio will be fulfilling the current power needs in shortly. Solar power generations are easy to install in short period and produce required capacity.

18. How to fulfill electric power requirement in future Myanmar?

Regarding this question, six informants gave suggestions. MOEE needs to widely cooperate and coordinate with WB, ADB, JICA, IPPs, local investors, legal firms and financiers. Review the policy frameworks for investment attraction. Long-term plan for more hydropower generation plants in Thanlwin river by run-off-river type which reduces the disaster if happens. Need to ensure public awareness of power resource. Increase investment in solar generation is a second priority for power sector suggested by retired personnel and independent power producers. There is new technology for solar in China and India now. The solar power price and gas-fired power price are narrowing now.

19. What are the major difficulties for power sector in Myanmar?

Regarding this question, eight informants gave suggestions. Low efficiency of old hydropower turbines and gas-fired turbines consume more gas but output is low. There is a lack of institutional capacity building development and advance technology training in MOEE. The budget is limited. The hydropower projects are facing environmental impact issues, project construction; timelines, unpredictable weather conditions and insufficient financial support.

20. What are the major challenges for GoM in IPP involvement projects?

Regarding this question, eight informants gave suggestions. The GoM is fully responsible for environmental and social issues. IPP must be followed according to the JV/BOT/PPP contract and existing laws, rules, regulations and restrictions. Reviews on existing legislation and frameworks are workable or not for both parties. Update aligned frameworks quickly if ineffective. Payment guarantee is another

important issue. Power Purchasing Agreement is a key and emphasizes on 2 way payments and penalties. Need to negotiate intergovernmental issues regarding tariff, tax exemption and asset controlled standards. GoM need to widely disseminate information to promote public awareness on power resources and their profits.

21. What are the priorities on sustainable development strategy?

Regarding this question, three informants gave suggestions. The government has recognized the need to give priority to rural and underserved areas to promote economic opportunities for all as well as peace and stability in response. The Myanmar Sustainable Development Strategy prioritizes on reliable and affordable electricity to support economic development, poverty reduction and reducing inequalities with universal electricity access by 2030. Need to renovate on lack of generating capacity and an insufficient and obsolete transmission and distribution infrastructure.

22. What are the challenges for MOEE?

Regarding this question, four informants gave suggestions. Adopt the right policies, institutions, strategies, planning and regulations on available own resources and environment as electric power development sector is important. In the electric power sector, legal frameworks for some resources are incomplete yet. The Electricity Regulatory Authority (ERA) is not established yet. Tariff regulation has not been established. MOEE has been preparing a draft for renewable energy law with the help of legal experts. The Government subsidies still high up to the fiscal year 2018-2019. The transmission and distribution line losses are still high. Not enough base loads in power system.

To be summarized of Part VI for existing power fulfillment, future Myanmar, major difficulties, major challenges, sustainable development strategy and challenges for MOEE**,** need to organize foreign investors in power generation sector. Need to open opportunities to investors for power transmission line investment to foreign and local investors. MOEE still lack of generating capacity and an insufficient and obsolete transmission and distribution infrastructure. Review again and again on exiting each generations and necessary actions on replace or renovate the generation system, power stations, sub stations, transformers, transmission and distribution and cables. Government owned gas-fired power plants are very old and less maintenance.

Efficient rate also low and natural gas consumption is high. Need to thoroughly overview on national electricity master plan, policy, regulation frameworks and aligned updates with current situation not only Myanmar but also World. The GoM needs to consider and essential measures on environmental and social issues. Need to closely negotiations on intergovernmental issues. Need to follow the PPA agreement strictly. The Myanmar Sustainable Development Strategy prioritizes on reliable and affordable electricity to support economic development, poverty reduction and reducing inequalities with universal electricity access by 2030.Need to increase more power generations and plan for generation mix with affordable price. Need to renovate on lack of generating capacity and an insufficient and obsolete transmission and distribution infrastructure. The Government of Myanmar and the people need to decide on what is important for the nation and the people.

CHAPTER V
CONCLUSION

5.1 Findings

Power generation, transmission and distribution are major operations in electric power sector and their balancing are important. MOEE need plans on efficient energy and energy conservation. Hydropower generation is a prime and gas-fired power generation is a major secondary generation and those 2 sources contribute in generation mix as 95% in Myanmar. Remaining 5% are generated by coal-fired power, diesel power and solar power. Generation mix is sensitive to politics, plans and electricity price. Need to maintain the stability of power prices and ensure fair power price for the country's people. Sometimes, Environmental impacts and social impacts are populated especially in hydropower generations. GoM is planning on minimizing the causes of environmental impacts and promote the CSR activities at hydropower generation and surrounding areas. Corporate social responsibility activities are important for the native people. Two major elements required such as resource guarantee for power generation and generation price. Myanmar generated less than 7% on proven exploitable potentials. Hydropower is the cheapest electric price in renewable energy resources. Myanmar can be generated more than 46,000 MW in 10 years if financial supports are available. There are still 12% to 18% transmission and transmission loss in urban areas. Technical loss was resolved in Yangon, Mandalay, Sagaing and Magwe areas by USD 60 millions of ADB loans in year 2016. Non- technical loss is still higher between 12% and 18%. Strongly suggest, carrying out township-by-township inspection thoroughly and systematically, and take appropriate legal action and penalty on the power theft and against the government staffs if involved.

Government needs to find out the way how to reduce impact of each project and their respective rescue plan. There are manmade causes and natural causes in dam failures. Can't prevent the natural causes but can prevent on manmade causes for dam failures. GoM establishes new villages and new farmlands to relocated people and pay

compensation for their loss of properties and infrastructures in hydropower project area. MONREC need to more emphasize on issuing EIA and SIA approval to investors. Today, technologies are improving in gas-fired power generation and improved designs resolve the noise issue.

Myitsone dam project postponement and coal-fired power projects suspension is base on social conflicts. Myanmar lost not only economically but also trusts from the foreign investors. Myanmar has a two way chance that electricity trading with neighbouring countries and ASEAN countries. The electricity export business can contribute to Myanmar's economic development in future. That is why foreign direct investment is important for power generation. Myanmar requires USD 2 billion every year to meet the electricity consumption. The Myanmar Investment Law has attractions and flexible which acceptable to investors. But, it is necessary to balance and update the aligned laws, rules, regulations and frameworks time by time. Technical loss in transmission and distribution is mostly controlled. But non-technical loss is still high. The management is mainly responsible for the power theft control. Local power tariff is Kyats 125/kWh. Hydropower purchasing price is lower and gas-fired power is much higher from local electricity price.

Today, power generation mix installed capacity is 5,798 MW and daily generates around 3,800 MW. 50 % of households are getting electricity from the national grid in December, 2019. That is not completely fulfilment for country consumption. Need to install more power generation and try to reduce transmission and distribution line losses. MOEE needs to widely cooperate and coordinate with WB, ADB, JICA, IPPs, local investors, legal firms and financiers. Review the policy frameworks for investment attraction. GoM is fully responsible for environmental and social issues and carefully manage on IPP's operation. MSDP prioritizes on reliable and affordable electricity to support economic development, poverty reduction and reducing inequalities with universal electricity access by 2030. Need to renovate on old generating plants and an insufficient and obsolete transmission and distribution infrastructures. GoM need to widely disseminate information to promote public awareness on power resources and their profits. The Government of Myanmar and the people need to decide on what is important for the nation and the people.

5.2 Suggestions

The experience and development thinking are prerequisites everywhere. In the electricity generation sector, the management must need to conduct detailed study on resources availability, setting the desired goals and establishing a suitable plan in very early stage. It is necessary to establish a systematic, centralized and holistic planning approach consideration on all aspects that as much as factors and data as possible. In the power generation sector, it is necessary to approaches such availability of approved resources, supporting infrastructure, public concerns, advantages and disadvantages, environmental and social impacts, aligned parties, technical possibilities and developments, quality aspects, ratio of power generation mix and budget. Most of the people are confused on energy mix and power generation mix. There are advantages and disadvantages in not only power generation sector but also everywhere. Hydropower generates more profits but has more impacts on social and environmental issues than gas-fired power generation. Hydropower is based on renewable resource. Gas-fired power bases on natural gas that is non-renewable source. The Government management bodies, technical experts and developers must be detailed study and considerations on impacts such Environmental Impacts Assessment (EIA), Social Impacts Assessment (SIA), Health, Safety and Environment (HSE) plan and Corporate Social Responsibility (CSR) activities before starting projects. MOEE has to approved to hire third party assistance on above studies if requires. Government and developers need to contribute certain ratio of project profits to states and divisions CSR fund.

Electric power generation mix has direct effects on policies, plans and prices of the country. The government's willingness is the most important on infrastructure development. It is necessary to decide on power generations which are most suitable for the country's development and how affordable and secured for the people. It is necessary to establish realistic generation mix to get the smart power system. Need to follow the standards and specifications which are conformity with ASEAN and international practices. Need to rehabilitate the aged plants and installed the new plants. Need to replace the ineffective transmission lines and sub stations. Need to promote the solar power, wind power, hydropower and biomass power in fulfilling at off-grid areas. The European Union countries are contributing 30 percent renewable power in their generation mix and Myanmar is using 2% in our generation mix. MEMP and NEMP have a plan to increase up to 9% of renewable generation at 2030-

2031. EU countries will promote their renewable generation up to 50% in the year 2030. Myanmar must also step up solar power generation instead of gas-fired power generation in order to save non-renewable fossil fuels. MOEE needs to study how to overcome the large renewable energy connect to grid at developed countries. Political instability is one of the major challenges for country's development. No investor wants to invest in unstable countries. That is why most of the long term business strategies failed. Expensive power is a key barrier to economic development in emerging economies. Need to guarantee the economic benefits for both users and producers.

More activation on existing MEMP and immediately update the suitable plan, policy, strategy, frameworks if needed. It is time to prepare a comprehensive Energy Plan for Myanmar, where all Parties and Ministries are aligned in (centralized planning) and where all major problems are reviewed and considered.

It is necessary to choose generation mix and not only plan for domestic sufficiency but also for export. Run-Off-River type hydropower generation is less impacts than reservoir dams. Preferable Run-Off-River type hydropower generation is a prime source of generation and secondary mix with solar power, gas-fired power, coal power and diesel power generations are the most suitable priorities for the generation mix. The Government should immediately look into transmission and distribution losses which have impact on the country's development. It is necessary to stop the expending of gas-fired power generation and replace with renewable generations. Opportunities to invest in renewable energy resources are plentiful in Myanmar. Need to participate in regional electric power trading by expanding the power grid to neighboring countries.

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APPENDIX-1

QUESTIONNAIRES FOR KEY INFORMANT INTERVIEWS (KII)

1. What are the basic operations in electric power?
2. What is electric power generation mix?
3. What objectives are major priorities for power generation?
4. How to resolve technical transmission and distribution losses?
5. How to resolve non-technical transmission and distribution losses?
6. How to support corporate social responsibility activities to relocated villagers?
7. What are the main causes of dam failures?
8. What are the environmental and social impacts in hydropower generation areas?
9. What are the environmental and social impacts in gas-fired power generation areas?
10. Are there any losses on postponement of the Myitsone hydropower projects and suspension of coal-fired power projects?
11. How about the price in PPA of hydropower generation?
12. How about the price in PPA of gas-fired power generation?
13. Has Myanmar an opportunities for electric power export?
14. How much investment required for power development up to 2030?
15. How to get required finance for power projects?
16. How do transmission and distribution losses affect economy?
17. Are existing power generations meeting the country's needs?
18. How to fulfill electric power requirement in future Myanmar?
19. What are the major difficulties for power sector in Myanmar?
20. What are the major challenges for GoM in IPP involvement projects?
21. What are the priorities on sustainable development strategy?
22. What are the challenges for MOEE?

APPENDIX-2

National Energy Policy, Strategies and Frameworks of Myanmar

Main duties and functions of NEMC are as follows:

- To formulate the National Energy Policy based on energy demand and production and fulfillment of energy requirement on energy matters of the State.
- To formulate energy regulations for ensuring implementation of energy development of the State in accordance with the National Energy Policy.
- For development of electrical sector, to fulfill the current requirements by laid down short term plans.
- To lay down long term plans based on sustainable development of industrial sector of the State and GDP (Gross Domestic Product) to be able to meet the increased demand for electricity.
- To generate electricity with the use of coal as in many other countries as there has been greater demand for electricity and to use CCT (Clean Coal Technology) aimed at placing emphasis on environmental conservation.
- To strive for generating electricity depending on regions and topographical situation with the use of solar power, hydropower, wind power, geothermal, biomass and bio-fuel to be able to meet the public demand for electricity.
- To take systematic measures in laying down development plans to be able to cover three sectors as energy, industrial and electrical sectors are mutually dependent.
- To prioritize and supervise oil, natural gas and natural resources to be able to meet domestic demands, etc.

Main duties and functions of EDC are as follows:

- To participate in laying down the energy development policy and plans of NEMC.
- To lay down objectives and adopt rules and regulations for short term and long term implementation in accordance with the energy development policy laid down by NEMC.

- To carry out yearly review over the weak and strong points when implementing objectives in accordance with short term and long term rules and regulations, and to amend the rules and regulations if necessary.
- To lay down objectives and strategies after making assessment to opportunities and limitations regarding the tasks for energy development.
- To adopt pricing policy and form pricing committee for purchase and sale of energy product.
- To lay down plans to attract foreign and domestic investments in renewable energy projects such as solar energy, wind power geothermal energy, biomass and bio-fuel projects, etc.

National Energy Policy of Myanmar

1. In extraction and utilization of natural resources in order to fulfill the nation's energy needs, the following measures will be taken;

- To minimize the environmental impacts
- To include a utilization plan for future generations
- To invite the local and foreign investments
- To continuously carry out Corporate Social Responsibility (CSR) activities.

2. To adopt prioritized plans on Energy Efficiency and Energy Conservation
3. In defining the energy pricing according to the market oriented economy, the necessary laws and regulations for following measures shall be promulgated by observing the ASEAN and international energy pricing policy;

- To maintain the stability of energy prices
- To guarantee the economic benefits for both energy producers and energy users
- To ensure fair energy price for the people
- To set up an energy support fund

4. To follow energy standards and specifications which are appropriate for the situations of the nation and which are also in conformity with ASEAN and international practices.
5. To encourage more cooperation with private sector according to the State's economic policy for thriving of the State-owned Enterprises (SOEs) or privatization of the SOEs

6. To lay down the short term and long term plans for not only renewable energy and hydropower projects but also feasible utilization of Liquefied Natural Gas (LNG) in thermal power plants to generate more electricity supply in order to meet the increased demand which will accompany the growth of the nation's Gross Domestic Product (GDP).
7. To produce energy by applying clean coal technology and waste management system which are economic viability in power generation
8. To participate in regional energy trading (such as electric power, crude oil and natural gas) by expanding the power grid and pipeline network to neighboring countries including ASEAN nations..
9. To implement the following short term and long term plans in order to get power generation stability;
    - Conserving the water catchment areas of hydropower dams and the reservoirs
    - Rehabilitating the aged plants and constructing the new ones in the grid system
    - Replacing the ineffective transmission lines, constructing new lines, expanding the existing lines and building substations in the national grid system.
10. To prioritize the use of solar, wind, hydro, biomass and other renewable energy resources in fulfilling the electricity demand of off-grid areas.
11. To establish Energy Database System for the compilation of reliable and accurate statistic pertaining to existence of energy resources, energy production, supply, demand and energy projection and to implement plans after conducting and analyzing yearly electricity demand surveys for entire nation.
12. To formulate a plan on civilian use of nuclear energy for future energy security.

Institutional Frameworks for Myanmar Energy Sector

Ministry of Electricity and Energy, Ministry of Natural Resource and Environmental Conservation (MONREC), Ministry of Industry (MOI), Ministry of Education (MOE), Ministry of Agriculture, Livestock and Irrigation MOALI), Myanmar Engineering Society (MES) and Renewable Energy Association Myanmar (REAM) are cooperation and coordination on petroleum, gas, coal, renewable energies, civilian nuclear energy respectively.

National Electrification Plan (NEP) wrote by World Bank (WB) funded under the programme of Sustainable Energy for All (SE4ALL) by United Nations (UN). The World Bank supported National Electrification Project aims for help scale-up access to electricity and support the implementation of the Government's National Energy Policy which aims for universal access to electricity by 2030. World Bank approved USD 400 million interest-free loans to MOEE (USD 310 million) and MOALI (USD 90 million) and the International Development Association (IDA), to provide technical assistance for NEP. The WB project was expected to electrification over 6.2 million people (1.2 million households and more). According to the NEMP, the WB plans to invest up to USD 1 billion in 3 sectors such electricity generation, transmission and distribution.

Need to implements under NEP are

- Extend the national grid and supply to 50 kilometers from national grid areas.
- Target 99% of households to be getting electricity from national grid in 2030.
- Required USD 5.8 billion investment for supply electricity to remaining 7.2 million of households, distribution costs calculated base on USD 800 per household.
- Required USD 760 millions for first five years plan. GoM received first time loan USD 400 from World Bank. Targeted USD 310 millions for transmission extension to 5,080 villages by MOEE and USD 90 for outer transmission works such lighting by MOALI.

Economic Policy of the Union of Myanmar was launched in July of 2016 that overall framework that guides Myanmar's economic and social development. The economic policy of the Union of Myanmar is people-centred and aims to achieve inclusive and continuous development. It aims to establish an economic framework

that supports national reconciliation, based on the just balancing of sustainable natural resource mobilization and allocation across the States and Regions.

Major objectives of Economic Policy are as follows:

- To support national reconciliation and the emergence of a united democratic federal Union.
- To achieve balanced economic development across the States and Regions.
- To create opportunities for the emergence of capable and skilled new generations for the benefit of the country.
- To establish an economic system that can achieve and maintain positive development outcomes through the participation, innovation and efforts of all citizens.

Myanmar is a largest country in mainland Southeast Asia region with a 53 million of population. The Myanmar Sustainable Development Plan (MSDP) provides a long-term vision; a vision of a peaceful, prosperous and democratic country. Founded upon the objective of giving coherence to the policies and institutions necessary to achieve genuine, inclusive and transformational economic growth, this MSDP has been developed to reinvigorate reform and promote bold action. The product of the work of multiple agencies and individuals in Myanmar, and the active consultation of a myriad of stakeholders, the MSDP has been designed as a living document that presents practical and implementable pathways toward addressing development challenges, while maximizing opportunities for the people of Myanmar to realize their full potential as individuals and citizens. The MSDP has taken maximum advantage of existing sector and thematic-level plans and policies, and those currently being drafted. In this regard, the MSDP is intended to provide a whole-of-government development framework that offers coherence to these existing strategic documents, ensuring that they are executed in ways that are consistent with macro-level national development priorities. Therefore, the MSDP is the integration and distillation of existing plans and priorities. Furthermore, the MSDP mediates between local developmental needs and global sustainable development agenda by aligning MSDP action plans with global SDG targets. Furthermore, and unlike previous strategies, the MSDP is designed to achieve its aims through coordinated effort involving public entities, the non-profit sector, as well as the private sector. The

tireless and passionate work of our nation's vibrant civil society, community-based and other grass roots organizations and networks, will be crucial to ensuring successful implementation. Some actions born from the MSDP will be achieved in months, others over many years. Likewise, as certain Action Plans are completed, others will emerge and take precedence. This will be reflected in subsequent MSDP revisions.

The MSDP is structured around 3 Pillars, 5 Goals, 28 Strategies and 251 Action Plans. All are firmly aligned with the SDGs, the 12 Point Economic Policy of the Union of Myanmar, and various regional commitments which Myanmar has made as part of the Greater Mekong Sub-region (GMS) Strategic Framework, the ASEAN Economic Community (AEC) and many others.

Strategy 5.4 highlighted on provide affordable and reliable energy to populations and industries via an appropriate energy generation mix.

The action plans for the strategies are

- Achieve an optimal level of renewable sources in the primary energy fuel supply mix.
- Scale-up use of renewable energy resources such as wind, solar, hydro, bio-energy and geothermal in partnership and with agreement of local populations.
- Develop and implement comprehensive national and sub-national energy development plans, prioritizing least-cost generation expansion, potential financing from sector revenues, while ensuring minimal adverse impact on our natural environment and local communities.
- Facilitate policy, legal, regulatory and broader good governance actions which will enable greater investment and private sector participation in energy generation and provision.
- Promote energy generation and distribution efficiency and conservation in industry, commercial, household, and public-sector use.
- Facilitate greater cross-border, regional and international collaboration in energy matters in partnership with State and Region governments.
- Formulate policies to inform appropriate electricity product pricing (including appropriate use of subsidies) which strike an appropriate balance between needs of producers and consumers.

- Ensure access to affordable, sustainable energy for rural populations and vulnerable groups.
- Create an enabling environment which promotes greater private sector participation in energy generation and supply including privatization of State-owned energy providers (Source: MSDP 2018-2030)

Energy Reforms base on

- Energy Policy with nine salient points
- National Energy Master Plan
- Modify Petroleum Act, Petroleum Rules
- Decree on Efficient Use of Energy
- Energy Standards & Specifications
- Electricity Law, Regulations and necessary guidelines
- National Electrification Plan
- National Electricity Master Plan
- Village Electrification Law

The MSDP delivers this strategy, providing an overall framework for coordination and cooperation across all ministries, and all States and Regions to forge a common path towards the emergence of a prosperous, peaceful and democratic Myanmar.