STUDY OF ELECTRICAL POWER GENERATION IN BANGLADESH

Thesis submitted in partial fulfillment of the requirements for the Degree of
Bachelor of Science in Electrical and Electronic Engineering

By
MD REFATUL HAQUE
ID: 152-33-2652
MUHAMMAD ARIFUZZAMAN
ID: 152-33-2678

Supervised by
DR. A K M ALAMGIR
Associate professor
Department of EEE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
FACULTY OF ENGINEERING
DAFFODIL INTERNATIONAL UNIVERSITY

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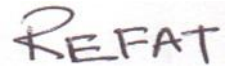
Certification

This is to certify that this thesis entitled "**Study of Electrical Power Generation in Bangladesh**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 15 November 2018

Signature of the candidates



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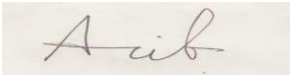
Name: Md Refatul Haque
ID: 152-33-2652



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Name: Muhammad Arifuzzaman
ID: 152-33-2678

_____

DR. A K M ALAMGIR
Associate professor
Department of Electrical and Electronic Engineering
Faculty of Science and Engineering
Daffodil International University.

The project and thesis entitled **" Study of Electrical Power Generation in Bangladesh,"** submitted by **Md Refatul Haque**, ID No: 152-33-2652, and **Muhammad Arifuzzaman,** ID No**:** 152-33-2678 Session: Summer 2015 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** on 25 November 2018

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Dedicated to

Our parents

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LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
BPDB	Bangladesh Power Development Board
APSCL	Ashuganj Power Station Company Ltd
EGCB	Electricity Generation Company of Bangladesh
NWPGCL	North West Power Generation Company Ltd
RPCL	Rural Power Company Ltd
CPGCBL	Coal based Power Generation Company Bangladesh Ltd
IPPs	Independent Power Producers
REB	Rural Electrification Board
PSMP	Power System Master Plan
HSD	High Speed Diesel
HFO	Heavy Fuel Oil
AC	Alternating Current
DC	Direct Current
HVDC	High Voltage Direct Current
BDT	Bangladeshi Taka
MW	Mega Watt
KW	Kilo Watt
SS	Sub Station
RS	Receiving station
CS	Central Station
GHS	Greenhouse Gas
Kcal	Kilo calories
KG	Kilo Gram
KVA	kilo volt Ampere
PF	Power Factor
PBS	Palli bidyut samity
ST	Steam Turbine
GT	Gas Turbine
RE	Reciprocation Engine
KV	kilo Volt

MHD	Magneto Hydro Dynamic
CLC	Chemical Looping Combustion
CT	Current Transformer
PT	Potential Transformer
SF6	Sulphur hexafluoride

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ABSTRACT

Electric power has been undoubted the most powerful object for economic growth, industrial evolution and social development of any country. Electric power generation means the production of electric energy from different kind of fuels. In this process, different kind of generation mechanism is used for different kind of fuels and energy sources. The study helps to understand the plot of existing and potential generation of electric power in Bangladesh. The study describes the general feature and aspects of the electrical power systems, different power plants and the fuels used, generation particles, analysis of some modern power plant, how to select appropriate site for a power plant and so on. The thesis also describes the key part indicators in power generation of Bangladesh. The analytical result is obtained in terms of the types of electricity generation in Bangladesh, the economic status of Bangladesh, the geographical status of Bangladesh. By analyzing this results if there will be new generation of electrical power, the company will take necessary actions, plans for future expansion, set targets for upcoming years and comparison can be made with international standards. Ultimately which will help to improve the standard of generation system performance in Bangladesh

CHAPTER 1

INTRODUCTION

1.1 Prologue

7th of December in 1901, Nowab Khawaja Ahsanullah installed a small generation in Dhaka. In 1933 a power generation station named Dhanmondi Power House was established with two 1500 KW generators. After partition in 1947 only 17 districts were limited to the township areas only for a limited time except Dhaka. In that time, the generation capacity of this plant was up to 21 MW. In 1959 East Pakistan Water and Power Development Authority(EPWAPDA) was established to look after generation, transmission, distribution and sale of electricity thought the East Pakistan. After the independence of Bangladesh in 1972 Bangladesh Power Development Board(BPDB) was created to look after the same function. With a population of 160 million, Bangladesh is one of the world's most populated countries. Agriculture used to be the main source of income for the people of this country. However, the Gross Domestic Product (GDP) in Bangladesh was 7.3% percent in 2017. Bangladesh Bank forecasts that on 2018 the economic growth will be more than 7.5%. Rapid urbanization fueled by stable economic growth has created a huge demand of energy.

In Bangladesh, electricity is the most widely used form of energy. So, future economic growth significantly depends on the availability of electricity. Bangladesh Government should ensure affordable and environmentally friendly source of electrical energy for the people. However, since its independence from Pakistan in 1971, the country has struggled to generate enough electricity to meet the demand. The state-owned electricity utilities suffer from large energy shortages. Moreover, due to poor pricing policies and huge corruption by policymaker, the energy sector has also failed to attract enough private investments in power business. This shortage of investment is a contributing factor toward energy crisis. The present government is committed to ensuring access to affordable and reliable electricity for all citizens by 2021. At present, 79.9 % of the population has access to electricity. The supply is also not enough reliable. The per capita energy consumption in Bangladesh is one of the lowest (407 kWh in 2017) in the world. To improve the situation, the Government has accepted a wide energy development strategy to explore supply-side options along with demand management that conserves energy and discourages inefficient use.

1.2 Problem Statement

Demand of power has been increasing extensively over the years. For residential, lighting, heating, refrigeration, air conditions, and transportation as well as critical supply to governmental, industrial, financial, commercial, medical and communication communities should be able to any country needs simultaneous supply of electrical power. In generation of electrical power there are always some issue that frequently disturbed by the machine or mechanism. System and mechanism performance standards are very important for generation electrical power. Because only they ensure the efficient and a secure generation of electrical power. For that reason, this research is needed to correct the system faults in specific way to admire the performance of power generation in Bangladesh. This thesis is intended to identify the key problems of electrical power generation. After that their way to solve them and secure a spontaneous way of electrical power supply.

1.3 Objectives

This research aim is evaluating to improve the technical and financial in power plant of Bangladesh.

The specific aims of this research are summarized as follow.

i. Study the structure and operation of power plant of Bangladesh
ii. To investigate economic and efficiency performance of power plant.
iii. Identify power plant efficiency optimization methods
iv. Finally evaluate the result of method of optimization.

1.4 Possible Outcome

There are many ways to evaluate the power generation plant performance of Bangladesh. Annual report (include installed and dreaded capacity, operation and off time) of power plant. In this thesis suggested to Bangladesh's power plant, how to operate high efficiently in chapter 6. This is not very fast research in Bangladesh, however this will work as pioneer for Bangladesh Generation sector.

1.5 Research Methodology

To prepare the thesis, information, data and graph are collected and analyzed from various sources among which the following are notable.

- Main information is collected form reference book.
- Some key information is collected from research papers.
- Other diagram, data, short note and template are also collected from online resources.

1.6 Thesis Outline

This thesis consists of ten chapters, and the main content of each chapter is described as follows:

Chapter 1: This chapter introduces the background of power generation of Bangladesh, statement of the problem, objectives, possible outcome of the research and research Methodology.

Chapter 2: This chapter introduce of power system, diagram, description of each section of power system and clarify between conventional and renewable power generation plant.

Chapter 3: This chapter discussed about different types of power plant used Bangladesh

Chapter 4: This chapter discussed about different types of fuel (calorific value, material, cost and availability) used in Bangladesh

Chapter 5: Main concern of this chapter is economic, efficiency, power factor and tariff of power plant.

Chapter 6: Optimization of efficiency

Chapter 7: This chapter disused different type power plant site selection

Chapter 8: Demand, forecast demand, generating voltage and frequency for power plant is concern this chapter.

Chapter 9: Synchronizing with step-up substation with detail description.

Chapter 10: This chapter describe how to operate plant at high efficiently and concern high power factor.

CHAPTER 2

INTRODUCTION OF ELECTRICAL POWER SYSTEM

2.1 Introduction

Electric power system is a network of electrical components located to supply, transfer, and use electric power. An example of an electric power system is the grid that supply power to an elongated area. An electrical grid power system can be in particular separated into the generators that supply the power, the transmission system that convey the power from the generating centers to the load centers, and the distribution system that feeds the power to close at homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes. The larger number of these systems depend on three-phase AC power system.

2.2 Outline Diagram of Electrical Power System

In power engineering, a one-line diagram or single-line diagram (SLD) is a simplified alphabet for representing a three-phase power system. The one-line diagram has its huge application in power flow studies. Electrical elements such as circuit breakers, transformers, bus bars, and conductors are shown by standardized schematic symbols. As an alternative of representing each of three phases with a different line or terminal, only one conductor is represented. Elements on the diagram do not represent the physical size or location of the electrical equipment, but it is a common protocol to organize the diagram with the same left-to-right, top-to-bottom sequence as the switchgear or other apparatus represented.

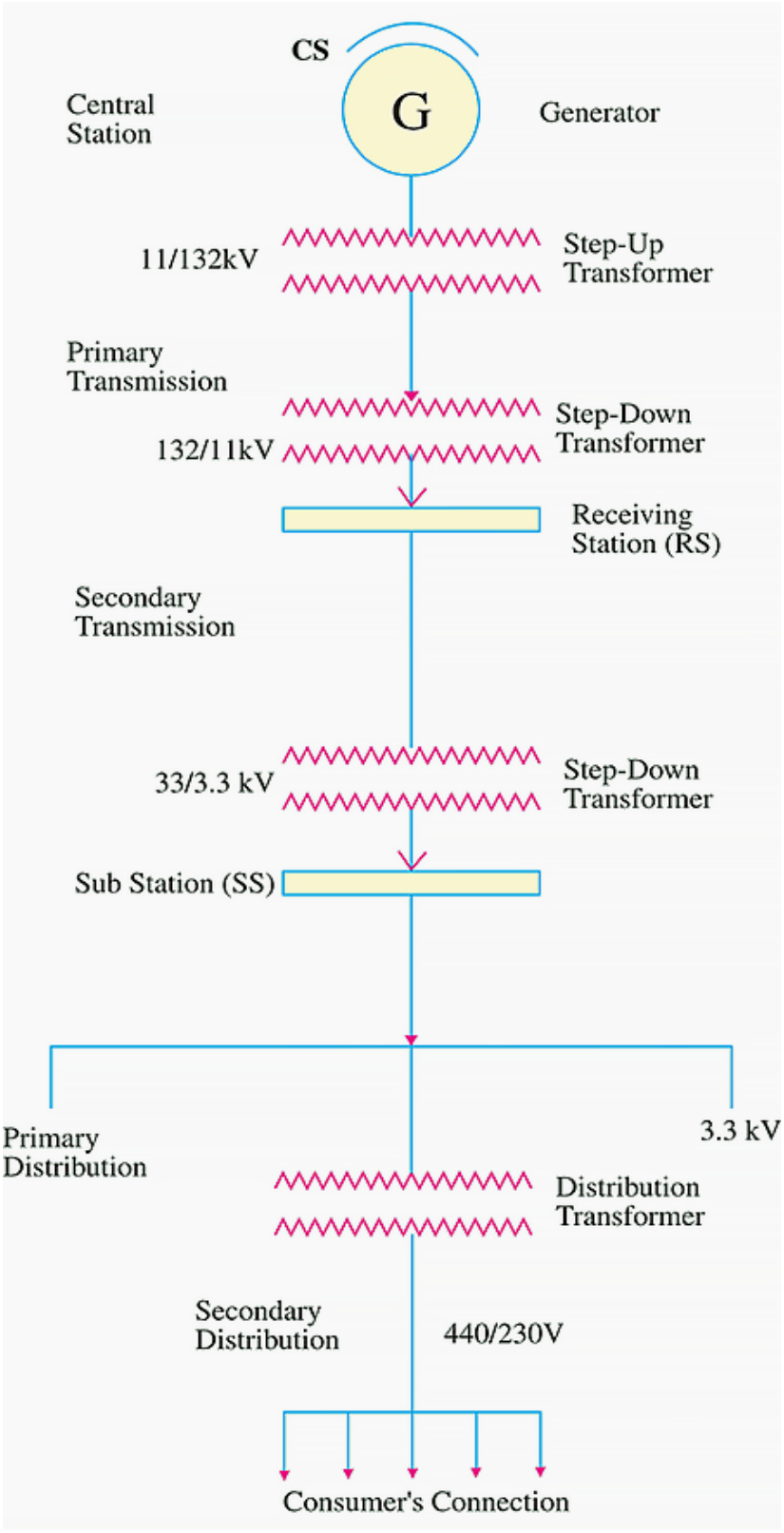

Figure 2.1: single line diagram of electrical power system

2.3 Components and Their Description, Function, Materials and Construction

In the power system it is divided by three sector such as:

i. Generation
ii. Transmission system
iii. Distribution system

2.3.1 Generation of Electricity

The generating station where electric power is produce by 3 phase alternators operating in parallel. The usually generation voltage is 6.6 KV,11 KV, 13.5 KV,15.75 KV. Then step-up the terminal voltage ate different range. The transmission of electric power at high voltage has several advantage including saving of conductor material and high efficiency.

2.3.2 Transmission of Electricity

Here each part can be divided further sub division. Which are – primary transmission and secondary transmission. it is an important notion that all power system not include all the stages that we were talked.

Primary transmission: In this process the step up transformers are used. The electric power at 132 KV, 230 KV is transmitted by 3- phase, 3- wire overhead system to the borders of the city, this is called primary transmission.

Secondary transmission: Using step down transformers are the first requirements in this process. primary transmission terminates at the receiving station which usually lies at the outside of the metropolitan. 33 KV is reduced by the step- down transformers. From this station electric power is transmitted at 33KV by 3-phase, 3-wire overhead system to different substation located at the certain point of the city.

2.3.3 Distribution of Electricity

Primary distributing: Secondary transmission line terminates at the sub-statin in where voltage is reduced from 33KV to 11 KV, 3-phase, 3-wire. The main 11KV line run alongside of the important point of the city. It may be noted that big consumers (demand is more than 50 KW) are generally using their own sub-stations.

Secondary distribution: The electric power from primary distribution line is terminates to distribution sub-stations. These sub-stations are located near the consumer's localities and they step down the voltage to 400 V, 3- phase, 4 –wire for secondary distribution. The voltage between any 2 phase is 400 V and the neutral is 230V. It may be referring to that secondary distribution system consists of feeders, distributors and service lines for low voltage distribution system.

Feeders: Feeders discharge from the distribution sub-station to the distributors. no consumers are given direct connection from feeders. They are connected their service mains.

2.4 Deference Between Conventional and Renewable Power Plant

This part donation a review about conventional and renewable energy scenario of Bangladesh. The ordinal terms of Consumption, Production and supply are familiarizing. In Bangladesh most of the power generation is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission. Setting up of new power plants is naturally dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources, such as biomass energy, solar energy, wind energy, geothermal energy and ocean energy. Last 10-15 years has been a period of rich hunt of activities related to research, development, production and demonstration at Bangladesh. Bangladesh has obtained application of a variety of renewable energy technologies for use in different sectors too.

2.4.1 Conventional Power Plant

Fossil fuel power station which also known as conventional power plant is a power station which burns a fossil fuel such as coal, natural gas or petroleum to produce electricity. Basic station of this type of power plants are designed on a large scale for continuous operation. In many countries, such plants provide most of the electrical energy. In Bangladesh most of the used energy produce by this type of power plant. Fossil fuel power stations have machinery to convert the heat energy of combustion into mechanical energy, which then operates an electrical generator. The prime mover may be a steam turbine, a gas turbine or in small plants, a reciprocating internal combustion engine. All plants use the energy take out from expanding gas, either steam or combustion gases. Although different energy conversion methods exist, all thermal power station conversion methods have efficiency limited by the Carnot efficiency and therefore produce waste heat. Conventional power plant is mostly used. So it has some advantages. These are like:

i. Reliability
ii. Affordability
iii. Abundance

On the other hand, there are also some significant disadvantages of coal fired plants including Greenhouse Gas (GHG) Emissions, mining destruction, generation of millions of tons of waste, and emission of harmful substances.

2.4.2 Renewable Power Plant

Renewable energy is energy that is collected from renewable resources, which are naturally refill on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation and rural (off-grid) energy services.

2.4.2.a The Advantages of Renewable Energy

One major advantage with the use of renewable energy is that as it is renewable it is therefore sustainable and so will never be expire.

Renewable energy facilities generally require less maintenance than traditional generators. Their fuel being derived from natural and available resources reduces the costs of operation.

Even more importantly, renewable energy produces little or no waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment.

Renewable energy projects can also bring economic benefits to many regional areas, as most projects are located away from large urban centers and suburbs of the capital cities. These economic benefits may be from the increased use of local services as well as tourism.

2.4.2.b The Disadvantages of Renewable Energy

It is easy to recognize the environmental advantages of utilizing the alternative and renewable forms of energy but we must also be aware of the disadvantages.

One disadvantage with renewable energy is that it is difficult to generate the quantities of electricity that are as large as those produced by traditional fossil fuel generators. This may mean that we need to reduce the amount of energy we use or simply build more energy facilities. It also indicates that the best solution to our energy problems may be to have a balance of many different power sources.

Another disadvantage of renewable energy sources is the reliability of supply. Renewable energy often relies on the weather for its source of power. Hydro generators need rain to fill dams to supply flowing water. Wind turbines need wind to turn the blades, and solar collectors need clear skies and sunshine to collect heat and make electricity. When these resources are unavailable so is the capacity to make energy from them. This can be unpredictable and inconsistent. The current cost of renewable energy technology is also far in excess of traditional fossil fuel generation. This is because it is a new technology and as such has extremely large capital cost.

2.5 Summery

Basically there are 2 type of energy which helps to generating electric power in the world. Which are conventional and renewable energy. All have some advantages and some disadvantages upon each other.in this section we try to clarify the conventional and renewable energy based power plant. And overall we try to draw a whole picture about the electrical power system.

CHAPTER 3

POWER GENERATION PLANT

3.1 Introduction

Electrification of the capital Dhaka city in 1901 by Nowab Khwaja Ahsanullah. Then it was established by east Pakistan government in 1948. In that time there was few stream turbine (10 MW) in Siddhirganj, Chittagong and Khulna. Then kaptai hydro-electric project was installed in 1962. Installed capacity of kaptai hydro-electric plant was 40 MW in that time. In 1971 after independent of Bangladesh 3 % population had access to electricity. At present it was increased geometrically, it is now 79.9 % in 2018. In this chapter will cover about different types of power plant in used Bangladesh, operation, working principal and there rating.

3.2 Type of Power Plant

Many types of power plant installed in Bangladesh. Now shown based on fuels and energy source. In this portion discussed about fuels and energy source which used in Bangladesh.

3.2.1 Fuels

A fuel is any material that can be made to react with other substances so that it releases energy as heat energy or to be used for work. Many kind of fuel used in electrical power plant so that the fuels are broadly classified as follows:

i. **Solid fuels:** Various solid fuels used are wood, coal including bituminous coal, anthracite, lignite, peat, etc.
ii. **Liquid fuels:** Liquid fuels include petroleum and its derivatives
iii. **Gaseous fuels:** Gaseous fuels consist of natural gas, producer gas, blast furnace gas, coal gas etc.

3.2.2 Energy Source

The electrical energy is produced from energy that available in the nature. The energy sources are broadly classified. Every source is not used in Bangladesh but most of the sources used in Bangladesh. These source of energy are:

i. Water (Hydro Power Plant)
ii. Ocean Water (Tidal Power Plant)
iii. Wind (Wind Power Plant)
iv. Sun Light (Solar Power Plant)
v. Heat (Geothermal Power Plant)
vi. Nuclear energy

Tidal and geothermal power plant does not use yet in Bangladesh but nuclear power plant in under construction so it will be used soon.

3.3 Description of Power Plant

Huge amount of electricity produces by special plants known as generating station or power plant. In this section we will discussed about power plant construction, block diagram and function of component.

3.3.1 Hydro Power Plant

A generating station or plant uses the potential energy of water at a high head for the generation of electrical energy is known as a hydro-electric power station or plant. Only one hydro power station has in Bangladesh, which is established in kapti. In the below given details about hydro power plant.

3.3.1.a Construction

A Hydro Power Plant generates electricity by use potential energy of water. The dam is constructed across a river or lake and water from the catchment area collects at the back of the dam to from a reservoir. A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstock. The valve house contains main sluice valves and automatic isolating valves. From the valve house, water is taken to water turbine through a huge steel pipe known as penstock. The water turbine converts hydraulic energy into

mechanical energy. The turbine drives the alternator which converts mechanical energy into electrical energy.

3.3.1.b Layout of Hydro Power Plant

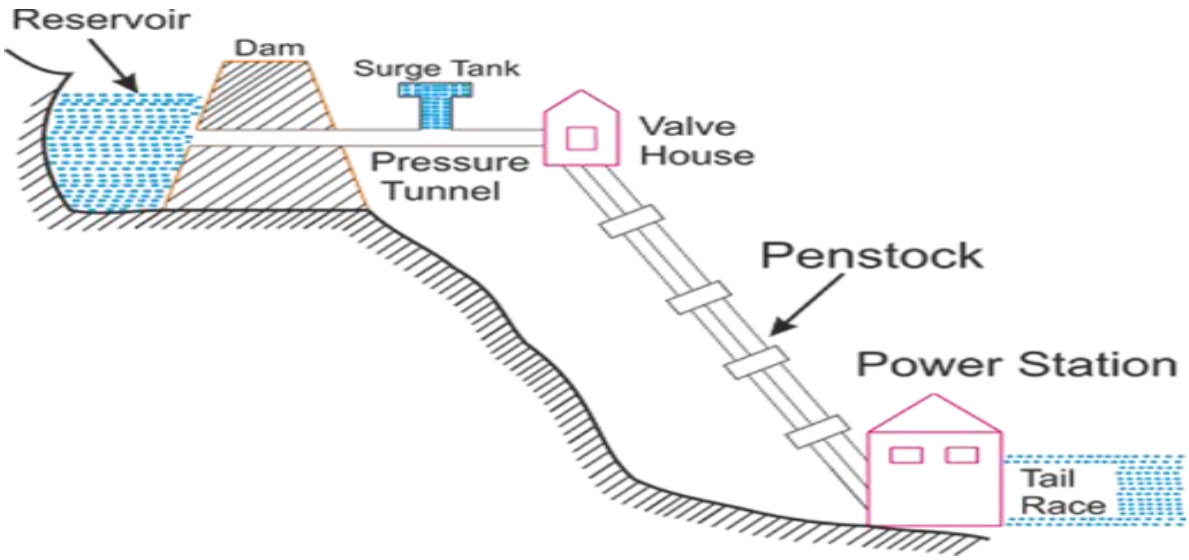

Figure 3.1: Layout of hydro power plant

3.3.1.c Function of Components

Dam and Reservoir: The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (called as water head) in the reservoir determines how much of potential energy is stored in it.

Spillways: A spillway is a structure used to provide the controlled release of flows from a dam or levee into a downstream area, typically the riverbed of the dammed river itself. Spillways ensure that the water does not overflow and damage or destroy the dam.

Control Gate: Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water which is to be released in the penstock can be controlled by a control gate. When the control gate is fully opened, maximum amount of water is released through the penstock.

Penstock: A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Headwork: Headwork generally is diversion structure which divert water. In the hydropower plants, headwork is insuring that the flow of water should be as smooth as possible to avoid head loss.

Water Turbine: Water from the penstock is taken into the water turbine. The turbine is mechanically coupled to an electric generator. Kinetic energy of the water drives the turbine and consequently the generator gets driven. There are two main types of water turbine; (i) Impulse turbine and (ii) Reaction turbine. Impulse turbines are used for large heads and reaction turbines are used for low and medium heads.

Generator: A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for the transmission purpose.

Surge Tank: A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the power house. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock. When there is sudden reduction in load on the turbine, the governor closes the gates of the turbine to reduce the water flow. This causes pressure to increase abnormally in the penstock. This is prevented by using a surge tank, in which the water level rises to reduce the pressure. On the other hand, the **surge tank** provides excess water needed when the gates are suddenly opened to meet the increased load demand.

3.3.2 Nuclear Power Plant

A generating station in which nuclear energy is converted into electrical energy is known as a nuclear power station.

3.3.2.a Construction

Nuclear power station is mainly constructed by 4 basic apparatus, such as 1) Nuclear reactor 2) Heat exchanger 3) Steam turbine 4) Alternator. In nuclear power station, nuclear fuel such as Uranium, Thorium are performing nuclear fission in an apparatus is called a reactor. The reactor produces huge amount of heat energy and thus released in heat exchanger, where heat is produces high pressure steam. The steam runs the steam turbine where converted steam energy into mechanical energy. The turbine connected with alternator and turbine drive the alternator and this alternator is converted mechanical energy into electrical energy.

3.3.2.b Block Diagram of Nuclear Power Plant

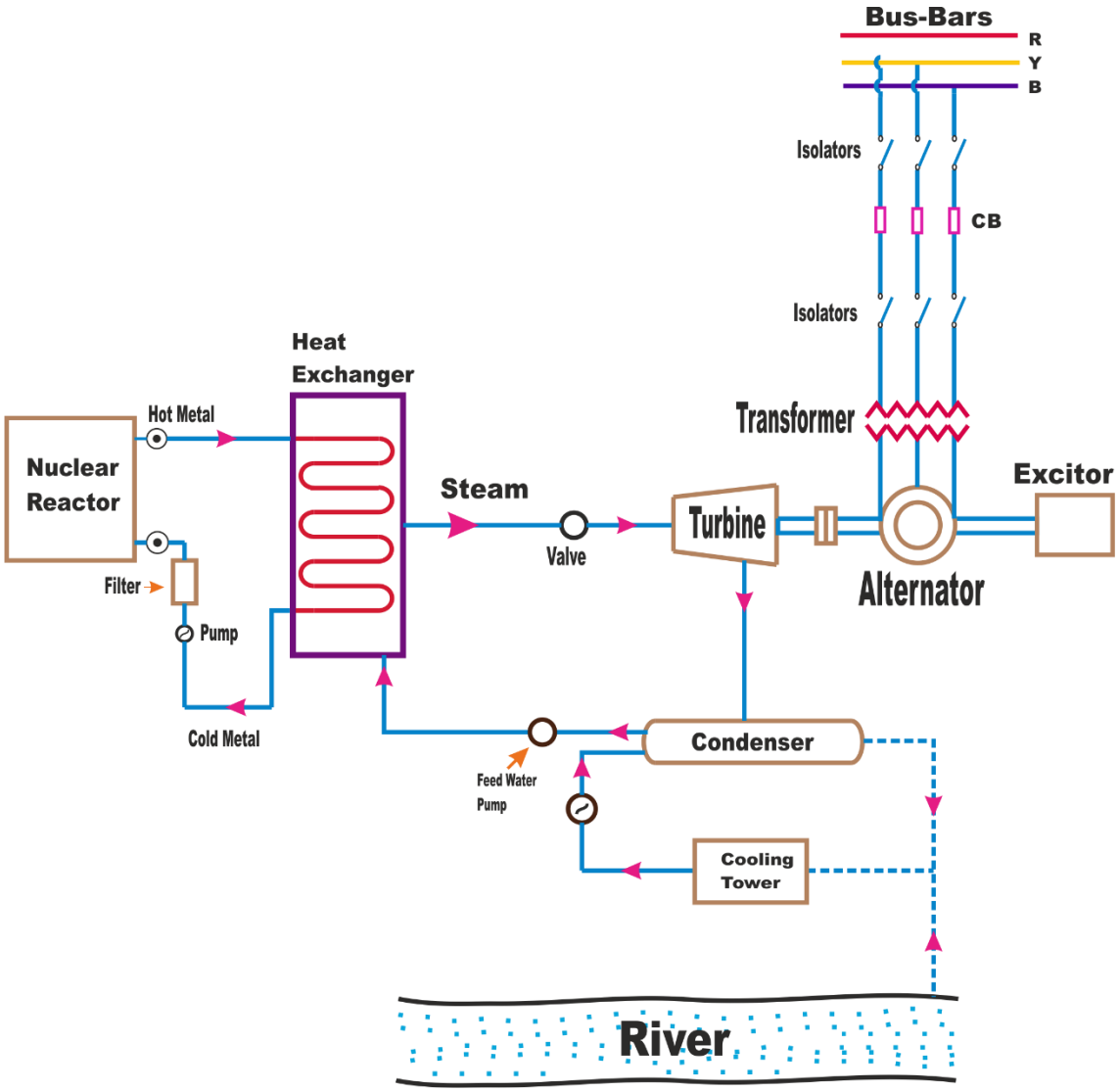

Figure 3.2: Block Diagram of Nuclear power plant

3.3.2.c Function of Components

Reactor: The nuclear reactor is the main parts of the nuclear power plants. A reactor is a cylindrical pressure vessel which is consist of various parts. Such as 1) Nuclear Fuel, 2) Moderator, 3) Control Rods, 4) Reflector, 5) Reactors Vessel, 6) Biological Shielding, 7) Coolant. The fuel rods consist of the fission materials which is release huge amount of energy. The moderator consists of graphite rods which is slow down the fast moving neutrons. The control rods of cadmium which is absorbed the neutron and control the fission process in the

reactor. In the reactors fuel rods produced huge amount of heat due to fission process is transfer to heat exchanger through coolant from reactor where rising heat converted into steam energy.

Heat exchanger: The coolant give heat to the heat exchanger and heat exchanger uses this heat and rise the high pressure steam, then steam flow the turbine and coolant also back to reactor through the feed pump.

Steam turbine: The purpose of the steam turbine is to convert the heat energy into mechanical energy. The stream produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchange through feed water pump.

Generator: The generator converts mechanical power supplied by the turbine into electrical power. Low-pole AC synchronous generators of high rated power are used.

Condenser: A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler. There are two types of condensers, such that; ***(i)*** Jet condenser ***(ii)*** Surface condenser

Feed water pump: The water level in the steam generator and the nuclear reactor is controlled using the feed water system. The feed water pump has the task of taking the water from the condensate system, increasing the pressure and forcing it into either the steam generators or directly into the reactor.

3.3.3 Steam Power Plant

A generating station which converts heat energy of coal combustion into electrical energy is known as a steam power station.

3.3.3.a Construction

steam is produced in boiler by the heat of coal combustion. The heat is than expanded in the prime mover and is condensed in condenser which is to fed into the boiler again. The turbine drives the alternator which converts mechanical energy of the turbine into electrical energy. Steam power plant consist of various units such as: **1**. Coal conveyor **2**. Stoker **3**. Pulverize **4**. Boiler **5**. Boiler furnace **6**. Super heater **7**. Economizer **8**. Air preheater **9**. Condenser **10**. Electrostatic precipitator **11**. Smoke stack **12**. Turbine **13**. Cooling towers **14**. Water treatment plant **15**. Electrical equipment

3.3.3.b Diagram

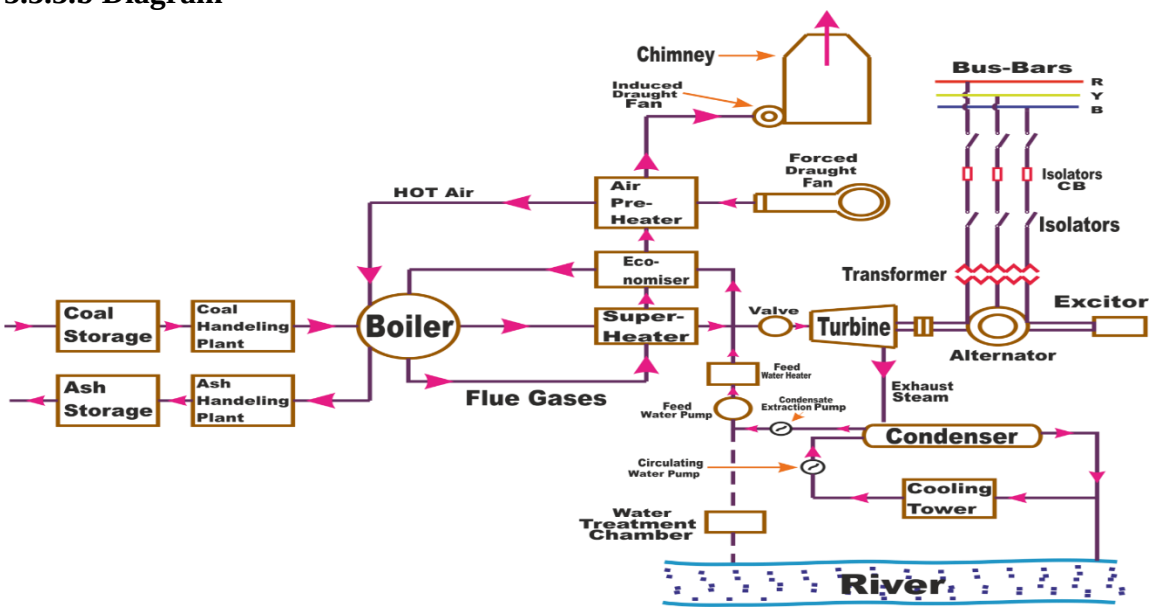

Figure 3.3: Block Diagram of Steam power plant

3.3.3.c Function of Components

Coal conveyor: This is a belt type of arrangement. With this coal is transported from coal storage place in power plant to the place nearby boiler.

Stoker: The coal which is brought nearby boiler has to put in boiler furnace for combustion. This stoker is a mechanical device for feeding coal to a furnace

Pulverize: The coal is put in the boiler after pulverization. For this pulverize is used. A pulverize is a device for grinding coal for combustion in a furnace in a power plant.

Boiler: A boiler is closed vessel in which water is converted into steam by utilizing the heat of coal combustion. Steam boilers are broadly classified into the following two types:

(i) Water tube boilers **(ii)** Fire tube boilers

Boiler furnace: A boiler furnace is a chamber in which fuel is burnt to liberate the heat energy. In other ward, it provides support and enclosure for the combustion equipment *i.e.* burners.

Super heater: A super heater is a device which superheats the steam. It raises the temperature of steam above boiling point of water. This increases the overall efficiency of the plant.

Economizer: It is a device which heats the feed water on its way to boiler by deriving heat from the flue gases. This results in raising boiler efficiency, saving in fuel and reduced stresses in the boiler due to higher temperature of feed water.

Air preheater: Super heaters and economizers generally cannot fully extract the heat from flue gases. Therefore, pre-heaters are employed which recover some of the heat in the escaping gases. The function of an air pre-heater is to extract heat from the flue gases and give it to the air being supplied to furnace for coal combustion. This raises the furnace temperature and increases the thermal efficiency of the plant.

Condenser: A condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to a very low pressure. This helps in converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler. There are two types of condensers, such that; **(i)** Jet condenser **(ii)** Surface condenser

Electrostatic precipitator: It is a device which removes dust or other finely divided particles from flue gases by charging the particles inductively with an electric field, then attracting them to highly charged collector plates. Also known as precipitator

Smoke stack: A chimney is a system for venting hot flue gases or smoke from a boiler, stove, furnace or fireplace to the outside atmosphere. They are typically almost vertical to ensure that the hot gases flow smoothly, drawing air into the combustion through the chimney effect it also known as the stack effect.

Steam turbine: The purpose of the steam turbine is to convert the heat energy into mechanical energy. The stream produced in the heat exchanger is led to the steam turbine through a valve. After doing a useful work in the turbine, the steam is exhausted to condenser. The condenser condenses the steam which is fed to the heat exchange through feed water pump. Steam turbines are generally classified into two types according to the action of steam on moving blades *such as* **(i)** Impulse turbines **(ii)** Reactions turbines.

Cooling towers: The condensate water formed in the condenser after condensation is initially at high temperature. This hot water is passed to cooling towers. It is a tower or building like device in which atmospheric air circulates in direct or indirect contact with warmer water and the water is thereby cooled. A cooling tower may serve as the heat sink in a conventional thermodynamic process, such as refrigeration or steam power generation.

Water treatment plant: The water from the source of supply is stored in storage tanks. The suspended impurities are removed through sedimentation, coagulation and filtration. Dissolved gases are removed by aeration and degasification. The water is then 'softened' by removing temporary and permanent hardness through different chemical processes. The pure and soft water thus available is fed to the boiler for steam generation.

3.3.4 Diesel Power Plant

A generating station in which diesel engine is used as the prime mover for the generation of electrical energy is known as diesel power station

3.3.4.a Construction

In a diesel power station, diesel engine is used as the prime mover. The diesel burns inside the engine and the products of this combustion act as the working fluid to produce mechanical energy. The diesel engine drives the alternator which converts mechanical energy into electric energy. Diesel power plant consist of such components: 1. Diesel engine 2. Engine starting system 3. Fuel system 4. Air intake system 5. Exhaust system 6. Lubrication system 7. Cooling system

3.3.4.b Diagram

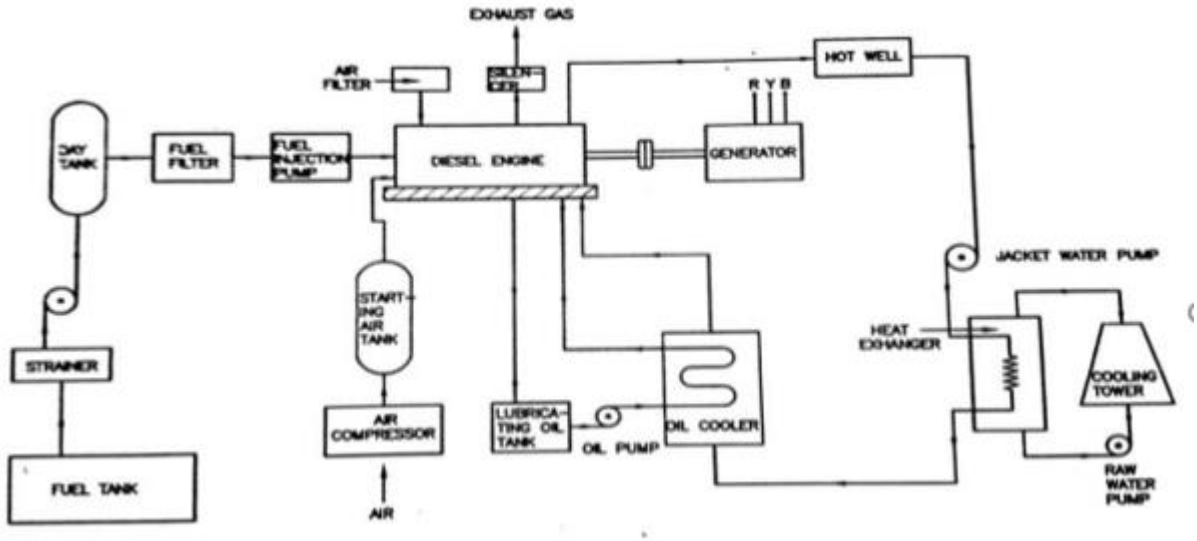

Figure 3.4: Block diagram for Diesel power station

3.3.4.c Function of Components

Diesel engine: Diesel engines or compression ignition engines as they are called are generally classified as two stroke engine and four stroke engines. In diesel engine, air admitted into the cylinder is compressed, the compression ratio being 12 to 20. At the end of compression stroke, fuel is injected. It burns and the burning gases expand and do work on the position. The engine is directly coupled to the generator. The gases are then exhausted from the cylinder to atmosphere.

Engine starting system: This includes air compressor and starting air tank. The function of this system is to start the engine from cold supplying compressed air.

Exhaust system: In the exhaust system, silencer (muffler) is provide to reduce the noise.

Air intake system: Air filters are used to remove dust from the incoming air. Air filters may be dry type, which is made up of felt, wool or cloth. In oil bath type filters, the sir is swept over a bath of oil so that dust particles get coated.

Fuel system: Pump draws diesel from storage tank and supplies it to the small day tank through the filter. Day tank supplies the daily fuel need of engine. The day tan is usually

placed high so that diesel flows to engine under gravity. Diesel is again filtered before being injected into the engine by the fuel injection pump. The fuel is supplied to the engine according to the load on the plant.

Cooling system: The temperature of burning gases in the engine cylinder is the order of 1500 to 2000'C. to keep the temperature at the reasonable level, water is circulated inside the engine in water jackets which are passage around the cylinder, piston, combustion chamber etc. hot water leaving the jacket is sent to heat exchanger. Raw water is made to flow through the heat exchanger, where it takes up the heat of jacket water. It is then cooled in the cooling tower and recirculates again.

Lubrication system: It includes lubricating oil tank, oil pump and cooler. Lubrication is essential to reduce friction and wear of engine parts such as cylinder walls and piston. Lubricating oil which gets heated due to friction of moving parts is cooled before recirculation. The cooling water used in the engine is used for cooling the lubricant also.

3.4 **Working Principal of Different Power Plant**

Working principal of different power plant is given in the below.

3.4.1 **Hydroelectric Power Plant**

Hydro power is electrical energy produced through the power of moving water. Power obtained from the movement of water., Hydropower plants derive energy from the force of moving water and harness this energy for useful purposes. Traditional uses include watermills. In modern technology, hydropower moves turbines that pass on their energy to a generator which then produces electric power.

3.4.2 Nuclear Power Plant

Nuclear power plants use uranium as fuel. When the reactor is on, uranium atoms inside the reactor split into two smaller atoms. When uranium atoms split, they give off a large amount of heat. This splitting of atoms is called fission.

The most popular atoms to fission are uranium and plutonium. Those atoms are slightly radioactive. The atoms produced when fuel atoms break apart are strongly radioactive.

3.4.3 Diesel Fired Power Plant

In the diesel engine power plant, the fuel mixture and air is used as a working medium. During the time of the suction stroke atmospheric air enters the combustion chamber. With the help of the injection pump fuel is injected in to the chamber. Inside the engine the air and the fuel is mixed and the charge must be ignited because of the compression present inside the cylinder. The main principle observed in the diesel engine is the thermal energy it must be converted in to the mechanical energy and further the mechanical energy must be converted in to the electrical energy. The main purpose is to develop electricity with the help of the alternator or generator.

3.5 Comparison of Different Power Plant:

Steam power	Hydro electric	Diesel power	Nuclear power
Located where water and coal and transportation facilities are adequate	Located where large reservoirs or dams can be created like in hilly areas	Located anywhere as very less water is required.	Located in isolated areas away from population.
Initial cost is lower than hydro and nuclear.	Initial cost pretty high due to large dam construction.	Initial cost is the least.	Initial cost is highest as cost of reactor construction is very high.
Running cost is higher than nuclear and hydro due to amount of coal required.	Practically nil as no fuel is required.	Highest running cost due to high price of diesel.	Cost of running is low as very less amount of fuel is required.
Coal is source of power. So limited quantity is available.	Water is source of power which is not a dependable quantity.	Diesel is source of power which is the least available among all.	Uranium is fuel source along with platinum rods. So sufficient quantity is available.
Cost of fuel transportation is maximum due to large demand for coal.	No cost for fuel transportation	Higher than hydro and nuclear power plants.	Cost of fuel transportation is minimum due to small quantity required.
Least environment friendly	Most environment friendly	A good friend of environment than steam or nuclear.	Better friend of environment than steam power plant.

25% overall efficiency.	Around 85% efficient.	About 35% efficient.	More efficient than steam power.
Maintenance cost is very high.	Maintenance cost is quite low.	Maintenance cost is less.	Maintenance cost is the highest as highly skilled workers are required.
Maximum standby losses as boiler still keeps running even though turbine is not.	No standby losses.	Less standby losses.	Less standby losses.

Table 3.1: Comparison of various power plant

3.6 Summary

In this part we introduced a short summery of generation history in Bangladesh. From starting to till now we categorize generation plant using different category. we also described working procedure, function, component of different kind of power plant. in this part we also discussed working procedure and function of component of upcoming power plant (nuclear power plant).

CHAPTER 4

FUEL MIX OF POWER GENERATION IN BANGLADESH

4.1 Introduction

Fuel is any material that can be made to react with other substances so that it releases energy as heat energy or to be used for work. The concept was originally applied solely to those materials capable of releasing chemical energy but has since also been applied to other sources of heat energy such as nuclear energy. The heat energy released by reactions of fuels is converted into mechanical energy via a heat engine. In Bangladesh many type of fuel is used for generating an electrical power. Different type of fuels contains different types of material, it's calorific value and availability different. In this chapter we are discussed about fuel mix. Now given to a list which types of fuel is used in Bangladesh.

Fuel Type	Capacity(unit)	Total(%)
Coal	524 MW	3.27%
Gas	9641 MW	60.19%
Heavy Fuel Oil (HFO)	3148 MW	19.65%
High Speed Diesel (HSD)	1815 MW	11.33%
Uranium (U^{235})	2000 MW	Under construction

Table 4.1: Fuel used in Bangladesh's power plant

4.2 Coal

The vegetable matter which accumulated under the earth millions of years ago was subjected to the action of pressure and heat. This changed the physical and chemical properties of matter and it got converted into what we call as coal. In Bangladesh mainly two types of coal are used. Such as: i) peat & ii) Anthracite coal. In the below we will have discussed that two types coal and those coal that used in international power plant.

4.2.1 Peat

It consists of decayed vegetable matter mainly decomposed water plants and mosses etc. It has high moisture content and should be dried before burning.

Calorific value: Calorific value of peat coal is 3500 kcal/kg.

Material: Approximate composition is C = 60%, H – 58%, 0 = 33%. Ash=12%

4.2.2 Lignite or Brown Coal

It is brown in color, it burns with a brightly slightly, smoky yellow flame.

Calorific value: Its calorific value is 5000 kcal/kg

Material: its approximate composition is C = 67%, H = 5%, Q =20% and Ash =8%.

4.2.3 Bituminous Coal

It is soft, consists of large amount of volatile matter and is widely used as fuel. It burns with a long yellow and smoky flame.

Calorific value: Its calorific value is 7800 kcal/kg and

Material: Approximate Composition is C = 83.5%, H = 5%, 0 = 5%, Ash = 6.5%.

4.2.4 Sub-bituminous Coal

Sub-bituminous coal contains 12 to 25% moisture. It is of black-color.

Calorific value: The approximate calorific value of this coal is 4600 kcal/kg.

4.2.5 Anthracite Coal

It is black in color and burns with a short bluish flame and the amount of ash produced due to its burning is very little.

Calorific value: Its calorific value is *8500* kcal/kg and approximate

Materials: composition is as follows C = 90%, 0 = 2%, H= 3% and Ash= 5%.

Fuels	Proximate Analysis,%				Ultimate Analysis, %						Calorific value Kcal/kg	
	Moisture	Volatile matter	Fixed carbon	Ash	C	H_2	O_2	N_2	S	Ash	As reported	Dry basis
Peat	57	26	11	6	23	10	59	1.5	0.5	6	2000	4600
Lignite	35	28	31	6	42	7	43	1	1	6	4000	6000
Low volatile	3.5	16	72	8.5	79.5	4.5	4.5	1.5	1	9	7600	7900
Medium volatile	3	24	62	11	77	5	5	1.5	0.5	11	7500	7700
High volatile	8	36	49	7	68.5	16.5	16.5	1.5	1	7	6750	7400
Sub-bituminous	19	31	46	4	59	29.5	29.5	1	0.5	4	5600	7000
Semi-bituminous	3	8.5	79	9.5	80	4.5	4.5	1.5	0.5	10	7500	7700
Anthracite	2.5	3	87.5	7	86.5	3	3	0.5	0.5	7	7500	7700

Table 4.2: A typical composition of various types of coals is given in Table

4.2.6 Availability & Cost of Coal

As of 2018, coal supplied only 3.27% of the electricity generated. In May 2018, the country's overall coal production was around 3000 MT a day. The bulk of the coal from the mine is supplied to the existing Barapukuria Coal Power Plant which, while comprising two 125 megawatt generating units, is rated as having an installed capacity of 200 megawatts. Current coal used for power generation is low, the Bangladesh government is looking to domestic and imported coal to fuel a significant proportion of its ambitious power generation.

Electricity production cost by coal is much lower than other fuel except Nuclear fuel. On the average, in 2018 coal power had electricity production costs at Tk. 2.71 per Kilowatt hour.

4.3 Gaseous Fuels

Fuel gas is any one of a number of fuels that under ordinary conditions are gaseous. Many fuel gases are composed of hydrocarbons, hydrogen, carbon monoxide, or mixtures thereof. Such gases are sources of potential heat energy. Two types of gaseous fuel. Such as: i) Natural gas. ii)Prepared gas (coal gas, blast furnace gas, producer gas, water gas). But Bangladesh only use natural gas. In below discussed about natural gas.

4.3.1 Natural Gas

Natural gas comes out of gas wells and petroleum wells.

Material: It is mainly composed of methane (CH_4) = 85%, ethane (C_2H_6) =10% and other hydrocarbons = 5%. It is colorless and nun poisonous.

Calorific value: The calorific value of natural gas is 525 kcal/cubic meter.

4.3.2 Availability & Cost of Gas

Bangladesh is the nineteenth-largest producer of natural gas in Asia. As of 2018, the natural gas reserves of Bangladesh are 14.16 trillion cubic feet. The country has an average daily natural gas production of around 2,700 million cubic feet. As of 2018, gas supplied 60.19% of the electricity generated. It is available fuel in Bangladesh that's why most of the power plant in Bangladesh as a fuel depend on gas.

Electricity production cost by gas is lower than liquid fuel but higher than Nuclear fuel & Coal. On the average, in 2018 gas power had electricity production costs at Tk. 3.78 per Kilowatt hour.

4.4 Heavy Fuel Oil (HFO)

Fuel oil is a fraction obtained from petroleum distillation, either as a distillate or a residue. In general terms, fuel oil is any liquid fuel that is burned in a furnace or boiler for the generation of heat or used in an engine for the generation of power, except oils having a flash point of approximately 42 °C (108 °F) and oils burned in cotton or wool-wick burners. Fuel oil is made of long hydrocarbon chains, particularly alkanes, cycloalkanes and aromatics.

Material: Its main constituents are C= 85.1%, H= 10.9%, S=4%.

Calorific value: Its calorific value is 9990 kcal/Kg.

4.5 High Speed Diesel (HSD)

Diesel Oil is a complex mixture of Hydro Carbons. It is a brown colored oily liquid with pungent smell. diesel is composed of about 75% saturated hydrocarbons and 25% aromatic hydrocarbons. The average chemical formula for common diesel fuel is $C_{12}H_{24}$, ranging approximately from $C_{10}H_{20}$ to $C_{15}H_{28}$. i)Petroleum diesel, ii)Synthetic diesel , iii)biodiesel. In Bangladesh only used petroleum diesel.

Calorific value: Its calorific value is 10,550 Kcal/kg.

Property	Heavy Fuel Oil	High Speed Diesel
A.P.I gravity at 15˚C	57	34
Specific gravity	0.76	0.85
Viscosity at 10˚C	0.72	4.5
Viscosity at 40˚C	0.55	2.4
Catani number	18	45 to 55
Paraffin's & Naphthenic	51.5	65
Olefins	30.5	7
Aromatic	18	17

Table 4.3: Heavy Fuel Oil (HFO) and High Speed Diesel (HSD) mixtures properties.

4.5.1 Availability & Cost of Liquid Fuel

In Bangladesh liquid fuel is very unavailable. Little amount collects from natural gas field. The present annual demand of liquid fuel in the country is 3,300,000 tons. Total products in Bangladesh is 687,500 tons, which is 20.83% of total requirement. Therefore, it is less impact for total electric generation system. Liquide fuel power plant use in very remote area where did not connect grid line.

Per KWh electricity generation by liquid fuel is very expensive due to unavailability and more about 80% fuel is imported from gulf. Electricity production cost by HFO & HSD is higher than every fuel. On the average, in 2018 HFO & HSD power had electricity production costs is more than Tk. 18 per Kilowatt hour.

4.6 Uranium

Fuel of a nuclear reactor should be fissionable material which can be defined as an element or isotope whose nuclei can be caused to undergo nuclear fission by nuclear bombardment and to produce a fission chain reaction. It can be one or all of the following U^{233}, U^{235} and Pu^{239}.

Material: Natural uranium found in earth crust contains three isotopes namely U^{234}, U^{235}, U^{238} and their average percentage is as follows U^{238}-99.3%, U^{235} - 0.7%; U^{234} - Trace.

Uranium	Neutrons	Protons
Uranium-234	142	92
Uranium-235	143	92
Uranium-238	146	92

4.6.1 Availability & Cost of Uranium

Bangladesh Atomic Energy Commission chief scientific officer AKM Fazle Kibria claimed uranium mines have been found in Sylhet and Moulvibazar districts. But there is no commercial mining. Whole amount of uranium is imported from several countries.

Bangladesh have not any Uranium power plant but one is under construction. Therefore, its electricity generating cost define is default but hope that it will be cheaper than other fuel.

4.7 Summary

In this part we described about fuels that used for generation electrical power in various plant in Bangladesh. Fuels are basically 2 types, which are conventional and renewable. In Bangladesh most of the plant using conventional fossil fuel for generation. We also discussed about how many verity of fuels and which fuels is appropriate for generation electrical power with concern of financial status.

CHAPTER 5

ECONOMY AND EFFICIENCY ANALYSIS OF POWER PLANT

5.1 Introduction

The function of a power station is to deliver power to a large number of consumer. Their power demand also different according to them activates. The result of this variation, plant cannot have generated constant power, unfortunately, electrical power cannot have stored, therefore the power station must produce when needed demand. On the other hand, power must be operating at maximum efficiency. In this chapter, we shall focus how to operate plant economically and maximum efficiency.

5.2 Analysis of Load Curve

Load curve is the graphical Statement into load and times. The curve displays the change of load on the power station with reference to time. The load on a power station is never constant, it changes from time to time. If load is plated for 24 hours of a day, then it is called daily load curve. If load is plated for a day over a month, then it is called monthly load curve. If load is plated for 8760 hours or months of a one year then it is called annual load curve. The area in the load curves indicated how much energy need to be generated in this period. The top point in the curve is called maximum demand or peak load in this daily load curve. The area of the load curves divided by number of hours then it is called average load. In the below show that a daily load curve.

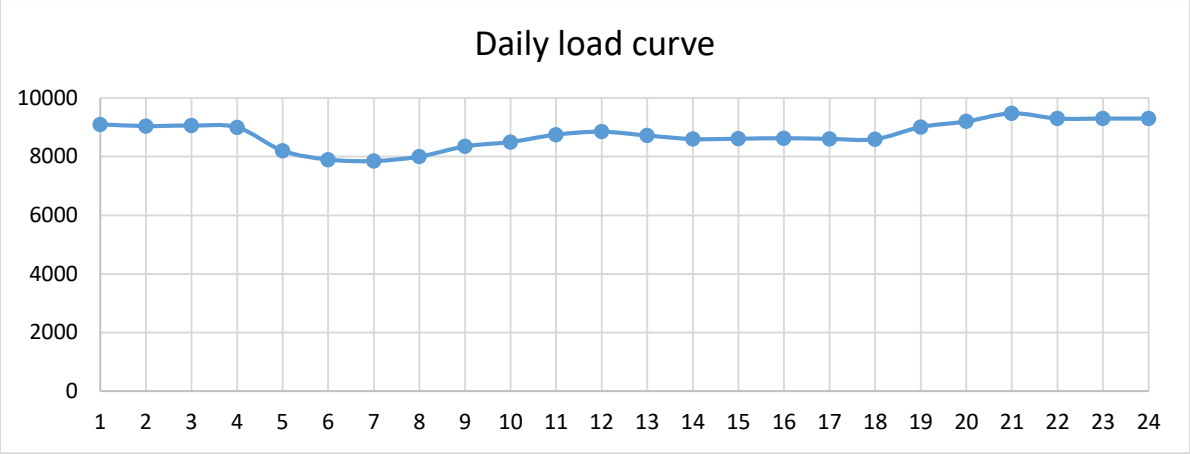

Figure 5.1: Daily load curve

A generating station has the following daily load cycles:

Time (hours): 0-6 6-10 10-12 12-16 16-20 20-24

Load(MW): 40 50 60 50 70 40

Draw a load curve and discuss about the variation of load respect to the curve.

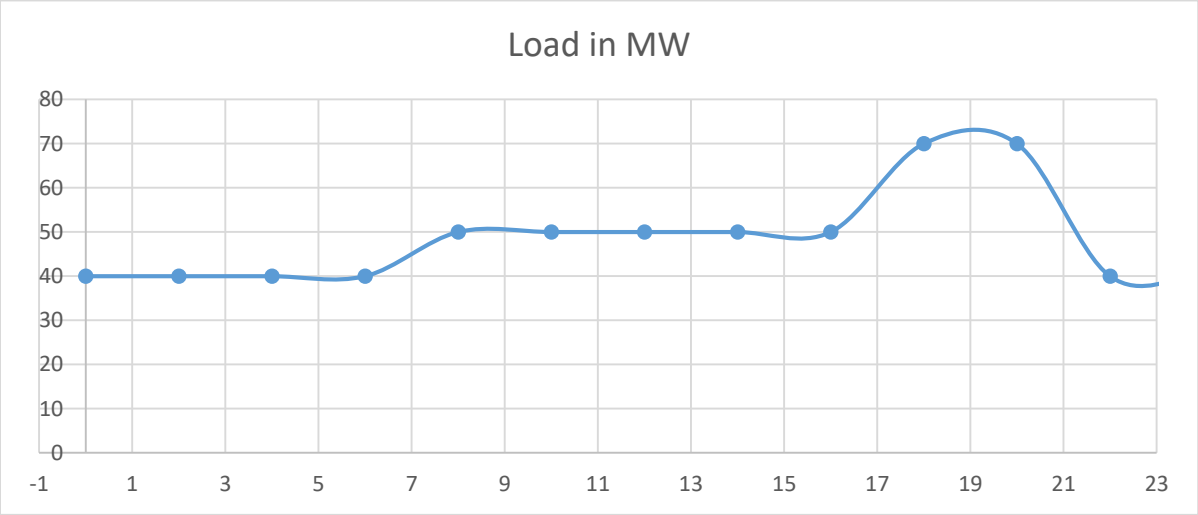

Figure 5.2: A model generating station load curve

This load curve is the one model power station load curve. This load curve shows that change of load

respect to the time, maximum demand and average load. In the mid night to 6 am maximum commercial and industrial load are not connected, domestic, municipal and irrigational load are connected therefore load demand is very low but after 6am to 4 pm load demand is increased due to commercial and industrial load but municipal load will be shut down in this time. After

4 pm to 10 pm also add municipal load therefore demand also increased. After 10 pm load is decreased due to industrial and commercial load will be shut it down.

5.3 Selection and Arrangement of Alternator

The load on the power station is not a constant position, it varies respect to times. The causes of load variation power plant should need to installed more than maximum demand (peak load). If power plant used in single alternator it is not a perform economically. Same of time load may very light, in this time plant provide very poor efficacy due to full unit of power plant re running. So cost of electrical generation will be increased. For this limitation of single alternator, every power plant installed two or more than two alternator units in different size. The selection of the number of alternator and size will be depending on annual load curve.

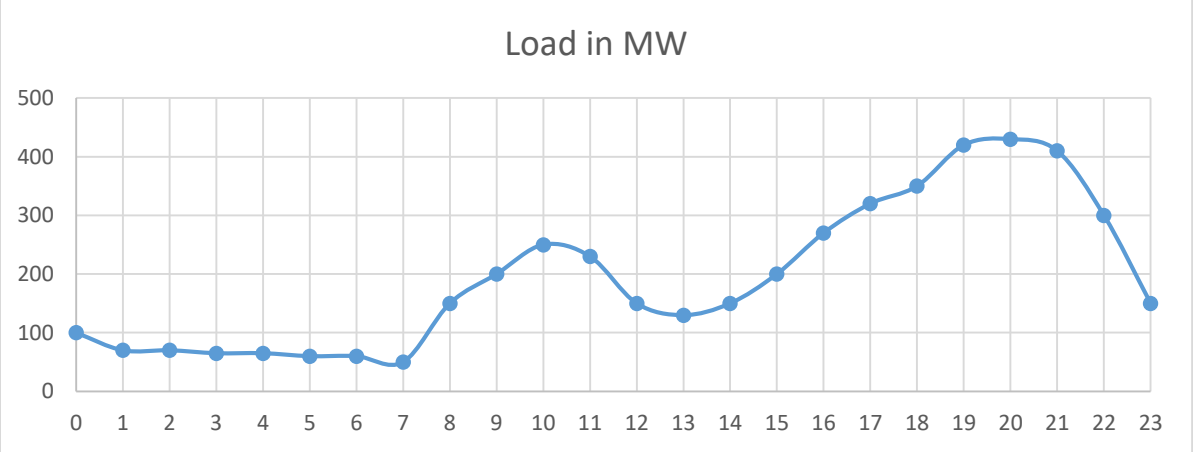

Figure 5.3: Gorashal power plant daily load curve.

From this load curves it is easily being represent that load is varied time to time very widely. In this load curve show that the minimum load near the 50 MW and maximum demand (peak load) near 430MW.

We are studying gorashal power plant. This plant overall capacity is 950 MW but they provide 450 MW. In this demand gorashal power plant can easily to provide maximum demand (peak load). In this case if used single alternator it is show very uneconomical operation. So need to use two or more alternators. How many alternators need to be installed it depend from plant capacity and variation of load demand in different period of time. In gorashal power plant overall capacity is divided by four units in different sizes. In the value show the alternator rating.

Alternator 1	40 MW
Alternator 2	50 MW
Alternator 3	170 MW
Alternator 4	190 MW

Table 5.1: Rating of alternator

After the alternator selection it is ensure that alternator must be highly utilized in properly and it run economically. Arrangement of alternator show the below.

Mid night to 6 am: Load demand near 70 MW. In this time alternator no 1 & 2 put in the operation together and two alternator provide 90 MW but demand near 70 MW. So it can cover the load demand.

6 am to 7 am: Load demand only 50 MW, in this scenario alternator no 1 is shut it down and alternator no still on the working.

7 Am to 8 Am: Load demand near 150 MW. Now alternator no 3 put in the operation and alternator no 2 is stopped.

8 Am to 9 am: In this scenario again alternator no 2 put in the operation with alternator no 3.

9 am to 11 am: In this time load demand is near 250 MW. Alternator no 1,2,3 now in the working.

11 am to 2 pm: Alternator no 3 put in the operation and alternator no 1 & alternator no 2 is now shut down.

2 pm to 3 pm: Load demand is now 200 MW, so now alternator no 1 & no 3 In the do the operation.

3 pm to 4 pm: Show the load curve demanded load is more than 270 MW. In this scenario Alternator no 1,2,4 are put in the work and alternator no 3 is stopped.

4 pm to 6 pm: from load curve studying now connect alternator no 3 and no 4 and alternator no 1 & no 2 are stopped.

6 pm to 9 pm: In this time load is peak load demand approximately 430 MW, in this scenario all of the alternator are working in full efficiently.

9 pm to 10 pm: Alternator no 3 and no 4 are in the work and alternator no 1 & no 2 are shut down.

10 pm to mid night: Alternator 3 only in the work in this time and stopped other alternator.

Before selection and arrangement of alternator should be concern some specific points. The number of alternator and size should be fit the annual load curve. Installed alternator should be different size which provide different load requirement. Overall plant capacity should be extra 15% to 20% more than maximum demand (peak load). For future extension. To arrange extra

alternator to continue supply when an alternator in servicing or overhauling. If selection and arrangement of alternator is properly then plant will be proved economical and efficient operation.

5.4 Determination of Tariff

The electrical energy produced by power station and this energy will have used by Various consumers. The consumer will take the energy if the rate of energy will reasonable price, this rate not only cover the cost of generating energy but also it concerns about transmission, distribution, the wages of the employees, depreciation and interest of capital investment.

"The tariff is the rate of electrical energy which supplies to the various consumers"

The tariff provides different method for different consumer. The rate will be depending on maximum demand and energy consumption by consumer. It will be low rate for high energy consumer compared with light energy consumer.

Some factors should be concern for the tariff:

I. It should be recover all cost for power station
II. It should be reasonable price for different demanded consumer.
III. It should be easy provide easy method to calculate and apply.
IV. It should be attracted to consumer for use more energy.

Types of tariff: There are different type of tariff, the following very common types of tariff.

i. **Straight-line meter rate tariff**
ii. **Flat demand rate tariff**
iii. **Block meter rate tariff**
iv. **Two-part tariff**
v. **Power factor tariff**
vi. **Maximum demand tariff**
vii. **Seasonal rate tariff**
viii. **Three-part tariff**

The various type of tariff derived by the general equation, which is following that:

Y= DX+EZ+C

Y = Total amount of bill

D = Rate per kW of maximum demand.

X = Maximum demand in kW

E = Energy rate per kW.

Z = Energy consumed in kWh

C = Constant amount

5.4.1 Sample Tariff

In the sample tariff method, rate of per unit energy will be fixed. It also known as a **Uniform Tariff** or **straight line meter rate tariff**. In this type of tariff, it is not charge if load is either increased or decreased. It is a very simple method to calculate and recorded energy and consumer can understand easily. It also derived by equation, Y=EZ. This method has a disadvantage. If consumer not used an energy than consumer did not pay any amount. Another is if consumer expansion the consumption of energy, consumer did not pay extra charge due to its fixed rate per unit energy.

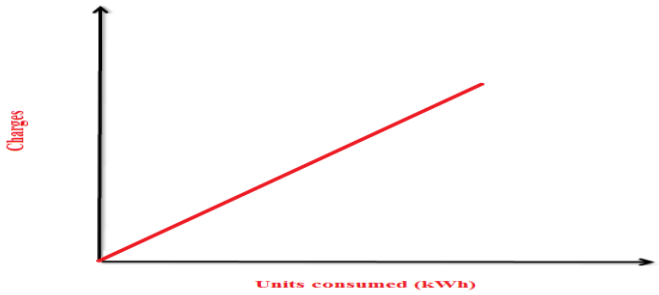

Figure 5.4: Sample Tariff

5.4.2 Flat Rate Tariff

In the flat rate tariff, first of all whole consumer divided into different group by consumption rate. Then fixed the rate of energy in different prices for different groups. But same group per unit energy rate will be fixed like sample tariff. For example: Category1 rate of energy is Tk.5.50 per unit of energy. Category1 consumer will pay total consume energy by rate of Tk5.50. Consider Category2 energy rate is Tk10, then all consumer in category2 will pay Tk10 per unit of energy. This method is more fair to different consumer but have a disadvantage like sample tariff. In this tariff same category consumer will pay same rate either load is increased or decreased.

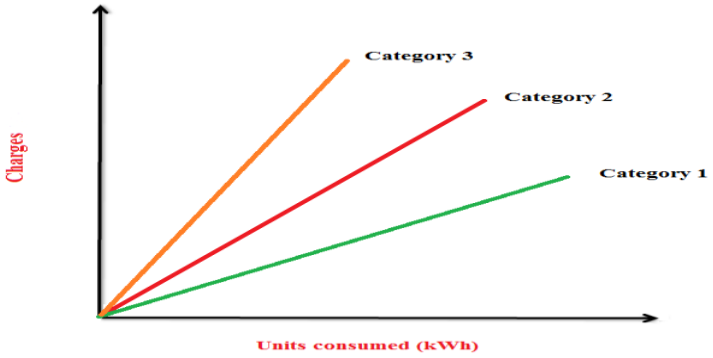

Figure 5.5: Flat rate tariff

5.4.3 Block Rate Tariff

In block rate tariff, overall consumption of energy is divided into block than fixed the rate of energy in different blocks. In this method first block energy rate is highest than consequently it will be decreased. For an example: An energy rate of first block is Tk11 per unit (where limit is 50 unit). Second block is Tk8 per unit (where limit is 50 to 200 unit) and consequently it will have decreased. In this way, consumer will have attracted to used energy. Therefore, load factor will be increased, as a result rate of energy generation will be decreased. Generally, this method used in residential and commercial load.

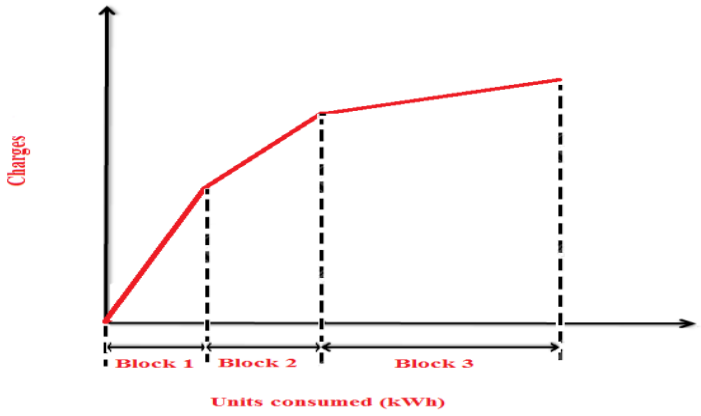

Figure 5.6: Block rate Tariff

It will have derived by the equation, Y=EZ

$Y=EZ$ If $0 \leq Z \leq A$

$Y=E_1Z_1$ If $A \leq Z \leq B$

$Y=E_2Z_2$ If $B \leq Z \leq C$

Where,

E, E_1, E_2 = Energy rate of different blocks

A, B, C = Limits of energy consumption.

5.4.4 Two-Part Tariff (Hopkinson Demand Rate)

In this method, rate of energy fixed on maximum demand and consumption of electrical energy. This rate will calculate by adding of charge such as i) Fixed charge and ii) Running charge. The fixed charge depends on the maximum demand of consumer and the running charge will be depending on number of unit consumed by the consumer. It is also derived by the equation Y=DX + EZ. In this method use two several meter to reading the maximum demand and energy consumption in the supplier side. Generally, this tariff is used in industrial consumer.

5.4.5 Power Factor Tariff

In this tariff, rate of energy depends on power factor of the load. Power factor is a most important part in power system. If the power factor is low than line loss will be increased. Therefore, effect of low power factor consumer charged more for energy losses. Power factor tariff will have divided by three types:

i. **KVA Maximum Demand Tariff:** This method something like two-part tariff but in this scenario maximum demand unit KW is replaced by KVA. KVA is inversely proportional to power factor. If consumer used low power factor load than fixed rate of maximum demand will be increased. Supplier attraction to consumer to operate high power factor load and supplier ask to consumer to installed "power factor correction" equipment.

ii. **Sliding scale Tariff:** Sliding scale tariff another name is **Average power factor tariff**. Usually average power factor is 0.8 lagging. In this method, supplier want to consumer use 0.8 lagging power factor. If consumer power factor is lower than reference power factor, consumer gate penalty, include extra charge with bill. If consumer used over power factor compared with reference power factor than supplier provide discount for consumer. Generally, it is used in large load.

iii. **KW and KVAR Tariff:** In this scheme, consumer will pay separately for both active power (KW) consumption and reactive power (KVAR) consumption. If a consumer used low power factor load, of course they will have to pay fixed charge.

5.4.6. Seasonal Rate Tariff

In this tariff, rate of energy depends on load demand on seasonal. In summer season load demand is very high. This time supplier supplies extra energy for additional load. Therefore,

cost of generating energy slidely increased. In this scenario consumer will pay high rate for per unit energy. After summer season rate of energy will be decreased.

5.4.7 Maximum Demand Tariff

Maximum demand tariff work like two-part tariff. It also charged on the basis of maximum demand. But they have little bit change with two-part tariff. In two-part tariff maximum demand is record by supplier side but in this method maximum demand meter also installed at the side of consumers. Therefore, removes all conflict between supplier and consumer. Generally, it is used in industrial load, light load is not suitable for this method.

5.4.8 Three Part Tariff

In this scheme, total cost is divided into three parts. Such as: i) Fixed charge, ii) Semi fixed charge iii) Running charge. It is derived by the equation is:

Total charge = Tk [A+ B(KW)+ C(KWH)]

Where,

A = Fixed charge

B = Semi fixed charge (Charge for maximum demand)

C = Running charge (Charge for consumed energy)

5.5 Power Factor Improvement

The cosine angel (cos θ) between voltage and current is an alternating current is known by the power factor. For reduce the cost of both consumers and generating stations it's very important to improve the power factor consistently. There are several problems with low power factor such as;

i. Equipment will have larger KVA rating
ii. Conductor size will increase
iii. There will be copper loss in large number
iv. The voltage regulation will decrease
v. Handling capacity will have reduced of the system

Quality of power is critical to efficient operation of equipment. One most important contributing element to power quality is power factor. To protect this problem there is no

alternative to improve the power factor. To improve the power factor there are 3 basic improvement technique that are used in great number. Which are:

i. Using static capacitor
ii. Using synchronous motor
iii. Phase advancers

5.5.1 Static Capacitor

To improve or increase lagging power factor, a static capacitor is widely connected in parallel basis with the equipment. The capacitor than draws a leading current and neutralizes the lagging reactive equipment of load current.

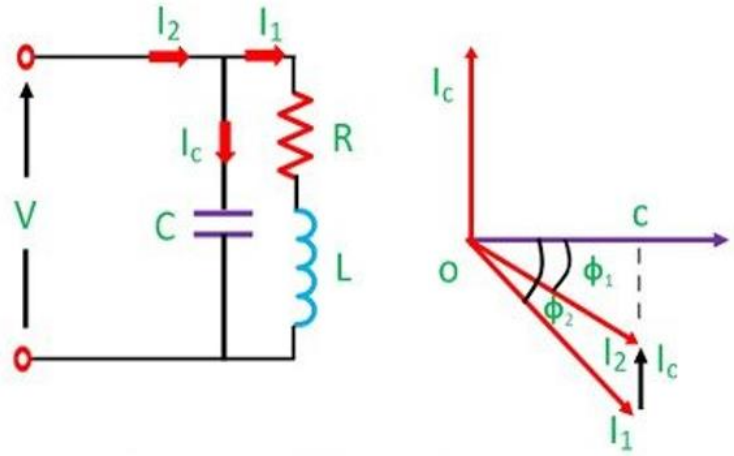

Figure 5.7: Circuit diagram of static capacitor

5.5.2 Synchronous Motor

They are 3 phase synchronous motor with no load attached to its shaft. The synchronous motor has the characteristics of operating under any power factor leading, lagging or unity depending upon the excitation. For inductive loads, synchronous condenser is connected towards load side and is overexcited. This makes it behave like a capacitor. It draws the lagging current from the supply or supplies the reactive power.

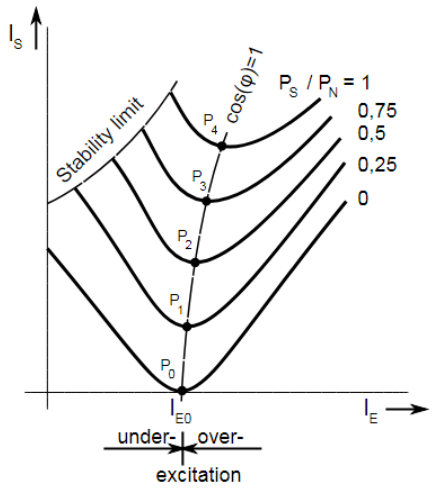

Figure 5.8: V curves for a synchronous machine

5.5.3 Phase Advances

Phase advancers basically an ac exciter which mainly used to improve power factor. They are mounted on shaft of the motor and is connected in the rotor circuit of the motor. It improves the power factor by providing the exciting ampere turns to produce required flux at slip frequency. Further if ampere turns are increased, it can be made to operate at leading power factor.

5.6 Summery

In this part we analyzed about the efficiency and economy of power plant. huge number of consumer used electrical power simultaneously. A lot of machine running randomly taking this electrical power. so it is a major issue to maintain an efficiency and economy standard of the whole system. In this part we discussed about how to maintain efficiency in plant. we also talked about the economy standard which is must necessary in a power plant.

CHAPTER 6

PLANT AND PROCESS OPTIMIZATION SYSTEMS

6.1 Introduction

The plant and process optimization products that improve the efficiency and lower the energy consumption of plant equipment and entire power plant units. Optimization of efficiency is a very complex issue for ever power plant. Lots of power plant professionals are studying for the cost effective new technologies & best practices suitable for optimization of efficiency of the power plants. In this chapter will discussed about how to optimize plant and process.

6.2 Intelligent Multi-Pump Control

Intelligent Pump Control (IPC) organized all the functions necessary to make pumps operate energy efficiently. Designed for multi-pump applications where the flow rate is variable, IPC delivers significant energy savings by among other things adjusting the number of pumps in operation to match the changing flow rate. Its built-in excess ensures the highest levels of availability, even if one of the pumps fails.

6.3 Pump Efficiency Monitoring

Pump Efficiency continuously and accurately monitors pump efficiency and flow by measuring the water temperature, water pressure and motor power of each pump. The solution
is based on the High Accuracy Delta-T Transmitter (HADTT), which was developed and patented especially for this application. This easy-to-install product provides a rich source of data that can be used for maintenance planning and for optimizing load allocation to pump groups.

6.4 Combustion Optimization for Thermal Boilers

Dynamic Optimizer provides multivariable model predictive control for optimizing the combustion process in coal-fired boilers. Dynamic Optimizer has a long track record in improving boiler efficiency through its ability to focus on a wide variety of optimization targets, such as NOx, CO and CO2 emissions, excess air, exhaust gas temperature, boiler wall atmosphere, and fire configuration.

6.5 Boiler Start-Up Optimization

Boiler Max is predictive model-based multivariable controller for online optimization of boiler start-up. It reduces start-up and shutdown times, while taking into account specific process conditions such as thermal stress of critical components and the margins for maximum permissible loads. The resultant savings in fuel and auxiliary power are between 10 – 20 % for each plant start-up.

6.6 Turbine and Boiler Coordination

Large energy savings can be achieved during plant start-up and shut down through the coordination of turbine and boiler control. MODAN and MODAKOND unit control systems enable controlled start-ups / shutdowns and load changes under economically optimized conditions. One of their main functions is to reduce the unnecessary throttling of turbine control valves. A reduction of just 3 bar can save around 1500 MWh in energy a year and result in smoother operation and less stress on the main plant components.

6.7 Boiler Temperature Control

State Space Controller provides advanced temperature control and improves temperature control performance. It lowers the deviations for live steam and reheat temperature and allows higher set points to be made for the live steam and reheat temperature. This reduces the spray flows and improves unit efficiency. Lower steam temperature deviations extend the operating life of thick-walled components.

6.8 Lifetime Monitoring of Steam Generators

BoilerLife provides lifetime monitoring of boilers and heat recovery steam generators. It measures the onset of fatigue and creep in major thick-walled components against German TRD and European EN standards for steam boilers. Benefits include improved boiler

maintenance scheduling, feedback on the effects of operational methods, and the avoidance of excessive stress on the boiler and costly unscheduled repairs.

6.9 Power Plant Performance Monitoring

PlantPerformance continuously compares actual plant performance with expected plant performance. Users can configure models based on their own calculation principles or integrate simulation models to calculate the best achievable plant performance. Plant Performance provides an early warning of equipment degradation and performance deviations, and is a valuable decision-support tool for predictive maintenance and energy trading.

6.10 Load Scheduling Optimization

PowerFit determines the optimal distribution and scheduling of power and heat generation for multi-unit power plants (also known as unit commitment). Users can define technical and commercial constraints, as well as lifetime and emission constraints. PowerFit optimizes generated and purchased energy to satisfy load demands posed by energy consumers, and acts as a decision-support tool for cost-optimal trading in deregulated markets.

6.11 Summery

Optimization means the action of making the best or most effective use of a situation or resource. In this chapter discussed about how to optimize plant efficiency process efficiently to use plant resource and what is need to additional equipment to optimize the efficiency.

CHAPTER 7

SITE SELECTION OF DIFFERENT POWER PLANT

7.1 Introduction

Selecting a proper site for a power plant is vital for its long term efficiency and a lot many factors come into play when deciding where to install the plant. Of course it may not be possible to get everything which is desirable at a single place but still the location should contain an optimum mix of the requirements for the settings to be practical for long term economic foundation of the plant. All side selection is based on Bangladesh's installed power plant. In this chapter we will cover site selection of steam power plant, hydroelectric power plant and nuclear power plant.

7.2 Steam Power Plant

For **Steam power plant** the requirements of selecting a site is given below

- **Fuel supply**: the whole plant should be located in near the fuel mines, so that the transportation cost of fuel will be less.
- **Water availability**: we are talking about steam power plant so huge amount of water is required for condenser. Therefore, the plant should be located in near of a river bank or near a canal which ensure the continuity of water.
- **Transportation facilities**: power plants often required the transportation of material and others machinery. therefore, good transportation facilities must exist in power plant site.
- **Land cost and type**: steam power plant should be located in a place where's land is cheap. Because of it is necessary to extend the plant in near future. Also the bearing capacity of that land will be adequate.
- **Nearness to load centers**: to reduce transmission cost the plant should be near with the center of load.
- **Far from populated area**: for steam a huge amount of coal is bunt every time, so that there is a lot of smoke produces which pollutes the neighboring area.

7.3 Hydro-Electric Power Plant

For Hydro-electric power plant the requirements of selecting a site is given below

- **Water availability**: since the main requirement of a hydro-electric power plant is water, a huge amount of water or water carrying plants should very close at the power plant.
- **Water storage**: water supply is varied from time to time during year. This makes it important to store water so that the plant can get water for generation of power throughout the whole time. The storage helps in equalizing the flow of water so that any excess quantity of water at a certain time of the year made available during times of very low flow in the river.
- **Cost and type of land**: land for the plant construction should be at a reasonable price. Also the bearing capacity of the ground should be adequate to withstand the heavy equipment to be installed.
- **Transportation facilities**: the site should be accessible by transportation facilities. Because the important equipment's are transported plant through road or rail.

7.4 Nuclear Power Plant

For Nuclear power plant the requirements of selecting a site is given below

- **Water availability**: as sufficient water is required for cooling purposes, therefore the plant site should be located where ample quantity of water is available like across a river or by sea side
- **Waste disposal**: Fission reaction produces o lot waste in nuclear power station which is generally radioactive. These must have disposed of properly to avoid health hazards. Therefore, the site selected which have the arrangement for disposal of these radioactive waste.
- **Distance from populated areas**: the site for nuclear power station should be quite away from populated areas because there is a danger of presence of radioactivity in the atmosphere near the plant.
- **Transportation facilities**: the site should be accessible by transportation facilities. Because of the movement of important equipment's and workers.

7.5 Diesel Power Station

For Diesel Power Station the requirements of selecting a site is given below

- **Near to Load Center:** As far as possible the plant should be installed near to load center, to reduce transmission & distribution cost of electrical energy.
- **Availability of Land:** For erection of diesel power plant, land should be available near to load center at low cost.
- **Availability of Water:** The soft water is freely available for the purpose of cooling.
- **Foundations:** As we know that, the diesel engines or a machine produces vibrations. So provide good foundation to erect the diesel engine.
- **Fuel Transportation:** The diesel plant is far away from fuel mines. So to provide fuel to the plant arrange good transportation facility like road, rail etc.
- **Local Conditions:** For increasing the demand of power & future expansion space available.
- **Noise Pollution:** The plant should away from local areas, because it produces noise.

7.6 Summary

Every plant is different from others. Different in various status. in this part we described one of this status, which is site of a power plant. Plant using coal needs huge amount of water to produce steam for generating electrical power. so its necessary to select site for this kind of plant in near of river or water sources. In hydroelectric power plant water is the key features for generating electrical power. So its mandatory to choose site in where water is always available through out every time in year. This thesis part will help how to select site for plant and which key indicators will be in main concern for developing a new plant.

CHAPTER 8

DETAILS OF GENERATION TERMINOLOGY

8.1 Introduction

Generation particular are the most important element in the modern generation sector. In this portion deliver a report about electricity demand, plant generation voltage and frequency. Electrical generation sector divided into two public and private sector. Public and private sector generating voltage and demand are different. This chapter mainly cover to generation capacity, demand power, generating voltage and system frequency.

8.2 Generation Capacity

The installed capacity of Bangladesh is 16048 MW as of July 2017 (Annual report by BPDB). Bangladesh already started to construction of the 2.4 GW Rooppur Nuclear power plant, which is go into operation in 2023. Generation power of Bangladesh is divided by two sector, public and private. Also energy import from neighbor's country. At public sector installed generation capacity is 7582 MW, which is 56% of the overall installed capacity. At private sector installed capacity is 5122 MW, which is 40% of overall installed capacity. Otherwise 600 MW energy is imported which is contributed 4% of total energy.

Due to the fuel shortage, maintenance, aging plant can't operate their maximum efficiency. In the bellow show installed capacity by owner on June 2018.

A) Public Sector	**Installed Generation Capacity (MW)**
BPDB	4508
APSCL	1508
EGCB	622

RPCL	77
NWPGCL	718
BPDB-RPCL JV	149
Subtotal	7582 MW
B) Private Sector	**Installed Generation Capacity (MW)**
IPP/SIPP	3232
RENTAL	1890
Subtotal	5122 MW
C) REB (For PBS's only)	251
D) Energy Import	600
System Total Installed Capacity	13555 MW

Table 8.1: Installed Generation Capacity (owner wise)

The generation capacity by fuel is given

Fuel types	**Total Capacity (in MW)**
Coal	230
Gas	8806
HFO	855
HSD	2834
Hydro	230
Imported	600

Total	13555 MW

Table 8.2: Installed Capacity of Bangladesh's Power Plants (fuel type)

Also the generation capacity plant type is given

Plant Type	**Total Capacity (in MW)**
Steam Turbine (ST)	2116
Gas Turbine (GT)	1105
Combined Cycle	4859
Reciprocating Engine (RE)	4645
Hydro	230
Imported	600
Total	13555 MW

Table 8.3: Installed Capacity of Bangladesh's Power Plants (plant type)

8.3 Load Demand

In the Bangladesh load is varying at season-wise. At the summer season demand is very high, winter season demand is quite low. At summer generated electricity is not enough to make up the load demand. Therefore, some of the area need to impose load sheading due to shortage of electricity. Although demand of electricity is increased very quickly due to enhance economic avidities in the country with sustained GDP growth. At present growth of demand is about 7.3%, in future this rate will be increased. According to PSMP-2016 study year wise peak demand forecast is given in table.

Fiscal year	Peak Demand (MW)
2015	10,283
2016	11,405
2017	12,644
2018	14,014
2019	15,527
2020	17,304
2021	18,838
2022	20,443
2023	21,993
2024	23,581
2025	25,199
2026	26,838
2027	28,487
2028	30,134
2029	31,873
2030	33,708

Table 8.4: Demand Forecast 2015-2030

The maximum peak generation and maximum peak demand of Bangladesh in last ten year illustrated in table. It is preparing by Annual report in BPDB.

Maximum generation in 2009	4296 MW as on September 18
Maximum generation in 2010	4698.5 MW as on August 20
Maximum generation in 2011	4925.50 MW as on August 23

Maximum generation in 2012	5999.00 MW as on August 01
Maximum generation in 2013	6254.00 MW as on July 12
Maximum generation in 2014	6886.00 MW as on July 13
Maximum generation in 2015	6254.00 MW as on July 12
Maximum generation in 2016	6886.00 MW as on July 13
Maximum generation in 2017	7349.00 MW as on August 13
Maximum generation in 2018	11387 MW as on July 18

Table 8.5: Ten-year maximum generation

8.4 Generated Voltage and Frequency

Generated voltage is the voltage develops across the terminals of the generator without any load connected. Generation voltage also called the excitation voltage. This is not a fixed value. Different generator provides different voltage. Another most important element of generation is output frequency. The electrical output of generator must be maintained at a fixed rating of frequency. Normally in the Bangladesh it is 50 Hz. Here the given different generating voltage and frequency in different power plant of Bangladesh.

Power Plant Name	**Terminal Voltage**	**Frequency**
Ashuganj Power Station	11 KV, 13.8 KV, 15.75 KV	50 Hz
KUTUBDIA DIESEL GENERATOR	11 KV	50 Hz

BAGHABARI POWER STATION	11 KV	50 Hz
GHORASHAL POWER STATION	11 KV, 11.5 KV & 15.75 KV.	50 Hz
SHIKALBAHA POWER STATION	15.75 KV	50 Hz
SHAHJIBAZAR POWER STATION	11 KV	50 Hz
TONGI POWER STATION	11.5 KV	50 Hz
SIDDIRGONJ POWER STATION	11 KV, 11.5 KV & 15.75 KV	50 Hz
Rupsha 800-Megawatt Combined Cycle Power Plant	15.75 & 10.5 KV	50 Hz
CHADPUR CC POWER PLANT	15.75 KV	50 Hz
KHULNA POWER STATION	11 KV	50 Hz
Siddhirganj GT	6.6 KV	50 Hz
Meghnaghat CCPP (Summit)	15.75 KV	50 Hz
Meghnaghat IEL	11 KV, 11.5 KV	50 Hz
Gazipur RPCL	11 KV , 11.5 KV and 15.75 KV	50 Hz
BHERAMARA POWER STATION	11KV	50 Hz
BARISHAL GAS TURBINE POWER STATION	11 kV, 11.5 kV & 15.75 kV	50 Hz
HATIYA DIESEL GENERATOR	3.3 - 13.8 kV	50 Hz

KUTUBDIA DIESEL GENERATOR	11kV	50 Hz
THAKURGOAN DIESEL GENERATOR	3.3 - 13.8 kV	50 Hz
SAYEDPUR DIESEL GENERATOR	3.3 - 13.8 kV	50 Hz
RANGPUR GAS TURBINE POWER STATION	11 kV	50 Hz
Bhola 225 MW CC Power Plant	11KV	50 Hz

Table 8.6: Different power plant terminal voltage

8.5 Summery

In this portion we discussed the basic 3 generation particle. in description we can see that the terminal voltage of generation part is changes from plant plant. somewhere is 230 KV, and somewhere is 11 KV. Terminal voltage is basically differing for fuel that we used for generation electric power in different power plant. If it's used natural gas its terminal voltage is high and if diesel is used for fuel it will be low as 3-11 KV.

CHAPTER 9

FEEDING TO TRANSMISSION

9.1 Introduction

If consumer not found any electrical power, there is no value to generate electrical power so it need to transmit power consumer from power plant. Initial terminal voltage from generator is very low, it's not possible to transmit. Therefore, voltage need to step-up. It is done by substation. A substation is an important part of electrical generation, transmission and distribution. Substation did transform voltage from high to low and low to high or perform any of several important function. Substation are the point in the power network where transmission line and feeder are connected together through circuit breaker or switches via busbar and transformer.

In the power plant, must installed step-up substation where voltage should be step up or transform low to high. Here we are discussed about Ashuganj power station com. Ltd. (APSCL) substation. The substation is an assembly of the following major electrical equipment.

i. Transformer
ii. Power Transformer
iii. Instrument Transformer
iv. Isolator
v. Busbar
vi. Lightning Arrestor
vii. Circuit breaker
viii. Relay
ix. Transmission line

9.2 Transformer

A transformer is a static electrical machine which is transfers electrical energy one circuit to anther circuit through electromagnetic induction process. Frequency remain constant when electrical energy was transfer but the voltage can be increased or decreased according to

requirement. In generation section installed substation transformer must be used for increased voltage level. Usually two types of transformer used in the substation. Such as:

i. Power Transformer
ii. Instrument Transformer

In this section we will discussed all transformer according to APSCL setup.

9.2.1 Power Transformer

Power transformer are used in substation for transmission purposes according to requirement for stepping up or down the voltage. It operates mainly during high or peak load and has a maximum efficiency at near full load. In APSCL's substation has 9 units, every unit used three power transformer and one auxiliary transformer. Here listed to APSCL's power transformer.

Unit	**Primary voltage**	**Secondary voltage**	**Rated power**	**Phase**
Unit 1&2	11 KV	132 KV	76 MVA	3Φ
Unit 3,4&5	15.75 KV	132 KV & 230 KV	Up to 100 MVA	3Φ
Unit 6,7&8	13.8 KV	132 KV	76 MVA	3Φ
Unit 9	11 KV	132 KV	76 MVA	3Φ

Table 9.1: APSCL power transformer rating

9.2.2 Instrument Transformer

In the substation need to measure high magnitude current and voltage. Therefore, need to measuring instrument having high range mean huge instrument or there's another way using transformer whose turn ratio is well known. This types of transformer called instrument transformer. Which is measured the current or voltage. These instrument transformers are two types. Such that:

i. Current Transformer

ii. Potential Transformer

9.2.2.a Current Transformer

Current transformer is an instrument transformer which is used for purposed in measured alternating current. It is produced a current in its secondary which is proportional to the current in its primary. Here listed APSCL's current transformer rating.

Rated current	1920 A
No of phase	Single phase
Ratio	800 : 1
Burden	30 VA
Class of accuracy	0.2
Rated frequency	50 Hz

Table 9.2: APSCL's Substation used current transformer rating

9.2.2.b Potential Transformer

Potential transformer is an instrument transformer which is used for measure high voltage. Potential transformer is stepping down high voltage to lower safe voltage. Which is parallel connected with line. APSCL's used outdoor type 132 KV rated voltage potential transformer. Here listed APSCL's potential transformer rating.

Rated voltage	132 KV
Secondary voltage	110 V
Burden	60 VA
Insulation level	275/650 KV
Rated frequency	50 Hz
Class of accuracy	0.2
Ratio	132000/110

Table 9.3: APSCL's Substation used potential transformer rating

9.3 Isolator

If substation need to breakdown the circuit where circuit breaker cut the circuit temporary but Isolator is used to permanently break the circuit. Isolator is a mechanical switching device that in the open position allow to isolation of the input and output. Isolator is placed in both end of the circuit breaker. Isolator do not have any current breaking or current making range. Isolator are interlocked with circuit breaker.

9.4 Busbar

Busbar is important part of substation. Which is conductor or group of conductor used for collecting electrical power from several incoming feeder and supply to the outgoing feeder. On the other ward busbar is like junction in which all the incoming and outgoing current meet. Several types of busbar have. Such as

i. Single busbar
ii. Double busbar
iii. One and a half busbar
iv. Ring busbar
v. Mesh busbar

In the APSCL's substation double circuit bus bar is used. Which diameter are 50mm or more and used solid cupper used as a busbar material.

9.5 Lightning Arrestor

A lightning arrestor is a device which is protect substation's equipment from lightning. It also called surge diverter. Alighting arrester has two terminals, high voltage terminal when thunder strikes any equipment in substation, connected lightning arrester made a low resistance path for pass high voltage electricity equipment to ground without damage the equipment. Many types of arrestor used in outdoor substation, such as:

i. Rod arrestor
ii. Horn gap arrestor
iii. Multi gap arrestor
iv. Expulsion type lightning arrestor
v. Valve type lightning arrestor

vi. Metal oxide lightning arrestor

In APSCL's substation used i) Horn gap arrestor ii) Rod arrestor and iii) Metal oxide (zinc oxide) lightning arrestor are used.

9.6 Circuit Breaker

In substation circuit breaker is one of essential parts. Circuit breaker is automatic switch which design for protect electrical equipment from damage caused by excess current from overload or short circuit. When fault is occurred, relay sense this and send a signal at circuit breaker which can operate and disconnect healthy parts from faulty parts. Many types of circuit breaker, such as:

i. Oil circuit breaker
ii. Air circuit breaker
    a. Cross-blast circuit breaker
    b. Axial blast circuit breaker
    c. SF6 circuit breaker (Sulphur hexafluoride)
    d. Vacuum circuit breaker

Following types of circuit breaker are used in APSCL's substation.

i. SF6 circuit breaker (Sulphur hexafluoride)
ii. Oil circuit breaker

At APSCL's substation oil circuit breaker is used for protect 33kv and132 KV busbar and SF6 circuit breaker (Sulphur hexafluoride) is used for protect 230 KV busbar. The rating of both circuit breaker is listed at table.

Type	3AP1DT
Rated voltage	145 KV
Rated lightning impulse withstand voltage	650 KV
Rated power frequency withstand voltage	275 KV
Rated frequency, f	50 Hz
Rated normal current, I_r	3150 A
Rated short circuit breaking current, I_{sc}	40 KA
Rated duration of short circuit, t	3 sec
Rated out-of-phase breaking current, I_d	10 KA

Rated line-charging breaking current	50A
Temperature class	-25˚c to 55˚c

Table 9.4: oil circuit breaker rating

Now listed SF6 circuit breaker (Sulphur hexafluoride) rating

Type	H 80/-132/1250-5000E
Rated voltage	132 kv
Max. service voltage	170 kv
Rated current	1250 A
Breaking capacity	5000 MVA
Frequency	500 Hz
Natural frequency	1.5 KHz
Making current	55/43 KA
Short time current	32 KA

Table 9.5: SF6 circuit breaker rating

9.7 Relay

A relay is an electrically controlled switch which is used for detecting any type of abnormal condition of the system and send a signal to the circuit breaker to operate and protect healthy part of the system from faulty part.

At APSCL's substation used in different types of relay. The following types of relay are used in APSCL's substation.

i. Induction type relay
ii. Percentage differential relay

9.7.1 Induction Type Relay

Induction type relay is used for include load and over current protection for APSCL's substation. It has "Inverse Definite Minimum Time" (IDMT) characteristic. In this relay

angular force is used for time adjustment to direction. The relay is sensitive to direction. This type of relay is used for providing protection of generator, motor and feeder at substation.

9.7.2 Percentage Differential Relay

Percentage differential rely is operates on the phase difference of two or more similar electrical quantities. At APSCL's substation used it for protection proposes of power transformer. Two current transformer placed on the where need to protection and two point of both CT are connected with percentage differential relay. The current difference between two current transformers. It is sensed by relay and send a signal to circuit breaker to operate. If the current different is greater than zero, then the relay will be operating.

9.8 **Transmission Line**

After generation of electrical energy, it is need to supply the consumer. To transfer energy generating station to national grid, it is done by transmission line. Two type of transmission line have.

i. Underground transmission
ii. Overhead transmission

Underground transmission is more expansive than overhead transmission and they have lots of limitation. Therefore, APSCL's used in overhead transmission line. Two transmission line and one distribution line cover by APSCL's substation.

Distribution line: use for local area, 33 KV line are installed in APSCL's substation.

Transmission line:

i. 132 KV transmission line used to transmit power plant to national grid.
ii. 230 KV transmission line used to transmit power plant to national grid.

9.9 Summary

In generation of electrical power, it is most important to sending this power to consumer through different instrument. in this part we discussed how to prepare electrical power to send in transmission line. initially the terminal voltage is very low that couldn't transmit to consumers. so been through a process every plant succeeds to send electrical power to its consumers. in this part we described that process with each instrumental functions.

CHAPTER 10

IMPROVEMENT OF EFFICIENCY AND POWER FACTOR OF TRANSMISSION LINE

10.1 Introduction

High efficiency and high power factor is the most important issue for any power plant. Load demand at consumer side is not constant for power plant. Therefore, plant cannot operate at sane rated all the time but plant cannot shut down instantly. On the other hand, if plant operate same rated than increased the generation loss, economically plant will get loss therefore plant cannot run efficiently. So it is urgent to design that plant will full-fill the demand and plant will run high efficiently. Another important issue is power factor, at load side it is not constant due to consumer side not always resistive, inductive or capacitive load. Therefore, power factor is varied. If power factor varied than it is harmful for consumer. Load will be damaged or face other problem. Therefore, high power is also important for plant.

10.2 Concern of High Efficiency

In the generation sector of Bangladesh many kind of power plant are used; each power plant has a different way to operate plant at high efficiency. In this section we discussed, how to operate coal fired power plant at high efficiency. Currently, almost all coal-fired power plants are steam power generating units using the Rankine cycle. The maximum efficiency of a Rankine cycle is restricted by the second law of thermodynamics and is limited to below the Carnot efficiency. To operate the plant in high efficiency then may concern the technological progress including reduction of stack losses, improved combustion, coal drying, advanced controls, reduction in auxiliary power demand, improved steam turbine aerodynamics, flue gas heat recovery, and other measures, as well as increases to the underlying thermodynamic cycle

by increases in steam temperature and pressure. In the below discussed how to operate plant high efficiently.

10.2.1 Fuel Cell

Fuel cells are electrochemical devices that convert chemical energy in fuels into electrical energy directly. The intermediate steps of producing heat and mechanical work typical of most conventional power generation methods are avoided, fuel cells are not limited by the thermodynamic limitations of heat engines such as the Carnot efficiency. Also, because combustion is avoided, emissions of pollutants from fuel cells are minimal and hence, fuel cells can produce power with high efficiency and low environmental impact.

10.2.2 Magneto Hydro Dynamic (MHD) Power Generation Systems

An MHD power generator is a device that generates electric power by means of the interaction of a moving conductive fluid (usually an ionized gas or plasma) and a magnetic field. As all direct energy conversion processes, the MHD generator can convert thermal energy of a fuel directly into electricity. In this way the static energy converter, with no moving mechanical parts, can improve the dynamic conversion and work at temperatures much higher than conventional energy conversion processes. The MHD power generation process can be directly coal fired that means of making more efficient use of coal.

10.2.3 Indirect Coal-Fired Combined Cycle Power System

This is a new way of burning coal to achieve high efficiencies and low emissions. It uses a topping Brayton (gas) cycle and a bottoming Rankine (steam) cycle. Clean air is the working fluid, therefore avoiding the expense of hot gas cleanup and the corrosion of turbine blades by coal ash. This concept is based on thermodynamically optimized, indirectly fired combined cycles.

10.2.4 Combined Cycles

Efficiency increases of a steam power plant operating on a condensing mode is one of the challenging tasks for researchers. Because no single cycle can offer high efficiency due to the own limitations and the impossibility of operating within a broad temperature range, combined

and advanced cycles have been addressed. Steam Rankine cycles can be combined with topping and bottoming cycles to form combined thermodynamic cycles that better resemble the Carnot cycle and improves efficiency.

10.2.5 Chemical Looping Combustion

Chemical looping combustion (CLC) is an indirect form of combustion in which an oxygen-containing solid material, typically a metal oxide, supplies the oxygen to a fuel, and the spent oxygen 'carrier' is separately regenerated by a high temperature reaction in an air stream. As there is no direct contact between air and fuel, CLC produces a stream of CO_2 and water vapors from which the CO_2 can be readily recovered by condensing the water vapors, eliminating the need for an additional energy intensive CO_2 separation.

10.2.6 Solar-Coal Hybrid Power Plants

A hybrid power system integrates two or more energy conversion devices into one power generation process.

10.3 Concern of High Efficiency

Power Factor (PF) is the ratio of working power to apparent power, or the formula of PF = $\frac{KW}{KVA}$. An inductive load, like a motor, compressor or ballast, also requires Reactive Power to generate and sustain a magnetic field in order to operate. We call this non-working power KVAR's, or kilovolt-amperes-reactive. Every home and business has both resistive and inductive loads. The ratio between these two types of loads becomes important as you add more inductive equipment. Working power and reactive power make up Apparent Power, which is called kVA, kilovolt-amperes. We determine apparent power using the formula, $kVA_2 = KV \times A$.

10.3.1 Improvement of PF

Low power factor means lower operating efficiency which results in a need for larger conductors (wires) and increased equipment capacity, as well as causing voltage drops as power losses increase. These equate to higher capital investment, higher expenses, and diminished distribution system performance. Power factor correction actually does not save much energy (usually less than 1% of load requirements), and even that reduction depends on how low the power factor is to begin with and how heavily loaded inductive devices are in the distribution system. However, even though energy savings are minimal, correcting power factor can bring significant savings in energy bills if the utility imposes a low power factor penalty in their rate structure, as most utilities do for industrial customers. How much your company can save through installing power factor correction methods depends on your initial power factor, the level you correct it to, motor horsepower rating versus loading, and how the penalty charge is calculated by the utility. All of these variables should be considered when determining the payback potential for different power factor correction methods.

The first step in the process of correcting your power factor is identifying what is causing the low power factor. This information will be extremely important in determining the right approach for bringing your power factor closer to unity. There are many different strategies that can be used individually or in combination to correct low power factor. A few of these strategies are:

i. Install capacitors in the distribution system.
ii. Minimize operation of idling or lightly loaded motors.
iii. Install variable frequency drive (VFD) systems to lightly loaded induction motors.
iv. Install new motors that will be operated near their rated capacity
v. Replace lightly loaded motors with motors sized to be operated near their rated capacity.
vi. Avoid operation of equipment above its rated voltage.

10.4 Summery:

In this part we discussed about the effect of high efficiency and high power factor in generation. for random supply of electrical power how high efficiency and power factor causes great effort, and how supply is changed if there is change of efficiency and power factor we described in this part.

CHAPTER 11

CONCLUSION AND RECOMMENDATION

11.1 Conclusion

In Bangladesh generation of electrical energy is big challenge people from different stages suffers maintain a low life for this problem. For solving this problem, we try to gather some efficient information which helps us to facing this huge problem.

They are various type of way to generate energy. first we talked about conventional fossil fuel type power plant using different kind of fossil fuel like gas, coal, diesel is main source of generating electrical energy in our country. And most of the generated energy came from this type of plant. But they have some issue that we must look after. Using conventional fuel is harmful for environment and fossil fuel is very limited asset in every country. We have limited fund of coal and gas. Using gas for generation is causes many difficulties in our society, the price of gas increases day by day is one of these. Nowadays in metropolitan using gas for living is become difficult day by day. On the other hand, most of the vehicles is our country runs by gas. If we don't take necessary steps to stop using gas in various steps in our daily life, we will suffer for this kind of fuel a lot.

Bangladesh is one of the most populated country in the world. People in this country don't get their basic human needs. I Bangladesh approximately 1252 people live in per square kilometer. so we don't think about solar power plant. Or wind power plant. Because this type of power plant required vast land area which we don't have in our country

on the other hand, our seas don't have enough tide to build tidal power plant. Plus, we don't have scope to builds geothermal power plant. Moreover, some of these conventional plant in our country built only for 3-15 years. after that they stop their supply of energy. but building this plant costs a huge investment. So this type of plant causes loose a great amount of money of our government and other privet company.

So concluded with problems in our thesis we were tried to made some solution of generation problem in our country. From the chapter 6 we talked about how to improve and increases

efficiency in plant. We also show some facts how we solve our generation problem with help of our country's resources.

11.2 Recommendation

The aim of this thesis was to explore a new result of generation electrical power in Bangladesh. Generation of electrical power is not new in Bangladesh. We had almost every conventional power plant in our country. We used natural gas, coal, diesel for this kind of plant for generation. And we have also used some renewable way to generate power. We have hydroelectric power plant too. In 2023-24 we will have also nuclear plant that helps to continuous supply of electrical power in all over the country

We have known that Bangladesh is a land of river. But nowadays river lost their heritage and people who use these rivers for their living fall into poverty. river lost their Navigability day by day. It causes lots to our society. Drought and flood visits every year and costs huge amount of assets and life for this Navigability problem of us rives.

Hydroelectric power plant costs more than other power plant. But its running cost is practically nil because of no fuel is required for generation. Its fuel transportation cost and maintenance cost also very low in compare than others.it have also no standby losses and this type of plant starts instantly. The simplicity and cleanliness of this kind of power plant is very simple and clean. Our largest hydroelectric power plant name is kaptai dam which is generates 230 MW in national grid. So the thing is if our government focuses this particular matter and works for retaining our rivers Navigability, it will help to maintain a healthy river site and help in many ways. First of all, it will help us to regain our lost heritage and tradition about our river it will help to maintain a good way of tread and food. But foremost and most importantly it will help us to gain capability to generates our own electrical power in our own country. If our government builds more hydroelectric power plant in some of our rivers than it will help the national grid to dependable in our own generating electrical power. Yes, it will cost huge amount of initial funding but it has no side effect (emission of CO_2 gases) like coal or diesel power plant. It will definitely not have the chance to produces any kind of radiation. In nuclear power plant there is slight but strong chance of radiation which is very dangerous for society and humanity. But in hydroelectric power plant occurring these kind of problem has no chance. So despite all the facts and issue our thesis recommends hydroelectric power plant is more reliable to generates electrical power.

On the other hand, Bangladesh is the 9th most populated country in the world. The urban population growth rate is increasing day by day. With this vast population there is a problem increases which is waste management. Right now the waste generation in Bangladesh is almost 22.4 million tons per year or 150 kg/ cap the rate is increasing day by day. This rate will be 220 kg/ cap in 2025. The irony of this problem is there is no proper collection of waste. Moreover, most of this waste disposed illegally. This makes a serious environmental and health hazards to human. On the other hand, if we see Switzerland generate more than 700 kg/ cap, which is the highest rates in the world. but they turn this huge amount of waste to energy. A main waste to energy plant in Switzerland that eventually process 200000 tons of waste per year and turns them into energy which is 155GW. IF They turns their problem into solution why don't we try this?

Energy is very big problem in Bangladesh. If we use our everyday waste and generates energy from them, we will get energy and rid of our environmental problem too. So our government should make necessary steps to build this kind of plant and make our country dependable in energy.

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