EFFECT OF CLIMATE CHANGE ON ELECTRICITY DEMAND AND POWER GENERAION OF BANGLADESH

A Thesis

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Of

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DECLARATION OF ORIGINALITY

We hereby declare that this thesis has not been submitted, partly or fully for the award of any other degree or diploma in any university. To the best of our knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text and ethics procedures and guidelines have been followed.

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ABSTRACT

Twenty first century has faced a lot of challenges among them climate change is one of the major concerning issue. Climate change has threatened to the human settlement industrial sectors specially the power sector. Frequent study has been conducted to identify to impact of climate variation on electricity demand and power generation in Bangladesh. For maintain the minimum living standard and economic growth, a sustainable power generation and electricity market is necessary. The objective of this study is to detect the effect of climate change on electricity demand and power generation in developed country like Bangladesh. The study consists of two cases (a) Electricity demand and power generation in Bangladesh (b) Electricity market in Bangladesh. By conducting this research, some direct and indirect parameters affecting the electricity demand, power generation and electricity market due to environment change. The parameters will shake the efficiency of the power generation and can create physical threat on infrastructure. Electricity demand also affected by climate change for instant heat island. Consequently the electricity market of Bangladesh has been changed according to global market.

To investigate the impact on electricity demand and power generation present and future power capacitated has been noted till 2100. This study identified the effect of climate change power generation capacity which is followed by electricity demand and electricity market. Due to climate change in Bangladesh 30% of total power generation especially in coastal area will face severe risk. Additionally electricity demand will be affected by heat island due to 2.4℃ temperature rise.

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Q_F	Cooling water demand (m^3)
KW	Installed capacity (kW)
h	Operations hour (h)
η_{total}	Total efficiency (%)
η_{elec}	Electric efficiency (%)
α	Share of water heat not discharge by cooling water (%)
β	Share of water heat released in air (%)
ρ	Water density (ton/ m^3)
AS	Permissible temperature increase of the cooling water (°K)
EZ	Densification factor

ABBREVIATIONS AND ACRONYMS

MW	Mega Watt
MJ	Mega Joule
kJ	Kilo Joule
kWh	Kilo Watt Hour
Ppm	Parts Per Meter
Ppt	Parts Per Ton
TWh	Terra Watt Hour
SST	Sea Surface Temperature
SLR	Sea Level Rise
FO	Furnace Oil
HSD	High Speed Diesel
LDO	Low Density Oil
GDP	Gross Domestic Product
HRZ	High risk zone

Chapter 1

Introduction

1.1 Worldwide Climate Change on 21st Century

Due to global climate change various natural calamities occurs like sea level rise, frequent natural disaster. It has been creating bad impact on economy, environmental and social aspects of hundreds of millions people across the world. The global climate change is supposed to make a significant impact on industrial processes. The dependency and operation of industrial apparatus can be greatly hindered by the global climate change. Under existing plan rehearses, some generally utilized fundamental plan parameters are encompassing temperature, outline temperature, wind speed, dampness, and weight etc. Raising worry about the worldwide environmental change underlines the minimization of the effect. The worldwide environmental change is a mix of man-made demolition of habitants, verdure, and industrialization. It also depends on common changes in our planet's environment, which has continuously transformed. In any case, the pace of this environmental change has been dramatically quickened inside most recent couple of hundreds of years. After the invented of mechanical insurgency of carbon outflow has been expanding quickly. This expanded carbon emanation has made the worldwide atmosphere defenseless against human and other living creatures. It can make colossal harm and catastrophe human life, economy. Regardless of various on- going verbal confrontations about the rate of environmental change in the industrialized world, there is no question about the up and coming outcome of environmental change impact. The decrease of ozone depleting substance discharge, adjustment of new outline practice and moderation can just diminish the effect of environmental change. For the adjustment of atmosphere change, the outline of machines and handling plants likewise should be viewed as the environmental change. Figure 1.1 schematically shows the impact of the global climate change and causes of the greenhouse effect. The Geopolitical Panel on Climate Change in their Fourth Assessment reasoned that the impact of ozone harming substance will make additional changes in the worldwide atmosphere design amid the 21st century in contrast with the watched changes in the twentieth century.

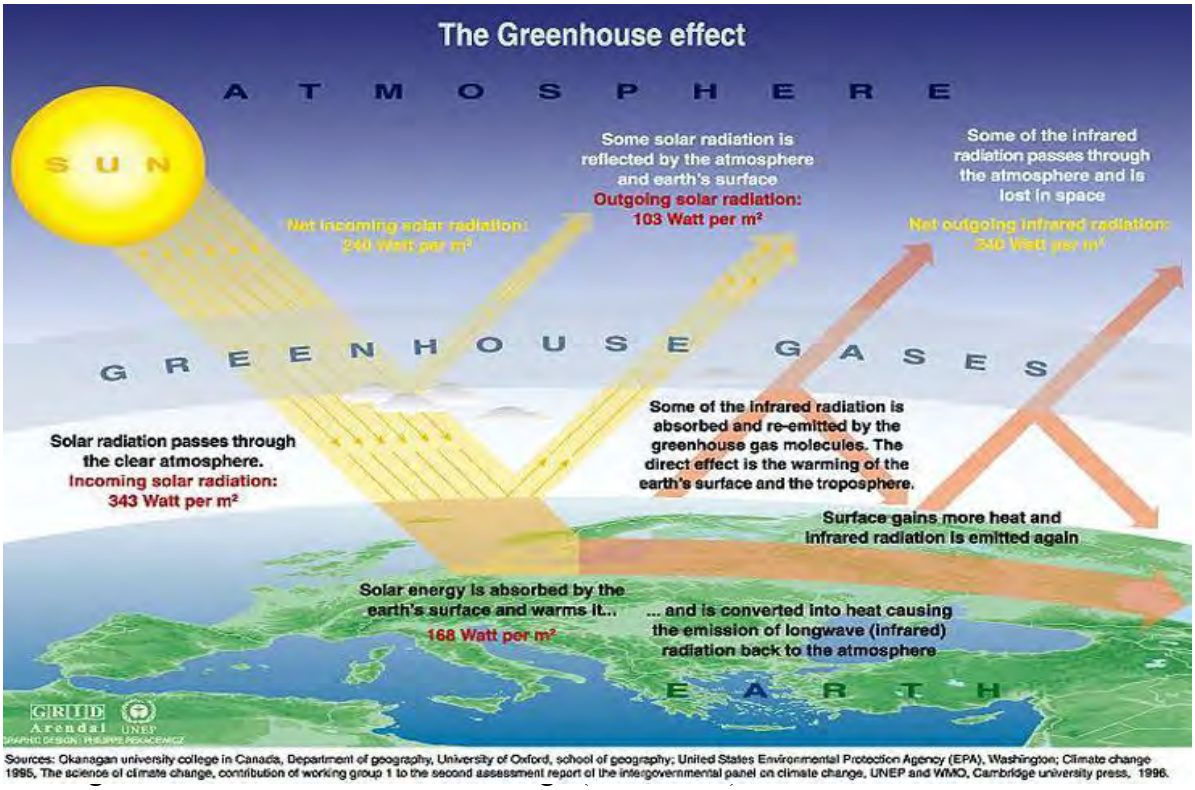


Figure 1.1: The Green House Effect

1.2 Worldwide Climate Change in Bangladesh

To explain the global warming and the problems faced by different countries, we study Bangladesh climate change. A standout amongst the most helpless and seriously influenced nations, which faces 4 catastrophic events consistently. Because of its land area and territory make it a most delicate nation on the globe. It situated on the lower region of the Himalaya Mountain in the north and the Bay of Bengal toward the south. It made by the silt conveyed by Asia's two monster streams: Ganges and Brahmaputra. The state's 145,000 km square territory is only a few meters over the ocean level. Furthermore, Bangladesh is the world's most highly populated nation with restricted normal assets. Nevertheless, the issue is that the nation can't meet up its power request. The electronic power is the help for Bangladesh's monetary improvement. Because of the power lack, outside and nearby ventures are drying out. Environmental change effect will cause a gigantic effect on the power age limit of the nation. As of late, the Government of Bangladesh has taken anticipates and the establishment of energy

plants with the goal that it can take care of its demand. These plans of advancement of energy age limit will be extraordinarily hampered because of environmental change.

1.3 Effect of climate change

Barely any works has been completed to recognize effect of environmental modification on industry particularly on control plants asked the significance of effect appraisal of environmental change on ventures particularly on control age businesses. The dry season on 1990s in numerous nations has had negative effect on control age. Environmental change effect, for example, temperature increment of waterway and diminishing steam stream may extremely influence control age. Featured that expanding surrounding temperature will make negative effect particularly on atomic power plants. The decrease of energy age in European nations because of the expansion of both encompassing what's more, cooling water temperature has been recognized. Wilbanks underlined that the effect of worldwide environmental change to be adjusted in vitality arrangement. Numerous investigations have been done on impact of environmental change. A few investigations have been done to recognize the effect of an Earth-wide temperature boost on atmosphere of Bangladesh. Temperature increment of 2.4℃ by 2100 has been anticipated in the investigation of Ahmed and Alam anticipated. High dry season chance areas in Bangladesh have been recognized. Mohal have evaluated that at least 15% land region of Bangladesh will be immersed because of environmental change. Sarwar (2007) has distinguished 15.5% of land region of Bangladesh will be immersed by 21th century. Besides, Islam has called attention to the high danger of surge influenced locale. There is a shortage of intense research contemplate on the effect of environmental adjustment in Bangladesh. Handisyde featured the impacts of environmental change on aquaculture in Bangladesh. Mourshed has contemplated the effect of the anticipated temperature increment on warming and cooling necessities in structures in Dhaka, Bangladesh. For creating nations, for example, Bangladesh, a feasible vitality supply is foremost for its financial advance. Moreover, Bangladesh is in a high danger of a dangerous atmospheric deviation. No examination has been done on effect of environmental change.

1.4 Objectives of research:

The key objectives of this research are to:

(a) Distinguish effect of environmental change on control plants.

(b) Decide the limitations that can be influenced by the environmental change.

(c) Examinations probable hazard factor for control age.

(d) Anticipate short, medium and long haul influences on control age.

(e) Associate the effects on power generation in emerging nations

(f) Identify regions with high risk in Bangladesh.

1.5 Research Questions

To accomplish the examination destinations following exploration questions has been derived:

(a) How environmental change can impact power generation limit (output)?

(b) What parameters can conceivably influence the power plant effectiveness?

(c) What are the consolidated impacts of general and environmental change factors on power generation?

(d) How these belongings can be minimized in developing states?

1.6 Reason of the Study

Environmental change will have enormous effect on human lifespan, biodiversity and infrastructure. The impact of temperature increment will increase ocean level, expanded atmosphere inconstancy and extraordinary atmosphere events. Moreover, Vitality is a key component for a flat task of both human life and economy of a country. For a supported monetary development and success, any nation needs satisfactory supply of energy for its mechanical, rural and private/benefit segments' request. It is essential to recognize how the power age limit will be influenced because of the atmosphere change. It is additionally imperative to recognize whether both the created and creating nations are in danger of environmental change or just a single of them. Along these lines the investigation chose

Bangladesh as contextual analysis for the exploration work. Moreover, it keeps on intensifying in the future. Along these lines, there is a need to contemplate the effect of environmental change on control plant. Little study has been completed on the effect of environmental change on businesses in Bangladesh. As far as effects of environmental change on control plants in Bangladesh, no study has been finished. No hazard appraisal has been completed on the environmental change effect on existing force plants. This announcement is supported in the yearly report, for example, Bangladesh Power Development Board, Power Cell information book, and Power division (2013). Power framework groundbreaking strategy is the long haul and short power age arranging of the legislature of Bangladesh. Essentially, there is no arranging or hazard evaluation for future environmental change effect on control plant in Power framework. Otherwise, the vitality arranging of the nation does not account the future environmental change affect. Consequently the existing force plants and future power age are in an awesome danger of environmental change. An examination on the environmental change effect on creating nation, for example, Bangladesh has risen as pressing and truly necessary to guarantee a economical future. This investigation has examined and distinguished the environmental change effect on control plants in Bangladesh. The investigation will demonstrate how show control plants and anticipated future power plants will be influenced by worldwide warming and environmental change. It will likewise demonstrate the conceivable areas of high hazard regions for control plants. The investigation initially anticipated the power age of the chose nations up to year 2100. At that point it has distinguished the area of the power plants and the effect of environmental change on these areas by utilizing the environmental change display. With the power age projection up to year 2100, the examination demonstrates a conceivable situation of future vitality planned. In this manner, the investigation will distinguish the pathway for vitality security as for atmosphere change affect.

1.7 Scope and Methodology of the Research

In the event that investigations of this exploration work, just fossil operated control stations have been considered, as they are the real fuel source for control plants in a large portion of the nations on the planet. On the off chance that review broke down various effect of environmental change, for example, temperature increment, ocean level ascent, surge, storm surge and typhoon,

and stream disintegration on the power plants in Bangladesh. In this examination existing force age limits by year 2013 and arranged power age limit by year 2016 have been considered. Because of the absence of accessible information, the examination accounted the area of energy plants in year 2016 to extend it up to year 2100. Moreover, the administration vision for coal based power plants by the year 2030 has additionally been accounted in the examination. Also,

because of absence of downscaling of worldwide atmosphere model to districts in Bangladesh, the investigation took the temperature increment set by the National Adaptation Program. The lessening of productivity of the power plants because of temperature increment relies upon particular power plant site parameters such aggregate productivity, electric proficiency, densification factor, offer of water warm discharged in air, offer of water warm discharged in air, offer of water warm not release by cooling water etc. Because of the absence of this particular information of each power plant, the investigation has not accounted the lessening of effectiveness of the power plants because of temperature increment. Secondary data analysis strategy has been followed for the situation contemplates on effect of environmental change on control plants in Bangladesh. The examination thought about optional information source, for example, government give an account of energy age, and give an account of future arranging of control age to assess present and future power age. From this information source the examination recognized area of energy plants and anticipated power age to year 2100. Some of these reports are yearly report of Bangladesh Power Development Board, Power Cell (2013) information book, Power framework end-all strategy (2013), and Power division (2013). For energy projection up to year 2100, the investigation additionally thought to be other optional information, for example, past examination on projection on control age in Bangladesh. Result of Long-Range-Energy Alternative Planning (Jump) displaying by Mondal ponders has been accounted in the vitality projection displaying. The measurements of World Data Bank and United Nations have additionally been utilized for vitality projection. The examination utilized 'Microsoft Excel' programming to show the power projection up to year 2100. To discover the effect of environmental change the investigation utilized previous research information on various environmental changes affect. After that, broke down the impacts with anticipated power age in various locales in Bangladesh.

Chapter 2

Literature Review

2.1Meaning of Climate Change

Climate Variation has ended up being a champion among the most basic issues which our planet is going up against by and by. Atmosphere is changing principally on account of the expression "A dangerous atmospheric deviation" which implies the ascent of the normal worldwide temperature. The expansion of worldwide temperature in the climate and seas greatly affects the precipitation examples, storms and dry spell, developing seasons, dampness and ocean level. The adjustment in characteristic wonders furthermore, parameters because of the dangerous atmospheric deviations is characterized as 'Worldwide weather Change'. Environmental change can be depicted as the massive change available for use of climate design over a time of time. As a result, the biosphere over will observe different kinds of changes. There is a concrete relationship amongst atmosphere and human prosperity's with respect to socio- economy and business. Hence, a little change may make an immense change on individuals, creature and vegetation. For instance, changes in temperature and precipitation design can limitlessly influence the development system of plants and biodiversity and may influence our sustenance creation. Be that as it may, human prompted exercises (e.g., consuming petroleum derivative) are the significant supporter of these atmosphere changes. For legitimate adjustment and relief of environmental variation, human conduct of vitality use in everyday life should be altered in cost-effective ways. As prior the adjustment begins, the cost will be less. An effective upcoming arranging won't just react to crisis circumstances yet additionally spare survives and cash.

2.2 Causes behind Climate Change and impact:

Changes in climate may be made by both regular reasons and man-made reasons. There are by and by new and more grounded certification that a huge bit of the warming over the span of the most recent fifty years was caused by a couple of human activities. It is in like manner showed that, people are changing the climate with exercises that make outpourings of ozone draining substances for instance, carbon dioxide and methane. The Earth's environment changes after

some time scales. Components that have been impacting the climate after some time scales from hundreds to a great many years are consolidated into following sub-territories.

2.2.1Natural cause:

Earth has changed and been impacted by a few common causes. All things considered, the progressions are comfort back in contrast with the developments caused by human. Sea flow, world's orbital variations, sun oriented varieties and volcanic ejections, are some characteristic reasons for environmental variation.

Change of earth orbitals:

Earth is inclined to opposite horizontal at a point of 23.5° of its orbital way .In the event that any progressions happen in the slope of the earth, it appears to be too tiny yet climatically it is imperative. It is a little incline change, but modifies the feature of the seasons. All things considered, more incline makes warmer summers and icier winters, and again this less slope makes chillier summers and slighter winters.

Sea flow:

Sea flow causes most to change the warmth over the sphere. This courses frosty water from the shafts to the equator and transfer warm water from the equator to the shaft. In the event that the development discontinues, the posts will be cooler and the equator will be hotter.

Volcanic discharge:

Due to emission, spring of gushing lava tosses out a lot of Sulphur dioxide (SO2), water vapours, tidy, and fiery remains in the air. By the revolution of phase, gases and fiery remains can modification the example of our atmosphere. Gases are affecting the preservation arrangement of actuality, by reflecting sunlight based vitality back to the universe and having a conserving impact on the world.

Change in solar:

As of late, researchers are conjecturing that an expansion in the yield of sun based vitality is the reason for the boiling of a segment in the principal portion of twentieth century. Adjustments in the yield of sun's vitality can origin the environmental change.

2.2.2Man-made reasons:

A report by the Royal Society stated that the heating of the Earth throughout the last 50 years is essentially caused by human exercises. Due to Industrial Revolution, which started in the eighteenth era, expanded measurement of carbon dioxide (otherwise called CO2) into the climate by around 40%. The measure of assimilation of CO2 in the Earth's climate appears that now it is higher than whenever in at any rate the most recent years. Nearby 30% daylight returning on earth reproduces by the highest point of our climate. About two-third of this reflection happens because of cloud and some little particles called mist concentrates. This airborne is produced by the fire of industry, fountain of liquid magma. Human exercises are primarily expanding the measure of nursery impact by three conducts. They are:

Deforestation:

A noteworthy supporter of environmental variation is chopping down the woodlands quicker than they are supplanted. Deforestation makes a gigantic effect carbon outflows. The trees integrate CO2 when they rise up. At the point when the measure of cutting trees will expand, the sponges of CO2 from air will diminish.

By burning fossil fuel:

By consuming petroleum products, billion tons of carbon dioxide came into the air .The primary source is the gas which is consuming of petroleum product in industry, rural hardware, a wide range's of transportation vehicles and private utilize, for example, warming homes, cooking nourishments thus on.

World population:

The number of inhabitants is expanding step by step. In any case the vitality asset isn't expanding. The over developing individuals utilize nature for their sustenance, domesticated animals and vitality, and by utilizing the assets, they discharge ozone harming substance.

2.3 Impact of climate change

Worldwide environmental change has effectively influenced our condition. Between 1900 and 2005, the worldwide temperature expanded 0.78°C. In spite of the fact that, this temperature change has all the earmarks of being little sum, it is extremely unsafe. This little change can cause a massive change.

The effects of global climate change are:

Effect on rainfall:

Environmental change has turned into the reason for substantial precipitation over various portions of the world. Rate is expanding in a substantial scale and producing common pulverization for example, waterway surge which can cause gigantic financial misfortunes by harming the framework, property and rural land. Because of the expansion of precipitation, storm surge what's more, tornado, the effect and force of surge will be higher.

Change on temperature:

When information accumulation began, it has been observed that a decade ago was the hottest span .The normal temperature of the air close to the Ground's surface has ascended by around 0.75 degrees Celsius .It will melt the icy masses and ocean ice in speedier rate, which will quick climb up of ocean levels. These changes in atmosphere will make extraordinary climate occasions.

Impact on cyclone and monsoon:

Increment in temperature may actuate more incessant, more grounded twisters later on. According to a recent study agriculture in Bangladesh might be ruined and late due to this rising temperatures in the future, as monsoon is highly related to agriculture,

Numerous creatures and plant species:

Precipitation and temperature will similarly influence numerous creatures and plant species around the world which will prompt eradication numerous types of plants and creatures.

Sea level rising:

As Earth's atmosphere warms, the temperatures of seas additionally increment. Because of ice tops dissolving, sea water growing, ocean level increases. Rising ocean levels can surge little, coastal islands and can threaten a huge number of individuals living in coastal regions.

Disease:

The infection jungle fever, West Nile ailment, dengue fever and waterway visual impairment are expanding. It is anticipated that million more individuals could be presented to intestinal sickness.

Rain forest:

Because of environmental change, the measure of rain fall is evolving. People have already cut down many trees because of their food, to make open place to live and cultivate.

2.4 Climate change and natural disaster:

Environmental change has expanded the catastrophic event altogether by its power also, recurrence. The investigation by Munich (2018) showed that the cataclysmic events have expanded fundamentally finished most recent 37 years particularly from 1980 to 2017. Figure 2.1 delineates the expanding pattern of recurrence of cataclysmic event from 1980 to 2017. Since 1982, the warmth wave and rapidly spreading fire (bramble fire) due to extraordinary surrounding temperature. From 1985 to 1999, the quantity of cataclysmic events expanded forcefully. A comparable increment was noted for the time of 2003 to 2017.

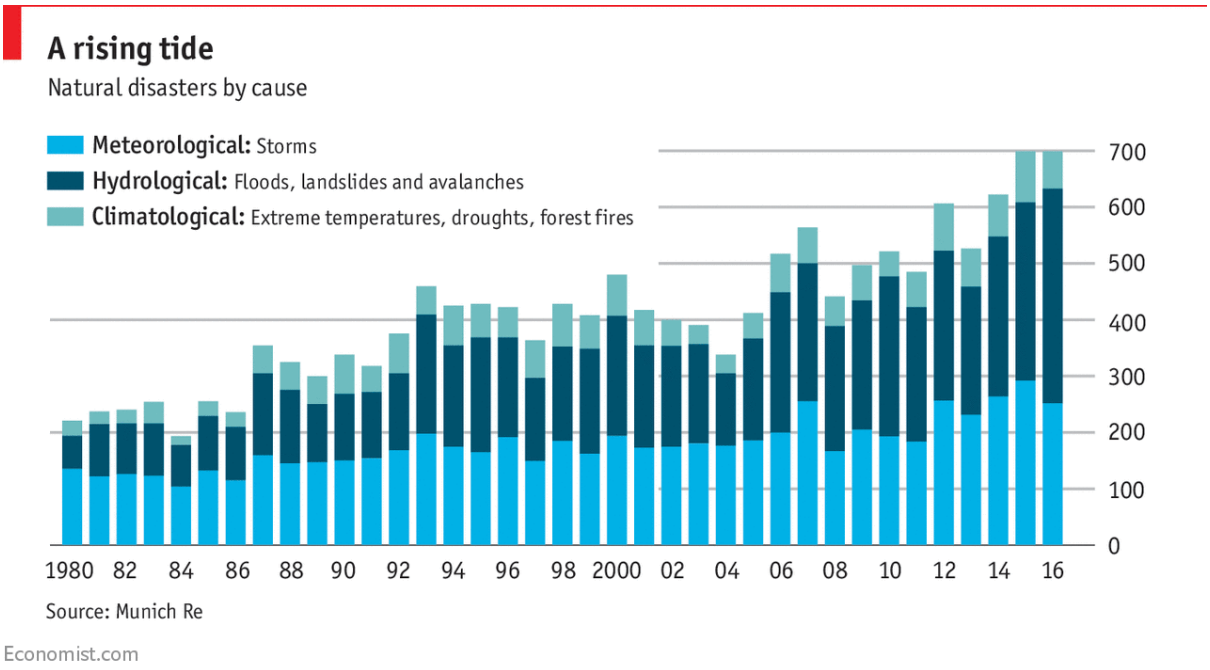


Figure 2.1 Natural disaster

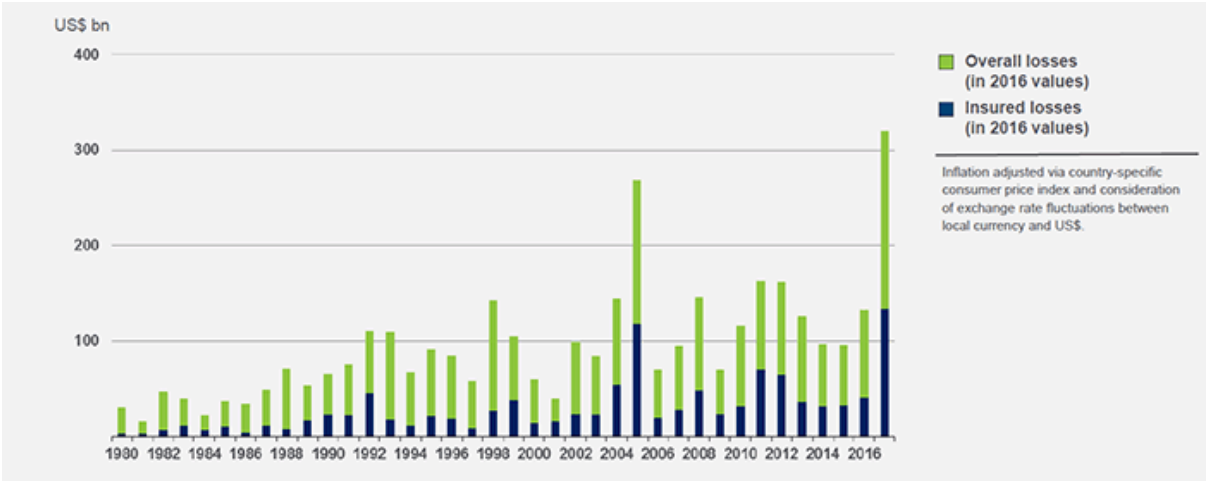


Figure 2.2 Overall losses

2.5 Impact on industry:

Two main considerations caused by the environmental change should be thought of one as, is to diminish the ozone harming substance emanation and other is to guarantee the unwavering quality of the modern task. In Table 2.1, the immediate and circuitous effect of environmental change on industry. Assembling condition coordinate effect is to guarantee auxiliary honesty, security, administration and task. Manufacturing condition such as building development and structural designing, coordinate effects are vitality costs, material, basic honesty and the procedure of development. Circuitous effects are the new standard and enactment.. Beach front ventures and frameworks are in an extraordinary danger of atmosphere change. For example, solid structure will encounter expand erosion. Moreover, extraordinary warmth wave will cause disturbance of activity of business and private structures, gear, for example, ventilating frameworks, lift and quickening agent, pumping gear et cetera.

Sector	Direct impacts	Indirect impacts	References
Built Environment: Construction, civil engineering	Energy costs External fabric of buildings Structural integrity Construction process Service infrastructure	Climate-driven standards and regulations Changing consumer awareness and preferences	Consodine, 2000; Graves and Phillipson, 2000; Sanders and Phillipson, 2003; Spence et al., 2004; Brewer, 2005; Kirshen et al., 2006
Infrastructure Industries: Energy, water, telecommunications, transport (see Section 7.4.2.3)	Structural integrity of infrastructures Operations and capacity Control systems	Changing average and peak demand Rising standards of service	Eddowes et al., 2003; UK Water Industry Research, 2004; Fowler et al, 2005
Natural Resource Intensive Industries: Pulp and paper, food processing, etc.	Risks to and higher costs of input resources Changing regional pattern of production	Supply chain shifts and disruption Changing lifestyles influencing demand	Anon, 2004; Broadmeadow et al., 2005

Table 2.1 Impact on various sector

New building materials should be acquainted with shield from environmental change. Another effect would be in vitality utilization pattern and adjustment for green material and offices. An expansion of temperature will make the issue in cooling framework as well as improve the request of energy supply for private and business aerating and cooling frameworks. In addition, new normal and direction for decreasing carbon outflow and vitality utilization, will include minor effect these ventures.

2.6 Impact on design equipment:

Climate change impacts should be improved in design parameters to ensure safety, operability as there is a noteworthy impact of climate change on design parameters.

Temperature:

Change in temperature is a major worry for environmental change affects. . In Voiland (2011), the temperature increment from 1880 to 2000 in light of four examinations has been plotted in Figure 2.3. The figure demonstrates the temperature expanded steadily from 1910 to 2000 with a few variances. The diagram obviously demonstrates the steady temperature rise.

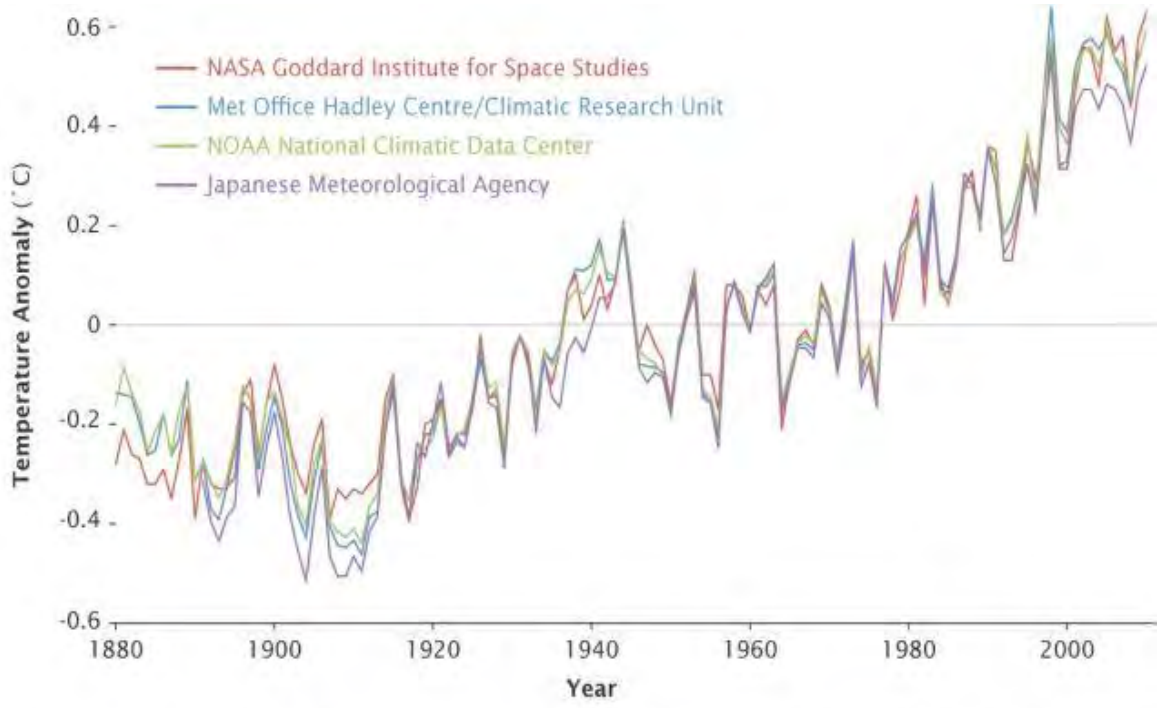


Figure 2.3. Increase of world temperature based on different meteorological studies

Structural design:

In high temperature metal twists and makes disappointment of the structure, for example, rail line harms. During planning a metal structure, architect should consider authentic temperature information as well as conceivable future temperature information. The examination uncovered that lower than common temperature was utilized as a part of plan parameters.

Cooling system:

For the cooling arrangement of energy plants, the environmental change on the nearby cooling water supply source, ought to be altogether examined. Rather than considering previous verifiable greatest temperature information, anticipated most extreme water temperature amid summer season in up and coming hundreds of years. For the outline of energy plant cooling frameworks. Besides, the effect of environmental change on the hydrology of cooling water supply ought to be measured. Probability of expanding dry season period in summer season and the expanding pattern of climatic temperature ought to likewise be considered in outlining cooling frame.

Wind speed:

In beach front regions, the breeze speed can be expanded altogether because of worldwide atmosphere change. Thus, in computing structures in waterfront zones, the anticipated increment of wind speed ought to be considered.

Height of plants:

The generation plant zone of an industry in immersion chance area ought to be tall enough to kill the impact of ocean level ascent. Additionally the valve, instrument ought to be at a stature to dispense with harm because of expanded flooding. A surge security divider around the plant can be intended to diminish the hazard because of surge.

2.7 Review of different power plant:

Power stations are characterized as mechanical to produce electric control. There are a few sorts of energy plants. In following subsections brief depiction of most broadly utilized power plants is spoken to:

2.7.1 Thermal power plant:

In thermal power plant energy of fuel is converted to rotational energy. There are a number of Thermal Power Plant. A short brief of these power plants are:

Steam power plant:

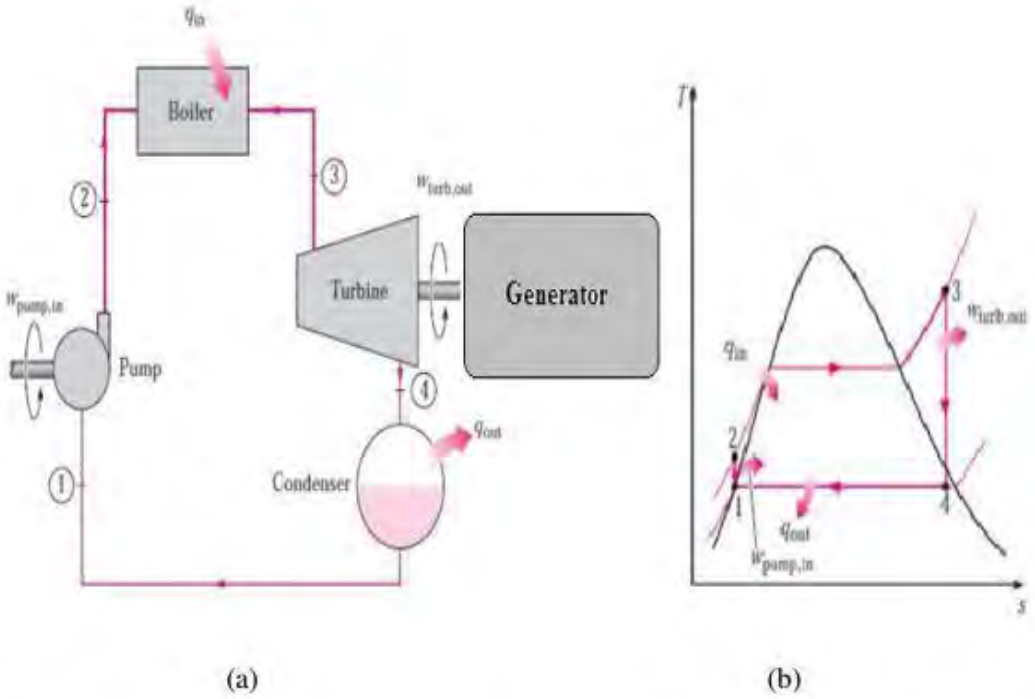


Figure 2.4. Steam Power Plant with an Ideal Rankine Cycle. (Cenegal and Boles, 1998)

Warmth is included the evaporator which changes over aquatic to steam. The steam streams over the turbine and pivots pole of the turbine. Thus turns the pole of the generator and create control. After, the steam streams to condenser and consolidate to water. The water at that point streams to pump which streams water back to the heater and the circle proceeds and the plant produces control. A segment of the created in the plant is used to work the machines and gear in the framework. The power plants have the proficiency running in the middle of 20 to 40%.

Gas turbine power plant:

In gas turbine control plant dynamic weight of streaming gases turns turbine and create power. The guideline of energy in this kind of energy plant is Bryton cycle. In Figure 2.5, a schematic is spoken to depict the essential employed guideline .in gas. Compacted air and fuel influences synthetic response and consumes in ignition to chamber, which thusly create high temperature (900 to 1500°C) fumes gas. These high speeds fumes gas streams over turbine and pivot it and deliver control through generator. Gaseous petrol fuelled control station has the ability to supply

control rapidly. Consequently it is for the most part utilized as a part of pinnacle stack control plants. Be that as it may, the creation cost is high in this write of energy plants.

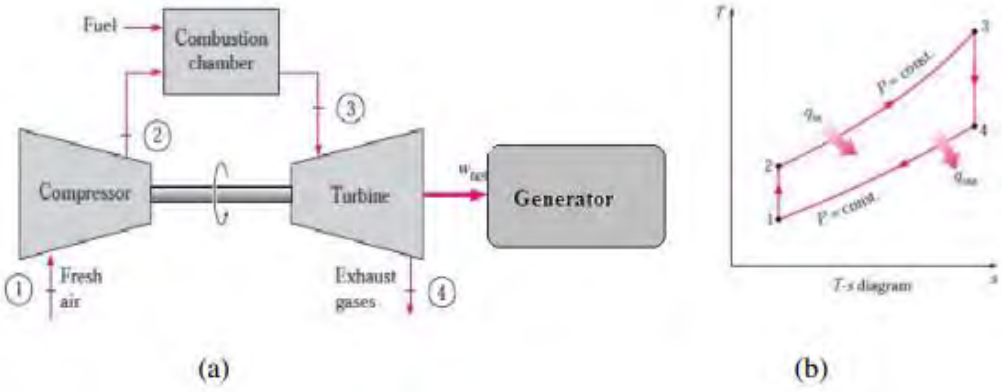


Figure 2.5. Schematic of Gas Turbine Power Plant with Brayton Cycle. (Rehman, 2012)

Combined cycle power plant:

Combined cycle control plants are the mix of both steam turbine control plants and gas turbine control plants. The fundamental parts of a combined cycle control plants are a gas turbine, a steam generator and a steam turbine. The working standard is spoken to in Figure 2.6. Fumes gas originating from the gas turbine is reused to bubble water and deliver steam. This turns turbine and create power. The fumes gas from gas turbines comes at a temperature of 450 to 650°C. These goes through a warmth recuperation steam generator unit which produce steam at a normal temperature of around 550°C and high weight (30-120 bar). The steam turbine use 30 to 40% vitality of the fumes gas and increment the general proficiency. As the generally effectiveness of this sort of energy plant is high, they are utilized as a part of most base load control stations now days and for the most part worked with gaseous petrol.

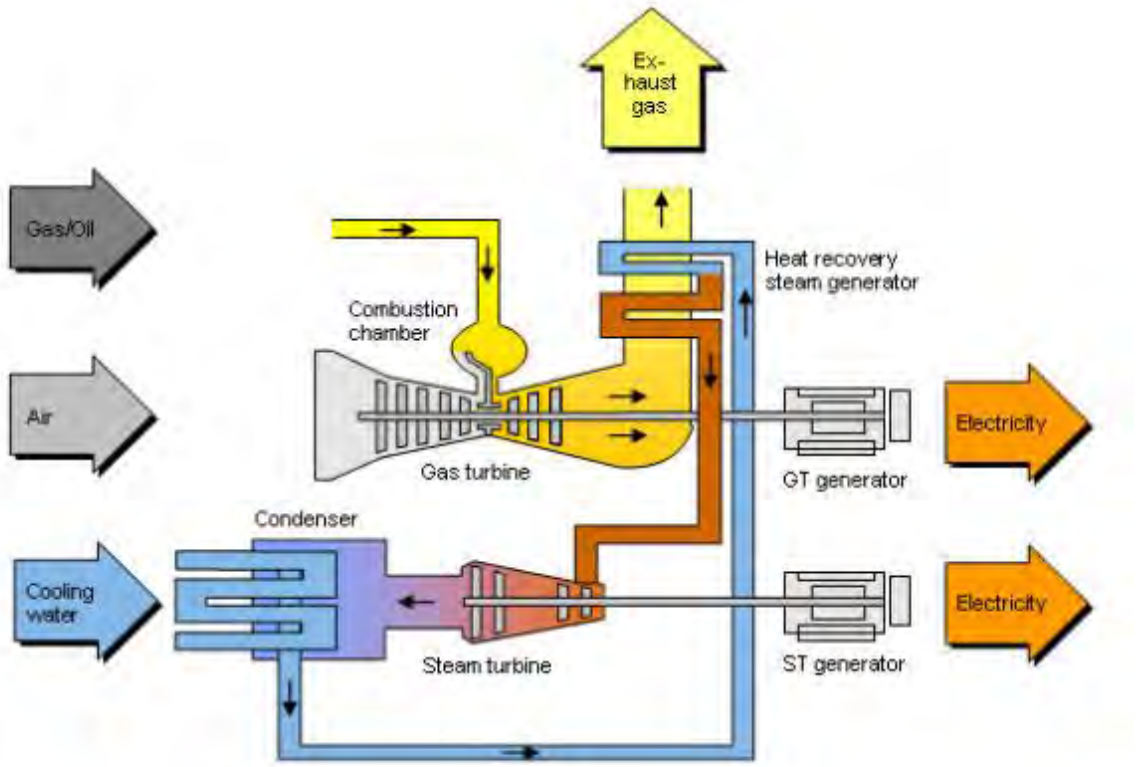


Figure 2.6. Combined Cycle Power Plant. (ZERO, 2012)

2.7.2 Nuclear power station:

At present 30 nations delivering power from 437 Nuclear Reactors, which constitute 12.5% of aggregate electric power age of the world. The warm vitality discharged in an atomic splitting response of radioactive material is utilized to produce control in atomic power plant. Uranium 235, truncated as U-235 is regularly utilized as fuel in atomic reactor as it split promptly and discharges huge measure of vitality as warm amid atomic parting response. U 235 is just 5% of material in fuel bar utilized as a part of atomic reactor. As the parting response is a chain response with nonstop arrival of neutrons, control poles are utilized as a part of the reactor to control the chain response. The water in the reactor achieves 325°C. To keep the water from heating up a weight of around 150 times of climatic weight is kept up in the reactor. The discharged enormous warm vitality is consumed by the water in the reactor which thus warms the water in steam generator and creates steam. These steams from the steam generator streams over the steam turbine, turns it and create control (Figure 2.7). Atomic power plants does not include non-renewable energy source consuming, therefore it is a green innovation. It additionally encourages colossal control age without reliance on non-renewable energy source. That is the reason it is generally utilized as

a green innovation for vast scale control creation. Be that as it may, atomic power plant includes a noteworthy security worry because of its danger of uncontrolled chain response in the reactor.

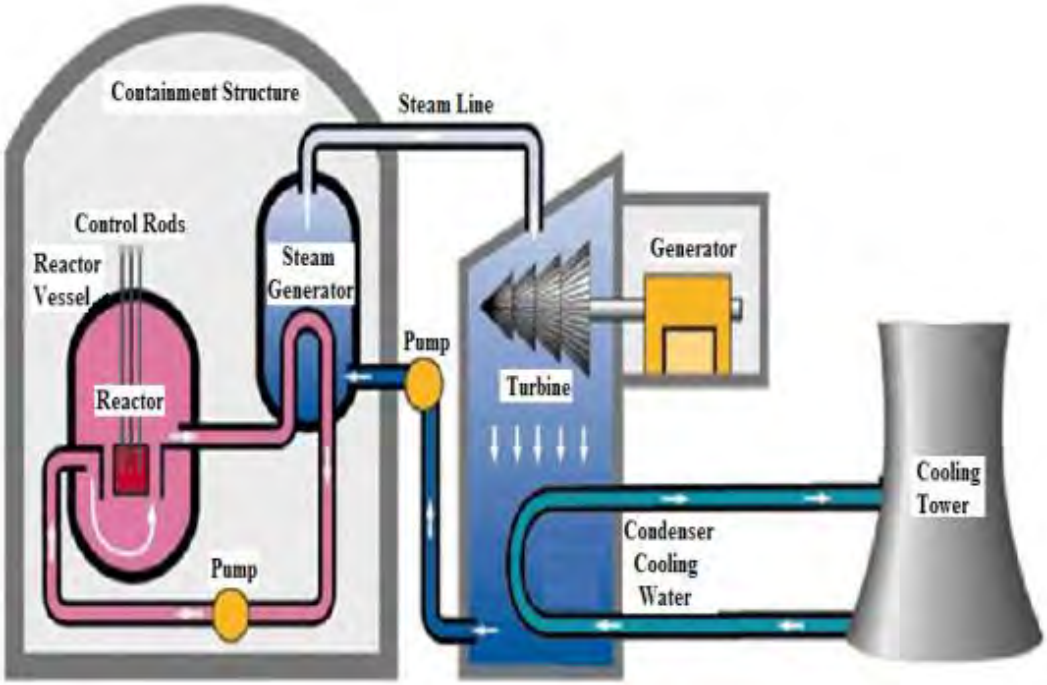


Figure 2.7. Schematic of a Nuclear Power Plant. (Dettmering, 2012)

2.7.3 Hydroelectric power plant:

Hydroelectric power plant is a biggest sustainable power source. Hydroelectric power plant outfits the vitality of stream and changes over it. For,helpful mechanical vitality through the revolution of turbine. Figure 2.8 speaks to the schematic of hydropower plant. A dam is based on the mouth of stream. There is an admission structure in the dam which manages the water to the control door. At the point when the entryway is open, water streams to the turbine through the penstock. The turbine turns and power is produced through the generator. Active vitality of the steam stream and potential vitality of the put away water in the repository is used in the hydroelectric power plant. Hydroelectric power plant is one of the high productivity sustainable power age frameworks with zero discharge. Be that as it may, it has some ecological issues, for example, change of common stream, risk on biodiversity of marine lives, plausibility of dry season and surge.

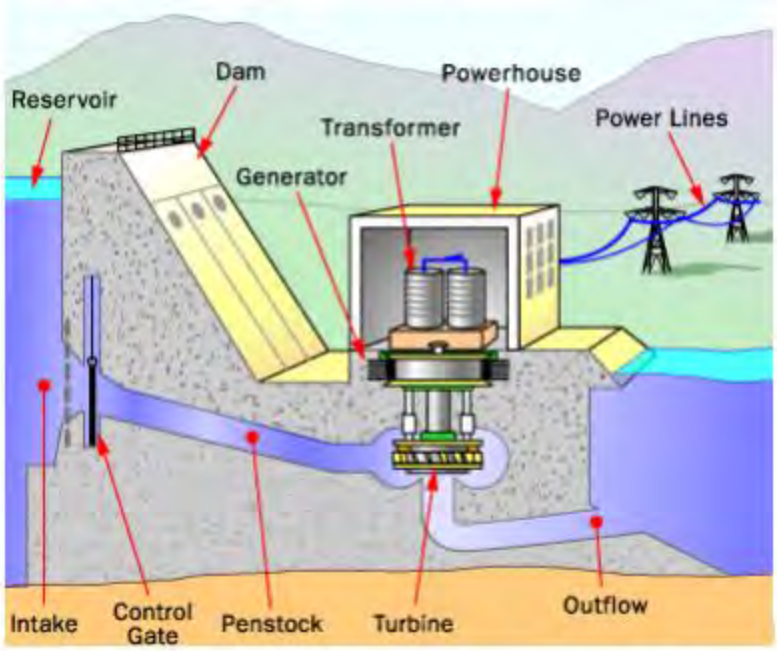


Figure 2.8. Schematic of a hydro-electric power plant. (Bonsor, 2012)

2.8 Climate change effect on electricity demand:

As said before, vitality is the key main impetus for every single financial movement and development. For the supported financial development, secured vitality and power supply are crucial. The adjustments in temperature and precipitation designs because of the environmental change can have huge ramifications for the current and future power plants and power framework. Climate and atmosphere can influence every single real component of the electric power Segment, including power age, transmission and conveyance frameworks, and end-user interest for control. The possibly Influenced parts of energy plants, transmission, dissemination and buyer request loads are appeared in Figure 2.5. The power age at warm power stations turns out to be less productive. Hydropower plants can likewise be influenced by the worldwide Environmental change. Factors, for example, precipitation sum, sleet pack levels, and the planning of snow dissolving may influence the stream and store levels. For Illustration, the power age by sun oriented boards might be impacted by overcast cover and sunlight based protection. Additionally, an adjustment in wind designs may bring about a recognizable effect on future power age from the breeze. Due to high temperature, the warm extension of transmission and dispersion control lines can make line list causing less sum and deferred control supply through lines. Besides, higher temperature amid summer may build the interest for power to run aeration and cooling systems and fridges. As of late, a few

disturbances of energy transmission have been seen. Because of the outrageous climate conditions accepted to be environmental change in a few nations.

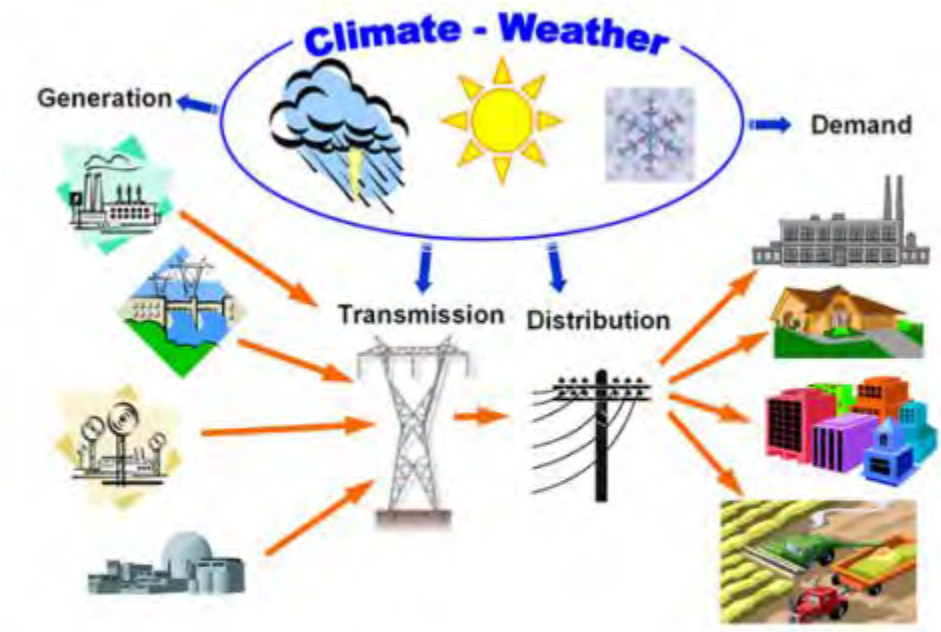


Figure 2.9. Potential impacts of climate change on power systems (Department of Energy Office of Science, 2012)

For cooling reason control plants require a consistent supply of new water. Lower temperature of water by and large guarantees the higher productivity of the cooling framework increases the proficiency of the power plants.

2.9 Remarks for the chapter:

Planning of the enterprises, for example, temperature, basic outline, cooling framework outline, consumption recompense, wind speed, stickiness, plant stature, entrance security and water protection should be altered to adjust with environmental change. Among the businesses control age plant, particularly non-renewable energy source based power plants are much defenceless. The productivity of petroleum are defenceless against environmental change. Hardly any investigations have demonstrated that the worldwide environmental change will decrease the power age limit. There is an examination hole in comprehension and evaluating the potential danger of worldwide environmental change on control age limit in creating nations like Bangladesh. The measure of energy age and the hazard areas by the year 2100, should be researched and distinguished. This will top off present hole in the collection of learning in appreciative the effect of environmental change on control plant and guarantee future maintainability in control age.

Chapter 3

Case Study-I: Bangladesh

Bangladesh is one of the creating nations on the planet which has danger of atmospheric deviation and uncertainly climate changes its behaviors, because of this chapter 3 discuss about the environmental aspects which is related to electricity demand all over Bangladesh. This chapter also emphasizes on the power generation of Bangladesh for the recent times and future plans of the government. Finally, the impact of climate change on both demand and generation has been examined.

3.1 Electricity Demand

Bangladesh's aggregate introduced power age limit (counting hostage control) was 15,351 MW as of January 2017.As 2015 92% urban populace and 67% country populace have the entrance to the power for their wellspring of light . Normal 77.9% population have the entrance to the power in Bangladesh. For a supported financial development, the nation needs satisfactory supply of energy for its modern, rural and private areas. The administration of Bangladesh is looking for remote and neighborhood interests in its industrialization and infrastructural improvement.

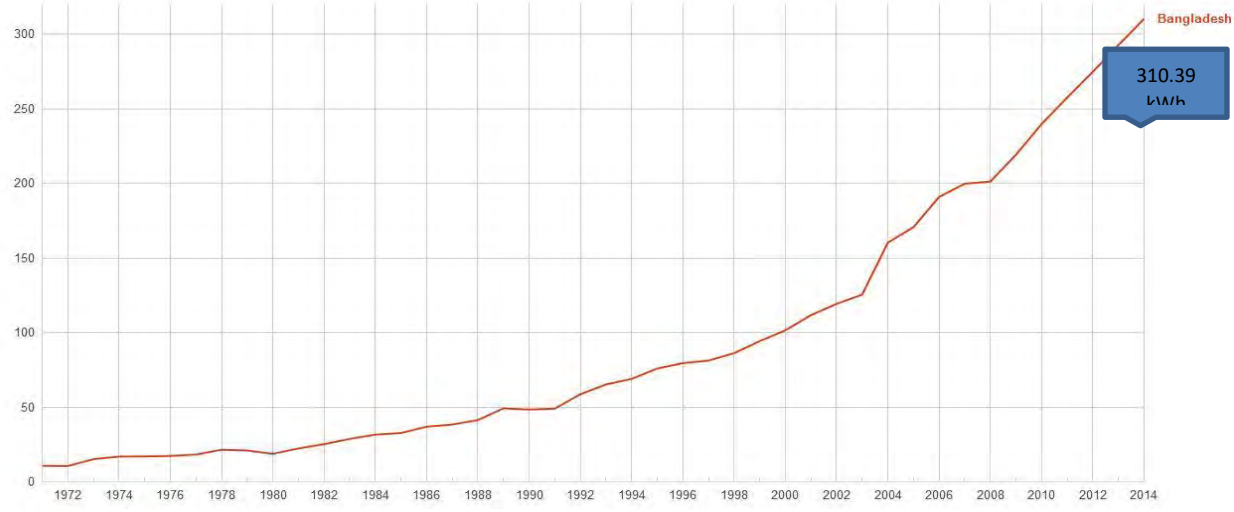


Figure 3.1: Electric power consumption (kWh per capita)

Table 3.1: Electricity consumers in Bangladesh [Bangladesh Power development Board, 2017]

Year	Residential household user	Agricultural User	Large Industry and Commercial user
2007-08	1,134,074	18,293	1,890
2008-09	1,221,324	17,215	1,999
2009-10	1,270,727	15,084	2,038
2010-11	1,359,724	14,285	2,183
2011-12	1,165,265	12,484	1,867
2012-13	1,114,679	14,311	2,010
2013-14	1,272,144	17,693	2,163
2014-15	1,385,424	21,191	2,299
2015-16	1,495,195	25,175	2,534

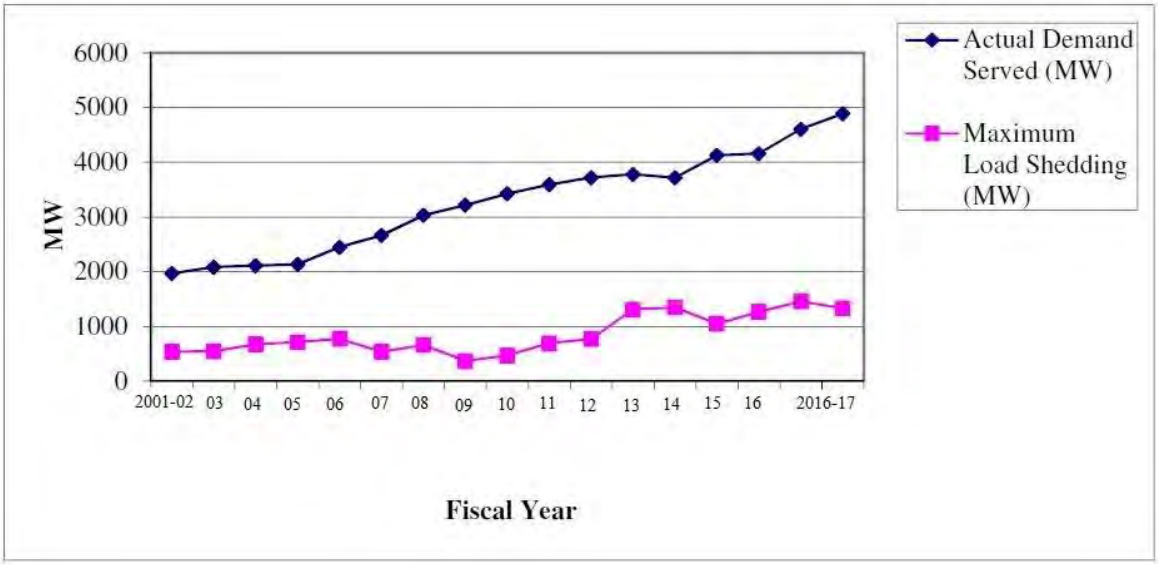


Figure 3.2: Actual demand and maximum Load shedding (MW)

3.2 Power Generation:

Present Installed Generation Capacity (MW) as on 30 August, 2017

Public Sector	Installed generation capacity (MW)
BPDB	4402
APSCL	1508
EGCB	622
NWPGCL	718
RPCL- BPDB-RPCL JV	77 149
SUBTOTAL	7476 (55%)
PRIVATE SECTOR	
IPPs	3245
SIPPs (BPDB)	99
SIPPs (REB)	251
15 YR. Rental	169
3/5 YR Rental	1721
Power Import	600
SUBTOTAL	6085 (45%)
Total	**13,561**

Table 3.2: Present Installed Generation Capacity

Present Installed Generation Capacity:

Power plant across Bangladesh as December, 2017 given below [Bangladesh power development board]

Tabel 3.2 Private Sector (Existing)

SL No.	Name of Power Station/ Location	Number of Unit(s)	Unit Type	Commissioning date (DD/MM/YY)	Type of Fuel	Installed Capacity (MW)	Present (Derated) Capacity (MW)
	East Zone						
1	**KARNAFULI HYDRO** (Kaptai) (230 MW)	2	Hydro	26-02-1962	Hydro	40	40
			Hydro	08-01-1962	Hydro	40	40
		3	Hydro	08-01-1982	Hydro	50	50
			Hydro	11-01-1988	Hydro	50	50
			Hydro	11-01-1988	Hydro	50	50
2	**RAOZAN** (420 MW) (Chittagong)	2	ST	28-03-1993	Gas	210	180
			ST	21-09-1997	Gas	210	180
3	**SIKALBAHA** (88 MW) (Chittagong)	1	ST	24-04-1984	Gas	60	40
		1	CT	13-10-1986	Gas	28	10
4	**ASHUGANJ** (724 MW) (B.Baria)	2	ST	17-07-1970	Gas	64	64
			ST	08-07-1970	Gas	64	64
		3	ST	17-12-1986	Gas	150	100
			ST	04-05-1987	Gas	150	140
			ST	21-03-1988	Gas	150	140
		1	CT } CC	15-11-1982	Gas	56	40
		1	ST }	28-03-1984	Gas	34	18
		1	CT } CC	23-03-1986	Gas	56	40
5	**GHORASAL** (950 MW) (Polash, Norshindi)	2	ST	16-06-1974	Gas	55	55
			ST	13-02-1976	Gas	55	30
		4	ST	14-09-1986	Gas	210	190
			ST	18-03-1989	Gas	210	190
			ST	15-09-1994	Gas	210	190
			ST	31-01-1999	Gas	210	190
6	**HARIPUR** (96 MW) (Narayangonj)	3	CT	31-10-1987	Gas	32	32
			CT	15-11-1987	Gas	32	32
			CT	02-12-1987	Gas	32	32
7	**SIDDHIRGANJ** (210 MW) (Narayangonj)	1	ST	03-09 2004	Gas	210	190
8	**TONGI** (105 MW) (Dhaka)	1	CT	28-03-2005	Gas	105	105
9	**SHAHJIBAZAR** (130 MW) (Hobigonj)	4	CT	1968-69	Gas	60	38
		2	CT	28-03-2000	Gas	35	34
			CT	25-10-2000	Gas	35	35
10	**FENCHUGANJ CC** (97 MW) (Sylhet)	1	CT	24-12-1994	Gas	32	31
		1	CT } CC	31-01-1995	Gas	32	30
		1	ST }	08-06-1995	Gas	33	30
11	**SYLHET**(20 MW)	1	CT	13-12-1986	Gas	20	20
	Total(East)	**38**				**3070**	**2700**
	West Zone						
12	**KHULNA** (170 MW)	1	ST	25-05-1973	F.Oil	60	35
		1	ST	07-07-1984	F.Oil	110	60
13	**BHERAMARA** (60 MW) (Kustia)	3	CT	28-07-1976	HSD	20	18
			CT	27-04-1976	HSD	20	18
			CT	19-01-1980	HSD	20	18
14	**BARISAL** (55 MW)	4	D	1975-1980	HSD	5.5	3.0
		2	CT	05-08-1984	HSD	20	16
			CT	04-10-1987	HSD	20	16
15	**BHOLA** (5 MW)	1	D	08-10-1988	F.Oil/HSD	3	2.0
		2	D	2006	HSD	2	2.0
16	**BAGHABARI** (171 MW)	1	CT	04-06-1991	Gas	71	71
	(Sirajgonj)	1	CT	25-11-2001	Gas	100	100
17	**BARAPUKURIA** (250 MW) (Dinajpur)	2	ST	31-01-2006	COAL	250	220
18	**SAIDPUR** (20 MW)	1	CT	17-09-1987	HSD	20	19
	(Dinajpur)						
19	**RANGPUR** (20 MW)	1	CT	16-08-1988	HSD	20	20
	Total (West)	**20**				**742**	**618**
	Public Sector total	**58**				**3812**	**3318**

Private Sector (Existing)

SL No.	Name of Power Station/ Location	Number of Unit(s)	Unit Type	Commissioning date (DD/MM/YY)	Type of Fuel	Installed Capacity (MW)	Present (Derated) Capacity (MW)
	East Zone						
1	**Barobkundo** SIPP	8	CT	23/05/2009	GAS	22	22
2	**Feni** SIPP	8	CT	16/02/2009	Gas	22	22
3	**Jangalia, Comilla** SIPP	4	CT	25/6/2009	GAS	33	33
4	**Meghnaghat power Ltd.** (450 MW) (Norshindhi)	2 1	CT } CC ST }	26-11-2002	Gas	450	450
5	**Haripur Power Ltd.** (360 MW) (Narayangonj)	1 1	CT } CC ST }	23-05-2001 01-12-2001	Gas GAS	235 125	235 125
6	**NEPC** (110 MW) (Haripur BMPP)	8	D	30-06-1999	Gas	110	110
7	**Tangail** SIPP	8	CT	12/11/08	Gas	22	22
8	**RPCL** (210 MW) (Mymenshing)	5	CT CT } ST	20/11/99, Jan 00 Oct. 00,Dec.00 June'06	Gas	210	175
9	**Shahjibazar** 3 Yrs Rental	27	CT	13/11/2008	Gas	50	50
10	**Shahjibazar** 15 Yrs Rental	32	CT	09/02/09	Gas	86	86
11	**Fenchuganj** 15 Years Rental	19	CT	18/10/2009	Gas	51	51
12	**Kumargoan** 3 Yrs Rental	27	CT	23/07/08	Gas	48	48
13	**Kumkargoan**15 Years Rental	6	CT	15/03/2009	Gas	10	10
14	**Feni** SIPP (REB)	4	CT	22/4/2009	GAS	11	11
15	**Rupganj , Narayanganj Summit REB**	4	CT	9/6/2009	GAS	33	33
16	**Chandina Summit power**(REB)	5	CT	1/9/2003,15/11/06	Gas	25	25
17	**Mhadabdi Summit power**(REB	6	CT	1/9/2003,16/12/06	Gas	35	35
18	**Ashulia Summit power**(REB)	7	CT	1/9/2003,4/12/07	Gas	45	45
19	**Mouna, Gazipur SUMMIT (REB**	4	CT	12/5/2009	GAS	33	33
20	**Narsindi** SIPP (REB)	8	CT	21/12/2008	GAS	22	22
21	**Hobiganj** SIPP (REB)	4	CT	10/01/09	GAS	11	11
	Total(East)	**199**				**1689**	**1654**
	West Zone						
20	**KPCL** BMPP (Khilna)	19	D	12-10-1998	F.Oil	110	106
21	**Khulna** 3 years rental	50	CT	12-06-2008	HSD	40	40
22	**Bhola** 3 Years Rental	1	CT	12/7/2009	GAS	33	33
23	**BAGHABARI** BMPP WEST MONT (WPL) (Sirajgonj)	2	CT	26-06-1999	Gas	90	70
24	**Ullapara Summit SIPP (REB)**	2	CT	02-03-2009	GAS	11	11
25	**Bogra** 15 Years rental)	5	CT	11-04-2008	Gas	18	18
	Total(West)	**79**				**302**	**278**
	Private Sector total	**278**				**1991**	**1932**
	GRAND TOTAL	**336**				**5803**	**5250**

SUMMERY

	Installed Capacity	Derated(Present) Capacity
Public Sector	**3812**	**3318**
Private Sector	**1991**	**1932**
TOTAL	**5803**	**5250**

3.3 System loss:

System loss is one of the significant performance pointers. to reduce the system loss, continuous monitoring the performance of utilities are essential. In FY 2016-17 the system loss has come down to 9.99%.

FY	DISTRIBUTION (%)	TRANSMISSION LOSS (%)	DISTRIBUTION & TRANSMISSION LOSS (%)
1999-00	26.09	--	31.80
2000-01	25.34	--	28.43
2001-02	23.92	4.05	27.97
2002-03	21.64	3.79	25.69
2003-04	20.04	3.48	24.49
2004-05	17.83	3.42	22.79
2005-06	16.53	3.44	21.25
2006-07	16.26	3.15	20.25
2007-08	15.65	3.51	18.45
2008-09	14.33	3.06	16.85
2009-10	13.49	3.08	15.73
2010-11	12.75	2.66	14.73
2011-12	12.26	2.96	14.61
2012-13	12.03	2.94	13.79
2013-14	11.96	2.74	14.13
2014-15	11.36	2.76	13.55
2015-16	10.96	2.63	13.10
2016-17	9.98	2.67	12.19

Table 3.3: System loss

3.4 Power generation for next five years:

Year	2017	2018	2019	2020	2021	Total
Government sector (MW)	1464	1449	2645	1385	2805	9748
Private sector(MW)	385	803	2454	2029	1464	7135
Total	1849	2252	5099	3414	4269	16883

Table 3.4: Power generation for next five years

Table 3.5: District wise current power generation and five year power generation plan in Bangladesh [Power Division (2016), Bangladesh Power Development Board (2015) and Power Cell (2016)].

District	Power Generation in MW by year 2030		Power Generation in MW by year 2050		Power Generation in MW by year 2070		Power Generation in MW by year 2100	
	Case A	Case B	Case A	Case B	Case A	Case B	Case A	Case B
Barisal	142	64	312	140	831	373	993	446
Bhola	328	147	722	324	1,921	862	2,296	1,030
Bogra	248	111	546	245	1,454	652	1,738	780
Brahmanbaria	2,409	1,081	5,307	2,382	14,121	6,337	16,881	7,575
Chandpur	263	118	579	260	1,540	691	1,841	826
Chapainawabganj	221	99	488	219	1,298	582	1,552	696
Chittagong	4,897	3,682	10,791	8,114	28,710	21,588	34,321	25,807
Cox's Bazar	0	1,800	0	3,966	0	10,551	0	12,614
Comilla	232	104	512	230	1,363	612	1,629	731
Dhaka	1,837	824	4,048	1,816	10,771	4,833	12,876	5,778
Dinajpur	738	8,429	1,626	18,575	4,326	49,423	5,172	59,082
Feni	49	22	107	48	286	128	341	153
Faridpur	74	1,383	163	3,047	433	8,108	517	9,692
Gazipur	598	268	1,317	591	3,504	1,572	4,189	1,880
Gopalganj	148	66	325	146	865	388	1,034	464
Habiganj	1,415	635	3,119	1,399	8,298	3,723	9,920	4,451
Jamalpur	148	66	325	146	865	388	1,034	464
Jessore	214	96	472	212	1,255	563	1,500	673
Khulna	3,099	2,380	6,830	5,246	18,171	13,957	21,722	16,685
Kushtia	782	351	1,724	773	4,586	2,058	5,482	2,460
Mymensingh	359	161	790	355	2,103	943	2,514	1,128
Munshiganj	443	199	976	438	2,596	1,165	3,103	1,392
Narayanganj	6,204	3,684	13,672	8,118	36,376	21,598	43,486	25,820
Natore	74	33	163	73	433	194	517	232
Nilphamari	177	79	390	175	1,038	466	1,241	557
Narsingdi	1,801	808	3,969	1,781	10,559	4,738	12,623	5,664
Pabna	251	1,612	553	3,553	1,471	9,453	1,758	11,300
Rangpur	30	13	65	29	173	78	207	93
Rajshahi	148	66	325	146	865	388	1,034	464
Sirajganj	1,198	538	2,641	1,185	7,026	3,153	8,399	3,769
Sylhet	576	258	1,268	569	3,375	1,514	4,034	1,810
Tangail	62	28	137	61	363	163	434	195
Thakurgaon	83	37	182	82	485	217	579	260
TOTAL	29,244	29,244	64,443	64,443	171,460	171,460	204,971	204,971

3.5 Forecast Power Generation by 2100:

Mandal noted that sparse data is accessible on future requests for control age in Bangladesh. They made a similar investigation of energy age request up to year 2030. In their investigation, they took the base year 2010. They utilized the Long-Range-Energy Alternative Planning (LEAP) display with three unique levels of total national output (GDP) projections. These GDP projections are: a) Low GDP, b) Average GDP, and c) High Gross domestic product. Under Low Growth GDP situation, the genuine GDP development rate balanced out at 5.5% in 2016. It proceeds at this level through to 2025. From that point, it stays stable till 2030. For normal development GDP situations, the GDP development rate raises to 7% by 2011 tops at 8% of every 2016. It drops to 6.5% by 2026 and remains at this level till 2030. For high development GDP situations, the GDP development ascends to 7% by 2011, tops at 9% out of 2016 and decreases to 8% by 2030. It is noticed that as indicated by the normal development GDP situations the aggregate power age request by year 2030 is around 40,639MW which is a nearby the government intends to create 39,000 MW control by year 2030. Hence, the control request projection for the normal development GDP projection has been considered in this investigation. Moreover, Mandal (2015) have separated the request into five areas, in particular as a) mechanical, b) business, c) private, d) rural, and e) different areas. Private power requests incorporate urban private and country private segments. In this investigation, same projection for rural and other segments has been utilized. Be that as it may, for the private request some basic examinations are required.

In Siddique (2015) and Bangladesh Power Development Board, it was expressed that by
2020, 100% of the Bangladesh populace will approach the framework associated power and power. By thinking about this arrangement, it is accepted that by 2030, Bangladesh will meet 100% of its private power request. So for projection of the power request in Bangladesh up to year 2030, Mandal et al. (2015's) projection of private control request is utilized. In any case, from the year 2030 to 2100, an expanded power request has been viewed as in view of the populace development projection by the United Countries (2015). A suspicion of a 7% expansion in modern development request has been utilized. Not with standing, this growth has been

considered till the year 2070 and kept at steady for the rest of the years till 2100. The premise of this supposition is made by examining the authentic information of energy utilization by western industrialized nations, for example, Sweden, Denmark, Spain, and Japan from the World Information Bank (2014). In the report, it is noticed that a development in power utilization (request) in previously mentioned industrialized nations from 1960s to mid-2000 was around 7% which was prevalently because of the development of modern segments as populace and other sectorial developments were negligible. From the earliest starting point of 2000 (when it crested) the mechanical division development was either steady or on the decay. The purpose behind this decrease is principally because of the immersion of industrialization and transshipment of minimal effort assembling to creating nations particularly to China and India.

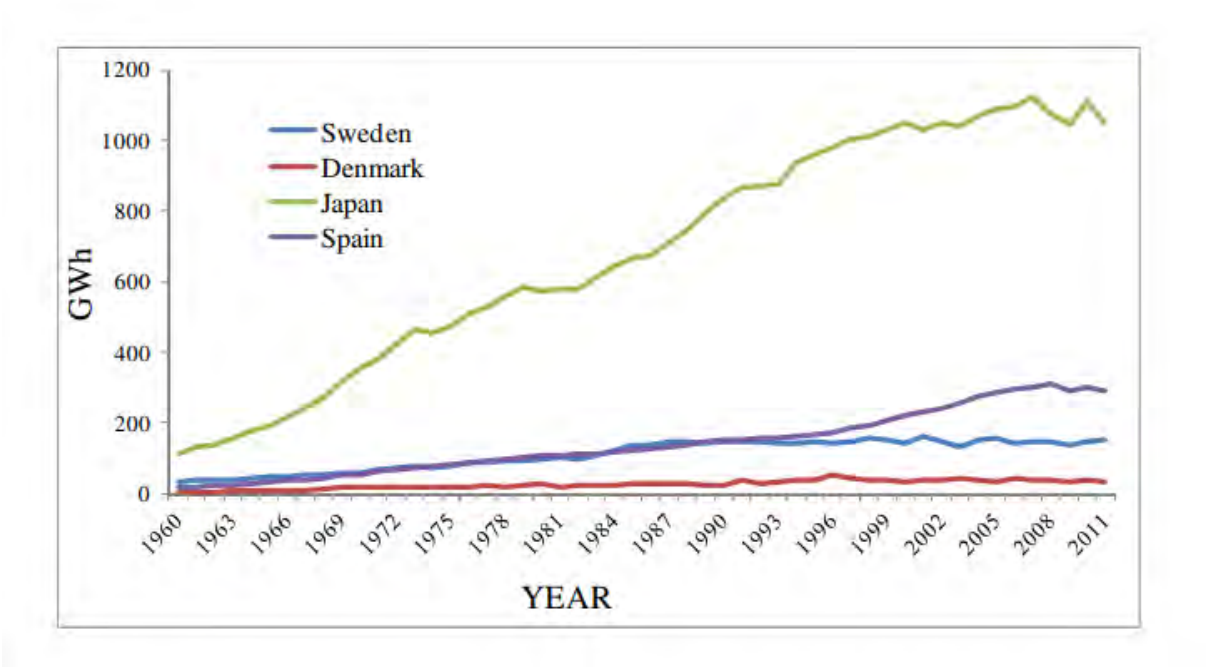


Figure 3.3: Historical data of power generation Spain, Japan, Denmark, Sweden.

According to historical trend for the power demand mentioned earlier, forecast was made that Bangladesh will be fully industrialized by year 2070 and thereafter the power demand in the industrial sector will remain constant. For commercial, agricultural and other sectors the projected trend of Mandal is used in this study and projected to year 2100.

Table 3.6: Projected power generation in Bangladesh by year 2030, 2050, 2070 and 2100

Demand Area	Total Generation in MW in different years			
	2030	2050	2070	2100
Residential	15,922	17,016	16,279	13,757
Agriculture	1,989	6,374	13,276	28,489
Commerce	2,500	7,491	15,269	32,293
Industry	8,225	31,827	123,159	123,159
Other	608	1,736	3,477	7,272
Total	29,244	64,443	171,460	204,971

Two investigations embraced by Haydar (2017) and Rahman (2017) revealed that at show half of Bangladesh populace approaches matrix associated powers. Matrix associated buyers don't really get control supply ceaselessly due the requests surpassing the age. As indicated by Bangladesh government Power Framework Master Plan (2010), the age limit necessity by 2021 is 24,000 MW also; age limit prerequisite by 2030 is around 39,000 MW. Power System All-inclusive strategy 2006 gave a point by point want to new establishments, areas, plant age limits up to year 2016.The arrangement proposed to introduce a progression of coal let go control plants to create

more than 20,000 MW. The guide for coal let go control plant advancement by year 2030 has unmistakably demonstrated the imminent area (Bangladesh Power Development Board, 2011). In spite of the fact that, there is a probability that coal terminated power plants will transmit more ozone harming substance, Bangladesh does not have some other suitable choices because of nation's rare money related assets and innovative ability.

Table 3.7: Prospective coal based power generation in different region by year 2030

Coal Based Power Generation in MW by 2030	
Imported Coal	
Khulna	1,320
Chittagong	1,980
Faridpur	1,800
Cox's Bazar	2,400
Narayanganj	1,200
Local Coal	
Dinajpur	10,800
Total	= 19,500

For the examination of energy age from each provincial area, the examination thought about two cases. In Case A, it is viewed as that the rate offer of energy age of every district by the power age design up to year 2020 in light of information from Power Division (2011), Bangladesh Power Development Board (2011) and Power Cell (2015). In Haydar (2017) and Rahman (2017), it was noticed that by year 2030, almost half of energy age will be from coal based power plants. In Case B, it is considered portion of the power age by year 2030 will take after the power age slant by year 2016. For the rest half of the power age, a rate offer of the Coal Based Power Generation in MW by 2030 Imported Coal Khulna 1,320 Chittagong 1,980 Faridpur 1,800 Cox's

Bazar 2,400 Narayanganj 1,200 Nearby Coal Dinajpur 10,800 Add up to = 19,50045 coal let go control plant has been included as appeared in Table.

Considering these two contemplations (Case A and Case B), the examination assessed the power age limit with regards to each area by year 2030. Same rate drift has additionally been utilized for the year 2050, 2070 and 2100. In Table 3.8, the anticipated power age for various areas is shown in view of Case A and Case B.

Table 3.8: Prospective power generation for different regions by year 2030, 2050, 2070 And 2100

District	Power Generation in MW on 2030		Power Generation in MW on 2050		Power Generation in MW on 2070		Power Generation in MW on 2100	
	Case A	Case B	Case A	Case B	Case A	Case B	Case A	Case B
Barisal	142	64	312	140	831	373	993	446
Bhola	328	147	722	324	1,921	862	2,296	1,030
Bogra	248	111	546	245	1,454	652	1,738	780
Brahmanbaria	2,409	1,081	5,307	2,382	14,121	6,337	16,881	7,575
Chandpur	263	118	579	260	1,540	691	1,841	826
Chapainawabganj	221	99	488	219	1,298	582	1,552	696
Chittagong	4,897	3,682	10,791	8,114	28,710	21,588	34,321	25,807
Cox's Bazar	0	1,800	0	3,966	0	10,551	0	12,614
Comilla	232	104	512	230	1,363	612	1,629	731
Dhaka	1,837	824	4,048	1,816	10,771	4,833	12,876	5,778
Dinajpur	738	8,429	1,626	18,575	4,326	49,423	5,172	59,082
Feni	49	22	107	48	286	128	341	153
Faridpur	74	1,383	163	3,047	433	8,108	517	9,692
Gazipur	598	268	1,317	591	3,504	1,572	4,189	1,880
Gopalganj	148	66	325	146	865	388	1,034	464
Habiganj	1,415	635	3,119	1,399	8,298	3,723	9,920	4,451
Jamalpur	148	66	325	146	865	388	1,034	464
Jessore	214	96	472	212	1,255	563	1,500	673
Khulna	3,099	2,380	6,830	5,246	18,171	13,957	21,722	16,685
Kushtia	782	351	1,724	773	4,586	2,058	5,482	2,460
Mymensingh	359	161	790	355	2,103	943	2,514	1,128
Munshiganj	443	199	976	438	2,596	1,165	3,103	1,392
Narayanganj	6,204	3,684	13,672	8,118	36,376	21,598	43,486	25,820
Natore	74	33	163	73	433	194	517	232
Nilphamari	177	79	390	175	1,038	466	1,241	557
Narsingdi	1,801	808	3,969	1,781	10,559	4,738	12,623	5,664
Pabna	251	1,612	553	3,553	1,471	9,453	1,758	11,300
Rangpur	30	13	65	29	173	78	207	93
Rajshahi	148	66	325	146	865	388	1,034	464
Sirajganj	1,198	538	2,641	1,185	7,026	3,153	8,399	3,769
Sylhet	576	258	1,268	569	3,375	1,514	4,034	1,810
Tangail	62	28	137	61	363	163	434	195
Thakurgaon	83	37	182	82	485	217	579	260
TOTAL	29,244	29,244	64,443	64,443	171,460	171,460	204,971	204,971

3.6 Relation between climate change and Power Generation:

Due to environmental change a few characteristics parameters will be shifted. This perimeter will impact sly affect control plants, transmission and appropriation. Some of these parameters are

(a) Increase of temperature.
(b) Inundation and salinity increase.
(c) Strom and cyclone.
(d) Erosion risk.
(e) Drought and flood threat.

The effect of previously mention parameters on control plants with respect to their land areas. There are free noteworthy classifications.

(a) Cooling system.
(b) Immersion effect due to sea level rise, salinity, storm search
(c) Physical hazard because of disintegration

3.6.1 Cooling system of power station:

As global warming, the temperature will rise. Due to shortage of fresh water cooling system will be affected by temperature rising.

Temperature:

Cooling arrangement of power plant is required for the maximum efficiency of plant. Generally, there are three cooling frame works (a) gets cooling water (b) passing through the cooling tower (c) Close circuit cooling system

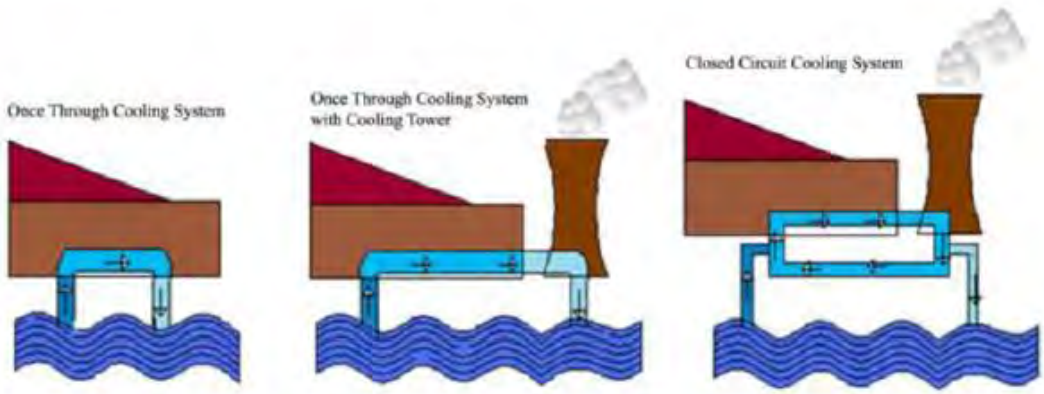


Figure 3.4. Schematic of three widely used different cooling system for power plant

Koch,Vögele and Rübbelke (2011), build up a numerical equation that execute the temperature rise effect on cooling system. As they found the request of fresh water can be communicated utilizing accompanying condition.

$$Q^F = \frac{KW \cdot h \cdot 3.6 \cdot \frac{1-\eta_{total}}{\eta_{elec}} \cdot \lambda \cdot (1-\alpha) \cdot (1-\beta) \cdot \omega}{\rho \cdot c \cdot AS} \cdot EZ \qquad (1)$$

Where,

Q^F = cooling water demand (m^3),

KW = installed capacity (kW),

h = operation hours (h),

3.6 = factor to convert kWh to MJ,

η_{total} = total efficiency (%),

η_{elec} = electric efficiency (%),

α = share of water heat not discharged by cooling water (%),

β = share of water heat released into the air (%),

c = specific heat capacity of water (MJ/ton °K),

ω = correction factor accounting for the effects of changes in air temperature and humidity within a year [-] (usually between 0.7 and 1.25),

λ = correction factor accounting for the effects of changes in efficiencies [–],

ρ = water density (ton/m^3),

AS = permissible temperature increase of the cooling water (°K), and

EZ = densification factor.

Equation (1) expresses the connection among vitality discussion, fuel and cooling water request. To measure of aggregate waste warmth can be evaluated in view of created power period (KWh) and productivity information. Condition (1) demonstrates the sum of vanish warmth that is expelled by the cooling water from add up to squander warm outcomes (KW.h.3.6. (1-ηtotal)/ηelec) increased by different amendment factors. On the off chance that the admission temperature increments to 25ºC and most extreme permissible temperature is 29ºC, to disperse a similar measure of warmth vitality (42 MJ), no less than 2 m3 of crisp water is required. In this manner, the absence of new water will bring about huge misfortunes of influence age limit. The power time limit of a power plant can identified with equation (2).

$$KW = \frac{Q^{F} \cdot \rho \cdot c \cdot AS}{h \cdot 3.6 \cdot \frac{1-\eta_{total}}{\eta_{elec}} \cdot \lambda \cdot (1-\alpha) \cdot (1-\beta) \cdot \omega \cdot EZ} \qquad (2)$$

Shortage of cooling water:

Table 3.9: The given table shows that drought threat reasons which bring shortage of water.

Very High Risk				High Risk				Moderate Risk			
Region	Year				Year			Region	Year		
	2030	2050	2100	Region	2030	2050	2100		2030	2050	2100
				Thakurgaon	37	82	260				
				Rangpur	13	29	93	Shirajganj	538	1,185	3,769
Nilphamari	79	175	557	Bogra	111	245	780	Pabna	1,612	3,553	11,300
Dinajpur	8,429	18,575	59,082	Rajshahi	66	146	464	Faridpur	1,383	3,047	9,692
Natore	33	73	232	Chapainawabganj	99	219	696	Gopalganj	66	146	464
				Kushtia	351	773	2,460	Barisal	64	140	446
				Jessore	96	212	673				
Total	8,542	18,823	59,871	Total	774	1,706	5,426	Total	3,663	8,071	25,671

3.6.2 Inundation and salinity:

Ocean level rise will prompt a few dangers, for example, immersion and saltiness increment, and storm surge and tornado in beach front areas of Bangladesh. In the accompanying subsections, the effect of these environmental change impacts has been broke down and recognized. Expanded saltiness factor because of is specifically relative to the measure of crisp water. Then again, the saltiness has altogether bigger impact on control age. As appeared in condition with the expansion of densification, the power generation will diminish contrarily. It is currently unmistakably obvious that the expanding saltiness negatively affects control plant effectiveness and general power creation. Moreover, expanded saltiness will build erosion of the hardware.

Table 3.10: Affected areas due to various natural calamities and threat to power Generation (in MW)

Risk Type	Barisal	Bhola	Chandpur	Chittagong	Feni	Jessore	Khulna	2030	2050	2100
Inundation	√	√		√	√		√	8,514	19,340	61,515
Salinity	√	√	√	√	√	√	√	8,991	19,812	63,015
Storm Surge	√	√	√	√	√		√	8,777	19,340	61,515
Tidal Wind	√	√		√	√		√	8,514	18,762	59,674
Cyclone	√	√	√	√	√		√	8,777	19,340	61,515

3.6.3 Strom and cyclone:

The water surrounded district of Bangladesh faces high danger of violent because of its complex geographical position and low rise from the sea level. As of late, the nation has been confronting various crushing violent winds and tempest surges which are generally accepted to be because of atmosphere impacts.

Table 3.11: Effects of sea level rise (SLR), water temperature, wind speed and water Surge height

Scenarios	Wind Speed (km/h)	Surge height (m)
Scenario-I. SLR (m) = 0, SST rise(°C) = 0	225	7.6
Scenario-II. SLR (m) = 0, SST rise(°C) = 2	246	9.2
Scenario-III. SLR (m) = 0, SST rise(°C) = 4	274	11.3
Scenario-IV. SLR (m) = 0.3, SST rise(°C) = 0	225	7.4
Scenario-V. SLR (m) = 0.3, SST rise(°C) = 2	246	9.1
Scenario-VI. SLR (m) =0.3, SST rise(°C) = 4	274	11.3
Scenario-VII. SLR (m) = 1, SST rise(°C) = 0	225	7.1
Scenario-VIII. SLR (m) = 1, SST rise(°C) =2	246	8.6
Scenario-IX. SLR (m) =1, SST rise(°C) = 4	274	10.6

3.6.4 Erosion risk:

Because of the geographical properties stream system will be exceptionally responsive. Due to the temperature rise, the Himalayan ice layer will soften at a speedier rate. Terrains are made by flashed away as conveyed by the waterways from the upstream; the dirt subjugation is one of the weakest. Accordingly, exorbitant water release will cause serious waterway. Environmental Change Cell - CCC (2009) assessed the effect of environmental change on rainstorm flooding by the stream Brahmaputra and Ganges, which announced that the pinnacle surge level in the waterway is by and large expanded by 37cm in contrast with a direct surge. Furthermore, a few low lying landmasses is likewise vanishing because of ocean level ascent. On the off chance that this procedure proceeds, the whole region of Bhola will be submerged inside next 40 years. Alongside surge release, the siltation will make different islands in the waterway bed alongside their inconsistent courses bringing about more flighty stream bank disintegration than those found before. This stream disintegration will not just influence the power plant establishments in

the region of the waterway yet in addition uproot a great many individuals and decimate existing foundation causing huge financial misfortunes furthermore, human tragedies.

3.6.5 Flood and Drought risk:

As indicated by IPCC (2008), the surge force and day and age of flooding will be expanded because of the environmental change. A far reaching study on surge hazard for various areas of the nation has been completed.

Table 3.12: Power generation in high flood risk regions (in MW)

High Risk	2030	2050	2100	Very High Risk	2030	2050	2100
Brahmanbaria	2,409	5,307	16,881				
Dhaka	1,837	4,048	12,876				
Gopalganj	148	325	1,034	Narayanganj	6,204	13,672	43,486
Habiganj	1,415	3,119	9,920				
Munshiganj	443	976	3,103				
Natore	74	163	517				
Narsingdi	1,801	3,969	12,623				
Pabna	251	553	1,758	Sirajganj	1,198	2,641	8,399
Sylhet	576	1,268	4,034				
Tangail	62	137	434				
Total	9,016	19,865	63,180	Total	7,402	16,313	51,885

3.7 Concluding Remarks for this Chapter:

The increasing water temperature, saltiness, flood, stream disintegration, delayed dry spell, and so on will have significant consequence on control time limit in Bangladesh. Bangladesh has considered any conceivable impact of environmental change (e.g., ascent of water temperature, saltiness, flooding, waterway disintegration, delayed dry spell) during the time spent plan, site determination, establishment, and support. This represents an awesome hazard as the power creation limit and proficiency will significantly be influenced. In this section, the examination endeavored to distinguish some parametric impacts by considering the rise of sea level, temperature, saltiness. Unique locales of Bangladesh will be experienced impacts of atmosphere in an unexpected way. The ocean level rise will cause control plants in seaside area to encounter expanded saltiness. Subsequently, the outline of cooling arrangement of energy plants must be intended to limit the impact of saltiness increment. In draft circumstance, the sufficient healthy water supply for cooling must be guaranteed by reusing water. Moreover, the consumption stipend of the power station structure and the cooling framework ought to likewise be deliberately viewed as situated in the seaside district. Being one the minimum created countries of the world and most defenseless against atmosphere change, the effect of the environmental adaptation might be thought about genuinely in any present furthermore, advancement exercises particularly control age limit and framework.

Chapter 4

Case Study-II: Electricity Market

Electricity Market refers to the "Unbundling", "Restructuring" and "Deregulation" in the generation, transmission and distribution sectors (GTD). This concept was first introduced in the year 1992 by FERC (Federal Energy Regulatory Commission) by United States. The main purpose for this new process of making electricity available was to unbundle the traditional GTD companies from becoming monopolistic. However, this was not the only issue regarding the bringing of a new system in the GTD of the country. In 1996 FERC has ordered complete separation in all of the Generation, Transmission and Distribution. This restructuring later helped increase stakeholders in the GTD sectors separately therefore enhancing better competition in the utility companies today.

The following diagram explains the nondiscriminatory access to be provided by the GTD sectors when separated.

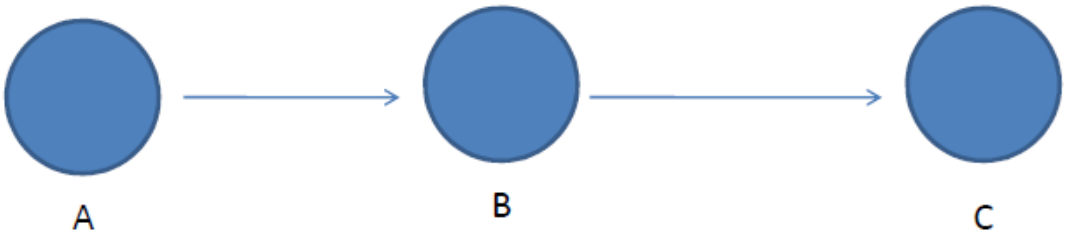


Figure 4.1: GTD sector

If A be considered the generation, B the distribution and consecutively C be the distribution then it is inevitable that B must operate at all times without and must provide nondiscriminatory access to its available network. A will sell to the stakeholders in B while the stakeholders in C will buy the entities (MW) from B. Depending on the policies of unbundling, restructuring and deregulation a country may set its priorities on how the GTD sectors may operate in synchronism as well as cost effectiveness.

4.1 Stakeholders

There are several types of stakeholders when the entire GTD will be unbundled. Some of these stakeholders include:

- Traditional IOU (Investor Owned Utilities)
- Independent Power Producers (IPP)
- NUG (Non-Utility generation) owned by municipalities
- Merchant Power
- Distributed Energy Resources (DERs) which includes small fossil or renewable power sources, storage plants like batteries, fly wheels, plug-in hybrid vehicles etc.

Investor owned utilities (IOU)

IOUs are business organizations providing a service as a utility which is not government controlled rather it is owned by private enterprises. These privately owned utility companies purchase power through contracts on procurement plans. The utility rates are set in order to recover costs and earn reasonable returns for the risk an IOU may bear in new facilities.

Independent Power Producers (IPP)

IPPs are private entities under unbundled market which own and operate facilities to generate electricity and then sell to other stakeholders, government, consumers, etc. IPPs invest in the technology (generation) and recover the costs on sale of the power in megawatts. The IPPs have special characteristics on attracting outside capital to meet the rapidly growing electricity demands. These factors enhance competition and reduce overall costs of the electricity produced.

Distributed Energy Resources (DERs)

Distributed energy resources (DERs) refers to the installation of energy units near to the consumer side. DERs are mainly the renewable energy sources or other sources rather than the main grid itself, used for household or lightly loaded purposes. The DERs can however be a new innovation in the arena of power technology as energy consumption can be made more feasible and efficient at the same time. These entities focus on upbringing of new researches into technologies that actually determines the progress in lesser dependency on main grid lines.

4.2 Why is Electricity Market a requirement in today's world?

A recently released report of the international energy outlook (IEO2009) forecasts an increase in the total world's demand for energy by 44% from 2006 to 2030 and a drastic increase in the electricity generation by 77% worldwide. The competition in power production is quite the recent solution to handling such rising global demands in power. Nevertheless, there will be a silent but effective liberalization in other businesses such as carriage, telecommunications, banking services, gas supply, and so on. The investors for generation technologies may recover their capital by unrestricting the rate of return. Then again, the G,T,D sectors will work like a vertically integrated system.

The disadvantage of having a traditional oligopolistic market for electricity is drawbacks in the usage of power plant capacity, efficiently. In addition, it is very likely that the prices for electricity will be far more than normal as the companies may have the freedom to keep the prices at any rates they want; this is in case a single company owns all of the GTD sectors. Having all of the electrical connections in a heavily loaded marketplace can impose risks over

the system's reliability. If a fault occurs, all of the marketplace will lose power. Whereas if there are several utility companies with power bids and deals over generation, reliability and continuity of power during fault can be well maintained.

The further advantages of introducing electricity market in a nations GTD systems is the ability to produce better, cheaper and much reliable electricity at competitive prices and ensure reliability at the same time. An added advantage would be the fact that the separation of the GTDs will create three new markets and several other entities on the distribution end. This will give rise to the employment rates in the country.

4.3 Other Players in the Electricity Market

The other players in the electricity market besides the generation, transmission and distribution asset owners are the power exchangers, brokers, load serving entities (LSE) and power marketers. These entities in the market do not have a direct connection to the physical assets but do affect the transactions between distribution companies (DisCos) and the generation companies (GenCos) for a small commission per KWh electricity transacted.

The diagram below shows a simple structure on how the other players work and affect the mechanism of operation of the electricity market.

or RTO (Regional Transmission Organization)/ Transco who look after the real time operation of the entire grid.

4.3 Why is Electricity Market important for Bangladesh?

Considering the effect of climate changes it can be deduced that electricity market would be an effective solution for meeting the rising demands in the developing country Bangladesh. Well known for its population, Bangladesh has the seventh most densely populated capital in the world. Over the years Bangladesh had quite a breakthrough in being able to provide nearly reliable electricity than the previous years where blackouts in many regions were common. Being in a monsoonal region there had been many natural disasters countrywide. These natural calamities hold a vital effect on the generation, transmission and distribution of electricity in the country. However, Bangladesh is comprised of the traditional system in producing electrical power where the generation, transmission and distribution are owned by the same entity.

The disadvantage of one entity owning all of the GTD is that whenever a fault occurs, many of the connections may lose power which is again a question of reliability. Another vital fact is that the rate of increase of population in Bangladesh is higher than that of many other countries. This adds to the effect of climate change on the electricity demand. The rising population will also require a source of employment then why not separate the GTDs and create new job markets?

The remedies would be simple if the concept of electricity market can be introduced in the generation, transmission and distribution sectors in Bangladesh. There will be entries of new IPPs and DERs which will trigger competitions between the power producers and the utility companies. Thus, the overall pricing on the units of megawatts or kilowatts will reduce. In addition, there will be far greater chances of ensuring reliability.

Nevertheless, introducing electricity market in Bangladesh will-

- Provide power at competitive prices
- Rectify the power producing policies
- Ensure reliability
- Meet plant efficiency

- Create a new job market for the growing population

4.4 Present Operation Conditions in Bangladesh

Currently in Bangladesh there are six large entities in control of the GTD sectors in Bangladesh. BPDB (Bangladesh Power Development Board) and PGCB (Power Grid Company of Bangladesh Limited) controls the entire generation and transmission from power plants in Bangladesh. DESCO(Dhaka Electric Supply Company Limited), DESA (Dhaka Electric Supply Authority) and REB(Rural Electrification Board) controls the overall distribution in Bangladesh.

According to the division of control in the present state of Bangladesh in the power generation, transmission and distribution sectors, it is seen that there is traditional single entity owned power concept remaining. The total plant capacity of Bangladesh ranges up to 13,555MW while the maximum demand in a peak hour may be over 8,500MW. On the contrary having a higher plant capacity does not solve the problem of meeting the peak demands efficiently. Therefore, there is large gap between the peak demand and the total available plant capacity. For now several load shedding are having to be introduced to somewhat keep up with the reliability in the major city areas.

Table 4.1: The total plant capacity and the peak demand is shown in the diagrams below-

Installed Capacity by Plant & Fuel Type

By type of plant		By type of fuel	
Hydro	230 MW (1.70 %)	Gas	8,810 MW (64.99%)
Steam Turbine	2,404 MW (17.74%)	Furnace Oil	2,785 MW (20.55%)
Gas Turbine	1,105 MW (8.15 %)	Diesel	880 MW (6.49%)
Combined Cycle	4,625 MW (34.12%)	Power Import	600 MW (4.43%)
Power Import	600 MW (4.43%)	Hydro	230 MW (1.70 %)
Reciprocating Engine	4,591 MW (33.87%)	Coal	250 MW (1.84 %)
Total	**13,555 MW (100%)**	**Total**	**13,555 MW (100%)**

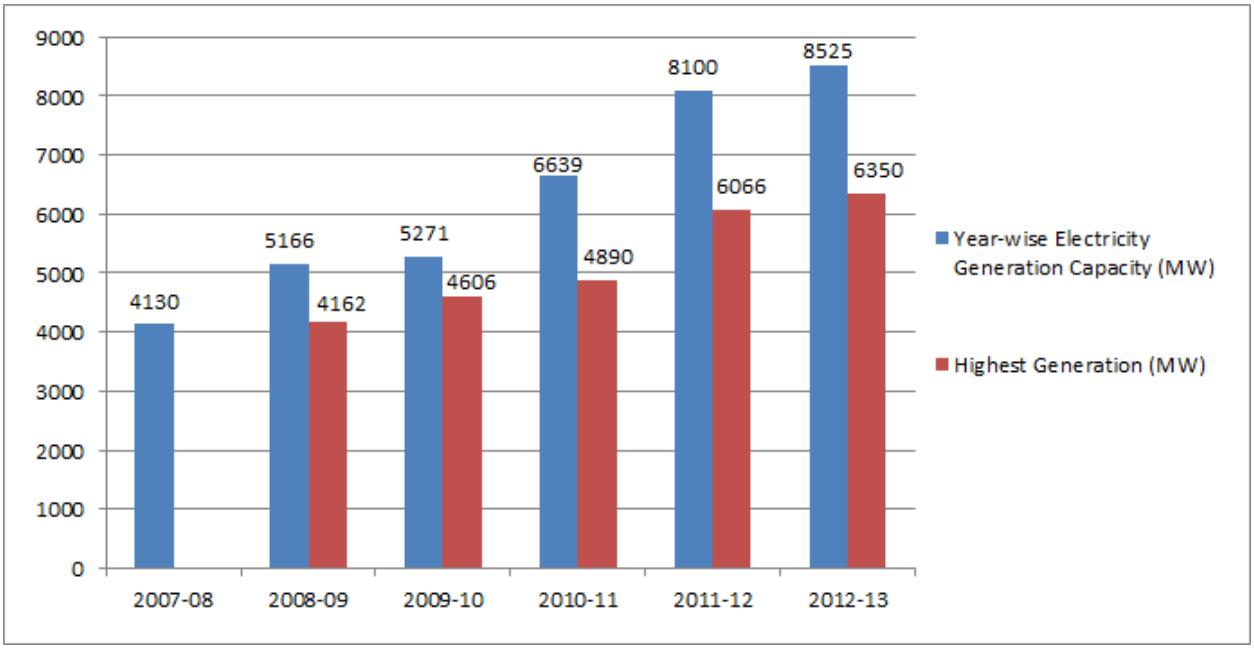


Figure 4.3 Generation capacity

It can be seen from the data analysis that the demand always exceeds the highest generation capacity from plants. During these years (2012-2013) the available plant capacity was nearly 13,555MW whereas the peak demand was 8525MW. The de-rated capacity for the plants is almost 5000MW power which is almost 38% of the total available plant capacity. This portrays the fact that there is inefficient usage of power in the generation, transmission and distribution sectors.

According to this research, the reason that unfolds the generation capacity drawbacks is that there is no real time demand forecasting (RTD) in the distribution sectors DESCO, DESA and REB. The prices per megawatt are set in flat rates while the peak demand is considered to occur in between a fixed time e.g. 10:00 am to 12:00 pm.

In this year (2018) the maximum generation capacity is observed to be over 10,000MW while the plant capacity is over 16,000MW. Inevitably, the gap due to the de-rated capacities (almost 6000MW) does remain. Therefore, introducing electricity market in Bangladesh would be a superior solution to meeting electricity demands and maintaining reliability in power supply.

4.5 Introducing Electricity Market in Bangladesh

As mentioned earlier, the structure of the electricity market in Bangladesh will be the same as per the American FERC conditions for deregulation, unbundling and restructuring. The GTDs will be set free from single entities BPDB, PGCB, DESA, DESCO and REB or these entities will separate into new markets where there will be new stakeholders such as the IPPs, DERs and other utility companies. This will give the opportunity to the make real time demand forecast (RTD) to the stakeholders who will bid for megawatts for following hours of electricity demanded.

Then again, the biddings will be made by both the generation side and the demand side. This will yield a new MCP (market clearing price) for the forecasted hours. The entire mechanism is shown by using a simple example as follows. The box diagram shows the offers and the bids made to approach to the MCP (intersecting point).

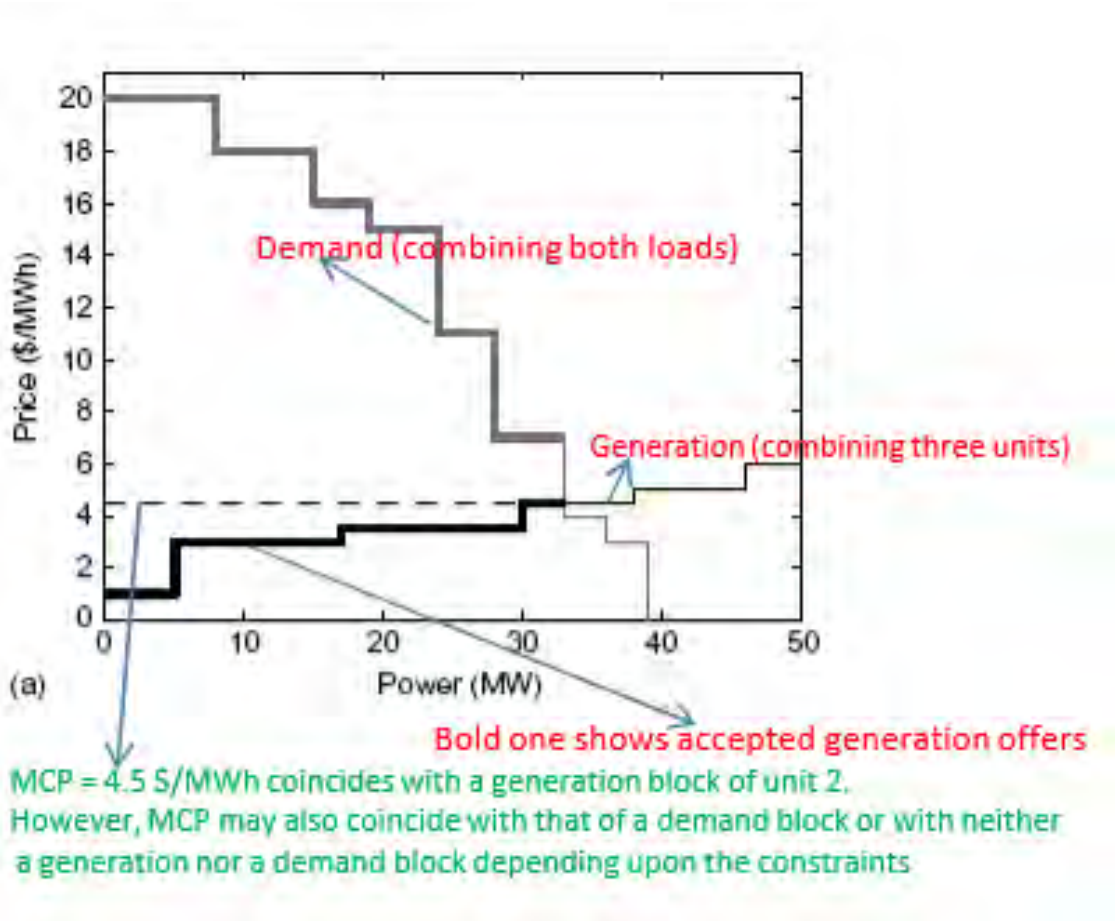
Unit Data	Unit 1	Unit 2	Unit 3
Capacity (MW)	30	25	25
Minimum power output (MW)	5	8	10
Ramp up/down limit (MW/h)	5	10	10
Initial status (on/off)	on	on	on
Initial power output (MW)	10	15	10

Offers by generators and bids by demands are provided in the tables as follow:

Offers	Unit 1			Unit 2			Unit 3		
Block	1	2	3	1	2	3	1	2	3
Power (MW)	5	12	13	8	8	9	10	10	5
Price ($/MWh)	1	3	3.5	4.5	5	6	8	9	10

Bids	Demand 1				Demand 2			
Block	1	2	3	4	1	2	3	4
Power (MW)	8	5	5	3	7	4	4	3
Price ($/MWh)	20	15	7	4	18	16	11	3

Figure 4.4: The MCP yielding from the generation (offers) and demands (bids)-



Chapter 5

Conclusion & Recommendations

All in all, the research conducted on the effect of electricity demand on climate change have resulted a wide range of hypothesis on the energy conditions of Bangladesh. The case studies discussed about the overall generation, transmission and distribution capacities in Bangladesh. Bangladesh being a riverine country had been able to successfully install power plants where the plant capacities are much higher than that of the peak demand. On the contrary, it was found that there was a significant de-rated capacity in the generation, transmission and distribution sectors. The second case study conducted about introducing electricity market in Bangladesh focused on the capability to increase the generation, reduce the peak demands, restructure, unbundle and deregulate. However, the facts discussed about the electricity market and the introduction of the concept of electricity market in Bangladesh yielded to bring in new ideas to the restructuring, deregulating and unbundling the traditional oligopolistic system in the country.

Nevertheless, the experiences gathered in the research may provide opportunities of carrying these new ideas to further and enriched level. Electricity demand in Bangladesh or any other developing country is bound to rise as the population grows with time. Introducing the electricity market will bring in new competitors in the energy market which will not only increase to total generation capacity but also provide efficient and cost effective megawatts. In addition, employment opportunities will rise as there will be new utility companies joining the market. Real time demand forecast will provide the actual demands before the hours targeted by the megawatt offers and bids made by the stakeholders and the generation entities, yielding an MCP. These stakeholders will be separate companies adding power to the grid or maintaining small loads. Thus, reliability in the power system transmission in Bangladesh will be recovered.

Reference

[1] . Distributed energy resources and benefits to the environment - ScienceDirect. [online] Available: https://www.sciencedirect.com/science/article/pii/S1364032109002561[Accessed: 16 Apr 2018].

[2] . Distributed energy resources | AEMC. [online] Available: https://www.aemc.gov.au/energy-system/electricity/electricity-system/distributed-energy-resources[Accessed: 16 Apr 2018].

[3] . Independent Power Producers (IPPs) - energypedia.info. [online] Available: https://energypedia.info/wiki/Independent_Power_Producers_(IPPs)[Accessed: 16 Apr 2018].

[4] Differences. Differences Between Publicly and Investor-Owned Utilities. [online] Available: http://www.energy.ca.gov/pou_reporting/background/difference_pou_iou.html [Acces sed: 16 Apr 2018].

[5] . "ABS. (2005). Year Book Australia. Industry Structure and Performance: 100 Years of Change

in Australian Industry. Report 1301.0, Canberra: Australian Bureau of Statistics.." vol. 0(

[6] . "ABS. (2005). Year Book Australia. Industry Structure and Performance: 100 Years of Change

in Australian Industry. Report 1301.0, Canberra: Australian Bureau of Statistics.." vol. 2(

[7] . "Ahmed, T., Muttaqi, K.M., & Agalgaonkar, A.P. (2012). Climate change impacts on electricity

demand in the State of New South Wales, Australia. Applied Energy, 98, 376-38.." vol. 1(

[8] . "Ahmed, A.U., Alam, M. (1999). Development of climate change scenarios with general

circulation models. In: Huq S, Karim Z, Asaduzzaman M, Mahtab F. (Eds.), Vulnerability

and Adaptation to Climate Change for Bangladesh. Dordrecht: Kluwer Academic

Publisher.." vol. 2(

[9] . "Alam, S.M.S. (2004). Bangladesh Power Sector: Present Status & Future Development Plans.

The World Bank's Energy Week, Washington DC, USA.." vol. 8(

[10] . "Alexander, L., Hope, P., Collins, D., Trewin, B., Lynch, A., & Nicholls, N. (2007). Trends in

Australia's climate means and extremes: a global context. Aust. Meteorol. Mag., 56, 1-18.

Andrew, G., & Turner, H. (2012). Climate change and the South Asian summer monsoon.

Nature Climate Change. doi: 10.1038/nclimate1495.." vol. 5(

[11] . "Bangladesh Power Development Board. (2011). An overview of power sector of Bangladesh.

Dhaka, Bangladesh.." vol. 8(

[12] . "Bangladesh Power Development Board. (2010). Annual report 2008-09. Dhaka, Bangladesh.." vol. 3(

[13] . "Bangladesh Power Development Board. (2009). Annual Report: 2008-2009. Dhaka,

Bangladesh." vol. 5(

[14] . Climate change | Ministry for the Environment. [online] Available: http://www.climatechange.govt.nz/resources/reports/effect-coastal-sep01/index.html [Accessed: 16 Apr 2018].

[15] . [online] Available: http://scienceillustrated.com.au/blog/science/scientists-uncertainhow-

[16] . "Cenegal, Y. A., & Boles, M.A. (1998). Thermodynamics: An Engineering Approach. The

McGraw-Hill Companies, 3rd Edition.." vol. 8(

[17] . "Chen, K., & McAneney, J. (2006). High-resolution estimates of Australia's coastal population

with validations of global population, shoreline and elevation datasets. Geophys. Res.

Lett., 33. doi:10.1029/2006GL026981.." vol. 6(

[18] . "Church, J., Hunter, J., McInnes, K., & White, N.J. (2004). Sea-level rise and the frequency of

extreme event around the Australian coastline. Coast to Coast '04: Australia's National

Coastal Conference, Conference Proceedings, Hobart, Tasmania.." vol. 5(

[19] . "Climate Change Cell - CCC. (2009). Impact assessment of climate change and sea level rise on

monsoon flooding. Dhaka, Bangladesh: Climate Change Cell, DoE, MoEF; Component

4b, CDMP, MoFDM.

." vol. 8(

[20] . Climate change Home Page | Department of the Environment and Energy, Australian Government. [online] Available: http://www.climatechange.gov.au/~/media/Files/minister/combet/2009/Speeches/ [Accessed: 16 Apr 2018].

[21] . [online] Available: http://www.direct.gov.uk/en/Environmentandgreenerliving/Thewiderenvironment/Climat

[22] . [online] Available: http://www.ga.gov.au/fossil_fuel/map.php?type=operating

[23] . [online] Available: http://www.ret.gov.au/

[24] . "Förster, H., & Lilliestam, J. (2010). Modelling Thermoelectric Power Generation in View of

Climate Change. Régional Environnemental Change, 11(1), 211-212.

." vol. 2(

[25] . [online] Available: http://www.gfdl.noaa.gov/noaa-gfdl-climateresearch-

[26] . "Greis, S., Schulz, J., & Müller, U. (2009). Water management of a thermal power plant – a site

specific approach concerning climate change, in A. Troccoli (ed.), weather and climate

risk management for the energy sector, NATO Science for Peace and Security. Series C:

Environmental Security, Springer, Dordrecht.." vol. 1(

[27] . Electric power consumption (kWh per capita) | Data. [online] Available: https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?cid=GPD_28&locations=BD [Accessed: 16 Apr 2018].

[28] . Bangladesh Power plants | Power Station | Hydroelectricity. [online] Available: https://www.scribd.com/doc/39747966/Bangladesh-Power-plants[Accessed: 16 Apr 2018

THE END