

Czech University of Life Sciences Prague

Faculty of Economics and Management

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Bachelor Thesis

**Natural energy resources impact on foreign trade – Case
study of Bangladesh**

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BACHELOR THESIS ASSIGNMENT

Jabed Mahmud, BBA

Economics Policy and Administration
Business Administration

Thesis title

Natural energy resources impact on foreign trade – Case study of Bangladesh

Objectives of thesis

The basic objective of the thesis will be an analysis of the impact of natural energy endowments on the foreign trade balance and structure of Bangladesh. The country is facing rapid economic development, which is increasing the demand for energy resources. Comparison of main available energy resources (coal, raw oil, natural gas, water and solar) should discover the vital role of the natural gas as the main energy source to the rapid development of Bangladesh. Dramatically increasing production and consumption during the last decades increased demand on all forms of energy resources impacting the foreign trade with these commodities and its negative current account balance. Recent geological and geophysical explorations have identified significant quantities of natural gas reserves in Bangladesh what can improve the foreign trade structure and balance in a positive way, reacting to the global shiGs in energy resources. The theses will try to verify this hypothesis and based on it to define recommendations for national energetic and foreign trade policy.

Methodology

The initial hypothesis will be verified using comparative analysis of global energy resources structural changes with the recent development in Bangladesh. The analysis will follow the main components of the energy mix of the country, its influence on the foreign trade structure, and its potential changes expected due to last explorations of natural resources together with inflow of foreign direct investments, governmental energy policy focused on the domestic private and public investments into this promising sector of the national economy.

The proposed extent of the thesis

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Declaration

I declare that I have worked on my bachelor thesis titled "Natural energy resources impact on foreign trade - Case study of Bangladesh" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 11th of march,2021

Jabed Mahmud

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Natural energy resources impact on foreign trade – Case study of Bangladesh

Abstract

The bachelor thesis deals with the process of transformation of Bangladesh 's energy sector from non - renewable natural resources, which partly form a significant part of its import structure to renewable domestic resources. The analysis of the reserves of natural energy resources shows that the process of retreat from traditional non-renewable energy sources, especially coal and oil, which showed a significant burden in terms of import structure of foreign trade as well as negative effects on ecology has already begun. The basic factor of this transformation is so far the increase in the share of own natural resources of natural gas, which is a non-renewable resource, but with much smaller negative ecological and economic consequences. With this change in the country's energy mix, the possibilities of using real renewables become more realistic, as they allow time and space to be mobilized for more intensive use of renewables and national energy policy goals, as well as converging with UN goals under the 2015 SDGs.

Keywords: Renewable and non-renewable energy resources, Bangladesh economy, energy sector transformation, foreign trade structure

Vliv přírodních energetických zdrojů na zahraniční obchod – případová studie Bangladéše

Abstrakt

Bakalářská práce se zabývá procesem transformace energetického sektoru Bangladéše od neobnovitelných přírodních zdrojů, které částečně tvoří významnou část jeho importní struktury k obnovitelným domácím zdrojům. Analýza rezerv přírodních energetických zdrojů ukazuje, že proces ústupu od tradičních neobnovitelných energetických zdrojů, zejména uhlí a ropy které prokazovaly značnou zátěž z pohledu importní struktury zahraničního obchodu jakož i negativní vlivy na ekologii již započal. Základním faktorem této transformace je zatím zvyšování podílu vlastních přírodních zdrojů zemního plynu, který je sice neobnovitelným zdrojem, ovšem s mnohem menšími negativními ekologickými a taky ekonomickými důsledky. Možnosti využití skutečných obnovitelných zdrojů se touto změnou energetického mixu země stávají reálnějšími, jelikož umožňují získat čas a prostor pro mobilizaci finančních zdrojů pro intenzivnější využití obnovitelných zdrojů a dosažení cílů národní energetické politiky, tak i přiblížení se cílům OSN v rámci programu SDG z roku 2015.

Klíčová slova: Obnovitelné a neobnovitelné zdroje energie, ekonomika Bangladéše, transformace energetického sektoru, struktura zahraničního obchodu

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List of abbreviations

AC	Alternating Current
BBS	Bangladesh Bureau of Statistics
BBIN	Bangladesh, Bhutan, India, Nepal
BDT	Bangladeshi Taka
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BPDB	Bangladesh Power Development Board
BPC	Bangladesh Petroleum Corporation
BNBC	Bangladesh National Building Code
BSTI	Bangladesh Standards and Testing Institution
CH ₄	Methane
CC	City Corporation
CO ₂	Carbon Dioxide
DESA	Dhaka Electricity Supply Authority
EE&C	Energy Efficiency & Conservation
ERL	Eastern Refinery Limited
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HVDC	High voltage direct current
IMF	International Monetary Fund
IPP	Independent power producer
ISO	International Standard Organization
Kg OE	Kilograms of Oil Equivalent
KV	Kilovolt
LDC	Least developed countries

LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MEPS	Minimum Energy Performance Standard
MKWh	Million-Kilowatt Hour
MmSt	Millions of Short Tons
Mtoe	Millions of tonnes of oil equivalent
MoU	Memorandum of Understanding
MW	Megawatt
NTPC	National Thermal Power Corporation
REB	Rural Electrification Board
RES	Renewable Energy Sources
RMG	Readymade garments
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
Solar PV	Solar Photo Voltaic
TCF	Trillion Cubic Feet
UN	United Nations
UN-ESCAP	United Nations Economic and Social Commission for Asia
USEIA	United States Energy Information Administration

1. Introduction

My bachelor thesis is focused on problems related to the energy situation in my home country of Bangladesh. This country, which belongs to the group of the least developed countries in the world (LDCs), faces a number of problems in this area.

From the global point of view, the energy situation is the key structural issue in global economic development and is particularly critical in LDCs. The number of people with access to electricity is constantly growing at a global level but even in these countries. On the other hand, the global population continues to grow, which created a growing demand for cheap energy. But an economy reliant on fossil fuels is creating drastic changes to our climate what is another Bangladesh will be facing in upcoming years. The UN declared in 2015 the transformation of the global energy structure as one of the principal objectives of its sustainable development goals (SDG) strategy. That is the reason why Bangladesh needs principal changes in the economic policy in this area as well. Implementation of that strategy has many implications for the structural, investment, trade policies of the country. To ensure energy for all inhabitants of the country has to deal with investing in renewable power resources, improvement of energy productivity, but also expanding infrastructure and technology provide to more efficient energy in all countries will encourage growth and help the environment. Such a policy will have a positive impact also on the foreign trade structure and balance of the country.

This thesis intends to contribute to analysing the energetic, environmental and foreign trade issues connected with the problem mention above, my country is facing especially in the context of contemporary global economic development. The situation will require a comprehensive approach considering more aspects of the processes of the country's economic and social structure transformation. That is why I am trying to focus not only on the problem of energetic and foreign trade sector transformation but also on their broader consequences like environmental or even social changes. I understand that the bachelor thesis can't solve the whole complex issue. Still, it can be understood as an introduction to the solution to my country's broader economic changes.

2. Objectives and Methodology

2.1 Objectives

The thesis's primary objective will be to analyse the impact of natural energy endowments on the Bangladesh economy's foreign trade balance and energetic structure. In the last decades, the country is facing rapid economic development, increasing the demand for energy resources significantly. The comparison of primary available energy resources (coal, raw oil, natural gas, water, and solar) should discover the vital role of natural gas as the primary energy source in Bangladesh's rapid development. Dramatically increasing production and consumption during the last decades increased demand on all forms of energy resources impacting the foreign trade with these commodities and its negative current account balance. Recent geological and geophysical explorations have identified significant quantities of natural gas reserves in Bangladesh that can improve the foreign trade structure by declining oil imports and positively changing the trade balance by reacting to the global shifts in energy resources. The theses will verify this hypothesis, based on it to define recommendations for national energetic and foreign trade policy modifications and make a comparison with existing governmental measures in this field.

2.2 Methodology

The initial above-mentioned hypothesis will be verified using comparative analysis of global energy resources structural changes with Bangladesh's recent development. The study will follow the main components of the energy mix of the country, its influence on the foreign trade structure, and its potential changes expected due to last explorations of natural resources together with inflow of foreign direct investments, governmental energy policy focused on the domestic private and public investments into this promising sector of the national economy.

The structure of the thesis from the methodological point of view is built on the methods of literature review focused on the energy sources structure transition. It is followed by analysing the position of renewable and non-renewable resources in the energy mix of countries in general and particularly in Bangladesh's economy. The next step is the analysis of the foreign trade structure and the role of energetic resources in it. Finally, an assessment of the transformation process in the energy sector and its influence on the foreign trade structure of

the country is done. The last chapter consisting of discussion and results is focused on the review and assessment of the country's energy policy and its impact on the energy mix transformation process. The conclusion chapter tries to summarise the most important ideas and the final assessment and evaluation of the thesis's hypothesis and the results of the energetic policy. The methodological problem of this bachelor thesis was the lack of current and accurate statistical data. This is due to the limitations and shortcomings of a good database and relatively less developed statistical services in less developed countries such as Bangladesh and its complementarity with international data. As a result, it was not possible to ensure all analysed data with sufficient relevance and their actualness. In some cases, for example, in the UN statistical yearbooks on trade, relevant data are published with a delay of up to 5 years; in other cases, from other sources managed to obtain data for 2019, even partially in 2020.

However, the problem in these cases is less complementarity and homogeneity of data, including their comparability. From this title, it is necessary to consider some preliminary conclusions resulting from these gaps as not entirely accurate but only indicating certain trends. The data about the foreign trade of Bangladesh with energy resources are analysed based on United Nations Statistical Department data.

A deeper overview of the literature and data sources is given in Chapter 3 and a final overview of the literature, lists of figures, tables, and graphs.

3. Theoretical and Literature Review

3.1 Theoretical definitions of renewable and non-renewable energy resources

Energy resources are opportunities that allow a region to generate electricity based on its natural conditions and circumstances. Some of these energy resources are obvious; An area may contain coal, oil, wood, or gas. But other such renewable resources as wind, solar, hydroelectricity, and wave power are not so obvious - they are based on the natural weather patterns and characteristics of a region. Energy resources, their actual future availability in the market depends on various limitations: shifting of production towards increasingly small deposits in increasingly harsh environments; Increase the cost of exploration, production, and marketing; Additional environmental burden; Decrease in energy ratio; And more stringent environmental policies and regulations (Rogner, 2012).

In principle, there are two types of energy sources available in the contemporary world economy:

- Renewable energy source.
- Non-renewable energy source.

3.1.1 Renewable Energy Sources

Renewable technologies are considered a clean source of energy. The best use of these organizations is to reduce the environmental impact, produce minimal secondary waste and be sustainable based on current and future economic and social needs. The sun is the source of all energy. The earliest forms of solar energy are heat and light (Panwar, Kaushik, & Kothari, 2011).

Advantages:

- Renewable energy is eco-friendly: Renewable energy is considered clean energy as it does not cause serious environmental pollution and has low or zero carbon and greenhouse emissions. Fossil fuels emit high greenhouse gas and carbon dioxide levels, responsible for global warming, climate change, and deteriorating air quality. Solar and wind energy are considered environmentally friendly because they emit zero toxic gases into the atmosphere.

- It's a renewable resource: Energy sources (oil, gas, and coal) such as fossil fuels are considered limited resources and are likely to run out in the future. Renewable energy can help developing countries avoid over-reliance on fossil fuels.
- It's a reliable source of energy: The use of fossil fuels has increased sharply. This over-reliance on fossil fuels poses a security threat. Fossil fuels include trade risks, political instability, rising fuel prices, and the risk of an unnecessary war. While most argue that solar and wind power are not reliable, a strong infrastructure puts this argument to rest.
- Renewables save money: There is no need to pay for refuelling when using technology that produces energy from the sun, wind, steam, or natural processes. The amount of money saved using renewable energy can vary depending on various factors, including technology.
- Job creation: Renewable energy creates real economic sense because it is a cheaper alternative to most traditional energy sources. Since the establishment of renewable energy, new and stable jobs have been added to most of the world economy.
- Stabilized global energy prices: Changing the renewable source of energy means stabilizing fuel prices around the world. This is because the cost of renewable energy depends on the initial cost of installing renewable energy technology instead of fossil fuels, which increases and decreases depending on current inflation and the availability of companies.
- Less maintenance of facilities: Renewable energy technologies require less overall maintenance than traditional thermal generators that use conventional fuel sources. These renewable energy generation technologies, such as solar panels and wind turbines, have few or no running parts. After all, they do not rely on combustible, combustible fuel sources for management, reducing operating costs.
- Health benefit: The use of fossil fuels causes greenhouse gases (GHG) and other harmful pollutants to cause respiratory problems and cardiac health problems. Renewable energy helps to reduce the tendency of these pollutants and contribute to an overall healthy environment.

- It is a technology: Renewable energy technology is a term used to refer to hybrid technology or other forms related to technology that store energy produced or produced by a renewable source.

Disadvantages:

There are also some disadvantages of renewable energy sources:

- Low-efficiency levels: Renewable energy technologies are still significantly new to the market, meaning they still lack the necessary skills. Lack of adequate knowledge of how to effectively utilize these variants' power makes installation and maintenance costs even higher for such facilities.
- A lot of space to install: It takes more than 40 hectares of panels to generate about 20 MW of energy using current solar power generation technology.
- Not always a commercially viable option: To be effective, a distribution network needs to be created to transfer renewable energy to the required space. These
- Renewable energy can be unreliable: Renewable energy technology relies entirely on the weather (e.g., sun and wind) to harness any energy. If atmospheric conditions are not adequate, any renewable energy technologies will lack the ability to generate electricity.
- Requires a huge upfront capital outlay: Huge financial outlay is required to set up renewable energy generation facilities. Installation of wind turbines, solar panels, and hydropower plants are relatively expensive (Kukreja, 2009).

Conclusion:

From all the above discussion, renewable energy plays a more important role for each person and environment with each passing day. Abundant renewable energy is becoming an important solution to the world's energy needs. Besides, renewable energy to protect the environment and reduce global warming or pollution also brings many positive effects.

The major types of renewable energy sources are:

- Solar Energy.
- Wind Energy.
- Geothermal Energy.

- Hydropower Energy.
- Biomass Energy.

Solar Energy

Solar energy is a source of renewable energy that can be produced from solar photovoltaic (PV) panels installed in homes, buildings, and solar farms around the world. Each solar panel is made up of small solar cells that convert daylight into electrical current, which feeds into homes or other premises through inverters to receive light and equipment. The energy generated during the day can be stored in solar batteries so that the energy can be continued when needed even after the sun has set once.

Advantages

There are many advantages of the solar energy resources listed as follows:

- Electricity bills: By generating energy through solar panels, it can reduce annual electricity bills. Also, it can produce more energy than it uses, making money by selling it on the grid through the smart export guarantee.
- Renewable sources of energy: In addition to fighting climate change, solar renewable energy also helps reduce air pollution, which is one of the biggest challenges worldwide.
- Easy to install: It can be easily installed. It usually takes a day or so for a home to run on solar energy.
- Low cost: Solar power systems usually do not require maintenance. The initial cost of the solar system for maintenance and repair work is meagre.
- Technology development: Technology in the solar energy industry is constantly advancing, and improvements will be even more intense in the future. Innovations in quantum physics and nanotechnology could increase solar power panels' efficiency and double or even triple the solar power system's electrical output.

Disadvantages:

- Investment cost: The initial cost of purchasing a solar system is fairly high, including payment for solar panels, inverters, batteries, wiring, and installations.

- Weather-dependent: Solar energy is effectively dependent on sunlight for solar energy collection. Solar energy can be collected by reducing the efficiency of solar power on cloudy and rainy days.
- Storage is expensive: Solar energy can be stored in large batteries. These batteries can be charged during the day to use energy at night, but it is also quite expensive.
- Uses a lot of space: Solar PV panels require a lot of space. Some roofs are not enough big that solar panels could fit on that.
- Associated with pollution: Solar energy pollution is lower than other energy sources related to solar power. However, some toxic and hazardous products are used during the manufacturing process of solar PV systems that can indirectly affect the environment (Vourvoulias, 2021).

Conclusion:

Solar energy is an infinite source of directly usable energy and ultimately produces other energy sources: biomass, wind, hydroelectric, and wave energy.

Wind Energy

Wind energy provides a sustainable alternative to the search for renewable energy. The wind has long been a source of energy for humans. The ancient mariners used sails to catch the wind. People used windmills to grind their grains and pump water. Over the past decade, wind turbine usage has grown by more than 25 per cent per year. Most come from turbines that can be as tall as a 20-story building and have three 200-foot (60-meter) long blades. The air spins the blades, which rotate a shaft connected to the power generating generator. The largest wind turbines produce enough electricity to supply the United States a year (about 12 megawatts-hours).

Wind energy advantages:

- Friendly fuel sources: Wind energy does not pollute the air; it depends on the combustion of fossil fuels like a power plant. It does not emit atmospheric emissions that cause acid rain or greenhouse gases such as carbon dioxide (CO₂) or methane (CH₄).
- Cost-effective: It is completely free, and anyone can use it. It is one of the lowest-cost renewable technologies that depend on air resources and specific projects' financing.

- Domestic and industrial installation: Wind turbines can be built on existing farms or ranches where most of the best wind sites are found. It uses a portion of the land, which does not cause any hassle to work for the farmers and pastoralists.
- Job creation: Works have been created for wind turbine manufacturing, wind turbine installation, maintenance, and wind power consultancy. Wind is expected to support globally more than 600,000 jobs in production, installation, maintenance, and support services by 2050 (Watson, 2013).

Disadvantage:

- The fluctuation of wind & good wind sites: It has a disadvantage that it is not a constant energy source. It can cause serious problems for wind turbine developers, who will often spend significant time researching whether a particular site is suitable for wind power generation.
- Noise & aesthetic pollution: Wind turbines can generate noise and visual pollution. A single turbine of wind can be heard from a few meters away. Although away from housing, steps are often taken on-site wind turbines.
- Threats to wildlife: It is thought that wind turbines pose less of a threat to wildlife than other human-made structures such as cell phone masts and radio towers.

Conclusion:

The wind is a variable element, its variations varying in different timescales, and spatially its length can vary dramatically depending on the local climate and terrain. The accuracy of weather forecasting models has increased significantly over the past few decades. These models have been able to provide insights into variability in hourly and daily time periods. Understanding local-scale spatial differences in wind significant progress has been made (Watson, 2013).

Geothermal Energy

Geothermal energy is a type of renewable energy derived from the earth's core. It comes from the heat generated during the planet's core formation and the radioactive decay of materials. This thermal energy is stored in rocks and liquids in the centre of the earth. The difference between the centre of the earth and the surface temperature carries an uninterrupted thermal energy flow from the centre to the outer part of the planet. Geological energy has three distinct

designs: dry steam, flash and binary. The oldest type is dry steam, which takes direct steam to drive turbines from broken soil. Flash plants draw high-pressure hot water from groundwater and mix it with cold low-pressure water. Instead, it produces steam which is used to run turbines. The binary plant uses heated water with a secondary liquid that has fewer boiling points than water. Secondary liquid evaporation drives the turbine. Most of the underground power plants of the future are expected to be binary plants. The United States is the largest producer in the world. They have the largest geological development globally, located at The Geysers, north of San Francisco, California.

Advantage:

- Renewable: Geothermal energy provides a renewable energy source that has the potential to supply a reasonable amount of electricity, heat, and cooling (Anderson & Rezaie, 2019)
- Environmentally-friendly: Geothermal energy is more environmentally friendly than conventional energy sources such as coal and other fossil fuels. Also, geothermal power plants' carbon footprint is low; although some pollution is associated with geothermal energy, it is relatively minimal compared to fossil fuels.
- Reliable: The energy generated from this source is easy to calculate because it does not fluctuate in the same way as other energy sources such as solar and wind.
- No fuel required: Geothermal energy does not require any fuel as a naturally occurring resource.
- Heating and cooling: For efficient use of geothermal for power generation, turbines require a water temperature of more than 150c. Alternatively, temperature differences between surface and ground sources can be used. Since the ground is more resistant to heat transfer from the air, it can act as a heat sink/source with geothermal heat pumps just two meters below the surface (Anderson & Rezaie, 2019).
- Sustainable: Geothermal provides a more reliable energy source than other renewable sources such as wind and solar power. This is because the resource can always be tapped compared to wind or solar energy.

Disadvantage:

- High costs: Geothermal energy is an expensive resource with a price tag of about 2\$ to 7\$million for a 1 MW power plant.
- Location restricted: The biggest single problem with geothermal energy is that it is location-specific. Geothermal plants need to create places where energy is accessible, which means some regions cannot harness this resource.
- Environmental side effects: Although geothermal energy does not normally emit greenhouse gases, large amounts of this gas are stored beneath the earth's surface, which is released into the atmosphere during excavations. Although these gases are released naturally into the atmosphere, this rate increases near geothermal plants.
- Earthquakes: Geothermal energy also carries the risk of triggering earthquakes. This problem is further compounded by the growing problems of underground power plants due to changes in the earth's structure as a result of excavation, which forces the earth's surface water to explode towards greater exploitation of resources.

Conclusion:

Geothermal energy arises from the decay of naturally occurring radioactive isotopes inside the Earth, resulting in different heat fluxes across the Earth's surface depending on the tectonic setting. Heat flux can be very high locally in volcanic areas. Geological power generation requires heat (most effective in cases of high enthalpy); Plenty of heated water in the aquifer (or crystal breaks artificially in hot, dry style); An impenetrable hat-rock that prevents her from escaping (Sheldon, 2005).

Hydropower Energy

Hydroelectric power is a type of energy that uses the energy of flowing water to generate electricity. It is one of the oldest methods of strengthening energy as well as the cleanest and most renewable. In 1753, a French engineer named Bernard Forrest de Belvidere published his final construction, the architecture of which was a hydraulic one. This work described both vertical and horizontal-axis hydraulic machines and laid the foundation for future innovations in hydropower. The first hydroelectric plant Niagara Falls built-in 1879. In 1881, the street lamps city of Niagara falls had powered by hydroelectricity. In 1882 work began on the world's first hydroelectric plant United States Wisconsin (Vahid, Bagher, Mohsen, & Parvin,

2015). Hydropower plants are an important source of electricity in the United States. In a hydroelectric plant, the flow of natural water provides the energy that can be converted into electricity. It has different types of hydropower facilities, all based on the kinetic energy of running water. There are two kinds of facilities:-

Impoundment facilities: It uses a dam to store water from the river in an artificial reservoir. As water is released from this reservoir, it flows and activates a generator that produces spin and turbines that generate electricity.

Diversion facilities: This type of hydroelectric facility channels along or without a dam along a portion of the river flowing through the canal.
Pumped storage facilities: Pumped storage facilities are designed to store electricity derived from other energy sources such as nuclear power plants or wind farms. Water from one reservoir is raised above a second reservoir at a higher altitude.

Advantage:

- It is a renewable source of energy. It is a constant source of energy. Unlike gas, fossil fuels, solar and wind energy, hydropower availability does not fluctuate but is constantly available.
- It is flexible: Hydropower is still rich during peak electricity demand periods because rainwater can be reused. Water flow can be changed to meet this demand without compromising on the quality of energy produced.
- It helps in flood prevention. Reservoirs used for hydropower use help control river flows, thus preventing flooding.
- Hydropower does not contribute to air pollution. Since it takes energy from flowing water and does not require any fossil fuels' combustion, it does not release greenhouse gases and other harmful air pollutants.
- In the western United States, 58 power plants generate an average of 42 billion kilowatt-hours per year, enough to meet the residential needs of about 15 million people. It would be equivalent to the electrical energy of about 72 million barrels of oil in this context (Vahid, Bagher, Mohsen, & Parvin, 2015).

Disadvantage:

- Hydroelectric dams can change the oxygen level of a river, affecting local fish's health.
- Dams are costly to build, and they must be built in very high quality.
- Extensive land flooding means that the natural environment is destroyed.
- The high cost of building the dam must mean they must work for many decades to become profitable.

Conclusion:

Hydropower is one of the cleanest energy sources, and it is also the most reliable and cheap. Hydropower plants enable stable and regular electricity generation by ensuring reliable electricity distribution, which is not the same as other renewable energy sources like solar and wind energy.

Biomass Energy

Biomass energy is a relatively clean, renewable energy source that involves the use of organic matter that collects energy from the sun and converts it into living chemicals. It is a renewable source because it continues to increase and absorb solar energy, especially where biomass crops are grown. Most biomass energy is generated from plants that collect energy from the sun through the process of photosynthesis. Advances in technology have allowed biomass energy to be used in a variety of applications, including liquids and gases used for biofuels in electrical transport. In most countries, biomass plants have been built in rural areas to supply electricity to the local people.

Advantages:

- **Renewable:** It is considered a renewable form of energy because the organic matter used to produce it never runs out. The main positive about biological energy is that it generates energy using renewable resources. These resources probably handle wood waste, tree buildup, wood shells, or urban waste.
- **Carbon neutrality:** The amount of carbon emitted into the atmosphere contributes greatly to climate change. Biomass fuels emit only carbon into the atmosphere which is absorbed by plants during their lifetimes.

- It's cheaper compared to fossil fuels: The costs involved in collecting biomass fuels are much lower than building drilling or gas pipelines for oil. This low cost can also go to consumers, whose energy bills can no longer rely on issues such as availability and the decisions of energy suppliers. These lower costs make biomass more attractive to producers and they can get higher returns for lower output.
- It is versatile: Biomass power is one of the most versatile options available, it can be converted to many different fuel sources, each with different applications. For example, biomass can be processed to make biodiesel for vehicles, but it can also be used to use methane gas and various biofuels.
- Availability: Abundant amounts of biomass fuels. Such as the sun and water, are found anywhere on the planet. Biomass fuels will always be available because they are part of the natural planet life cycle, and it will not be irresponsible to use them.
- Domestic production: The nature of biomass means that anyone can produce practical and use it domestically. Although it does some work, even using a central heating system can save some money, such as burning wood, and have a more beneficial effect on the environment (Ecavo.com, 2016).

Disadvantages:

- It's not completely clean: Although biomass is a carbon-neutral fuel source, it is not completely clean. The burning of wood and other plant life causes emissions other than carbon. which can pollute the local environment, even if its effects are not as intense as those from fossil fuels.
- Little expensive: Although the cost of extracting biomass fuels is lower than most types of fossil fuels, they still generally outperform many other types of renewable energy. This cost comes from the need for biomass resource maintenance and the need to replace the extracted biomass.
- Possible deforestation: Although biomass fuels are renewable, they also need to be maintained. Failure to do so could result in massive deforestation. This is a big environmental problem.
- Space: The materials used in biomass energy require a lot of space to grow. This space is not always available, especially in built-up areas like cities. It also limits the places

where biomass power plants can be built, as they need to be close to fuel sources to reduce transportation and other costs.

- It requires water: The most often overlooked problem with biomass energy is the amount of water needed to produce it. This not only increases the cost of irrigation, but also makes it less accessible to water sources people, and wildlife.

Conclusion:

Biomass energy is a carbon-neutral energy source that provides lower costs than fossil fuels, even being highly diversified. However, there are a number of issues that have held it back from widespread adoption. In particular, more needs to be done to address the issue of efficiency as fuel, as well as issues such as space and cost.

3.1.2 Non-renewable energy

Non-renewable energy is a source of energy that can be exhausted one day and cannot be used repeatedly. Fossil fuels (natural gas, coal, oil), minerals and nuclear fuels are nonrenewable resources. They have high carbon emissions and hence are not environment friendly. These were formed millions of years ago from organic matter in the depths of the earth's crust, like plants and animals' remains. There are several different types of non-renewable energy, but fossil fuels are most commonly used. Fossil fuels are formed when organic matter from plants and animals that died millions of years ago was converted by pressure and heat inside the Earth's crust:

- Natural gas (formed 252-66 million years ago).
- Coal (formed 400 million years ago).
- Crude oil (formed 252-66 million years ago).
- The formation of new fossil fuels takes billions of hours.

Advantages:

- Non-renewable supplies can be supplied wherever necessary for their proper identification in different regions, supporting positive results as some locations are not suitable for renewable energy generation. Hence, it applies to solar, wind, and even geothermal for some geographical locations.

- In comparison to non-renewables, because it is possible to build energy processing stations everywhere. There can be problems with transport loss when using them, but a well-developed infrastructure can reduce this predicament rather effectively.
- There are still opportunities for improvement of the energy potential of non-renewables by processing them. Their implementation can allow generating more power from traditional fossil fuels than in their raw format. Moreover, the hydrocarbons found in fossil fuels allow creating plenty of products being used in almost all people's contemporary life.
- The non-renewable sector plays an influential role in the global economy and the national economies of all states. Producers and manufacturers of fossil fuels create many jobs that contribute to the local economy and their growth.
- Another advantage of non-renewable energy is that it still provides a stronger energy output than renewables. Refining crude oil into usable products generates 12 times more power than the direct consumption of the resource. Also, coal energy provides eight times more energy during consumption after refinement.
- Renewable energy is cheaper than other resources. According to some sources, renewables need 30 times more energy to produce the same amount of energy currently available from fossil fuels.
- Non-renewable energy sources are used in various other forms of energy use. Only about 30% of crude oil is taken as hot oil or diesel; the next 50% is used to produce gasoline and other automotive fuels.
- The global availability of nonrenewable resources gives relatively remarkably stable pricing during the last decades, allowing the predictability of private and public budgets. Non-renewable products nowadays produce even clean energy because the renewables sector's infrastructure comes from fossil fuels.

Disadvantages:

- If only subsidized figures are taken from the non-renewable energy industry, fossil fuels represent 26% of the global greenhouse gas emissions released each year.

Removing this problem on its own can reduce premature deaths associated with pollution by about 50%.

- Although estimates for the availability of fossil fuels have been steadily changing over the past 30 years, there is always the possibility that irreversible resources may become unavailable in the future.
- Countries are often at war over access to the necessary agencies. The economy's reliance on non-renewable energy forms the basis for future conflicts.
- When coal fuel burns, they release particles into the atmosphere until a filter catches them. These tiny particles, often just microns in diameter, increase the risk of cancer, heart attack, and stroke when people get exposed to them.
- While improving to support networks for non-renewable energy, the environment increases the adverse risks it faces every day. Establishing production centres, refining systems, and transportation systems require investment in fossil fuels that are much higher than those used for solar and wind items.
- Currently, only five countries are responsible for 75% of global coal product consumption. India, China, Russia, Japan, and the United States all support the huge non-renewable energy industry and are also the world's largest GHG polluters (Miller, 2020).

Conclusion:

Although there is a potential danger of managing non-renewable energy, fossil fuels are still needed to manage modern life. If natural gas, oil, and coal can take control measures in contact with hazardous substances, the industry can operate more efficiently. It may be healthier to use sustainable resources when comparing renewable energy with non-renewable energy, but this method is not always affordable. The advantages and disadvantages of renewable energy lead to sustainable ways of creating electricity requirements.

The major types of non-renewable energy are:

- Coal
- Natural gas
- Nuclear energy

- Petroleum/ Crude oil

Coal

Coal energy is a nonrenewable energy which means it is a kind of energy that cannot be regenerated. Coal power is used to generate electricity in industrial or manufacturing centres and even electrical appliances at home. Many manufacturing plants and industrial plants use coal energy to generate electricity because coal energy is affordable. Moreover, although coal is not renewable, it is abundant because it has the world's largest reserves.

Advantages:

- Coal power is an affordable source due to its stable price compared to other energy sources.
- Coal produces high energy on combustion.
- Coal power is cheap
- Coal power is a reliable energy source.

Disadvantages:

- Coal power produces large amounts of carbon dioxide, leading to global warming and climate change.
- Coal burning is not environmentally friendly because it emits harmful gases such as sulfur dioxide, nitrogen oxides, carbon dioxide, and gases that pollute the environment with acid rain.
- Coal is declining rapidly because it consumes large quantities.
- Coal mining destroys the environment and endangers human lives, especially coal miners.

Conclusion:

The fact that the use of coal power is significant is not denied. We all want an affordable and reliable energy source that is only available using coal power. Although the use of coal fuel is extremely significant, and it is impossible to survive without it, the damage that can be caused to the environment by the uninterrupted use of coal power should always be considered (Gaille L. , 2017).

Natural gas

Natural gas has been produced naturally for millions of years. It is formed when the layers of rotting trees and animals are exposed to intense heat and rock pressure from the earth. All this heat, pressure, and millions of years of natural materials turned into petroleum, coal, and natural gas.

Advantage:

- Natural gas is environmentally friendly than oil and coal.
- It is easier and safer.
- Natural gas is highly reliable, as opposed to electrical electricity, which is blown out during storms.
- It's not expensive.

Disadvantages:

- Natural gas contributes to greenhouse gases.
- is a combustible material; it must be handled with care.

Conclusion:

Natural gas is combustible and easily explosive if mishandled. With a leak, gas is created in a house or structure. It explodes when the gas is ignited. The intensity of the explosion depends on the amount of leak. Natural gas is toxic if inhaled, causing serious health risks or even death (MET, 2020).

Nuclear energy

Nuclear energy is the energy generated from the use of uranium. Energy is produced through complex chemical processes at nuclear power plants. The major chemical reactions involved in the nucleus division of atoms take place in reactors.

Nuclear energy divided into two-part

- Nuclear fission
- Nuclear fusion

Nuclear fission: Heavy nucleus splits into two nearly equal lighter nuclei by the bombardment of slow-moving neutrons. The release of energy phenomenon that accompanies the breaking

up of a heavy nucleus is called nuclear fission. The heat release in this process is used to make steam and generate electricity.

Nuclear fusion: Two or lighter nuclei combine to form a heavy nucleus, and a large amount of energy is released. The phenomenon is termed nuclear fusion to deuterium nuclei are combined to form a heavy helium nucleus. A large amount of energy is produced nuclear fusion principle is involved in the production of energy in the sun and the stars. The nuclear fusion principle is used in the design of the hydrogen bomb.

Advantage:

- It does not produce any pollutant gas.
- Not contributing to global warming.
- Low fuel consumption reduces the impact of excavation and transportation on the environment.
- The need for high-tech research benefits other industries.

Disadvantage:

- Safe disposal of waste and radioactivity is complicated and expensive.
- The public perception of nuclear power is negative.
- Large-scale accidents would be catastrophic.
- The cost of building and safe decommissioning is expensive.
- It cannot respond quickly to changes in electricity demand.

Conclusion:

The use of nuclear energy has many advantages in terms of economy and security. The difficulties of using nuclear energy cannot be denied, but as shown above, ignoring the disadvantage, or reducing its severity. So, the advantages of using nuclear energy far outweigh the disadvantages, making nuclear energy a safe, secure, and economical alternative to power generation (Kuet, Jesse, 2018).

Petroleum/ Crude oil

It is a naturally occurring liquid found under the earth's surface that is refillable for use as fuel in equipment and cars. It is the primary catalyst for global economic growth and has so much

influence on world politics. Despite its relevance to the global economy, it is a source of environmental pollution and civil unrest.

Advantage:

- Although petroleum is available at the rock level; this resource is easy to access. Different methods can be used to drill into the rock layer and then pump the petroleum to be further refined in the future. Even when petroleum reserves are located deep underground or at the bottom of the ocean floor, modern technology allows us to access these energy resources for our society's convenience.
- Petroleum is not the highest concentration of fuel on the planet, but it is one of the best.
- Petroleum is extracted. The liquid form is easy to move from place to place due to its viscosity. Transport networks that include tracking, pipeline, and tanker-based shipping can quickly bring petroleum from one part to another of the world.
- Petroleum can produce fuel for transportation. It also produces fuels that are used to heat businesses and homes. The fuel can be adjusted to generate electricity.

Disadvantage:

- Like other fossil fuels, petroleum represents a limited organization. The demand for petroleum increases year by year as it is used to produce fuel, various medicines, textiles, wax, Vaseline, cosmetics, and various other products.
- Fuel combustion from petroleum, greenhouse gas emissions, particulate matter, and other toxic gases are major contributors to air pollution on planet Earth. Plenty of vehicles, including internal combustion engines (burning petrol or kerosene), have lost air quality today, especially in the big cities of the planet, making places a nightmare for all the people living there.
- After refining, petroleum is used to produce many useful products for our society, but they contain plastic, non-biodegradable material. Plastic pollution affects humans and the environment (it suppresses our ponds, rivers, and oceans and kills marine life). Leaving chlorinated plastics on land can release dangerous chemicals into the soil, reaching and contaminating groundwater sources (Gaille B. , 2018).

Conclusion:

Petroleum has driven society since the middle of the twentieth century. These reserves will last until the middle of the twenty-first century, so it can be said that oil and other petroleum products have been here to serve humankind for almost a century. By 2050, a cleaner and healthier society need to develop large-scale renewable and low-carbon energy sources to replace waste fossil fuels (including petroleum) successfully.

3.2 Natural energy resources characteristics in literature

The economic and environmental literature has a broad coverage of natural energy resource issues. There are many different formal and informal national and international organizations, think tanks, and similar institutions involved in analysing the topics of renewable energetic resources, mostly in connection with environmental changes and structural reforms needed to face them. One of the representatives and influential institutions of this group is the UN Environment Program and its International Resource Panel organization focusing on this thesis globally. The program regularly publishes” Global Resources Outlook” (Bringezu, Oberle, & all, 2019). This report provides an analysis of how to proceed with climate change issues through a combination of climate mitigation, resource efficiency, biodiversity protection policies, and carbon removal. The analysis and modelling presented in this report is the first attempt to understand and harmonize the effects of growing resource use and find that it is feasible and possible to grow all national economies, increase our well-being, and remain within global planetary boundaries the condition that the action must begin immediately.

This institution also publishes specialized reports as sustainable trade-in resources: global material flows, circularity, and trade. These reports follow the environmental impacts and trade flows of material resources. It further shows that both multilateral trade rules and regional trade agreements can be actively used to reduce the environmental impacts associated with circulars and the progress of green economies and resource mobilization (Resourcepanel.org, 2020).

Another of its reports is “Resource Efficiency and Climate Change”, which conducts a rigorous assessment of the contribution of material efficiency to greenhouse gases (in next only GHG) abatement strategies focusing on reducing GHG emissions potential and reviews

policies that address these strategies. This shows that increasing material skills is a key opportunity to achieve the Paris Agreement's aspirations (Hertwich, 2020). All the above-mentioned reports made some contribution to the general methodological approach of these.

Another influential institution that contributed to this thesis is the NRDC (Natural Resources Protection Council), founded in 1970 in the USA by leading law students and attorneys in the environmental movement. They work as partners with businesses, elected leaders, and a community group. Lora Shinn from this institution (Shinn, 2018) describes the present situation regarding the energy sector's structural changes as a clean energy revolution and brings some new knowledge about renewable natural resources and how to use them.

Climate change is crucial for the energy sector of all countries, particularly for less developed like Bangladesh. Many economists and environmentalists have also discussed this topic, among them, e.g. Asumadu Sarkodie, Phebe Asante Waa, Shashi Dubey, and others (Asumadu Sarkodie, 2016). In their understanding, climate change is one of the big issues in the world. From the beginning of the creative climate has been changing all the time, but it is worrying that the pace of change in recent years could be one of the Earth's threats.

Carbon dioxide has been increased in the last 36 years. Before 1995, the average was about 1.4 ppm per year and thereafter, 2.0 ppm per year. UN framework convention defines that climate can change directly or indirectly to human activities, which alter the composition of the global atmosphere and shows a picture of natural climate change observed over a comparative time. So, this topic is of particular attention to Bangladesh. These authors (Asumadu Sarkodie, 2016) focused on this topic, which was also useful in defining this thesis's approach.

Recent research mentions that public health messaging may strengthen the argument for mitigating climate change. In fact, there has been a positive response to climate change as a public health problem in almost all countries. This research typically focuses on the future health consequences of climate change. It fails to capitalize on the current health co-benefits of reduced fossil fuel use or combined health risks of inactivity and the health benefits of action with a single frame.

3.2.1 Natural energy resources in Bangladesh in economic literature

More resources are describing the energetic situation in Bangladesh. An important source of information on these issues is Banglapedia - the National Encyclopedia of Bangladesh, an output of more than 1450 scholars (Bangla,pedia, 2021). It provides access to all branches of knowledge related to the country. It has become a vital and important guide to teachers, students, researchers, professionals, and general readers. E.g. the structure of energy resources of Bangladesh had been described by (Rahman, 2014). He states that energy stands for stores of convertible energy, which are non-renewable (including fossil fuels like coal, oil and gas, and nuclear-fission fuels) and renewable (like wind, tidal, and geothermal power). On another side, he states that renewable energy is not a new phenomenon in Bangladesh. Local citizens have used solar or wind energy from ancient times.

Solar energy is used for drying cloth, agricultural products, fish, salt, etc. Also, wind energy was used by sailboats in deep history as the primary source of mobility. However, the modern use of renewable resources of energy, e.g., electricity generation or water pumping systems from a wind turbine on a commercial basis, has not yet been started on a broad scale. His text has an origin in 2014, it is necessary to comment that despite his statement, the situation is slowly improving in the last few years. Other issues mentioned by him are problems in the power system include shortfall of generation, load-shedding, and low voltage, largely due to excess pressure on the supply network, dilapidated transformers and transmission lines, and management failures in distribution systems (Rahman, 2014).

Another issue critical for Bangladesh is energy access. It has no universal definition, but it has some normal definition identifying the relationship between access to energy and the population's income level. In the literature, poverty is usually related to adequate income and consumption to meet essential needs, which refers to the deprivation of a people's basic minimum needs. From this perspective, energy access means ensuring a minimum amount of energy to meet the population's needs.

In literature occurs the parallel with the regional poverty average and levels of electricity consumption. A family with reliable and affordable access to clean cooking facilities is first connecting to electricity to reach the energy access (Bhattacharyya, 2012). Typically,

engineering estimates or normative values determine the required requirements, but these assumptions have their own problems due to innate subjectivity.

3.2.2 Natural energy resources in the Foreign Trade of Bangladesh in literature

Many expert articles are devoted to the different issues connected with energy resources transformation and its influence on foreign trade in Bangladesh. Among them, it was possible to identify authors and their publications as follows:

K.R. Dhungel, in his book named “South Asian regional energy trade: problems and prospect”, states that the generation of electricity and extraction of liquefied natural gas in Nepal and Bangladesh respectively. First all, these sources of energy replace the use of hydrocarbons that have brought. Second, these energies will reduce the imports of energy into the country (Dhungel, 2008).

Another author, U.Pan, in his professional journal article “Trade openness, technological innovation, dynamics of financial development, and energy intensity Evidence from Bangladesh”, identifies the benefits brought to energy problems solution from trade openness because it helps utilize the resources properly and energy consumption through economies of scale, combined effects of production factors, and development, trade openness, technological innovation, economic growth, and energy intensity (Pan U. e., 2019).

Mondal et al. in their article “Impact of technology selection for power generation in Bangladesh and CO2 emissions restriction on energy companies”, point out that growing costs of primary energy resources lead to the situation when the country would need to import energy resources such as coal from 2025 onwards to meet the required demand (Mondal, 2011).

A.Wazed in the article in the Australian Journal of Basic and Applied Sciences named “Micro-hydro energy resources in Bangladesh” concludes that Bangladesh's exploitable hydropower potential is one of the major primary energy resources current use of this potential is minimal. If this exploitative energy source could be used using sustainable technology, the overall fuel situation would be appreciated. Source of micro-hydro energy is rivers, lakes, and streams (Wazed, 2008).

Some authors identified in their article “Industrialization and trade openness affect energy intensity, Evidence from a one-way model in the case of Bangladesh” a positive correlation between per capita income and industry's share of production with energy. Growth as two mediating factors to analyze their impacts on energy intensity. Availability of natural resources, political stability, available workforces helps a country being industrialized (Pan, Uddin, Saima, & al, 2019).

4. Practical Part

4.1 Bangladesh Economy Characteristic

Bangladesh is a country located at the centre of the Ganges-Brahmaputra-Delta in the south of the Asian continent. Bangladesh is bordered by India on three borders (West, North, and East, Myanmar in the southeast, and the Bay of Bengal in the south). The Republic of Bangladesh was established in 1971 when the Bengali-speaking people fought for independence from west Pakistan because they were considered the then Eastern Provinces of Pakistan.

It is considered as one of the countries affected by climate change every year, as natural disasters often hit this country. For example, Tropical cyclones hit coastal areas almost twice a year, accelerating both sea-level rise and heavy flooding, causing erosion of riverbanks and loss of arable land. Bangladesh has also recently experienced an intense trend of prolonged heat, so both natural disasters and environmental challenges have endangered the livelihoods of Bangladeshis who are largely dependent on agriculture (Etzold & Mallick, 2015).

Considered as one of the fastest-growing economies in South Asia, 75% of the total population lives in rural areas (Mohiuddin, 2019). Bangladesh has a total of eight divisions (Dhaka, Barisal, Chittagong, Mymensingh, Raj Shahi, Rangpur, Khulna, and Sylhet). Each division is the first level administrative geographical partition of the country and each division is subsequently divided into 64 districts. Each district is further subdivided into smaller geographical regions, with clear rural and urban titles. Also, the urban areas of the main divisions of Dhaka, Chittagong, Khulna, and Raj Shahi have been classified as City Corporation (CC) and other urban areas. By 2019, Bangladesh is the 8th most populous country in the world (Ahmad & Karim, 2019).

The standard of living is slowly but constantly improving. Poverty in Bangladesh has significantly decreased between 2010 and 2016 but has declined in recent years. Urban poverty has come down from 21.3 to 16.9 per cent, and rural poverty has come down from 35.2 to 26.4 per cent (Paralkar, 2017). According to a 2010 survey, the number of households at each level is 1.31 at the national level, 1.40 in urban areas, and 1.27 in rural areas. The total income for the earners in 2010 was BDT 8795. In rural areas, it was BDT 7592 and in urban areas, it was BDT 11778.

The important role in economic development in last decade Bangladesh's garments and textile industry plays an influential role in poverty alleviation and socio-economic transformation. The readymade garments (RMG) sector which is the labour-intensive component of the second manufacturing sector being the largest earner of foreign exchange and the largest contributor to GDP. Bangladesh's pharmaceutical industry is gaining significant momentum and competing in emerging giants, including China and India. Bangladesh has one of the lowest records of per capita drug use in the world, which has occurred in the past due to lack of access to medicines for the public and poor health care.

The country has a very limited energy reserve (coal, oil, and natural gas reserves). The country is suffering from an internal energy crisis, as about 93% of the country that produces thermal power is gas-based, but the industry also needs gas (Pranti, Iqbal, & Ahmmed, 2013). About 62.9% of Bangladesh's electricity generation comes from natural gas, while 10% comes from diesel, 5% from coal, 3% from oil, and only 3.3% from renewable sources (Janik & Taheruzzaman, 2016). Because diesel and oil are mostly directly or indirectly dependent on imports the energy transformation will have a positive impact not only on positive changes in energy but also on foreign trade structure.

Bangladesh is an agriculture-driven economy. A total of 87% of the nation's population is, directly and indirectly, involved in lives and farming in rural areas (World Bank, 2016). Due to the high fertility of the soil and the adequate water supply, thousands of rivers whose branches are zigzagging across the country, Bangladesh can collect three crops per year. Crops meet enough local consumption needs, but due to cyclones and floods, causing damage to crop, agriculture does not produce enough production for export purposes each year.

The third– i.e. servicing sector, which contributes a lot to the nation's economy, is the export of workforce, bringing remittances to Bangladeshi workers working abroad such as in the Middle East, Singapore, Malaysia, etc.

Due to cultural and religious rules, women lived on the premises being responsible for taking care of their family and house-holding activities. The role of men was the sole earner and head of the family. But as for the high cost of living of the family life, the men's earnings were not enough; the women had to involve themselves in the labour process as industry employees contributed to a higher employment rate. According to different sources (mainly CIA World Fact-Book), published in 2017, the economic structure of Bangladesh was as follows:

Table 1: Basic Characteristics of Bangladesh Economy

GDP Growth	7.40%
GDP (per Capita)	\$1.12
Public Debt/National Budget	33.1%/25.1 Billion
Inflation Rate	5.60%
Exports	\$27.568 Billion
Imports	\$36.001 Billion
External Debts	\$50.26 Billion
GDP(PPP)	\$562.006 Billion

Sources: CIA (World Factbook, 2020)

Following the released a beat-up report of the World Bank, Bangladesh is one of the five fastest-growing economies globally, despite inadequate private sector investment. The report suggested that Bangladesh should emphasize deepening its industry base, integrating more into the world market, and prioritizing urban economic development.

The country has vast reserves of natural gas, low-grade coal but limited petroleum deposits. All these minerals are rare and in-demand globally, especially for industry and energy production. The advantage of cheap labour is to make local products internationally competitive. Many competitive products were introduced and encouraged through FDI in the

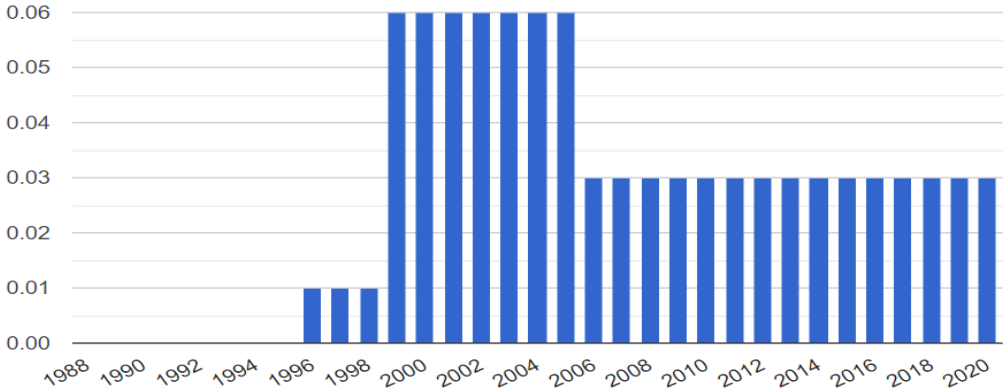
global market first by the government formed in 1991 only. The export of garments and textile is a significant source of foreign income recently generated, of great importance and revenue from remittances sent by Bangladeshis workers from abroad (Hussain, Mahmood, & Khan, 2019).

4.1.1 Natural Energy Resources of Bangladesh

Bangladesh is a small country, and it has a lot of mineral resources like raw oil, coal, and natural gas. Natural gas is the only mineral product that makes a significant contribution to the national economy. More than 90% of the country's fuel demand is met by natural gas, with total reserves of 12.43 trillion cubic feet (TCF) estimated in 1993 and 21.35 TCF, respectively, in 1999. And in 2011, the amount became around 26.84 (TFC) (Akhtar, Afia, 2005). In 2017 it grew to about 27.12 (TCF). Around 15.22 has been produced from this amount, and the rest of the 12 (TCF) gas can be used for the future (Shetol, 2019). This increase in gas reserves results from intensive prospection works organised by foreign and domestic corporations with some support from the government. The following essential energy sources are coal. In 2016 Bangladesh held 323 million tons (MMst) of proven coal reserves. The proven reserve is equivalent to 153.8 times its annual consumption, which seems to be a good source of energy, but its use harms the environment. That means that it can be considered the future sources of countries energy resources, even if its extraction could help alleviate poverty in the country through industrialisation. It is expected that coal will be extracted on a commercial basis soon, of which 70 to 80% will be used for power generation. The country's mineral resources are limited compared to its high population needs, which requires more intensive exploration and development to meet the growing needs of the economy and achieve sustainable development. This target requires foreign assistance because it is difficult for Bangladesh to conduct the necessary activities to exploit the hidden resource. The review of different sources provides a more detailed view of the natural energy resources of the country:

The importance of raw oil in the national economy is decreasing—the data for oil reserves available from 1988 to 2020 document this fact (see Fig.1). During that period, the average value for Bangladesh was 0.03 billion barrels, with a minimum of 0 billion barrels in 1988 and a maximum of 0.06 billion barrels in 1999.

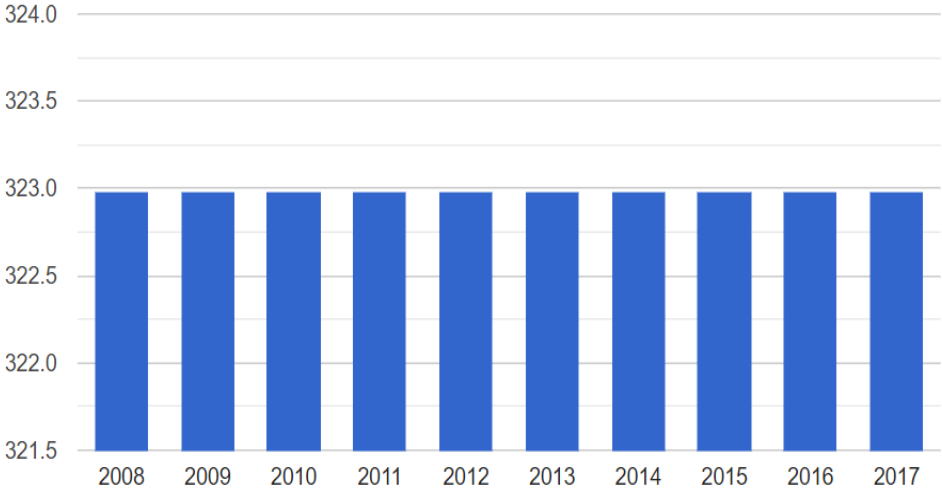
Figure 1: Bangladesh crude oil reserves



Source: The Global Economy.com (The U.S. Energy Information Administration, 2020)

Traditional natural energy source coal shows stabilised level of reserves. There are available data from 2008 to 2017 which document that the average value during that period was 322.98 million short tons with a minimum of 322.98 million short tons in 2008 and a maximum of 322.98 million short tons in 2008. The latest value from 2017 was 322.98 million short tons see (Figure 2).

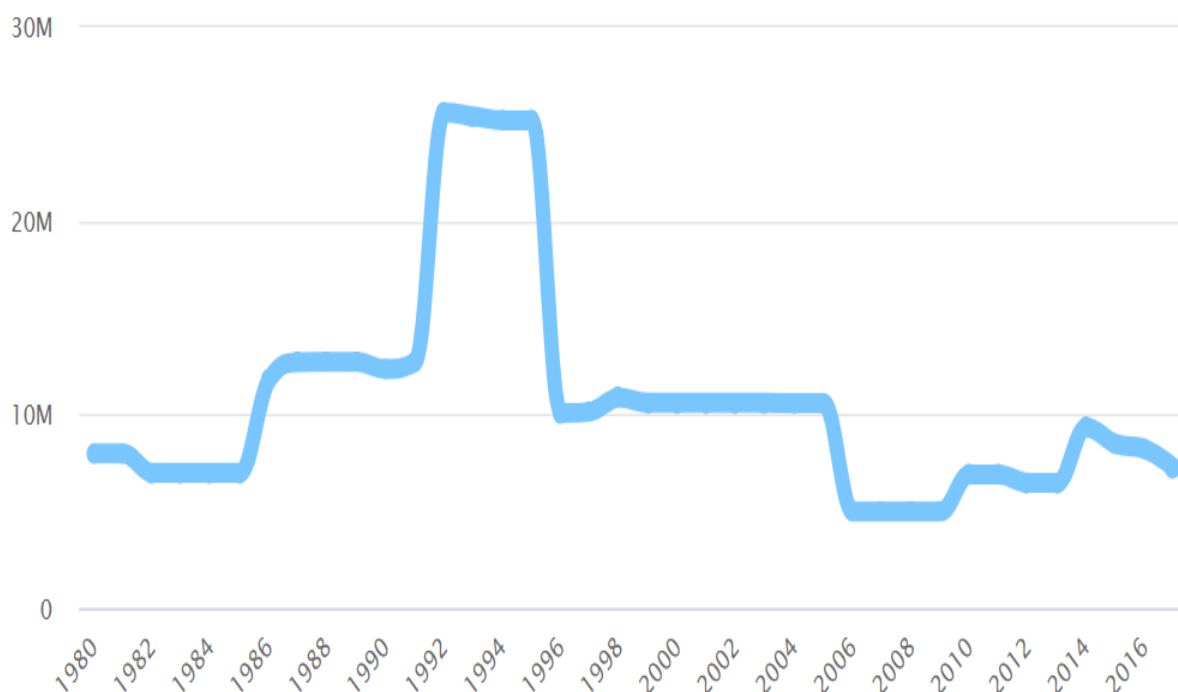
Figure 2: Bangladesh coal reserves



Source: The Global Economy.com (The U.S. Energy Information Administration, 2020)

The more optimistic view is on natural gas reserves which are of particular importance for Bangladesh. In 2017, Bangladesh contained 7.25 trillion cubic feet (TCF) of proven gas reserves, ranking 42nd in the world and about 0.105% of the world's natural 6,923 TCF natural gas reserves. Bangladesh has proved its reserves equal to 7.0 times its annual expenditure.

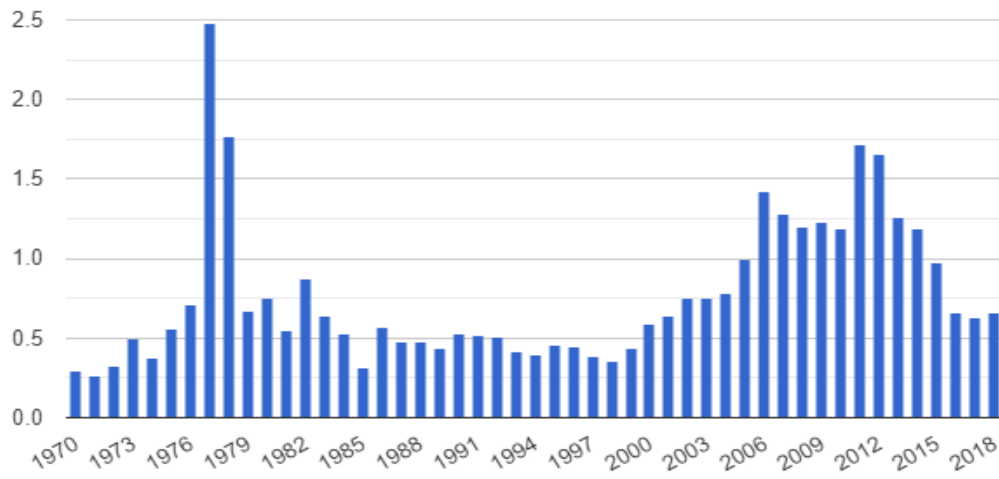
Figure 3: Bangladesh net gas reserves



Source: (Worldometers, 2020)

Income from natural resources contributes to the GDP growth inadequately (see figure 4). Data available between 1970 and 2018 show their share reaching minimum of 0.26 per cent in 1970 and a maximum of 2.48 per cent in 1977. In 2018 the latest value was 0.66 per cent. For comparison, the world average based on 166 countries, was 6.60 per cent in 2018.

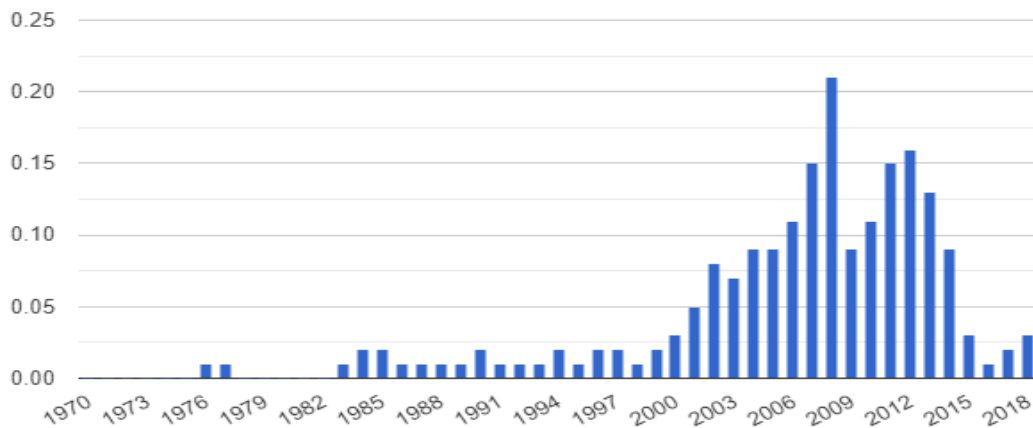
Figure 4: Income from natural resources as percent of GDP



Source: The Global Economy.com (World Bank, 2020)

If considering net revenues of this kind (i.e. revenue minus production cost of oil, as a percent of GDP), the contribution is almost negligible. The data available between 1970 and 2018 document, the average contribution of natural resources as the share of net revenues to GDP of Bangladesh was 0.04 %, with a minimum of 0 % in 1970 and a maximum of 0.21 % in 2008. In 2018 the latest value was 0.03 per cent. For comparison, based on 182 countries, the world average in 2018 is 3.00 per cent.

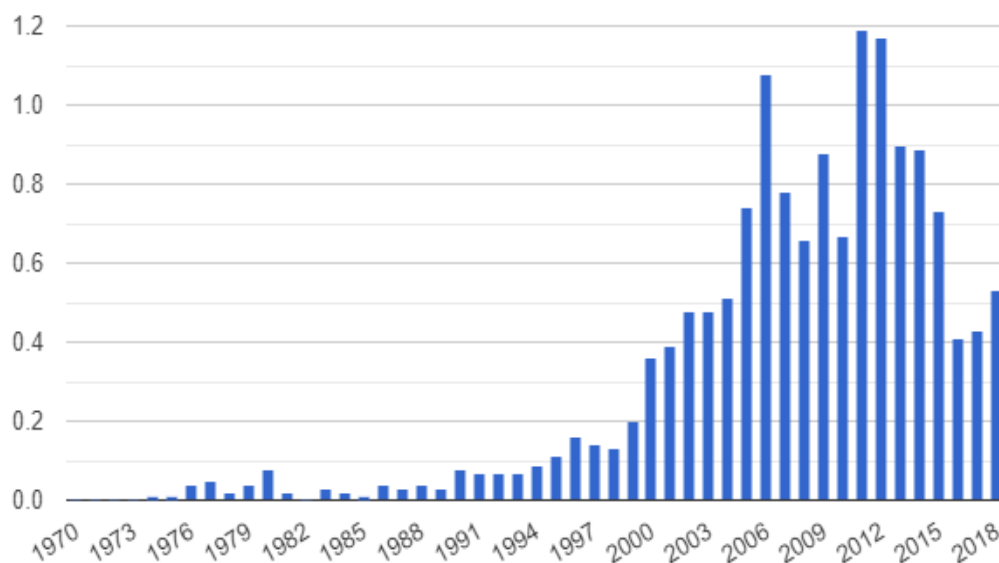
Figure 5: Bangladesh crude oil revenues as the share of GDP



Source: The Global Economy.com (World Bank, 2020)

A similar statistical indicator is much better in the case of natural gas. Its net revenue production cost was expressed as a percentage of GDP generation in the same period from 1970 to 2018. The average value for Bangladesh was 0.3 %, with a minimum of 0 % in 1970 and a maximum of 1.19 % in 2011. In 2018 the latest value was 0.53 %. Based on 136 countries, the world average in 2018 was 0.87 %. It shows that natural gas can play an essential role in the country energy sector transformation, at least during the transitional period. One of the important problems dealing with natural gas in the role of the most important component of country energy mix is that this source is heavily subsidised as its production cost are relatively high. These subsidies impose a significant fiscal burden providing disproportional benefits to high-income households. Such a situation requires substantial reforms energy subsidies which should be in benefit of the whole national economy rather than to the biggest energy user (Timilsina, Govinda R,et all, 2018).

Figure 6: Revenue production cost of natural gas, percent of GDP



Source: The Global Economy.com (World Bank, 2020)

The road to a sustainable society needs a prioritisation of the development of its existing natural resources. They can play an important role in restructuring the country's social and economic structure. In this process's future growth, the more significant role can be fulfilled by the country natural wealth. However, renewable energy resources partially replacing

traditional energy non-renewable resources (out of natural gas, which can still play a dominant role in the transitional period).

4.1.2 Energy Production in Bangladesh

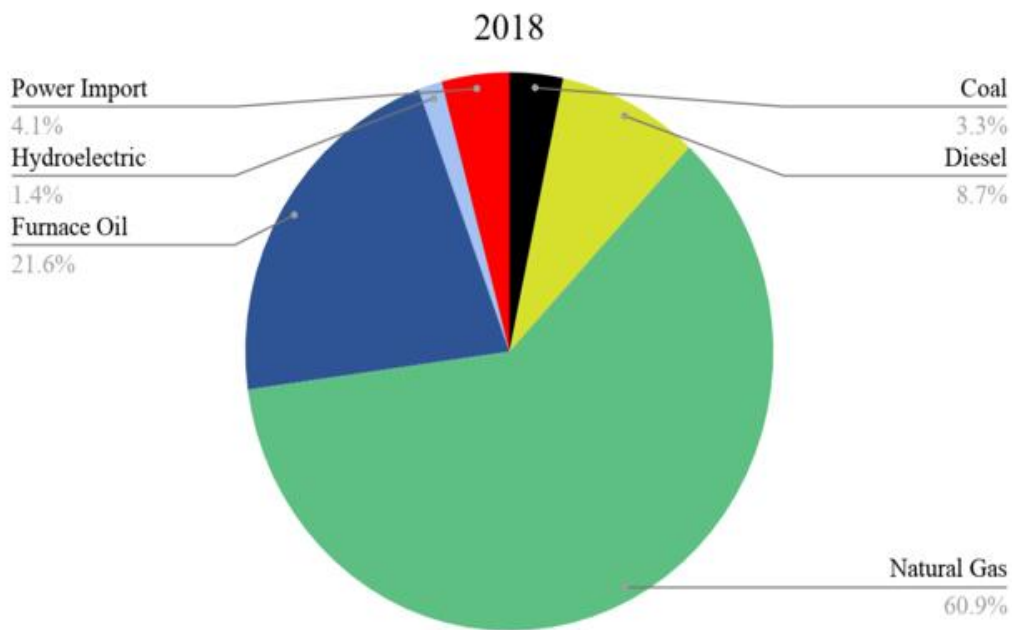
Bangladesh's power sector is dependent on fossil fuels, as natural gas and coal are influential sources of power generation in the country. 62.9% of the electricity generated in Bangladesh comes from natural gas, while 10% comes from diesel, 5% from coal, 3% from heavy oil, and 3.3% from renewable sources. The Bangladeshi energy sector uses and covers various products, natural gas, electricity, solar, petroleum products, coal, biomass. But policy and decision-makers are mostly pre-occupied with electricity, as it is the most widely used form of electricity in the country. In 2016, the total number of subscribers connected to the grid was 21.8 million. 16 million out of 21.8 million internal connections represent about 30% (30-40 million) of all Bangladeshi households. The major problem of the grid extension is power cuts and the low reliability of the power supply. There are attempts to solve this issue by building the import capacity of 500 MW from India. Newly installed capacities (in total 11,532 MW) plus 13,540 MW captive power generation should also contribute to the solution.

The grid infrastructure and other electrification measurements have been massive expansion. The rate of electrification is about 75%. The modern energy supply of population and industry is deficient compared to countries with similar economies. In 2010 per-capita production of commercial energy increased about 371 kWh. (energypedia.info). In the future, it is expected that Bangladesh will need to triple electricity production to achieve its target to become a middle-income country by 2021. Another possible source of the increase in energy consumption is to reduce energy wastage in both the industrial and household sectors.

Another source of energy production is natural gas. The problem is that these energy provider sources can be accessed by about 6% of the entire population only, primarily in urban areas. Cow dung, different agricultural residues and wood are typical biomass fuels used as cooking fuel and are collected manually by local inhabitants and farmers, mainly from the local environment. These materials have become a traded commodity because access to local biomass becomes more and more difficult. The most common but inefficient source of light is kerosene lamps(energypedia.info) (Situation, 2020).

The share of renewables in total energy production is meager (only 2%), but it is an energy source, which has excellent potential for future energy mix in Bangladesh. The most significant potential for renewable resources is solar and hydro/marine power. Solar energy is also the most rapidly growing renewable source in the last period (+41,2% between 2018-2019 see Table 2).

Figure 7: Fuel-Mix in Power Generation of Bangladesh in 2018



Source: (www.energyforgrowth.org, 2019)

The low level of use of renewable resources in-country energy production is not the only problem the country is facing. There are also other problems connected with the production and distribution of energy within the country. (www.energyforgrowth.org, 2019) there are also other crucial issues connected with energy production and distribution. The most important issues in this sphere are as follows:

Insufficient generation: The installed capacity is about 20 gigawatts, but the actual production is less than 12 gigawatts, which is less than the current demand. Government projects claim to reach at least 52 gigawatts by 2041.

Reliability: World Bank surveys show that isolation is a significant barrier, with traders experiencing outage hours each day. Reliable power is, therefore, a priority of the government.

Domestic gas dependence: Bangladesh is dependent on heavily subsidised domestic sources of natural gas (61% of total production). Analysis done by the World Bank shows that removal of subsidies to natural gas would increase GDP of the country (Timilsina, Govinda R, et al, 2018). Domestic gas reserves are slowly declining, which means importing much more expensive LNG will require new subsidies or price increases.

Table 2: The capacity and the dynamic of energy production

Capacity in 2019	MW	%
Non-renewable	21095	98
Renewable	522	2
Hydro/marine	230	1
Solar	284	1
Wind	3	0
Bioenergy	5	0
Geothermal	0	0
Total	21617	100
Capacity change(%)	2014-2019	2018-2019
Non-renewable	73	10.6
Renewable	47	18.9
Hydro/marine	0	0
Solar	137	41.2
Wind	53	0
Bioenergy	24	0
Geothermal	0	0
Total	72	10.8

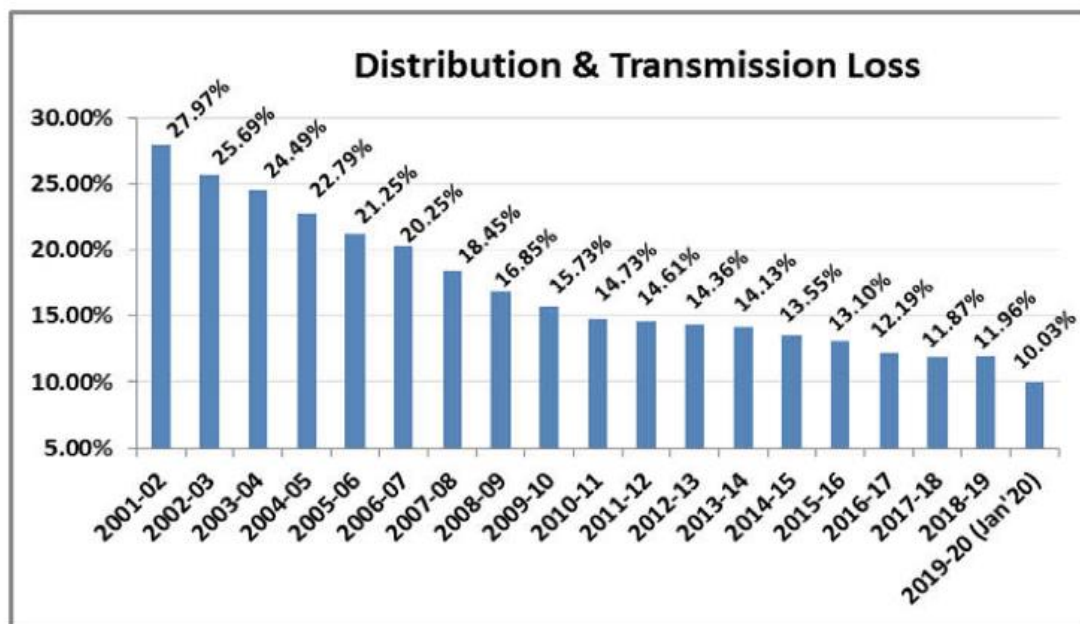
Source: (www.energyforgrowth.org, 2019)

Insufficient transformation capacity: Although the transmission loss of 14% is comparable to other South Asian markets, the transmission capacity has not kept pace with generation growth.

Losses of distribution grid: Another large obstacle in distribution is the low efficiency of power delivery caused by an inefficient distribution system (Taskin, 2012), Even if the situation has been improved in the last few years, its losses are extremal. It is estimated that its total losses (summarising transmission and distribution / Figure 8) in Bangladesh amount to 10 per cent of the whole generation (Saleh Ebn, 2020).

To increase the energy access rate Bangladesh needs to build up and expand its power generation system up to 100 %. Building new power plants without taking into consideration the technology will require not just generating capacities, but also new infrastructures, like power grids, spatial planning, a stable policy framework, and access to finance.

Figure 8: Transmission and Distribution Loss of Bangladesh



Source: Bangladesh power sector review (Saleh Ebn, 2020)

4.1.3 Energy Consumption

Energy consumption in the country grows at rapid rates. About 96% of the total population has excess electricity and per capita generation of 510 kWh. The electricity demand has been growing permanently in the last decades.

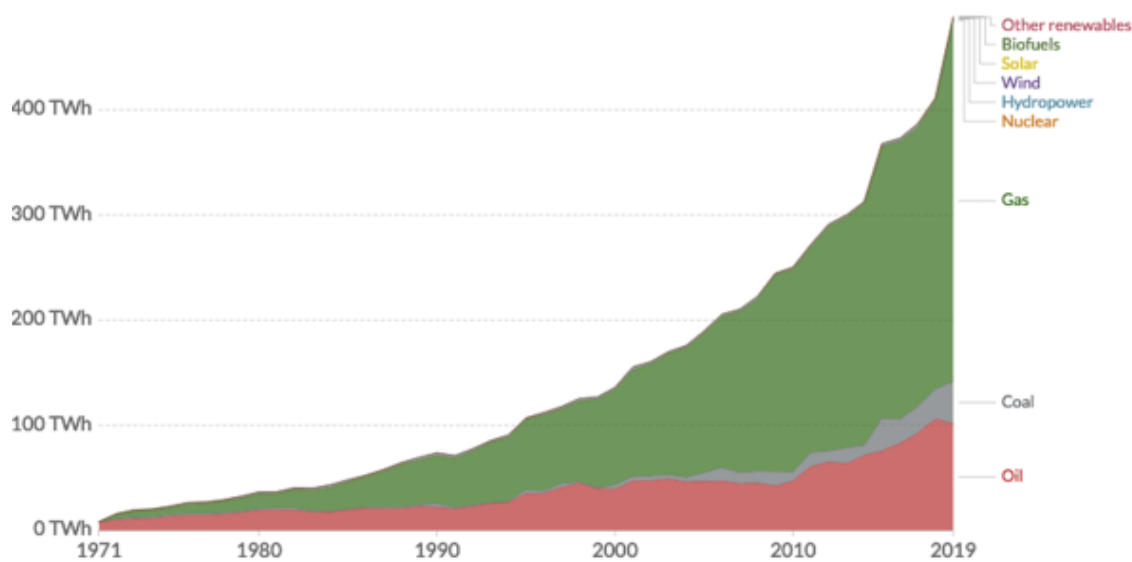
Table 3: Bangladesh primary Energy consumption Since 1975 in Mtoe

Year	1975	1985	1995	2000	2005	2010	2015	2016	2017	2018
Rate	2	4.1	9.2	11.7	16.1	21.6	31.1	31.9	33	38.9

Source: (Energylopedia, 2019)

Figures 9 and 10 below show growing dynamism and essential structural characteristics of energy consumption, confirming the dominant position of non-renewable sources in the total consumption and still the negligible position of renewables.

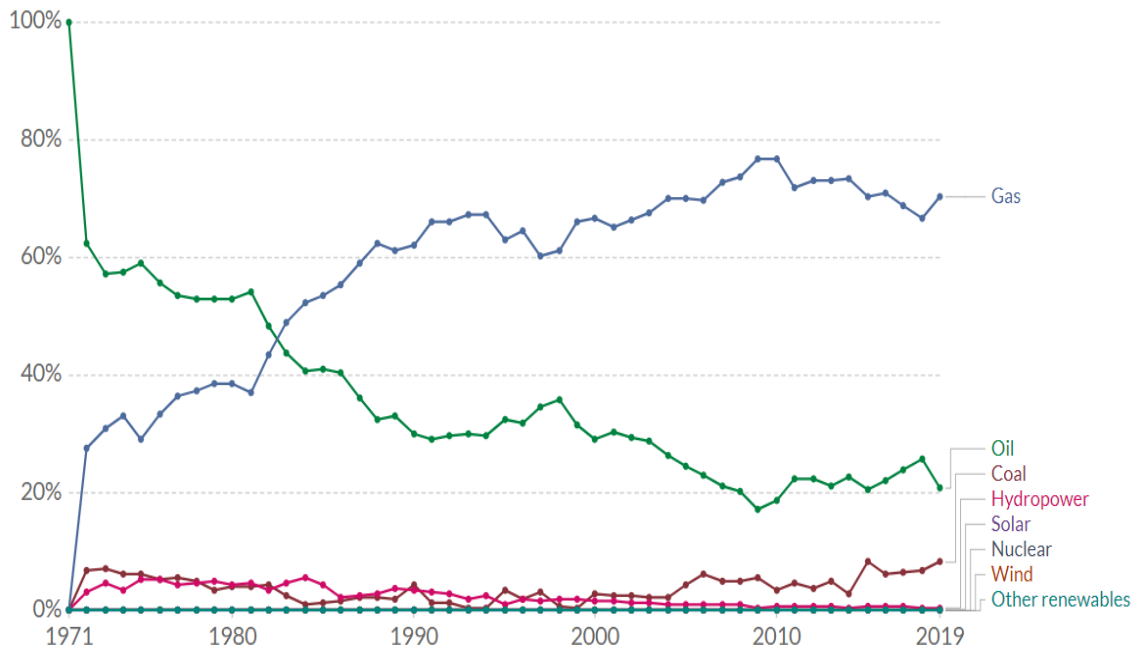
Figure 9: Bangladesh energy consumption by source 1971-2019



Source: Our world in Data/Energy (Ritchie, 2014/2020)

The majority of Bangladesh's total primary consumed energy goes to natural gas, solid biomass, and waste, which are followed by oil, coal & hydroelectric. (Our World in Data 2020).

Figure 10: Share of energy consumption of Bangladesh by source 1971-2019



Source: Our World in Data based on BP Statistical Review of World Energy (Ritchie, 2014/2020)

There are some positive structural changes in the primary energy consumption sources favouring declining oil and stagnation of natural gas share, representing non-renewable energy resources with some negative impact on the environment. The positive feature is an increase (even relatively slow but remarkable) in favour of renewable resources. Another positive feature is the relative decrease of the country's energy intensity, which is measured as primary energy consumption after this in KWh /per unit of GDP (2011\$PPP) (Ritchie, 2014/2020). Table 4 is reflecting these relatively positive structural changes. It's important to state that the decrease in the share of oil in the energy mix recorded since 1975 has some positive impact on the structural characteristic of the trade balance (Ritchie, 2014/2020).

Table 4: Structural changes of energy consumption mix

	Oil	Natural Gas	Coal	Nuclear	Hydroelectric	Solar	Other Renewable	wind
2016	22.2	70.9	6.1	----	0.6	0.14	<0.01	<0.01
2017	23.9	68.8	6.4	----	0.7	0.18	<0.01	<0.01
2018	25.7	66.6	6.9	----	0.5	0.2	<0.01	<0.01
2019	20.8	70.3	8.2	----	0.4	0.21	<0.01	<0.01

Source: (Ritchie, 2014/2020)

Bangladesh's characteristic as a developing country is reflected in the underdevelopment of energy consumption in rural areas. Most Bangladeshi households in rural areas (99%) and urban areas (60% - 66%) use biomass such as wood, jute sticks, cow dung, or other agricultural wastes for cooking in traditional steam stoves. Stoves are often fed with large pieces of wood or dung. Families are unstructured and unwilling to cut the wood into pieces. Besides, traditional steam stoves are made so that the fuel naturally moves a little more as the burning fuel ignites what allows multitasking while cooking (Barun Kumar Das, 2014).

The power sector has made significant progress in meeting the electricity demand. Access, coverage, and customer levels have increased significantly over the years. Daily load shedding has decreased substantially: from 1107 MWh in 2009 to 32 MWh in 2018. However, coverage and access in Bangladesh still lag regional standards (Bangladesh v South Asia average: 76 % vs 85.6 % in 2016).

Besides, the efficiency of energy consumption is improving. According to SREDA, energy consumption per GDP (Kg OE/1000 US\$) decreased from 307 OE kg in 2007 to 218 kg OE in 2014. This fact is due to the strong economic development supported by its five criteria of a low-energy-intensive export industry like the RMG sector. The power sector has recovered from the crisis period after 2008 (SREDA, 2016).

The domestic and industrial sectors consume about 43% and 44% of the electricity, meaning that electricity consumption in these two sectors is about 87%. A large portion of this electrical energy is consumed for illumination. All power sector experts have acknowledged

that the maximum power outage occurs mainly in the evening. One way to manage evening loads is to introduce energy-efficient lighting systems. (ProthomAlo, 2020)

Table 5: Bangladesh’s Installed Electricity Capacities from Different Source

Source	Fossil Fuels	Nuclear Fuels	Hydroelectric Plants	Renewable Sources
% Total Installed Capacity	97	0	2	1
World Ranking	32	45	136	134

Source: (Energylopedia, 2019)

There is a conflict between the growing demand for energy and the limited local traditional non-renewable resources for its production. Deficits mostly cover foreign trade, which is another issue for the country economy. Comparison between production, consumption, and demand for energy documents that Bangladesh's economy is not self-sufficient in energy resources. That is why Bangladesh must cover its energy demand also from other countries either or in the form of raw energy materials and in the form of electricity, although not permanently (in a particular situation like 2014 due to national wide blackout). (IEA statistic of 2018) states that in 2014 the country covered by net imports of energy 16.84 %age all energy use. Energy imports are a vital part of the commodity structure of a country's foreign trade, while the net import balance was in 2018 about 5.1 TWh. Thus, as there is a continuous and rapidly expanding gap between power supply and demand, it is a significant challenge for Bangladesh's energy sector.

Due to the neutral impact of nuclear energy on climate change, representing recently one of the critical global crisis factors, the vital role in the structural transformation of the energy sector and solution of the growing gap between supply and demand will have to play also the nuclear energy. The urgency of the climate changes issue for Bangladesh emphasis this process. Even if many countries' general approach to this source is reserved, some specific

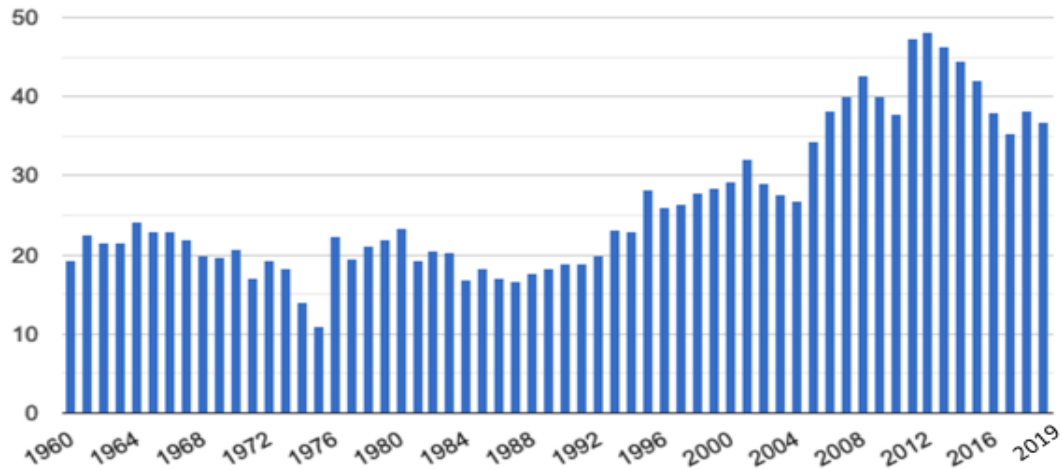
factors will support the necessity of this strategic shift and will force the country's governments to approach this not very popular solution to the energy problem. Bangladesh started its first nuclear power reactor in November 2017 followed by the second one in July 2018. These power reactors should be put in commercial operation since 2023 and 2025 generating a total of 2,160 MWe. The construction is financed partially by the provision of \$500 million by the Russian federation. The second nuclear power plant is proposed to be built by a Chinese company. Moreover, their nuclear energy agreement was signed between Bangladesh and India in 2017 dealing with scientific and technical as well as regulatory cooperation in this field.

4.2.1 The Role of Foreign Trade in Bangladesh Economy

Bangladesh's economy is, in comparison with other countries, not too open. Trade openness average value (defined as a percentage of GDP in terms of total sum exports and imports) between 1960 and 2019 was 26.46 %, with a minimum of 11 % in 1975 and a maximum of 48,11 % in 2012. Foreign trade represented 36.76% of Bangladeshi GDP in 2019 (World Bank 2020). But this sector of the country's economy has a growing role in economic strategy, focused on pro- export strategy, which is recently typical for many Asian countries. The degree of openness in Bangladesh's economy has seen a mixed trend over the last ten years as economic expansion has outpaced foreign trade growth. Bangladesh's trade-to-GDP ratio has reached 46.30 per cent in fiscal year (next FY only) 2012-2013, increasing from 37.8 per cent in FY 2010. However, this ratio has fluctuated during the next six fiscal years up to FY 2019. In FY 2019, the trade-GDP rate came down to 38.89 % and 44.51 % in FY2014, according to a measurement based on Bangladesh Bureau of Statistics (BBS).

The data in Figure 11 show that foreign trade growth, including goods and services, has presented a mixed trend since FY 2014 when its GDP growth has increased rapidly during this period. Such a fluctuation in foreign trade resulted mainly from the lack of synchronisation between GDP growth and overall foreign trade.

Figure 11: Trade openness of Bangladesh economy



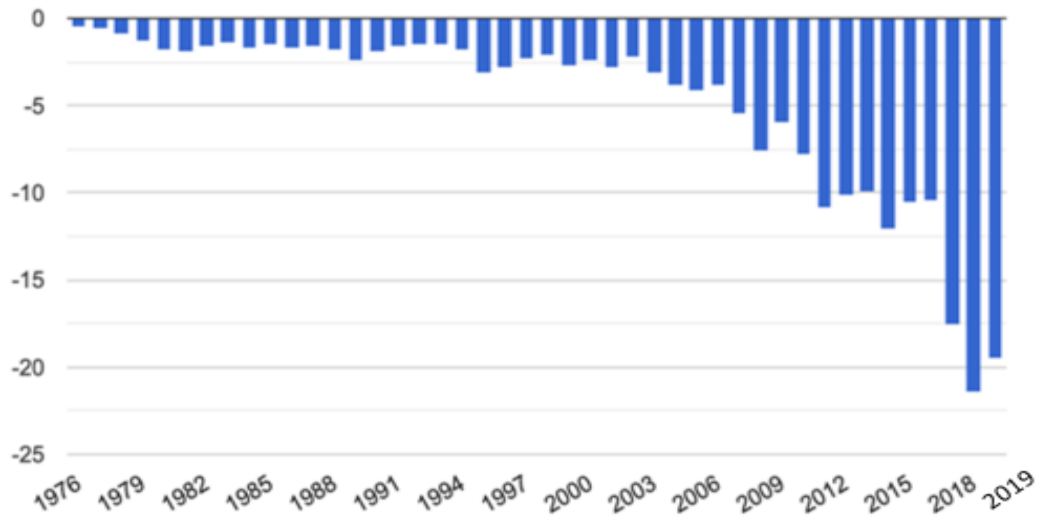
Source: The Global Economy (World Bank, 2020)

Another reason is a trade and industrial policy focusing on export-orientated trade policy and rationalising tariff structure to help achieve sustainable economic growth. Economists recommend time-limited protectionism of trade policy and tariff rates rationalisation, warning that economic growth would otherwise slow down. (Islam, 2019)

Although the trade openness supports economic growth, the trade balance shows negative values, nevertheless. The comparison of export and import of goods and services documents this development resulting in the deficit of the current account of the balance of payments. The average value of trade balance for Bangladesh during the period from 1976 to 2019 was -4.88 billion U.S. dollars with a maximum of -21.46 billion U.S. dollars in 2018 and a minimum of -0.48 billion U.S. dollars in 1976. The latest value from 2019 was -19.56 billion U.S. dollars.

It is another figure, figure 12. Comparison of import and export developments shows the reason. The average value of import for Bangladesh during the period 1960-2019 was 11.84 billion U.S. dollars minimum of 0.4 billion U.S. dollars in 1960, and a maximum of 64.86 billion U.S. dollars in 2019. The latest value from 2019 is 64.86 billion U.S. dollars.

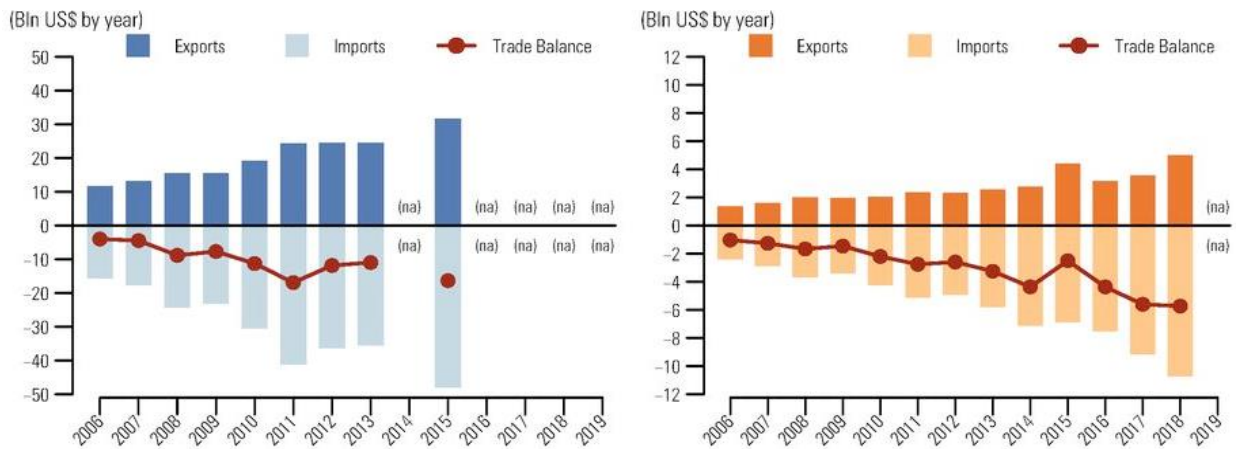
Figure 12: Bangladesh Trade balance in bill, USD Dollars.



Source: The Global Economy (World Bank, 2020)

The average value of the export of goods and services for Bangladesh from 1960 to 2019 was 8.21 billion U.S. In 1972 dollars with a minimum of 0.36 billion U.S and in 2019 a maximum of 46.36 billion U.S. dollars. In 2019 the latest value was 46.36 billion U.S. dollars. This unsatisfactory trade balance development can be explained by analysing the unfavourable commodity structure of the country's foreign trade.

Figure 13: Total merchandise and service trade by value



Source: Foreign Trade Structure of Bangladesh in UN Statistical Yearbook (UN, 2020)

4.2.2 The Foreign Trade Structure of Bangladesh

The main export products of Bangladesh are clothes, leather, fish, raw jute and its derived products, and frozen seafood, it is the products with low added value, which is a typical feature of many least developed countries.

Bangladesh mainly imports chemical products, machinery and equipment, steel and metals, cement, and food. Since 1976, Bangladesh has been recording a permanent trade deficit mostly due to high import prices. The main imports are petroleum and oil (11 % of total imports); textiles (10 %), and food items (11 %). The principal exports are mainly RMG (80% of export earnings). (UN 2019) In the absence of the United Nations Statistics Division's actual statistical data, the last general description of the foreign trade structure is provided for 2015 only. In 2015, Bangladesh's exports were valued at US\$ 31.7 billion, while its merchandise imports reached US\$ 48.1 billion see (Figure 13, Table 6). The commodity trade balance recorded a moderate deficit of 16.3 billion US\$ (see Figure 13). Commodity export and import partners in Bangladesh were relatively well-diversified. Top 14 partners accounted 80 % or more for exports and 17 partners accounted for 80 % or more of imports. The value of Bangladesh's service exports increased significantly by 39.5 % to US\$ 5.0 billion in 2009, while its service imports increased by 16.7 % to US\$ 10.7 billion (see Figure 13), so service deficit was of US\$ 5.7 billion.

The country's main export partners are China, the European Union, and the United States. Bangladesh imports mainly from India, China, Indonesia, Thailand, and Singapore. The country serves as a passageway between the centre of India and its eastern provinces. Tariffs are relatively high in Bangladesh; however, the government is implementing several measures to reduce trade barriers, including tariff exemptions, tariff recovery measures, and high-level negotiations with export processing zones and key countries. As an LDC, the country has benefited from more simple procedures and laws for exporting its products to the European Union.

Table 6: Comparison of export and import commodity structure of Bangladesh**Export**

HS code	4-digit heading of Harmonized System 2012	Value (million US\$)			Unit value			SITC code
		2013	2014	2015	2013	2014	2015	
	All Commodities.....	24537.3	...	31734.2				
6109	T-shirts, singlets and other vests, knitted or crocheted.....	4609.5	...	6100.6	12.5	11.8	US\$/unit	845
6203	Men's or boys' suits, ensembles, jackets, blazers, trousers.....	4618.4	...	5972.8	14.6	14.3	US\$/unit	841
6204	Women's or girls' suits, ensembles, jackets, blazers, dresses, skirts.....	2367.8	...	3394.8	16.2	16.2	US\$/unit	842
6110	Jerseys, pullovers, cardigans, waist-coats and similar articles.....	2410.9	...	2952.6	15.5	15.3	US\$/unit	845
6205	Men's or boys' shirts.....	1761.6	...	2325.3	18.1	18.0	US\$/unit	841
6105	Men's or boys' shirts, knitted or crocheted.....	634.2	...	794.8	13.4	13.1	US\$/unit	843
6104	Women's or girls' suits, ensembles, jackets, blazers, dresses, skirts.....	545.4	...	871.8	13.5	13.7	US\$/unit	844
5307	Yarn of jute or of other textile bast fibres of heading 53.03.....	464.2	...	496.2	0.8	1.0	US\$/kg	651
6103	Men's, boys' suits, jackets, trousers etc knitted or crocheted.....	401.3	...	529.6	13.2	12.9	US\$/unit	843
6302	Bed linen, table linen, toilet linen and kitchen linen.....	470.0	...	449.7	6.9	6.4	US\$/kg	658

Import

HS code	4-digit heading of Harmonized System 2012	Value (million US\$)			Unit value			SITC code
		2013	2014	2015	2013	2014	2015	
	All Commodities.....	35493.3	...	48058.7				
2710	Petroleum oils, other than crude.....	2328.9	...	4359.4	0.4	0.5	US\$/kg	334
5201	Cotton, not carded or combed.....	2134.8	...	2229.5	2.1	1.7	US\$/kg	263
1511	Palm oil and its fractions.....	1981.0	...	1784.7	0.9	0.6	US\$/kg	422
5208	Woven fabrics of cotton, containing 85 % or more by weight of cotton.....	1484.3	...	1762.4	8.9	8.6	US\$/kg	652
5209	Woven fabrics of cotton, containing 85 % or more by weight of cotton.....	1138.2	...	1471.2	7.3	7.2	US\$/kg	652
5205	Cotton yarn (other than sewing thread), containing 85 % or more.....	786.6	...	953.8	4.3	3.5	US\$/kg	651
1001	Wheat and meslin.....	726.0	...	991.3	0.4	0.3	US\$/kg	041
8908	Vessels and other floating structures for breaking up.....	855.3	...	845.0	4.6	3.9	mIn US\$/unit	793
1507	Soya-bean oil and its fractions.....	693.0	...	944.6	1.2	0.8	US\$/kg	421
6217	Other made up clothing accessories.....	697.0	...	856.5	11.1	11.8	US\$/kg	846

Source: International Trade Statistic Yearbook 2019 (UN, 2020)

However, progress in health, longevity, and economic growth has led to the possibility of leaving the LDCs by 2024, the UN said.

In 2018, exports from Bangladesh rose further from record levels a year ago, reaching 39.3 billion due to strong clothing sales. Product imports in 2018 were equivalent to 60.5 billion. Since independence, Bangladesh has had a negative trade balance, the deficit of which is financed by international aid and remittances. The WTO's 2018 trade balance is estimated at 16.9 billion. Regarding services, 2018's imports were 10.4 billion, while exports were 2.9 billion, with an overall trade balance of 21.3 billion. According to the Central Bank of

Bangladesh, the country's trade deficit widened by 5.4% to 8.22 billion in the first half of the 2012-201 fiscal year (July 2019 to June 2020) (Santander, 2021).

Energy resources (oil) and direct electricity imports are essential items that affect Bangladesh's foreign trade structure which is as follows:

The data recorded by UN Trade statistics (UN 2019) show the main import items of the country (see table Nr.6 above). Bangladesh is considered a net importer of crude oil and other liquid fuels as its oil consumption increases. Some sources announce that the main items were: Petroleum oil (latest data from the United Nations International Trade Statistics 2019) (UNDESA, 2020), accounting for 9.07% of total imports. Imported crude oil is used for the local production of energy. The following figure shows examples of the country's fuel production from various sources in the last few fiscal years 2016 / 2017 FY. They show, natural gas is the most influential local source; other sources partly depend on imported crude oil (diesel and furnace oil).

The figure shows that imported energy plus diesel and furnace oil are important sources for covering the domestic energy demand. Another trade item covered by the growing demand for domestic energy use is the direct import of electric power (4.1% in 2018). Anyhow the essential energy resource of Bangladesh is natural gas. So, there is some potential to replace the country's energy import with a mix of different local resources, which can combine the most important non-renewable resources: domestic natural gas and new renewable resources. This structural change could improve the country's negative trade balance (negative foreign trade balance is affecting the development of the country's payment balance) and environmental protection, which is of crucial importance for the Bangladesh economy.

The country's foreign trade's structural change in favour of local energy means increased use of energy sources, which are renewable (such as wind, tidal and geothermal energy) and non-renewable (including fossil fuels such as oil and gas, and nuclear-fission fuels). The per capita consumption of such fuels in Bangladesh was equivalent to 170 kg of oil, the third lowest in Asia in 2005 after Cambodia and Nepal. It is represented mostly by non-commercial energy (65.5 %), which composes biomass in various forms, mainly in rural households and factories. Almost all rural households use open stoves for cooking, usually fed by dry leaves, fuelwood, agro-wastes, rice husk, and cow dung. Some families have built biogas plants using imported coal for local purposes. Several cities in the eastern part of the country have supplied piped

gas. Most urban and rural households in the country thus rely on fuelwood, with an annual cost of about 40 million tons for cooking. This fact has led to a rapid decline in the country's forest conservation and has become a threat to the ecological balance.

The use of other renewable energy is not a new phenomenon in Bangladesh. People using solar power or wind for various purposes since ancient times. Solar energy is used to dry fish, cloth, salt, agricultural products, etc. Modern solar energy use based on PV systems has a big potential for its growing importance in the last decade. Daily average solar radiation varies from 5.05 kW / m² in winter to 8.36 kW / m² in summer. However, solar PV systems are newly being used by people in some rural areas as modern technology to generate electricity. Even the Power Development Board of Bangladesh (BPDB) has two solar PV installations - one for rain gauges and the other for east-west interconnection at Aricha. The solar PV system is used for illumination in some transmission towers (Chittagong, Karnapuli River Crossing). BPDB conducted a feasibility study on developing a solar power system in three districts of the Chittagong Hill Tracts already in 2001. Nowadays, out of 25 sub-districts of these three districts, the 21 solar power grids had been installed, and the rest received partial power supply from diesel generators.

The modern use of wind energy on a commercial basis for power generation from wind turbines has not yet begun. Various agencies have identified different locations to determine wind power and wind power companies' potential use in coastal areas for utilising power generation. Still, the real implementation of projects didn't start yet.

According to private marketing companies' data operating in Bangladesh, the demand for LPG (liquefied petroleum gas) in 2001 was about 300,000 tons. The recent annual LPG production, LPG storage, bottling and distribution centres was an additional 5,000 tons. So far, 11 non-government and government organisations have been allowed to import, store, bottle, and market LPG in the country. At present LP Gas Limited (as Bashundhara LP Gas) is marketing about 8,000 tons per year. Joint venture with Australian Wesfarmers Jamuna Space tech and EPPI - the Malaysia-Bangladesh joint venture markets 25,000 tons, respectively. However, it has an annual import and market summit capacity of 60,000 tons. In Bangladesh, less than 20 % of the population has access to commercial energy. About 6% of the population has access to this type of hydrocarbons (natural gas, liquid fuels, and LPG). In 2011, the annual per capita consumption of electricity was estimated at 144 kW.

There is a lot of potential for hydropower in the country. The only hydropower plant is the 230 MW Karnafuli power plant, which is considered to expand two new units of 50 MW each. The country's proven oil reserves (including condensate) are estimated at 65 million barrels. Natural gas is the country's leading primary commercial energy resource, and its reserves estimates are at 23 TCF, of which net recoverable reserves are about 12.19 TCF. Since discovering the first gas field in the country in 1955, the total production volume in June 2000 was about 4.10 TCF. The projections included in the Plan and Vision Statement for the Gas Sector indicate that the country needs at least 12 TCF of gas by 2020 to meet the demand. In recent years gas consumption growth has been at an annual rate of 8-10%. It is estimated that 11% of the country's total gas consumption is concentrated in the household sector. With the expansion of gas pipelines on the eastern and western banks of the Jamuna River, household and other uses are likely to increase rapidly. A conservative estimate is that at least 65.5 TCF of gas will be needed over the next 50 years to meet growing domestic demand, including 42 TCF for power generation and 19 TCF for fertiliser production.

The replacement of energy resources imports by traditional coal resources is not a realistic alternative for Bangladesh. It is not only due to its negative environmental impact but also because of economic conditions. Peat and coal reserves in the south and north of the country are located below the surface, making them difficult to develop. Petro Bangla has built only one coal mine, Barapukuria, for the proposed 250 MW power plant with a limited annual output target. The country's current power generation capacity is about 3,803 MW, of which about 600 MW is independent power generation (IPP). Some IPPs, especially barge-mounted ones, often run below production capacity due to lack of funds and BPDB's inability to take full production of IPP stations during off-peak hours. A recent estimate proves that about seven-tenths of the country's total energy demand is met by traditional energy sources such as biomass, wood, bags, etc. Of the remaining three-tenth, about 70% is derived from domestic natural gas and the rest from oil. The amount of natural gas used per day in the country is about 1,000 million cubic feet and about one-third of it is used as feedstock for fertiliser production and about half for power generation. Imported petroleum is mainly used for vehicle fuel and lighting and cooking (kerosene) in much smaller quantities. Crude oil and its derivatives are also used in power generation, commercial purposes, and as aviation fuel and raw material in the chemical industry. 43% households, 42% industry, 11% commercial

establishments, and about 4% agriculture (mainly irrigation) directly or indirectly depend on the oil, even if natural gas proportion to oil in commercial energy is already 70:30. The decrease in crude oil imports positively reflects this development.

Another local source of energy is its local electricity generation, which is unfortunately partially dependent on imported fuel. In addition to public and independent power producer (in the next IPP only) generators, a captive generation of more than 500 MW is available in various industrial and commercial units for exclusive activities. Regarding power generation, in 2000, 85% of the total production was in gas-fired power plants. However, the available generation (average per day) is only 2,650-2,800 MW across the country because Bangladesh has a great unsatisfactory demand for commercial fuel due to limited supply in most urban areas. The country's economy operates on a low level of imported commercial fuel, which is an important economic development obstacle. The country spends about 640 USD million a year on fuel (petroleum) imports. The rural electrification program connects an average of 200,000 new customers each year. In 1990, keeping pace with the global trend,

Bangladesh has opted for private sector partnerships in power generation. By 1999, a 330 MW barge mounted IPP had been implemented under BPDB, and the average world cost of such plants was 6.5 USD per / kWh, compared to an average of 5.1 USD per/ kWh recently, with a total capacity of 600 MW. The new ground based IPP was established with a replacement rate of about US2.75 per / kWh. The Power Systems Master Plan for Bangladesh provided a 20-year forecast, which has put the country's electricity demand at 4,600 MW in 2005, 6800 MW in 2010, and about 15,331 MW in 2018 (Rajib Dhar, 2018). The construction of nuclear power plant to be finished between 2023 and 2025 could contribute with next 2,160 MW and improved the gap between electricity supply and demand.

The government's power policy statement said that the electricity demand was about 3,000 MW in January 2000 and would increase about 20,000 MW by 2020. The government considered in the said statement that it is appropriate to limit power generation by IPP to 2,238 MW. Agreements are already in place for the generation of 1,188 MW of power through IPPS and further contracts are under negotiation for the additional 1,050 MW of power generation in IPP.

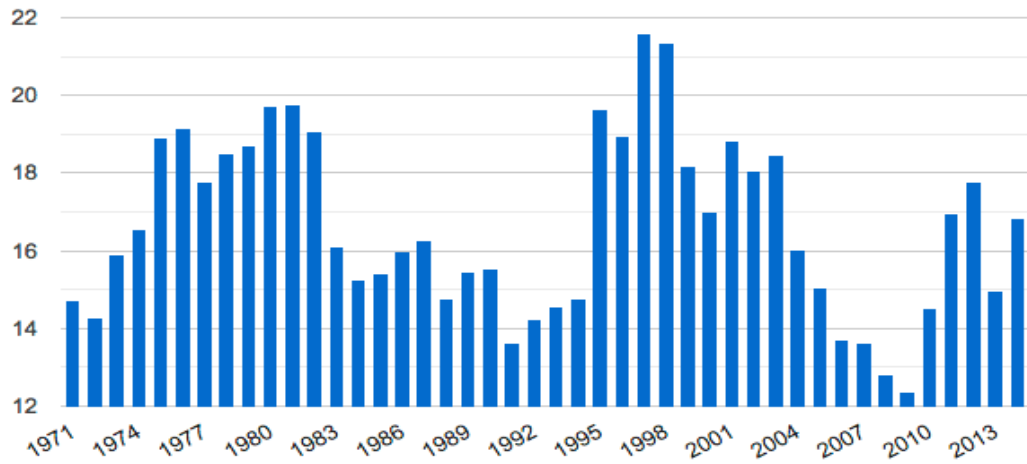
Other issues in Bangladesh's power system include shortfall of generation, load-shedding, and low voltage, mainly due to excess pressure on the supply network, dilapidated transformers

and transmission lines, and management failures in distribution systems. The problems are often solved by installation costly diesel-fuelled small power plants located in remote places and islands. These installations have become liabilities because of the unusually high per-unit cost of electricity generation and production at levels far below the installed capacity. BPDB feels it urgent to overhaul many of its existing power plants. Still, it cannot systematically go for such a move as there is no reserve margin of power generation capacity at this moment. Moreover, such installations increase the need to import fuels for them or crude oil as the raw material input for local fuel production.

30% of the electricity generated by BPDB is distributed by the power company, 50% by DESA, and the remaining 20% by the Rural Electrification Board (REB). At the beginning of the new millennium, the public sector decided to invite private sector investment based on an estimate that the power sector would need to invest \$ 6 billion between 2000 and 2010. To increase power generation, the government also sought external assistance and changes of the legal basis for reform energetic policy. One of these reform's objectives was to establish an independent regulatory authority, the Power Reform Act (replacing the Power Act 1910) (Rahman, 2014).

The data in previous chapters confirmed that Bangladesh is not self-sufficient in domestic energy resources and production. Its sources can't cover the rapidly growing consumption conditioned by its economic growth. Relatively autonomous is the natural gas sector, but all other parts of the energy sector are depending on imports and oil-derived products. The consequence is that the essential components of Bangladesh's import commodity structure are energy items like coal, oil, and electricity in some critical situations. Data for Bangladesh describing energy imports from 1971 to 2014 show that their average share was 16.63 %, slightly higher than the world average. The lowest share was 12.36 % in 2009, and the highest was 21.59 % in 1999. The last available value from 2014 was 16.84 %. Based on 134 countries, the world average in 2014 was 14.91 % (World Bank, the global economy.com).

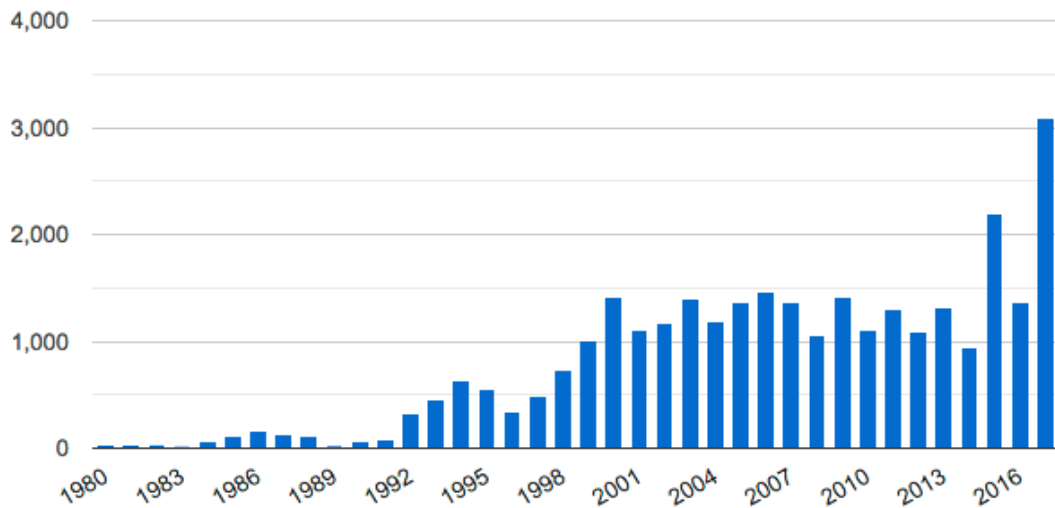
Figure 14: Bangladesh Energy-imports (in per cent of total consumption)



Sources: The Global Economy.com (World Bank, 2020)

The details of the energy sources trade in Bangladesh present the following data: The average volume of coal imports, in thousands of tons (data from 1980 to 2017 is only available) was 810.05 thousand short tons with a minimum of 17.97 thousand short tons in 1983 and a maximum of 3097.48 thousand short tons in 2017. In 2017 the world average based on 192 countries was 8030.13 thousand short tons.

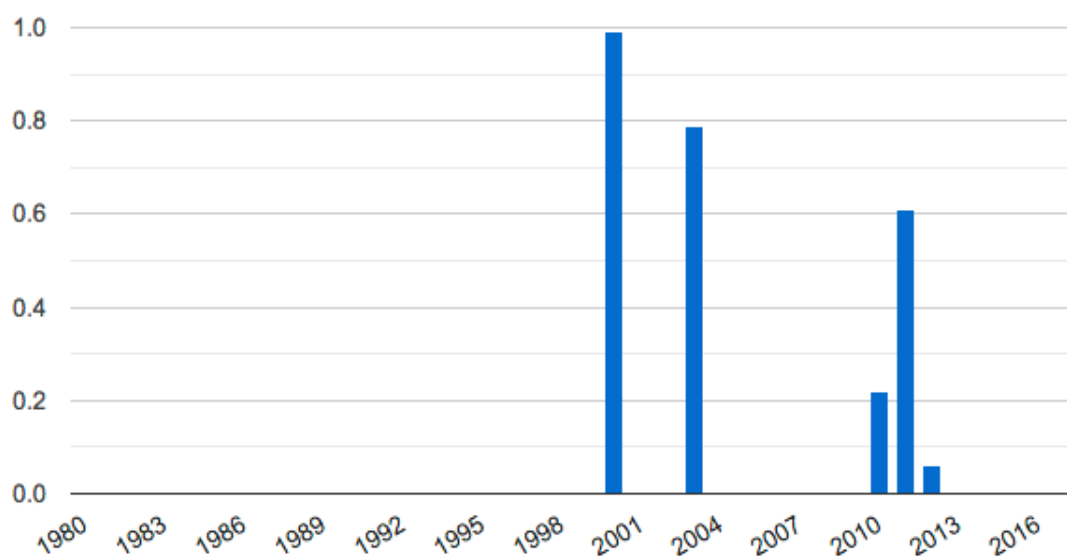
Figure 15: Bangladesh coal imports (in thousands of short tons)



Sources: The Global Economy.com (USEIA, 2020)

Data available for coal exports from 1980 to 2018 in thousands of short tons show that the export was not stabilised and is extremely low compared to imports during this period. The average volume was 0.07, a minimum of 0 thousand short tons in 1980 and a maximum of 0.99 thousand short tons in 2000. The world average in 2017 was 7897.55 based on 192 countries. In principle, the exports of coal are almost negligible. They play no role in the country's trade balance, which confirms that the country is a net importer of this energy commodity until now, still relatively significant for domestic electricity generation.

Figure 16: Bangladesh-coal exports



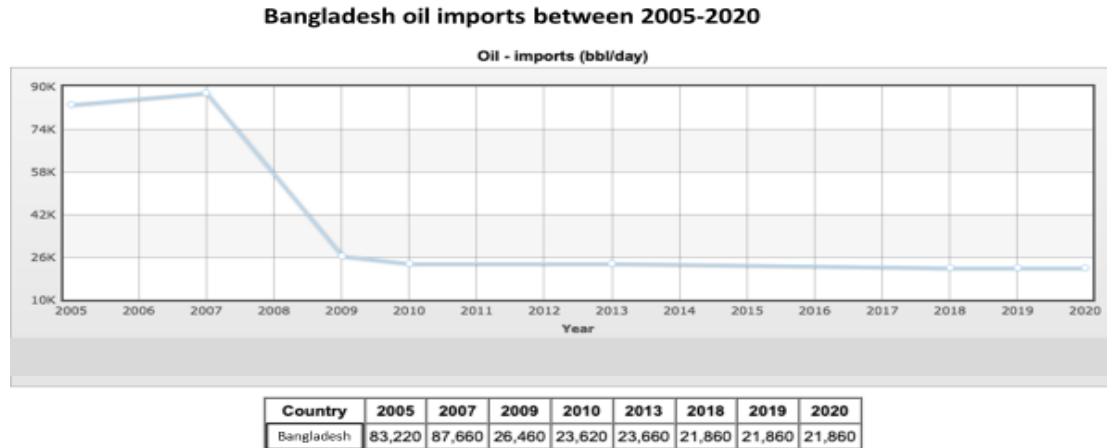
Sources: The Global Economy.com (USEIA, 2020)

The import of crude oil was an initially important component of the country's energy mix and trade balance. The statistical data on crude oil trade is available from the year 2005 up to 2020. The metrics used are also different from the above-used items, i.e. in barrels per day. Figure 17 below, documents a significant structural change, reflected by a sharp decrease in oil imports of almost $\frac{3}{4}$ of the top volume in 2007. This development proves the positive change in the energetic policy of the country to self-sufficiency.

The last component of the energy trade structure is electricity. Bangladesh is not a systematic net importer of electricity; nevertheless, there is relatively intensive cooperation of the country with regional neighbours India, Nepal, and Bhutan reflected in short time exchange of

surpluses and deficits of electricity production. The Government of Bangladesh is working with neighbouring countries and UN-ESCAP, SAARC, BBIN, BIMSTEC and similar for regional cooperation in power sector development.

Figure 17: Oil Imports Bangladesh



Note:

Definition of Oil - imports: This entry is the total oil imported in barrels per day (bbl/day), including both crude oil and oil products.

Source: (Indexmundi.com/Bangladesh, 2020)

Bangladesh and India have also initiated cross-border electricity trade through bilateral and multilateral cooperation with Nepal, Bhutan, and Myanmar. Steps have been taken to import hydropower from Nepal, and a memorandum of understanding has been signed. A Memorandum of Understanding (MoU) is underway between Bangladesh and Myanmar. Efforts to cooperate with SAARC countries continue. The infrastructure for importing electricity from India with the capacity of 500 MW from Balarampur, India is operable since October 2013. An additional 500 MW of electricity is being imported from Bheramara from September 2018, after increasing the same grid's capacity. It has been decided to import another one thousand MW of electricity by adding a separate line to this existing line.

Since March 2016, 100 MW of electricity has been imported from Palatana in the Indian state of Tripura. An additional 60 MW is being imported from July 2017, using the same

infrastructure. It has been decided to import 500 MW of electricity by 2020 by converting the existing 132 KV AC grid line interconnection to HVDC 500 MW. An agreement has been signed with Adani Group of India to import 1600 MW (net 1496 MW) Jharkhand coal-based power. The technical report has been prepared for the import of electricity from India to the northern part of Bangladesh through the 765 KV interconnection. A feasibility study is underway to import 2000 MW of hydropower from India. In addition, the 1300 MW Ram pal coal-fired power plant is being commissioned with NTPC, India through JV. Import of electricity from Nepal Initiatives have been taken to import 2000 MW of electricity from Nepal. A memorandum of understanding has been signed with GMR Group, India, and NTPC Power Traders Corporation Limited (NVVN) to import 500 MW of power from Nepal. Import of electricity from Bhutan an initiative has been taken to import hydropower from Bhutan. A tripartite agreement between Bangladesh, India, and Bhutan to build a power plant through joint ventures is in its final stages. Discussions are underway to set up Katihar/ Baropukuria-Barunagar 765 KV grid interconnection facility for import of 2000 MW power. The collaboration of BIMSTEC an initiative has been taken for regional cooperation through BIMSTEC (Saleh Ebn, 2020).

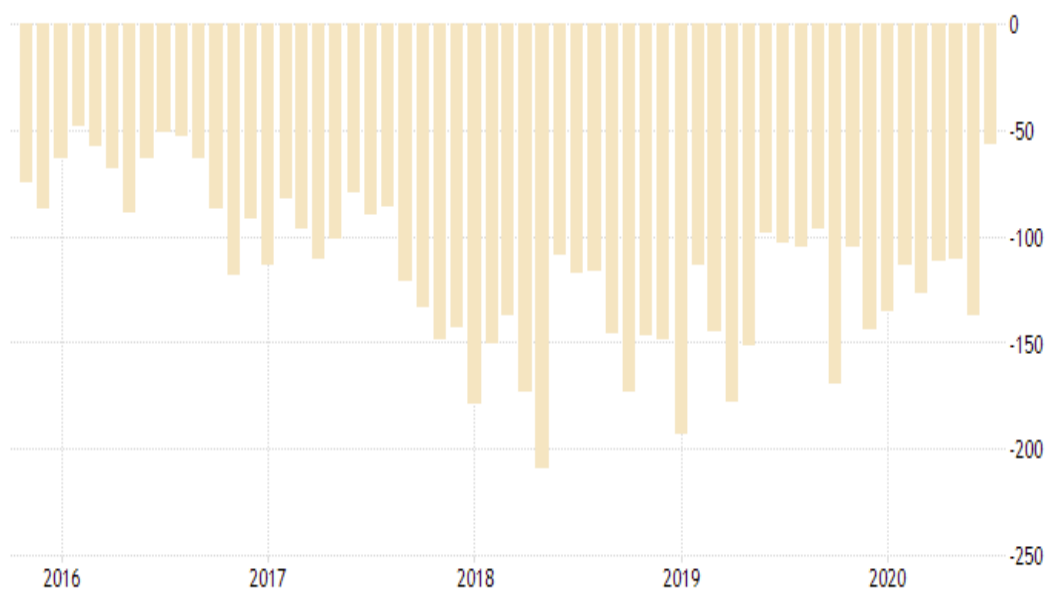
5. Results and Discussion

5.1 The measures to increase the self-sufficiency of Bangladesh in energy consumption

One of the most important features of the country's foreign trade is its partial dependence on imports of some non-renewable energy production sources. Since the country does not import electricity regularly (only in certain circumstances), it uses imported crude oil for local diesel fuel production. It follows up power generation and fuel production for transportation purposes. These inputs for power generation and fuel production have a relatively high share (see Table 8), which averaged 13.7% between 2010-2015, making it the highest share in the commodity import structure. The development of existing dependence on external sources requires some policy measures to increase the self-reliance of the energy sector in Bangladesh and to shift it to local renewable or eventually also non-renewable energy sources. These

policies can also improve the country's trade balance and improve the balance of payments and indebtedness (see Figure 18 and Table 9 below) as Bangladesh has recorded (trade deficit based on Bangladesh Bank data 56.70 BDT billion) July 2020.

Figure 18: Foreign Trade deficit of Bangladesh between 2016-2020 (in bill. BDT).



Sources: Bangladesh Balance of Trade (WB, 2020)

The ways how to solve the problem of the trade deficit caused by the country energy sector could be:

- structural changes in energy production
- increase in energy consumption efficiency
- transition to renewable resources
- improvement of the energy distribution infrastructure through investments (including foreign direct investments)
- Search for new geological deposits of progressive sources and attenuation of classical fossil fuels
- reduce the negative impact of GHG (CO₂) generated by electricity production
- innovative energy policies of the government
- opening of the discussion of nuclear energy utilization.

Table 7: Foreign Trade deficit and selected balance of payment (2016-2020)

Actual	Previous	Highest	Lowest	Dates	Unit	Frequency
-56.70	-137.20	0.00	-209.80	1976 - 2020	BDT Billion	Monthly

Bangladesh Trade	Last	Previous	Highest	Lowest	Unit	
Balance of Trade	-56.70	-137.20	0.00	-209.80	BDT Billion	[+]
Current Account	-2439.00	-871.00	1852.00	-3293.00	USD Million	[+]
Current Account to GDP	-1.70	-3.50	3.20	-4.40	percent	[+]
Imports	288.02	334.67	465.30	0.57	BDT Billion	[+]
Exports	231.31	197.48	279.82	0.05	BDT Billion	[+]
Terms of Trade	85.70	87.10	104.70	80.01	points	[+]
Capital Flows	3.83	3.26	679.50	-12.72	BDT Billion	[+]
Remittances	1963.94	2598.21	2598.21	856.87	USD Million	[+]
Gold Reserves	14.00	14.00	14.00	3.29	Tonnes	[+]
Foreign Direct Investment	2650.00	1583.00	2650.00	276.00	USD Million	[+]
Crude Oil Production	3.00	3.00	6.00	1.10	BBL/D/1K	[+]
External Debt	37.80	33.51	37.80	16.17	USD Billion	[+]

Sources: Bangladesh Balance of Trade (WB, 2020)

In the past and recent periods, the government has published more policies and programs for the public and private sector-focused implementing of the new energetic policy focused on different measures. Table 8 below provides a brief review of them.

Table 8: Energy Policy Measures of Bangladesh Government

Policy	Country	Year	Status	Jurisdiction
SREDA Standard and Labelling Regulation-2018	Bangladesh	2018	In force	National
The Sustainable and Renewable Energy Development Authority Act 2012	Bangladesh	2012	In force	National
BDS 1853:2012 Performance of close control air conditioners — minimum energy performance standard (MEPS) requirements	Bangladesh	2012	In force	National
Energy Efficiency and Conservation Master Plan up to 2030	Bangladesh	2015	In force	National
BDS 1852:2012	Bangladesh	2012	In force	National
Scaling Up Renewable Energy Program for Bangladesh	Bangladesh	2015	In force	National
Renewable Energy Policy of Bangladesh	Bangladesh	2009	In force	National
Import Duty Exemptions for Solar and Wind of Bangladesh (Statutory Regulatory Order)	Bangladesh	2004	In force	National
Act 2003 establishing Bangladesh Energy Regulatory Commission	Bangladesh	2003	In force	National
Policy Guidelines for Small Power Plants in Private Sector	Bangladesh	1996	In force	National
BDS ISO 13253:2011 Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance	Bangladesh	2011	In force	National
Private Sector Power Generation Policy of Bangladesh 1996	Bangladesh	1996	In force	National

Sources: (IEA, 2020)

The detailed description of the most important individual measures of energy policy are as follows:

- SREDA Standard and Labelling Regulation-2018:

The established rules and procedures for 'Minimum Energy Efficiency Standards (MEPS)' and 'Labelling of Machinery and Equipment' according to their energy efficiency performance offer customers a free alternative to energy efficiency improvement cost reduction measures through the market process'. The BSTI (Bangladesh Standards and Testing Institution) shall determine the Minimum Energy Performance Standard (MEPS) in the prescribed form as requested by the Authority and/or revise the MEPS of various applications and comply with the BSTI standards.

- Energy Efficiency and Conservation Master Plan up to 2030:

The Master Plan for Energy Efficiency and Conservation is one of Bangladesh's top plans on energy efficiency and conservation, the preparation requirements of which are laid down in the Energy Efficiency and Conservation Rules (2014). The plan declares Bangladesh's neutral commitment to the implementation of EE&C. This master plan has been developed with 7 policy axes

1. Power system Large industrial power for customers
2. Energy efficiency labelling program for residential customers based on the following steps:
 - a. Laboratory approval system
 - b. EE measurement method and standardization of star labels
 - c. Rating Criterion Star Label Standardization (Integration)
 - d. Participation in manufacturing, importers, and retailers (compulsory/voluntary)
 - e. MEPS (Minimum Power Performance Standard)
3. Energy efficiency building program based on Bangladesh National Building Code (BNBC)
4. Energy efficiency and conservation finance programs for private companies
5. Government's own initiative (green purchase program for the environmentally friendly public collection and adoption of some ISO certifications)
6. Energy. Collection of energy usage data (by energy, sector, and energy intensity data)
7. Global warming countermeasures, including the formulation and quantification of the national carbon market; carbon reduction projects as capacity development.

Renewable Energy Program Scaling Up for Bangladesh (SREP Bangladesh):

The Scaling Up Renewable Energy Program (SREP Bangladesh) was launched in late 2015 to outline potential developments and investments in the country's renewable energy sector. If the SERP's investment plan is implemented, it will be transformative for Bangladesh, as it will launch aggressive campaigns to integrate renewable energy generation into the grid, and the country will continue to expand its off-grid electrification program. Bangladesh aims to increase renewable energy capacity by 3.1 gigawatts by 2021, following the technology capacity target (see Table 9).

In 2015, according to data available, Bangladesh's total renewable energy capacity was 437 MW, and half of it was connected to the grid.

Table 9: Scaling Up Renewable Energy Program for Bangladesh (SREP Bangladesh)

Technology	New capacity (MW)	Year
Solar PV	1 676	2021
Onshore wind	1 370	
Biomass	47	
Biogas	7	
Hydropower	4	
<i>Total</i>	<i>3104 MW</i>	

Source: (IEA/IRENA, 2016)

5.2 Assessment of the energy policy of Bangladesh

The economic statistics prove Bangladesh's uninterrupted average GDP growth of an annual 6% over the last two decades. The previous country achievements in other socio-economic metrics have also been impressive and recognised by different global authorities like IMF, WB etc. The scope of irresistible economic initiatives in the private sector, including the government's commitment, clearly demonstrates its transformation from a primarily agricultural economy to a country with rapidly developing manufacturing and service sectors. The advantage of Bangladesh is the ability in conserving fossil fuels on a limited scale.

However, these are insufficient to manage the ongoing large-scale development activities in the private and public sectors. The acuteness and significances of this problem for Bangladesh are underlined because it is one of the countries in the future most affected by the devastating effects of global climate changes. A favourable geographic position of the country on the world map with the availability of abundant renewable energy sources (RES), its policymakers have already taken the initiative to utilise these resources to meet the growing country's energy demand. The significance of this issue generates, and the size of its threats create administrative, legal, technological, socio-cultural, and environmental challenges. Addressing them requires a broad policy initiative, including research presented by several technical and

scientific studies. Some of the recommendations (Sukki, Karim, Hemmati, & Newaz, 2020) state that measures that can effectively support the achievement of equitable and sustainable development in Bangladesh should include:

- (1) reduction of the cost of power generation through RES and provide support for initial investments,
- (2) increasing government participation in the development of renewable energy,
- (3) localisation and decentralisation of RE technology,
- (4) introduction of the new legal and regulatory policy for the development of RES industry in the country
- (5) measures improving sufficient public awareness of the energetic issues

In addition to these policies, it is important to consider the general recommendations of the UN SDG 7 recommended outside the structural changes in favour of the transition to renewable energy sources, which are of equal importance, especially for LDCs. They are also of particular importance in Bangladesh, where they include expanding infrastructure, upgrading the grid and increasing its efficiency, focusing on expanding access to clean and more efficient energy, which will support the country's economic growth and help protect the environment.

Still opened is the share of nuclear energy in the country's total energy mix. The experience of advanced countries with zero electricity generation in nuclear power stations policy shows the contradictory character of this policy due to many issues in the transition to renewable resources. The international cooperation with different partners from Russia, China, and India confirms that the government of Bangladesh doesn't ignore the importance of these energy resources for the national economy. Important this controversial component of the energy mix will be of growing importance specially about the environmental issue of global climate change because of its neutral impact on global warming, which is vital for Bangladesh in the next future.

In the last years, there is an intensive discussion that none of the renewable energies has a purely economic explanation and cannot replace fossil fuels on a full scale. There are some serious weaknesses of non-renewable energy sources like that some of them also produce GHG like CO₂.

Moreover, most renewable solutions are intermittent and non-stable and cannot provide the baseload capacity needed to replace large fossil fuel power producers. In the last years, some scientists believe nuclear energy is the best choice to replace fossil fuel; even for some of them, it is the only practical solution. Even some governments are reconsidering their zero nuclear energy policies. If governments of Bangladesh decide to accept model predication for global warming and comes to a conclusion to ignore the budget incomes from taxation of hydrocarbons and consider their real price with carbon tax policy, then it will move faster to zero-emission energy source like nuclear energy (Hejazi, 2017).

6. Conclusion

In this thesis, the current transition to renewable energy sources in Bangladesh is comprehensively presented, including its influence on foreign trade. Bangladesh has a significant advantage in its own huge natural gas resources, which can already reduce its crude oil imports. Proven natural gas reserves in Bangladesh will suffice the country for the next 20 years. Even now, 82% of natural gas is consumed in the power sector for power generation.

Although these represent a non-renewable energy source, the use of which in the energy sector has more significant advantages than conventional coal-fired power plants that burden the environment or energy sources using dielectric fuel, demanding oil imports. Using these resources will help gain the time needed to mobilize capital resources for a much broader transformation of the energy sector, favouring the wider use of renewable natural energy resources where only 3% of electricity was generated from renewable energy sources. The new studies and geological research prove that there is a great opportunity to meet Bangladesh's overall electricity demand through renewable resources and proper use of existing but more efficient and cleaner non-renewables.

The government has already tried to overcome the country power crisis by adopting some necessary measures launching the transformation process. But different sources, including this thesis, underline that renewables like solar energy should be given more importance. It has the potential to represent the emerging renewable energy sector of Bangladesh that will give a chance to meet the growing power demand of most of the country population. To achieve

these objectives, both the government and the private sector must cooperate in emphasising renewable energy sources to generate electricity to solve the potential power crisis in Bangladesh, accompanying its economic growth dynamics. As fossil fuel reserves dwindle, more emphasis should be placed on renewable energy sources to meet global electricity demand. The author also remarks on the necessity to open the discussion from previous periods dealing with nuclear energy implementation as the energy source contributing to environmental protection, which is important for a country like Bangladesh.

The work showed that this thesis's initial hypothesis confirms the possibility and necessity of transformation of the energy sector by deviating from traditional ecologically burdensome and import-oriented resources in favour of renewable natural resources was correct.

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