World Journal of Social Sciences
Vol. 8. No. 3. September 2018. Pp.155-170

Prospects Coal as an Alternative Environmental Friendly Fuel to Mitigate Energy Crisis in Bangladesh Economy

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The substratum of any nation's economy is energy. It constitutes crucial infrastructural inputs into the economic development process. Extensive research been conducted in the past, and all of them stated that energy is vital for the developing process. Bangladesh has been blessed with substantial amount of natural gas that helped the nation to make significant economic process for its vast population. However, the natural gas reserves are depleting, which will become a threat to the energy sector to keep up with the increasing demand. Various political, social and economic reasons haveforced us to realize the importance of finding an alternative energy resource such as coal and the purpose of this research is to find out whether coal-fired power plants, are feasible or not in context to the Bangladesh energy sector. To prove the feasibility of this research, various analysis of numerous research papers is scanned throughout the last 2 decades, to get a proper concept of the whole topic so that it can be applied for Bangladesh. Information regarding the cost and environmental effect from different part of the world has been gathered for this project. After studying various research papers, I was able to come to conclude that the whole research is, feasible and sustainable if conducted properly. The feasibility of this research paper will lead us to become less mono-fuel dependent and allow us toapproach towards the road of economic solvency.

Field of Research: Economics

1. Introduction

Energy is the essence of economic growth for any country and it constitutes essential infrastructural inputs into the economic development process. Life without energy is unimaginable, in the modern time. Energy has become the far-reaching aspect for people throughout the globe. It has remove darkness from the world. Even the small mechanical instruments require energy for daily usage. Powerful forces such as population, industrialization, urbanization and standard of living causes the demand for energy to rise exponentially.

Bangladesh having a land mass of 147,570 km², the population stands on 163 million people. Around 1971, only 3 percent of the total population had access to

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electric energy. At present times, the percentage has increase to 62 percent. The demand for electric energy has been increasing by 9.8 percent per year, mainly due to rapid urbanization and industrialization in Bangladesh. Unfortunately, when compared to the world, access to electric energy is still low in Bangladesh. Commercial sector of Bangladesh holds the lowest per capita consumption of energy in the South Asian region, but still there is a notable gap between the demand and supply of energy. The source of energy in Bangladesh is either fossil fuel or not efficient enough. Search for alternative source of energy has become an important factor. Apart from fossil fuels, opportunities of extracting energy though renewable resources in Bangladesh are slim. Most of the renewable resources, whichdiscussed later on, are geographically limited or constrained by high cost of operations. Therefore, one of the best options for the Government of Bangladesh is to shifts its dependency to coal, in order to generate energy. Coal-fired power plants have the potential to generated affordable energy. It can provide stable amount of energy even at the peak demand period. Coal-fired power plants can help Bangladesh sustain a higher economic growth and lower its dependency on natural gas.

The purpose of this research paper is to investigate the prospects of coal as environmental friendly fuel to diminish energy crisis in Bangladesh, which has not been addressed properly in context of Bangladesh, by any paper. Electric powerconsumption, electric energy production from coal sources and access to energy are presented along with discussions of other factors that may influence the feasibility of coal for Bangladesh.This research paper is formulated as a qualitative research, where both primary and secondary research has been conducted.

The paper consists of literature review followed by a detailed discussion of coal technologies, such as clean coal, carbon capture and storage. Then more discussion of the feasibility of coal technologies, such as desulfurization, nitrogen oxide reduction and mercury control. All of these are discussed in the literature review section. After that, a detailed analysis of Bangladesh's energy sector. After that, we have case studies of both developed and developing counties using coal-based power plants. Then the case studies are summarized in the next section as lessons learned from case studies. And lastly, the conclusion and policy recommendations that are aimed towards Bangladesh's energy sector, on how to regulate and implement coal-based power plants, as Bangladesh is relatively new to coal-based power plants.

2. Literature Review

There are numerous studies regarding coal and its affects, carried out by different counties to check the correlation between coal, environment affect and energy usage. But the studies are subjective, as it varies by considerable amount across counties. In terms of Bangladesh, the study can be considered significantly new as the country is highly dependent on its natural gas reserves and the coal reserves are left almost untouched. There are limited to no literature

review available to look into the missing points or knowledge gaps that came a found by examining various relatable papers.Therefore, the below consist of brief analysis of global demand for energy and the resources to produce it, which will help to understand the significance of coal.

A little over1.3 billion people, from 7.4 billion, are currently living without electric energy and almost a 1 billion more people live their lives with interrupted and unreliable energy. In 2012, roughly 25 percent of the overall population of all developing counties did not have any energy. Africa accounted the largest share, 57 percent, of the global darkness. Throughout the African continent, electricity considered as scarce commodity. Consumption of electricity in Africa is directly proportional to the availability of resource. Natural gas and oil are found in the northern part. In the southern part, coal and nuclear resources are available. In the eastern part, oil and hydropower dominates. Lastly, in the western part wind energy and hydropower are convenient for the usage of energy production.

Asia registered 17 percent where India accounted the largest share. India, heavily populated country, meets half of its energy demand through coal. A case study has been constructed in this paper that describes the situation of India's energy sector. Middle East registered 8 percent of the global darkness. The primary reasons of energy shortage are associated with civil wars. Many of the power stations bombarded during wars and corruption in the energy sector have oversighted the formation of any new power stations to meet the demands. After Middle East, Latin America registered 5 percent of the global darkness. Most of the people without energylives either in rural areas or at the bordering edge of the cities, where the development process is slow. The main challenges for Latin America's energy sector are, rising middle-income class, limited infrastructure and climate change.

The information collected for the above countries, are commendable. They have taken their best available resource and utilized it. However, the scenario has changed as the availability of fossil fuels have changed over the years. Primarily, natural gas and oil has been considered widely as the resource to generate energy. But coal has been often neglected when other forms of fossil fuels are available.

2.1. Importance of Coal in Developing Countries

Coal can be utilized as a strategic resource, which can be one of the primary elements that facilitate a high-quality modern life, a contributor to sustainable development and most importantly, if the natural resource is employed to its full capacity, then assurance for energy security can be obtained. The demand for electric energy globally, stated in (IEA, 2015), is predicted to increase by 33% by 2040.

Along with gas and oil, coal will serve as the key stone for provision of energy in the future, since the very few features provided by this natural resource are low-

cost, high-reliability energy grid. Coal, as an important source of energy comes into play when we look at the history, (Viljoen, 1979) emphasized that the production and availability of oil and gas may reach a breaking point as predicted in 1990. Middle East, which is key supplier of energy, and the unstable political situation, may create turbulence in western economies due to over depletion of resources. Hence, these situations play a vital role in determining a plan for alternative resource. Among, solar, tidal, wave, and geothermal, coal is receiving substantial attention.

By 2020, 1.6 billion people in underdeveloped countries will not have access to energyestimated by(Priddle, 2002). Affordability is a factor, which developing countries lack and the environmental protection remains poor. Most of the developing countries are largely dependent on agriculture that prevents production of biomass energy system. As for other forms of energy, developing countries lack the labor and technologies to operate nuclear energy, and renewable resources like wind and solar power will be hard to implement due to the unpredictable availability of wind and solar energy, which makes all of these inadequate for energy security for a nation(CIAB, 2002). Hence, coal is the only form of energy left to the developing countries that is cost efficient, abundant in supply, reliable in terms of availability and can be converted to energy, conveniently.

2.2 Positive Effects of Coal

Due to the growing appetite of energy throughout the whole world, coal as energy has the ability to provide an alternative source of energy, which can provide energy security for the upcoming future. The benefits derived from using coal will be immense starting from economic benefits, social benefits etc. For example, creating jobs. Coal extraction requires human labor, thus increases the employment rate to a great margin. Coal is inexpensive source of energy and the extraction process is relatively easy. Transportation cost of coal is much lower than oil and gas, as pipelines are not required. It can be stored safely andburned when required.

According to the estimates provided by the researchers of Pennsylvania State University, a clear indication is presented on the positive impacts of replacing expensive forms of energy like natural gas, by coal, which can serve as a potential form of energy stated by(Trisko, 2006). The annual usage of coal can result in $ 1 trillion worth of GDP, an augmented $360 billion in household income and can create 7 billion jobs. (Trisko, 2006)also emphasized that there is a possibility that a 33% reduction in coal-fired power electric power generation may result in a decline in GDP by $166 billion, household income by $64 billion and jobs by 1.2 billion.

2.3 Negative Effects of Coal

In a paper, written by (Burt, et al., 2011), it has been highlighted that various health diseases stemming from the consumption of coal. According to their research, the underlying effects due to the utilization of coal are respiratory effects, cardiovascular effects, neurological effects etc. From respiratory point of view, burning coal renders the emergence of an amalgamation of Sulphur dioxide, and Nitrogen oxide. The oxidizing molecules in the pollutants have the potential to affect the airways and lungs through damaging and weakening the cells. The research further reveals, particulate matters which are less than 2.5mm in diameter are closely linked and responsible cardiovascular diseases and one of the primary elements that coal contain is mercury, which is given off while heating the coal, as a result the mercury is emitted in gaseous form and plagues the aquatic food chain.

According to the UN, the consumption of ethyl mercury, contaminated fish may have a devastating effect on the neurological development on the progeny, which can reach up to the extent of problems concerning vision, memory and languages. Hence, from the health perspective coal may not be the wisest form of energy that could serve the human race, as it is very likely to affect the soundness of health and quality of life.

3. Working Principles of Clean Coal

Clean coal technology is a helpful technology that can secure Bangladesh from energy crisis. The primary objective of clean coal technology is to reduce the harmful effects that coal emits after burning it. Clean coal is mainly a preparation plant, where the coals are separated from rocks, soils, sands and all other impurities, so that the end product is pure coal. Washing of the coal improves the quality of the coal and the relative price of the coal. Inorganic substance, such as Ashes, can be separated from coal. Once separated, the transportation cost lowers down substantially. In addition, the efficiency of the power plants can be increase to a greater scale. Sulfur dioxide can also be washed away by significant amount. Clean coal technology catches and secludes carbon dioxide emissions, from power plants. Other forms of pollutions can be controlled within three processes, performed inside the power plants. The first process, removing the source of pollution before burning it. Second, avoid the production of pollutants in the combustion process. Lastly, removing pollutions from the flue, via ‘End of Pipe’ method. (Removing contaminants, formed from a steam of air, water, waste or any other products).

3.1. Carbon Capture and Storage

The best way to reduce carbon dioxide emissions is to capture it in the combustion process and store it in a suitable place. Worldwide 36 power plants, planned to demonstrate the carbon capture and storage process. Many countries are adopting to this technology. According to Haszeldine, carbon capture and

storage technologies has the potential to reduce future world emissions from energy by 20 percent. Coal is on the track of contributing 28 percent to the global energy, which implies that 57 percent of carbon dioxide emission is likely to increase,(Haszeldine, 2009). In the recent time carbon capture and storage is already in trails. There are 3 Megatons of carbon dioxide being captured and stored from the coal and natural gas power plants. Carbon capture and storage, is already operating in trials. By 2020, the emission of carbon dioxide should take a downward trend.

3.2 Feasibility of Coal Technology

Fischer-Tropsch technology is a stock of chemical reactions that converts a mixture of carbon monoxide and hydrogen into liquid hydrocarbon. This is a key component of gas to liquids technology to produce a synthetic lubricant and fuel, typically from coal or natural gas. Coal has high energy density and it is convenient as a heating fuel. The problem is that coal is associated with pollutants that negate any sort of advantage, when compared to any other burning fuel.

Coal, when converted into other form of fuel such as liquid hydrocarbon, synthetic gas and electric power, the conversion plants initially concentrate the pollutants in one large-scale conversion site. This enables the end users of the energy to experience a cleaner fuel. Unfortunately, no matter how successful the technology is in cleaning up the emission from large-scale coal facilities, it is a fact that every ton of carbon in mined coal will eventually end up as 3.67 tons of carbon dioxide in the atmosphere. Large-scale coal combustion has a nasty effect on the environment. There is an alternate approach, which is to gasify the coal and produce a low heating value synthesis gas that can be cleaned when combusted.

The thermal effect of manufacturing syngas, through Fischer-Tropsch technology, for coal and natural gas is 60 percent and 80 percent respectively. The relative capital cost for coal is 200 and for natural gas is 100. The Fischer-Tropsch reaction is highly accompanied with heat, therefore large amount of heat is produced to control the reactors temperature. The steam that comes out of the reactor can be send to the steam turbine to generate electricity. The efficiency of the turbines will increase if the steam increases.

3.3 Desulfurization

Coal has a notable amount of sulfur present inside it. When coal burned, 95% or more of the sulfur is converted into sulfur dioxide. Sulfur dioxide is an acidic gas that causes acid rain. Therefore, an alkaline is required to neutralize sulfur dioxide. Flue Gas Desulfurization (FGD) is practiced widely, in sulfur dioxide removal process. It is a technology used to remove sulfur dioxide from the exhausted flue gas pipe of the coal-fired power plants. FGD process includes wet scrubbing that includes the usage to limestone, alkaline, for desulfurization.

Spray dry, includes scrubbing with sorbent slurries. And wet-sulfuric acid process is a wet gas catalytic process. The efficiency range of FGD is in between 70 to 98 percent. In USA, cost of SO2 scrubbers applied with electricity, reported as $100/kW (Smith, 2001). In 2015, the capital cost rose to $470/kW.

3.4 Nitrogen Oxide Reduction

A mass number of nitrogen oxide can be formed in the combustion process in the coal-fired power plants. This depends on the amount of fuel used, combustion condition, air ratio and the flame of the burners. Fuel bound nitrogen-to-nitrogen dioxide during combustion and reacting to atmospheric nitrogen with radical like carbon, carbyne, and carbene: can form nitrogen oxide. As a post treatment in controlling nitrogen, one widely used method is known as Selective Catalytic Reduction (SCR). SCR technology is constructed to reduce the nitrogen oxide reaction in an oxidized atmosphere.

3.5 Mercury Control

Controlling mercury can be achieved with the help of sorbent and oxidizing agents that can change the gaseous state of mercury into solid states. The oxidizing agents work inside the wet flue that uses a scrubber to capture mercury in the sulfate by-product and the remaining products, mostly harmless, are released into the atmosphere. Mercury is formed in three figures, ionic, metallic and particulate. The primary goal for mercury control system is to oxidize all the available metallic mercury into ionic stage, so that later on the mercury can be removed in the FGD system.

4. Bangladesh's Energy Sector

Bangladesh wants to climb up to GDP of 7 per cent in the near future. In order to attain that, the energy framework needs to keep up with demand, which are likely to occur due to further industrialization and urbanization. Public-Private Partnerships have increased the electric energy generation and future demand for energy are listed below.

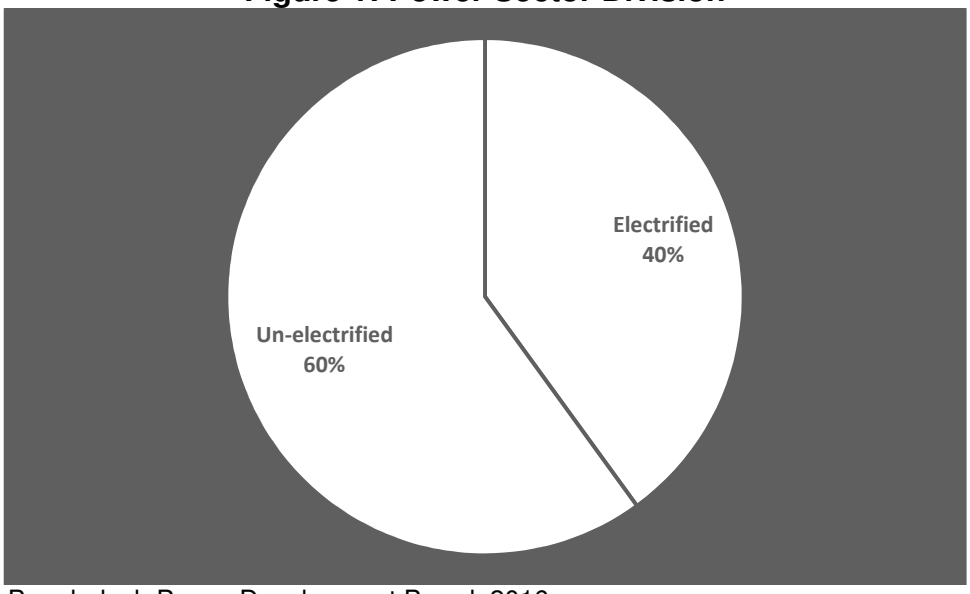
Table 1: Power Generation Report, Bangladesh

Year	Peak Demand (MW)	Generation (MW)	Shortage (MW)	Shortage (%)
2015	10,283	6,170	4,113	40.0
2020	17,304	10,382	6,922	40.0
2025	25,199	15,749	9,450	37.5
2030	33,708	21,910	11,798	35.0

Source, *Bangladesh Power Development Board, 2016*

The energy sector of Bangladesh is divided into 3 parts: electrified, un-electrified and off-grid. Un-electrified is defined as government planning to provide energy in the future and off-grid is defined as the government having no plans on providing energy in the future.

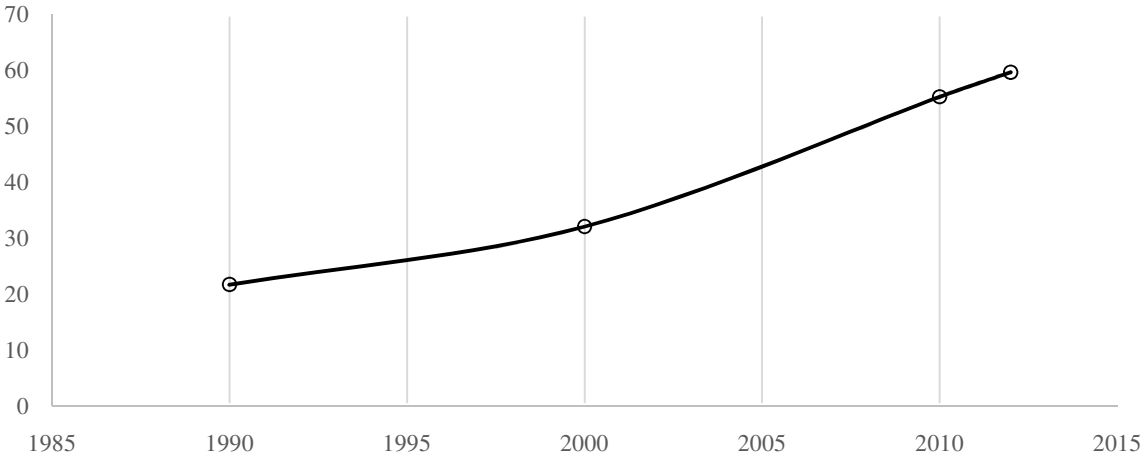
Figure 1: Power Sector Division



Source, Bangladesh Power Development Board, 2016

Currently 62 percent, of 163 million (subject to change) people are served with energy. 10 million people are going to be served. The remaining 46 million people are living their life without energy. In December 1, 2016, the present installed generation (MW) though public sector and private sector reported at 7,092 MW and 6,003 MW, respectively. The maximum demand of electricity served thus far is 9,036 MW.

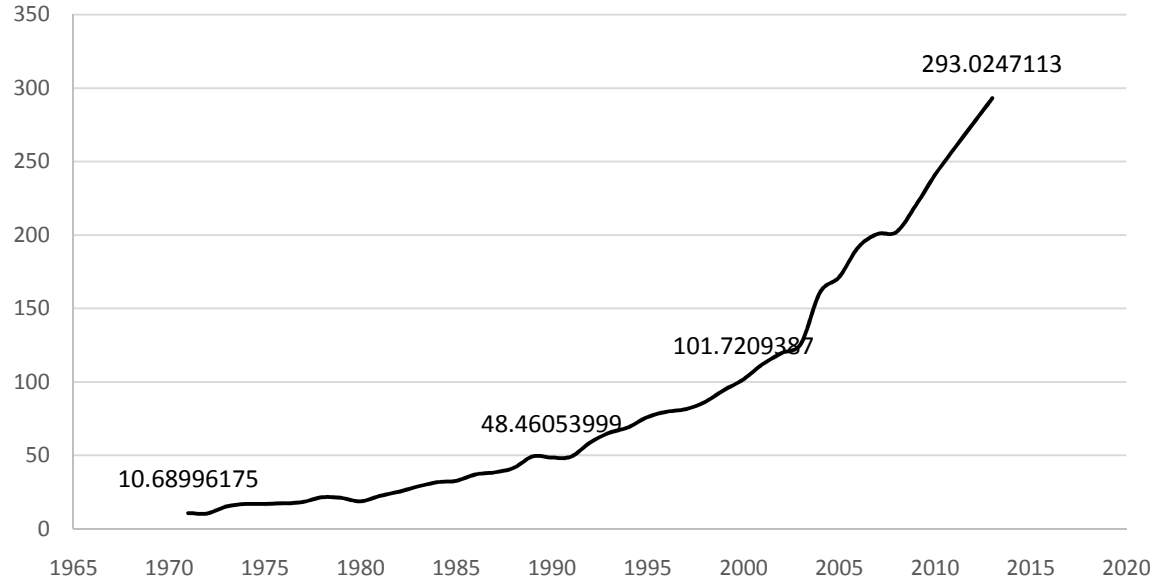
Figure 2: Access to Electric Energy (% of Population), Bangladesh



Source, World Bank, Bangladesh, 2015

The graph illustrates the accessibility of electric energy in Bangladesh from 1990 to 2012. From 1990s to 2000s, the trend has been moderately slow, mainly because lack of proper planning, infrastructure and usage of petroleum products as the primary resource. In 2000s, the government replaced petroleum products with natural gas that caused upward trend. Thus, helping Bangladesh to reach 62 percent(Islam, 2011).

Figure 3: Electric Energy Consumption (kWh per Capita), Bangladesh



Source, World Bank, Bangladesh 2014

The per capita electric energy consumption in Bangladesh in 1970 and 1990 was 10.689 kWh and 48.460 kWh. Thus, implies an increase of 37.77 kWh in the course of 30 years. From 1990 to 2000, per capita electric energy consumption

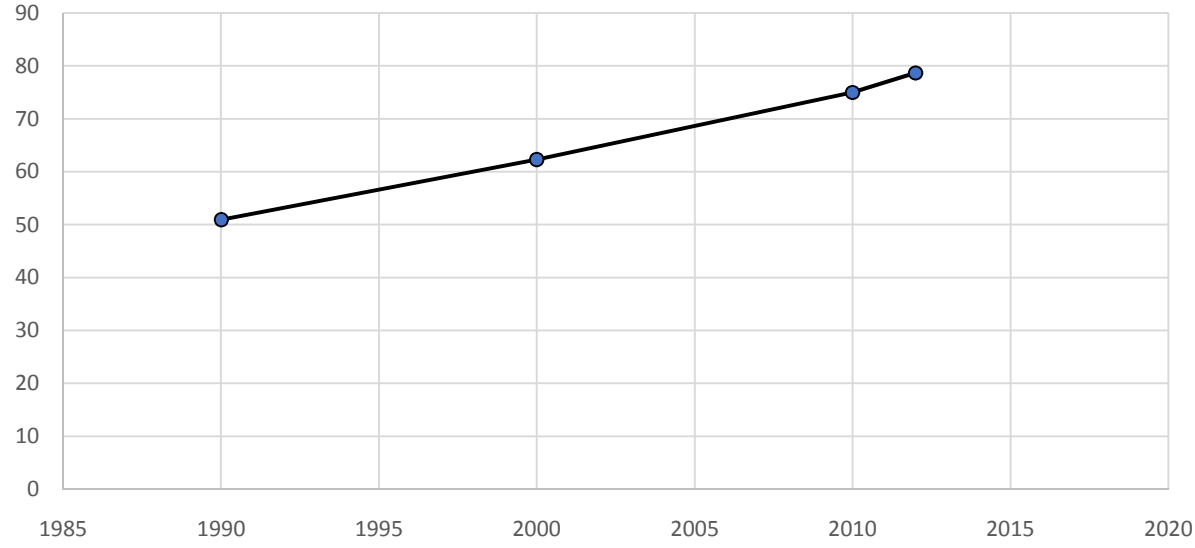
more than double and stood to 101.720 kWh. Moreover, in 2013, the number rose to 293.024 kWh. The main driven force for the drastic increase in energy consumption is natural gas. The unit cost of electricity generation natural gas accounted of 2.07 Tk/kWh for BPDB power plants and 4.21 Tk/kWh for rental power plants. But in 2016, the unit cost has increased by 1.30 Tk/kWh. Thus, indicating the situation of natural gas reserve.

5. Case Studies

5.1. India

In 2014, India and United States had talked about the corporation regarding clean energy, which concluded in a positive manner. However, India has five energy problems that needs to be addresses. Coal is a primary factor in India's energy sector. In the fiscal year 2012-2013, India produced 557 metric ton of coal to power their rapidly growing energy sector. In the upcoming year, India aims to increase it to 795 metric tons. But due to natural disasters, summer heat waves and repetitive labor strikes, the proposed target is hard to meet. This leads India to import coal, to meet the demand.

Figure 5: Access to electricity (percentage of population), India



Source, World Bank, India, 2014

India is currently world's fourth largest consumer of oil and petroleum products due to rapid growth of urbanization and expansion of middle-class families. India has made new reforms, which had increased the competition in the refining sector of oil. These reforms have also encouraged foreign investment, which were dominated by domestic players for a long period. The efforts to meet the demand of energy with respect to natural gas has been highly determined by geopolitical issues. There have been numerous plans with Myanmar, Pakistan, Iran, Afghanistan and few more countries, to install pipelines transporting the

natural gas. Unfortunately, due to the border dispute and few more issues, it could not be placed in operations.

Another problem is India is the inequality distribution of energy. More than 77 million residents still use furnace fuel, such as kerosene, for lighting purpose. The scenario is much more severe in the rural areas, where almost half of the households do not have access to energy. The investment of solar photovoltaic system is 8.5 times higher than the investment of coal. In other words, the investment will be 90 per cent more than the total expenditure of the government. Therefore, it is believed that coal will preserved it dominance as the main electric energy supply for India, for the upcoming 30 years.

5.2 Turkey

Turkey is the 17th largest economy in the world. Over the last 12 years, demand for energy has been growing at 5.7 percent, annually. In 2020, the growth rate will reach to 6 percent. The primary strategy for Turkey from 2015 to 2019 is to emphasis the security of the energy supply, which includes reducing its dependency from imported resources to generate electricity. Turkey's primary energy generation source is natural gas. However, natural gas production has been significantly low when compared to its consumption. Copious natural gas is imported from Russia, Iran and Azerbaijan. The second source to produce energy is coal, which accounts for 28 percent of the overall energy production. Renewable energy is considered as the alternative energy resource. By 2023, Turkey plans to generate 61,000 MW of electricity through renewable resources. But, till then electricity production from coal power plants are being focused as the mid-term solution to reduce the heavy dependency from importing natural gas.

5.3 United Kingdom

There are growing demands in energy and even more demand on preserving the environment, to limit the harmful emission, requires upgrading the steam turbine system, according to E. ON UK. It displayed cost-effective and a practical improvement by upgrading two of its turbine. E. ON UK's aim is to improve the performance of steam turbine of unit 2 and unit 4 at Ratcliffe power station. The expected performance gain for each of these retrofits is an efficiency improvement of 0.59%. Two of the benefits are, same output can be generated if fuel input is decreased, or the output can be increase keeping the same amount of fuel input. This technology has helped UK to save 52,000 tons of coal, annually. Along with that CO2 emission has been avoidable for 127,000 tons of coal, annually.One of the tool of E. ON UK is GNOCIS™ Plus, which is one of the lowest-cost options to reduce pollutions. It is a boiler optimizing system that works to reduce nitrogen oxide, by 15 percent and low-carbon flying ashes

5.4 Germany

In Germany, Rheinisch-Westfälisches-Elektrizitätswerk-Aktiengesellschaf (RWE) Power believes in climate protection. The vertically integrated activities by RWE, are reinforced with research programs to safeguard new investments, cost effective improvements and the impact on environment. (Walsh & Todeva, 2006) In 2003, lignite-fired power plant at Niederaussem, was introduced that generates same amount of electric energy as traditional ones but emits 3 million tons less amount of carbon dioxide into the atmosphere. In 2006, RWE Power started developing new hard coal-fired power plants to achieve 46 per cent efficiency, where the worldwide average in 30 per cent, (Walsh & Todeva, 2006). The estimated cost of constructing the power plant was 2.1 billion Euro, and in 2010 the construction started.

5.5 Canada

Canada established Genesee 3 in 2005, the most advanced and greenest coal-fired power plant that costed CAD 360million. It used the first supercritical technology; whose primary objective was to bring greenhouse emission level down to natural gas combined-cycle plants' level. EPCOR Canada, operator of Genesee 3, believes in working with the community to assure that coal continues to have an impact in the future. The community include landowners, regulators and business operation, where the power plant is situated. This sort of community is very diverse with various interest, but they are the aspects to allow EPCOR conduct their work in those areas,(Zhang, et al., 2010).

The advisory committee of Genesee focused in bringing the farming community together. The farmers were concerned regarding fair prices for their land for extraction purposes. The growing concerns of reclamation, water well policies, relocation, wildlife management, investment via community and policies on environment, all have been successful addressed towards the community. This lead EPCOR and the community towards a mutual understanding that both parties respected.

5.6 China

China's energy sector largely revolves around coal and it is likely to prevail in the future, given that coal reserves persist in the future. China is looking ways to use coal without the massive air pollution. China has been proposed a coal energy system, characterized as 'Near-Zero' emission for greenhouse gases and air pollution. The key enabling technology is oxygen-blown (O2–blown) gasification to generate synthesis gas from coal. This technology can cause the emission level of coal-fired power plants as low as natural gas combined-cycle plants. Polygeneration can enable the producers to an attractive energy cost, without additional technological advancement. In polygeneration, the fuel converted into syngas, by using of carbon monoxide and hydrogen.(Chen & Xu, 2010). China is in good position to become the leading country, producing clean synthetic fuel

from coal. The world average usage of oil for transportation is 18 percent, whereas in China it is 4 percent.

6. Lessons Learned from Case Studies

Many of the case studies above, suggests that coal can be used as a sustainable energy without hampering the environment and for some countries coal still possess great importance in their energy sector. Technologies invented with the sole purpose to trim down the harmfulness of coal without diminishing the output level have successfully allowed the power plants to counter attack the pollutants such as flying ash, carbon dioxide and greenhouse gas, for countries listed in this research paper. Fischer-Tropsch's low Sulphur emitting liquid hydrocarbon is recognized by many countries. This fuel can also be used in vehicles, taking the burden off from the traditional petroleum products. Fischer-Tropsch technology has helped China to continue using coal without further distorting the environment.

Germany simply focused more on minimizing the air pollutions and increasing the output level and efficiency of the power plants. Thus, allowing Germany to achieve higher efficiency than world's average and use 10 percent less coal. Just like Germany, United Kingdom adopted technologies for its coal-fired power plants, that allows to use less coal input and produce same amount of output as before or increase the electric energy output while keeping the coal input same. Alongside with other technologies carbon capture and storage and steam turbine system, has been proven beneficial in minimize harmful emissions from the power plants, for all countries that adapted it.

Working hand in hand with the community can ease the tension that usually arise in the production site. Enabling the community to participate in the production process, can help both parties. Canada took this initiative and as Bangladesh is considered as an ecological gem, the farmers located nearby the power plants can be compensated or be provided with jobs, ensuing social justice. It is fact that water usage is an important factor in the operation process of a coal-fired power plant. The traditional power plants consume vast amount of water to cool down the plant, for a smooth operation. Apart from that, water is required to extract and wash the coal from impurities, such as Clean Coal Technology. Countries like China used enormous amount of water, otherwise the whole energy sector will collapse. In certain scenarios, water is being used as transportation device, through coal pipeline. Slurry pipeline one of the widely practice transporting system. In this system, a semi-mixture of coal and water, usually 1:1 ratio goes through a pipeline and transported to long distances where railway or waterway is not available. There is another transportation system for long distances, but the ratio of coal to water is 4:1. This transportation system, known as log, requires the diameter of the pipelines to be twice the size of slurry pipelines.

This paper has been constructed though examining various papers that concentrate on the utilization of clean coal technology. Country specific case studies are also used to critically examine scenarios that may not be part of other empirical research methods. This kind of analytical exercise can provide a very detailed information about a particular subject which otherwise would not be possible to acquire through a different type of experimentation, provided that Bangladesh is relatively new to coal-based power plants. Data from Bangladesh Power Development Board and World Bank are used to assess the energy sector of Bangladesh and few other developing counties. This data has helped to provide a clear picture for the current access to electric energy and electric energy consumption. Thus, indicating the demand and supply of electric energy of Bangladesh and selected counties

7. Conclusion and Policy Recommendations

The shortage of electric energy has been a long clamor in Bangladesh and it is likely to exist in the upcoming years. Even being one of the lowest per capita energy consuming country in the world and having insufficient energy infrastructure, the demand for energy is astonishingly high. Bangladesh, being blessed with significant amount of natural gas reserves, allowed the government to generate the required energy from natural gas for a long period. However, currently, there are no gas wells being drilled, therefore the natural gas reserves are graduallydeteriorating.

Bangladesh requires adequate amount energy to fuel its enormous population. There is a huge positive change in accessibility of electric energy from 1971 to 2014. Unfortunately, the positive change is still not good enough for the current growth rate. There are still parts in the country, where there is no electricity. It is transparent that there is a huge difference in the demand and supply in Bangladesh's energy market. The frequent increase in gas price, portraits the current natural gas reserves. Bangladesh's government introduced quick rental power plants, in response to the rapid increase in energy demand. This did make notable impact in addressing the shortage of energy, but the cost of production for per unit of energy is high than others and it also created a distortion in price.

Apart from fossil fuel, Bangladesh has the chance to generate energy from wind power, biofuel and solar power. Unfortunately, due to geographical prospect, few these opportunities are limited. For Bangladesh, solar photovoltaic system is very auspicious but high costs, huge land requirement and expensive remedies such as voltage flicker make solar power less favorable option, at present times. Therefore, one of the best options for Bangladesh to generate energy is to shift its dependency to coal. Coal can help Bangladesh to generate electric energy at an affordable price. It can provide a secured amount of energy even in the peak demand session. Technologies, such as clean coal, carbon capture and storage, and Fischer-Tropsch can redeem coal's negative side to a great margin. Clean coal focuses in cleaning the coal, carbon capture and storage concentrate on

storing carbon dioxide and later using it for other purposes. Fischer-Tropsch technology makes synthetic fuel from carbon monoxide.

Some of the policies that can help Bangladesh to increase its' energy capacity is to install a coal-fired power plant. A single coal-fired power plant is currently enough to provided significant amount of energy. Policies to safeguard the environment, such as mandatory carbon capture and storage, overcapacity crisis, reusing the end products for other use, limited water usage, and providing mining jobs for the community can be undertaken. If these policies are maintained, then Bangladesh will be able to mitigate the energy crisis and keep the environment out of harm.

In this research paper, there are drawback that prevented the paper to be more detailed.Firstly, there are limited to no research paper concentrating on this topic, in context of Bangladesh. As the government has recently announced their interest on utilizing the current coal reserves of Bangladesh, papers concentrating on the feasibility of coal are on the primary stage. The second limitation of this study, is the lack of imperial data. This research depends a lot on recorded information for its feasibility. However, some recorded information was regrettably unavailable and we had assumed that information and this is a major limitation of this research paper. Another limitation of this research paper is time management. Research like these takes a lot of time to perfect and if there were more time available then it would have been possible to deliver an even better report. The lack of coal-based power plant in Bangladesh, to visit and inspect how it is operated, is another limitation to this research paper. One more limitation to this research is that, the financial side of coal-based power plants. The risks and rewards, in the financial investment views, has not been explored within this paper, as it is believed (personal) that it requires a stand-alone research paper of its own.

Recommendation for future researchers, can be to test the validity of coal in Bangladesh, in a more empirical approach. Notable data of energy generation in Bangladesh, with respect to coal usage, will provide new paths for future research. Technological advancement will also help to investigate the feasibility of coal in environmental friendly manner. Along with that, data concentrating on the environment once the coal-based power plant has been fully operational, is a monumental factor that will provide a solid understanding on this topic. Future researchers can also look solely into the financial benefits and/or drawbacks of investments made in the energy sector though the usage of coal.

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