Mid-Span Schemes for Energy Demand & Supply Strategies in Bangladesh

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Abstract— As a developing country, Bangladesh still produces inadequate amount of energy and electricity. Without enough production of these two, further development cannot be ensured. Along with the production, there should also be a suitable plan for demand. If dynamic plans for both demand and supply can be made, the best result can be achieved. BD2050 calculator is an open source energy and emissions model which deals with a total of forty different factors to analysis the supply and demand of energy. This online calculator has been used to predict the outcome of the proposed plan of this study. In this research article, a number of factors which influence energy and electricity demand have been analyzed. Considering the reality, each of these factors has been set to a particular level. Based upon this analysis, total demand has been forecasted for the year 2030. Then the similar steps have been done for the factors of energy and electricity supply. The levels of all these factors have been chosen to obtain optimum growth for both demand and supply. In short, the scopes of energy consumption and supply have been analyzed and some options are recommended to meet the demand.

Keywords — Energy demand; Energy supply; Electricity optimization; Renewable energy; BD2050;

1 INTRODUCTION

Bangladesh is a rapid growing developing country with unique challenges for the development of the energy infrastructure. Like most of the developing countries, energy crisis is becoming a major issue because of limited resources and rapid growth of demand. Demand for convenient forms of energy is set to grow due to steady economic growth, in a context of dwindling domestic reserves of conventional fuels. It is imperative to better understand the impact of today's energy choices on future energy security.

To meet up the energy demand of Bangladesh, processes of reasonable increment of energy demand and increasing the energy supply should work simultaneously. BD2050, the first ever integrated model of energy, emissions and land use in Bangladesh, has been used as an efficient tool to identify and aim energy secure pathways for supply and demand of energy between now and 2030 [1]. This model emphasizes on nineteen demand factors and twenty-one supply factors for a realistic evaluation.

2 MATERIALS & METHODS

2.1 Selecting the Demand Factors with Target Levels

As Bangladesh is an agricultural land, the demand of agricultural fuel mix creates great impact. Transport system of Bangladesh is currently under question and changes for this sector can easily be adopted. If proper public awareness programmes are operated, people of both rural and urban area will use energy efficient lighting and appliances. Commercial demand for cooling is currently increasing and the changes can be applied by Government rules and architectural development. Protein sources can also decrease the energy demand at a large span. As this strategy deals with a huge amount of energy, TWh, i.e. 3.6×10^{15} J has been considered as the unit of the energy in most of the cases in this paper.

To forecast the energy demand, there are five major sectors in the society – public health, agriculture, households, transport and business sectors. These have been subcategorized into nineteen factors.

2.1.1 Public Health

The population growth rate of Bangladesh is very high. With the help of proper planning, this rate may be controlled. According to WHO upper bound fertility rate, the population may go up to 236 million by 2030 [2].

Though local protein gain is not fully depending on dairy product but proper planning for increasing exportation of this type of protein source with demand fulfilment may encourage mass people for cattle farming. In parallel major protein gain of local people may have open options. And a huge amount

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of foreign currency can be earned by exporting them.
A standard of 3006 kilocalorie nutrition intake is considered for each person. Ensuring this amount energy for each person 2030 seems very much likely.

2.1.2 Agriculture

With the development of the agricultural technology, there will be more machinery like tractors, power tillers and irrigation pump used in the farms. Considering the highest level, an assumption has been made that there will be 3.84 times increase in usage of machinery in this sector.
The farm fuel demand for increasing mechanized instruments use will be shifted towards renewable sources for energy security. As the off grid solar power is expanding in Bangladesh, the manufacturers are looking for potential system for solar powered irrigation pump. With the major financing from the World Bank and JICA, solar energy is being used in some areas as agricultural energy. So an assumption can be clearly made that the use of solar panel will increase eventually. By 2030, almost 50% of the total agricultural energy should come from solar energy.

2.1.3 Households

As a summer dominant country, water heating is not a prime need for the people here. So the usage of solar panel in households for water heating has been considered minimum.
Both urban and rural lightings and appliances are two very important factors to set the demand. With increased education and lifestyle, most of the people will be careful to reduce the demand. New energy efficient electrical products are supposed to dominate in the near future. So CFL and LED will be dominant for an obvious reason. As a result the highest level of reduction can be achieved from these sectors.

2.1.4 Transport

Metro rail project in Dhaka has been started very recently. But the focus of this project is only on the capital city. By 2030, no other train-based project is going to be started as per knowledge. So bus will definitely dominate the domestic transport system.
Most of the vehicles of the urban areas have been already converted to CNG engine. But they are causing the vehicles not to perform with full efficiency. At the same time, most of the long distance vehicles still prefer liquid fuel. So considering less emission from the industries, in this article, the proposal is internal combustion engine dominated transport system, by 2030.
Another factor is the choice of fuel cells or batteries. The assumption is electric battery cell will be preferred.
The freight transport of Bangladesh is basically road based so far. If the focus can be shifted towards rail and water, that will be more energy efficient. And with the increase of the developing factors, these ideas can be popular among the mass people. In this proposal, it is considered that around 50% of the total goods will be transported via off road.
International travel is more dominant by air than any other means. An improvement in ticketing system and management can reduce the flight number and can increase passenger number at each flight. If the number of passengers per flight is increased, that will be more energy efficient. So the best guess should be, even the highest level of efficiency may not be ensured, but it may be very close to that.
Shipment of cargo, goods or crops is a very vital factor of today's society. Energy required to refuel container ships used for international freight is also a valid point. Policies should be taken so that a reasonable amount of energy may require.

2.1.5 Business Sector

The industries of Bangladesh will grow eventually. By 2030, they may not reach to the peak, but they will obviously boom a lot. And that will have an effect on energy demand.
With the rapid growth of industries, the demand will also be high. To maintain this demand, the government should set some rules that can divert them more towards the use of renewable energy technology.
The architectural designs are gradually developing with time. So it can be assumed that the architects will be able to design buildings that are capable of passive cooling. Thus the commercial demand for cooling can be reduced.
Commercial buildings should also focus on energy saving plans. CFL and LED and other energy saving products will dominate in this sector too.
Growth in gross domestic products is the last factor to discuss about to predict the energy demand. The industrial output in Bangladesh expanded 2.7 times than the time between 1990 and 2003 and again 1.6

times than the time between 2003 and 2010. So, 7% growth is conceivable if the current rate of development is maintained.

All the nineteen factors discussed in this section along with their target levels have been summarized in Table 1.

TABLE I

Targeted Levels for Selected Demand Factors

Demand Factors	**Targeted Levels**
Fertility and population growth	236 million population
Protein source	70% protein from Dairy source
Nutrition intake	Average daily intake 3006 Kcal
Farm power index	3.84 times increase in use of machinery
Agricultural fuel mix	Diesel 10%, electric pump 40% and solar 50%
Solar panels for hot water	0 m^2 panels for each households
Urban (lighting and appliances)	59% reduction of demand from Public education and 90% lighting is CFL or better
Rural (lighting and appliances)	30% reduction of demand from Public education and 90% lighting is CFL or better
Domestic transport policy	Bus focused
Shift to zero emission transport	Internal combustion engine dominated
Choice of fuel cells or batteries	80% electric battery cell and 20% fuel cell
Shift freight off roads	By road 50%, by train 25% and by water 25%
International aviation	Occupancy per flight 53-178
International shipping	Generation of 29.61 TWh
Industry output growth	Focus on Metalwork, ship building industry, basic & fabricated metal product
Energy technology in industry	20% Energy from Electricity, 15% from Gas and 65% from solar heating, also used to generate steam, contributing electricity
Commercial	4.8 TWh to 1.9 TWh
demand for cooling	
Commercial lighting and appliances	Energy demand for lighting increases 122%, 90% CFL lights, 19% heating by electricity, 90% kitchen appliance are electric and 80% solar
Growth in gross domestic product	Annual growth of 7%

The energy demand graph obtained using BD2050 from the above mentioned selected levels of factors is presented in Fig. 1. From this figure, it is notable that the projected energy demand by 2030 is almost 650 TWh/yr and it will be around 1350 TWh/yr by 2050.

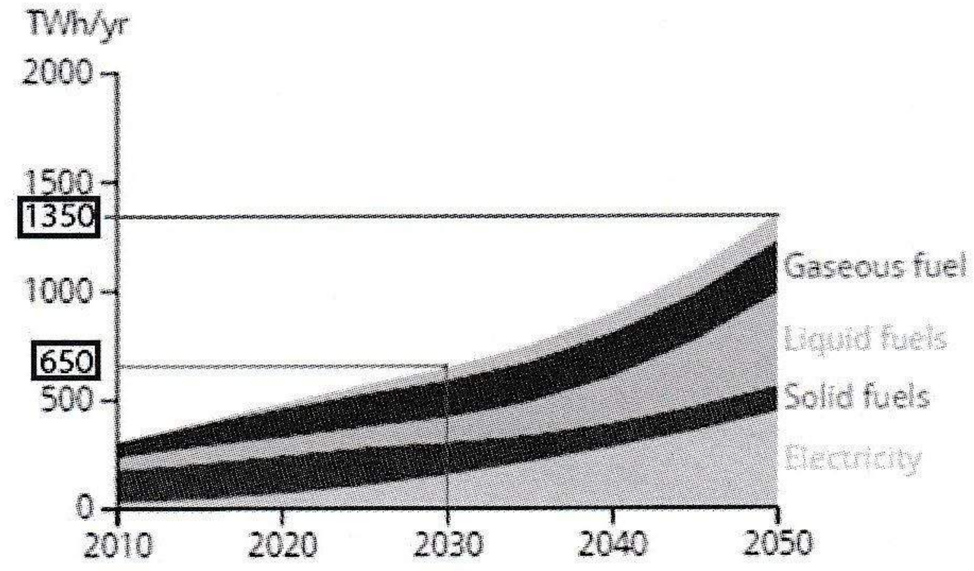

Fig. 1. projected energy demand by 2030 and 2050.

Anticipating only the major demand factors, the chart in Fig. 2 has been created. From this figure, it can be seen that by 2030, the demand of gaseous fuel will be highest, 177 TWh/yr. Electricity and solid fuel have almost similar level of demand.

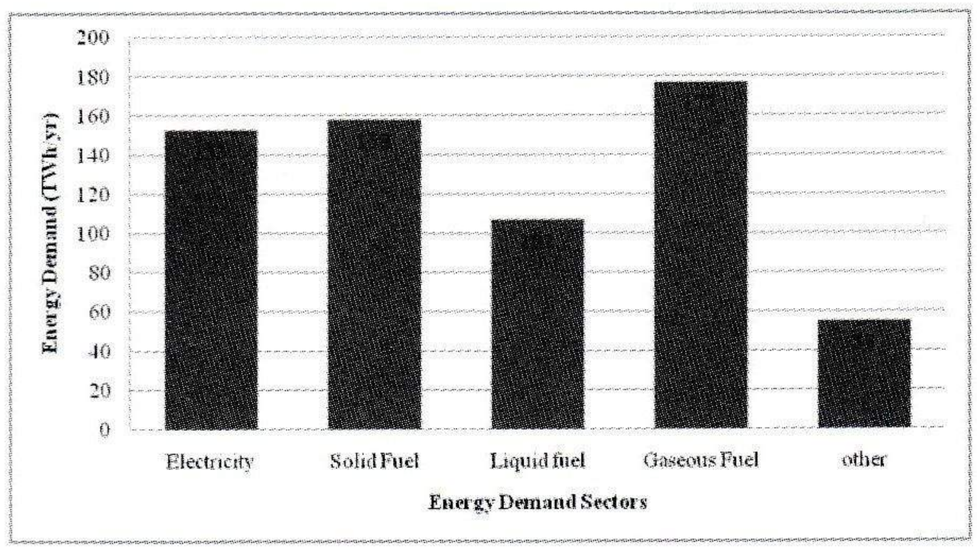

Fig. 2. Final energy demand sectors by 2030.

From Fig. 2, it is also seen that the demand of electricity is a little more than 150 TWh/yr. the same amount can be obtained using BD2050 calculator which is shown in Fig. 3.

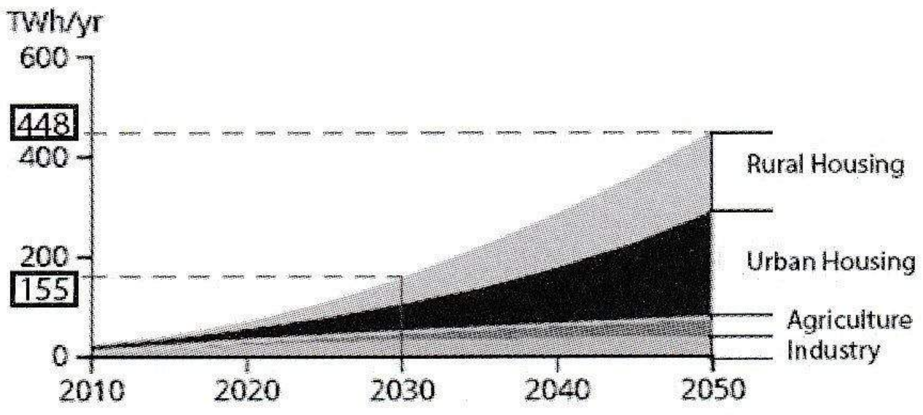

Fig. 3. Projected electricity demand by 2030 and 2050.

Fig. 4 illustrates the principal electricity demand sectors. From this figure it can be seen that by 2030, most of the electricity will be demanded by urban and rural housing, 55 TWh/yr and 52 TWh/yr, respectively.

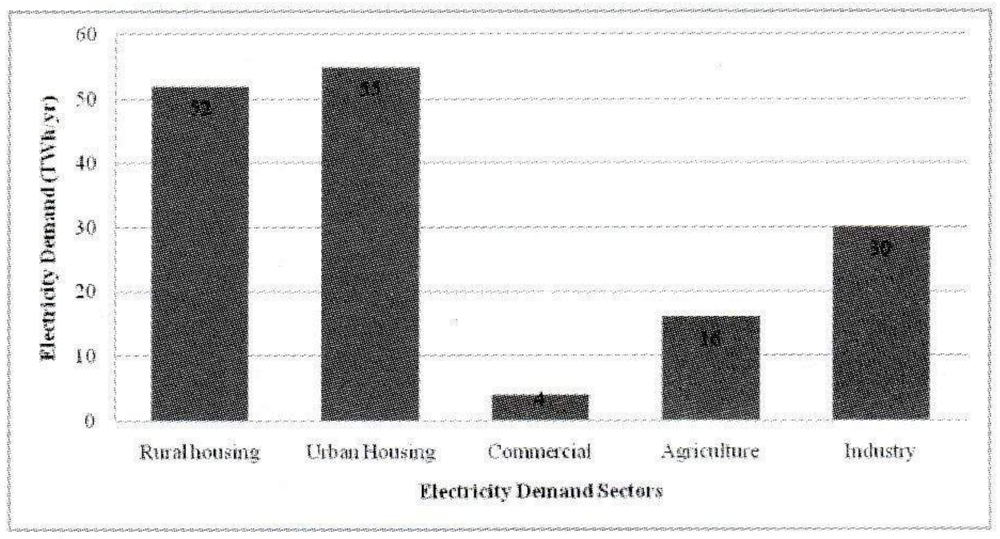

Fig. 4. Electricity demand sectors by 2030

2.2 Energy Supply According to Demand

The main objective of this article is to focus on renewable energy sources as much as possible. Thus the dependency on the limited fossil fuels can be reduced. Moreover, these fossil fuels are the causes of climate change and global warming. Whereas, renewable energy technologies ensure a liveable environment for the people.

Coal based power plants already exist in Bangladesh. And there is also a proposal of a 1320 MW coal power plant at Rampal, Bagerhat [3]. The goal is to meet PSMP (power sector management plan). The resultant final capacity in 2030 will be approximately 3000 MW.

Most likely, the current technologies of coal power plants will dominate for a while. No plan for establishing sub-critical (SC) power station, ultra-super critical (USC) and integrated gasifier combined cycle (IGCC) plants in the near future.

The number of gas power stations should be increased by 2030. As there is a limited storage of natural gas, eventually the power generation capacity declines from 7.43 GW to 2.35 GW. In short, least effort is considered in this sector.

Like gas, liquid fuel storage is also limited. So in this planning, there will be no new liquid fuel power plant. This may reduce the capacity to 2.13 GW by 2030.

Construction of country's first nuclear power reactor, Rooppur 1, has been started in November 2017. Construction of the second unit at Rooppur has been commenced in July 2018 [4]. The combined capacity of the two power units with VVER reactors will be 2.4 GW. Commissioning is scheduled for 2022 and 2023 [5]. In this analysis, the assumption has been made accordingly.

To increase the amount of renewable energy in this country, offshore wind will be a valuable factor. Wherever possible, the government should take initiative to establish wind turbines. Hopefully by 2030, a good amount of energy will be harvested from this sector.

Bangladesh has a long coastal area. They are very windy in most of the year. These areas may be utilized to generate onshore wind energy. Different areas have been taken under investigation in different research works. Kutubdia and Sandwip are the two most promising regions to harvest onshore wind energy [6].

Small-scale wind energy is also a very favourable sector in the supply analysis. With proper regulation from the government, an equivalent of 1.5 million largest micro-turbines can be built by 2030.

The Bay of Bengal is located at the south of the country. It is an enormous source of energy. Large amount electricity can be generated from the wave. But still there is no plan for this type generation. A small plant with an option of extension in the future can be established.

Like the wave energy, there is still no tidal range energy generation plan yet. But a trial with an option of extension in the future may be constructed.

Electricity generation from solar energy is a well-established technology. It is being very popular in Bangladesh also. Both government and non-government projects are running for solar energy throughout the country. But the main problem is its cost. That is why, by 2030, collecting the maximum amount of solar energy may not be possible. But it will be very close to the maximum.

A 200 MW geothermal power plant has been established in Thakurgaon [7]. And as it is understood, the government has no intention to

establish any other very soon. So, minimum amount of energy is considered from this sector.

Bangladesh already has a 230 MW hydroelectric power plant at Kaptai. Except that one there is not much natural resource [8]. So most probably no new hydroelectric power station will be established soon. By 2030, the hydroelectricity will be still 230 MW.

Electricity is the basic need for the other basic needs of people. Food, health, education, nothing can be ensured without electricity. So it is considered that by 2030, 100% of the urban population and, 84% of the rural people will be connected to grid.

The main plan of this article is to ensure the sustainability of Bangladesh. For an obvious reason any kind of import has been discouraged here. That is why, no import of gas, coal or electricity is considered in this analysis.

If the marginal lands can be used to grow some biomass plantation then that may increase the energy supply. 294,000 Hector marginal land, which is practically considered as a very small amount. No area from the agricultural lands has been allocated for this reason.

End use bioenergy can be another important sector for the energy supply. If properly utilized, a good amount of energy can be generated from biomass.

Everyday a large amount of wastage is thrown away by both urban and rural people. These waste materials can be used to generate energy. The garbages are almost free of cost. So the generation cost is very low. Germany, France and some other European countries are already using this technology successfully.

Table 2 summarizes the whole discussion of this section. All twenty-one sectors are listed with their targeted levels in this table.

Table II

Targeted Levels for Selected Supply Factors by 2030

Supply Factors	**Targeted Levels**
Coal power capacity	Capacity in 2050 will be 31.75 GW
Coal power technology	No SC, USC or IGCC plants by 2030
Gas power stations	Least effort, 8.7 GW
Liquid fuel power plants	No plants built
Nuclear power stations	0.4 GW test reactor built
Offshore wind	50 MW of new offshore wind capacity added per year, 49.3 %
Onshore wind	20 MW of new onshore wind capacity added each year, 1.1 MW
Small-scale wind	0.3 GW, 0.7 GW
Wave	0.15 GW by 2030 and 1.2 GW by 2050
Tidal range	0.1 GW by 2030 and 0.2 GW by 2050
Solar panel for electricity	Capacity 98.8 GW by 2050
Geothermal electricity	Less effort, no plant built
Hydroelectric power stations	230 MW
Access to electricity grid	Urban 100% and rural 84%
Electricity imports	No import
Gas imports	No import
Coal imports	No import
Bioenergy from marginal land	294,000 ha
Bioenergy from agricultural land	No area allocated
End use bioenergy	70% to liquid fuels and 10% to solid fuels, Electricity, CNG
Waste to energy conversion	70% available fuels are converted to Electricity

From the above mentioned selected levels of factors, the energy supply graph is depicted in Fig. 5. From this figure, it can be observed that by 2030, 1087 TWh/yr energy can be supplied. This number will rise to 2126 TWh/yr by 2050.

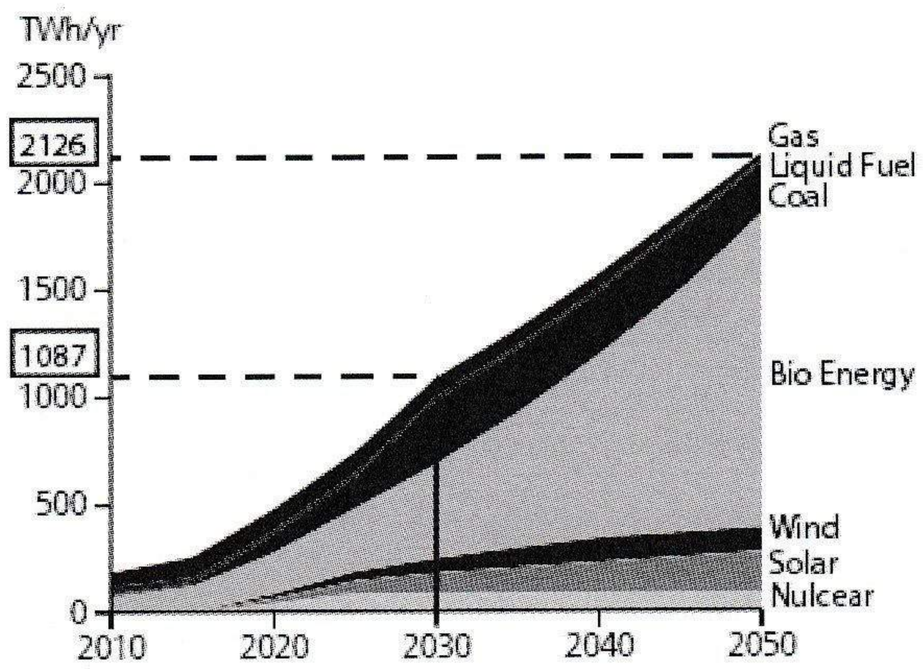

Fig. 5. Projected energy supply by 2030 and 2050.

Fig. 6 illustrates the energy supply by 2030 in terms of different sectors. If everything is done according to the proposal made in this article, then maximum energy can be supplied from bioenergy, 443 TWh/yr. Solar, nuclear, wind and gas can provide less than 100 TWh/yr energy each.

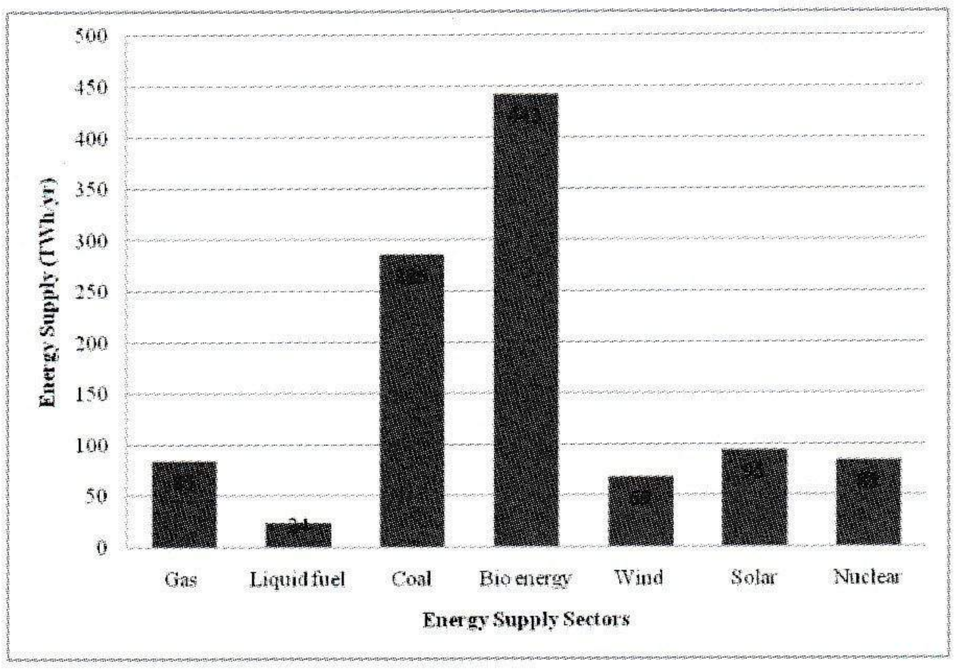

Fig. 6. Primary energy supply sectors by 2030.

Fig. 7 depicts the projected electricity supply. From this figure, it can be seen that by 2030 and by 2050, the electricity supply will be 281 TWh/yr and 527 TWh/yr, respectively.

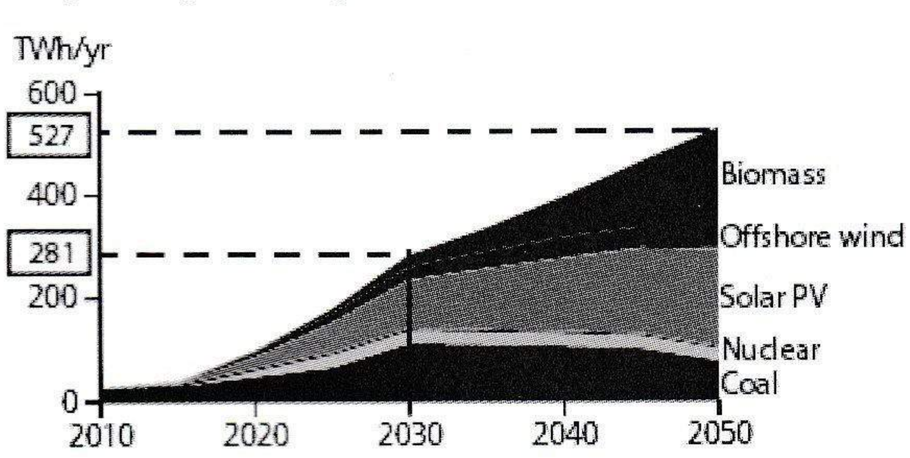

Fig. 7. Projected electricity supply by 2030 and 2050.

Fig. 8 shows the amount of electricity supplied from different sectors by 2030. According to the proposal, maximum electricity can be obtained from solar and coal. Their combined supply will be a little less than 200 TWh/yr. Wind, nuclear, bioenergy and gas will provide around more 100 TWh/yr.

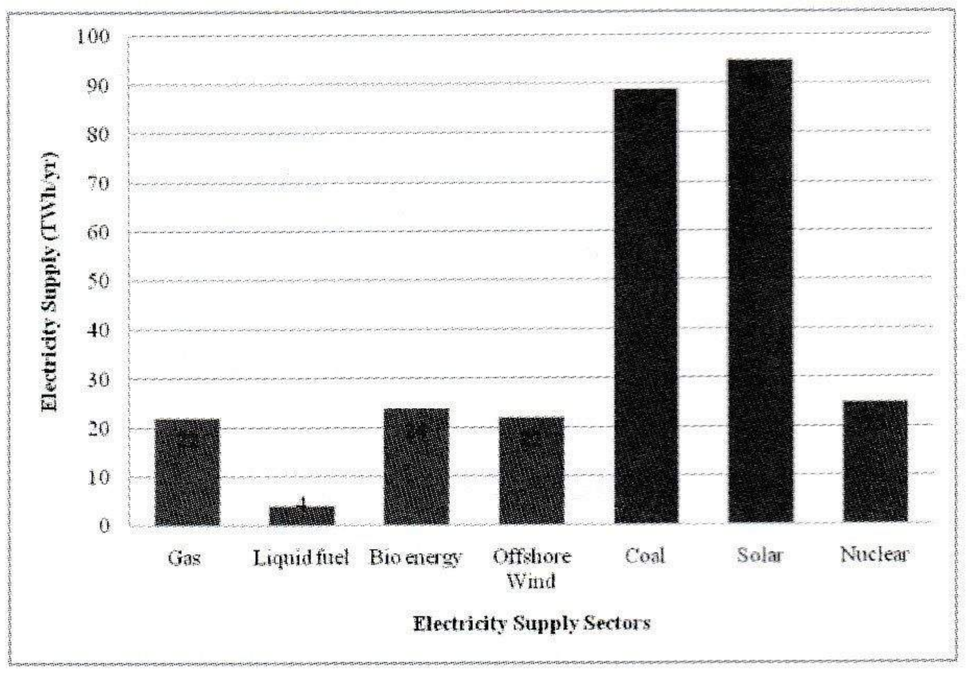

Fig. 8. Primary electricity supply sectors by 2030

3 RESULTS & DISCUSSION

In this section the demand, supply and surplus energy and electricity by 2030 and by 2050 have been investigated according to the proposed plan.

Fig. 9 depicts the projected energy scenario that have been already discussed in section II and III. From Fig. 1, it has already been noted that that the projected energy demand by 2030 is almost 650 TWh/yr and it will be around 1350 TWh/yr by 2050. And Fig. 5 shows that by 2030 and by 2050, 1087 TWh/yr and 2126 TWh/yr energy can be supplied, respectively. Accommodating these values of demand and supply, surplus energy can easily be evaluated. From Fig. 9, it can be noted that by 2030, 437 TWh/yr energy will remain surplus. This value will rise to 776 TWh/yr by 2050.

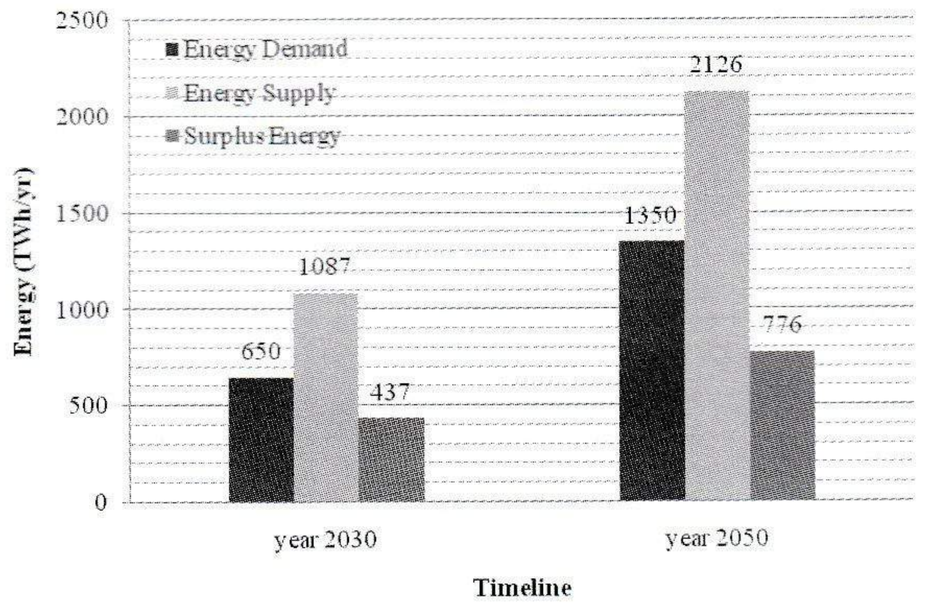

Fig. 9. Energy demand, supply and surplus by 2030 and 2050.

Similarly, Fig. 10 demonstrates the projected picture of electricity. Fig. 3, shows that the probable demand of electricity by 2030 is around 155 TWh/yr

and it will be around 450 TWh/yr by 2050. And from Fig. 7 shows that by 2030 and by 2050, 280 TWh/yr and 525 TWh/yr electricity can be supplied, respectively. Thus there will be a surplus of around 125 TWh/yr and 75 TWh/yr electricity by 2030 and by 2050, respectively, which has been shown in Fig. 10.

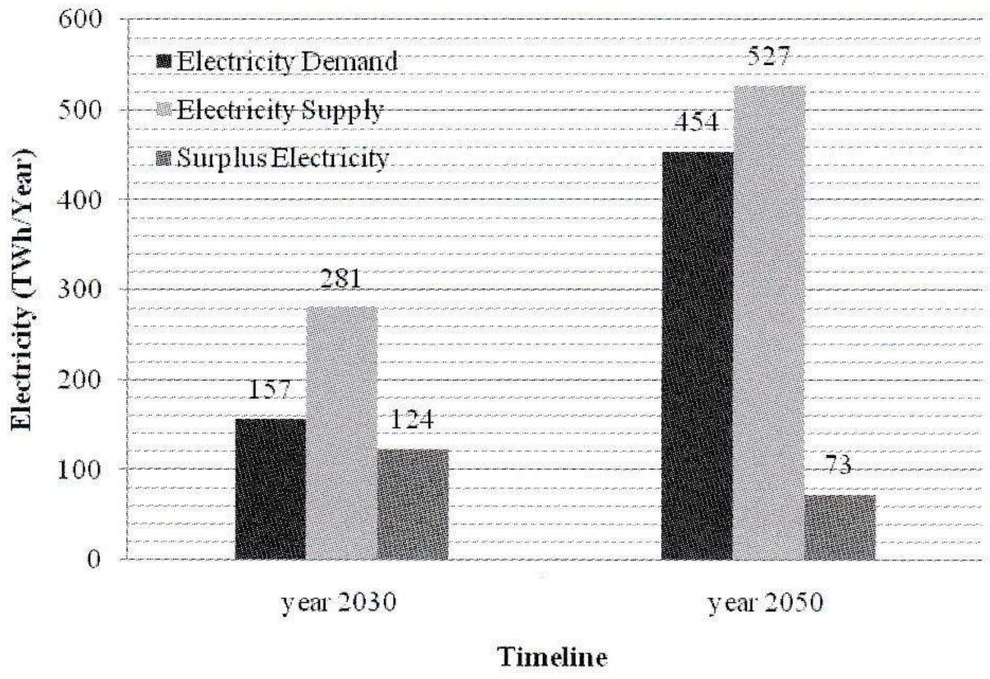

Fig. 10. Electricity demand, supply and surplus by 2030 and 2050.

These surplus energy and electricity can be exported to the neighbouring countries. This may have an important effect on the economy of Bangladesh. If the surplus energy and electricity are obtained according to the proposed planning, that will definitely helpful for the country to reach a respectable destination.

4 CONCLUSION

Bangladesh is a developing country. There are still a number of sectors that can be improved to lift her to the next level. Government and nongovernment organizations of the country are promoting different ideas and projects to ensure a stable condition both economically and environmentally. Keeping this in mind, the study and analysis of this article have been done.

In this modern era the development of a country is often measured by its electricity generation. Not only that, every aspect of a society has been extremely dependent on it. So this is the high time to become conscious about the reality. Only proper planning can guarantee a stable energy and electricity scenario.

And planning in this sector includes both dynamic demand and deliberate supply policy. This research can be a pathway of proper planning for the future. If appropriate policies are taken keeping the findings of this research work in mind, Bangladesh will be not only able to meet up the demand, but also produce surplus energy and electricity which can be exported for economical and social development.

ACKNOWLEDGEMENT

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