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Simulated Energy Scenarios of the Power Sector in Bangladesh

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Abstract

Energy is a strategic input necessary for socioeconomic development. Energy planning for Bangladesh is a challenge of enormous proportions such as imported energy options, selection of technology, environmental dimensions. A comparison has been drawn between two strategies, one with nuclear power plant without any provision of building nuclear power plant in Bangladesh. It was realized that if the country will not go for nuclear technology, it will become completely unsecured in terms of energy and it will almost rely on huge amount of imported petroleum products. Nuclear Power would diminish 448662 Kboe Gas Consumption, reduce 294721088 tons co_2 *emission within 30 years and it would be possible to reduce price. So NPP is more effective than any other conventional alternatives.*

Keywords: Nuclear Energy, Energy Network, Energy Scenario, Sustainable development.

1. Introduction

Bangladesh is a small developing country with limited indigenous energy resources. Per capita consumption of energy in Bangladesh is one of the lowest in the world. Present consumption of energy and electricity in the country is about 200 KGOE/year and 130 KWh/year respectively in which about 65% of its per capita energy is derived from biomass resources [1-2]. In recognition of the importance of energy in socio-economic development, the Government has given continuing attention to the overall development of the energy sector. But up to now, it has not been possible to achieve reasonable success in meeting the growing demands and the gap between the projected demand and the supply serve is increasing day by day because of inadequacy of indigenous resources, improper planning, unreliable policies and decisions on the development of power sector. Like many other developing countries, Bangladesh is facing enormous challenges to provide affordable, reliable and equitable energy supply to its citizens. About 25% of the population has only access to electricity. Consumption of energy and electricity in per capita terms is one of the lowest in the world. Noncommercial energy sources, such as wood, animal wastes, and crop residues, are estimated to account for 65% of the country's energy consumption [3-4]. In recognition of the importance of energy in socio-economic development, the Government of Bangladesh has formulated and approved the National Energy Policy (NEP) in which two different projections of energy and electricity were made covering the time horizon up 2020 aiming at sustainable development. BPDB had also carried out a twenty years "Power System Master Plan" (PSMP) for the time horizon 1996. In 1996 the government issued the "Private Sector Power Generation Policy of Bangladesh" and began to solicit proposals from international companies for Independent Power Producers (IPPs). Several structural changes in the Power Sector were also made for accelerating the power sector development. However, over the years, significant development in the power sector has not been realized. Moreover, the gap between the demand and the availability of supply of energy, in particular, electricity, has been

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increasing year in and year out. Presently, the shortages of electricity and commercial energy have become a persistent problem in the country [5]. We have investigated to find out the GHG mitigation options and it is realized that the nuclear energy and the solar energy will play a vital role in generation of electricity, natural gas in the transportation and high efficient biomass for cooking and other household activities.

2. Methods

2.1 ENPEP Model

The ENPEP for Windows model has its origins in the DOS version of the Energy and Power Evaluation Program (ENPEP), which is developed by Argonne National Laboratory (ANL) under the auspices of the U.S. Department of Energy (DOE) and the International Atomic Energy Agency (IAEA). However, ENPEP for Windows model is significantly modified and rather different in structure and capabilities from the older DOS version of ENPEP. It fully utilizes the Windows operating environment and provides the user with a graphical interface for designing a comprehensive model of the energy system of a country or region.

2.2. Description of the ENPEP Model

The ENPEP for Windows model works with an energy sector network that consists of nodes and links. The nodes represent processes, such as a petroleum refinery, while the links represent energy flows between pairs of nodes. The energy network is developed by defining the energy flows among 10 types of nodes. Each node type corresponds to a different sub- model in BALANCE and is associated with specific equations that relate the prices and energy flows to the input and output links of the node. The algorithm within the BALANCE module processes a system of simultaneous nonlinear equations and inequalities. These relationships, defined by input parameters associated with each node in the energy network, specify the transformation of energy quantities and prices through the various stages of energy production, processing, and use. In fig. 1 the energy chain of Bangladesh from supply to demand has been shown.

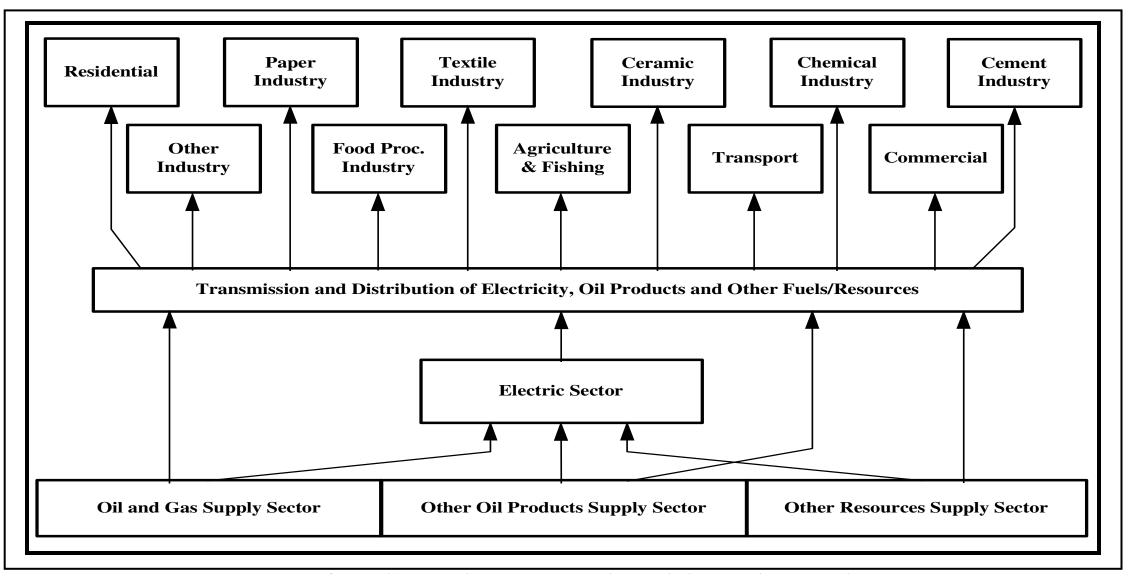

Fig: 1 Sectoral energy supply and demand network

An equilibrium model, represented by the energy network, is solved by finding out a set of energy prices and quantities that satisfy all relevant equations and inequalities. To find out the solution, the model requires initial estimates of values of fuel importation and production quantities at the bottom of the network. Then, the prices of fuel on each successive link of going up the network are computed from the prices equations defined by the various nodes. Next, the solutions to all the quantity equations associated with the nodes are computed for successive links going down the network. If all equations in the network are satisfied by the initial estimated quantities, a solution to the model has been found. Otherwise, the quantities at the bottom of the network are automatically adjusted, and all equations are solved again. This iterative process continues until the proper values for the quantities at the bottom of the network are attained. The equilibrium modeling approach used in the BALANCE Module is based on the concept that the energy sector consists of autonomous energy producers and consumers that carry out production and consumption activities, each optimizing individual objectives. In contrast, optimization models of the entire energy sector, such as linear programming formulations, can take on the interpretation of a central planning authority that has control over all energy flows and prices in the entire energy sector. The solution of an equilibrium model, such as the BALANCE program, should be interpreted as what is likely to happen, given that the assumptions about the relationships and data in the model are correct. In some circumstances, the output can also be interpreted as prescriptive, indicating what should happen or what will happen. For example, the model solution may prescribe what value energy prices should be set at in order to recover all costs of production and processing, if all government price controls are removed in a run of the model and prices are allowed to reflect only costs.

2.3. Application of the ENPEP Model

The objective of the ENPEP for Windows model is to simulate energy market and determine energy supply and demand balance over a long-term period of up to 75 years. To achieve this goal, the BALANCE module of ENPEP for Windows processes a representative network of all energy production, conversion, transport, distribution, and utilization activities in a country (or region) as well as the flows of energy and fuels among those activities. The environmental aspect is also taken into account by calculating the emissions of various pollutants. In addition to energy costs, the model also calculates the environmental costs. These costs can be used to affect the solution found by the market equilibrium algorithm. The main purpose of the software is to provide analytical capability and tools for the various analyses of energy and environmental systems, as well as for the development of a long-term energy strategy of a country or region.

3. Results and discussion

3.1. Technical properties

The technical parameters are taken from the "Power System Master Plan" (PSMP) and recent published data. The technical properties of different power plant are given in Table 1.

Table 1: Technical properties of different types of power plant

Power plant	*Investment* Cost	Variable O&M Cost	Fixed O&M Cost	Economic life time	Constr. period	Maint. Period per year	Plant Efficiency
	$/kW	$/kWYr	$/kW -Yr	Year	Year	Days	Fraction
G.T.	554	35	24	30	4	30	0.32
C.C.	781	35	24	35	4	30	0.42
Coal	1178	44	35	40	5	30	0.30
Nuclear	2000	18	70	50	6	15	0.33
S.T.	1018	35	26	30	4	30	0.33
Hydro	1400	22	15	45	5	30	0.70
Wind	1500	25	20	30	2	30	0.50
Solar	2000 (high from 2015 assumed)	2	2	25	2	10	0.20
	2000 (low from 2015 assumed)	2	2	25	2	10	0.40
Nuclear	2000	14.5	35	45	6	15	0.80

3.2. Peak demand

We have projected the demand of electricity and energy for four growth rates. The estimated results are shown in Tables 2 and 3. We have found that the electricity demand of our country for 7% growth rate will be 5468 MW, 11015 MW and 20936 MW in the year 2010, 2020 and 2030, respectively.

Table 2: Projected demand of electricity

Year	2005	2010	2015	2020	2025	2030	2034
Peak demand in MW For 6% growth rate	3819	5111	6840	9156	12250	16869	21699
Peak demand in MW for 7% growth rate	3718	5468	8287	11015	14949	20936	27228
Peak demand in MW for 8% growth rate	3854	5821	8554	12575	19197	28477	38772
Peak demand in MW for 9% growth rate	3854	5971	9187	14338	22812	35142	49640

Table 3: Projected Demand for Commercial Energy and Electricity

Year	1990	1995	2000	2005	2010	1015	2020
Population (million)	107	118	130	141	153	165	177
GDP Growth Rate	4.44%	5.25%	5.24%	5.24%	4.24%	6.65%	6.65%
Per Capita GNP(s)	190	214	242	276	317	366	424
Energy Co-efficient	1.62	1.37	1.37	1.37	1.08	1.08	1.08
Energy Growth Rate	7.13%	7.19%	7.18%	7.18%	7.18%	7.18%	7.18%
Per Capita KGOE	56	68	92	127	157	219	272
Total Energy (MTOE)	6	8	12	18	24	36	48
Total Energy (PJ)	256	342	512	769	1025	1537	2050
Electricity							
Percentage in Fuel	35%	37%	39%	37%	33%	33%	33%
Total GWH	8207	11584	18315	26063	30994	46491	61988
Per capita kwh	77	98	141	185	203	282	351
Load Factor	55%	57%	57%	57%	58%	59%	60%
Peak Load MW	1703	2320	3668	5220	6100	8995	11794

3.3. Historical growth of installed capacity

The strategy adopted during the energy crisis was to reduce dependence on imported oil through its replacement by indigenous fuel. Thus, almost all plants built after the energy crisis was based on natural gas used as fuel. Preference for this fuel is further motivated by its comparatively low price for power generation. Presently, indigenous energy sources (e.g. natural gas, hydro) are used for the generation of electricity in the East Zone and imported petroleum fuels (e.g. Furnace Oil (FO), Light Diesel Oil (LDO), Superior Kerosene Oil (SKO) and High Speed Diesel (HSD)) are used to generate electricity in some areas of the West Zone where natural gas supply is not available. In order to minimize the effect of fuel cost on power generation, electricity generated in the East Zone is transmitted to the West Zone via East West Electrical Inter-Connector established in 1982. The transmission capacity of the Inter-Connector has almost reached its limit (450 MW). The historical growth of installed capacity is shown in Fig 2.

Fig 2: Historical growth of installed capacity.

3.4. Estimated installed capacity

It is seen from the calculated data that at 7% growth rate the demand will be about 28000 MW in the year 2034. In order to meet this huge demand, a large number of installed capacities are required. In our calculations, we consider types of power plants based upon Gas, Coal (imported), oil (imported), Nuclear (imported) and others. It is seen from the calculated results that the installed capacity by the year 2010, 2020 and 2030 will be 5735 MW, 12125 MW and 28535 MW respectively. The estimated total installed capacity is shown in Fig- 3.

Fig 3: Estimated total install capacity.

3.4.1 Per capita electricity consumption

We have calculated per capita electricity consumption of our country for the growth rate of 7%, 8%, 9% and 6%. The calculated data is shown in Fig. 4.

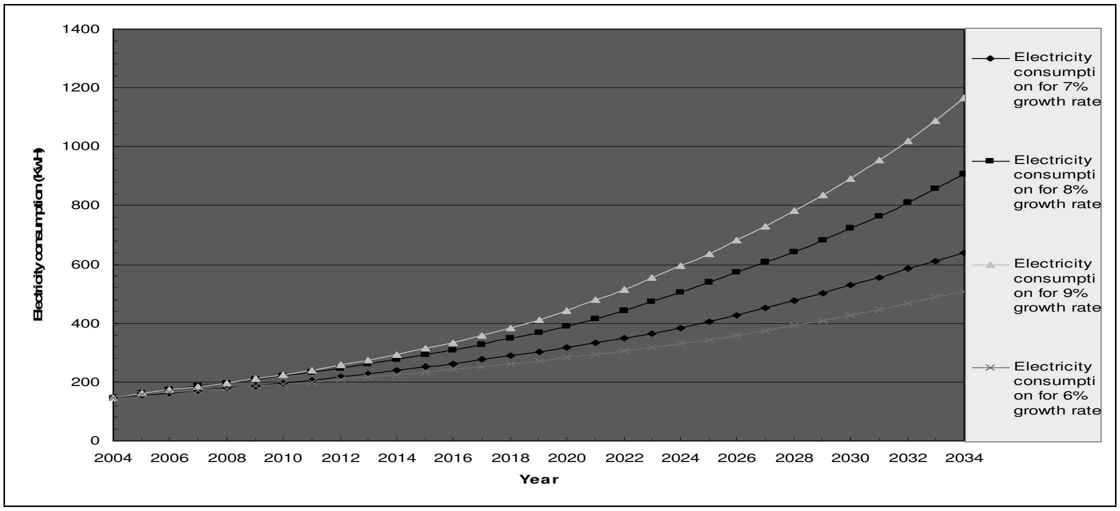

Fig. 4. Per capita Electricity consumption for different growth rate.

It is seen from estimated data that per capita electricity consumption of our country for 7% growth rate will be 638 KWh in the year of 2034. For 6%, 8% and 9% growth rates per capita electricity consumption will be 508 KWh, 908 KWh and 1164 KWh respectively.

3.4.2. Gas consumption analysis

We have analyzed the consumption of gas for power generation at 7% demand growth for different proposed scenarios. The calculated results are shown in Fig 5. If the installed capacity is developed based only on gas, the total consumption of gas in 2010, 2020 and 2030 will be 100000 kboe; 170000 kboe and 340000 kboe respectively. It will become 135000 kbboe if only coal is considered by the year 2020. If all types of fuels (mix) are considered then the gas consumption in 2010, 2020 and 2030 will be respectively, 75000 kboe,110000 kboe and 130000 kboe. Thus the consideration of fuel mixes for long-term generation is appropriate for the country.

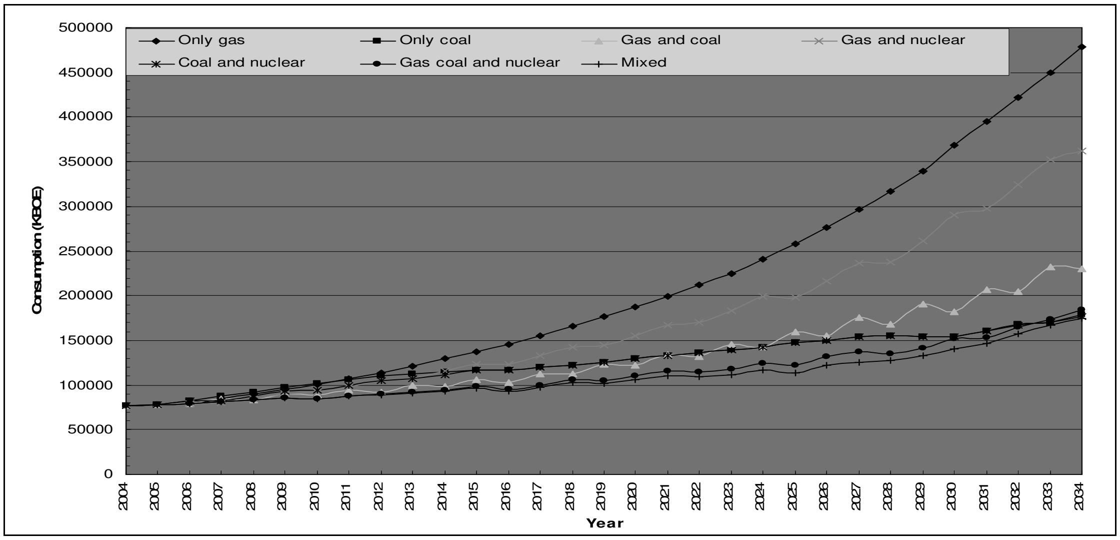

Fig-5. Gas consumption for different sceneries 7% growth rate.

3.4.2. Estimation of Installed Capacity of NPP

If we compare between the without and with Nuclear power plant estimated Installed capacity we would find that more 2400 MW Imported oil based power plant would be needed in without Nuclear power plant installed capacity. Without installing NPP we will fully depend on imported oil & coal. So our country will fall in great energy crisis without installing NPP. In this situation we have to consider installation of the NPP as early as possible. Some affective and applicable roles on energy sector are described in the next few sections. In realistic energy planning, expansion of nuclear power is important for the country. In order to meet the 7% growth demand, it is estimated that a unit of 600 MW needs to be added in the year 2012, 2018, 2024 and 2028. The total installed nuclear capacity over the projected period is shown in Fig 6.

Fig: 6. Estimated Installed Capacity of NPP.

In Fig 7 we have shown the impact of gas consumption if we consider units of each 600 MW sizes nuclear in the year 2012, 2018 and 2028. Under this situation, 448662 KBOE gas can be saved by introducing three units of nuclear power plants and the gas can be used in diversified sectors.

Fig -7 Gas consumption with time.

3.4.3. CO2 emission comparisons

We know that nuclear power (NP) plant do not emit CO_2 and the natural gas has lower emission than coal. We also study the effect of the emission of CO_2 in Gas base case and gas plus NP case.

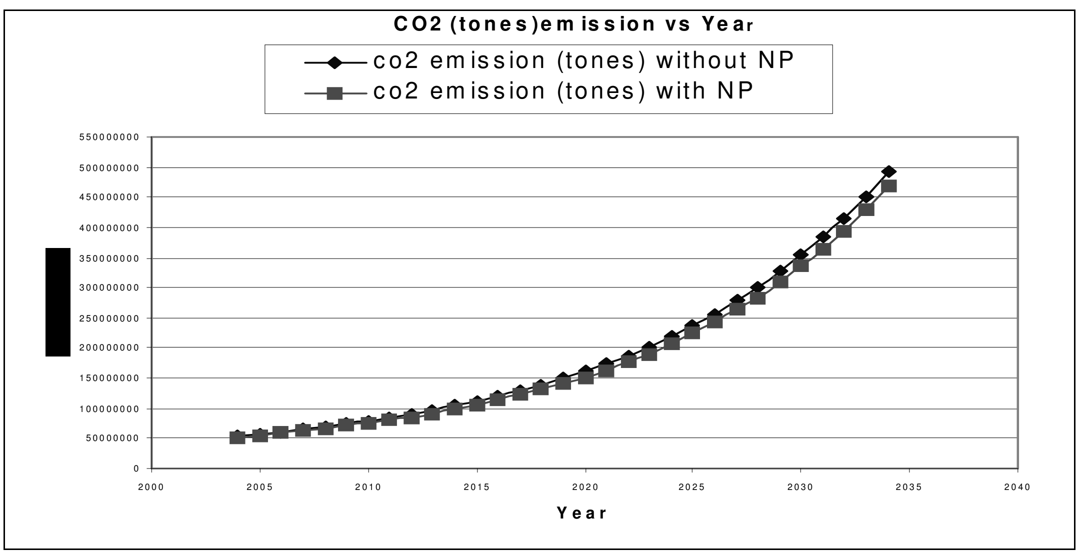

Fig – 8: CO_2 emission comparison.

We have also compared the emission of CO_2 between without NPP and with NPP. The estimated data is shown in Table 4. It is clearly seen that introduction of NP will help to reduce the emission of CO_2.

Table-4: CO_2 emission

Sum of co2 emission (tones) without NP	5920885276
Sum of co2 emission (tones) with NP	5626164188
NPP decrease co2 emission (tones)(2004-34)	294721088

It is seen that the introduction of 3 units of NPP of each size of 600 MW in the year 2012, 2018 and 20 28 t will reduce 294721088 tones CO2 emission.

4. Conclusion

It is revealed through our calculations that at 7% growth demand, the total demand of electricity would be about 28000 MW in the year 2034. In order to meet this huge demand, a large number of installed capacities would be required. The calculated installed capacity by the year 2010, 2020 and 2030 will be 5735 MW, 12125 MW and 28535 MW respectively. If the country would go for a limited number of nuclear power plants, the country would depend mainly upon imported coal and petroleum and if the country would not go for nuclear, the country would depend on huge amount of petroleum. Since the country has limited energy resources and will depend upon imported energy in the mid and long-term development and for future energy development, than it is clear that the nuclear is one of the best-imported fuel options for the country.

5. References

Akram, S. (2006). *Nuclear Power Plant for sustainable Energy Development for Bangladesh*, Int. J. Solar Energy, pp. 56-65.

Badrul, I. (2005). *Energy Resources of Bangladesh,* Int. Re. Ser. Met. pp. 82-94.

Akhter, J. (2002) *Trends of Biomass Energy Consumption in Bangladesh*, Bangladesh Renewable Energy Newsletter, pp. 33-45.

Islam, M. (2001). *Energy Security and Sustainable Human Development: Bangladesh Perspective, J. BPS.*

Nebojsa, N. and Alan, M. (1998), *Demand, supply and crisis of Energy,* J. Glob. En.