LONG TERM ENERGY SECURITY FOR BANGLADESH – FEASIBILITY OF NUCLEAR POWER

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INTRODUCTION

Energy and environment security are the two most soaring problems in the world today. The accessibility and affordability of energy have been significantly impacted in recent times due to increasing instability in the supply and also the fluctuating prices.[1] Since 1980, the global consumption of primary energy has doubled[2] and in future, consumption is projected to rise rapidly. According to an estimate, the world energy consumption will increase 53 percent from 2008 to 2035 in a business-as-usual-scenario, if no additional policy actions are taken to address energy and environmental issues.[3] Bangladesh as a developing state has been gradually falling short of its economic potential because of inadequate infrastructure, particularly in the energy sector. There is a strong need for sufficient supply of energy in order to achieve the goal of poverty reduction and social development through National Strategy for Accelerated Poverty Reduction (NSAPR-II).[4]

Nuclear energy emerged with lot of promises in the 1960s. It expanded rapidly in the 1970s amongst the developed countries. When it was expected to be spreading more specially among the second ranked countries, few accidents and their impacts held the world back. Towards the end of the last century nuclear power again got momentum. It is specially because the fossil fuels are decreasing gradually and they are less environment friendly than nuclear energy. Despite, huge initial cost, nuclear energy is cheap in the long run.

Energy security by and large is an association between national security and the availability of natural resources for energy consumption. Bangladesh has limited indigenous natural energy resources. Natural gas, coal, renewable energy

1. Col A K M Nazrul Islam, " Bangladesh:Mitigating Energy Insecurity and Environmental Vulnerability", in*Energy Security and Envirinmental Security: A Cooperative Approach in South Asia*, Ed D. SubaChandran and J. Jegannathan,Institute of Peace and Conflict Studies (IPCS), New Delhi, India, October, 2011, p-1.
2. Economic and Social Commission for the Asia and Pacific (ESCAF), "Energy Security and Sustainable Development in Asia and the Paicifc", Bangkok: United Nations, 2008.
3. Kensuke Kanekiyo, "Energy Outlook of East Asia and Challenges for Sustainable Development", Paper presented in the *Regional Workshop on Dealing with Energy Vulnerabilities: Case Studies of Cooperation and Collaboration in East Asia*, organized by RSIS Centre for Non Traditional Security(NTS) Studies on 09-10 December 2010 at Singapore.
4. General Economics Division, "Steps Towards Change: National Strategy for Accelerated Poverty Reduction (II) Revised: FY 2009-II", Planning Commission, Government of Bangladesh, *The Key thrust of macroeconomic policy is to ensure higher growth and generate employment,* p-xv.

including traditional biomass are the principal indigenous energy resources of Bangladesh. The country's energy and power sector are currently relying very heavily on indigenous natural gas. But the supply of these resources is not enough to meet the ever-growing energy demand of the country. The need for nuclear power plants is therefore a call of the time.

Nuclear power infrastructure in Rooppur was established primarily in the 1960s which was later never materialised. Now Bangladesh is approaching to acquire nuclear power by establishing its first nuclear power plant by 2018 with the cooperation of Russia. There are many advantages of nuclear power, while there are many challenges too. The challenges will have to be mitigated before the projects can give dividend. It is by far the biggest challenge in the power sector for Bangladesh and she will need her absolute professionalism in handling it.

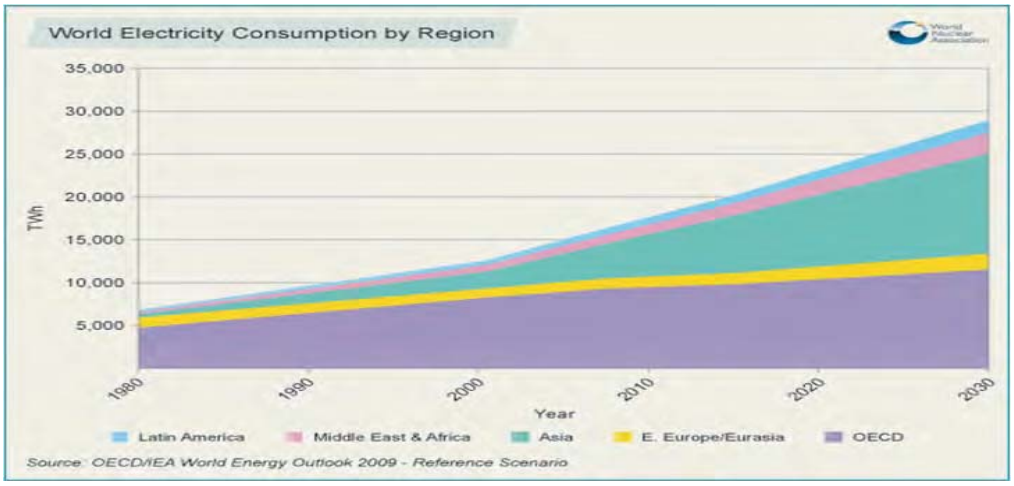
This paper, therefore, analyses the feasibility of nuclear power plant in Bangladesh to ensure long term energy security. In doing that, the paper will highlight the energy resources available in Bangladesh and their prospects in rendering long term energy security in Bangladesh. The paper will also analyse the nuclear power projects and its effect in some other countries as examples to draw lessons from. Last but not the least the paper will put forward some recommendations based on the critical analysis of the nuclear plant in Bangladesh.

NUCLEAR ENERGY IN GLOBAL PERSPECTIVE

Global Energy Scenario

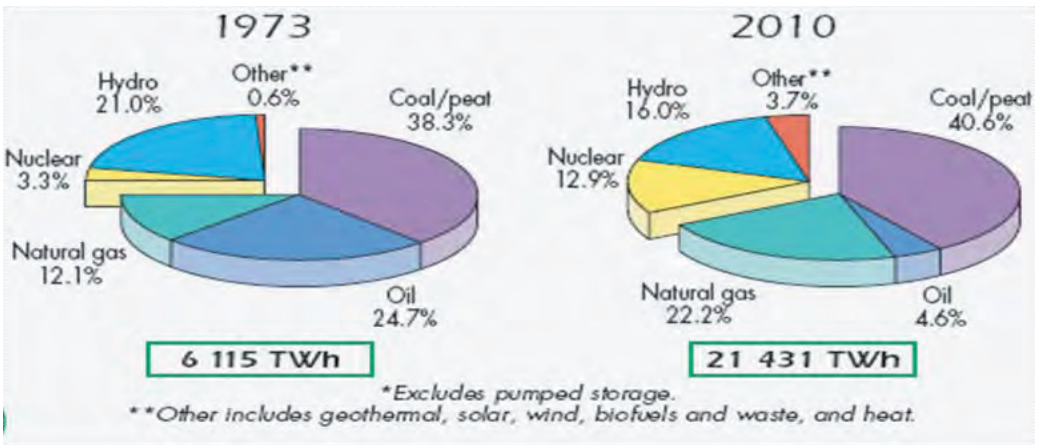
The United Nations predicts the world population growth from 6.6 billion in 2007 to 8.2 billion by 2030, with an ever increasing demand for energy substantially over that period. Both population growth and increasing standards of living for many people in developing countries will cause strong growth in energy demand. Over 70% of the increased energy demand is from developing countries, led by China and India.World Electricity consumption rate by region is given at **Figure 1**.

Figure 1: World Electricity Consumption by Region



Source: OECD/IEA World Energy Outlook 2009[5]

Figure 2: World Electricity Consumption Rate for Electricity Consumption



Source: IAEA, Energy Statistics Division

World energy consumption rate for electricity generation in 1973 and 2010 is given in **Figure 2**. What is noticeable in the statistics is that the consumption of oil has reduced over the years where as consumption of natural gas and nuclear has increased and consumptionof coal remains as the highest used energy resource.

5. OECD/IEA World Energy Outlook 2009, retrieved from World Nuclear Association (WNA) Website, http://world-nuclear.org/info/inf16.html, entered on 07 August 2012.
6. IEA, Energy Statistics Division, "Key World Energy Statistics 2012".

Global Scenario of Nuclear Energy

The global nuclear industry has evolved through three main stages. The first period, between 1954 and 1974 saw an upsurge of nuclear plans especially in the early 70s. The second period extends from the late 1970s to the mid-2000s, and is marked by a downturn in the 80s since the1979 Three Mile Island accident and the 1986 Chernobyl disaster. The third period extends from the mid-2000s until the beginning of 2011, and is commonly called the "nuclear renaissance". The global nuclear sector enjoyed an upward trend, largely because of rapid development in non-Organisation for Economic Cooperation and Development (OECD) countries (mainly China).

Despite the downturn of the second period, overall, these three periods saw a constant increase in nuclear production. However, the present revival of this upward trend of nuclear energy took a blow following the worst effects of the accident occurred at Japan's Fukushima NPP in 2011.

Fukushima NPP Accident in Japan and its Impact

Fukushima Accident. Japan's several nuclear power facilities including Fukushima Dai-ichi and Dai-niwere severely affected by a series of tsunami waves estimated to be over 14 m high. The Fukushima Dai-ichi facility was only designed to withstand tsunami waves of a maximum of 5.7 m high.[7]The tsunami meant that the emergency cooling system was flooded which caused continued lack of cooling resulting fuel meltdown and radioactive materials being released into the atmosphere.The International Atomic Energy Agency (IAEA) assessed the severity of the Fukushima accident as Level 7, based on the International Nuclear and Radiological Event Scale (INES).

Impact of Fukushima Accident. The Fukushima accident prompted an immediate review of the safety of nuclear energy in most countries with nuclear programmes.[8]However, the Fukushima accident has not so far led to a significant retraction in nuclear power programmes in countries outside Europe, except Japan itself. In Europe, changes in nuclear policies have only taken place in Germany, Switzerland, and Italy.[9]There are almost 50 countries that are operating, building, or simply considering nuclear generation as a viable solution for electricity generation. Half of them are "newcomers", including Bangladesh. These numbers suffice to indicate that nuclear power will continue to grow.

7. Mission Report, "IAEA International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP accident following the Great East Japan Earthquake and Tsunami", 24 May – 02 June 2011.
8. World Energy Council (WEC) report, "World Energy Perspective: Nuclear Energy one year after Fukushima", 2012.
9. Ibid.

AN OVERVIEW OF ENERGY AND POWER SUPPLY SCENARIO IN BANGLADESH

Energy Security and Bangladesh

The International Energy Agency (IEA) has described energy security as 'the uninterrupted physical availability at a price which is affordable, while respecting environment concerns'[10]. Long term energy security is mainly linked to timely investment to supply energy in line with economic developments and environmental needs. On the other hand short term energy security is basically the ability of the energy system to react promptly to sudden changes in supply and demand.[11]

At hindsight it can be said that Bangladesh has failed to attain short term energy security. It is, therefore, a long shot to attain long term energy security. To ensure guaranteed and uninterrupted supply of energy for next about 50 years, with the limited indigenous energy that it has, Bangladesh needs to plan and take necessary actions right from now.

Energy Consumption Pattern in Bangladesh

There are two distinct energy sectors in Bangladesh – the urban/industrial/ commercial sector and the rural/household/non-commercial sector each with different primary energy sources.[12] **Table 1** shows the share of primary energy consumption in Bangladesh.

Table 1: Share of Primary Energy Consumption

	1994	2008
Commercial	46%	68%[1]
Biomass	54%	32%

Source: Dr Mohammad Shawkat Akbar."[13]

10. Retrieved from *http://www.iea.org/subjectqueries/keyresult.asp?KEYWORD_ID=4103* on 05 June 2012.
11. Ibid.
12. Col AKM Nazrul Islam, "Bangladesh:Mitigating Energy Insecurity and Environmental Vulnerability," op cit,p-5.
13. Dr Mohammad Shawkat Akbar, "Energy sector development strategies in the context ofClimate change to face the challenges of the sustainableDevelopment", presentation given at National Seminar on Solar Energy – 2008, 24-25 March 2008.

The per capita availability of energy infrastructures and resources are very low in Bangladesh. Only 45% of the population has access to electricity and such access in the rural areas is only 25%.[14] The per capita electricity consumption in Bangladesh is 148.048 kWh which is the lowest among the South Asian countries.[15]

Present State of Supply and Demand of Power in Bangladesh

Though, the demand for power has been rising in Bangladesh almost by 10% every year, efforts of successive governments in the past for the development of this sector has been inadequate. As a result of that, the country today suffers from chronic deficit and unreliable supply of electricity which is the natural consequence of years of negligence.

Only 15% of the population have direct access to natural gas.[16] Diversification of energy supply sources is the starting point of energy security.[17]Bangladesh has a generation capacity of maximum 4,000 MW of power against a demand for 6,000 MW.[18]

Projected Growing Power Demand in Bangladesh

The demand in the country is increasing gradually. But the supply is not increasing in the same way. The existing power crisis and load shedding are interrupting the domestic life and severely affecting the national economy.

The future demand for energy is given in the **Table2.**

14. IjazHossain, "Present and Future of Bangladesh Energy Policy and possible areas of cooperation between Korea and Bangladesh", paper presented in the Roundtable on *Energy-Future of Korea-Bangladesh Energy and Power*, December 2009, p.4.
15. Retrieved from http://www.nationmaster.com/graph/ene_ele_percap-energy-electricity-consumption-per-capita accessed on 10 June 2012.
16. Dr Abdullah Al Faruque, "A Right Step for Energy Security", *The Daily Star*, Nov 28, 2011.
17. World Economic Forum, "The New Energy Security Paradigm", Spring 2006, p.5.
18. The New Age, 06 April 2010, p 15.

Table 2: Future Energy Demand (in MTOE)						
Energy Sources	2000	2010	2020	2030	2040	2050
Natural Gas	7.7	14.2	22.9	33.6	45.6	57.1
Oil	3.2	5.9	8.9	12.1	15.4	20.1
Coal	0.3	0.6	1.3	3.0	4.7	5.1
Renewable	0.1	0.2	0.5	0.7	1.3	1.7
Total	11.3	20.9	33.6	49.4	67.	84.0
Source: Razia Sultana,Quest for Energy Security in Bangladesh: Challenges and Prospects.[19]						

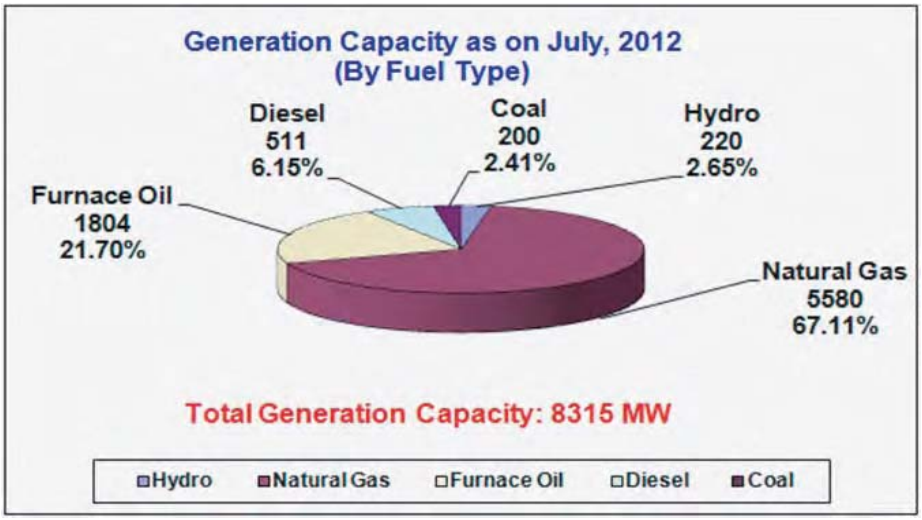
Present Energy Scenario of Bangladesh

21. **Natural Gas Scenario**. Natural gas is the principle energy resource of Bangladesh. Approximately, (4-5)% households of the country have natural gas supply.[20]

a. Present Utilization of Gas is to meet Power Needs. Over 80% of Bangladesh's power plants are now running by natural gas and the remaining 20% by hydro, coal and liquid fuel. Currently, per day about 2000 million cubic feet (mmcf) of gas is produced in the country against a demand of 2500 mmcf.[21] Present use of Gas vis-a-vis other energy resources for electricity production is given at Figure 3.

19. Razia Sultana, *Quest for Energy Security in Bangladesh: Challenges and Prospects*, BIISS Journal, Vol 29, No 1, January 2008.
20. IjazHossain, op cit.
21. PetrobanglaAnnual Report, 2009.

Figure-3: Present use of Energy for Power Generation



Source: Bangladesh Power Development Board (BPDB[22])

b. The gas initially in place (GIIP) has been estimated as 28.856 trillion cubic feet (tcf) out of which estimated proven recoverable reserve is estimated at 20.605tcf. Up to December 2011, as much as 10.132tcfgas has been produced, leaving only 10.473tcf of recoverable gas as on January 2012.[23]So the remaining possible reserve is likely to be 7.69tcf which is expected to last up to 2019.[24]

Coal Scenario.

a. **Present Utilization of Coal to meet Power Needs**. At present there is one underground coal mine in Barapukuria in operation with a production capacity of 1MT/per year[25]. This mine is being used to fuel the 250-MW Coal-Fired Power Plant at Barapukuria in Parbotipur since January 2006. At present it is continuing with actual production of only 0.5 MT per year which is half of its designed capacity.[26]

22. Retrieved from website *https://energypedia.info/index.php/Bangladesh_Country_Situation*.accessed on 16 August 2012.
23. Prof M Nurul Islam, "Energy Resources and Governance Issues: Bangladesh Perspective", presentation given at the National Seminar organized by the department of Chemical Engineering and the chemical Engineering Alumni Association at BUET, 06 April 2012.
24. Professor M Nurul Islam, "Energy Resources & Governance Issues: Bangladesh Perspective", presentation given to 52nd Senior Staff Course at BPATC on 25 February, 2010.
25. Professor M Nurul Islam,"Energy Resources & Governance Issues: Bangladesh Perspective", 25 February 2010.
26. Professor M Nurul Islam,"Energy Resources & Governance Issues: Bangladesh Perspective", 06 April 2012.

b. **How Long the available Coal is likely to last**. Bangladesh has around 12 identified coal basins and 5 depositors[27]. According to expert estimate total extractable coal from the discovered coal fields may vary 234 MT (Underground mining method) to 660 MT (Open cut and underground mining method) which are insufficient to meet requirement up to 2030.[28]

c. **Possibilities/Difficulties of exploring the Coal Mines**. Coal extraction is one of the most difficult, controversial and environmentally hazardous issues of Bangladesh. The price for open pit mining may be too heavy and it may not be plausible for the Government to embark on that till it can satisfy its people about its harmlessness through some test and trial mining in lower scale.

Renewable Energy Scenario. Hydropower, solar energy, wind turbines and bio-mass are the available Renewable Energy resources of Bangladesh. The clean and renewable energy technologies are yet to be developed for large scale commercial applications as the investment cost in it is generally higher as compared to fossil fuel alternatives.

Petroleum Products. Bangladesh has insignificant domestic production of petroleum products. Petroleum products constitute approximately 23% of the commercial energy used in the country.[29] The transport sector accounts for about 50% of the consumption of oil and irrigation makes about 16%. Dependence on imported oil for energy makes the country vulnerable to increases in oil price.

FEASIBILITY OF NUCLEAR POWER PLANT IN BANGLADESH

History of Bangladesh's Nuclear Power

Nuclear power in Bangladesh may be termed as a story of missed opportunities. Not long after the first nuclear power station was built in UK, the then government started feasibility studies for possible nuclear power in Bangladesh in 1961. The IAEA supported such a possibility in 1962 and a site measuring 262 acres of land in Rooppur were acquired. After liberation, Bangladesh government decided to go for a 125 MW French power reactor with

27. "Asia sustainable and alternative energy program, Hydroelectricity potential, A world Bank study report", retrieved from *http://web.worldbank.org,* accessed on 06 July 2012.
28. Professor M Nurul Islam,"Energy Resources & Governance Issues: Bangladesh Perspective", 06 April 2012.
29. NazmulAhsanKalimullah et al., "Bangladesh-India Energy Security Cooperation: Prospects and Challenges", *BIISS journal*, Vol 31, No.3, July 2010.

a Japanese turbo-generator[30]. Although the project was approved by Executive Committee of National Economic Council (ECNEC) in 1980 at a cost of Taka 603 crore, it could not be taken up for want of necessary funds. Instead, a 3 MW research reactor was set up in Atomic Energy Research Establishment (AERE) at Savar.[31]

More recently, in 2001 Bangladesh adopted a national Nuclear Power Action Plan (BANPAP). On 24 June 2007, Bangladesh's government announced it will build a nuclear power plant to meet electricity shortages.

Existing Infrastructure and Current Use

Existing infrastructure. Nuclear research in the country actually began back in 1965 with the establishment of Atomic Energy Centre at Dhaka. After the independence, Bangladesh Atomic Energy Commission (BAEC) was formed in Dhaka in February 1973 as an autonomous organization with a view to undertaking the research and development programmes for peaceful use of nuclear energy[32]. Some of its important establishments are:

a. Atomic Energy Centre, Dhaka (AECD).

b. AERE, Savar.

c. Nuclear Medical institute (NMI).

d. Institute of Nuclear Agriculture (INA).

e. Rooppur Nuclear Power Project (RNPP).

l. Institute of Nuclear Medicine at Bangabandhu Sheikh Mujib Medical University

Current use. Though Bangladesh could not set up a nuclear reactor for generation of power but in the field of nuclear science and research a significant progress took place over the years. Some of these important uses are stated below[33]:

a. Medicine and medical treatment.

b. Food Preservation.

30. Dr Anwar Hossain, Chairman Bangladesh Atomic Energy Commission, "Nuclear power for Bangladesh", *The Daily Star*, July 28, 2006.
31. Ibid.
32. Retrieved from Bangladesh Atomic Energy Commission website, *www.baec.gov.org*, accessed on 04 August 2012.
33. Ibid.

c. Isotope Application in Industry and Hydrology.

d. Tissue Banking.

e. Health Physics and Radiation Control.

Nuclear Energy Development Plan

The present and past Governments have recognized over the years that Bangladesh needs nuclear energy for its long term energy security. In the Draft National Energy Policy (NEP) 2006, Nuclear energy was identified as a component of energy mix. The Revised Draft NEP of Bangladesh (2008) has outlined the nuclear power program as given in Table 3 below:

Table 3: Government Plan of Nuclear Power Plant

PERIOD	PLAN ON NPP
By 2015 and 2017	Implementation of 2 units of medium sized (~600 MW) NPP
By 2025	Addition of more 2 units each of 1000 MW to ensure 10% of total generation from NPP
Beyond 2025	Nuclear share should be 15 - 20% in overall generation mix
Reference: Draft National Energy Policy of Bangladesh, 2008.[34]	

The present Government of Bangladesh, on assuming power, laid out its "Vision 2021: Energy Security and Electricity for all by 2021". The salient aspects of the Vision 2021 are:

a. Making electricity available for all by 2021.
b. Ensuring reliable and quality supply of electricity.
c. Providing electricity at a reasonable and affordable price.
d. Addition of 20,000 MW of generating capacity by 2021 as follows:
   (1) By the year 2013: 7,000 MW.
   (2) By the year 2015: 8,000 MW.
   (3) By the year 2021: 20,000 MW.

34. Draft NEP, 2008, cited in Dr Mohammad Shawkat Akbar, "A holistic approach for establishing Nuclear power infrastructure inBangladesh", a presentation given on *Topical Issues on Infrastructure Development: Management and Evaluation of a National Infrastructure*, 8 – 11 February 2011, Vienna, Austria.

Bangladesh's Preparation For Nuclear Plant

Endorsement of IAEA. Bangladesh requested the IAEA for cooperation regarding the development of nuclear power infrastructure for implementation of Rooppur Nuclear Power Project (RNPP) during 51st IAEA GC (17-21 Sep 2007) at Vienna, Austria. A three member IAEA Mission for Bangladesh formed of Agency staff and international experts conducted their mission from17 – 21 November, 2008 with the aim for "A holistic approach for the establishing nuclear infrastructure in Bangladesh".

Recommendations of IAEA Mission. The IAEA Mission recommended that a 'road map' to establish a nuclear power infrastructure should be developed. This road map should include the following:

a. The ratification of the remaining international instruments; Civil liability, Joint Convention.

b. The finalization of the Nuclear Law and derived regulations.

c. Completion of site safety report.

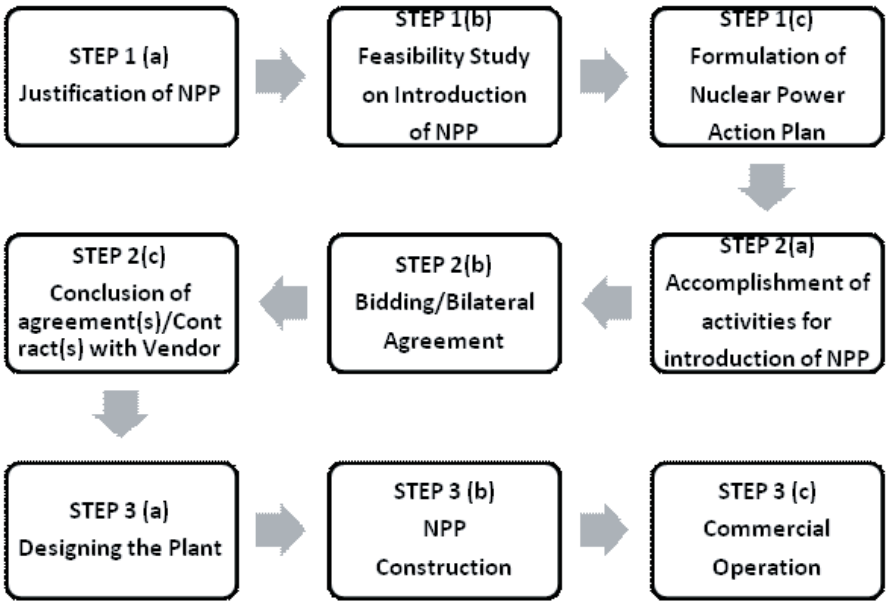
d. Communication with the International community and the completion of the national energy plan.

e. The decision on recruitment and the development of human resources for the operation of RNPP, regulatory body and technical supports organization.

f. The finalization of a funding and financing strategy.

Bangladesh's Roadmap for RNPP. A road map to implement RNPP has been formulated in line with the IAEA Mission's Recommendations.The stepwise implementation process of the Road map is given at **Figure 4**. It is to be mentioned here that Step 1 is completed, Step 2 is ongoing and Step 3 is in the planning stage.

Figure 4: Stepwise Implementation Approach For RNPP



Source: Author

The Feasibility of the Site

The RNPP Site is located at Rooppur, Ishwardi,160 Km North East from the Capital City Dhaka. The site area is about 260 acres. The land area of the Project Site is large enough for accommodation of two or more reactor power units. The communication network through roads, railway and waterway is excellent. The Site is located by the Padma River that ensures water use for transporting materials and disposal of hazardous waste.A combination of river water and cooling tower could be considered as for the cooling system. RNPP is located almost in the center of the western zone of National Power Grid and is just about 5 km from Ishwardi sub-station. This will facilitate RNPP to feed into the Ishwardi Sub-station which is very important for a NPP site.

A recent IAEA mission from July 2011 confirmed that on site selection and survey activities conducted are in accordance with IAEA applicable requirements. Based on the recent financial agreement a Russian funded technical feasibility study will soon be started on as many as 62 aspects including geo-technical, geo-morphological, hydrological and river morphology aspects.

Challenges and Prospects

Economic Feasibility- A Cost – Return Assessment. The first and foremost challenge that a country comprehends about establishing a NPP is the cost. Definitely, the initial establishment cost is very huge for any country, especially a third world poor country like Bangladesh. But the matter of fact is that nuclear power is very much cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels. For instance, in Spain the nuclear electricity cost was reduced by 29% over 1995-2001.[35]The quantities of uranium needed are very much less than for coal or oil. The comparative costs of power generation from different types of energy in different developed countries in the world are given at **Table 4**.

Table-4: World-wide Electricity Generation Cost Projection for the Year 2010

Ser	Country	Nuclear	Coal	Gas
1	France	2.54	3.33	3.92
2	Germany	2.86	3.52	4.90
3	Czech Rep	2.30	2.94	4.97
4	Slovakia	3.13	4.78	5.59
5	Japan	4.80	4.95	5.21
6	Korea	2.34	2.16	4.65
7	USA	3.01	2.71	4.67
8	Canada	2.60	3.11	4.00

Source: The Economics of Nuclear Power

35. "The Economics of Nuclear Power", retrieved from *www.wikipedia.org, accessed on 16 August 2012.*

Based on the basic agreements, a financial deal has been signed between Russia and Bangladesh on 13 August 2012. Under the deal Bangladesh would borrow $500 million for the technical study with an interest rate of not less than 4 per cent from Russia.[36] It takes about $1.5 billion to $2 billion to set up 1000-megawatt (MW) power plant depending on security features and technology standards. Bangladesh is planning for Government ownership based on equity and debt funding. Government own source/funding for local Currency requirement to be 15% mainly from the state credit and Debt funding for Foreign Currency to be 85% as loan on soft terms from the vendor source(s). However, a comprehensive financing and funding strategy for the evaluated costs should be revised and updated before Bangladesh makes the final financial agreement with Russia**.**

Management of RNPP. The management of a NPP is important as it is challenging for a country like Bangladesh. In 2010, Bangladesh government formed a Cabinet Committee Headed by the Honourable Prime Minister. A Technical Committee headed by the Honourable Minister of the State, Ministry of Science and Technology (MoST) was also formed.[37]Bangladesh Atomic Energy Regulatory (BAER) Act-2012 has been enacted on 31May 2012 and passed in the Parliament on 01 June 2012.[38] This law calls for an independent regulatory body to handle all matters related to RNPP. This Independent Regulatory Body has not yet been formed. IAEA defines it as Nuclear Energy Programme Implementation Organisation (NEPIO).[39]So the biggest challenge is forming all the legal bodies required to be formed with qualified personnel. It is also very important that all the different committees work with efficiency and their works are coordinated by the regulatory body. The government has to take necessary actions in this regard.

Safety vis-à-vis Risk Factors. Possibility of the potential hazard of both nuclear criticality and release of radioactive materials from generating electricity with nuclear power is one of the major causes of concern for any country having or planning to have NPP. However, in over 14,500 cumulative reactor-years of commercial operation in 32 countries, there have been only three major accidents to nuclear power plants - Three Mile Island, Chernobyl, and Fukushima.The

36. "Bangladesh-Russia nuclear power plant deal finalized", *Energy Bangla,* 13 August 2012, retrieved from website http://energybangla.com/201=82/08/13/2275.html#.UC03bKA_m9s, accessed on 15 August 2012.
37. Dr Mohammad Shawkat Akbar, "Experience Of INIR Mission For Phase 1 And Phase 2", Presentation given at Workshop on *Topical Issues on Infrastructure Development – Managing the Development of National Infrastructure for Nuclear Power Plants,* 24 – 27 January 2012, Vienna, Austria.
38. Daily ManabJamin, 01 June 2012.
39. "Responsibilities andCapabilitiesofA nuclear energy programmeImplementing organization", *IAEA Nuclear Energy Series* No. NG-T-3.6, Vienna 2009.

cumulative reactor years vis-a-vis nuclear accidents is given at Figure 5. It should be emphasised that a commercial-type power reactor simply cannot under any circumstances explode like a nuclear bomb - the fuel is not enriched beyond about 5%.

Figure 5: Cumulative Reactor Years vis-à-vis Nuclear Accidents

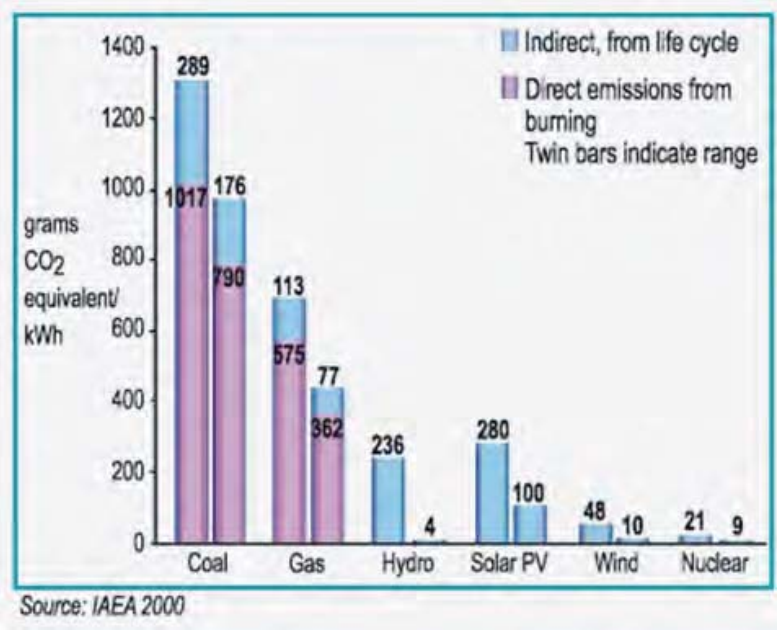
Source: Website, http://www.world-nuclear.org/

Sergey V Kirienko, director general of ROSATOM said, "We will build the plant with a new design in which five new safety measures have been included."[40]Bangladesh has signed a bilateral agreement with the Russian Nuclear Regulatory Body on 27 February 2012 for cooperation in establishing nuclear safety regulation and training and technical support. BAEC has created a separate Division, "Nuclear Safeguard and Security Division". However, a Radiation Protection Program is necessary which is still in process. Nuclear Power Plants and associated facilities are considered as the very Special Type of establishment namely KPI – A1 in the security system of the Government (highest level of security).[41]The security of such a strategic Key Point Installation (KPI) demands a separate security arrangement to ensure its security.[42]A separate study should be conducted to decide on the physical security of the installation by the Armed Forces.

40. Staff Reporter, "Nuclear Plant Agreement signed with Russia", *bdnews24.com*, Nov 02, 2011.
41. K M RezaurRahman, "Bangladesh Experience in Self-Evaluation of Nuclear Infrastructure", a presentation given on *Technical Meeting on Evaluation Methodology of the Status of National Nuclear Infrastructure Development and Integrated Nuclear Infrastructure Review (INIR)*, 18 - 20 June 2012, Vienna, Austria.
42. Consultation with Dr Mohammad Shawkat Akbar, Director Nuclear Power and Energy Division, BAEC on 06 September 2012.

Environmental Aspect of Nuclear Energy. Nuclear power plant does not emit any green house gases under normal operation. Environmental effect on different types of energy is shown at **Figure 6**. Recently, the nuclear industry is hoping that concern over climate change will result in support for nuclear power. In Bangladesh, there is no Environmental Impact Assessment (EIA)yet.The EIA is being prepared by the Bureau of Research, Testing and Consultation, BUET on behalf of BAEC. The EIA, on preparation, will be submitted to the Ministry of Environment (MoE) for the clearance process.

Figure 6: Environmental effect of different types of Energy



Nuclear Fuel Cycle (NFC) and Management of Nuclear Waste. Management of nuclear fuel is a challenge for running a NPP. Bangladesh has no intentions to develop any enrichment or reprocessing capacities. Guarantee for life-time fuel supply for RNPP and Spent Fuel (SF) take-back are required from the vendor. The Inter-governmental agreement with Russia has been done accordingly. According to the agreements, Russia will take away all the nuclear wastes from the plants from Bangladesh safely. In Bangladesh,interim storage for waste from research reactor already exists at the AERE, Savar. BAEC shall also operate and manage Central Waste Processing and Storage facility (CWPSF) that will be established on-site or close to the RNPP. NFC However, NFC Policy and RW Policy have not been finalized yet in Bangladesh.A comprehensive policy and strategy document on RWM and SF management should be drafted by BAEC.

Human Resource Development (HRD). HRD specific to nuclear power plant will be a great challenge for Bangladesh.[43] Based on a review of operating plants in Hungary and Russia and considering guidance of IAEA,BAEC has identified total 1635 personnel for the RNPP (2xunit) to perform different work functions and 75 personnel have been identified for the Project Management Team.[44] Government has taken initiatives to strengthen infrastructure for education and research in nuclear science and technology. The agreement signed between Russia and Bangladesh on 04 June 2012 on HRD outlines the development of human resources in nuclear power sector in Bangladesh, covering different tiers of managerial, technical and operational personnel, and eventually developing broad-based academic and training capabilities in Bangladesh.[45]However, though appreciable the steps taken so far are not adequate. Hence, a comprehensive HRD plan should be developed for the long term sustenance of the RNPP.

Public Information and Public Acceptance. Public acceptance of nuclear power is one of the most important factors for which intensive public information campaign should be launched. According to the agreement signed between Russia and Bangladesh on 04 June 2012, the Russian Government will establish an Information Centre on Nuclear Energy aimed at generating awareness among people, especially the younger generation, on various aspects of nuclear energy and nuclear power plants, including functioning, maintenance and safety measures in the nuclear plants. An interagency plan for public information involving the Government, future owner-operator and regulatory body should be developed.

Electric Grid Infrastructure. Incorporation of the RNPP into the National Grid system is a big challenge. The RNPP is planned to be fed into the Ishwardi Sub-station where the high voltage 230 KV East-West inter-connector, Khulna–Ishwardi; Ishwardi-Baghabari-Sirajgang-BograTransmission lines tie in. In addition, construction of Ishwardi - Rajshahi transmission line is under consideration. Current grid capacity of 8 GW is not sufficient to introduce two new 1000 MWe units. A detailed analysis for mid-term and long-term expansion of the electrical power system was carried out by Power Grid Company of Bangladesh (PGCB) and Japan International Cooperation Agency (JICA) in 2010.A separate arrangement will have to be made between BPDB and PGCBwith vendor source to carryout necessary study and modification/adaptation/improvements of the associated sub-station and grid system to incorporate the RNPP.[46]

43. Interview with Professor M. Nurul Islam, Institute of Appropriate Technology, BUET, 01 September 2012.
44. Dr Mohammad Shawkat Akbar, "Experience of INIR Mission For Phase 1 And Phase 2".
45. "Bangladesh, Russia further cooperation on nuclear power development", *Asian Power,* 04 June 2012.
46. Uddipan Das, "Overview of Nuclear Power Programme in Bangladesh", a presentation given at The IAEA Nuclear Energy Management School in Japan on 11-29 June 2012, Tokai-Mura. Japan.

RECOMMENDATIONS

After analysing the need and feasibility of the use of nuclear power in Bangladesh, following recommendations are made**:**

a. Based on the Bangladesh Atomic Energy Regulatory Bill-2012, an independent Regulatory body should be established immediately.

b. A comprehensive financing and funding strategy for the evaluated costs should be revised and updated.

c. BAEC should develop a comprehensive Radiation Protection Program. For safety, a separate study should be conducted to determine the forces required for the security and protection of RNPP.

d. For environmental aspects, the EIA should be formulated as soon as possible and get approved from the MoE.

e. NFC Policy document should be finalized by BAEC which should specify the RW management, supply of fuel and disposal of SF.

f. A comprehensive HRD plan should be developed for the long term sustenance of the RNPP.

h. An inter-agency plan for public information involving the Government, future owner-operator and regulatory body should be developed.

j. Necessary study and modification/adaptation/ improvements of the associated substation and grid system should be carried out to incorporate the RNPP by 2017 and 2018.

CONCLUSION

Energy consumption worldwide is likely to double between 2000 and 2050 and nuclear energy will remain a key element in future low-carbon energy systems. In respect of Bangladesh, energy consumption is very low compared to other nations. Only 35% people are under power supply coverage. The power sector is hardly capable of meeting its energy requirement with existing infrastructure. Bangladesh depends on natural gas, liquid fuel and hydro power for generation of electricity. According to the projections of Petrobangla, with the present rate of consumption, the reserve of natural gas (10.4 TCF) will be exhausted by 2021. Off late limited use of coal has taken place. There is great humane, environmental, ecological and political challenge for open pit mining. Prospect of hydroelectric

and other renewable energy projects are also not substantial enough. This limits us to go for nuclear energy.

Introducing NPP is a challenge for any country, especially for a third world country like Bangladesh. The main problems of establishing nuclear power reactor are high cost, skilled manpower, assured supply of raw materials, waste disposal and risk of accident. The initial cost of establishing a nuclear power generating unit is very high. But over the time the cost can be recovered as it involves less operating cost. The difficulties related to skilled manpower, supply of raw material and waste disposal can be overcome by engaging into long term agreement with the manufacturer for training of manpower, long term supply of raw materials and management of waste. A project to establish a nuclear power plant at Rooppur was taken long before. Now it is time we must be bold and decisive to implement it. Bangladesh aspires to become a middle income country by 2021. For that, the main factor is energy security,attaining which is not possible with the available energy resources in the country. Therefore, considering all the feasibilities, Bangladesh should pursue to attain the nuclear power capability as planned and take Bangladesh to a new height of progress and development.

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