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Holistic Technological Guideline of Nuclear Power Plant Inception of Bangladesh and Developing Countries

By Khizir Mahmud, Sayidul Morsalin & Md. Shamsul Alam

Chittagong University of Engineering & Technology, Bangladesh

Abstract - Energy performs a cardinal role in strategies of preferment for the developing countries. Traditional energy source reliance is a prima challenge for ameliorating the performance of their energy suppliers to benefit energy consumers. Hydrocarbons are already used a great deal as an energy source and they also harshly criticized because oil and gas are expensive. Consequently some developing countries are trying to cope up the challenge by considering the nuclear energy in their power production. Nuclear energy is the only non-greenhouse gas-emitting reliable and safe base load power source that can effectively replace fossil fuels and satisfy growing demands for energy. The average cost of producing nuclear energy comparing with coal and gas is quite low but sometimes takes cumbersome steps to establish the nuclear power plant. So this paper emphasizes on the supersede of conventional energy with nuclear power and the roadmap for the developing countries like Bangladesh to establish the nuclear power plant.

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Holistic Technological Guideline of Nuclear Power Plant Inception of Bangladesh and Developing Countries

Khizir Mahmud ^α, Sayidul Morsalin ^σ & Md. Shamsul Alam ^ρ

Abstract - Energy performs a cardinal role in strategies of preferment for the developing countries. Traditional energy source reliance is a prima challenge for ameliorating the performance of their energy suppliers to benefit energy consumers. Hydrocarbons are already used a great deal as an energy source and they also harshly criticized because oil and gas are expensive. Consequently some developing countries are trying to cope up the challenge by considering the nuclear energy in their power production. Nuclear energy is the only non-greenhouse gas-emitting reliable and safe base load power source that can effectively replace fossil fuels and satisfy growing demands for energy. The average cost of producing nuclear energy comparing with coal and gas is quite low but sometimes takes cumbersome steps to establish the nuclear power plant. So this paper emphasizes on the supersede of conventional energy with nuclear power and the roadmap for the developing countries like Bangladesh to establish the nuclear power plant.

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1. INTRODUCTION

Developing countries face major challenges for ameliorating the performance of their energy suppliers to benefit the energy consumers. The energy challenges affect developing differently according to their income levels and they impact income groups differently within these countries. These challenges have social, economic, financial, institutional and environmental dimensions. Besides, the least developed countries across the world face low and stagnant growth in access to modern fuels and electricity as the population has grown faster than energy supply. Accordingly present per capita availability of electricity in Bangladesh (as an example)

is 236 kWh (including captive), which is the lowest among the developing countries [10]. The majority of all primary energy comes from traditional fuels and biomass and typically less than 10 percent of the population in the least developed countries is electrified, mostly limited to urban areas [1]. Some developing countries are trying to meet the energy challenges considering the nuclear power as the replace of traditional power production. Nuclear power plants are a practical option for producing clean, cost-effective, reliable and safe base load power. Nuclear power plants typically have high capital costs, but low direct fuel costs (with much of the costs of fuel extraction, processing, use and long term storage externalized). The fuel used by nuclear plants is very efficient and hence very less amount of fuel is required. Therefore, comparison with other power generation methods in a nuclear power plant the expenses incurred in course of power generation in a nuclear power plant are very reasonable. The average cost of producing nuclear energy in the United States is less than two cents per kilowatt-hour which is cheap comparable with other sources [2]. Recycling spent fuel, which still contains 95 percent of its original energy, will greatly reduce the need for treatment and disposal [2]. There is a thought goes that Nuclear weapons are closely related to nuclear power plant. But it is no longer inextricably linked to nuclear power plants. Centrifuge technology now allows nations to produce weapons-grade plutonium without first constructing a nuclear reactor. Moreover, the latest reprocessing technology doesn't split the plutonium from the uranium. This technology has made the nuclear weapon manufacturing much more complex and sophisticated by using the civilian nuclear materials. So the combination of nuclear energy, wind, geothermal and hydro is the most environmentally-friendly way to meet the world's increasing energy needs. To fulfill this goal especially for the developing countries firstly a schematic overview of the road map of nuclear power plant is presented in this paper. In the latter part, the site selection criterions of a nuclear power plant especially for Bangladesh as well as the developing countries like this have been mentioned. Finally some feasible expenditure has been calculated to establish a new nuclear power plant in Bangladesh.

Author α : Department of Electrical Engineering, Northwestern Polytechnical University, Xi'an-710072, China. E-mail : khizirbd@gmail.com

Author σ : Department of Electrical & Electronic Engineering, Chittagong University of Engineering & Technology (CUET), Chittagong- 4349, Bangladesh. E-mail : morsalinbd@yahoo.com

Author ρ : Department of Electrical & Electronic Engineering, Chittagong University of Engineering & Technology, Chittagong-4349, Bangladesh. E-mail : samrat.ieee@yahoo.com

II. CONSTRUCTIONAL OVERVIEW OF A NUCLEAR POWER PLANT

It is very essential now to speed up the scrutiny of smart clean energy technologies to cope up the global challenges of climate change and energy supply security for sustainable development. Alike the developed country developing country should make energy technology roadmaps covering demand-side and supply-side technologies. The roadmaps will enable governments and industrial and financial partners to identify steps needed and implement measures to

accelerate the required technology development and uptake. This process starts with providing a clear definition of the elements needed for each roadmap. A dynamic set of technical, policy, legal, financial, market and organizational requirements identified by the stakeholders involved in its development. Each roadmap has major barriers, opportunities and measures for policy makers and industrial and financial partners to accelerate RDD&D efforts for specific clean technologies on both the national and international level.

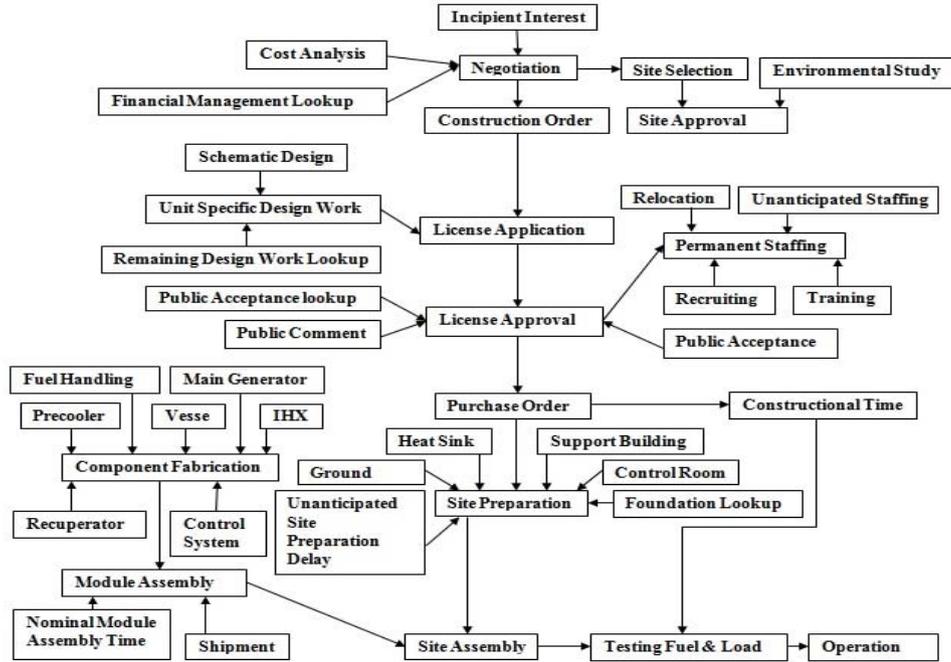


Figure 1 : A constructional overview of a nuclear power plant of developing countries

III. SITE SELECTION FOR NUCLEAR POWER PLANT: BANGLADESH PERSPECTIVE

An important stage in the development of a nuclear power project is the selection of a suitable site to establish the site-related design inputs for Nuclear Power Plant (NPP) [3]. For securing an optimum cost and natural and human safety site selection is a cardinal consideration. A proper selection process ensures the protection of internal employee and the local people living nearby the plant from the normal operational effect as well as from any kind of hazard. A lot of factors should consider during the site selection and installation process. Some common and cardinal safety point of view are depicted below.

- It should not be affected by the phenomena against which protection through the design is not practicable;
- The feasibility of occurrence and the intensity of pernicious phenomena against which the plant can

- be protected at an optimum additional cost which is not too high; and
- The site characteristics (population distribution, meteorology, hydrology, etc) are such that the consequences of potential accident would be at acceptable limits.

Bangladesh is situated in north-eastern part of south Asia and located between 20.30 to 26.38° North latitude and 88.04 to 92.44° East [4]. It is crisscrossed by hundreds rivers and the Bay of Bengal is situated in the southern part of the country. Bangladesh is a natural disaster prone zone like flood, storm and earthquake. So the countries like Bangladesh should consider these sorts of natural disaster in selecting the nuclear power plant location. The countries like Bangladesh should consider whether they are geologically and seismically safe, less prone to natural disaster, Low population density and comparatively close to the load center.

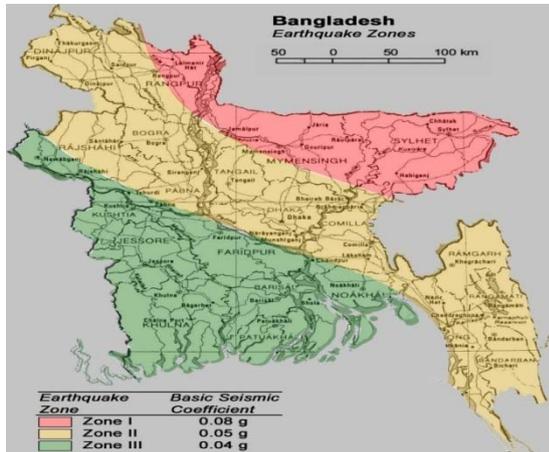


Figure 2 : Earthquake zone consideration for Nuclear power plant site selection in Bangladesh [5]

Table 1 : Seismic zone and its area of Bangladesh [14]

Zoning	Area
I	North and eastern regions of Bangladesh (Seismically relatively quiet)
II	Lalmai, Barind, Madhupur Tracts, Dhaka, Comilla, Noakhali and western part of Chittagong Folded belt.
III	Khulna division S-E Bangladesh (Seismically most active)

Bangladesh is one of the top flood affected countries in the world. Basically it is a plain land. Moreover, it consist of hundred of rivers which is originated from Himalayan that's why when suddenly they carry spring snow melt from that Himalayan mountain then the plain land of Bangladesh goes under water and affected by the flood. Some fifth of some rivers as well as the areas besides the major rivers is the flood prone zones. So these zones should consider in the nuclear power plant site selection.

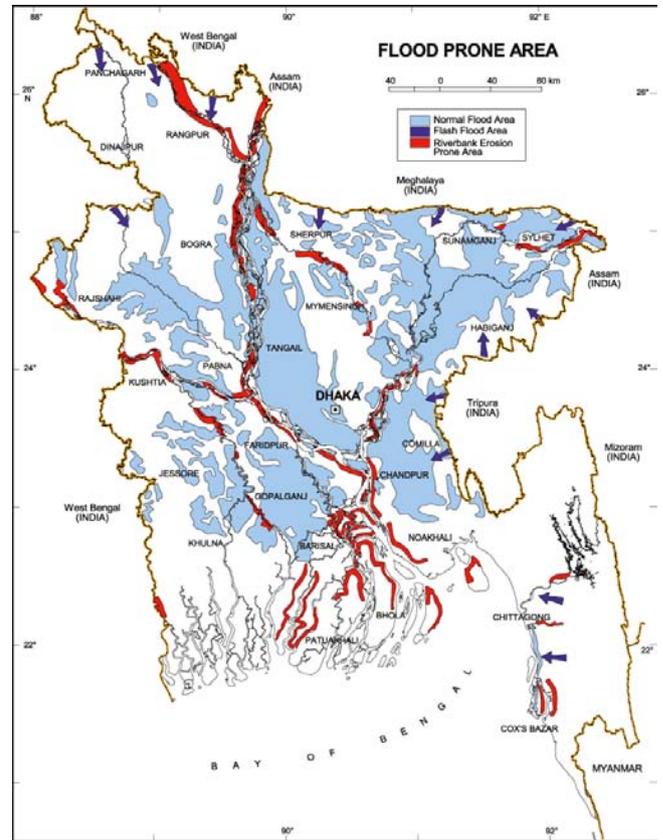


Figure 3 : Flood prone zone consideration for nuclear power plant site selection in Bangladesh [6]

The coastal districts of Bangladesh, particularly those flanking the Meghna estuary are susceptible to serious damage from cyclones which cause major losses of life and property. In the month of April and May when summer starts and in the month of September and October when the local monsoon period going to be end then the feasibility of occurring storm is higher. The storm create a high speed wind with an average speed of 100-150 miles per hour which lifts the water to a so high position which sometimes give a more peak like 20. This gigantic storm sometimes perishes everything in the coastal area and also offshore islands. There was a statistics of human injury by strom which shows that more than one million people have been killed since 18th century. There were three devastating storms occurring in 1737, 1876 and 1970 which killed 815000. Severe storms also occurred in May 1985 and April 1991. SO this thing should take into consideration to select the nuclear power plant site [7].

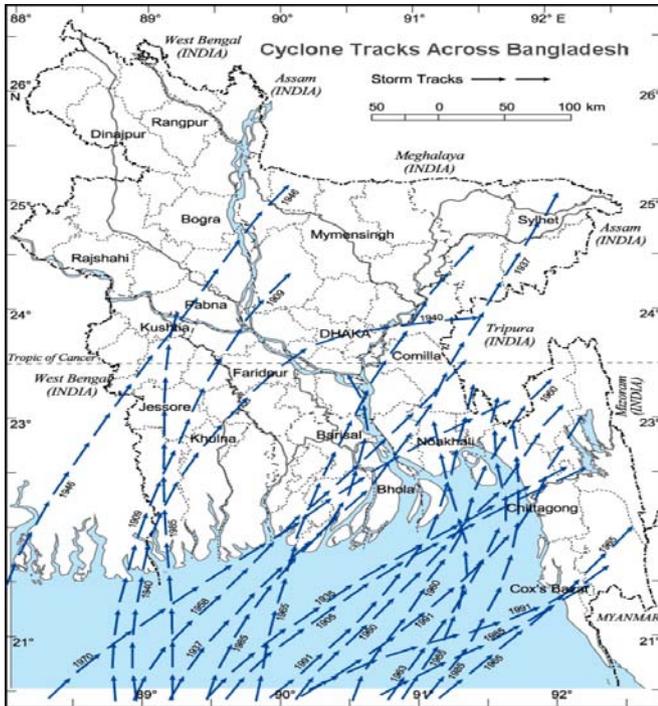


Figure 4 : Typical cyclone track consideration for Nuclear power plant site selection in Bangladesh [8]

IV. RECOMMENDED SITE FOR NUCLEAR POWER PLANT OF BANGLADESH

For the installation of nuclear power plant in Bangladesh the areas containing seismic zone-1 especially districts like Pabna, Rajbari, Natore, Faridpur may be suited under the given criteria. And for the establishment of the waste management treatment plant after 60 years or more of installation of the power plant, districts like Rangpur, Nilphamari, Dinajpur can be taken into the consideration. But considering the seismic zone, zoographical situation for low cost in waste management and others criterion the Rooppur in Pabna is the best place for nuclear power plant establishment. The place is situated within seismic zone-1, less prone to be affected by the flood, Low probability of being affected by cyclone storms, comparatively close to the load center, Low population density.

V. PRESENT STATUS OF NUCLEAR POWER PLANT OF BANGLADESH

In 2009 Bangladesh produced total 38 billion kWh from 6.1 GWe of plant which has a per capita consumption 250 kWh/yr [9]. Nation's 67.11% of electricity comes from natural gas [10]. So the production cost rises. Moreover, electricity demand is increasing so rapidly, sometimes need peak demand 7.5 GWe. The government has a roadmap to generate the electricity at least 7 GWe by the year 2014. Some HVDC to import from India is under construction which has an amount of 250 MWe. A new 2 GWe small coal

based power plant are under consideration by the year 2016 [11]. But still around half of the population of Bangladesh is out of electricity and rest half have to face low voltage, fluctuation and frequent power cut. In this circumstances Bangladesh shows its desire to inaugurate a nuclear power plant to resolve the power shortage. Actually very earlier in 1961 a nuclear power plant was proposed to establish. Then in the 200 km north side from the capital of Bangladesh a place named Rooppur was selected for nuclear power plant [12]. Since then lots of scrutiny had launched to figure out the actual technical and economical feasibility of inauguration. The Govt took formal initiative for inauguration and after independent in 1980 a 125 MWe nuclear power plant was approved. Bu that time it didn't built. But the countries energy demand increase more rapidly and finally in 1999 the Govt express firm commitment to start processing again to build a power plant. In 2001 it fixed its national nuclear power action plan and in 2005 Bangladesh signed a nuclear cooperation agreement with china. After that in the year of 2007 bangladesh atomic energy commission proposed two 500 MWe nuclear reactor by the cost 1.5-2.0 USD to implement within 2015 and another one of 1000 MWe [9]. International Atomic Energy Agency (IAEA) approved a Technical Assistance Project for Rooppur Nuclear Power Plant to be initiated between 2009 and 2011 [12] and an 1100 MWe power plant was envisad also. Though Russia, china and South Korea offered financial support in nuclear power plant but Russia made a formal proposal to build nuclear power plant. Then in 2009 a bilateral cooperation agreement was signed with Russia to build a 1000MWe nuclear power plant in Ruppur. Preliminary which will cost about \$2 billion USD and it will be implemented by the year 2017 [9] [13]. The Govt of Bangladesh also thinking more power production from nuclear sector to meet up the national power sortage. They desires to generate about 5000 MWe power from the nuclear power plant within the year 2030. For that a second plant to build is under consideration [9]. In May 2010 a treaty was signed with Russia to provide a legal basis for nuclear cooperation in areas such as sitting, design, construction and operation of power and research nuclear reactors, water desalination plants, and elementary particle accelerators [13]. Since 1986 Bangladesh has a Triga 3 MW research reactor. Bangladesh has a safeguards agreement in force with the IAEA since 1982 and an additional protocol in force since 2001 [12].

VI. FEASIBLE EXPENDITURE FOR NUCLEAR POWER PLANT INSTALLATION IN BANGLADESH

It is generally accepted that nuclear power plant construction cost estimates are very uncertain. In the recent years this cost goes up a little bit [16]. The costs

can be much higher for some factor in owners' costs such as land, cooling towers, switchyard, interest during construction, cost escalation due to inflation and cost overruns and sometimes contingency of Construction Company [16]. Moreover, it also depends on the technologies that are used by the construction company. For the initial estimation it will take 1000 to 1500 crore BDT for Bangladesh [15].

Table 2 : Pebble Bed Modular Reactor (PBMR) plant capital cost estimate in Bangladesh (January, 2012) [16]

Sl No.	Account Description	Cost Estimate (BDT)
1	Land & land rights	18.5 crore TK
2	Structures & improvements	1346 crore TK
3	Reactor plant equipment	4399 crore TK
4	Turbine plant equipment	2214 crore TK
5	Electric plant equipment	450 crore TK
6	Miscellaneous plant equipment	346 crore TK
7	Heat reject. system	179 crore TK
Total direct costs		8952.5 crore TK
8	Construction service	779 crore TK
9	Home office engr. & service	443 crore TK
10	Field office supv. & service	380 crore TK
Owner's cost		1029 crore TK
Total indirect cost		2631 crore TK

Table 3 : Pebble Bed Modular Reactor (PBMR) plant total summarized cost calculation in Bangladesh (January, 2012) [15] [16]

Account Description	Cost Estimate
Total base construction cost	11583.5 crore TK
Contingency (24%)	2780 crore TK
Total overnight cost	14363.5 crore TK
Unit capital cost (tk/kwe)	130200 TK
Interest = 12.2%	1750 crore TK
Total capital cost	16113.5 crore Tk
Fixed charge rate	9.85%
Levelized capital cost (crore tk/year)	1587.18 crore TK

VII. ASSESSING THE ECONOMICS OF NUCLEAR POWER: COSTING FOR GENERATION

Nuclear energy is, in many places, competitive with fossil fuels for electricity generation, despite relatively high capital costs and the need to internalize all waste disposal and decommissioning costs. If the social, health and environmental costs of fossil fuels are also taken into account, the economics of nuclear power are outstanding. From the outset the basic attraction of

nuclear energy has been its low fuel costs compared with coal, oil and gas-fired plants.

Table 4 : The approx. US \$ cost to get 1 kg of uranium as UO₂ reactor fuel (at current spot uranium price) (March, 2011)

Uranium	8.9 kg U ₃ O ₈ x \$146	US\$ 1300
Conversion:	7.5 kg U x \$13	US\$ 98
Enrichment	7.3 SWU x \$155	US\$ 1132
Fuel fabrication	per kg	US\$ 240
Total, approx		US\$ 2770

At 45,000MW d/t burn-up this gives 360,000 kWh electrical per kg, hence fuel cost: 0.77 c/kWh. The 2010 OECD study Projected Costs of producing Electricity comparing with 2009 data for generating base-load electricity by the year 2015. It also compares the costs of power from renewable sources and exposed that nuclear power was very competitive at \$30 per ton CO₂ cost and low discount rate. The scrutiny compared data for 190 power plants from 17 OECD countries. It also compares some data from China, Russia and Korea. The production cost competitiveness of different base-load technologies depend on local circumstances, types of fuel and also in the costs of financing. The US Nuclear Energy Institute revealed a survey which shows that for a coal based power plant 78% of the total cost depends on the fuel, for a gas turbine power plant this figure is 89% and for a nuclear power plant the uranium is about 14%, or double including all sorts of cost.

Table 5 : OECD electricity generating cost projections for year 2010 on - 5% discount rate, c/kWh [17]

Country	Nuclear	Coal	Gas	Onshore wind
Japan	5	8.8	10.5	-
USA	4.9	7.2-7.5	7.7	4.8
Korea	2.9-3.3	6.6-6.8	9.1	-
China	3.0-3.6	5.5	4.9	5.1-8.9
Russia	4.3	7.5	7.1	6.3

At 5% discount rate comparative costs are as shown above. Nuclear is comfortably cheaper than coal and gas in all countries. Comparing to gas turbine power plant and coal based power plant the nuclear power plant need much capital and sophisticated installation. But the lower fuel cost need very less maintenance cost. Moreover, the impact of cost of carbon emissions have also taken into account. So nuclear power is cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels.

VIII. CONCLUSION

Current trends in energy supply and use in developing countries like Bangladesh are patently unsustainable – economically, environmentally and

socially. So in the longer term, there is a great potential of nuclear energy technology in power plant to establish a sustainable energy future. Nuclear supplies base load to large grid-integrated markets where oil provides some peak supply, back-up capacity, small-scale and non-grid applications and nuclear plants are robust, secure long-term investments as part of a portfolio of environmentally sound technologies that make the world less dependent on damaging carbon emissions. Despite claims from the nuclear industry, still nuclear energy is a mature technology that can be a better option to meet the very real challenge of global warming. Many other developing countries including Bangladesh have a low GDP to uphold a continual supply of energy in recent future, and this problem is solvable only by nuclear energy. So the governments of the developing or least developed countries should ponder to make a long term road map of nuclear power plant for a sustainable development of the country.

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