



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: A
MECHANICAL AND MECHANICS ENGINEERING

Volume 15 Issue 2 Version 1.0 Year 2015

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN:2249-4596 Print ISSN:0975-5861

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GJRE-A Classification : FOR Code: 020202



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Nuclear Power Plant in Bangladesh and the Much Talked about Rooppur Project

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Abstract- Bangladesh is a land of about 16.5 core people. So, high population, industrialization and urbanization demands huge electric power. The government of Bangladesh now is in troublesome condition to provide huge electricity. The government of the country has already taken some necessary steps like hydroelectric power plant, coal based power plants, gas based power plants, oil based power plants and some power plants of renewable sources. But those are not sufficient according to the demand. That's why government is trying to introduce first nuclear power plant. "I believe it fulfills the nation's dream," Prime Minister Sheikh Hasina said this after laying the foundation stone of Bangladesh's first nuclear power plant on 2 October 2013 in Rooppur, Pabna. Some debate has already begun against this power plant. But to resolve energy crisis of Bangladesh government should introduce modern (generation 3+ VVER-1200, VVER TOI) nuclear power plant.

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I. INTRODUCTION

In recent times there has been a growing trend worldwide of adopting alternative source of energy in policy framework in the context of diminishing reserve of fossil fuel as well as the detrimental impact of its burning on environment and human health. Renewable and environment friendly energy sources come into consideration to tackle future energy crisis. Renewable energy sources like solar energy, wind energy etc. cannot cope with the huge consumption demands of industrialization and urbanization. In this perspective nuclear energy is considered as a suitable alternative, provided necessary safety measures are in place. Nuclear power plants are especially suitable for countries like Bangladesh having huge population and limited land area and resources. The prospect of nuclear energy had been recognized in policy plans of Bangladesh and necessary steps are being taken for early implementation of Rooppur Nuclear Power, Project at Rooppur, Pabna.

II. HOW NUCLEAR POWER PLANT WORKS

Just like a fossil (Coal, Gas, Diesel) fuel power plant, in nuclear power plant water is turned into steam, which in turn drives turbine generators to produce

electricity. The difference between them is the source of heat. In nuclear power plant, when nuclear fission takes place, the produced heat turn water into steam. There is no combustion in a nuclear reactor. There are two types of nuclear reactors.

a) Pressurized Water Reactor (PWR)

In pressurized water reactor, water is boiled under high pressure so that water in reactor vessel does not boil but heats. This heated water transfers the heat to the water in the steam generator. Water in the steam generator then is converted to steam and then turns the turbine generator. The generator then produces electricity. Water from the reactor vessel and the water in the steam generator that is turned into steam never intermingle.

b) Boiling Water Reactor (BWR)

In Boiling Water Reactors (also known as BWRs), the water heated by fission actually boils and turns into steam to turn the turbine generator. In both PWRs and BWRs, the steam is turned back into water and can be used again in the process.

III. HOW ENERGY RELEASED FROM NUCLEAR FISSION

The sum of masses of the protons and neutrons that comprise the nucleus exceeds the mass of the atomic nucleus. The difference in mass is called mass defect. The mass defect is converted to energy in a nuclear reaction is given by Einstein's law:
$$\Delta E = \Delta m C^2$$

This equation shows that lost mass (mass defect) will convert into energy. And by the same process we get the fission energy.

By fission process we extract nuclear energy from nucleus. In this process nucleus of an atom splits into smaller parts. Fission is a form of nuclear transmutation because the resulting fragments are not the same element as the original atom.

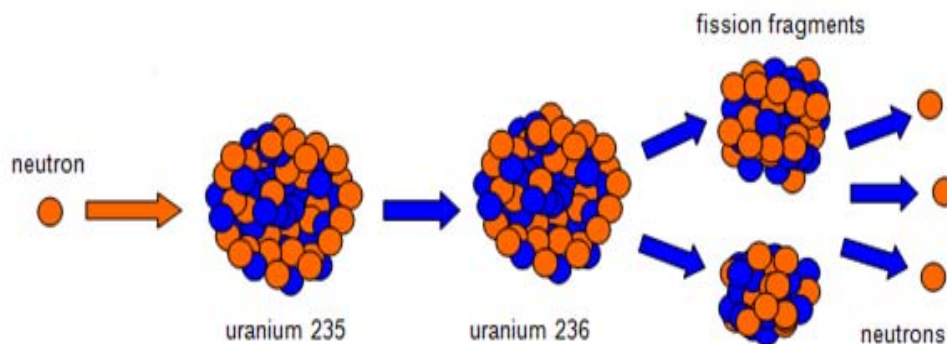
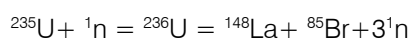


Figure: Nuclear fission

One of the fission products is represented as:



The mass equation for the above reaction is given as (in atomic mass unit):

$$235.124 + 1.009 = 147.96 + 84.938 + 3.029$$

The mass deficiency on the right hand side of above mass equation is 0.207 atomic mass unit or 0.3436×10^{-27} kg. This mass will convert into energy.

The equivalent release of energy in view of Einstein's law:

$$\begin{aligned} \Delta E &= \Delta m c^2 = 0.3436 \times 10^{-27} \times 9 \times 10^{16} \\ &= 3.0924 \times 10^{-11} \text{ Joules/atom} \end{aligned}$$

Now, one kg of uranium will have approximate 26.029×10^{23} atoms. If it is assumed that all the atoms have undergone fission, the total amount of released energy will be:

$$\begin{aligned} E &= 3.0924 \times 10^{-11} \times 26.029 \times 10^{23} \\ &= 80.49 \times 10^{12} \text{ joules/kg} \end{aligned}$$

The above released energy is approximately equivalent to 2.7 million kg of coal, 2 million m^3 of natural gas and 1.78 million kg of fuel oil.

IV. COMPARING RADIOACTIVE WASTE TO OTHER WASTE

In countries with nuclear power, radioactive wastes comprise less than 1% of total industrial toxic wastes, much of which remains hazardous for long periods. Overall, nuclear power produces far less waste material by volume than fossil-fuel (Coal, Gas, Diesel) based power plants. The flue gas from combustion of the fossil fuels is discharged in the air. This gas contains carbon dioxide and water vapor, as well as other substances such as Nitrogen oxides (NO_x), Sulfur oxides (SO_x), Mercury, traces of other metals, and, for coal-fired plants, fly ash. Fossil fuel power stations emit CO_2 , a greenhouse gas (GHG) which according to a

consensus opinion of scientific organizations is a contributor to global warming as it has been observed over the last 100 years.

A 2008 report from Oak Ridge National Laboratory (ORNL) concluded that coal power actually results in more radioactivities being released into the environment than nuclear power operation. Indeed, coal ash is much less radioactive than nuclear fuel on a weight per weight basis, but coal ash is produced in much higher quantities per unit of energy generated, and this is released directly into the environment as fly ash, whereas nuclear plants use shielding to protect the environment from radioactive materials, for example, in dry cask storage vessels. An international organization has raised serious questions about the much-debated Rampal coal-fired power plant, saying it does not maintain the minimum social and environmental standards.

V. NUCLEAR ENERGY IN BANGLADESH

The nuclear power plant will be built at Rooppur, on the banks of the Padma River, in the Ishwardi subdistrict of Pabna, in the northwest of the country.



Figure 1 : Site location of Rooppur nuclear power plant.

The proposal was first raised in 1961. Government took 253.90 acre of land of current place at that year to build the plant. In 1963 the plant was approved. Discussions took place with the Canadian government in 1964 and 1966. Discussions with the governments of Sweden and Norway were also going on in those years. However, no real progress was achieved. After the independence of Bangladesh, the Government of Bangladesh started discussion with the Soviet Union in 1974 however, which was not successful.

Finally, In February 2011, Bangladesh got an agreement with Russia to build the 2,000 megawatt (MW) Rooppur Nuclear Power Plant with two reactors. The Rooppur Nuclear Power Project (RNPP) is estimated to cost up to US\$2 billion, and is going to start operating by 2021. The inter-governmental agreement (IGA) was officially signed on 2 November 2011. Prime Minister Sheikh Hasina laying the foundation stone of Bangladesh's first nuclear power plant on 2 October 2013 in Rooppur, Pabna. Prime Minister Sheikh Hasina, gave the final go-ahead to the draft Nuclear Power Plant Act 2015.

But several separate issues were raised, from the unsuitability of the site to the obsolescence of the VVER-1000 model (Pressurized Water Reactor (PWR)) proposed, questionable financing arrangements and a

lack of agreement with Russia over nuclear waste disposal. Besides, Bangladesh has no technical expertise or skilled manpower to undertake such a complex and high tech project. Generation 2 model Nuclear power plant falls in accident like in 1979 Three Mile island (US) accident, in 1986 Chernobyl (Ukraine) accident and in 2011 Fukushima (Japan) accident. Generation 2 type nuclear power plant was less protective from any type of natural and manmade disaster. Life span of this reactor was in between 25 to 30 years. It takes long time to build this type of reactor and its waste production rate is high. That's why VVER - 1000 model was introduced and this model is known as generation 3 nuclear power plant. Russia went to build generation-3 VVER-1000 model nuclear power plant in India but this project face public resistance due to low grade instruments.

Bangladesh can take learning from this. Generation-3+ VVER-1200 model is more efficient, safe and modern than generation-3 VVER-1000. Bangladesh government may go for generation-3+ VVER-1200 model nuclear reactor which is also known as evolutionary reactor. This type of reactor fulfills the requirements of the IAEA and the EUR. VVER TOI model is more modern than VVER-1200. This VVER TOI model has some specific characteristics like, high endurance power in earthquake and tornado, high endurance

power in aircraft crashes and flood, fuel efficient, less waste production etc. Russia is going to build this type of plant in their country and Turkey. Rooppur nuclear power project is likely to cost around \$10 billion, more than three times the initial estimate of the government. The project's Russian developer Rosatom has been dropping hints since last year that the cost may go up to \$10 billion. A couple of years ago the government had

estimated that the plant would cost between \$2 billion and \$3 billion. Bangladesh is seeking 90 percent of the project financing from Russia. The loan will be repaid in 28 years with a 10-year grace period. But similar power plants being built by Russia in different countries are coming with a price tag between \$10 billion and \$13 billion.

Table 1 : Price list of nuclear power plants at different countries

country	plant	price
Finland	1200 mw plant	\$6.5b
Hungary	1200 mw x 2 units	\$3.5b
Turkey	1200 mw x 4 units	\$20b
South Africa	1200 mw x 8 units	\$50b
Belarus	1000 mw x 2 units	\$10b
Vietnam	1000 mw x 2 units	\$9b

The plant is located in an earthquake zone, that's why construction cost goes high. Additional safety installations also add up to the cost. In addition, lack of qualified nuclear power engineers, enterprises, employees increases the project cost. On top of that, the country has no industrial infrastructure and the

transport system is absolutely rudimentary. Most of the materials to be used in the plant such as the quality assured high grade stainless steel, pipes, valves, pumps and other components will have to be imported and the cost will increase. This site is also vulnerable to flood and tornadoes.

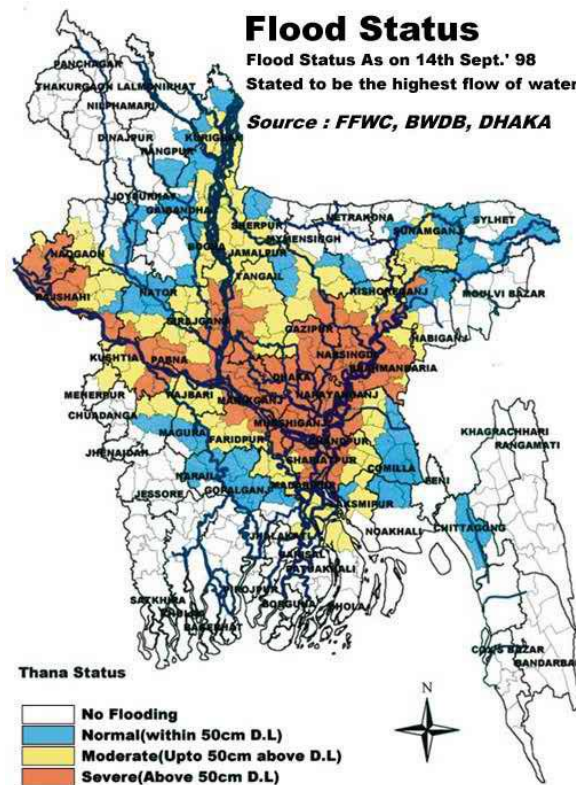


Figure 2 : Rooppur nuclear power plant

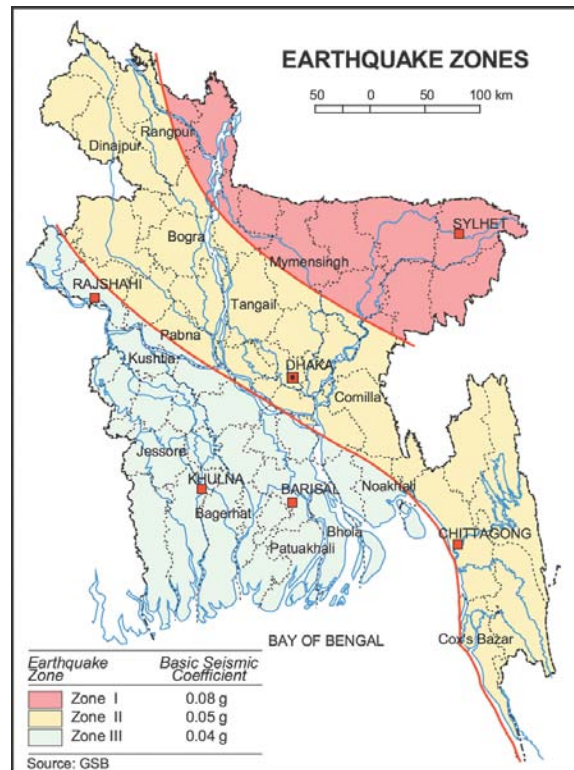


Figure 3 : Rooppur nuclear power plant

Site is located in the severe flood region.
Site is located in the earthquake region.

When Pakistan had proposed the site, it was a sparsely populated area. In contrast, right now, it is a densely populated region. Ishwardi Upazila has population density of 1186 (per sq km). Any sign of an accident would necessitate an immediate evacuation of all the people in the 20 sq km area adjacent to the nuclear power plant. But to evacuate the whole population on a long term or lifetime basis from a 20 sq km area in the most densely populated country and relocate them will be a virtually prohibitive, most challenging and arduous task. Soil of Rooppur is soft in nature, that's why some initiative has to take to stable this soil.

We have to think about geopolitics. During the first half of the year, much of the water of the river is already withdrawn by India through the Farakka Barrage, leaving insufficient cooling water for the plant and other activities in Bangladesh. According to debate about nuclear power plant some advanced countries like Germany, Italy, Switzerland have all given up nuclear power plants and with Japan is tapering down nuclear power production after the Fukushima disaster, Bangladesh seems to be charging ahead recklessly. But we have to remember that still now 30 countries worldwide are operating 438 nuclear reactors for electricity generation and 67 new nuclear plants are under construction in 15 countries. In spite of these

threats, nuclear power plant is the best decision to meet rapidly increasing demand and reduce dependence on natural gas. But these threats should be kept in mind.

VI. RESULT

From this research, the result is obtained that it is perfect time to introduce modern nuclear power plant for Bangladesh. Because this plant will be able to resolve the power crisis of Bangladesh and it will sustain for a long time. Bangladesh use natural gas and coal for most of its electricity production.

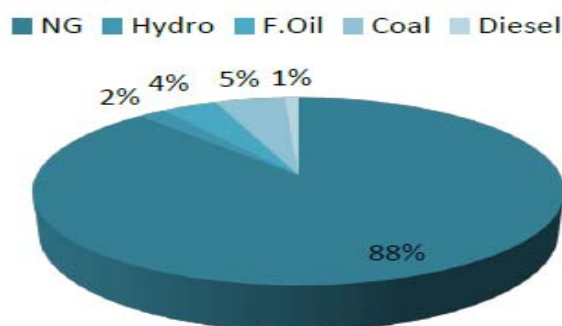


Figure 4 : Fuel consumption pattern of Power Generation.

But these sources of energy create serious environment pollution, and these sources will finish one day. Because, these sources are not renewable sources. That's why Bangladesh has to go for alternative power sources. Already Bangladesh has started to use some renewable energy sources those are environment friendly. But these sources produced small range of energy. So by considering the entire problem regarding nuclear power plant, Bangladesh should go for modern (generation 3+ VVER-1200, VVER TOI) nuclear power plant. Initial coasting may be high but thinking about future safety Bangladesh government should go for modern nuclear reactor.

VII. CONCLUSION

Now a days for lower Greenhouse Gas Emission, Efficiency, Reliability, Cheap Electricity, Low Fuel Cost, Easy Transportation nuclear energy has got top most priority. But we have to remember the accidents of nuclear power plant, like in 1979 Three Mile island (US) accident, in 1986 Chernobyl (Ukraine) accident and in 2011 Fukushima (Japan) accident were devastating. Now a days it has become very challenging to generate sufficient electric power for Bangladesh to meet the energy demand with its rapid growing population and industrialization.

The Government of the country is trying to lessen the power crisis by taking several initiatives like small (10-20MW) power plants, coal based power station, IPP (Independent Power Producer), QRPP (quick rental power plant) and small scale renewable energy plants. But these are not a permanent solution. Moreover, QRPP and IPP are mainly oil and gas based, which are very costly and these are also not very efficient. Besides coal based power station are required very large space, its initial cost is high and create serious environmental threat to the surroundings. In this perspective nuclear energy is considered as a suitable alternative for Bangladesh, provided necessary safety measures are in place and we can hope that this plant will resolve energy crisis of Bangladesh. Initial coasting may be high but thinking about future safety and

efficiency Bangladesh government should consider modern nuclear reactor.

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