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Prospect of Green Power Generation Using Rooppur Nuclear Power Plant in Bangladesh

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Abstract: Bangladesh, a standout amongst the most crowded regions of Asia is at present experiencing Major energy emergency. Years of unconsciousness, absence of potential assets, labor, innovation and investment have taken the circumstance to an emergency level. Commercial energy consumption depends on natural gas (around 70%) trailed by coal, oil and hydropower. At present there is a huge difference between demand and generation of electricity. A step of building a nuclear power plant named Rooppur Nuclear Power Plant (RNPP) is taken by Government to fulfill this crying need. Bangladesh has planned to establish two Russian nuclear power reactors in operation (Rooppur-1 & Rooppur-2). The power plant will be built at Rooppur, 200 km north-west of Dhaka, at Paksey union on the bank of the Padma in the Ishwardi subdistrict of Pabna District, in the northwest of the nation. This paper discusses the prospect of green power generation using RNPP and evaluates different parameters whether it is a proper decision or not and also provides some necessary recommendations regarding the implementation of Rooppur Nuclear Power Plant.
Keywords: RNPP; Rooppur Nuclear Power Plant; Power Plant; Bangladesh

INTRODUCTION

Bangladesh has noteworthy stores of natural gas and coal, a fact that has been known for several years. However the nation is as of now going through an intense energy emergency. The emergency is maybe even more an impression of the inability to abuse its accessible assets as opposed to an absence of them. Bangladesh's energy infrastructure is very small, inadequate and ineffectively managed [1].

So Bangladesh is confronting huge load shedding of electricity. In Bangladesh power isn't producing as much as our request. As per the official measurements, the nation's power deficiency has gone up 1000 megawatts (MW) to 1259 MW [2]. In this specific circumstance, Bangladesh is in the prompt need of complex increment of existing power generation capacity. At present, power creation in Bangladesh is for the most part in view of existing store of conventional energy sources, (for example, petroleum derivative like gas, coal, oil and so forth.) which won't be accessible later on if power is produced just from conventional sources. In addition, generation of power from traditional sources is expensive and all the more altogether contaminating nature and worsening worldwide environmental change. Once more, power generation from sustainable power sources like sunlight based and wind won't be sufficient to satisfy the huge lack of power in our nation as they can't create energy in tremendous scale. It is in this manner fundamental for Bangladesh to give real fixation on expansive scale power generation which is sustainable in nature and furthermore can enhance the large power emergency apace. In this unique circumstance, Nuclear Power Plants could be the best choice for Bangladesh for tremendous measure of power generation [3].

NUCLEAR ENERGY SCENARIO IN THE WORLD

The production of electricity using nuclear energy was first demonstrated in the early 1950s, and the first large-scale nuclear power plants entered operation before 1960. The first countries to employ this new energy source for power generation were the ex USSR (1954), the United Kingdom (1956), the United States (1957) and France (1963). Several others followed in the early 1960s, including Belgium, Canada, Germany, Italy, Japan and Sweden.

Table 1: Nuclear reactors of the world (country wise)

Country	In operation		Under construction	
	Number	Electricity net output MW	Number	Electricity net output MW
Argentina	3	1632	1	25
Armenia	1	375	-	-
Belarus	-	-	2	2218
Belgium	7	5913	-	
Brazil	2	1884	1	1245
Bulgaria	2	1926	-	-
Canada	19	13524	-	-
China	36	31402	20	20500
Czech Republic	6	3930	-	-
Finland	4	2752	1	1600
France	58	63130	1	1630
Germany	8	10799	-	-
Hungary	4	1889	-	-
India	22	6225	5	2990
Iran	1	915	-	-
Japan	43	40290	2	2650
Korea, Republic	25	23133	3	4020
Mexico	2	1440	-	-
Netherlands	1	482	-	-
Pakistan	4	1005	3	2343
Romania	2	1300	-	-
Russian Federation	36	26557	7	5468
Slovakian Republic	4	1814	2	880
Slovenia	1	688	-	-
South Africa	2	1860	-	-
Spain	7	7121	-	-
Sweden	10	9651	-	-
Switzerland	5	3333	-	-
Taiwan, China	6	5052	2	2600
Ukraine	15	13107	2	1900
United Arab Emirates	-	-	4	5380
United Kingdom	15	8918	-	-
USA	99	98868	4	4468
Total	**450**	**391915**	**60**	**59917**

Source: IAEA Power Reactor Information System (PRIS) [18]

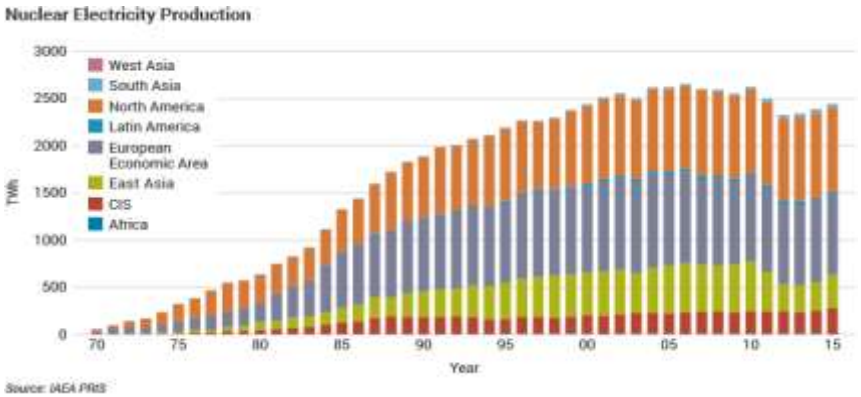

Fig-1: worldwide nuclear electricity production (Source: IAEA PRIS)

At the end of 2016, 450 power reactors were in operation in 30 countries with a combined capacity of about 392 Giga Watts (GW) of electricity,1 providing over 2 500 TWh (or 2.5 trillion kWh) annually (see Table 1). Nuclear energy supplies about 8% of the world's total primary energy and about 18% of all electricity (see Figure 2). Over 80% of all nuclear generation occurs in OECD countries, in which it provides about 21% of the overall electricity supply and represents the largest low-carbon energy source.

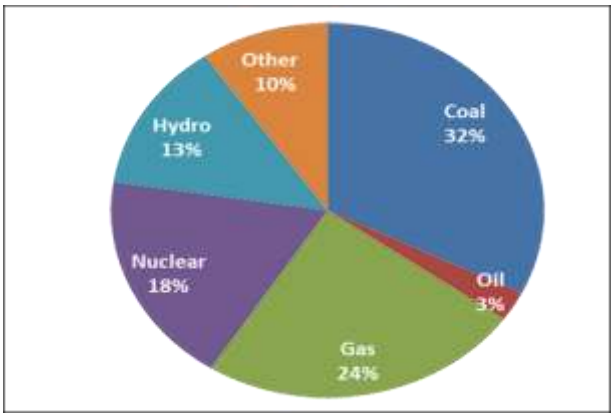

Fig-2: Percentage Pie chart of worlds total power generation

ENERGY SCENARIO IN BANGLADESH

The energy framework of Bangladesh is very little, lacking and ineffectively managed. The per capita energy utilization in Bangladesh is one of the least (321 kWh) [4] in the world. Non-commercial energy sources, for example, wood fuel, animal waste, and crop deposits, are assessed to represent over portion of the nation's energy utilization. Bangladesh has small reserves of oil and coal, and medium measure of natural gas assets. Commercial energy utilization is generally natural gas, trailed by oil, hydropower and coal [5]

Table 2: Public and Private Electricity generation capacity of Bangladesh (2017)

Public Sector	Installed Generation Capacity (MW)
BPDB	4402
APSCL	1508
EGCB	622
NWPGCL	718
RPCL BPDB-RPCL JV	77 149
Subtotal	7,476 (55%)
Private Sector	
IPPs	3245
SIPPs (BPDB)	99
SIPPs (REB)	251
15 YR. Rental	169
3/5 YR. Rental	1721
Power Import	600
Subtotal	6,085 (45%)
TOTAL	**13,561 ***

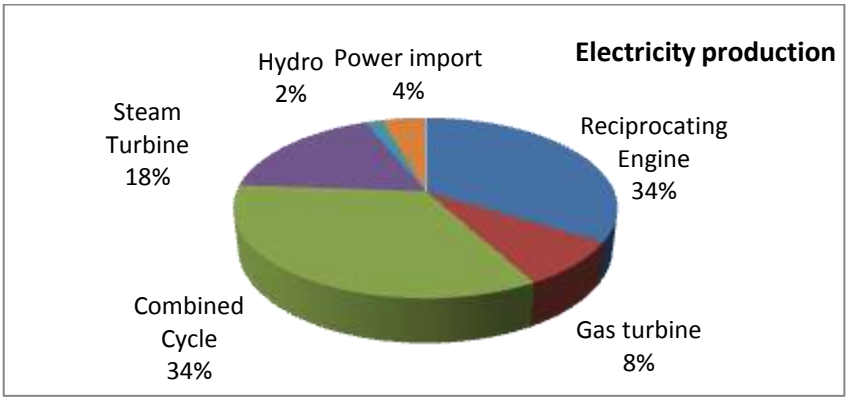

Fig-3: Total Installed power capacity in Bangladesh on June, 2017 (source: BPDP, 2017)

In Bangladesh the production curve has lagged behind than the demand curve. Due to this the development of the country has always hampered.

Table 3: Demand & Production data of past few years [6, 7 and 8]

Fiscal Year	Peak Demand (MW)	Maximum Generation (MW)
2010	6454	4698.5
2011	6765	5174
2012	7518	6350
2013	8349	6675
2014	9268	7418
2015	10283	7817
2016	11405	9036

WHY NUCLEAR POWER IS NECESSARY IN BANGLADESH

Nuclear power plants use nuclear fission reaction to produce heat which is then used to produce electricity. In nuclear fission atoms are separated to form smaller size atom, releasing huge amount of energy. Most often, in case of producing nuclear energy Uranium and plutonium isotopes are used. The general reaction is like below-

235 U+ neutron fission = Fission fragments + 2.4 Neutrons + 192.9 MeV

239 Pu+ neutron fission = Fission fragments + 2.9 neutrons + 198.5 MeV

This huge energy is not produced in open places. It needs isolated and controlled environment to produce this massive energy. Nuclear plants have its own unique cooling system, that's why most of the plants are built near river or sea.

Bangladesh needs stable and powerful energy source to produce electricity. The electricity demand is increasing day by day. The existing power plants cannot full fill the demand of electricity. The major cities of the country have to face approximately 3 to 4 hours load shedding per day. Nuclear energy is the best solution of this. Moreover, Nuclear power plants have more life span than any other type of power plants. A comparison between heating values of different fuels are given below-

Table 4: Comparison between heating values of different fuels

Fuel Type	Heat Value (MJ/kg)
Fire wood	16
Brown Coal	9
Black Coal (low quality)	13-20
Black Coal	24-30
Natural gas	39
Crude oil	45-46
Natural Uranium	500000

Nuclear power plants do not produce any greenhouse gases during the production of electricity. A small amount of greenhouse gas is produced due to the use of Turbine and collar. So, nuclear power plants are sustainable in nature and save the earth from toxic and greenhouse gases compared to the other power plants.

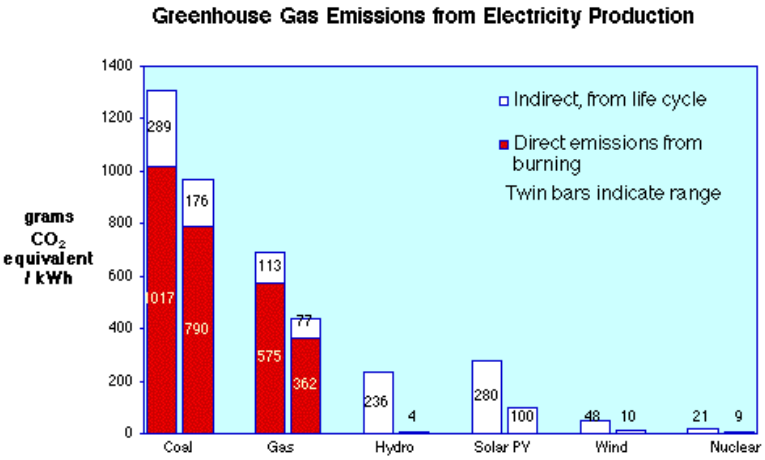

Fig-4: Grams of CO_2 equivalent/KWh (source: IAEA)

HISTORY OF ROOPPUR NUCLEAR POWER PLANT

The structure of the nuclear power plant in the western part of the country was first proposed in 1961. Since then, a series of feasibility reports has been completed which established that the plant is technically and economically viable. The site was selected in 1963 and 292 acres (118.3 hectares) of land (105.3 hectares per plant and 13 hectares for residential purposes) were purchased for the project. physical infrastructure such as residential buildings, office space, vacation home, inner freeway, electric substation, home pump, etc. were established in the project area. In Pakistan time the government granted official approval for the 70 MW, 140 MW and 200 MW nuclear power plants (Nuclear Power Plant) in 1963, 1966 and 1969. Following ECNEC release in 1980 they approved the 125 MW nuclear power plant. There were several suppliers both before and after the submission, proposals were submitted to the project. The project, however Failed to implement, as many of the funding problems were the main obstacle. Taking into account the changed circumstances at national and international levels, the Bangladesh government expresses its firm commitment to the implementation of the Rooppur Nuclear Power Plant Project (RNPP). It is possible to mention that excessive delays in implementing the project have caused many changes in the design process.

Table 5: Some key milestones of Rooppur nuclear Power Plant [9] -

Period	Actions
1963	Site selected for power plant
1971-78	NPP did a feasibility study
1996	National Energy Agency took nuclear power in consideration
2000	Government was approved by BANPAP
2010	NPP project was first approved National Parliament
2011	IGA with Russia signed for the first NPP with two VVER units, each 1000 MW(e)
2012	Parliament was introduced with Nuclear Energy bill
2014	Moscow AEP said that the plant would be an AES-2006 with a form of its V-392M reactors, with Novovoronezh II being the reference plant and A $190 million assentation for real site attempts to get ready for first cement was marked in June 2014
2016	Cabinet affirmed a draft assertion for Russia to give an $11.38 billion credit facility for 90% of the project
2017	Bangladesh Institute of Peace and Security Studies arranged a seminar in Dhaka titled 'Entering the World of Nuclear Energy

SAFETY AND SECURITY CONSIDERATION OF RNPP

Safety for sudden explosion

The first fundamental consideration is the area and the density of people. According to the international law the radius of area of a nuclear power plant should be at least 30 km's. Researchers have divided this area into 3 circular zone of 3.14*30*2 = 2826 sqr km. Zone-1,2,3 are accordingly reactor area, security area and area for planning disaster.Area-1 is only for the people working in the reactors. No civil people are allowed in this area. The zone should be 5 km away from the center of the total area. All kinds of agricultural and industrial works are prohibited inside this area. The zone -3 must be 30 km from the center and should be a no-man's land.

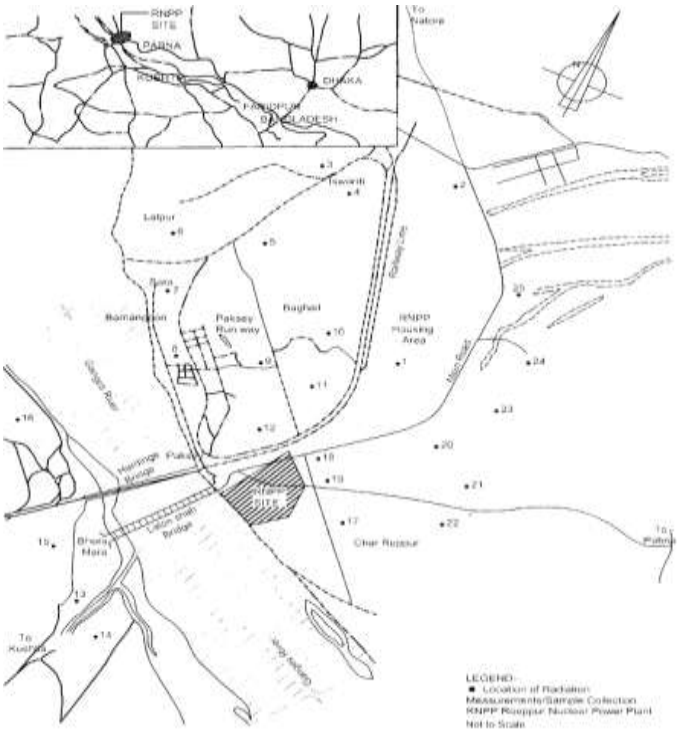

Fig-5: Location map of RNPP (Rooppur Nuclear Power Plant) site

If there is an explosion in the RNPP then living people must be transferred 3.14*40*2= 5024 sqr km outside. If 1200 people live per sqr km then almost 1200000 people must be transferred, this is quite impossible within a very short time. But this problem can be overcome by changing some regulation, like Because of this type of problem India has shifted their nuclear plant to another zonal area. But for RNPP this safety issue is considered and if in future there is any sort of problem then people won't be affected near this zone.

Earthquake and Natural Disaster

Earthquake and various natural disasters are another major concern. Bangladesh is an earthquake prone country. But the good news is-In RNPP area there is no indication of surface faulting realized. For a return period of 2475 years the peak ground acceleration is estimated about 0.18g, which is lot smaller than designed PGA values. On the basis of seismic hazard analysis and sub-soil investigation, a plant like RNPP of above 0.20g to 0.25g should withstand 7.5 to 9.5 Mw earthquakes. Recently, in few years Bangladesh has encountered several floods, Tsunami etc. But it is a great relief that the RNPP area is out of tsunami zone. According to several research it is estimated that the BAY OF BENGLE is the most tsunami prone area which may be face 7 MW (in rector scale) earthquake.

Waste disposal

Waste disposal is a major concern for any power plant. But for nuclear power plant it is the fundamental one. In a nuclear power plant there may be no greenhouse gas emission but it emits a lot of radioactive particles. Radioactive particle are very harmful for human and plants. Bangladesh claimed that, Russia has assured Bangladesh about the safety of the plant. Rosatom [10] ensured that, RNPP would be a generation 3+ power plant with safety and hazard resistant technologies. Bangladeshi specialists favored the innovation of unit-6 of Novovoronezh NPP to be duplicated in Rooppur in light of its security highlights.

Its plant in central Russia is considered as the safest nuclear power unit in the world. Russia has an advanced system to keep the radioactive nuclear waste making it further processed and has been taking the nuclear waste from others countries.

Cyber security

In modern age due to internet and other facilities cyber-crime has become a burning issue. There are many challenges involved in forestalling cyber-crime. Many foreign governments or organizations, politically and ideologically roused activists and people spurred by voracity, severe dislike or interest for the most part perform digital assaults. It is generally trusted that Stuxnet computer worm was made as a digital weapon focusing on modern computer frameworks and this weapon made harm Iran's nuclear program. Disturbing news is that the duplicates of these progressed digital weapons are in the hands of numerous nations and programmer gatherings. In February 2016; 951 million US dollars was stolen from the Bangladesh Bank by means of the SWIFT system. Later it was distinguished that Dridex malware was utilized for the digital assault. Digital hoodlums were likewise engaged with the skimming racket that stole cash from a few ATM corners of three business banks. The offenders skimmed off at least BDT 25 lacks in February 2016. In this scenery, it is obviously that digital security arrangement of Bangladesh is not upgraded and safe yet. Along these lines, in the event of Rooppur Nuclear Power Plant, Bangladesh needs most elevated digital security framework. It is not clear till now what initiatives have been taken to defend any cyber-attack on Rooppur Power Plant. In 1st February, 2017 a seminar was organized named "Entering the world of nuclear energy" about cyber security of nuclear power plant. The occasion was composed by Bangladesh Institute of Peace and Security Studies (BIPSS); Dr. Petr Topychkanov from Carnegie Moscow Center stated, "Digital security must be guaranteed. Generally there may be a tremendous hazard. In the event ,there is no activity taken and it ought to be taken as right on time as possible"[11].An unknown organization claimed that No initiates have been taken regarding the cyber security of Rooppur nuclear power plant and different news are also not convincing.

Radio activity and radiation levels

Levels of the common radio nuclides, ^{238}U, ^{232}Th and ^{40}K in the earthly condition of the NPP site stay worldwide midpoints and 137Cs tainting levels in the dirt and water are below detection level. The world average(1～4) radioactivity levels of ^{40}K, ^{232}Th and ^{238}U are recorded as 400, 30 and 35 $Bq.kg^{-1}$, individually, whereas the normal esteems in the NPP site at Rooppur recorded as 379.6, 26.6 and 17.9 Bq.kg–1 separately, are inside the world esteems. The general outer foundation gamma assimilated indoor and outside measurements rate in air over the NPP site is in the vicinity of 0.11 and 0.23 ȝGy.h^{-1} and the mean is 0.17 ȝGy h^{-1}. The normal yearly viable measurements is observed to be 0.96 $mSv.y^{-1}$ (96 $mrem.y^{-1}$) considering the indoor and outside inhabitance factors 0.8 and 0.2 separately [12].

J.ferdous et al. in 2015 experimented on Radioactivity of soil in proposed RNPP site and suggested not be concerned about radioactivity. They got on average 30.85 $Bqkg^{-1}$ ^{236}Ra, 40.88 Bqkg-1 ^{232}Th and 390.10 Bqkg-1 ^{40}K [13]

Below table shows a comparison of amount of radioactive particle of RNPP with other work all around the world.

Table 6: Comparison of RNPP with other locations of the world [14, 15, 16, 17]

Location	Activity in $Bqkg^{-1}$		
	^{226}Ra	^{232}Th	^{40}K
Dhaka, Bangladesh	37.8	58.2	790.8
Chittagong, Bangladesh	34.6	60	438
Jessore, Bangladesh	48	53	481
Nine Southern Districts, Bangladesh	42	81	833
Eastern Sichuan Province, China	26	49	440
Peshwar, Pakistan	65	84	646
Nigeria	8.3	34.3	684
Nile Delta, Egypt	17	-	316
Louisiana, USA	43-95	50-190	43-729
Worldwide average	40(15-50)	40(7-50)	580(100-700)
RNPP Site (Average taken evaluating different results)	29.55	42.07	393.60

Economics and sustainability

Primarily, a Nuclear power plant needs a huge cost for establishment but has a low fuel and external costs. Coal based power plants will be always favorable in countries like China, USA etc. as long as the CO_2 emissions are cost free. Nuclear power plants are relatively expensive to build, but cheap to run. But in some countries like Bangladesh, India where there is a lack of natural resources there nuclear power plant is mandatory. Nuclear energy is competitive with fossil fuel in many conditions as a means of electricity generation. If social, health and environmental costs of fossil fuels are considered then Nuclear Power plants are outstanding compared to them.

Table 7: Comparison among different energy generation technologies

Technology	Unit time	Lead time	Capital cost	Operational cost	Fuel	sustainability
CCGT	Medium	Short	Low	Low	High	No
Nuclear	Huge	Long	High	Low	Low	Yes
Coal	Large	Long	High	Low	Medium	No
Hydro	Huge	Long	Very High	Very Low	Nil	Yes
Wind	Small	Short	High	Medium	Nil	Yes

TECHNOLOGICAL EVALUATIONS AND RECOMMENDATIONS

Nuclear power technology is growing day by day. At present not only Genaration-1, 2 and 3 but also now the latest Fourth generation technology is available. Various types GEN-3 and GEN-4 types of pressurized water reactors are available and the most common are the modern PWR system of pronouns Mitsubishi, Japan, CANDU Atomic Energy Canada Limited, VVER (VVER is the Russian version Pressurized water reactor (PWR). There are 3 most advanced - two 6 loops - 440 megawatts [440-230 (large) and 440-213 (new)] and 4 loop-1000 megawatts production plans. GEN-3 VVER reactors are built in Taiwan and are being made in India. GEN-2 Reactors are suitable Bangladesh, but this is not the best choice. There are two the most important types of G-2 reactors. These are pressurized water Reactor (PWR) and Boiling water reactor (BWR). GEN-2 Reactors Hold some Disadvantages. Because it is a pressurized reactor, rather than a boiling Water reactor, water must be under high pressure, fission activity in the core builds up to a high level; Uranium must be enriched, which is a rather expensive process; the double loop system is required. Because the heat transfer creates a significant loss of heat, in addition Inefficiency and also causing security risk. To take these disadvantages in mind, Bangladesh should go for GEN-3 or GEN-4 Reactors considering simplicity, cost, control system, safety and performance.

Terrorism is a great threat to Bangladesh. If RNPP is established then nuclear terrorism threat may be imposed in Bangladesh. In current world nuclear terrorism is a very common issue. So, Government should take proper action regarding this, and they should apply special force for increasing security.

According to several survey from a nuclear power plant like RNPP approximately 30 to 40 tons of high-level waste is produced per month from a reactor. This is very dangerous for living animals and plants. But in present years science has eliminated this threat. RNPP can use experimental Breeder Reactor. This reactor uses liquid sodium as a coolant and its internal reactor temperature is way too high than conventional reactors. Another major advantage of this reactor is that, its fuel is not weapon grade quality.

RESULTS AND DISCUSSION

Electricity production from RNPP is safe, reliable and hazard free because of its generation-3+ technologies and in-built safety features. At present Bangladesh is facing a lack of massive amount of energy, the demand and generation curves completely lie on a different region. Safe generation of electricity from RNPP can be a great solution to this. From the above discussions it's clear that Bangladesh is in perfect condition for adopting nuclear power plants like RNPP.

CONCLUSION

Implementation of Rooppur Nuclear Power Plant is one of the best decisions of the Government taken for the generation of electricity so far. Already the construction process has started. But there are some impregnable issues present in the project. Bangladesh government should take necessary and proper steps regarding this. Hopefully, Rooppur Nuclear power Plant will solve the huge energy crisis of Bangladesh along with other power plants.

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