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Journal of MECHANICAL ENGINEERING – Strojnícky časopis,
VOL 68 (2018), NO 3, 167 - 182

STU SjF

ROOPPUR NUCLEAR POWER PLANT: CURRENT STATUS & FEASIBILITY

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Abstract: In the present world, nuclear energy is a must need for various purposes. The main cause of nuclear energy is because of the increasing energy demand, which is not possible to provide by using convenient energy generation. Bangladesh is a lower income country and the energy sector is not so developed here though there is a very high demand for energy. Rooppur Nuclear Power Plant is the only one nuclear generation plant which can provide this kind of huge energy within a very short time. This paper mainly depicts the ins and outs of this plant and discusses it’s feasibility in Bangladesh. It also focuses on the worlds various power generation methods and comprises it with nuclear energy generation. A detailed technical brief is presented in this paper along with advantages, location selection, financial and environmental impacts. This will help researchers to do further researches about nuclear energy in Bangladesh.

KEYWORDS: RNPP, Energy, VVER, Reactor, Safety, Bangladesh.

1 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]. Normally nuclear energy is presented as a destructive source of energy, but many Asian countries are using this energy as a source of life saving and enormous electric generation manner. Among those Asian countries China and India has developed a lot in this sector and using nuclear energy in medicine and power plant sectors securing human life and national power demand. No remarkable accident has occurred in these two countries using nuclear reactors in lieu of meeting 25-30% national electric generation contribution. 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. In early 60’s, a plan on using nuclear power for human betterment was taken into consideration for Bangladesh (Late East-Pakistan), by the Govt. of East-Pakistan. But due to numerous political and social clashes this proposal was not applied practically. Later on 1974, Russia (Then USSR) accepted to help Bangladesh to make a nuclear power plant, which was finally passed on 2001 due to political and economic reasons [2]. In 2009, a memorandum was signed finally between Bangladesh and Russia on setting up a nuclear power plant on Rooppur (near Pabna Dist.) and Russian state

DOI: 10.2478/scjme-2018-0033, Print ISSN 0039-2472, On-line ISSN 2450-5471 ©2018 SjF STU Bratislava

atomic corporation 'Rosatom' was directed to head this project [3]. Rooppur Nuclear Power Plant (RNPP) will be a 2.4 GWe rated nuclear power plant by 2023. This plat is currently under construction at Rooppur, Ishwardi Upazila, Pabna on the bank of river Padma. This project is jointly directed by 'BAEC' (Bangladesh Atomic Energy Commission), 'AECI' (Atomic Energy Commission of India) and headed by 'Rosatom'. It will be one of the biggest power plants in Asian region [4].

2 Literature Review

Only a few literatures are found about the Rooppur nuclear power plant. There are a few numbers of researches on the radioactivity and safety analysis of RNPP. No reliable feasibility analysis paper found, few conference papers are found which describes some part of feasibility like if the weather, climate and current status of Bangladesh are suitable for taking a nuclear power plant like RNPP in consideration.

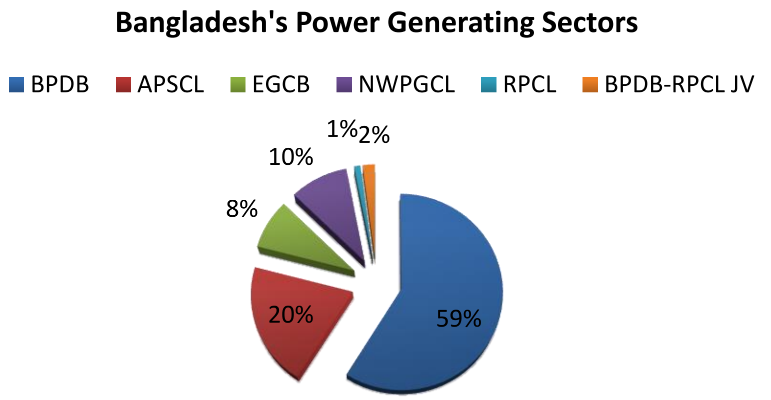
Siddiky et al. described and mentioned some key point's whether RNPP is good or bad for Bangladesh and different situation of current Bangladesh is ready for RNPP [5]. Reza et al. in his research compared different electricity production techniques and found nuclear generation to be more suitable for Bangladesh to meet annual load demand. He showed Bangladesh lacks a huge power demand and RNPP can fulfill this demand [6]. Mollah et al. reviewed present power generation technologies of Bangladesh and made an analysis on how RNPP will be environment friendly; specially pointed acute analysis on nuclear waste disposal in an eco-friendly manner [7]. M. S. Laskar made a statistical research on health and environment safety issues of Bangladesh on implementing RNPP project and made very good recommendations along with [8]. Arman Arefin et al. did a research on feasibility study on RNPP only considering safety and security issues [9]. In this paper a brief analysis of nuclear energy production is done and several points are found out which shows that RNPP is a great choice for Bangladesh in present situation. An analysis on power plant design, reactor, fuel, coolant, moderator ratio, control rod and feasibility is conducted in this paper. Several recommendations are also provided considering several current issues of RNPP and issues may occur in future. GÁLIK Gabriel et al. worked on modelling of coolant flow within the spent fuel storage pool of a VVER 440 [10]. Paulech Juraj et al. performed the numerical simulation of thermo-hydraulic behaviour of coolant in the VVER- 440 nuclear reactor under standard outage conditions reactor [11]. MUŠKÁT PETER et al. worked on the Extensive tests, oriented on the velocity and temperature profiles at the fuel assembly outflow of the nuclear reactor fuel assembly installed in the laboratory of the Institute of the Thermal Power Engineering of the Slovak University of Technology in Bratislava [12].

3 Methodology

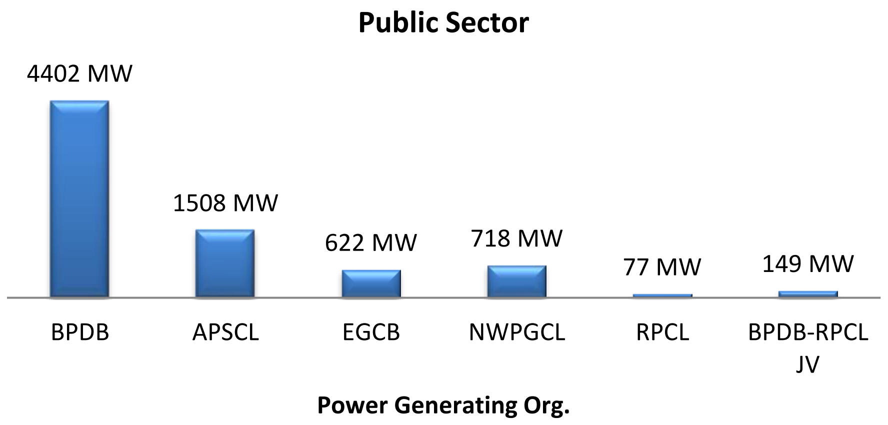
In this paper first, a brief discussion is done on the nuclear energy production in world. Then a total evaluation of different power generation sectors of Bangladesh are described and some very important logic is found about why RNPP is suitable for Bangladesh. Different design parameters considering reactor design, plant area, safety, security are evaluated. Then several issues like radioactivity, demand of water are discussed and compared with the other nuclear power plants of the world. All the data are collected from different national and international journals and reports, several government and non-government surveys are also included where necessary. Some important data are collected from the RNPP project presentation and newspapers.

4 Energy Scenario in Bangladesh

The energy generation sector of Bangladesh is very little, less efficient and unorganized. The per capita energy utilization is about 321 kWh in Bangladesh; one of the least in the world [13]. Bangladesh has small reserves of coal (nearly 2000 mt), and medium measure of natural gas (about 14.15 tcf); alternative fuel use is not so familiar here [14]. Commercial energy utilization is generally natural gas, trailed by oil, hydropower and coal. Figure 1 (a), (b) and (c) shows the public and private sector power generation schematic of Bangladesh.



(a)



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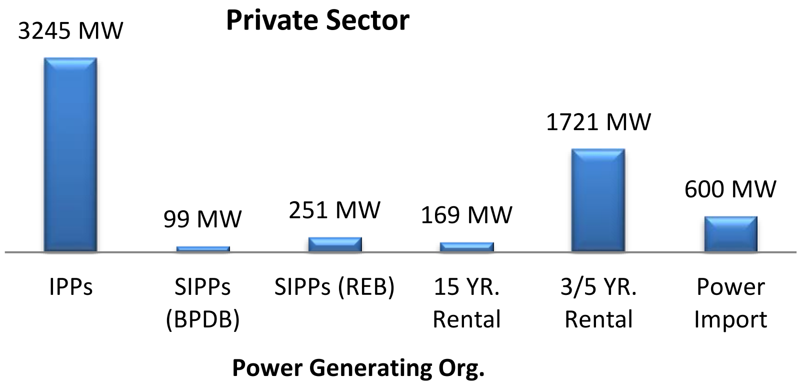

(c)

Fig. 1 (a) Bangladesh Power generation percentile (b) Public sector generation, (c) Private Sector Generation

In Bangladesh private sectors provides almost 50% of the total power generation. Among the public sectors BPDP alone provides almost 4402 MW and privates sectors IPPs provides 3245 MW. From Figure 1; it is clear that public sector does not generates sufficient load to meet the public demand, thus private sector has to make a cut in this energy sector. From Figure 1 (c), 3/5 years Rental plants are providing about 55% load from private sector generation which is very costly. Those cost 20 tk/Unit, which is a very high amount.

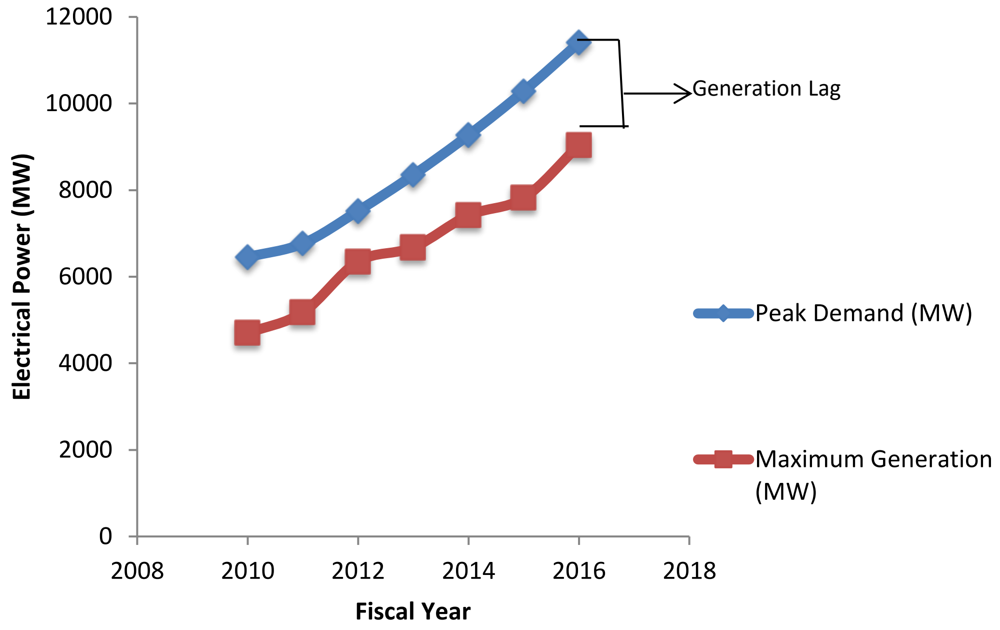

Fig. 2 Peak Demand vs Max. Generation of Electricity graph (2010-16)

5 Use of Alternative Energy Source for Bangladesh

Alternative energy means that type of energy source which is alternative to fossil fuel. Among various alternative energy sources ‘Nuclear Energy’ is the most effective and powerful. This source is capable of producing enormous power ensuring least fuel consumption. Though some controversies, nuclear energy is best for producing great power in less time. Most often, in case of producing nuclear energy Uranium and plutonium isotopes are used. The general reaction is like below:

$$235U + Neutron\ fission = Fission\ fragments + 2.4\ Neutrons + 192.9\ MeV \qquad (1)$$

$$239Pu + Neutron\ fission = Fission\ fragments + 2.9\ Neutrons + 198.5 MeV \qquad (2)$$

Bangladesh needs stable and powerful energy source to produce electricity. The existing power plants are unable to supply the needed load. The major cities of the country have to face approximately 3 to 4 hours load shedding every day. Nuclear energy is the best solution of this. A comparison between heating values of different fuels are given below in Table 1 [15].

A small amount of greenhouse gas is produced due to the use of Turbine and collar. So, nuclear power plants are sustainable in nature. From below Figure 3 it is seen that nuclear power plants emits about 90% less GHG than conventional natural gas or coal-based plants.

Table 1. Comparison between heating values of different fuels (Source: Worldwide Fuel Charter-OICA)

Fuel Type	Heat Value (MJ/kg)
Fire Wood	16
Brown Wood	9
Black Coal (Lower Grade)	13-20
Black Coal (Higher Grade)	24-35
Natural Gas	40
Crude Oil	45
Uranium (Natural)	500000

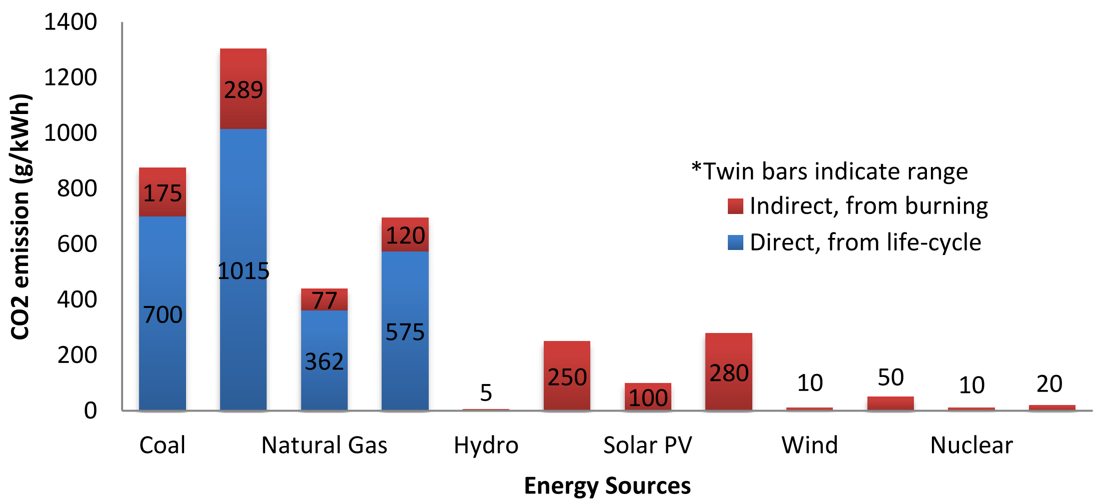

Fig.3 Greenhouse gas emission from different sources of electricity production unit

6 Logics behind Nuclear Energy Development in Bangladesh

6.1. Rising electric demand: A country cannot obtain targeted economic and technology development without providing the inhabitants with access to an uninterrupted and secure electricity supply. Bangladesh currently lags about 3000-7000 MW in spite of having generation capacity of about 16000 MW per day [16].

6.2. Pollution and Climate Change: Using non-renewable energy sources to produce power is very harmful to environment. It produces greenhouse gases (i.e. COx, NOx, SOx and etc.) when fuel is burned to produce power. This causes pollution increment and significant changes in climate change causing greenhouse effect by warming earth's surface. So, Nuclear energy in this respect is less harmful for environment as it causes very few exhaust gas emissions.

6.3. Enhancement of Technology: The nuclear industry is technology-intensive and its development tends to have spill-over effects on the country's industrial development and enhance the productivity of capital, labor and other factors of production. For these Asian countries, developing the technology and technical capacity is essential for both domestic and international concerns. The dual nature of nuclear technology has allowed countries to use it in medicine, agriculture and national defense.

7 RNPP: Feasible or not?

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 [17, 18]. Being a big project, it is being divided into two units RNPP-I and RNPP-II, both plants of same specifications. The specification of the power plant is given below in Table 2.

7.1. Reactor Design

In the RNPP, Russian technology is used. 'Rosatom' is supplying the reactors. The model used in RNPP is VVER-1200/523; in RNPP-I the installation of reactor will start at 2018 [19]. Figure 7 shows the schematic diagram of VVER-1200 reactor. The VVER (formerly WWER) is complicated designed high output reactor developed with Russian technology. A total of 67 VVER reactors has been made and supplied by Rosatom since 1960. In Bangladesh V-523 will be installed which has the highest known power output among all the VVER models. It is capable to produce minimum 1158 MW of power [20, 21]. Figure 4 and Figure 5 show a typical VVER plant layout and VVER-1200 reactor head schematic respectively.

Table 2. Basic specification of RNPP (Source: Rosatom, Wikipedia, BAEC)

Parameters	**Type/Value**
Owner	BAEC
Material Supplier	Rosatom
Reactor Type	VVER-1200/523
No. of Reactors	2
Power Units	2; RNPP-I & RNPP-II
Cooling Source	Padma River
Cooling Tower	2
Load (per unit)	1200MW
Load Output	1158-90 W (approx.)

Table 3. Key specifications of VVER-1200 Gen-III$^+$

Parameter	**Value/Type**
Service Life	60-90 years (approx.)
Electric output (per unit)	1158-90 MWe
Thermal output (pr unit)	3200 MWt
Heat supply capacity	300 MWt
Efficiency	>90%
Labour-Power ratio (person/MW)	0.35-0.5
Fuel Campaigning duration	4 years (Minimum)
Max fuel burn-up	60 MWd/kgU
Refuelling frequency	12-18 months
Outlet steam pressure	7 MPa
Primary coolant flow rate	83000 m^3/h

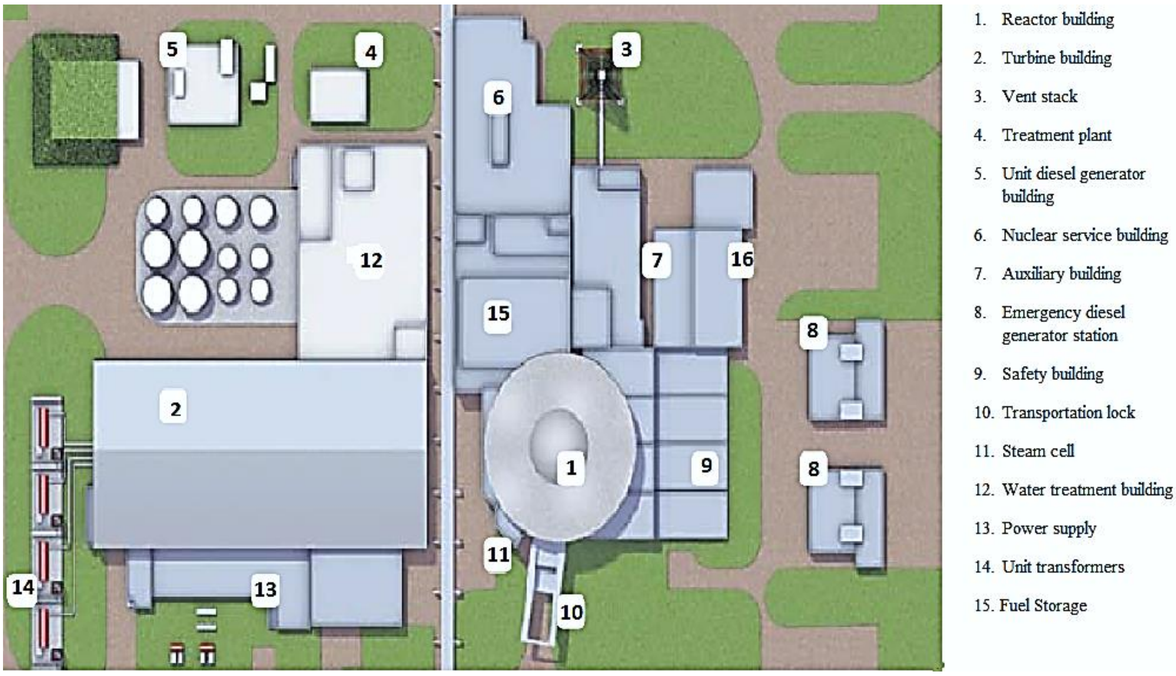

Fig.4 Schematic layout of a typical VVER plant

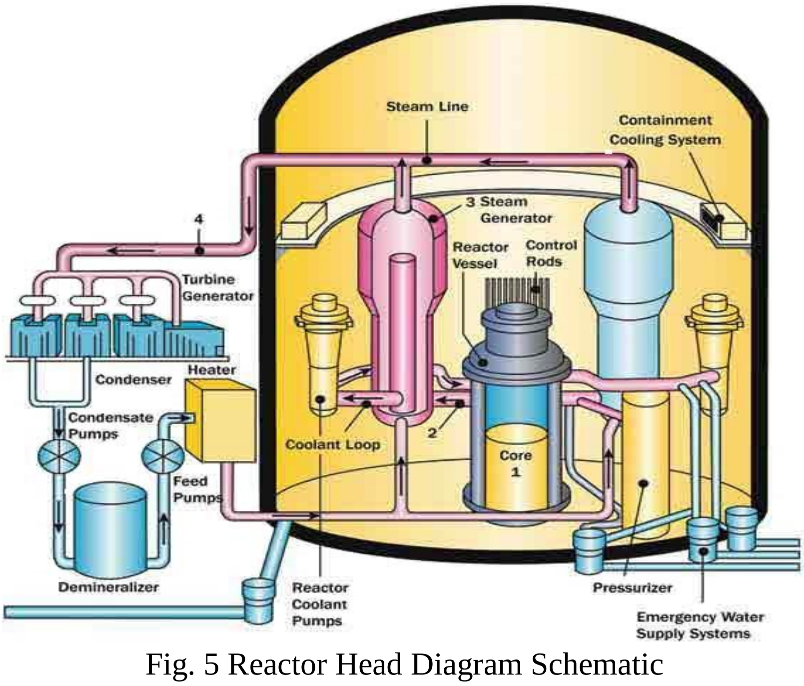

Fig. 5 Reactor Head Diagram Schematic

The characteristics of VVER-1200 Gen-III$^+$ reactor is given below in Table 3 [20, 22 and 23].

7.2. Coolant

The heat released by fission in nuclear reactors must be captured and transferred for use in electricity generation. Coolant flows around and through the reactor core ensuring a good heat transfer from the plant to atmosphere securing the reactor to be over heated. VVER-1200 is a PWR type reactor where primarily light water is used as coolant. This coolant takes the heat produced in reactor in lieu of chain reaction and transforms into highly pressurized steam capable to rotate the turbine blades. Light water is a good coolant for thermal reactors but not for fast breeders; pressurized water also moderates (slows down) the neutrons because hydrogen-1 (H-1), which comprises much of water, has a scattering cross section of $\sigma = 82.03$ barns, far larger than any other atom. PWRs have an intrinsic failsafe should the reactor overheat to the point where the water in the primary loop boils; neutrons interact less with steam and do not get thermalized, so the abundance of fast neutrons causes the rate of fission to drop. After a few minutes, the reactor achieves passive shut-down.

7.3. Fuel

Fuel plays the most important role in a nuclear power plant. In most cases, U^{233} (Natural Uranium) is used as the primary fuel of nuclear power plant, but this fuel is the most unstable though it can sustain chain reaction at a higher rate. In VVER-1200 Gen-III^{+}, the reactor cores contain 163 fuel assemblies (FA). The FAs are intended for heat generation and its transfer from the fuel rod surface to coolant during the design service life without exceeding the permissible design limits of fuel rod damage. The FAs are 4570 mm high (nominal value). When the reactor is in the hot state the height of the power generating part of the fuel rod is 3750 mm. Each FA contains 312 fuel rods. The FA skeleton is assembled of 18guide channels, 13 spacer grids welded to them, an instrumentation channel and a support grid. The fuel rod cladding is a zirconium alloy tube. Sintered UO_2 pellets with a 5% (4.95±0.05) maximum enrichment are stacked inside the cladding. The average linear heat rate of a fuel rod is 167.8 W/cm. Using UO_2 as a fuel has some remarkable advantages because of its higher stability (about 12 times of natural uranium), non-corrosive manner, well density (11000 kg/m^3) and easy compatibility with any types of coolants though it lags in good thermal conduction. Another key feature of this fuel is that it is not attacked by H_2 and N_2 where most of the fuels lag behind.

7.4. Nuclear fuel storage and handling systems

The nuclear fuel storage and handling system complex is a set of systems, equipment and components designed for nuclear fuel storage, loading, unloading, transferring and monitoring. The complex comprises a number of systems and equipment to implement all the fuel handling procedures on the site:

- Fresh (non-irradiated) nuclear fuel storage and handling system;
- Core refueling system;
- In-containment spent fuel storage system;
- On-site nuclear fuel transfer system that comprises all the handling procedures, beginning with the fresh fuel delivery vehicles acceptance up to spent fuel vehicles dispatch; arrangement of on-site nuclear fuel management record system at the Unit.

7.5. Moderator and Moderating Ratio

In nuclear reactors, fission reaction takes place. This type of reaction follows a chain rule and is of superfast manner, so to utilize the fission of neutrons in the best way it is a mandatory that after a scheduled time the speed of reaction should be reduced, thus some extra auxiliary materials are used to control this reaction termed as moderator. Light water is the cheapest and worst moderator used in nuclear power plants. It has an advantage of low-cost consumption while it lags in working as a very low-grade moderator.

7.6. Control Rod

In nuclear fission reactions, enormous amount of energy (mostly heat) is generated and as a chain mannered reaction it goes on and on. So if this reaction takes place in an uncontrolled way then the huge generated heat could severely damage the power reactor along with mankind through radiation. Control rods are used to control this chain reaction inside reactors to secure the needed amount reaction. Figure 5 shows the VVER-1200 reactor core with control rod banks. In VVER-1200 Gen-III$^+$, the control rod is made of an alloy material composed of Boron Carbide (B_4C) and Dysprosium Titanate ($Dy_2O_3.TiO_2$) [25-28]. This control rod is the most delicate part of VVER-1200 Gen-III$^+$ reactors. This alloy is highly resistive to corrosion (about $1e{+}008\times10^{-8}$ohm.m), has an extreme heat transfer capacity along with great harness (around 72000 MPa). This alloy can is also extremely resistive to heat having good heat conductivity (65 W/m.K) and specific heat (5000 J/kg.K). Figure 6 shows the core points with atomic structures of VVER-1200 [25].

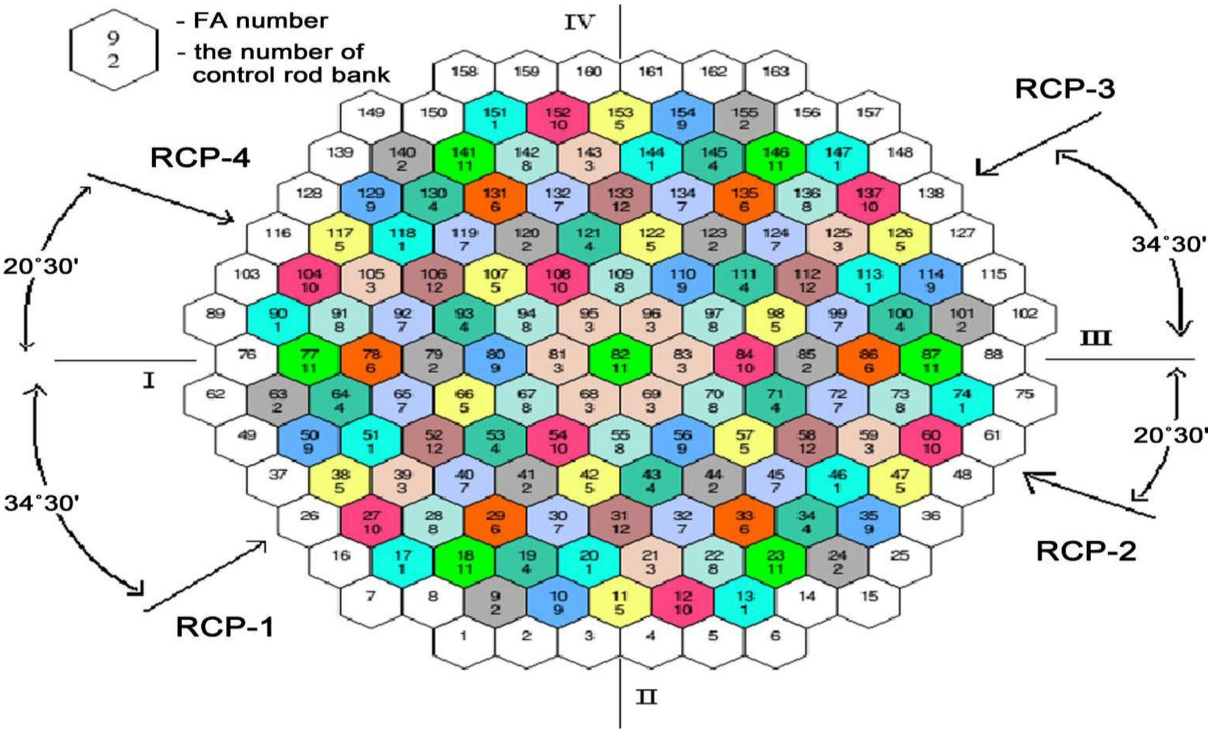

Fig. 6 Reactor core with control rod banks. (RCP- Reactor Core Point) [Reprinted with permission and proper citation]

8 Safety and security consideration of RNPP

8.1. 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 sq km. Zone-1, 2 and 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.

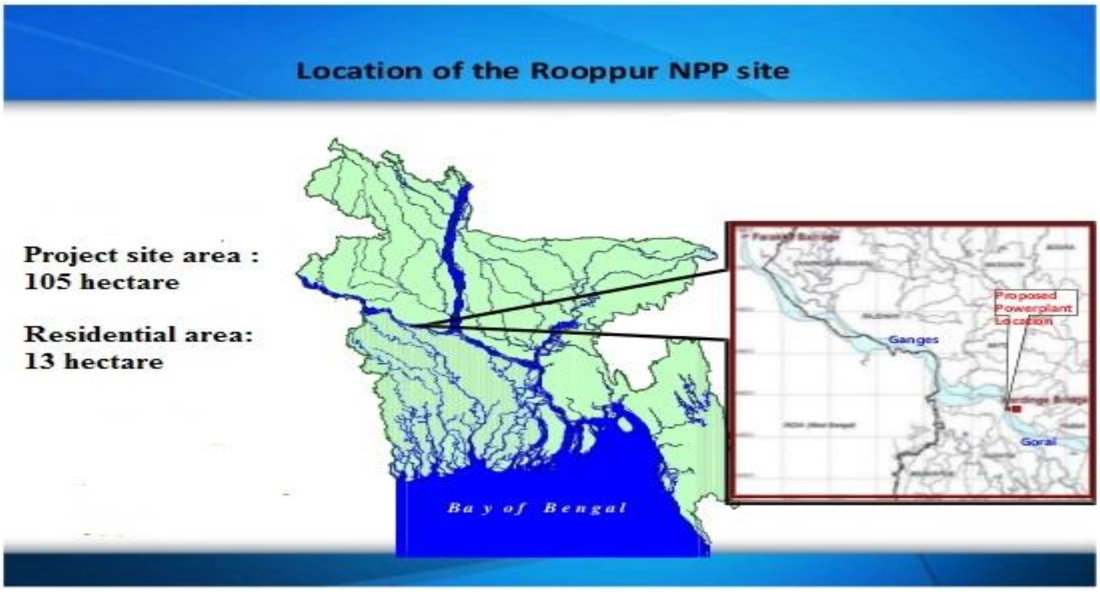

Fig.7 Location map of RNPP (Rooppur Nuclear Power Plant) site

If there is an explosion in the RNPP then living people must be transferred 3.14*40*2= 5024 sqr km outside. If 1,200 people live per sqr km then almost 1,200,000 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. Figure 7 shows the location of Rooppur nuclear power plant site.

8.2. Earthquake and Natural Disaster

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.

8.3. Waste disposal

In a nuclear power plant there may be no greenhouse gas emission but it emits a lot of radioactive particles. Radioactive particles are very harmful for human and plants. Bangladesh claimed that, Russia has assured Bangladesh about the safety of the plant. Rosatom ensured that, RNPP would be a generation 3+ power plant with safety and hazard resistant technologies [26, 27]. 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.

8.4. Cyber security

The 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. 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" [28].

8.5. Radio activity and radiation levels

The normal yearly viable measurements are 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 [29]. J. Ferdous et al. in 2015 experimented on Radioactivity of soil in proposed RNPP site and suggested not to be concerned about radioactivity. They got on average 30.85 $Bqkg^{-1}$ ^{236}Ra, 40.88 Bqkg-1 ^{232}Th and 390.10 $Bqkg\text{-}^{1}$ ^{40}K [30]. Below Table 4 shows a comparison of amount of radioactive particle of RNPP with other work all around the world [31-33].

8.6. Sustainability and Power Economics

Nuclear power plants are relatively expensive to build, but cheap to run. Table 5 shows comparison among different techniques of power generation.

Nuclear plants are economical only when used as base load plant running at higher load factors. The capital cost of a larger capacity plant like RNPP is approximately 2500-3100 USD/kW installed. So, the installation cost is a bit higher than conventional power generation plants. A typical subdivision of cost is stated at Table-6 [34].

Table 4. Comparison of RNPP with other locations of the world

Location	**Activity in Bq/kg**		
	^{226}Ra	**^{232}Th**	**^{40}K**
Dhaka, Bangladesh	37.8	58.2	790.8
Chittagong, Bangladesh	46.7	60	438
Jessore, Bangladesh	47.8	53	480
9 Southern Districts, Bangladesh	26	81	833
East-Sichuan Province, China	65	49	440
Peshawar, Pakistan	8.3	84	646
Nigeria	8.3	34.3	684
Louisiana, US	17	-	316
Nile Delta, Egypt	43-95	50-190	554-730
Worldwide (avg.)	15-50	40-43	580-700
RNPP site, Pabna, Bangladesh	41.6	21	N/A

Table 5. Comparison among different methods of energy generation

Technology	**Time (unit)**	**Time (lead)**	**Cost (Capital)**	**Cost (Operation)**	**Fuel Necessity**	**Sustainability**
CCGT	Medium	Short	Low	Low	High	NO
Nuclear	Huge	Long	High	Low	Low	OK
Coal	Large	Long	High	Low	Medium	NO
Hydro	Huge	Long	Very High	Very Low	N/A	OK
Wind	Small	Short	High	Medium	N/A	OK

Table 6. Coasting of Nuclear Power Plant of larger capacity.

Items	Approximated Cost (%)
Capital cost of land, machinery and setup etc.	65%
Fuel Cost	20%
Maintenance Cost	5%
Interest on capital cost	10%

Capital investment items include: (i) Reactor Plant (Reactor Vessel, Fueling and Handling System), (ii) Coolant System, (iii) Steam Turbines, (iv) Generators and associated equipment's and (v) Land and construction costs.

9 Technical Evaluations and Recommendations

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.

For RNPP Bangladesh is going to set up VVER (water-water energetic reactor) nuclear reactor. Power output ranges are up to 1200 MW. It is very similar to Pressurized water reactor (PWR). But, has several advantages over PWR. Some advantages are-

- Hexagonal fuel assemblies,
- No bottom penetration in the pressure vessel.
- Horizontal steam generators.
- High capacity pressurizes enable the feed water to absorb more heat.

Feed water inside the reactor serves as both coolant and moderator, which is a very important safety feature of this reactor. If for any reason the coolant capacity fails, the reaction rate diminishes and moderation effect of the water reduces, hence compensate the cooling lost.

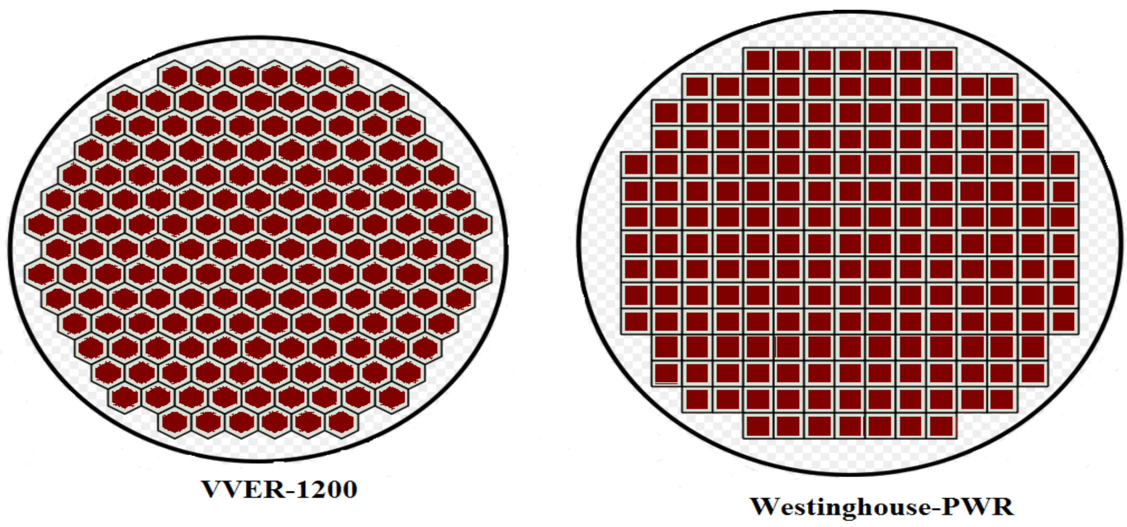

Fig. 8 Arrangement of hexahedral fuel assemblies of VVER-1200 compared to conventional PWR design

But the generation 4 – fast breeder reactors has several advantages over VVER. This type of reactors can produce 200-300 times more energy than VVER reactors. Even encapsulated aw fuels can be used in generation 4 reactors. An extraordinary advantage of this type of reactors are- the ability to consume existing nuclear waste in the production of electricity, which is a closed nuclear fuel cycle. The other advantages are automatic reactor shut down in emergency, no risk of contamination coolant water. In the start of January, 2018 reactor building companies are releasing this type of reactor for commercial uses. Since Bangladesh is going to run the power plants from 2023, so Bangladesh should go for this type of 4 generation reactor. A schematic of GEN-4 VVER and conventional PWR is shown in Figure 8.

Sometimes in nuclear power plants the reaction of fuel does not take place with uranium containing .71% of U^{235}.In such cases it becomes essential to use uranium containing higher content of U^{235}.This is called uranium enrichment. Among several methods of uranium enrichment Electromagnetic method is preferable for Bangladesh. This method is based on the fact that when ions moving at equal velocities along a straight line in the same direction are passed through a magnetic field, they are acted upon by forces perpendicular to the direction of ion movement and the field.

As this force is centripetal,

$$P = evH \tag{3}$$

$$P = \frac{mv^2}{R} \tag{4}$$

$$R = \frac{mv}{eH} \tag{5}$$

P = force acting on the Ion, e = charge on Ion, v = velocity of Ion, H = magnetic field strength, m = Ion mass, R = radius of Ion patch

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 safety and security issues present in the project. All these issues must be fixed before the opening or starting the power plant. 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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