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Rooppur Nuclear Power Plant: A New Era for Power Sector in Bangladesh

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Abstract*—*Bangladesh is a developing country. In last 15 years. Bangladesh did a tremendous development in its power sector. But still, Bangladesh is not achieved its desired goal for providing power to all sectors. One cause behind this, Bangladesh is dependent on fossil fuel based power and hydro power. Though, solar power is contributing in power sector since last 10 years, but still Bangladesh needs more and more power and energy as government of Bangladesh is establishing more industries and they need a huge amount of power. So, Rooppur Nuclear Power Plant is one of the best establishments by Bangladesh to meet its power demand. Full phase power plant will go for operation in December,2024. In this article, we tried to put some information about Rooppur Nuclear Power Plant according to the information published in several news portals and previous articles researched by researchers.

***Keywords*—** *Radioactivity, Safety, Waste management, Nuclear Reactor, Fossil Fuel. Rooppur Nuclear Power Plant.*

I. INTRODUCTION

Electricity demand in every sector is growing in a rapid way while the amount of fossil fuels is being decreased every day. Consequently, we need to think another way for power generation rather than generation of power from fossil fuel. Energy generation from Nuclear Fuel is one of the best jobs in power generation system considering that 1951 [1]. Bangladesh is a country which electricity demand could be very high in previous couple of years & growing at a fast rate with the ongoing improvement of the USA. But the USA mainly dependent on natural fuel to fulfill its excessive energy call for which aid isn't always sufficient to provide demand & is jogging out. Therefore, it is time for the USA of a to look ahead to different power generating alternatives. Numerous renewable strength resources can be a solution, but it desires an amount of time and big investment, which does not appear to a solution. Lately the authority of the USA is looking ahead to nuclear energy technology mission named Rooppur Nuclear energy Plant to remedy this electricity disaster. But protection is a totally critical aspect in nuclear electricity technology. If If we investigate a few current nuclear failures like 3 Mile Island (USA) Chernobyl (united states) & Fukushima Daiichi (Japan) where remaining two are the worst nuclear electricity plant accident & rated as seven at the seven-factor worldwide Nuclear occasion Scale, so the main problem in nuclear power era will be the safety. However, at gift safer reactors were invented and used worldwide. The maximum lately invented nuclear reactors are referred to as third era reactor and called easy and secure. Then again fuel of nuclear power plant could be very available than traditional generations. Some years earlier, the army misuse of nuclear techniques becomes a provocative question, but now recent technologies save you the ones possibilities, which make the machine more secured and dependable. fee is one of the most important elements of power era which could be very low in nuclear though its initial fee could be very a whole lot better than some other structures however era and renovation fee could be very a great deal low that makes nuclear economically possible. Nuclear waste management is a further critical challenge at the way to nuclear strength. Even though amount of this waste is very low, comparing to the alternative fossil gasoline used strategies [2]. But this waste can be technically disposed and not so difficult to manipulate. Greenhouse fuel emission is other essential aspect that is a lot lower in nuclear than different conventional electricity technology strategies meaning its far quiet environmentally pleasant to a few factors. As the density of population in Bangladesh is alarming so any undesirable situation may additionally cause extreme loss of both existence and assets in addition to environmental risks. However, to address the prevailing in addition to upcoming electricity crisis some scale of nuclear may be applied whilst protection must be the concern maximum factor. Again, as lifecycle of a nuclear reactor is much higher than a conventional fossil gasoline reactor so from this sense it may be referred to as reliable additionally. Formerly a few studies have been executed where common protection look at and technological details had been not discussed with key situation [3], [4]. Hence, this paper mainly cantered on technical info of nuclear power as well as RNPP and unique safety.

II. THE IMPACT OF REPLACING FOSSIL FUELS WITH RENEWABLES AND INCREASING ENERGY EFFICIENCY

The impact of replacing fossil fuels [19] with renewables and increasing energy efficiency can have several positive effects on reducing emissions and mitigating climate change. Here are some of the key impacts:

A. Reduction in greenhouse gas emissions:

Significantly less greenhouse gas emissions result from the replacement of fossil fuels with renewable energy sources including solar, wind, and hydroelectric power. When operating, renewable energy sources emit minimal to no greenhouse gases, in contrast to fossil fuels, which lowers the total carbon footprint of energy production.

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B. Improved air quality:

Enhancing the quality of the air can also result from using renewable energy sources. Renewable energy methods don't release pollutants like sulphur dioxide, nitrogen oxides, or particulate matter, which are known to be harmful to both the environment and human health when fossil fuels are used.

C. Energy independence and security:

Reducing reliance on imported fossil fuels can improve energy independence and security through the diversification of the energy mix with renewables. Building up domestic renewable energy resources can help nations that depend significantly on imported fossil fuels have more energy security.

D. Job creation and economic growth:

Energy efficiency and renewable energy projects have the potential to provide new employment opportunities in sectors including solar and wind power generating, energy efficiency consultancy, and renewable energy technology manufacturing. Both local development and economic growth may benefit from this.

E. Technological innovation and development:

The rising emphasis on renewable energy and energy efficiency frequently spurs technical innovation and R&D in the energy sector. This can lead to breakthroughs in energy storage technology, grid management systems, and other relevant sectors, promoting sustainable energy practices even further.

F. Mitigation of climate change impacts:

Adoption of renewable energy and energy efficiency measures can help global efforts to combat climate change by lowering the overall carbon footprint and minimizing the discharge of greenhouse gases. This can aid in meeting international objectives set by agreements like the Paris Agreement, which aim to limit global temperature rise.

It is crucial to highlight that the implementation of renewable energy sources has its own set of obstacles, such as intermittent, storage concerns, and initial investment costs. It is critical to address these difficulties properly to ensure the successful integration of renewables into the energy mix.

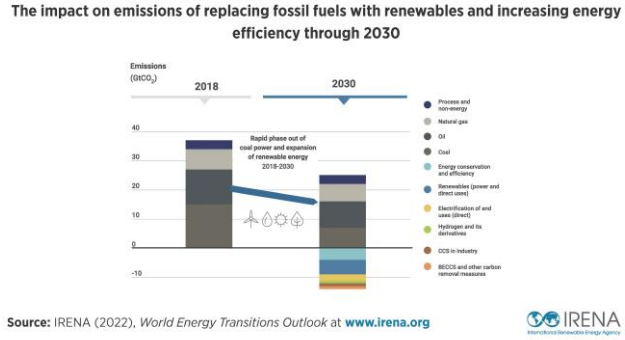

Fig.1: The impact on emission of replacing fossil fuels with renewable and increasing energy efficiency through 2030 (Source: IRENA)

III. Planning For Nuclear Power Plant

The plan for undertaking Rooppur Nuclear electricity Plant became first conceived by using Pakistan executive. In 1960 below Pakistan Atomic electricity commission (PAEC) to meet the destiny energy disaster.

Initial negotiation with USAID for a 70 MW nuclear electricity plant started in 1963. With the passing of time a number of feasibilities examines were done however due to the unwillingness of the ruling Pakistani govt. of that point, the task did no longer pop out to mild. In 1968 Russian business enterprise Techno export proposed to construct four hundred MW Pressurized Water Reactor (PWR) even as a Belgian company also submitted a proposal of 200 MW PWR plant in 1969 which regarded extra appealing and more secure than Russian one [3]. The agreement for supply, creation and erection of the plant changed into signed with WENESE in early 1971. However, after liberation struggle the assignment were postponed for some time. In 1977 a French consulting company named Sofratome began a pre-feasibility look at, which led to 1978, confirming the site as possible for one hundred twenty five MW reactors [5].

Later at some point of 1988-1989 feasibility examine were achieved by means of Lahmeyer global, Germany in association with Motor Columbus, Switzerland for Rooppur NPP (300 MW reactors). Then Bangladesh Nuclear energy action Plan (BANPAP) authorized in 2000 by way of govt. the entire nuclear roadmap is divided into 3 milestones [5]. They are :

1. Milestone-1: expertise the dedication
2. Milestone-2: equipped to invite bid/negotiation and
3. Milestone-3: equipped to fee and perform the NPP.

On 24th February 2011 Bangladesh government. have signed a number one deal with Russia for putting in a 2000 MW nuclear energy plant of two reactors every having capacity of 1000MW at Rooppur in Pabna.

Responding to the request of Bangladesh, IAEA carried out the integrated Nuclear Infrastructure evaluation (INIR) venture to study the reputation of the country wide Nuclear Infrastructure in Bangladesh throughout nine-15 November 2011, which led the United States of America to Milestone-2. A Nuclear industry information Centre (NIIC) has been installed in Bangladesh and inaugurated in Bangabandhu Sheikh Mujibur Rahman Novo Theatre, Dhaka on second October 2013 which important goal is to offer facts to the local community at the planned RNPP venture. It's far hoped that by way of 2021 one of the reactors may be in operation and by using 2030 second one will even be available in operation. Lately, in June 2014, the USA has needed its choice of constructing another nuclear strength plant with Japan's help inside the southern location of the USA.

IV. Nuclear Technologies

There are key factors in nuclear technologies, which might be generation of technology and type of technology. These are:

- *Generation Of Technologies*

There are some individual generations classified as Generation-I, II, III, III+ and IV [6].

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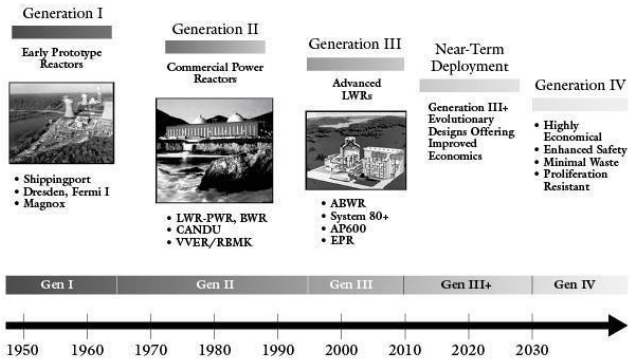

Fig.2: Generations of Nuclear Technologies

➢ *TECHNOLOGY-I:*

Early prototype and strength reactors constructed in 1950's and 1960's is particular as era-1 Reactors. Most of the G-I reactors have already been decommissioned.

➢ *TECHNOLOGY-II:*

Commercial power Reactors designed and constructed around 1970, 80 and 90 are technology-II reactors. G-II reactors are considered to have a lifetime of around forty years. Those are specially water-cooled mild Water Reactors (LWR) and enriched Uranium gas reactors. PWR, CANDU, BWR, AGR and VVER are some of the G-II reactors of which around 400+ reactors have been constructed internationally.

➢ *TECHNOLOGY-III:*

These are essentially the advanced design of LWRs. Those advancements are in the fields of gasoline technology, thermal performance, modularized production, safety systems and standardized design. The usual existence cycle of these reactors is around 60 years and considered greater easy and safe.

➢ *GENERATION-III:*

An evolutionary improvement of G-III reactors mainly within the field of safety are generation-III reactors. These are the presently to be had safer reactors.

➢ *GENERATION-IV:*

Those reactors were hoping to be the last future of nuclear trend and are available in light through 2030.

V. Different Types of Reactor Technologies

➢ *PRESSURIZED WATER REACTOR (PWR):*

Round 60% of general nuclear reactors of the world (over 230) are PWR kind. Its thermal performance is 33-34%. In Russia those are referred to as Voda Voda Energo Reactor (VVER) [8].

➢ *BOILING WATER REACTOR (BWR):*

It's a moderated layout of PWR. around 20% of total nuclear reactors numbered 84 are BWR [8].

➢ *GASOLINE-COOLED REACTOR (AGR & MAGNOX):*

Superior gas-cooled Reactor (AGR), evolved shape Magnox reactor is the second one technology British gas-cooled Reactor which makes use of natural U (steel) and UO2 as gasoline, CO2 as coolant and graphite as moderator. Its thermal performance is 40% [9]. At present 17 reactors of this kind are in operation.

➢ *MILD WATER GRAPHITE REACTOR (RBMK & EGP):*

Also called Reactor Bolshoy Moshchnosti Kanalniy (RBMK), designed and developed by way of Russia of which sixteen reactors are in operation and developed from plutonium production reactors. There are no reactors of this kind outdoor United States [8].

➢ *SPEEDY NEUTRON REACTOR (FBR):*

There are forms of FNR rapid Breeder Reactor (FBR) and Burner. best one reactor has constructed in Russia. Its generated energy is 60 instances of conventional reactors however it is still in the studies stage [8].

There are numerous types of nuclear reactors based on the cooling and moderating systems worldwide numbered around 436 [8]. Reactor manufacturers are looking for the most inexpensive and safest way to stay at the tune of the competition of large and moneymaking nuclear market.

VI. Rooppur Nuclear Power Plant

Rooppur Nuclear Power Plant is the first ever nuclear undertaking taken through Bangladesh Government. Even though there is a lot of delay in view that 1961. However, the undertaking goes to be happened through predicted year of 2021. It consists of assignment site location of one hundred and five Hectare and residential region of 13 Hectare. It's situated far beside the Ganges River from which required water for power plants is proposed to supply. The complete Rooppur assignment consists of two reactor units. The primary unit could be in operation by way of 2020 and the 2nd one by 2030. The price for the first reactor is anticipated approximately 2 billion US$ which 80% will be financed through Russia considered as tender period loan and different 20% could be USA's self-financed. Bangladesh has signed settlement with Russia for cooperation in sitting, design, construction and operation of strength and studies nuclear reactors, water desalination plants, and elementary particle accelerators. For fuel supply, waste control and decommissioning for 2 one thousand MW AES-92 type reactors to be built at Rooppur for the Bangladesh Atomic power fee (BAEC) a settlement with Rosatom turned into signed. any other intergovernmental agreement was signed for the whole venture to be built by means of atomic export [10]. For the regulation and safety another agreement became signed with Russia's Rostechnadzor to offer technical and other support to Bangladesh at Rooppur challenge.

VII. Details Of Rooppur Nuclear Power Plant

➢ *REACTOR*

The reactor has finalized for Rooppur is AES-92 1000 MW reactor wherein AES stands for Russian Atomnaja Electrostancija meaning Nuclear power Plant. AES-92 is an updated model of VVER 1000/3203 that is a Russian reactor and referred to as third technology VVER a thousand reactor (alias VVER 1000/V392). the first unit of this form of reactor went into operation in January 2007. This customized version of VVER a thousand reactor fulfils the conditions safety and reliability of IAEA and EUR. The running lifestyles cycle of this custom designed reactor is longer than all other present reactors, which is 60 years as claimed by way of Russia [10]. This reactor has greater backup systems for secure shutdown

and cooling in emergency than its older version. This newly designed reactor was advanced by way of the Russian reactor design and construction employer GIDROPRESS in cooperation with western institutions [11]. This layout has higher efficiency (56 %), longer core lifestyles, decrease in keeping with unit capital charges, shorter length of production and more suitable safety towards earthquakes with passive emergency cooling device and double containment [12].

Fig 3: Reactor of Rooppur Nuclear Power Plant

➢ *FUEL*

The middle of VVER a thousand G-III includes 163 gas assemblies, equal in design, but one of a kind in gasoline enrichment. It makes use of closed gasoline cycle with MOX fuel. MOX gasoline is the blended oxide fuel that provides 2% of the brand-new nuclear fuel used nowadays [13] distinct information of gasoline will be used has now not yet published and nevertheless remained categorized.

Russia officially Delivers 1st batch of Fuel for Rooppur Nuclear Power Plant. Total fuel will come from Russia by 7 seven segments. Already 4 segments of fuel have reached in Bangladesh in September 2023. All fuel will come by the end of December in 2023.[20]

As we already know, main fuel of Rooppur Nuclear Power Plant is Uranium

Now, this fuel is injected to reactor by following below structure.

Fig 4: Uranium Injector of Rooppur Nuclear Power Plant

➢ *COOLING*

The reactor AES-92 is a water-cooled type of reactor. They designed four loops in primary cooling circuit in AES-92. The coolant through the reactor is 86000 m3/h, strain even as operational is 15.7 MPa (max. 17.6 MPa). Temperature of coolant at inlet is 291ºC and at outlet is 321ºC [11].

➢ *SAFETY*

It's far stated that AES-92 has met European Union requirement for protection and reliability. It's declared by Bangladesh Government that the protection has total 7 layers, though no information about protection structures have been published because of confidentiality issue. However, it does fulfill EUR and IAEA recommendations. [19-20]

VIII. Safety Study

The Rooppur Nuclear Power Plant (RNPP) is a nuclear energy project in Bangladesh. Nuclear power plant safety procedures are critical to preventing accidents and protecting the environment and public health. Here are some of the most important safety precautions and procedures that are routinely implemented at a nuclear power facility like Rooppur:

1. Regulatory monitoring: To maintain compliance with safety standards and regulations, the plant should operate under the tight regulatory monitoring of the national nuclear regulatory body.

2. Design and Engineering: To prevent and minimize accidents, the plant's design and engineering should have many layers of safety, including redundant safety measures.

3. Safety Systems: Nuclear power stations have several safety systems in place, such as cooling systems, emergency power supply, and containment structures, to avoid overheating and radioactive material discharge.

4. Radiation Monitoring: It is necessary to continually track radiation levels within and outside the site in order to spot any irregularities as soon as possible.

5.Emergency Preparedness: Detailed emergency plans, including procedures for relocating workers and adjacent communities, should be in place to respond to accidents or events.

6. Drills and Training: Regular training of plant staff and emergency response teams, as well as drills and exercises, helps assure readiness for disasters.

7. Security: To prevent unauthorized entry to the plant and to defend against potential sabotage or terrorism, strong security measures are required.

8. Quality Control: To guarantee that components fulfill safety requirements, strict quality control techniques are implemented throughout construction and maintenance.

9. Aging Management: As the plant ages, it is subjected to constant inspection, maintenance, and refurbishment to guarantee the safety and integrity of its systems. [19-20]

10.Collaboration: Collaboration with international organizations such as the International Atomic Energy Agency is an example of international collaboration.

11. Public Interaction: It is crucial to maintain open and honest interactions with the public about the plant's activities and safety measures in order to grow assurance and ensure public awareness.

12. Earthquake Safety: Given the region's earthquake history, the plant's design should include methods to withstand earthquakes and other natural calamities.[17]

13. Environmental Protection: Measures should be put in place to reduce the plant's environmental effect, including proper disposal of radioactive waste.

14. Inspections on a regular basis: Independent safety inspections and audits are performed to guarantee that the facility is functioning safely and that all safety protocols are followed.

These are some of the standard safety precautions and safeguards that would be used in a nuclear power station such as Rooppur. Specifics may differ based on the design of the plant.

IX. Waste Management

In contrast to different traditional power plant structures, nuclear power generation takes complete obligation of the disposal of produced radioactive waste though the manufacturing of waste isn't very high with respect to generated energy.

However, this radioactive waste control is the maximum crucial thing of nuclear energy generation. Radioactive wastes are labeled into some classes relying on the price of radiation.

- *EXEMPT WASTE AND VERY LOW DEGREE WASTE (VLLW):*

It especially includes demolished fabric (together with concrete, plaster, bricks, metallic, valves, piping and many others.) produced at some stage in rehabilitation or dismantling operations on nuclear commercial web sites and now not considered as harmful to the environment. The waste is generally disposed with home refuse, while a few countries (i.e. France) are presently developing facilities to store VLLW in mainly designed VLLW disposal facilities [18].

- *LOW LEVEL WASTE (LLW):* It contains very small amount of radioactivity which doesn't require shielding whilst handling and transport. Comprising 90% volume, about 1% of it is radioactive [18].
- *Intermediate degree Wastes (ILW):* It is composed better quantity of radioactivity than LLW and some of it requires shielding.
- *Excessive level Wastes (HLW):* It contains the fission products and is relatively radioactive (includes about 95% of total radioactivity). That's why it requires cooling and unique shielding in addition to long term disposal facility. There are some long-time procedures to address this type of waste like mining and milling, conversion, enrichment, gasoline fabrication and so on. From fuel uranium, it is then converted to uranium hexafluoride fuel (UF6) which undergoes to boom the U-235 [19]. Then it's became UO2. Main fuel is U-238 which can be reprocessed into plutonium and utilized in navy projectiles. So, it's also a critical point of challenge. Again, there is also use of those wastes and waste merchandise in Breeder Reactor, which generates extra fissile cloth in gas than it consumes and subsequently this waste may be used as gas [3].

According to the news, published in various media in Bangladesh, this waste will be returned to Russia as like as the form when it came. The life span of every fuel packet will be 60 years.

Bangladesh Government still didn't make any waste management plant for nuclear waste.

X. Conclusion

Nuclear fuel is taken into consideration as higher risk but this dilemma can be removed via taking proper safety precautions for all situation. Bangladesh is quite dedicated to build its first nuclear power plant at Rooppur. Though there are numerous evaluations against this project, however, to fulfil its power generation crisis, going for nuclear power plant is a wise decision for the government of Bangladesh.

The research paper concludes by highlighting the significance of Bangladesh's Rooppur Nuclear Power Plant as a potential source of clean, sustainable energy. It draws attention to the extensive safety precautions put in place to reduce hazards and underscores how nuclear power may help the nation to achieve its environmental and energy objectives. The article also offers suggestions for continued enhancements and global cooperation to guarantee the Rooppur Nuclear Power Plant's long-term viability and safety.

The article also explores the sustainability and environmental aspects of the Rooppur Nuclear Power Plant. It looks at how it might lower carbon emissions, support sustainable development, and supply more energy to Bangladesh, which is a rising country. The study also explores the effects of the facility on nearby populations, addressing issues with radioactive waste disposal and any mishaps.

In order to examine the safety and sustainability performance of the Rooppur Nuclear Power Plant, the study uses a multidisciplinary methodology that integrates data from technical studies, environmental impact evaluations, and worldwide standards. Along with the tactics used for community involvement and openness, it also covers how the public views nuclear energy.

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