BANGLADESH NATIONAL REPORT

to the 8th and 9th Review Meeting

CONVENTION ON NUCLEAR SAFETY

August 2022

BANGLADESH ATOMIC ENERGY REGULATORY AUTHORITY

FOREWORD

Bangladesh had signed the Convention on Nuclear Safety (CNS) on 21 September 1995. It was formally accepted and entered into force on 24 October 1996. Pursuant to Article 5 of the Convention, this is the third full-fledged National Report being submitted by Bangladesh for review by the Contracting Parties. The Report manifests Bangladesh's adherence to its obligations under Articles 6 through 19 of the Convention. This National Report has been prepared in accordance with the "Guidelines Regarding National Reports under the Convention on Nuclear Safety" issued as information circular INFCIRC/572/Rev.6.

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LIST OF ABBREVIATIONS

BAEC	Bangladesh Atomic Energy Commission
BAERA	Bangladesh Atomic Energy Regulatory Authority
BPDB	Bangladesh Power Development Board
CNS	Convention on Nuclear Safety
DBE	Design Basis Earthquake
DPP	Development Project Proposal
ECCS	Emergency Core Cooling System
EIA	Environmental Impact Assessment
EPSS	Emergency Power Supply System
FE	Feasibility Evaluation
IAEA	International Atomic Energy Agency
IGA	Inter Government Agreement
INIR	Integrated Nuclear Infrastructure Review Mission of IAEA
IRRS	Integrated Regulatory Review Service
LDC	Least Developed Countries
LOCA	Loss of Coolant Accident
MCP	Main Circulating Pump
MOST	Ministry of Science and Technology
NDMC	National Disaster Management Council
NNRERP	National Nuclear or Radiological Emergency Response Plan
NPCBL	Nuclear Power Company of Bangladesh Limited
NPP	Nuclear Power Plant
NPT	Non-Proliferation Treaty
NSRC	Nuclear Safety and Radiation Control
PMU	Project Management Unit
PRZ	Pressurizer
RF	Russian Federation
RNPP	Rooppur Nuclear Power Plant
RP	Reactor Plant
RPV	Reactor Pressure Vessel
SBO	Station Blackout
SSE	Safe Shutdown Earthquake

1. INTRODUCTION

Government of the People's Republic of Bangladesh signed the Convention on Nuclear Safety (CNS) on 21 September 1995. After the formal acceptance, it was subsequently entered into force on 24 October 1996. As per the obligations set forth by the CNS, each Contracting Party is required to apply widely accepted nuclear safety principles and tools in order to maintain a high level of safety in the nuclear installation(s) in its jurisdiction. In addition, as per the provisions of Article 5 of the CNS, it is also required to present a national report on the implementation of these principles to the review meetings of the Contracting Parties.

Until now Bangladesh does not have any "nuclear installations" in operation or decommissioning stage as defined in the Convention. However, Bangladesh is going on with the construction of two units of its first nuclear power plant named Rooppur Nuclear Power Plant (Rooppur NPP) project in the north-western part of the country with the help of Russian Federation. The Rooppur NPP units are VVER-1200 (AES 2006) PWR based on Unit 1 and 2 of Novovoronezh NPP-2 in the Russian Federation, which is the reference plant for the Rooppur NPP. In addition, Bangladesh has a 3 MW research reactor in operation for more than three decades.

Bangladesh started presenting its full-fledged national reports from the 7th Review Meeting of the Contracting Parties of the CNS in 2017 just after the inception of construction of the Rooppur Nuclear Power Plant unit 1. Accordingly national report for the 8th Review Meeting was submitted and the present national report for the 8th and 9th Review Meeting is the updated version of the Eighth National Report; it has been prepared in accordance with the requirements of the Convention on Nuclear Safety and Guidelines regarding National Reports under the Convention on Nuclear Safety (INFCIRC/572/Rev.4) and includes the progress made so far after the submission of that report. It also includes the actions taken or in progress to improve safety or challenges identified during the last Review Meeting of the Contracting Parties. The Report manifests how Government of Bangladesh continues to fulfil its obligations under Articles 6 through 19 of the Convention.

2. SUMMARY

Bangladesh has firmly made its transition from LDC to middle-income country status and aspires to become a developed country by 2041. With rapid energy demand growth, especially for electricity the indigenous resources of primary energy (natural gas) would be inadequate to meet the incremental demand of energy on a sustainable and long-term perspective. Nuclear

power offers diversification of energy resources and contributes to the stability of energy supply-demand structure. Its low and stable operational cost will make it a reliable source of energy for sustainable development. Subsequently, Bangladesh decided and is currently implementing its first nuclear power programme to produce safe, environment friendly and affordable base load electricity and to reduce dependence on imported energy and to increase diversity of energy resources for ensuring long term energy security. The first initiative of installing a nuclear power plant in the territory of Bangladesh was taken in 1961. Since then, particularly post-independence (1971) till present days, several feasibility studies have been conducted and based on those studies nuclear power project at Rooppur site has been recognized to be a viable option.

Bangladesh adopted a Nuclear Power Action Plan [1] in 2001 considering the role of nuclear power as vital for long-term energy security and sustainable development of the country. Later in 2007 government affirmed its plan to build a nuclear power plant in the Rooppur site of Pabna district (about 140 km W-NW of Dhaka, the capital city of Bangladesh) to meet the shortage of electricity as well as to diversify the sources of energy. Around that time, Bangladesh had inadequate infrastructure, resources, professionals and expertise to kick-off developing necessary infrastructure for nuclear build. However, it had a clear understanding on the requirements for NPP build according to the IAEA guidelines and national and international obligations. Acknowledging the importance of an appropriate, phased and comprehensive approach to the development of national nuclear power infrastructure, the government had taken all necessary steps required for establishing national nuclear power infrastructure based on the widely used IAEA document “Milestones in the Development of a National Infrastructure for Nuclear Power” (IAEA Nuclear Energy Series No. NG-G-3.1) [2]. Accordingly, the nuclear infrastructure development activities of Bangladesh were divided into three progressive phases with outlining 19 infrastructure issues to be addressed in each phase.

After considering various proposals from number of vendor countries, Bangladesh finally signed an intergovernmental agreement with the Russian Federation in November 2011 on cooperation for construction of a nuclear power plant in the People’s Republic of Bangladesh.

According to the current legislation in Bangladesh, namely the Bangladesh Atomic Energy Regulatory (BAER) Act-2012 [3], the prime responsibility for the safety of a nuclear installation lies with the utility. A statutory regulatory body, named Bangladesh Atomic Energy Regulatory Authority (BAERA), has been established in February 2013 to oversee all nuclear and radiation safety related aspects and has been given appropriate authority/powers to develop

safety rules, regulations and guides and has powers to inspect & enforce safety provisions in nuclear installations and related activities. In this regard, Nuclear Power and Energy Division (NPED) of Bangladesh Atomic Energy Commission (BAEC) was assigned the responsibility for carrying out all project related activities of construction of Rooppur NPP before formal creation of the project management unit (PMU) named First phase of Rooppur Nuclear Power Project. In December 2015, BAEC signed the main contract of the construction with JSC Atomstroyexport (ASE) of the Russian Federation.

Later, Government of Bangladesh has promulgated the Nuclear Power Plant Act-2015 [4] that establishes a company named Nuclear Power Plant Company Bangladesh Limited (NPCBL) under the ownership of BAEC to run the Rooppur NPP.

On 21 June 2016, Bangladesh Atomic Energy Regulatory Authority (BAERA) issued "Siting Licence" to Bangladesh Atomic Energy Commission. Design and construction licences of Unit 1 and Unit 2 of Rooppur NPP have been issued by BAERA on 02 November 2017 and 08 July 2018, respectively after fulfilling all regulatory requirements and terms & conditions of Siting Licence. Necessary site improvements and preparatory civil engineering works have also been completed by the time frame mentioned above for each unit. Accordingly, the First Concrete Pouring (FCP) of the Reactor building of Unit 1 and Unit 2 have been formally done on 30 November 2017 and 14 July 2018, respectively. By August 2018, molten core catcher of Unit 1 and June 2019 molten core catcher of Unit 2 has been installed. In October 2021, Reactor Pressure Vessel of Unit 1 has been installed and preparation has been taken for the installation of Reactor Pressure Vessel of Unit 2 by this year. Currently, construction activities of both units of Rooppur NPP have been going on in full swing.

Bangladesh has taken all necessary steps required for developing national nuclear power infrastructure based on the widely used referring document, the "Millstones in the Development of a National Infrastructure for Nuclear Power" (IAEA Nuclear Energy Series No. NG-G-3.1) [2]. Accordingly, the whole nuclear infrastructure development activities have been divided into three progressive phases where underlying 19 infrastructure issues will be addressed in each phase.

To realize the establishment of national nuclear power infrastructure in an appropriate, phased, coordinated and comprehensive manner, high level Government Committees have been formed. These are National Committee for the implementation of the Rooppur NPP Project, Technical Committee for regular supervision of progress in implementation of the Rooppur NPP Project, review and decide on project related and technical matters,), Working Committee

and further 08 Sub-Groups to help the Working Committee. This committees establishes overall administrative provision for coordinating the activities on 19 infrastructure issues, developing relevant policy and strategy on "Rooppur NPP" project development and implementation, monitoring the progress of the project activities and providing recommendations and directives required for successful implementation of the project. The Hon'ble Prime Minister chairs the National Committee whose terms of reference include providing necessary directives and policy decisions on nuclear infrastructure program, deciding ownership pattern and project execution approach, selecting funding mechanism, strategic partnership and development of contract arrangements for "Rooppur NPP", capacity building and technical competency development, nuclear safety and regulatory infrastructure development, etc. Alongside the National Committee, the Technical Committee mentioned above is headed by the Minister, Ministry of Science and Technology (MOST). The Working Committee and eight Sub-Groups, headed by the Secretary, MOST, have been formed to coordinate the overall work on 19 infrastructure issues of the concerned ministries/organizations and review the progress of "Rooppur NPP" project activities. The Technical Committee and the Working Group and Sub-Groups are coordinating all activities in relation to the infrastructure issues and monitoring regularly the progress of the project activities. Further to this, the Coordination Committee and various Sub-committees of BAEC are dealing with different technical aspects and providing support and cooperation to the project. Significant progress has been made in the development of national nuclear power infrastructure following the Integrated Nuclear Infrastructure Review (INIR) mission to Bangladesh conducted by the IAEA in November 2011 to review the status of the National Nuclear Infrastructure as a newcomer country for NPP. The INIR mission had reviewed the 19 issues of Phase 1 and Phase 2. After reviewing the activities, the INIR mission provided 50 recommendations and 20 suggestions and concluded in general that the nuclear power infrastructure development of the country had progressed into Phase 2 by then.

Later, in May 2016, IAEA conducted the INIR follow-up mission to Bangladesh; The INIR follow-up team concluded that Bangladesh has made manifested progress on the national infrastructure for nuclear power in general by initiating its actions responding to all recommendations and suggestions and in particular by completing implementation of 26 of the recommendations and 14 of the suggestions from the 2011 INIR mission, in the areas of Management, Funding and Financing, Legislative Framework, Safeguards, Regulatory Framework, Electrical Grid, Human Resource Development, Stakeholder Involvement, Site and Supporting Facility, Environmental Protection, Emergency Planning, Nuclear Fuel Cycle,

Radioactive Waste, Industrial Involvement and Procurement. However, as per the mission's report the other 24 recommendations and 6 suggestions require further work to complete. By 2022, Bangladesh has addressed most of these recommendations thereby firmly proceeding with the construction work of the two units of Rooppur NPP setting exemplary record as a nuclear newcomer country.

3. ARTICLE 1 TO 5

These Articles cover the following:

- Article 1 – *Objectives*
- Article 2 – *Definitions*
- Article 3 – *Scope of Application*
- Article 4 – *Implementing Measures*
- Article 5 – *Reporting*

No report is required in respect of these Articles.

4. EXISTING NUCLEAR INSTALLATIONS (ARTICLE 6)

Till date, no nuclear power plant is in operation or decommissioning stage in the territory of Bangladesh. Following the framework agreement with the Russian Federation on peaceful uses of atomic energy in 2010, an intergovernmental agreement was signed between the two countries in November 2011 to construct two VVER type reactor power units at the Rooppur site (Figure 1).

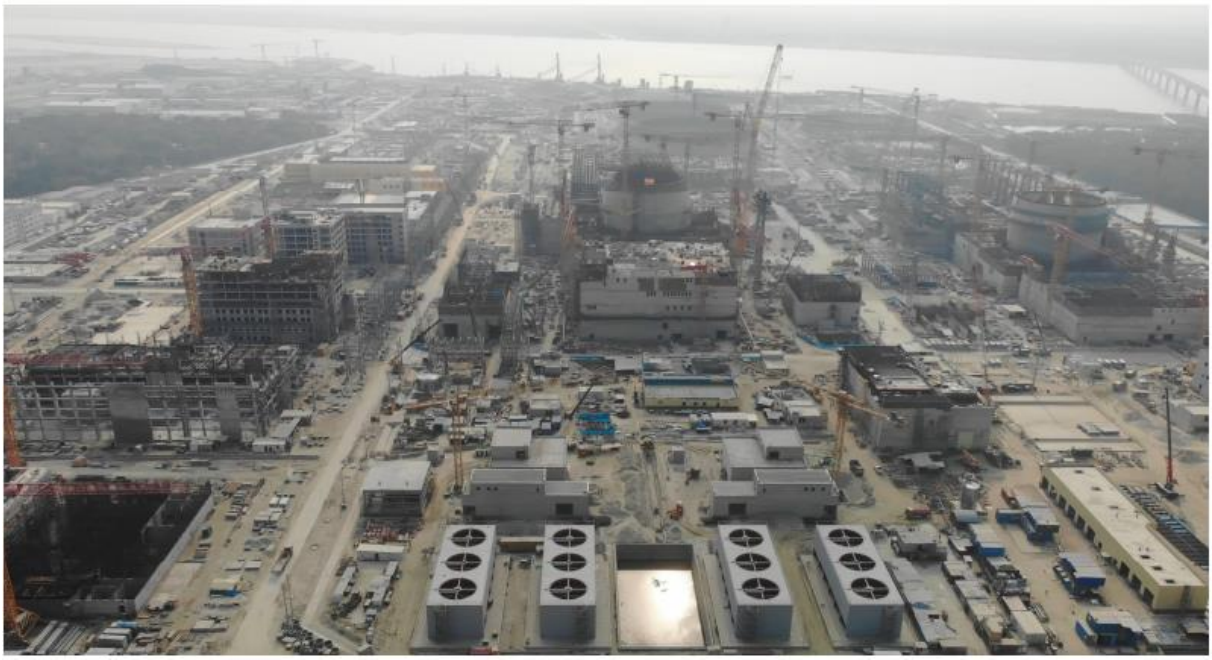

Figure 1:Roopur NPP construction activities

On 16 September 2015 government promulgated a law that established a company named Nuclear Power Plant Company Bangladesh Limited (NPCBL) to run the plant; the same recognized BAEC to be the owner of the plant.

The General Contract for the construction of Rooppur Nuclear Power Plant (Rooppur NPP) between Bangladesh Atomic Energy Commission (BAEC) and JSC Atomstroyexport was signed on 25 December 2015, and it was finalized that the plant will be of type AES-2006 with V-392M reactors, where Novovoronezh II will serve as the reference plant for the Rooppur NPP project.

Bangladesh Atomic Energy Regulatory Authority (BAERA), the nuclear regulatory body of Bangladesh, granted “Siting Licence” to the BAEC on 21 June 2016 for building Rooppur NPP with 2 units of VVER-1200 PWR.

Figure 2: Construction of reactor building of Rooppur NPP Unit1 and 2

Under the provisions of the Siting Licence of Rooppur NPP Unit-1 and 2, BAEC completed soil stabilization works and other preparatory civil construction works under the Reactor building Unit-1 and Unit-2 and prepared the safety status report for consideration of BAERA. After thorough review and assessment of the Preliminary Safety Analysis Report (PSAR) and Soil Stabilization Safety Report, BAERA has issued the Design and Construction Licence for the first unit of Rooppur NPP on 02 November 2017. On 30 November 2017 construction of the first unit of Rooppur NPP was formally started with the pouring of the first nuclear safety-grade concrete at the base of reactor building. In the 3rd and 4th quarter of 2021, Reactor Pressure Vessel (Figure 3) and Steam Generators of Unit 1 have been installed into the design position. Currently, construction activities of Unit 1 and Unit 2 have been going on in full swing.

Figure 3: RPV of Rooppur NPP Unit 1

Figure 4: Construction of Cooling Towers – Rooppur NPP

BAERA had successively granted the Design and Construction Licence for Rooppur NPP Unit-2 on 08 July 2018. After finishing necessary site improvement activities and getting the required regulatory approval, first concrete pouring at the reactor building of the Unit-2 of Rooppur NPP was done on 14 July 2018, which marks the formal inception of its construction work. Expected date of installation of Reactor Pressure Vessel and Steam Generators of Unit 2 are in the 3rd and 4th quarter of 2022, respectively.

Although, at present Bangladesh has no nuclear installation/nuclear power plant as per the definition of the convention, Bangladesh Atomic Energy Commission, has the mandate for development and application of nuclear science and technology for peaceful uses of atomic energy in Bangladesh. The BAEC commissioned a cylindrical shaped pool type light water cooled and graphite-reflected 3 MWt TRIGA MARK II research reactor named BAEC TRIGA Research Reactor (BTRR) in 1987 for research as well as production of isotopes for industrial and medical uses.

Figure 5: Reactor Hall of BAEC TRIGA Research Reactor (BTRR)

BTRR uses uranium-zirconium hydride fuel elements in a circular grid array. The array also contains graphite elements that serve to reflect neutrons back into the core. The core is situated near the bottom of a water filled tank and the tank is surrounded by a concrete bio-shield, which acts as radiation shield as well as provides structural support. Figure 5 shows the reactor hall and Figure 6 shows the old and new (digital) console of the BTRR. This research reactor is licensed by the Bangladesh Atomic Energy Regulatory Authority (BAERA) to operate at a maximum steady state power of 3 MW (thermal) and can also be pulsed up to a peak power of about 852 MW with a maximum reactivity insertion of up to $2.00 having a half-maximum pulse width of nearly 18.6 milliseconds.

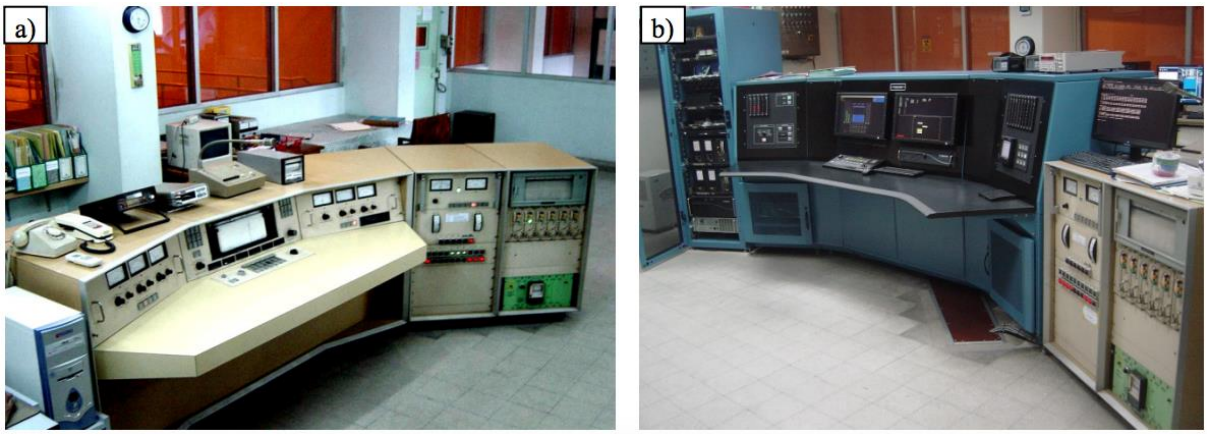

Figure 6: (a) Old and (b) new (digital) console of the BTRR

5. LEGISLATIVE AND REGULATORY FRAMEWORK (ARTICLE 7)

5.1 ESTABLISHING AND MAINTAINING A LEGISLATIVE AND REGULATORY FRAMEWORK

5.1.1 Overview of the legal framework in Bangladesh

The legal framework in Bangladesh consists of Act/laws, rules, regulations, guides, and codes & standards. The hierarchical pyramid that forms the legal basis for control with respect to activities/facilities using ionizing radiation including nuclear installation is given in Figure 7. This legislative and regulatory framework of Bangladesh ensures compliance with international conventions and treaties, and International Atomic Energy Agency (IAEA) safety requirements with almost all the aspects of nuclear safety and security in addition to those for domestic/local requirements.

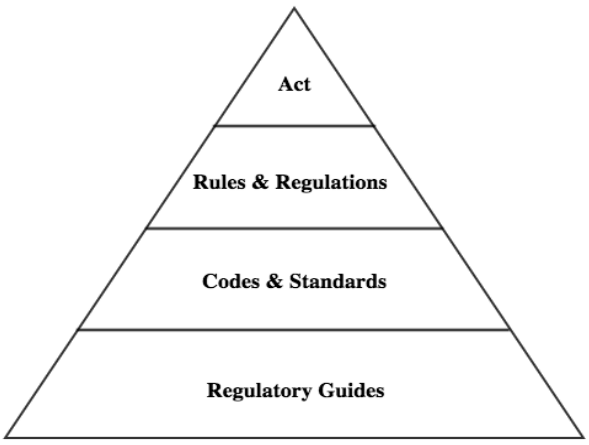

Figure 7: Hierarchy of regulatory instruments in Bangladesh

The present legislative and regulatory framework of Bangladesh guarantees proper consideration for health, safety, security and protection of the worker, people and environment whilst utilizing nuclear materials and facilities as well as carrying out any nuclear and ionizing radiation related activities. Bangladesh, as a non-nuclear weapon state party to the Non Proliferation Treaty (NPT), has established a state system of accounting for and control of nuclear materials based on the agreement between Bangladesh and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Safeguards Agreement) and Protocol Additional to the Agreement between the People's Republic of Bangladesh and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Additional Protocol). Bangladesh is also a party to the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities.

Bangladesh Atomic Energy Commission (BAEC), which was established in 1973 by a Presidential Order [5] (which is repealed in 2017) for the promotion of the peaceful uses of atomic energy through executing all possible activities, such as research work, generation of electricity via nuclear power plants, etc. was also assigned the role of the nuclear and radiation safety regulator in the country through the promulgation of the Nuclear Safety and Radiation Control Act of 1993 [6]. Under the umbrella of the BAEC, a separate division named Nuclear Safety and Radiation Control Division was created to regulate all nuclear and radiation related activities in Bangladesh including that carrying out by the BAEC itself. To effectively control the activities under its jurisdiction, Nuclear Safety and Radiation Control Rules [7] was issued in 1997. Since then, it was the only supervisory body for all nuclear and radiological activities in the country until 2012, when the government promulgated new act named Bangladesh Atomic Energy Regulatory Act, 2012 [3] to address the shortcomings in the repealed NSRC act-1993. This new act, which was drafted, based on the IAEA Handbook on Nuclear Law [8], has established a regulatory body (BAERA) in Bangladesh to regulate the nuclear and radiation safety in a rigorous and broad way to fulfill all the requirements set by the IAEA as well as other international instruments. In addition to the BAER Act-2012 [3], owner/operator of any nuclear or radiation facilities/installations must abide by other relevant laws/acts in the country; for instance, Environmental Conservation Act-1995 [9] regulates environmental impact of these facilities, The Disaster Management Act-2012 [10] regulates the role of different organizations and management schemes in case of natural and manmade disasters that encompass nuclear and radiological incident/accidents, etc. Bangladesh Nuclear Power Plant Act, 2015 [4] was also promulgated that established the Nuclear Power Plant Company Bangladesh Limited as

the NPP operating organization for all future NPP's including the current Rooppur NPP project. On 22 November 2017, Bangladesh Atomic Energy Commission (BAEC) Order,1973 [5] has been repealed and re-enacted as Bangladesh Atomic Energy Commission (BAEC) Act- 2017 [11] for the continuity of BAEC as well as making it up to date according to the sprits of the age. The National Nuclear and Radiological Emergency Preparedness and Response Plan for the country has been promulgated in November 2020 and has been entrusted with the responsibility of the concerned agencies or agencies to mitigate nuclear and radiological emergencies. National policy on the management of radioactive waste and spent fuel has also been promoted in October 2021.

5.1.2 International Legal Instruments Related to Nuclear Safety

Bangladesh is a party to the following international legal instruments for safe, secure and peaceful uses of nuclear energy:

a) Convention on Early Notification of a Nuclear Accident (Entry into force 07 February 1988)

b) Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Entry into force 07 February 1988)

c) Convention on Nuclear Safety (Entry into force 24 October 1996)

d) Convention on Physical Protection of Nuclear Material (Entry into force 10 June 2005) and its amendments (July 2017), known as the Convention on Physical Protection of Nuclear Material and Nuclear Facilities

e) Application of Safeguards in connection with the Treaty on the Non-Proliferation of nuclear weapons (Entry into force 11 June 1982)

f) Protocol Additional to the Agreement between the People's Republic of Bangladesh and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Entry into force 30 March 2001)

g) Treaty on the Non-Proliferation of Nuclear Weapons (Accession on 27 September 1979).

5.2 PROVISIONS OF LEGISLATIVE AND REGULATORY FRAMEWORK

5.2.1 National Safety Requirements and Regulations

The national legal requirement on nuclear and radiological safety for all activities related to the safe and peaceful uses of atomic energy in Bangladesh stems from the Section 18 of the BAER

Act-2012 [3] that imposes restrictions to undertake certain activities in the country without having appropriate form of authorization by the Bangladesh Atomic Energy Regulatory Authority (BAERA). BAERA, by exercising powers under section 11 of the Act, is the competent authority in Bangladesh to ensure the compliance of nuclear safety in any nuclear installation. Moreover, Section 30 of the BAER Act-2012 explicitly states that it is the sole responsibility of an authorization holder to ensure nuclear safety in his/her nuclear installation. The same Section allows BAERA the power to make regulations on the requirements of nuclear safety. There is also a provision in the BAER Act-2012 that allows the NSRC rules 1997 [7] made under the repealed NSRC Act 1993 [6] continue to be in force as if made under the present BAER Act with necessary adjustment until comprehensive and detailed regulations are in place under the BAER Act-2012. These rules (NSRC Rules 1997) also provide list of applicable standards, codes and guides relevant to different stages of nuclear installations to ensure nuclear safety. Moreover, number of regulations is in the development process that encompasses the authorization process and addresses the safety principles in detail to ensure nuclear safety in light of the present knowledge base of post-Fukusima era.

5.2.2 System of Licensing

5.2.2.1 Requirements and Legal Provisions of Licensing under the BAER Act

The requirements and process for obtaining licence from the Authority (BAERA) is specified in Section 18 and 19 of the BAER Act-2012 [3]. Section 18 of the Act clearly states that no person, operator or overseas operator shall siting, design, construct, commission, operate, and decommission any nuclear installation and release the site from regulatory control without holding an authorization issued by the Authority. In addition, the Act restricts to procure, produce, own, import, export, possess, use, transport, process, reprocess, trade, transfer, displace, store, abandon or dispose any nuclear material, radioactive waste and spent fuel and carryout research on them without having appropriate form of consent of the BAERA.

As per Section 19 of the BAER Act-2012, BAERA issues the authorization in the form of License and Permits to a nuclear installation for different life stages (for instance, Siting Licence, Design and Construction License, Operating Licence, etc.) and carries out safety monitoring, inspection and enforcement activities under the provisions of Section 51 and 52 of the Act. Section 21 of the Act prescribes the general procedure for issuing authorization. For different stages/types of authorization, BAERA follows specific standards, codes and guides or adopt regulations from vendor country that specify the minimum safety related requirements

that must be fulfilled by a nuclear installation (NPPs) to get the regulatory approval at every stage leading to authorization for full operation (Operating Licence) as per NSRC Rules 1997 [7]. Presently safety requirements for nuclear installations are substantiated by requiring compliance with the vendor country's regulations and the IAEA safety documents in addition to the local requirements. To facilitate the licensing process the Applicant is required to submit to the BAERA relevant approved documentation of a reference plant of the proposed design that is licensed in the vendor country.

These authorizations are issued by BAERA on the basis of its rigorous review and assessment process. Adherence to the regulatory requirements and licensing terms & conditions are verified by conducting periodic onsite inspections. Section 51 and 52 of the Act specifies the requirement on regulatory inspection and enforcement to be carried out by the BAERA in NPPs. For NPPs, the authorizations are issued for the major stages like Siting, Design and Construction, Commissioning, Operation and Decommissioning and these authorization types are known as licences or permits. So far, apart from the experience in regulating the TRIGA MARK II Research Reactor, the newly established BAERA has recently issued the Siting License and Design & Construction License for the two units of VVER-1200 reactor at Rooppur NPP. The detailed licensing process in Bangladesh is described in section 15 and 16 of this report, which is in Article 17 of CNS (Siting) and Article 18 (Construction), respectively. The BAERA also conducts regular reviews to establish whether the terms and conditions under which a licence has been granted are still adequate and appropriate for the present and future to protect workers, the public and the environment, taking account of any developments that have occurred in the present construction phase that might have bearing on nuclear safety in the future operating stage. Given the developments, if a review indicates that the level of safety can and should be improved, the BAERA is empowered by the Act to amend the terms and conditions accordingly.

5.2.3 System of Regulatory Inspection and Assessment

One of the main responsibilities and functions of the BAERA is regulatory inspection. The regulatory inspection and assessment process as specified in Section 51 of the Act [3] ensures compliance of the authorization holder/licensee's performance of the licensed/permitted activities with the safety provisions as prescribed in BAER Act-2012 and the rules/regulations and guidance documents made or adopted under it.

Both inspection and enforcement activities (Section 52 of the Act) cover all areas throughout the lifetime of a nuclear installation. The scope and content of the inspection to be conducted

are not only limited to the authorized NPPs premises but also include its contractor and supplier chains. BAERA conducts inspections to make sure that the authorization holder is in compliance with the conditions set out in the authorization and all applicable regulations, codes and standards. BAERA may resort to enforcement actions as deemed necessary in the event of gross deviations from, or non-compliance with conditions and requirements. Regulatory inspection includes announced and unannounced inspections in the entire lifetime of a nuclear installation including safety related activities on site and contractors/suppliers off site activities to ensure compliance with regulatory requirements.

BAERA can conduct inspection to:

- verify that the safety regulations formulated under the Act are being properly complied with;

- verify that the nuclear safety conditions, limits of radioactivity and doses of ionizing radiation are being complied with, collect related documents, equipment or materials or their samples for analysis, and demand necessary information from the person(s) concerned;

- examine designs, drawings, modification of layout & structure pertaining to nuclear safety and radiation protection, physical protection, records, memoranda, reports or documents pertaining to the use, operation, maintenance or storage of any radiation source or, nuclear or radioactive material;

- direct the authorization holder(s) to take necessary measures in order to ensure the safety of the public health, property and environment as per provisions of the Act and regulations made there under;

- verify the compliance with security requirements and cover the safeguards related activities under the Act.

5.2.4 Enforcement of Applicable Regulations and Terms of Licences

According to Section 11(3) of the BAER Act-2012 [3], BAERA may issue, amend, suspend or revoke authorizations such as license, permit etc. if it deems necessary for all the restricted activities as mentioned in the act. These include all the authorization steps associated with a nuclear installation.

To be specific, if any authorization holder –

- violates any provisions of the Act and rules or regulations made there under or the conditions of authorization applicable in case of action or services; and

- obtains authorization by providing incorrect or misinformation;

Then the authority shall issue a notice to that person to show cause within specific time limit as to why he/she shall not be punished, and the authorization shall not be suspended or cancelled. The notice shall have specific description of the nature of violations and amendment or remedial action; provided that the authorization holder shall be obliged to perform the above-mentioned measures by his own responsibility within specified time up to the quality accepted by the Authority. If the authorization holder fails to comply with the notice, the Authority may lock and seal or cease the operation of any nuclear installation or radiation facility as applicable.

In this regard, it is worth to mention that one of the enforcement actions as mentioned in the BAER Act-2012 "lock and seal" has relevance with radiation facilities rather than nuclear installations. For nuclear installations, the term "cease the operation" is the last resort before enforcing other minor form of penalties or enforcement actions.

6. REGULATORY BODY (ARTICLE 8)

6.1 ESTABLISHMENT OF THE REGULATORY BODY

6.1.1 Legal foundations and mission of BAERA

To regulate the peaceful uses of atomic energy and its safe management, Bangladesh Atomic Energy Regulatory Act-2012 [3] [12] was passed in the National Parliament on 19 June 2012. The Government of the People's Republic of Bangladesh, exercising the powers conferred by Section 4 of the BAER Act-2012, has established a regulatory body named Bangladesh Atomic Energy Regulatory Authority (BAERA) on 12 February 2013 to carry out regulatory and safety functions with regard to nuclear power generation and use of ionizing radiations in the country.

According to the Schedule I (Allocation of Business among the different Ministries and Divisions) of the Rules of Business-1996 [12] of the Government of the People's Republic of Bangladesh, MOST looks after all matters relating to science and technology in the country. Its mission is to support attainment of overall socio-economic development of the country through research, development, extension and successful utilization of science and technology. Therefore, both the organizations BAERA and BAEC responsible respectively for regulations and development of nuclear power plant (up to the point of integration to the national grid), are,

accordingly, placed under MOST. Regarding the status of the BAERA, Section 4 of the BAER Act – 2012 states that Government shall, for carrying out the purposes of this Act (BAER Act-2012), establish a Statutory Regulatory Body to be called the Bangladesh Atomic Energy Regulatory Authority after the commencement of the Act. Concerning the power of the regulatory authority, i.e., BAERA, Section 6(5) of the Act states that "The Chairman and the Member shall exercise such powers and perform such functions as may be prescribed or assigned to them under this Act or the Rules or the Regulations made under this Act". In this context, Section 11 (Responsibilities and Functions of the Authority) does not impose any clause that can compromise BAERA's independent decision-making process. At present, BAERA is the regulatory body (as per the Convention on Nuclear Safety) and the competent authority of the People's Republic of Bangladesh (as per the Amendment to the Convention on the Physical Protection of Nuclear Material).

BAERA's mission is to authorize and regulate the sources of ionising radiation and the use of nuclear energy in Bangladesh to ensure adequate protection of workers and public health and the environment. Therefore, BAERA is entrusted with the responsibility of regulating activities related to nuclear power generation, research and industrial and medical uses of radiation and radioactive sources.

6.1.2 Responsibilities and functions of BAERA

According to the relevant section of BAER Act-2012 [3], the major responsibilities and functions of the Authority (BAERA) are as follows:

- Ensure whether safe and peaceful use of atomic energy is established or not
- Issue and apply necessary Regulations, Guides and Codes
- Authorization of the otherwise restricted activities by the BAER Act-2012 in the form of Licence, Permit, Registration, Certificate, etc. and their amendment, suspension or cancellation
- Ensure compliance of the regulations related to nuclear safety, radiation protection, security, safeguard, and import & export as relevant to different authorized activities.
- Formulate and establish a system or method for review and assessment of regulatory functions;
- Carry out review and assessment, inspection, and issuance of authorization (licence, etc.).

- Take initiative and establish program to carry out inspection;
- Publish guidelines for the purpose of enforcement activities and take actions against noncompliance of the BAER Act 2012 and Rules and Regulations made under the act;
- Define matters for exclusion;
- Define and grant exemptions of any radiological or nuclear facilities from regulatory control;
- Define obligations, including financial matters of persons or entities authorized;
- Establish limits of radioactivity into soil, water and air or any matter use as food for human beings and animals or use otherwise by;
- Establish a public participation system through seminar, workshop, electronic and print media and internet, etc. for information and consultations with interested parties about the possible risks associated with facilities and activities;
- Participate in determining the definition of the design basis threat for the implementation of security measures;
- to establish and maintain a national register for radiation sources and update it regularly;
- Establish and maintain a national register and update it regularly for persons authorized to carryout activities or practices under this Act or Rules and or Regulations made under this Act;
- Carryout duties as an organizer and a coordinator for implementing Safeguards Agreements;
- Establish and promote activities related to the international agreements, protocols and convention (in which Bangladesh is a party) on safeguards, physical protection including illicit trafficking of nuclear and radioactive materials, nuclear safety, radiation protection and radiological emergency situation;
- Establish and maintain a State System of Accounting for and Control of nuclear material (SSAC);
- Conduct research for regulatory purposes;
- Liaise and co-ordinate with other governmental or non-governmental bodies having competence in such areas as health and safety, environmental protection, security, and transport of dangerous goods;

- Formulate state nuclear and radiological emergency planning and to coordinate all the activities in this regard;
- Approve an effective reporting procedure with respect to radiation incidents and to ensure plans for radiological emergency preparedness and protective actions have been prepared;
- Ensure that appropriate measures for physical protection of nuclear material, radioactive materials and nuclear installations are taken;
- Detect unauthorized or potentially dangerous activities against nuclear or radioactive materials and related facilities including protection and response to them, as well as establish regulatory control system on such materials or facilities mentioned above;
- Ensure that corrective actions are undertaken when unsafe or potentially unsafe conditions are detected concerning a nuclear installation, radiation generator, nuclear material, nuclear substance or radioactive material; and
- Determine the liabilities and circumference of nuclear damage and direct activities related to them;
- Liaise and cooperate with any regulatory bodies, any international organizations or agencies concerning nuclear safety and radiation protection;
- Determine criteria for appointment of officers and staff and to establish service regulations for them;
- Establish and maintain human resources development and training program for its employees;
- Exchange regulatory information and expand cooperation with regulatory bodies of different countries, international organizations, and agencies;
- Publish related information and communicate with relevant agencies, the public and the media;
- Take initiative for creating awareness among the public concerning nuclear safety and radiation protection;
- Establish schedules for fees and charges;
- Formulate or adopt necessary policies and issues and implement orders or instructions in areas of its responsibility;

- Perform any other duties prescribed or assigned to the Authority by the Government from time to time as deemed necessary to meet its statutory obligations.

6.1.3 Structure of the BAERA

6.1.3.1 The Authority

According to the Section 6 of the BAER Act-2012 [3], the Authority (BAERA) shall consist of one Chairman and four Members. They will be appointed by the Government for a fixed tenure of three years and are fulltime officials of the Authority. The Chairman is the Chief Executive of the Authority. The Chairman and the Members exercise powers and perform functions as prescribed or assigned to them under the BAER Act or the Rules or the Regulations made under the Act. In addition, government appoints a full time Financial Advisor and a Secretary to the Authority to cooperate and assist in the activities of the Authority.

6.1.3.2 Advisory Council and Expert Committee

The authority (BAERA) may form Advisory Council consisting of reputed scientists, engineers, physicians and representative from different ministries as per BAER Act 2012 to seek advice on the scientific and regulatory aspects of nuclear safety and radiation protection. Moreover, the Authority, if necessary, may form required number of expert committees comprising one or more members, or any of its employees, or one or more invited experts for assisting its functions. The Authority may assign responsibilities to such expert committees and its terms and references. At present, BAERA has formed an advisory council with adequate experts from different disciplines; in addition, several expert committees are also functioning to support the Authority to carry out its responsibilities properly.

6.1.3.3 Organization of BAERA

Bangladesh Atomic Energy Regulatory Authority has its office located in Dhaka, the Capital City of Bangladesh. The present organizational structure of BAERA in Figure-8.

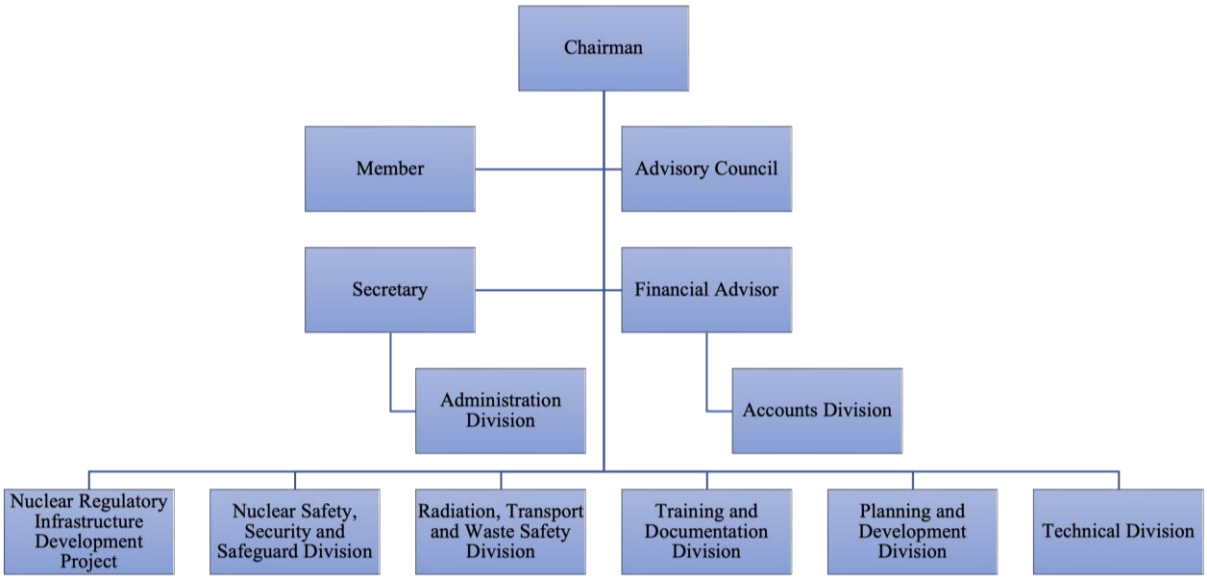

Figure 8: Present organizational structure of BAERA

To assist the Authority in its regulatory functions, presently BAERA comprises of one development project and five technical divisions. These are:

- Nuclear Regulatory Infrastructure Development Project (NuRIDP)
- Nuclear Safety, Security & Safeguard Division (NSSSD)

  Main Responsibilities: Authorization of nuclear installations and associated activities (review and assessment of documentation important to nuclear safety), development of regulations, inspection of nuclear installations and liaison with relevant Technical Support Organization, liaison with IAEA on safeguard matters.
- Radiation, Transport and Waste Safety Division (RTWSD)

  Main Responsibilities: Authorization of facilities/activities other than nuclear installation.
- Training & Documentation Division (TDD)

  Main Responsibilities: Public Information, Regulatory document development, In-house training of BAERA staff, Training of Radiation Control Officers (RCO) and users of radiation/radioactive sources.
- Planning & Development Division (PDD)

  Main Responsibilities: Planning and execution of the development activities of BAERA.
- Technical Division (TD)

  Main Responsibilities: Provide technical and logistic support to BAERA.

Besides, there are three laboratories under BAEC namely, HPD, HPRWMU and RTML that provide technical supports to the regulatory services of BAERA. [13]

6.1.4 Human Resources

The technical and support staffs of the BAERA predominantly consist of people with various backgrounds related to different aspects of nuclear and radiation technology for fulfilling the requirements of carrying out its regulatory functions. Last two years BAERA has recruited around 46 technical staffs through the government approved requirement process and at present it has in total 128 staffs including technical and supporting staff. Government has approved the new Organizational Structure as per IAEA INIR mission recommendation. The basic philosophy of the proposed Organizational Structure is consistent with IAEA-TECDOC-1513 [13]. A significant number of regulatory technical and supporting staff has been identified to perform different regulatory functions for the effective regulatory control of Rooppur NPP and other non-power installations.

Government has approved two Development Project Proposal (DPP) submitted by BAERA for the development of its nuclear regulatory infrastructure; one of these is exclusively for the human resources development through higher education, long and short training and retraining in vendor country, workshop, fellowship, etc. For the Rooppur NPP project, MoST has developed a national HRD plan in consultation with BAERA and BAEC. Two committees had been established, one has identified the HR needs (demand side committee) and another has identified potential sources of HRD (supply side committee). From these a series of initiatives have been put in place. These include activities with IAEA, Japan, Korea, India, the Vendor (Russian Federation) as well as developments in the national education system and the development of a nuclear institute in BAEC.

BAERA's present manpower consists of 68 technical staffs and 60 supporting staffs (including outsourced supporting staffs). BAERA is pursuing time bound recruitment training plan to strengthen staffing and regulatory capabilities of its staff by the end of 2026. BAERA is getting active support for human resource development from Russian Federations RB Rostechnadzor and its TSO's and Indian RB AERB in this phase transition time.

6.1.5 Financial Resources

Regular yearly funds of the BAERA accrued from the following sources as per Section 15 of the Act [3]:

(a) Funds granted by the Government annually;

(b) Fees and charges deposited under the Act;

However, the following sources can also be included if required:

- Grants received from National and International Agencies with prior approval of the Government; and

- Fund received from any other source with prior approval of the Government. BAERA has separate budget line in the Government budget through MOST. Therefore, the funding requirements for regulatory infrastructure development and maintenance have been well established and are funded directly by the government. An Annual Development Project has already been approved by the government with allocation of all necessary budgets for nuclear regulatory infrastructure development of BAERA. This DPP covers recruitment of necessary manpower, human resources development, construction of new offices and arrangement of logistics both in the HQ in Dhaka and at Rooppur NPP site, expert services fees, etc.

6.1.6 External technical support

On 27 February 2012, MoST and ROSTECHNADZOR have gone into an inter-agency agreement (IAA) for cooperation in the field of safety regulation during siting, design, construction, commissioning of nuclear power plants in the following main areas:

- Development of legislative basis in the field of nuclear and radiation safety;
- Licensing of activities in the field of peaceful use of atomic energy;
- Training of nuclear regulatory body personnel.

Based on this agreement, a bilateral meeting was held between BAERA and ROSTECHNADZOR in March-April, 2015, where both parties agreed to finalize the draft assistance proposal for BAERA that encompasses the following areas:

- Review and assessment of licensing documents
- Joint inspection at the RNPP site
- Joint inspection at the manufacturing company
- Joint meeting/workshop on NPP safety related topics

- NPP licensing related regulatory documents and requirement
- NPP inspection and related procedure
- Development of NPP related regulation and guidance
- Human Resource Development

In this regard, on 14 October 2015, a joint protocol was signed between BAERA and ROSTECHNADZOR. Following this, BAERA has signed a General Framework Contract (GFC) on 18 November 2016 with ROSTECHNADZOR's TSO to get the assistance on the aforementioned areas for the next 11 years. On 08 April 2017, a MoU has been signed between Atomic Energy Regulatory Board (AERB) of India and BAERA on the development of regulatory infrastructure in Bangladesh.

6.2 STATUS OF THE REGULATORY BODY

6.2.1 Place of the BAERA in the governmental structure

Bangladesh is a parliamentary democracy where Prime Minister is the head of the government. The present BAER Act -2012 [3] is enacted by the Parliament in late 2012 and enforced by the Government in 2013 by establishing a regulatory body BAERA. Figure 9 shows the statute of the BAERA within the government structure.

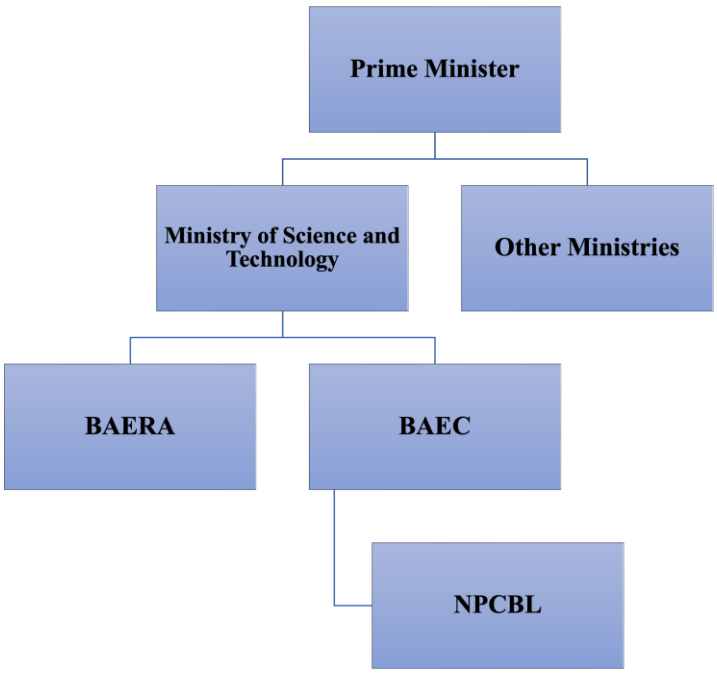

Figure 9: Statute of the BAERA within the government structure

6.2.2 Reporting obligations

BAERA is the competent authority in Bangladesh in regulating nuclear safety, security, safeguards and radiation safety. It was formally separated in 2013 from the promoter of peaceful use of nuclear energy in the country, i.e., BAEC, which is the owner of NPCBL. Government provides budget for BAERA activities through MoST and therefore BAERA is functionally independent, as it only needs to present its Annual Report and Budget Proposals to the MoST once a year. BAERA's position in the government structure provides complete and effective separation in its regulatory work.

6.2.3 Review of regulatory activities of BAERA

BAERA has requested the IAEA to perform an Integrated Regulatory Review Service (IRRS) 'full scope' mission in Bangladesh. The IAEA has agreed to have an IRRS mission visit Bangladesh in the 4th quarter of 2022 (27 November – 09 December 2022). In preparation of the full-scale mission, in April 2022 IAEA has conducted preparatory meeting for IRRS Mission for the participants going to be present in the full scope Mission to have tentative analysis of the compliance of Bangladesh with the requirements defined by the IAEA. Besides, there is an action plan between Bangladesh and IAEA under the IAEA Integrated Work Plan (IWP) from 2019 to 2023, which is reviewed and updated at the end of every year. According to the IWP, there are some scheduled missions like the IPPAS mission in Q1 2023 and the EPREV mission in Q3 2023. The IAEA ISSAS mission has been successfully conducted by IAEA from 20-28 March 2022 in Bangladesh with the participation of BAERA, BAEC, MOST, other relevant ministry representatives and stakeholders. At present IAEA is conducting an IPPAS workshop and IPPAS preparatory meeting in Bangladesh from August 01 to 04, 2022.

7. RESPONSIBILITY OF THE AUTHORIZATION HOLDER (ARTICLE 9)

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

As per the Section 18 of BAER Act 2012, "Restrictions on certain activities: No authorized person, operator or overseas operator shall select site, design, construct, commission, operate, and decommission any nuclear installation or radiation facility or close radioactive waste disposal facility and release the site from regulatory control without taking authorization from the Authority in such manner as prescribed by regulations." Government also enacted the

Nuclear Power Plant Act-2015 [4] that established a company named Nuclear Power Plant Company Bangladesh Limited (NPCBL) under the ownership of BAEC which assumes the responsibility of operation as an operator of the Rooppur NPP as well as implementation of future nuclear power projects in the country.

This Act, consisting of 35 sections, establishes the composition, duties and responsibilities of the company. As per the Section 7(1) of NPP Act-2015, NPCBL/BAEC is responsible for site development, designing, construction, commissioning, operation and decommissioning of Rooppur nuclear power plant and all other future nuclear power plants in the country.

As per the Section 23 of BAER Act-2012 [3], the authorization holder is solely responsible for ensuring the safety for all stages of lifecycle of a Nuclear Power Plant and needs to demonstrate to the BAERA's full satisfaction that the safety is ensured at all the times.

As per the Section 23 of the Act [3], the authorization holder is responsible to-

- Ensure nuclear safety, radiation protection, physical protection, emergency preparedness including verification thereof, during all the phases of nuclear installation or radiation facility from siting to decommissioning;
- Generate a decommissioning fund for nuclear installation;
- Establish preventive measures as well as measures to mitigate or eliminate consequences of incidents and accidents at nuclear installation during all the phases from siting to decommissioning or during the shipment of nuclear or radioactive material; make physical inventory and keep records of the nuclear material, radioactive material and of the radioactive waste and spent fuel; identify loss or theft of nuclear material or radioactive material or suspicious that or has the knowledge of a damage to nuclear material or radioactive material, of monitoring equipment or seals controlling the status and flows of nuclear material, and notify the Authority, without any delay;
- Ensure the safety measures to control or mitigate the environmental pollution caused by discharge or dispose of radioactive waste or material in the environment;
- Establish and maintain human resources development programme with adequate funding;
- Ensure the establishment and maintenance of safety culture in order to encourage a questioning and learning attitude for nuclear safety and radiation protection and to discourage complacency;

- Comply with additional duties as specified in the regulations made under the Act.

Further to the responsibilities assigned to the authorization holder of any type of facilities/activities by the Section 23 of the Act [3], Section 30 specifically addresses the requirement for nuclear safety of any nuclear installation and related activities. Section 30.2 states that the responsibility for nuclear safety shall lie with the authorization holder. The authorization holder shall be liable to provide for adequate funds and human resources to ensure nuclear safety, including the necessary engineering and technical support activities in all areas related to nuclear safety.

Section 30.3 through 30.7 details the requirements need to observe by the authorization holder to ensure nuclear safety throughout the lifetime of a nuclear installation. For instance, Section 30.3 affirms the liability of the authorization holder to perform regular, comprehensive and systematic assessments of nuclear safety considering the state-of-the-art knowledge and understanding in the area of nuclear safety review, and to take measures to eliminate any deficiencies identified during the entire operating life and the decommissioning stage of a nuclear installation.

Section 30.8 allows BAERA to issue regulations on detail of requirements to further strengthen the nuclear safety aspects of a nuclear installation and authorization holder's responsibilities for different stages, such as siting, design, construction, commissioning, operation, decommissioning and closure of repository, as well as the criteria for the categorization of classified equipment into safety classes.

8. PRIORITY TO SAFETY (ARTICLE 10)

The safety is assumed as the number one priority for construction of Rooppur NPP in every circumstances. Bangladesh Atomic Energy Regulatory Authority (BAERA) and the utilities (BAEC/NPCBL) have established policies that stressed strict adherence of priority to safety in all their activities. Ensure prioritizing of safety has been an on-going process during the designing, manufacturing and construction phase of the Rooppur NPP. Moreover, to ensure adherence to the regulatory requirements for Rooppur NPP in the Operational Stage, the requirement of fulfilling the gaps of the Preliminary Safety Analysis Report (PSAR) by the end of the Commissioning phase to have an updated Final SAR and its comprehensive safety review with positive outcome is a regulatory requirement. Both enhancements and priority to safety post- Fukushima accident were the key points of discussion during the numerous meetings with

the vendor in the designing phase and has been incorporated in the design to have safe operation throughout the life span of the Rooppur NPP. The questions arose on the National Report submitted in the seventh review meeting of the Convention have also given due consideration to enhance and prioritize the safety related aspects.

BAERA's mission is to ensure the safe and secure use of nuclear energy in Bangladesh so that undue risk to human health and the environment is practically eliminated. To realize this mission, BAER Act-2012 provides the main legal basis; on the other hand, national rules, regulations, guides and international instruments, codes, and standards are the primary documents detailing principal, requirements, practices and policies for enhancing safety. The rules and regulations are chiefly based on IAEA safety requirements, standards and guides, giving top priority to the safety. BAERA uses IAEA safety requirements and vendor country regulations where the issues are not explicitly covered by the national regulations. Through a comprehensive authorization scheme, inspection and enforcement system, BAERA attains regulatory control of nuclear installation with proper consideration for the protection of workers, public and the environment and nuclear security. As per the Section 7(2) of NPP Act – 2015 [4], NPCBL/BAEC will get licence and ensure full compliance of nuclear safety & security, radiation protection and emergency remedial measures by strictly adhering to the BAER Act -2012, its own guidelines and standard safety system, internationally well-established practice during implementation of any NPP construction project in the country.

9. FINANCIAL AND HUMAN RESOURCES (ARTICLE 11)

The Inter-Government Agreement (IGA) signed between Bangladesh and the Russian Federation on 2nd November 2011 covers technical and financial cooperation for the construction of Rooppur NPP. Under the provision of the IGA, the Russian Federation will deliver ready nuclear fuel for Rooppur NPP for its entire life. The two parties also signed a separate IGA to send back the spent nuclear fuel from Rooppur NPP for its management in Russian Federation. The Financing and Procurement Sub-group committee formed by the government of Bangladesh provided a detailed report on the ownership options and financing strategy for Rooppur NPP Construction for the consideration of the National Committee; Based on its recommendations it was decided that the NPP will be solely Government owned and will be financed through a state credit agreement with the vendor country and the project will be implemented under a Turnkey approach.

Initially, the Executive Committee of National Economic Council (ECNEC) of the Government approved a Development Project Proposal (DPP) for the Preparatory Construction Phase activities of the Rooppur NPP project for the period of 2013 – 2016. The Bangladesh and Russian Governments agreed a state credit of 500 million USD for financing up to 90% of the preparatory phase activities, which has already been accomplished. Bangladesh Atomic Energy Commission (BAEC), the owner organization of Rooppur NPP signed necessary contracts with JSC Atomstroyexport (JSC-ASE), a subsidiary of the Russian State Nuclear Corporation (ROSATOM) for the preparatory phase construction activities during 2013-2016, and later has signed a General Contract on 25 December 2015 for the construction of Rooppur NPP.

A DPP has been approved with allocation of all necessary budgets for the main stage of Rooppur NPP construction project. Prior to that, a detailed analysis of the financial risks regarding change of price, change of scope and delays in construction has been conducted as part of the feasibility evaluation of the contractor. Outcome of the analysis along with other relevant factors were reviewed by several committees and finally accepted by the National Committee. On 26th July 2016 Bangladesh and Russian governments formally signed the Intergovernmental Credit Agreement (IGCA) amounting to 11.38 billion USD for the construction of the two units of Rooppur NPPs against the total cost of 12.65 billion USD that fixed the level of state credit at 90%. The Bangladesh Government will generate funds for the rest of the 10% of the contract as well as necessary infrastructure costs for all future phases of Rooppur NPP project.

The funding requirements for regulatory infrastructure have been developed and will be funded directly by the Bangladesh government. A DPP for accomplishing the General Framework Contract (GFC) between BAERA and Rostechnadzor/ JSC VO “Safety” is in the final stage of approval by the government with allocation of all necessary budgets for nuclear regulatory infrastructure development of BAERA. In addition, government is funding developments in national education related to the nuclear power programme.

Moreover, the government is also providing funds for the development of all other infrastructure areas (grid, roads, railway, water way transportation etc.) through separate projects managed by the respective government departments/organizations.

Most importantly, the Rooppur NPP project is one of the 10 fast track governmental projects under regular supervision of the Prime Minister’s Office. For the last couple of years,

government has been allocating the highest sum of money from the yearly revenue budget for the implementation of the Rooppur NPP Project.

Bangladesh Power Development Board (BPDB), which is a government organization and is also the sole purchaser of electricity in Bangladesh, will sign a Power Purchase Agreement for the purchase of all the electricity produced by the NPP at a price based on the overall cost of production. Concerning the operational phase before the handover of the NPP, several other contracts covering services for operation and maintenance support, fuel supply, spent fuel and waste management are being finalized. Human Resources Development program of RNPP is an ongoing process. The costs of these services/products, both before and after the handover of the NPP to BAEC/NPCBL, will be funded through the tariff structure of electricity sales to be agreed with BPDB. As per the Section 22 of BAER Act-2012, the Government of Bangladesh shall establish a decommissioning fund for all NPPs in its jurisdiction that shall be raised from the contributions mainly from operating company of the NPP (NPCBL).

As already mentioned earlier, a national human resource development (HRD) plan had been developed. Two committees had been established; one to identify the HR needs (demand side committee) and another to identify potential sources of HRD if any (supply side committee). Lot of efforts have been put in place to develop necessary human resources; these include cooperation activities in the field of nuclear energy with IAEA, Japan, Korea, and India, Russian Federation as well as developments of relevant sectors in the national education system and the development of a nuclear training institute in BAEC.

Concurrently, under the clause of the General Contract for main stage of NPP construction, education and training programme of the future operational and maintenance personnel of Rooppur NPP has been going on in the universities and relevant training facilities of Russian Federation. For successfully operating two units of RNPP, a total 1927 manpower has been identified. Out of this total 1927 manpower, RNPP NPP station general management requires 307 manpower and RNPP Units operation and maintenance requires 1620 manpower. Training requirement for this workforce is estimated as 1119 manpower out of which 851 is getting training in Russian Federation.

BAERA has also recruited necessary technical manpower and going on with the development of its manpower to cope with the challenge of licensing and inspection activities in different stages of the Rooppur NPP, although technical supports have been taken from local and foreign organization, such as BUET, ROSTECHNADZOR, JSC VO “Safety”, IAEA, India etc. to address the gaps in expertise as needed.

10. HUMAN FACTORS (ARTICLE 12)

In the interface/interaction between humans and technology in an NPP, which is important to nuclear safety, role of an individual becomes critical owing to the actual capabilities attainable as well as limitations of human performance. These human factors chiefly consist of two elements, namely internal factors such as aptitude, competence, professional abilities, motivation, endurance against stress, adaptability to changing situation, etc. and external factors, such as work environment process control, procedures, training and education, accessibility of components and automation, etc.

To avoid human errors, these factors has been considered in design, construction, and commissioning and operation stage of the envisaged NPPs to ensure that the capabilities and the limitations of human performance are considered. Existing NSRC Rules-1997 covers the requirement for qualification of operating personnel. Adopted Russian regulations as well as regulations in the drafting stage concerning the authorization process of a nuclear installation and related activities further substantiate strict requirement of overall criteria (both physical and mental) of key NPP personnel as stipulated below:

-The NPP shall be staffed with personnel having the necessary qualification and admitted to independent work in the established order prior to delivery of nuclear fuel to the plant.

-Admission of operational personnel to performance of certain types of activities shall be affected in case permit (reactor operator licence) granted by BAERA are available.

-The list of positions of NPP workers which shall obtain permits from BAERA on the right of executing works in the field of use of nuclear energy shall be drawn up by the BAERA in consultation with relevant parties.

-Accordingly, qualification requirements to workers obtaining permits/licences according to the list of positions shall be specified by the Operating Organization in qualification manuals concerning positions of managers and experts, must be agreed upon with BAERA and other concerned bodies (such as Ministry of Labour, Ministry of Science and Technology, etc.) of Bangladesh.

-Qualification requirements to other NPP personnel shall be established by the operating organization (BAEC/NPCBL) of the NPP.

-The operating organization (BAEC/NPCBL) of the NPP shall ensure appropriate selection, training, admission to independent work and maintaining the operational personnel qualification level. The system for selection and training of NPP operational

personnel shall be aimed at achieving, control and maintaining its level of qualification required for ensuring safe operation of the NPP in all regimes as well as performance of actions directed towards mitigating consequences of accidents occurred.

-Training shall imply inculcation of safety culture in operational personnel.

-The system for training operational personnel and exercising practical actions in operating the NPP operation shall involve technical provisions for training including simulators of various types permitted in the established order for application in training NPP personnel. Particular attention shall be paid to exercising actions on probable abnormalities (including accidents) in NPP operation and taking into account experience gained from previous errors and accidents.

-Prior to admission to independent work and periodically operational personnel shall go through medical check-up. The state of health of workers from operational personnel shall ensure performance by them of professional duties relating to NPP operation safely and reliably.

Further to these, Russian Regulations on Ensuring Safety of Nuclear Power Plants [14], which form the basis of the draft regulations, require human factor to be considered throughout the lifetime of an NPP. According to [14]:

-The design shall provide for the possibility to exclude personnel's single errors and mitigate their consequences; in the design of NPP and reactor plant systems (elements) priority shall be given to systems (elements) design, which has been based on the passive principle of action and inherent safety features (self-control), thermal inertia and other natural processes;

-In the design of the control room, problems of man-machine interface shall be solved. Parameters to be controlled shall be so selected and displayed as to provide personnel with unambiguous information indicating that NPP safe operating limits and conditions are met, and identification and diagnostics of automatic response and functioning of safety systems are possible.

Moreover, Russian Federations normative document [15] sets forth main requirements to full-scope simulators as to a technical tool for training of the operating personnel of nuclear power plants and, especially, operators of nuclear power plant unit control rooms (figure 10).

Figure 8: Rooppur NPP Training Centre Simulator

11. QUALITY ASSURANCE (ARTICLE 13)

Bangladesh always recognizes the importance of good safety and quality management system at a nuclear installation or any facilities using ionizing radiation; this is manifested in operating BTRR research reactor for more than three decades without any major complications. The aim of safety management is to formulate good safety policies for the relevant reactor installation, and this includes ensuring that the reasons, effects, and consequences of those policies are communicated downwards to every level in the organization.

The requirement of quality assurance programmes stems from former Nuclear Safety and Radiation Control Act-1993 [6]. The present BAER Act-2012 enhances this further to incorporate establishment of NPP in Bangladesh. Section 32 of the BAER Act-2012 [3] states the requirements for establishment and implementation of quality assurance programme in all stage of a nuclear installation in order to ensure nuclear safety. The authorization holder is liable to establish the organizational structure, procedures and ensure availability of resources necessary to assure the quality for all activities of nuclear installation that is important for nuclear safety.

Moreover, it is the responsibility of the authorization holder to comply with the quality requirements for nuclear installation, classified equipment, their classification into the safety classes in the field of use of nuclear energy including equipment suppliers and provision of services as per the Act, the regulations made there under and applicable codes and standards.

BAERA is in the process of implementing Quality Management System (QMS) for its core regulatory processes viz, authorization process, regulatory inspection/enforcement and

document development based on its earlier experience (NSRCD), its policy and regulatory documents, IAEA (GSR-part-2 [16-17] and GS-G-3.1 [18]), Russian Federations's "Requirements to quality assurance programs of nuclear facilities (NP-090-11)" [19] and other international standards. In this regard, BAERA is identifying all the requirements applicable for its organization (as derived from national legislation, international conventions, international safety standards, stakeholders' expectation, etc.) in management system and exercising a Management System Manual.

GSR-Part 2 [16] defines the requirements for establishing, implementing, assessing and continually improving a management system for facilities and activities that integrates safety, health, environmental, security, quality and economic elements. To be a competent regulatory body, BAERA has put in place regulatory and management systems for establishing policies and objectives, and for implementing them so that objectives are achieved in an efficient and effective way. Moreover, GSR-Part 2 has also been used in addition to the legal, statutory and other requirements to impose on a regulated organization, in the present case on the licensee (BAEC-NPCBL) of Rooppur NPP. It is the licensee/operators' responsibility to put in place a management system that satisfies these requirements. In contrast, at the interface between the nuclear facility operator and a supplier of equipment and services, the operator requires the supplier to put in place a management system for the delivery of items and services that satisfies requirements imposed by the regulatory body; these requirements include IAEA GS-R-3 [20] requirements. A supplier with a management system based on ISO 9000s would then have to ensure that its management system satisfies these additional requirements.

12. ASSESSMENT AND VERIFICATION OF SAFETY (ARTICLE 14)

Section 30 of the BAER Act-2012 clearly addressed the requirement for Nuclear Safety of any nuclear installation and related activities. As per the Section 30.2, the responsibility to ensure the nuclear safety lies with the authorization holder of a nuclear installation. The authorization holder is liable for the provision of adequate funds and human resources as well as capable of carrying out necessary engineering and technical support activities to ensure nuclear safety in their nuclear installation.

As already mentioned earlier, section 30.3 through 30.7 detailed the requirements need to be fulfilled by the authorization holder to ensure nuclear safety throughout the lifetime of a nuclear installation. According to the Section 30.3, the authorization holder needs to perform regular,

comprehensive and systematic assessments of nuclear safety taking into account the state-of-the-art knowledge and understanding in the area as well as in the light of operating experiences of similar NPP's and take all necessary measures to eliminate any deficiencies identified during the entire operating life and the decommissioning stage of a nuclear installation. The authorization holder also needs to keep records of safety assessment activities and about modifications of their nuclear installation if any. As per Section 11.7, BAERA carry out review and analysis of the safety assessments and invoke necessary action as required. For instance, BAEC has carried out feasibility evaluation, site engineering survey and environmental studies, and environmental impact assessment of Rooppur NPP to receive materials for confirmation of the construction site and appropriate NPP technology in terms of nuclear safety and obtaining the authorization for design and construction of Rooppur NPP from BAERA. BAEC with the support from JSC Atomstroyexport and local TSOs, has prepared twelve documentation packages containing total 3436 books that include NPP Design Documentations (316 books), PSAR (18 Chapters and 2 Appendices: 44 books), PSA Level-1 (11 books), EIA Reports (4 books), first-priority design documentation (1301 books) and first priority working documentation (1770 books). In addition, the Technical Assignment for Design of Rooppur NPP Unit-1 and Unit-2 was also developed.

Based on its own regulatory requirements, international standards, RF's "Nuclear safety rules for reactor installations of nuclear power plants, NP-082-07" [21], BAERA with the support of its own manpower and TSO, has conducted thorough review and assessment of the PSAR, PSA Level-1 and other necessary documents separately for Unit 1 and 2 of Rooppur NPP with VVER-1200 (AES-2006) technology before granting their Design and Construction Licences. In this regard it is worth to mention, upon request from BAERA, IAEA has also independently participated in the review and assessment of some selected Deterministic Accident Analysis based on initiating events and their outcome from the Chapter 15 (Accident Analysis) of PSAR. Their review outcome was presented to the BAERA through an Expert Mission during 24-26 April 2018 (IAEA Expert Mission on the PSAR Exemplary Review).

Besides, Section 51 of the BAER Act 2012 gives power to the Authority to conduct regulatory inspection in a nuclear installation to verify that the nuclear safety requirements of the Act and the relevant regulations formulated or adopted under the Act are being properly complied with.

BAERA has a planned systematic inspection programme in place for Rooppur NPP ongoing activities. The frequency of inspection is linked to the importance and nature of the hazard associated with work and the licensee's past performance. Several types of inspections are

carried out, such as: pre-licensing, routine announced, unannounced, prior to license renewal and in response to abnormal events. BAERA inspectors (Scientists and Engineers) prepare written reports following inspections and findings are discussed with senior regulators.

Based on the previous inspection experiences, the BAERA established an inspection framework for the Rooppur NPP under its regulatory decision mentioned in the BAERA notification in 2016. At present, the BAERA has established a site inspection office at the Rooppur NPP site to oversee the ongoing construction phase. Two teams have been formed for the inspection: one team consists of the BAERA regulators, mainly from NSSSD and other team consists of external experts of the vendor country's regulatory body to assist the BAERA personnel. Daily Inspection includes witnessing of major surveillance tests, investigating of the occurrence of an abnormal condition at the site, etc.

To establish regulatory control over all activities related to nuclear and radioactive material and associated facilities, the BAERA establishes communication with the authorized parties by sending prior written notifications and also via verbal notifications during the regulatory inspection.

Moreover, BAERA regularly organizes joint meeting with the licensee/applicant to discuss the safety related issues and the fulfilment of licence terms and conditions.

Inspection is carried out in accordance with the inspection plan; typical procedure is as follows:

- Entrance meeting with the High official of Utility
- Practical arrangements for conducting the inspection is agreed with the utility.
- Deviations from the inspection plan are to be shown in protocol
- Regulators are divided into group based on their expertise/field during the inspection
- Joint meetings for the inspection team at the start and end of the day.
- Assess the appropriateness and adequacy of the licensee's procedures in respect of the inspection area and to get evidence that licensee operates according to the procedures
- The methods of assessing procedures are interviews and monitoring/observing the activity/operation.

- The inspection findings and the consequent requirements are recorded in the protocol and are explained to the representative of the utility at the final/exit meeting.

For example, a comprehensive inspection has been carried out during 14-22 September 2021 at Rooppur NPP project Site during the installation activities of RPV of Unit 1. The inspection was conducted with the participation of the experts of JSC "VO "Safety" and regulators from BAERA.

13. RADIATION PROTECTION (ARTICLE 15)

According to the Section 11.4 of the BAER Act-2012 [3], BAERA is the competent body in Bangladesh to oversee that the provisions related to the radiation protection in its jurisdiction are properly complied with or not. According to Section 31 of BAER Act 2012, authorization holder is responsible to ensure radiation protection of nuclear installation. So far, Radiation Protection infrastructure and programme in all relevant activities/facilities, such as the research reactor (BTRR), Central Radioactive Waste Management Facility, numerous radiation facilities, etc., are comprehensive and satisfactory and is strengthened on continual basis based on experience and technology development. As a legacy from the former Nuclear Safety and Radiation Control Division of BAEC, safety surveillance/inspection and regulatory mechanism of BAERA in the area of radiation protection is also comprehensive, continual, and thorough. Therefore, there were no recommendations/suggestions in this area/issue in the 2011 INIR mission report.

Main regulatory document to prescribe the requirement for Radiation Protection is the Nuclear Safety and Radiation Control Rules 1997 [7], which was developed based on the BSS 115 [22]. It covers the requirements of radiation surveillance and its procedures, Radiation Protection Programme (RPP), dose limits for different target groups, limits of radioactivity in environments, the duties and responsibilities of Radiation Control Officers (RCO), etc.

Dose Limits for Occupational Workers

- an effective dose of 20 mSv/yr averaged over five consecutive years;

- an effective dose of 50 mSv in any single year;

- an equivalent dose to the lens of the eye of 150 mSv in a year;

- an equivalent dose to the extremities (hands and feet) of 500 mSv in a year and

- an equivalent dose to the skin of 500 mSv in a year.

Dose Limits for members of public

The estimated average dose to the members of the public shall not exceed an effective dose of 1 mSv in a year.

14. EMERGENCY PREPAREDNESS (ARTICLE 16)

As per the requirement of the BAER Act-2012, all future nuclear installation(s) in Bangladesh will be designed, constructed, commissioned, and operated in conformity with relevant nuclear safety requirements as set out in regulations, codes & standards and guides. These requirements will guarantee sufficient margin of safety so that NPPs can be operated without unnecessary radiation exposure risks to the plant staffs and general public. Nevertheless, things can go out of control, therefore it is necessary to develop Emergency Preparedness and Response (EPR) plans. EPR plan is an essential requirement for operation of nuclear installation in Bangladesh.

According to the Section 40 of BAER Act-2012, "Authorization holder, operator or overseas operator shall have the ability to take measures for emergency preparedness, planning and preventive and remedial actions in order to effectively deal with potential nuclear or radiological accident or impact of such incident or damage to the public health, environment and properties". And the Act also distinguishes following emergency plans:

(a) preliminary on-site emergency plan, which contains scheduled measures to be taken on the site of a nuclear installation/radiological facility or several nuclear installations/ radiological facilities during its/their construction;

(b) on-site emergency plan, which contains scheduled measures to be taken on the site of a nuclear/radiological facility or several nuclear installations/radiological facilities, operated by a single authorization holder, and links to off-site emergency plan;

(c) off-site emergency plan, which contains measures to be taken for the protection of the population within the emergency planning zone during the release of radioactive substances into the environment, as well as links to on-site emergency plan.

For prevention and mitigation of all types of disasters including Nuclear and Radiological Emergencies, Government of Bangladesh has enacted Disaster Management Act [10] in September 2012 and formed National Disaster Management Council (NDMC) headed by the honourable Prime Minister as the apex body for development of policy and planning and

directing relevant activities regarding National Disaster Management. To implement the provisions of the Disaster Management Act-2012 and to support the NDMC, government also formed an office named Department of Disaster Management. According to BAER Act-2012, BAERA shall be the coordinator in formulating national nuclear and radiological emergency plan and for all activities concerning mitigation of emergency situation.

The National Nuclear or Radiological Emergency Response Plan (NNRERP) includes, among other issues, roles and responsibilities for each organization involved and establishment of the chain of command for emergency response management. The NNRERP reflects inter-agency relationship and concept of operation, which is compatible with other emergency response, plans of different organization in Bangladesh. A draft Regulation on Emergency Preparedness and Response has been developed. According to the INIR mission's recommendation of 2011, the EPREV mission will be conducted during the Phase-3 of the nuclear power programme.

15. SITING (ARTICLE 17)

15.1 GENERAL

The siting process for a nuclear installation in general comprises of a thorough survey of one or several locations to select one or more candidate sites and finally identifying suitable site or sites. Authorization for siting (Siting Licence) involves review of the various site characteristics as well as proposed plant specific safety aspects that ascertain suitability of the proposed nuclear installation in that site (figure 11). The requirement for approval of Siting stems from the BAER Act-2012 and the NSRC Rules 1997. To facilitate the siting process for the first two-units of Rooppur NPP, BAERA developed a regulatory guide named "Regulatory Guidance on Site Evaluation for the Safety of Nuclear Power Plants" [23]. Only when all relevant issues have been adequately addressed, the site can be considered as suitable to build and operate the proposed nuclear installation; this ensures that the risk to the public and the environment from the radiation hazards stays within acceptable limits in the entire lifetime of the plant. Figure shows the location of the Rooppur NPP site for which a Siting Licence has been issued by the BAERA to BAEC on 21 June 2016.

Since the site was selected earlier, it has become essential to perform comprehensive studies to reconfirm the conformity with regard to safety, security and safeguards of the Rooppur NPP project site with the current IAEA guidelines and international practices, techno-normative requirements of the vendor country as well as applicable domestic regulatory requirements to

obtain the necessary permission for the substantiation of the site applicability for the NPP location. BAEC conducted Site Investigation of Rooppur NPP project for confirming its suitability through involving national institutions during 2009-2012. The Site Report prepared for Rooppur NPP was based on the site-specific issues, namely demographic, transport, electric grid conditions, geotechnical, meteorological, morphological and hydrological features of the site. The baseline data for environmental assessment were also collected. After Fukushima NPP accident, it is given special emphasis on the site safety aspects and possible engineering solutions to increase resistance of plants to extreme events and cliff-edge effects as required. The vendor was made to revise safety features into their designs with adequate feature to increase robustness of their designs to extreme natural events. The most significant preparatory stage activities of the NPP project are site characterization and environmental studies, Environmental Impact Assessment (EIA) and comprehensive feasibility study of NPP project/Feasibility evaluation (FE). These studies are performed based on relevant domestic acts, regulations and guidelines, the techno-normative requirements of the vendor country and the IAEA guidelines with regard to safety assurance of the construction site.

The JSC Atomstroyexport of Russian Federation was assigned responsibilities by the BAEC for performance of these studies based on the techno-normative requirements of the Russian Federation, the applicable rules and regulations of Bangladesh, IAEA Siting Mission recommendations and IAEA guidelines. The seismic monitoring station, aero-meteorological and chemical monitoring stations were installed at the project site.

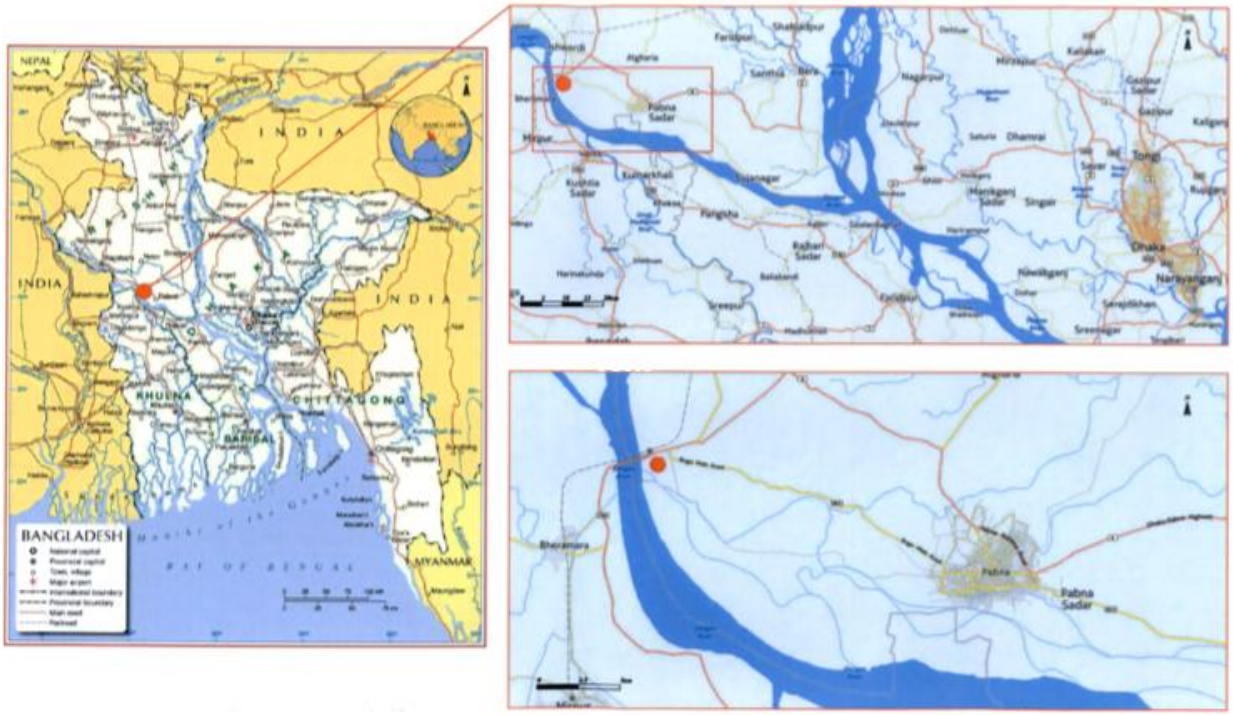

Figure11: Overview and Layout Scheme of Rooppur NPP

15.2 AUTHORIZATION OF SITES (SITING LICENCE)

Applicant/owner of a site notifies Bangladesh Atomic Energy Regulatory Authority (BAERA) before commencing any site investigations in writing of their intention; first regulatory intervention begins with the site inspection by the BAERA team. Application document for site licence includes relevant chapters of the Preliminary Safety Analysis Report (PSAR), Environmental Impact Assessment (EIA), Feasibility Evaluation (FE) reports, General Quality Assurance Program, and Quality assurance program for project siting. In addition, following elements are also considered:

- Information about the site evaluation with respect to natural phenomena such as earthquakes floods and storms.

- Information about the site evaluation with respect to man-made external events such as aircraft crashes, fires, explosions and failure of dams, etc.

- Information regarding the water availability for cooling purposes for the lifetime of the plant.

- Information regarding the national electrical grid connection and reliability of the off-site electrical power

- Preliminary studies on radiation exposure of the public due to liquid and gaseous radioactive effluents during normal operations, anticipated operational occurrences (AOOs) and accident conditions.

After submission of all required documents, BAERA conducted review and assessment by its own and external experts (FSUE VO "Safety" and SEC-NRS- TSOs of Rostechnadzor) and the whole process are coordinated by the Nuclear Safety and Security Division of BAERA. An illustration of the basic scheme for authorization process is given in Figure .

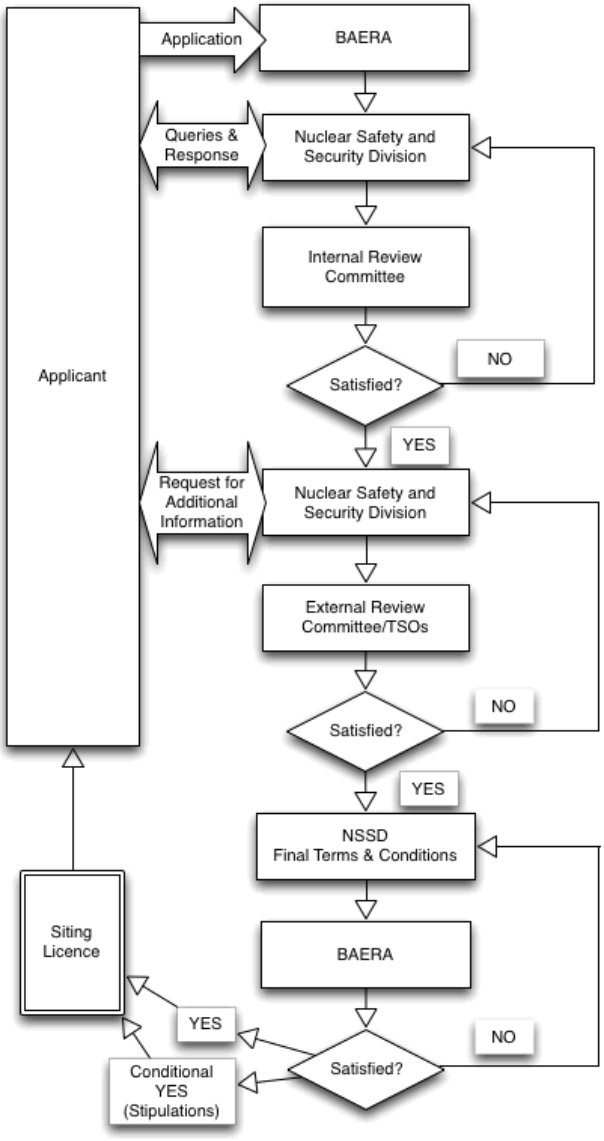

Figure 12: Siting Licence authorization scheme in Bangladesh

15.3 EVALUATION OF SITE RELATED FACTORS AFFECTING SAFETY

Before furnishing the application for the Siting Licence, the applicant must stipulate all pertinent site-relevant external events that may affect the safety of the Rooppur NPP. These site-relevant external events are factors induced by human activities, such as aircraft crashes or chemical explosions, and events due to natural causes such as seismic phenomena, flood, tornados, high tides, etc.

Moreover, the reports specify brief design information and overview of the proposed NPP project, overall safety approach, dose limits, emergency preparedness aspects and offsite power supplies, etc.

A systematic engineering-geological study had been completed at the project site by the BAEC with the support from Atomstroyexport, local universities, and laboratories; more than 400 explorations were drilled, and more than 6700 samples were studied in laboratory. Necessary equipment was also installed, and aero-meteorological models were developed, and the engineering-hydro-meteorological studies were performed. The topographic survey of the site region was completed and engineering-geodetical studies were performed. Necessary site monitoring system was established, and the required studies were performed for engineering-ecological survey and assessment of man-induced off-site impacts.

The outcome of the geological survey of the Rooppur NPP project site indicated that the site soils have weak weight bearing capacity. Therefore, for ensuring long-time nuclear safety, soil improvement had become inevitable for construction of the NPP and other complex engineering facilities of industrial and civil purposes. According to the study, the possible depth of liquefaction is minus 5.9m, i.e., it is mainly limited to the top layer of soil mass and the liquefaction study has confirmed that soil below 20m of Rooppur site will not liquefy. Based on comparative analyses, a technical and regulatory decision was made; soil stabilization method by deep soil mixing technology has been implemented up to the depth of about 20m (meter) to improve the soil below the excavation pits for buildings and structures of both units of Rooppur NPP to ensure safe operation during the entire lifetime of the plant. The technique of soil stabilization with cement slurry (boring and mixing technology) has proven references of construction of complex engineering industrial facilities. The estimated best possible volumetric amount of cement content found through trial run in the excavation pit was in the range of 240 – 250 kg/m^3. However, for the Rooppur NPP a conservative assumption was made where the volumetric content of cement was set to 275 kg/m^3 to ensure attainment of

predetermined positive results of all the strength and deformation indicators. BAERA has granted approval for the Soil Stabilization Works under the buildings of Units Nos. 1 and 2 of the Rooppur NPP construction site under the existing terms and conditions of the Siting Licence for Units 1 and 2 granted on 21 June. 2016.

The seismic and geotectonic studies have also been conducted. The study of seismic hazard assessment provided the seismic design parameters: Average Safe shutdown earthquake (SSE) intensity 8 points on MSK-64 scale (peak acceleration 0.33g) and average design basis earthquake (DBE) intensity 7 points on MSK-64 scale (peak acceleration 0.17g).

Based on comprehensive hydrological, hydraulic and morphological studies of the site, the scenario of the maximum probable flood (MPF) formation has been determined. In prediction of the MPF scenario, the combination of all possible hydrological events were taken into consideration with probability of 0.01% (with frequency once per 10,000 years): (1) simultaneous flood peak occurrence including precipitation on all major river basins, (2) Bay of Bengal water fluctuation (tidal) impact, (3) further precipitation and sea level rise due to global climate change (global warming scenario) and (4) a failure of the Farakka dam located upstream the river Ganges (Padma). Based on the analyses, the design values of the MPF level are found 17.981m elevation mark in the MSL (Mean Sea Level) system. According to relevant international guidelines, the general layouts of buildings and structures shall be at least 0.5 m higher than the design MPF level. For Rooppur NPP, a 19.00 MSL site level, more than 1.00 m above the design MPF level, was considered to ensure site protection against flooding. The mark 19.15m MSL is accepted as a relative mark 0.00 of power units to guarantee that the plant will remain non-flooding under maximum levels of water rising. Moreover, through analyzing the site under-flooding due to ground waters, it was ensured that the extreme level of ground waters would reach at elevation 15.50 m MSL. To protect all buildings and structures of the 1st category against the ground waters, the Rooppur NPP design has provided reliable waterproofing of the underground parts of the buildings and structures up to the grade. Thus, the engineering protection of Rooppur NPP against all possible flooding and under-flooding is provided by the design. In addition, the catchment drains are designed for removal of surface and overflow waters from the lower relief areas of the territories adjacent to the NPP site to ensure normal operation of the constructions related to I-III safety categories. The design solution of Rooppur NPP site protection from the river Padma (Ganges) has also been made.

The Rooppur NPP site has tropical climate. The detailed engineering survey on extreme wind loads including a tornado and extreme temperatures were performed. The maximum and

minimum air temperature observed were 44°C and 3.5°C, respectively. Based on the detailed study of the climatic conditions, the design parameters of the Rooppur NPP ventilation systems, plant cooling capacity, fluid coolant consumption parameter, supply pipelines diameters, air conditioning systems, architectural and planning concepts of the rooms have been designed. With due consideration of the quality and physio-chemical properties of the water of the Padma River as well as water level, the chemically demineralized water preparation system, structure of the cooling system of the main equipment (two cooling towers per unit), auxiliary power supply system, etc. has been designed.

The feasibility evaluation, site engineering survey and environmental studies and environmental impact assessment of Rooppur NPP justified the techno-economic feasibility of the construction project and substantiate the site for nuclear power plant construction.

BAERA carried out review and assessment of submitted documents in order to determine the potential consequences of interaction between the NPP and the site and the suitability of the site for the NPP from the point of view of nuclear safety.

15.4 ASSESSMENT OF IMPACT OF NPP ON PUBLIC AND THE ENVIRONMENT

BAERA issues “Siting Licence” by reviewing the documents as mentioned in section 15.2 of this report considering plant specific safety aspects of the site important to nuclear safety; This establishes suitability of the proposed nuclear installation in that site and ensure the nuclear safety as well as limits the risk to the public and the environment from the radiation hazards within acceptable limits for the entire lifetime of the plant. For all state of a NPP, namely normal operation, anticipated operational occurrences (AOO) and accident conditions, the effects on the general public and environment mainly arise from radioactive liquid and gaseous effluents and radiation exposure to the general public from these discharges. These effects, especially potential radiological impact on people and environment are assessed for the site for all operational states of the envisaged NPP, considering the atmospheric dispersion patterns, present and probable future population distribution in the area, etc. The acceptable doses to the public and environmental radioactivity limits are set as per the NSRC Rules-1997 [7].

15.5 RE-EVALUATION OF SITE RELATED FACTORS

As per the BAER Act-2012 [3] and the NSRC Rules-1997 [7], the Authorization Holder (Licensee) is required to perform regular safety assessments, the Periodic Safety Reviews (PSR). Terms and conditions in the licence (for instance, Siting Licence) state the type of these assessments and indicate the maximum period between performing the assessments. In addition, these include surveillance and re-evaluation of the site to ensure continued acceptability of site conditions by considering site relevant factors. Regulatory Guidance on Site Evaluation for the Safety of Nuclear Power Plants [11] provides detail of the re-evaluation scheme.

15.6 CONSULTATION WITH OTHER CONTRACTING PARTIES

Legislative and regulatory framework of Bangladesh ensures the utilization of nuclear materials and facilities and carrying out related activities with due consideration to the health and safety of the people and the environment from the harmful effect of ionizing radiation. All the obligations incurred from signing and/or approving related international agreements and conventions also support to achieve this objective. Bangladesh is party to the Convention on Early Notification of a Nuclear Accident (1988), and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1988) and fully complies with the obligations under these conventions.

16. DESIGN AND CONSTRUCTION (ARTICLE 18)

BAERA has been using the General Regulations on Ensuring Safety of Nuclear Power Plants [14] of Russian Federation and IAEA SSR-2/1 (Rev. 1) [24] for the Rooppur NPP Project. These safety regulations provide mandatory requirements for design and construction and developed by the vendor country (Russian Federation) based on latest international standards including that of IAEA as well as their domestic and international experience. In the designing of RNPP the vendor also incorporates the recommendation of IAEA experts on Chapter 15 accident analysis. These regulatory requirements contains both general requirements which are technology independent like implementation of defense in depth, safety analysis, concept of single failure, management of safety etc. as well as specific requirements which are technology specific like Russian variant of PWR systems specific requirements of shutdown system, ventilation system etc. The regulations/requirements have been utilized for the review and assessment of Rooppur NPPs Design and Construction licence documents as well. An

illustration of the scheme for the Design & Construction Licence authorization process is given Figure .

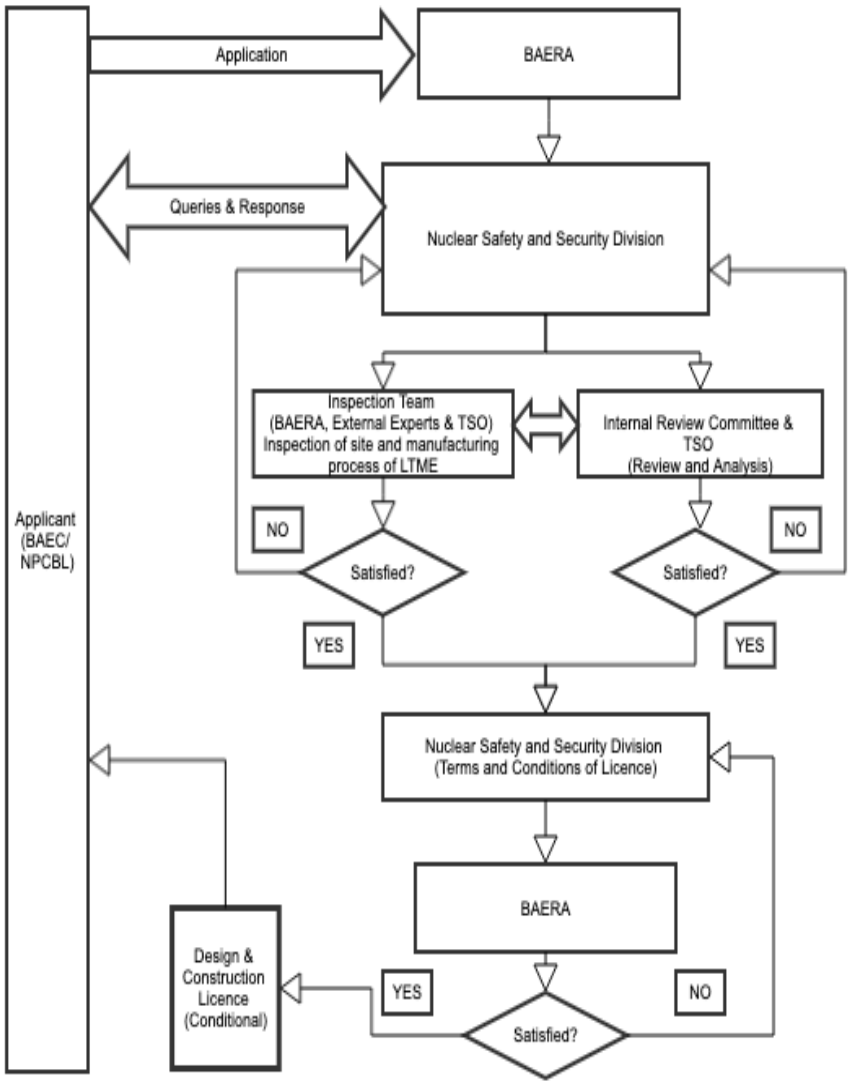

Figure13: Design & Construction Licence authorization scheme.

The criteria of the selection of the design of NPP technology was basically focused on the projected demand for nuclear power generation, size, lifetime, availability and capacity factor of the plant, provenness, licensibility, simplicity and standardization of the design, operability and maintainability of the plant, etc. The design of Rooppur NPP is selected due consideration of these key features of NPP technology assessment suggested by the IAEA guiding documents as well as economics of construction and operation of NPP and techno-normative basis of licensibility, constructability and operability of the plant.

The Rooppur NPP design is developed based on the size and stability of the national electricity grid, project site characteristics such as seismicity of the selected site, climatic condition, maximum probable flood scenario, soil condition, availability of water resources for ultimate cooling, the accessibility to water ways or other appropriate transportation routes for the transportation of large components or modules etc. are important factors in selection of the design. Radiation protection requirement, Environmental Impact Assessment, Emergency Preparedness, nuclear safety, security and safeguards aspects are also addressed into the design. With due consideration of project site suitability, techno-economic viability and regulatory and safety requirements, the latest addition to Russian VVER series i.e., AES-2006 (VVER-1200) design technology has been selected.

The Novovoronezh NPP-2 of Russian Federation is the reference plant for the Rooppur NPP. The reactor plant is assigned with index V-523, while the Novovoronezh NPP-2 is assigned with index V-392M. The Rooppur NPP (reactor plant V-523) is an evolutionary development of the VVER reactor plants, which meets all the safety features of a modern PWR as per the current Russian, Western, and IAEA standards and profitability requirements. It is a Gen-III+ VVER reactor. The Rooppur NPP is developed by the AEP (Moscow) based on calculations and experimental justification of VVER-1000 and VVER-1200 designs with elaboration of designing, equipment manufacturing, construction and commissioning experience of Novovoronezh NPP-II and experiences in operation of the most recent VVER reactors in Russia and abroad.

Each reactor unit (Unit-1 and Unit-2) of the Rooppur NPP comprises the reactor plant (RP) with water-cooled water moderated pressurized water reactor and a turbine unit, where the thermal diagram is double circuit. The primary circuit is radioactive and comprises mainly RP (heterogeneous reactor including reactor vessel, reactor internals, upper unit with control rod drives, core, in-core detector assemblies, main connector leaks control device, surveillance-specimens, compression unit); heating parts of four steam generators (under elevated conditions with increased diameter of vessel including supports and fasteners, leveling vessels, hydraulic shock absorbers); four main circulating pumps (MCPs) with supports and fasteners; a steam pressurizer (including pressurizer with support, fasteners and TEH units, pipelines, PRZ PSD, valves, bubbler tank with supports) and auxiliary equipment. The design service life of the reactor pressure vessel is 60 years, with maximum neutron flux of 4.22×10^{19} neutron/cm^2 (>0.5MeV) at the level of the surveillance specimens for the whole service life, and at the level of the top of the core 1.28×10^{19} neutron/cm^2. Measures to extend vessel service life have

included limitation of nickel content in welds, limitation of impurities in base mental and welds, decrease in ductile to brittle transition temperature of the nozzle area shell material to minus 35ºC. and reduction of neutron flux at vessel walls by increasing vessel diameter.

The RP also includes passive part of the ECCS (including four ECCS tanks, ECCS pipelines with valves and fasteners, ECCS PSD); passive core flooding system; passive hydrogen recombiners, emergency gas removal system; equipment of the reactor concrete pit, Inner and outer Containment etc. The secondary circuit is non-radioactive and comprises steam generating part of the steam generators, main steam lines, a turbo generator set with a turbine installation and a turbine generator, a condensate pump, a system of low-pressure regenerative heaters, a condensate system, deaerators, a feed water system including feed water pumps, and a system of high-pressure regenerative heaters.

The fuel is low-enriched uranium dioxide with maximum enrichment to 5.00 % in ^{235}U ((4.95 ± 0.05) %). Gadolinium in the form of gadolinium oxide (Gd_20_3) is used as the integrated burnable absorber. In the reactor core, ^{235}U absorbs thermal neutron and undergoes nuclear fission reaction generating thermal energy. Upon passing the reactor core, heated primary circuit coolant goes to horizontal steam generators where it gives away heat to the secondary coolant water through the walls of pipe system. The coolant goes through the main coolant pipe from the steam generator back to the reactor to be reheated. The four MCPs ensure circulation in the primary circuit.

Electrical systems of each Unit of Rooppur NPP consist of systems for the generation of power and its integration with the national grid. The system also includes the auxiliary power supply system for the startup and operation of the plant itself. The power generation system includes the generator with capacity of 1,200 MW with a voltage rating of 24KV and unit transformers with a capacity of 3x533 MVA.; The auxiliary power supply system contains sources of operating, backup and emergency power supply. Diesel generators and storage batteries ensure auxiliary emergency power supply. On the electrical systems, the Rooppur NPP has more powerful Emergency Power Supply System (EPSS) diesel generators and a common-unit diesel generator (DG capacity is 10,500 kW where the reference NPP has 6,070 kW of the DG. Moreover, the plant design provides for two storage batteries, which is designed to bring the NPP units into the controlled conditions and to actuate some of the safety systems during accident and post-accident (if occur, which is very unlikely to happen).

It is worth to mention that the Rooppur NPP meets the requirements of all four critical aspects of nuclear safety: structural integrity safety, thermal hydraulic safety, radiation safety and

neutronic safety. The plant design also envisages safety systems based on different action principles: (1) inherent safety features, (2) active/engineered safety features/ and (3) passive safety features. The operating time of active systems of this NPP is not limited if power supply is available. The passive safety systems do not rely on any electric power supply for their functioning. These safety systems use natural forces like gravity, natural circulation, pressure of compressed gas, etc. for ensuring safety of the reactors. The operating time and efficiency of the passive system ensure the performance of safety functions for at least 24 hours including the operation under station blackout conditions. The combination of active and passive safety systems of Rooppur NPP ensures that all three safety functions of a nuclear reactor: to control reactivity, to remove core heat and to contain radioactive substances will be fully functional during normal operating conditions as well as unusual situation or accidental conditions. For example, to control reactivity, the Unit-1 and Unit-2 of Rooppur NPP have adequate active safety systems: emergency boron injection system, high-pressure emergency boron injection system and spray system and a passive safety: reactor emergency protection system. There are several active safety systems and passive safety systems for remove decay heat from the Reactors active safety systems are as follows: steam generator emergency cool-down system, high-pressure emergency boron injection system, emergency and planned cool-down system, essential loads cooling water system, component cooling system for essential loads of the reactor compartment, ventilation and air-conditioning support system. The passive safety systems specified by the design for remove decay heat include 1st stage hydro-accumulator (passive part of the emergency core cooling system), low pressure second stage hydro accumulators and passive heat removal from steam generators. To ensure confinement of radioactivity, the active safety systems include containment sprinkler system and annulus ventilation and rarefaction system while the passive safety systems include double containment; emergency containment hydrogen removal system; containment hydrogen concentration monitoring system; annulus passive filtration system; leak-tight enclosure system and molten core catcher.

The other features of Rooppur NPP’s simple and strong-featured designs are, higher service life of main equipment (50 to 60 years that can be increased significantly) without necessity of replacement, a long "grace periods" requiring no active intervention for the first 24 hours during a design basis loss of coolant accident (LOCA) and station blackout (SBO) and the higher burn-up to reduce the fuel and the amount of radioactive waste, etc.

Moreover, required measures have been implemented in the Rooppur NPP site specific design to protect the plant against the extreme external natural impacts, such as seismic effects, extreme level of ground waters (NPP site under-flooding), extreme wind loads including a tornado, extreme temperatures, external air shock wave, lightning strokes, external fires, airplane crash, etc. and man-induced impacts (figure 14). The double containment provides protection against external events and the containment building is the single most important part of the multiple barriers provided against radioactive release to the environment. The building and facility structures, process pipelines and other communication lines and structures are designed based on seismic impacts; Safe shutdown earthquake (SSE): 0.333g, (intensity VIII according to MSK- 64 scale); design basis earthquake (DBE): 0.172g (intensity VII according to MSK-64 scale). The Rooppur NPP components of Seismic Category I (structural units of buildings and structures, equipment, process and other service lines) are being additionally tested for resistance to earthquake with intensity 1.4 SSE. The seismic impact as above is accounted as a beyond design basis impact. In the NPP design measures have been taken to ensure fire protection including fires caused by a seismic impact.

As per the design, release of radioactive material to environment is not permissible in case of 1.4 SSE seismic impacts. The calculations have demonstrated that the stability of main equipment and building structures is ensured in case of increased seismic impacts. Radiation safety is planned and in the process of implementation to prevent unacceptable effect of ionizing radiation on plant workers, population and environment in the Rooppur NPP site and surroundings. The Rooppur NPP is designed in such a way that it will fulfill the fundamental principles and radiation safety norms, as well as to limit radiation impact on environment so as not to exceed the limits established by national rules & regulations and international practices.

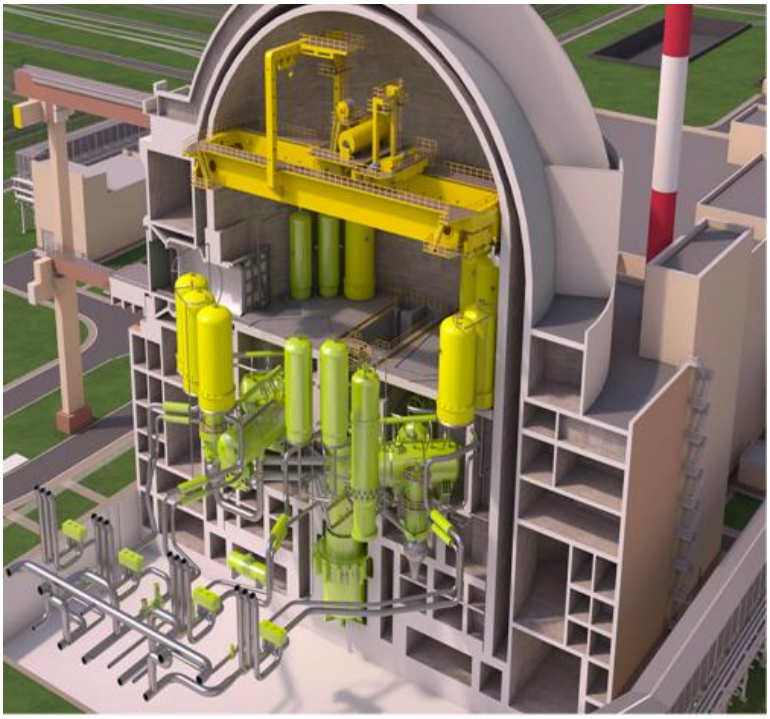

Figure14: Cut-away view of Rooppur NPP Reactor building/containment.

During normal operation, the exposure doses absorbed by the personnel and population, and the release of radioactive substances into the environment shall be kept below the established limits at reasonably achievable and socially and economically justified low level. The radiation consequences of design basis accident in the worst case would be limited within 300 meters at the border of sanitary protection zone maintaining the dose limits as per the regulatory requirement of BAERA. Reliable five layers of barriers prevent the radiation exposure to people and environment even in the worst-case scenario

The safety system of Rooppur NPP is based on active safety systems with both normal and emergency power supply. To prevent severe accidents or mitigate their consequences, passive safety systems are envisaged which function without the involvement of the NPP personnel and do not require any power supply. In case of a severe accident with extreme power loss due to grid failure (like Fukushima NPP accident) the Rooppur NPP will remain safely shut-down for at-least 72 hours without external intervention and off-site power supply.

16.1 IMPLEMENTATION OF DEFENCE IN DEPTH

The VVER-1200 (AES-2006) plant has been designed to meet the Russian general safety requirements issued in 1997 [14], which were consistent with the IAEA's International Nuclear

Safety Group (INSAG) recommendations. The INSAG group recommendations led to the development of what were called "Generation (Gen) III" nuclear power plants, and the current IAEA safety standard on nuclear power plant design safety[24], issued in 2012, builds on the same principles. The VVER-1200 (AES-2006) design takes account of Design Extension Conditions (DEC), in accordance with the current IAEA safety standard. Thus, all new VVER-1200 plants under construction already have design features that take fully into account the main "Fukushima lessons learned", including:

• long term cooling of reactor core without electrical power;

• long term decay heat removal that does not rely on primary ultimate heat sink (sea, river, cooling tower;

• protection of reactor containment integrity with dedicated systems after a core meltdown accident.

The safety systems are designed to have the capability for stable operation under adverse conditions due to natural phenomena such as earthquakes, floods, storm winds, hurricanes, snowfalls, tornadoes, low and high extremes of temperature, as well as such man induced events as aircraft crash (or impact from aircraft parts), air shock wave, fire, and flooding caused by water pipe breaks. The main principles include:

• The inherent-safety principle, that is, the ability of the reactor to ensure safety based on natural feedback processes and characteristics.

• Defence in depth principle, that is, use of successive barriers preventing the release of ionising radiation and radioactive substances to the environment as well as a system of technical and organizational measures for protection of these barriers. The main concept for providing fundamental safety functions is:

BAERA, has used the following safety regulations and IAEA Safety series

-General Regulations on Ensuring Safety of Nuclear Power Plants [14] of Russian Federation.

-IAEA SSR-2/1 (Rev. 1) [24]

According to the IAEA SSR 2/1 (Rev. 1) "Safety of Nuclear Power Plants: Design" [24], design of a NPP must be based on the defence-in-depth concept in order to achieve the general safety objectives. 'Defence-in-depth' safety philosophy consists of a set of diverse and overlapping strategies or measures, known commonly as 'levels of defence'. These levels of defence should

be practically independent from one another to ensure that the failure of one system will not affect more than one level of defence at a time. This principle is defined and applied in various nuclear safety standards and documents and accepted as the fundamental concept of ensuring safety in design of a NPP in the draft regulations in order to prevent any accidents as well as to mitigate their radiological consequences should they occur. According to the defense in-depth concept, design of the NPP shall have adequate safety systems intended to fulfill the following main safety functions:

- Reactivity Control;
  -Prevention of uncontrolled reactor power increase
  -Ensuring fast safe shutdown of the reactor, if required
- Removal of decay heat to the ultimate heat sink;
  -Cooling of the shut-down reactor
  -Cooling of the spent fuel
- Confinement of radioactive materials.
  -Prevention of significant radioactive releases in the environment.

The main concepts for providing fundamental safety functions are:

• Passivity: Passive means are used to deal with “design extension conditions” and “beyond design basis accidents” (passive SG cooling system, passive containment cooling system) and provide back up for active safety systems.

• Multiple train redundancy: The plant utilizes four trains for safety systems and for their control systems.

• Diversity: The backup systems for the systems providing basic safety functions use different equipment from the backed-up safety system and if possible, also a different operating principle.

• Physical separation: All four trains of safety systems and their control systems are physically separated, which addresses common mode failures due to fire, aircraft accident and terrorist act. Unit control rooms (main control room and emergency control room) are also physically located in separate rooms/building

Therefore, the design of the Rooppur NPP strictly adheres the Defense in Depth philosophy that ensures the presence of adequate safety systems to fulfill the main safety functions.

16.2 INCORPORATION OF PROVEN TECHNOLOGIES

As a newcomer country, Bangladesh's strategy is to use proven technology, equipment and systems as a whole for the installation of nuclear energy generating system following the "Reference Plant" approach as stated in the IAEA INSAG-22[25] and INSAG-26[26] documents. Accordingly, BAEC selected the Novovoronezh-II NPP in Russian Federation as the reference plant of the Rooppur NPP.

16.3 DESIGN FOR RELIABLE, STABLE AND EASILY MANAGEABLE OPERATION

The selected design for Rooppur NPP will ensure reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface. During the review and assessment process of PSAR for issuing "Design and Construction Licence", all the design safety related aspects have been evaluated in compliance with BAER-Act-2012, NSRC Rules 1997, adopted Russian Safety regulations as well as IAEA safety standards.

The Rooppur NPP design and NPP Safety Analysis Report contain analysis of response of control systems to postulated failures in control systems, reliability analysis of control systems functioning, and stability analysis of control circuits. Easily manageable unit control console (UCC) has been provided at both units of the Rooppur NPP.

Adequacy of measures has also been provided to ensure survivability, habitability and normal functioning of the unit control console in all regimes including design basis and beyond design basis accidents. The UCC problems of "man-machine interface" have been thoroughly reviewed in the review and assessment of the PSAR. Independence of the emergency control console from the unit control console and adequate survivability and viability and habitability of the emergency control console have also been reviewed properly.

It is ensured that the normal operations control system of the Rooppur NPP units shall perform control of processes under all operating conditions of the NPP unit with quality, reliability and metrological characteristics meeting the design values.

17. OPERATION (ARTICLE 19)

During the commissioning phase, before fuel loading and initial criticality, BAEC/NPCBL needs to formally apply to BAERA and submit a set of documents justifying future safe

operation of the NPP unit. The identified set of requirements as per the international as well as vendor country's (RF) established practice are:

- Provisional Final Safety Analysis Report;
- As-built design of the plant;
- The results of pre-operational tests;
- The operational limits and conditions;
- The specific operational limits and conditions for operation during the commissioning of the plant from first criticality to full power;
- The adequacy of safety significant operating procedures and instructions, including emergency operating procedures and accident management procedures;
- The staffing and management structure of the plant and arrangements for ensuring that qualification and training are performed;
- The arrangement for quality management for all commissioning, operation and maintenance activities;
- The radiation protection programme;
- On-site emergency preparedness and response;
- The arrangement for commissioning activities and operation activities;
- The arrangement for configuration control, especially control of plant modifications;
- The arrangements for the management of spent fuel and radioactive waste;
- The status of storage facilities for nuclear material;
- The fulfilment of the applicable requirements in respect of arrangements for accounting for and control of nuclear material and radioactive material;
- Fulfilment of the applicable requirements for physical protection system.

After finishing commissioning of a unit of NPP, operating organization (BAEC/NPCBL) needs to submit to BAERA all updated reports and records containing results of the work completed at each of the distinct stages (pre-start-up, fuel loading, initial criticality, full-power operation, etc.) of the NPP commissioning. Moreover, after completion of the tests all changes and deviations of the unit from the design characteristics will be considered and updated in the final version of the safety analysis report and operating documentation. Fuel loading, initial criticality and power operation of the NPP unit will be carried out after BAERA conducts necessary inspections of readiness of NPCBL to proceed with each of these stages. Before

routine operation at full power, a decision to issue an operating license for a nuclear power unit will be made by BAERA after review of following updated documents justifying safety of operation as well as results of inspections:

- The results of commissioning tests and their analysis;
- The updated final safety analysis report and updated operational limits and conditions;
- The updated as-built modifications to the plant that were made during commissioning.

It should be noted that Bangladesh's experience with final safety analysis and commissioning of a NPP is limited; therefore, during the Commissioning and Operation phase of the NPP the following elements will be addressed:

- Accomplishment of an appropriate safety analysis and a commissioning programme prior to the issuance of the operating licence, demonstrating that the installation, as constructed, is consistent with design and safety requirements;
- Operational limits and conditions (OLC) are in place, which are derived from the safety analysis; tests and operational experience are defined and revised as appropriate for identifying safe boundaries for operation;
- Approved procedures are in place for O&M, inspection and testing of a NPP;
- Establishment of procedures for responding to anticipated operational occurrences (AOOs) and to accidents;
- Availability of necessary engineering and technical support in all safety-related fields throughout the lifetime of an NPP;
- Reporting procedure of the licensee to the regulatory body of any incidents significant to safety.
- Establishment of operating experience feedback mechanism that allows sharing of important experience with international bodies and with other operating organizations and regulatory bodies.

The BAER Act-2012 [3], NSRC Rules-1997 [6] and the vendor country regulations have broadly addressed almost all the above mentioned requirements to ensure nuclear safety in the commissioning and operation stage of the Rooppur NPP. Moreover, development of related

regulations on the Safety of Nuclear Power Plant (NPP) based on the IAEA SSR-2/2 (Rev.1) [14] is on-going. The Act, rules and regulations mentioned above consider the post-Fukushima knowledge base and will facilitate the commissioning and operation of the Rooppur NPP as well as any other future NPPs ensuring all nuclear safety aspects. [11]

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