REPUBLIC OF GHANA

8TH AND 9TH REVIEW MEETING OF THE CONVENTION ON NUCLEAR SAFETY

NATIONAL REPORT PRESENTED BY THE REPUBLIC OF GHANA ON COMPLIANCE WITH THE CONVENTION ON NUCLEAR SAFETY OBLIGATIONS

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LIST OF ABBREVIATIONS

AOO	Anticipated Operational Occurrences
ASME NQA	American Society of Mechanical Engineers Nuclear Quality Assurance-1
BDBA	Beyond Design Basis Accidents
BDS	Borehole Disposal System
CIAE	China Institute of Atomic Energy
CNS	Convention on Nuclear Safety
CNSC	Canadian Nuclear Safety Commission
DBA	Design Basis Accidents
EC	European Commission
EPR	Emergency Preparedness and Response
GHARR-1	Ghana Research Reactor -1
GIIF	Ghana Infrastructure Investment Fund Act
GNPPO	Ghana Nuclear Power Programme Organization
GOG	Government of Ghana
HEU	High Enrich Uranium
HRD	Human Resource Development
IAEA	International Atomic Energy Agency
INSAG	International Nuclear Safety Advisory Group
INSEP	International Nuclear Safeguards Engagement Programme
KINS	Korean Institute of Nuclear Safety
LEU	Low Enriched Uranium
MOA	Memorandum of Agreement

MOU	Memorandum of Understanding
NADMO	National Disaster Management Organization
NNSA	National Nuclear Safety Administration of USDOE
NPID	Nuclear Power Infrastructure Development
NRA	Nuclear Regulatory Authority
PCSA	Post Closure Safety Assessment
PIE	Postulated Initiating Event
RANET	Response and Assistance Network
RDC	Regional Designated Centre
RWMC	Radioactive Waste Management Centre
SNAS	School of Nuclear and Allied Sciences
SSC	Structures, Systems, and Components
SSCs	Safety Systems and Components
USDOE	United States Department of Energy
USIE	Unified System for Information Exchange in Incidents and Emergencies
USNRC	United States Nuclear Regulatory Commission

INTRODUCTION

The Republic of Ghana seeks to derive maximum benefits from nuclear science and technology while ensuring the safe, secured and peaceful utilization of these nuclear technologies. Ghana acceded to the Convention on Nuclear Safety (CNS) in 2011.

A comprehensive legislation, Nuclear Regulatory Authority Act, 2015 (Act 895), covering the three thematic areas of safety, security and safeguards is in force. The Act established the regulatory body, the Nuclear Regulatory Authority (NRA). The powers of the NRA set out in the Act, include development of regulations, issuance of authorisation by registration and licensing, inspection, and enforcement.

Ghana's nuclear power programme and the needed infrastructure is still under development. A national roadmap for the Ghana's nuclear programme based on the IAEA Milestone Approach for Nuclear Power Development is being implemented. Actions have been identified for each of the 19 infrastructural issues spanning across the three Phases.

Ghana Nuclear Power Programme Organization (GNPPO) formed as part of the recommendation of the IAEA, has been mandated to coordinate the activities of all stakeholder institutions involved in the planning and implementation of Ghana's nuclear power programme.

Ghana's National Science Technology and Innovation Policy (2017) document identifies education, energy, nuclear science and technology sectors as key pillars for the country's development plan. In view of this, the country attaches great importance to nuclear education and training at the School of Nuclear and Allied Sciences of the University of Ghana. The School is an IAEA African Regional Designated Centre (RDC) for professional Training and Higher Education in Nuclear Science and Technology.

This National Report describes measures taken by the Government of Ghana for implementing its obligations under the Convention on Nuclear Safety (CNS). Its structure complies with the recommendations of the Guidelines of the CNS regarding the form and structure of national reports. Ghana is embarking on nuclear power programme, therefore reports on Articles 6-19.

The following Challenges were identified by the International Community during the 7th Review Meeting of the Convention:

- ✓ Establishment of general infrastructure for embarking countries as described in the IAEA Safety Standards.

- ✓ Recruitment of additional qualified staff including capacity building of staff for regulatory activities.
- ✓ Development of required regulations for review of site application and issuance of site license.
- ✓ Training on Human Factors Engineering and Suspect Items identification.

Establishment of general infrastructure for embarking countries as described in the IAEA Safety Standards

The following trainings have been supported by the International Atomic Energy Agency (IAEA), European Union's Instrument for International Nuclear Safety Cooperation (INSC) and Project 60, United States Nuclear Regulatory Commission (USNRC), Forum of Nuclear Regulatory Bodies in Africa (FNRBA), Regulatory Cooperation Forum (RCF) and Canadian Nuclear Safety Cooperation (CNSC) to assist the NRA to utilise IAEA's Safety Standards in the development of our infrastructure for nuclear safety:

The IAEA Legal and Regulatory Framework Development Workshop held from 5-9 February 2018 provided lessons which have been very useful in selecting the regulatory approach which is a blend of prescriptive and performance to optimize resources based on best practices of other Member States.

The USNRC-IRDP course on Inspection of Research and Test Reactors held from 12-16 March 2018 for FNRBA provided the requirements, expectations, and qualification of inspecting RTR; based on the NRC guidance. In addition, a preliminary review of the format of inspection reports and procedures, technical specifications (GHARR-1), and the Safety Analysis Report (GHARR-1) was performed and discussed in the classroom which also supported site visit.

The IAEA Workshop on Leadership, Integrated Management System and Safety Culture held from 16-20 April 2018 supported the NRA to receive experiences shared by experts and the hands-on exercises which enabled staff to provide inputs into many areas of the leadership and management system of the NRA.

The IAEA Workshop on Systematic Assessment of Regulatory Competence Needs held from 23-27 April 2018 provided competence management approaches for NRA supporting in improvement of NRA's competency model and application of IAEA Systematic

Assessment of Regulatory Competence Needs (SARCoN) methodology and tool and to complete the assessment of NRA competence needs and gap analysis.

The IAEA Basic Professional Training Course in Nuclear Safety was held from 7-18 May and 18-29 June 2018 to provide a broad overview of the safety concepts and their application to nuclear power plants and research reactors design and operation. The BPTC has formed part of Level 1 Training of NRA staff following the Course.

The IAEA Workshop on Licensing Process for Nuclear Power Plants was held from 13-17 August 2018 during which the NRA was enlightened on the licensing regimes applied in various Member States. The NRA has subsequently drafted the Licensing Regulation with the experience gathered.

The USNRC Workshop on Industry Codes and Standards held from 25-29 March 2019 brought together staff of the NRA and Ghana Standards Authority to support in the development and adoption of industry standards for the nuclear power programme in Ghana.

The USNRC-FNRBA Workshop on Emergency Preparedness and Response of Test and Research Reactors held from 16-20 December 2019 provided the requirements and expectations for overseeing the development, implementation and sustainability of emergency preparedness and response plans for research and test reactors based on the USNRC guidance.

The CNSC supported with a virtual engagement on review of our draft Fees and Charges Regulations for Nuclear Installations on 15th July 2021.

The USNRC-ADSTM Workshop on Regulatory Oversight of Nuclear Power Plants held from 19-21 October 2021 enlightened the NRA on the overview of regulatory oversight for Nuclear Power Plants and is supporting the development of regulations for NPPs in Ghana.

The European Union's Instrument for International Nuclear Safety Cooperation Project with the NRA has assisted in the development of the regulatory framework for safety in the areas of regulatory strategy, integrated management system, human resources development, development of regulations and guidelines, oversight of siting activities, transparency and stakeholder involvement. The activities started in December 2019 with

ENCO as lead consortium and supported by Hungarian Atomic Energy Authority (HAEA), Slovenian Nuclear Safety Administration and Nuclear Regulatory Authority of the Slovak Republic.

Staff of the NRA have participated in various activities of the IAEA to develop capacities in the areas of stakeholder involvement; safety, regulatory review, assessment and licensing of research reactors; strategic environmental assessments for nuclear power programmes; and a scientific visit to Pakistan Nuclear Regulatory Authority.

The RCF has supported in providing a platform for the NRA to obtain support from Providers and to share experiences with other Active Recipients.

Following these trainings, among others, an Integrated Management System Manual is being prepared in line with IAEA General Safety Requirements Part 2 (GSR Part 2) and ISO 9001:2015, competency framework is being developed in line with IAEA Safety Standards, regulations have been developed with IAEA Safety Standards forming the basis, the regulatory framework is being developed in line with provisions of SSG16 (Rev.1), among others. Expert Missions of the Agency were utilised to ensure adherence to the Safety Standards in the conduct of the conversion of GHARR-1 from HEU to LEU exercise.

Recruitment of additional qualified staff including capacity building of staff for regulatory activities

The NRA has developed a manpower plan which is discussed in Article 11 on Human Resource Development. The plan is assisting the NRA to prepare adequately, bearing in mind lead times, to recruit and train personnel to meet the roadmap for the first nuclear power plant. The NRA has recruited forty (40) new staff and has subsequently conducted Basic Professional Training Course for Nuclear Safety (BPTC) for them from 8th November to 2 December 2021 with staff of the NRA as instructors using the IAEA BPTC materials.

Development of required regulations for review of site application and issuance of site license

The Site Evaluation Regulations has been drafted and reviewed by Stakeholders as discussed in the regulatory framework section of this report. The process of its adoption is also discussed and it will be issued before a license is granted for the site. Review comments

on the draft Site Evaluation regulations received from United States Nuclear Regulatory Authority (USNRC) and through Task 5 of the European Union's Instrument for International Nuclear Safety Cooperation (INSC) have been received and used to finalise the regulations for approval.

Training on Human Factors Engineering and Suspect Items identification

Through the European Commission's European Nuclear Safety Tutoring and Training Institute (ENSTTI) programme, the NRA has received training on human and organisational factors. The human factors and suspect items identification forms part of the subjects to the treated under an IAEA Technical Cooperation Project with the NRA. A new staff with expertise in human factors engineering has been engaged to lead the preparedness of the NRA to address the impact of human factors and suspect items identification in the oversight of nuclear installations in Ghana.

SUMMARY

Ghana has since the promulgation of the Nuclear Regulatory Authority Act, 2015 (Act 895), established an independent Nuclear Regulatory Authority (NRA) with its functions and responsibilities defined. The law provides for the regulation and management of activities and practices for the peaceful uses of nuclear material or energy, radioactive material or radiation; the protection of persons and the environment against the harmful effects of radiation hazards and to ensure the implementation of the country's international obligations and for related matters. The NRA has set out to develop regulations and guidelines to ensure implementation of the provisions of the Nuclear Regulatory Authority Act, 2015 (Act 895).

The country's nuclear power programme is being developed in line with the IAEA recommended internationally accepted comprehensive framework for developing infrastructure for nuclear power. The Ghana Nuclear Power Programme Organisation (GNPPO) has an advisory body and a technical wing composed of the Nuclear Power Institute (NPI) of Ghana Atomic Energy Commission, Nuclear Installations Directorate (NID) of the Nuclear Regulatory Authority, Ghana and other stakeholders. The GNPPO recognises the need to establish mechanisms for developing and sustaining a human

resource base through a systematic approach to education and training for implementation of Ghana's nuclear power programme.

The Phase 1 follow-up Integrated Nuclear Infrastructure Review (INIR) Mission was held from 21–24 October 2019 in Accra, Ghana.

The follow-up INIR team concluded that Ghana has completed the studies needed for the government of Ghana to make a knowledgeable commitment to a nuclear power programme.

The GNPPO has completed the IAEA's Integrated Nuclear Infrastructure Review and its Follow-up Missions for Phase 1. Additionally, a National Nuclear Power Programme Comprehensive Report (PCR) has been developed and submitted to Government. The PCR is an evaluation of all the necessary technical considerations that provide bases for a knowledgeable commitment to the nuclear power programme. The Government has set up an Inter-Ministerial Committee comprising Ministers of Foreign Affairs and Regional Integration; Finance; Environment, Science Technology and Innovation; and Energy to inform neighbouring States of the intention to undertake the nuclear power project and evaluate the financing options.

Government has established an owner/operator organisation, the Nuclear Power Ghana, to lead feasibility for a nuclear power project, thus, effectively implementing Phase Two (2) of the Nuclear Power Programme.

The preparation of the Project Comprehensive Report (PCR) is underway to support the choice of a nuclear power plant technology.

The government of Ghana has also signed a Memorandum of Understanding (MOU) and a Memorandum of Agreement (MOA) with Russia and MOU with China on Cooperation on Ghana Nuclear Power Programme.

The Nuclear Regulatory Authority is receiving support from the Regulatory Cooperation Forum, Forum of Nuclear Regulatory Bodies in Africa, United States Nuclear Regulatory Commission (USNRC), United States Department of Energy (USDOE), European Commission (EC), and European Nuclear Safety Tutoring and Training Institute. The support through the European Commission's Instrument for Nuclear Safety Cooperation starts in 2019.

Ghana is implementing the Principles of the Vienna Declaration on Nuclear Safety in the provisions related to siting, design, construction and operation of nuclear installations as presented in Articles 6, 14, 17, 18 and 19 of this National Report.

The Conversion of Ghana Research Reactor-1 (GHARR-1) from High Enriched Uranium (HEU) fuel to Low Enriched Uranium (LEU) fuel was successfully completed in 2017 with support from the International Atomic Energy Agency (IAEA), USDOE, China Institute of Atomic Energy (CIAE) and various laboratories.

ARTICLE 6: - EXISTING NUCLEAR INSTALLATIONS

Ghana operates a tank-in-pool Miniature Neutron Source Reactor (MNSR), Ghana Research Reactor-1 (GHARR-1), mainly used for neutron activation analysis. The reactor originally used High Enriched Uranium (HEU) fuel with a rated power of 30 kW which has been converted to Low Enriched Uranium (LEU) fuel with a rated power of 34 kW. The Core Conversion project was carried out with support from the International Atomic Energy Agency (IAEA), United States Department of Energy (US DOE), Government of the People's Republic of China and the Republic of Ghana through various Laboratories and Institutions.

Expert missions were organised by the IAEA to guide the Nuclear Regulatory Authority (NRA) on various regulatory and technical issues aimed at enhancing their regulatory capabilities for the process. The NRA also collaborated with the regulatory authorities of the People's Republic of China to ensure safety and security of the core conversion activities.

Both the operator, Ghana Atomic Energy Commission (GAEC) and NRA participated in factory acceptance testing of some equipment for the removal of the HEU core and witnessed the testing of the LEU fuel to be installed and other packaging for transport of the HEU fuel. The Interim Transfer Cask (ITC), the main part of the Technical Equipment Set (TES) which was used to remove the irradiated core from the reactor vessel was designed and fabricated by SOSNY R&D Company of Russian Federation.

The GAEC submitted required documents such as Conversion Safety Analysis Report (CSAR), equipment and fuel package Safety Analysis Reports (SARs) to the NRA and provided responses to requests for additional information. The NRA conducted independent review on all the documentation received from GAEC and provided approval for the process.

The HEU fuel was unloaded on August 28, 2016. The removal of the HEU fuel was carried out by trained staff of GAEC in close collaboration with staff from China Institute of Atomic Energy (CIAE) and SOSNY R&D Company of Russian Federation. The ITC was used as a temporal storage cask for the irradiated HEU fuel for forty two days and was later

transferred into the SKODA MNSR Cask. The unloading of the HEU and its transfer into the SKODA MNSR Cask were supervised by IAEA Safeguards inspectors.

The LEU fuel was received in Ghana on June 22, 2017 and was loaded into the reactor vessel on July 12, 2017. The reactor with LEU core went critical on July 13, 2017 and subsequently got to full power on August 10, 2017. Several related experiments were conducted to ensure the reactor safety and nominal flux was not compromised. The HEU package was transported to the People's Republic of China on August 27, 2017. The Nuclear Security Committee of Ghana led by the National Security Coordinator's Secretariat was actively involved in the transport.

The criticality tests are conducted prior to every operation to ascertain whether the flux value indicated on the control console is the right value. The facility has been participating in the IAEA proficiency test which is done annually. So far, the results presented on samples received have been satisfactory per the outcome of the overall results compiled by the IAEA. Maintenance is carried out weekly, monthly and annually to ensure good ageing management is sustained. There are challenges with the availability of some components in the local market but thanks to our Chinese Counterparts components are supplied intermittently which greatly supports the sustainability of reactor operation. Currently the reactor is in a good shape and students are using the facility for their theses among other research activities.

There are three reactor operators with three others waiting for their operation licences after satisfactory performance in reactor operation examination conducted by the Operating Organization under the supervision of the NRA.

ARTICLE 7: - LEGISLATIVE AND REGULATORY FRAMEWORK

Establishing and Maintaining a Legislative and Regulatory Framework.

The Nuclear Regulatory Authority Act, 2015 (Act 895) was promulgated by the Government of Ghana to establish the Nuclear Regulatory Authority (NRA) to provide for the regulation and management of activities and practices for the peaceful use of nuclear material and radiation in the country. The NRA is also mandated by Act 895 to provide for the protection of the environment and persons from the harmful effects of radiation and to

ensure the effective implementation of the country's international obligations. One of the objects of NRA as the Regulator under the law is to pursue and ensure strict compliance with Act 895 and all Regulations made pursuant to the Act.

The legislative and regulatory framework established under Act 895 provides for the regulation of nuclear installations, a licensing regime, safeguards and prohibitions, inspections and enforcements, liability for nuclear damage among others.

The Atomic Energy Commission Act, 2000 (Act 588) established the Ghana Atomic Energy Commission (GAEC) as a promoter of nuclear energy, science and technology. GAEC carries out research and development activities in nuclear and related technologies and is mandated to oversee and facilitate the development of human resources in the fields of nuclear science and technology among others. GAEC is mandated by Act 588 to ensure that nuclear damage does not result from any of its activities.

Ghana is a member of the International Atomic Energy Agency (IAEA) and has over the years ratified various international and regional conventions. These are

- the Comprehensive Safeguards Agreement in connection with the Treaty on Non-Proliferation of Nuclear Weapons;
- Additional Protocol to the Agreement on Safeguards in connection with the Treaty on Non-Proliferation of Nuclear Weapons;
- the Convention on Nuclear Safety;
- the Comprehensive Nuclear Test Ban Treaty (CTBT);
- the African Nuclear Weapon Free Zone Treaty (Pelindaba);
- Convention on Physical Protection of Nuclear Materials (CPPNM);
- Amendment to the Convention on Physical Protection of Nuclear Material;
- The Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention);
- the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency,
- the Convention on Early Notification of a Nuclear Accident; and
- the Convention on Supplementary Compensation for Nuclear Damage (CSC).

In 2020, Ghana acceded to the three nuclear liability conventions;

- the Vienna Convention on Civil Liability for Nuclear Damage;

- the Protocol to amend the Vienna Convention on Civil Liability for Nuclear Damage; and
- the Joint Protocol Relating to the Application of the Vienna Convention and of the Paris Convention.

National Safety Requirements and Regulations.

The NRA is empowered by Section 91 of Act 895 to make regulations for the efficient and effective implementation of the Act. The NRA is again empowered by Section 92 of Act 895 to develop guidelines, standards and procedures for the radiation protection and safety requirements for workers, the public and the environment and for inspection and reporting procedures among others.

The NRA has developed draft regulations and guidelines in exercise of its powers in consultation with various stakeholders and relevant organisations. The following regulations and associated guidelines have been drafted:

i. Siting of Nuclear Installations
ii. Safeguards
iii. Security of Radioactive Sources
iv. Technical Support Services
v. Basic Radiation Control
vi. Radioactive Waste Management
vii. Licensing of Nuclear Installations
viii. Design of Nuclear Installations
ix. Nuclear Security
x. Construction of Nuclear Installations
xi. Emergency Preparedness of Nuclear Installations
xii. Commissioning of Nuclear Installations
xiii. Operation of Nuclear Installations
xiv. Integrated Management System for Facilities and Activities
xv. Decommissioning of Nuclear Installations

The following regulations and associated guidelines are under development:

1. Transport Safety
2. Environmental Impact Assessment for Nuclear Installations
3. Nuclear Liability and Civil Damage

4. Fees and Charges
5. Environmental Protection
6. Mining of Radioactive Materials
7. Nuclear Power Generation in Ghana

The process for development and approval of regulations and guidelines is as presented in Figure 1 below:

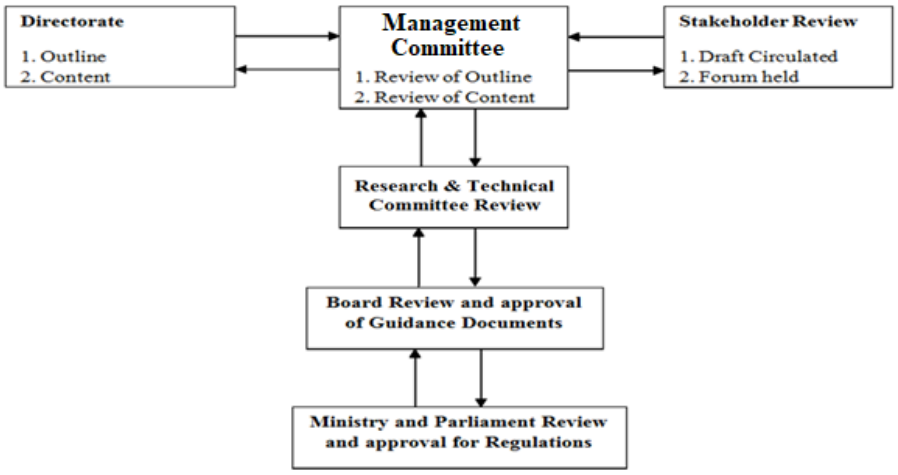

Figure 1: Process for Review and Approval of Regulations

System of Licensing, Regulatory Assessments and Inspections

Act 895 mandates the NRA to license activities that require the use of nuclear materials, radioactive materials, radiation and nuclear waste or radioactive waste. An applicant shall not engage in an activity or a practice which involves the use of nuclear material or any radiation source, unless that person is authorised by the NRA.

The NRA is also mandated to appoint Inspectors and Analysts to verify and analyse practices and nuclear installations of authorized persons. Inspectors and Analysts are empowered under the Act to ensure compliance to the Act and Regulations.

Enforcement of Applicable Regulations and Terms of Licences

The NRA may issue an order for an immediate temporary cessation of activities, in the case of an imminent or actual hazard to the public or the environment and immediate cessation when a situation for which the operator is responsible poses a safety or security hazard to humans and the environment, and shall ensure that the operator resolves the safety and security concerns.

The NRA may also modify, suspend or revoke the authorisation or issue a warning notice to an authorised person who contravenes a minor safety or security requirement or procedure.

Persons who knowingly make false or misleading statements to the NRA or obstruct Inspectors or Analysts in carrying out their functions under Act 895 and persons who carry out activities requiring licensing or authorization under Act 895 commit an offence and are liable on summary conviction to fines or prison terms as the case may be. Act 895 also makes it an offence to handle radioactive and nuclear materials and devices without authorization, to unlawfully use or threaten to use radioactive and nuclear materials and devices.

It is also an offence under Act 895 to damage a nuclear facility by interfering with the operation of that facility with the knowledge that the damage is likely to cause death or bodily injury, or substantial damage to property or the environment. A person who does an act directed at a nuclear facility and in manner that results in the release of radioactive material or risks the release of radioactive material with the intent that the act will cause death or bodily injury, or substantial damage to property or the environment is punishable under the Act.

ARTICLE 8: - REGULATORY BODY

The Nuclear Regulatory Authority Act, 2015 (Act 895) established the Nuclear Regulatory Authority (NRA) to provide for the regulation and management of activities and practices for the peaceful use of nuclear material or energy, radioactive material or radiation; to provide for the protection of persons and the environment against the harmful effects of radiation hazards; to ensure the effective implementation of Ghana's international obligations and for related matters. The legal hierarchy is presented in Figure 2.

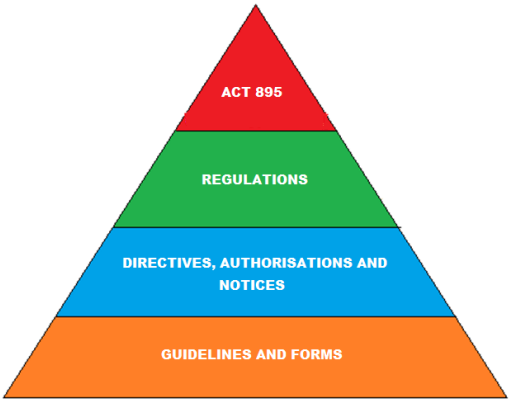

Figure 2: Ghana's Legal Hierarchy

The Vision of the NRA is "***To ensure humans and the environment are protected from the harmful effects of radiation***".

The Mission of the NRA is "***To regulate radiation and nuclear facilities/activities to meet national and international standards and obligations in a professional, objective and transparent manner***".

The NRA is committed to sound and transparent governance that will enhance the Authority's relationship with all stakeholders. This will be achieved through the following core values;

Professionalism	*Adhere to standard operating procedures in the performance of duties using competent staff*
Integrity	*Honesty in dealing with clients*
Transparency	*In communication, decision making with licensees, relevant stakeholders and the public in an appropriate and accurate manner*
Objectivity	*Being fair to all clients and other stakeholders*

The NRA is mandated to:

- To authorise and regulate the civilian use of nuclear and other radioactive sources in Ghana
- To ensure the protection of the general public, patients, people who work with radiation, property and the environment from the harmful effects of radiations
- To regulate the possession, use, transport, storage and the disposal of radioactive materials and radioactive waste and also licence the import and export of radioactive materials

The functions of the Authority as stated in the NRA Act 2015, Act 895 are:

1. To facilitate the development of national policies on the regulation and management of activities and practices with respect to nuclear safety and research; security of nuclear and radioactive materials; radiation and the implementation of safeguards specified under this Act.
2. Regulate the introduction of radiation sources, nuclear materials, equipment of practice that expose workers, patients, the public and the environment to radiation;
3. Issue, modify, suspend or revoke authorisation and determine conditions for authorisation;
4. Regulate research on radiation and nuclear safety and security, and of radioactive waste matters;
5. Regulate the use of radioactive materials in the exploration, exploitation and extraction of oil and gas, and the mining and milling of radioactive ores and other ores associated with radioactive and nuclear materials;
6. Define the detailed obligations to be placed on persons who possess radiation sources and nuclear materials, including financial conditions;
7. Establish and maintain a national register of radiation sources and of persons authorised to carry out any activity or practice related to a source of radiation;
8. Collect information, documents and views from private and public organisations or persons as may be necessary and appropriate for the discharge of its functions;
9. Collaborate with agencies responsible for emergency to establish plans and procedures for coping with any radiological emergency and abnormal occurrence involving a nuclear material, radiation source or any other radioactive source;
10. Ensure that the operators provide training, information and guidance on nuclear safety, security and safeguards and radiation protection of the public;
11. Educate the public on radiation and nuclear matters;
12. Establish regional and other offices as it may consider necessary for the proper performance of its functions;
13. Facilitate the conduct of inspections by designated inspectors of the International Atomic Energy Agency (IAEA) to verify design information, inspections and complementary access as provided for in the Safeguards Agreement and the Additional Protocols;

14. Collect, collate and provide information to the International Atomic Energy Agency in accordance with the Safeguards Agreement and any additional protocols to that Agreement;
15. Exchange information and co-operate with other regulatory authorities of other countries and relevant international organisations on matters of nuclear safety, nuclear security and safeguards;
16. Collaborate with the Environmental Protection Agency to identify activities and practices that may require Environmental Impact Assessment and develop environmental guidelines for those activities and practices;
17. Ensure that the polluter pays principle is applied in the management of nuclear and radioactive waste in the country;
18. Review nuclear safety assessment and safety analysis reports from authorised persons; and
19. Perform other functions that may be assigned to the Authority under this enactment.

The NRA exercises the following powers:

(a) define the exposures that are excluded from the scope of application of Act 895;

(b) establish the process for removal of a facility or activity from regulatory control;

(c) impose an administrative penalty on an authorised person including a prohibition or confiscation of the nuclear and radioactive material or equipment and its source, for noncompliance with Act 895 and any Regulations;

(d) levy fees for authorisation;

(e) collaborate with the Ministries responsible for National Security and the Interior in determining what constitutes a domestic threat for the variety of nuclear and radioactive materials used within the country and assess the country's vulnerability to each threat; and

(f) establish in collaboration with the Ghana Immigration Service and the Customs Division of the Ghana Revenue Authority a control system for import and export of nuclear material and other controlled items.

The NRA reports to the Ministry of Environment, Science, Technology and Innovation (MESTI). The Board of the NRA is appointed by the President and provides policy

direction for the Authority. The Director-General sees to the day-to-day administration of the NRA and reports to the Board.

The governing body of the Authority is a Board consisting of (a) the chairperson, (b) the Director-General, (c) one representative of the Environmental Protection Agency not below the rank of a Director, (d) one representative of the National Security Council not below the rank of a Director, and (e) three other members with cognate background and experience in the sciences at least one of whom is a woman.

The NRA has adopted a hybrid approach between prescriptive and performance approaches to regulatory infrastructure development. The hybrid is adopted to optimize on the number of staff and the roles to ensure effective use of experiences of other regulatory bodies in similar roles. The NRA has developed a Corporate Strategic Plan for 2021-2025 which is currently being implemented.

Regulatory Strategy

The NRA has a Corporate Strategic Plan spanning 2021-2025. A Work Plan is being finalized to implement the Strategic Plan. As part of Task 1 of the EU INSC Project, a strategy and action plan has been developed which is being integrated with the previous work plan of the corporate strategic plan. The strategy comprises eighteen strategy elements namely: Stable Legislative Framework, Functional Separation, Management System, Competent Staff, Budget, Prime Responsibility for Safety, Graded Approach, Technical Support Organisation, Record Keeping, Licensing, Review and Assessment, Inspection and Enforcement, Emergency Preparedness and Response, Management of Radioactive Waste and Spent Fuel, Interface of Safety with Nuclear Security, Transparency (informing the public), International Cooperation and Operating Experience Feedback. The NRA conducted a self-assessment based on IAEA GSR Part 1. The output of the assessment was reviewed by European Experts followed by the following activities:

- INSC Virtual Workshop on Regulatory Strategy, 28 July-27 August 2020
- INSC Project Task 1 Virtual On-Site-Assistance, 15, 17 February, 9 (TSOs), 11 (Safety and Security Interface), 15 (Inspection and Enforcement), 17 (Record Keeping, Graded Approach and Prime Responsibility), 19 (Budget, Financing and EPR), 23 (Operational Experience), 25 (Review and Assessment), 29 March 2021 (Radioactive Waste and Decommissioning);
- INSC National Policy & Strategy Virtual Meeting, 5 April 2022

- INSC Task 1 Strategic Plan & Action Plan Final Meeting, 26 April 2022

The NRA is synchronizing the output of the EU INSC Project Task 1 with the Work Plan already prepared for implementing the Corporate Strategic Plan and also including strategy elements for safeguards and nuclear security.

Human Resource Development

A Human Resource Department has been established at NRA to ensure the continual development and sustenance of the competence of staff. Staffs of the NRA continually participate in IAEA workshops, technical meetings, training and fellowship programs to build their competence. In-house seminars are organised for staff returning from such international programmes to share knowledge and skills acquired with colleagues. Key amongst the training programmes is the IAEA Post Graduate Education Course on Radiation, Transport and Waste Safety organised by the IAEA in cooperation with the Government of Ghana through the School of Nuclear and Allied Sciences, University of Ghana.

The NRA has developed a Training Programme with four levels of competence as recommended in IAEA Safety Standards. The Level 1 captures Basic Professional Training Course of the IAEA, Safeguards and Non-Proliferation and Nuclear Security modules. Level II addresses technical competencies in Nuclear Safety, Nuclear Security and Safeguards and Non-Proliferation while Level III addresses the core functions of the NRA in inspections, review and assessment and development of regulatory tools. The fourth level addresses Leadership training. Training activities have been organized from 2016 with support from IAEA, International Nuclear Safeguards Engagement Programme (INSEP) of USDOE, International Nuclear Security (INS) of USDOE, Office of Radiological Security of USDOE, European Nuclear Safety Tutoring and Training Institute (ENSTTI) of European Commission and United States Nuclear Regulatory Commission (USNRC).

The NRA currently has ninety-eight (98) staff, forty (40) of whom are newly employed in October 2021. The NRA implemented an Orientation Programme to welcome the new staff and conducted the Basic Professional Training Course on Nuclear Safety with internal instructors for thirty-five new staff from 8th November to 2nd December 2021. A Weekly Seminar has been instituted since 11th May 2021 to allow for sharing of knowledge among staff, 42 % of which has been on nuclear safety.

A Weekly Exercise is currently underway to develop Standard Review Plan for various chapters of the Safety Analysis report as part of training staff to be ready for review of submittals for the nuclear power programme. Activities held to develop human resources for the regulatory oversight of nuclear installations in Ghana are presented below.

The USNRC-FNRBA Workshop on Emergency Preparedness and Response of Test and Research Reactors held from 16-20 December 2019 provided the requirements and expectations for overseeing the development, implementation and sustainability of emergency preparedness and response plans for research and test reactors based on the USNRC guidance.

The USNRC-ADSTM Workshop on Regulatory Oversight of Nuclear Power Plants held from 19-21 October 2021 enlightened the NRA on the overview of regulatory oversight for Nuclear Power Plants and is supporting the development of regulations for NPPs in Ghana.

The IAEA provided training for Joint Convention National Report Reviewers on 11th January 2021.

The European Union's Instrument for International Nuclear Safety Cooperation (INSC) supported with site licensing workshop from 14-22 September 2020; safety principles, requirements, criteria for new nuclear reactors workshop from 18-22 January 2021; and human resources development workshop from 19-23 April 2021.

The European Union's Project 60 supported with safety and security interface workshop from 2-5 March 2021. The Nuclear Power Ghana supported with an EMODAL Leadership Training from 13-17 June 2022.

The planned activities to develop capacity of staff of the NRA include an upcoming USNRC-FIRST Workshop on Nuclear Safety and Licensing, 15-19 August 2022; EU-INSC On-Site-Assistance on Integrated Management System Drafting, 22-26 August 2022; EU-INSC European Leadership for Safety Education (ELSE) Face-to-Face Engagement, 5-16 September 2022; EU INSC On-the-Job Training at Hungary and Slovakia, 5 September-28 October 2022; and IAEA Regulatory Control Course, 10-21 October 2022.

Management System of NRA

The NRA management seeks to ensure that licensees operate their facilities at all times in a safe, secured and safeguarded manner. The NRA is dedicated to have good leadership that shall transform strategic direction into operational programmes and has public safety as her primary focus. The NRA has independence in regulatory decision making from any undue influence on the part of the nuclear industry and those sectors of government that sponsor this industry.

The senior management of the NRA has set out to develop a management system in order to make its day to day activities more efficient and effective. An integrated management system is needed to help the organisation meet its mandated objectives successfully while making sure that no competing objectives overrides safety. In order to do this a Committee is developing a management system compliant with IAEA General Safety Requirements Part 2 (GSR Part 2).

The NRA has technical competence at its core, with other competencies built upon this fundamental and essential requirement. The NRA seeks to be open and transparent in its development of regulations and decisions. The NRA in collaboration with other regulatory bodies and IAEA is currently developing requirements, guidelines and codes of practice that shall be clear and easily understood by all stakeholders. The NRA continues to make clear, balanced and unbiased decisions, and is accountable for those decisions; and is building a strong organisational capability in terms of adequate resources, strong leadership and a robust integrated management system. The NRA is performing her regulatory functions in a timely and efficient manner; has and encourages a continuous self-improvement and learning culture; including the willingness to subject herself to independent peer reviews. The Board of NRA initiates policies for the development of the Authority; ensures the proper management of resources and the implementation of the functions conferred on the Authority under Act 895 and any other enactments. The Board of the NRA meets at least once every three months. The Technical Committee of NRA reviews policies, criteria, guidelines, procedures and other related matters of the Authority, reviews the licensing and certification requirements for technical support services and consultancies, reviews and recommends for the NRA Board's approval reports to be sent to International Atomic Energy Agency. The Committee holds regular meetings in order to discharge its duties. The Finance Committee of NRA looks at the financial position of the

NRA at each time and suggest avenues of ensuring optimized use of financial resources of the NRA, reviews the financial statement of the NRA for each year and submits its comments and recommendations to the NRA Board for the necessary actions to be taken, reviews investment instruments for financial sustainability of the operations of the NRA for approval by the NRA Board.

The Executive Committee comprises the Director-General, Deputy Director-General, Directors, Heads of Legal Affairs and Audit. The Executive Committee assists the Director-General in the day to day administration of the affairs of the NRA as set out in Act 895; recommends policy criteria, guidelines, procedures and other related matters of the NRA for review by the Technical Committee; recommends the licensing and certification requirements for technical support services and consultancies; recommends for approval reports to be sent to the International Atomic Energy Agency, including reports on Ghana's obligations under the Joint Convention, Convention on Nuclear Safety, among others. The Executive Committee holds regular meetings in order to discharge its duties.

The NRA has three Directorates and fifteen Departments. Regulations are drafted at the Directorates, reviewed by the Management Committee, followed by review of the Technical Committee and the Board as presented in Figure 1. Stakeholders are consulted and involved in the development of the regulations through Workshops, Public Meetings and involvement in Committees. The regulations developed are forwarded to the Parliament of Ghana for promulgation. Efforts underway through Task 3 of the EU INSC Project in developing the components of the Management System Manual of the NRA include:

- Gap analysis of Safety Infrastructure based on GSR Part 1 using a questionnaire developed by ENCO, with various staff of the NRA forming the bases for Regulatory Strategy and Action Plan under Task 1 of INSC Project;
- Gap Analysis of the Management System based on IAEA GSR Part 2, GS-G 3.1 and GSG 12, using a questionnaire developed by ENCO, with the Task 2 Workgroup;
- Coordinated the drafting of processes and procedures for:

- Management Processes: Policy Making, Planning, Process Management, Directing and Managing the Organisation, Performance Management, Management of Change, and Project Management;
- Core Processes: Development of Regulations and Guides, Notification and Authorisation, Review and Assessment, Inspection, Enforcement, Emergency Preparedness and Response, Nuclear Safeguards Reporting and Communication and Consultation with Interested Parties;
- Support Processes: Procurement, Legal, Transport Management, Human Resource Management, Finance/Accounting, Information and Communication Technology Administration, Instrumentation, Document and Records Control, Estate Management and Security; and Knowledge Management;

- EU-INSC Virtual Workshop on Management System, Virtual Event, 22 - 26 February 2021;
- Meeting on Subtask 2.1 – Identification of the Status of the Management System Development of MS structure and priority elements, Virtual Meeting, 23 November 2021; and
- EU INSC Workshop 4 on Integrated Management System Kick-Off, 28 February-4 March 2022.

Planned activities to support development of the management system of NRA include:

- EU-INSC OSA on Integrated Management System Drafting, 22-26 August 2022
- Internal and External Audit of the Management System for compliance with ISO 9001:2015 as well as IAEA Audit of the management system for compliance with IAEA GSR Part 2.

Financial Resource and Technical Development

The Nuclear Regulatory Authority is financed through the following:

1. Moneys appropriated by Parliament
2. Loans, loan guarantees and grants

3. Fees and charges due the NRA from services rendered by or through the NRA etc.

The regulatory authority continues to collaborate with external agencies such as the IAEA, USDOE/NNSA, USNRC, European Commission, Regulatory Cooperation Forum (RCF), KINS, FNRBA and CIAE in the area of technical support for its activities and staff. The NRA received support from the Canadian Nuclear Safety Commission in reviewing the draft Fees and Charges for nuclear installations virtually on 15th July 2021.

Cooperation with Local and International regulatory organisations

The NRA signed an Arrangement for Technical Information Exchange and Cooperation in Nuclear Safety Matters with the USNRC in September 2017. The NRA is receiving support under the European Instrument for International Nuclear Safety Cooperation (INSC) programme of the European Commission to address key. The NRA signed a memorandum of understanding with Canadian Nuclear Safety Commission (CNSC) in September 2019. The NRA signed a memorandum of understanding with the Pakistan Nuclear Regulatory Authority in December 2021. The NRA is discussing MoU with Rostechnadzor of Russia and AMSSNUR of Morocco.

The NRA is collaborating with the Small Arms and Light Weapons Commission in the development of the National Control List. In similar manner collaboration with various security agencies in the framework of the Nuclear Security Committee to develop infrastructure for nuclear security in Ghana. This collaboration enables effective coordination with frontline officers in the conduct of their duties. Activities conducted to improve on coordination with international partners include:

- Virtual Bilateral Meeting with USNRC to Discuss Areas of Assistance to NRA, 27 October 2020
- Bilateral Meetings with USNRC, 1 March, 30 June 2021
- IAEA Group Scientific Visit, Pakistan Nuclear Regulatory Authority, Islamabad, Pakistan, 13 – 17 December 2021

Stakeholder Engagement

The NRA is involved in a lot of activities related to public education on radiation issues. It does this as a sole entity and also in collaboration with the larger Ghana Nuclear Power Programme Organization (GNPPO-Ghana's NEPIO).

a) The NRA has conducted two workshops to train media personnel on nuclear and radiation matters. In addition, a Press Corps has been formed and are being trained on nuclear and radiation matters reporting.

b) The NRA participates in the Annual Sector Ministry Meet the Press Series and exhibits on nuclear and radiation matters to the public.

c) In collaboration with the GNPPO, the NRA participates in the Ghana Industrial Summit and Exhibitions (GISE) of the Association of Ghana Industries and provides education on nuclear and radiation matters.

d) Publications are provided in the press and the print media and online portals; this includes fliers, posters and other public information tools for educating and informing the public on the work of the NRA.

e) With the GNPPO, a Quiz competition was organised for High Schools to introduce them to the operation of nuclear power plants.

f) Also, the GNPPO has been conducting television and radio interviews and discussion on nuclear and radiation safety.

Generally, it is noted that the confidence of the public in nuclear and radiation safety is improving, and continuous education is enabling the public to appreciate the work of the NRA.

The NRA participated in the GNPPO Environmental Impact Assessment Retreat held in February 2019; GNPPO Conference held in February 2019; hosted the GNPPO Meeting on Environmental Framework for Nuclear Power Programme during which working groups were formed to address interfaces with other competent authorities; GNPPO Frequently Asked Questions Formulation Meeting held in August 2020; held a meeting with Nuclear Power Ghana (Owner/Operator) in February 2021; participated in the Association of Ghana Industries Stakeholder Forum on Nuclear Power in June 2021; interacted with Customs on

joining the common platform for authorising import and export in February 2022; and participated in the IAEA Integrated Work Plan Hybrid Meeting in March 2022.

ARTICLE 9: - RESPONSIBILITY OF THE LICENCE HOLDER

Section 23(1) (b) of Act 895 provides as follows: A person authorised to conduct an activity or practice is responsible for the safe and secure conduct of the activity or practice in compliance with Act 895. A person authorised to construct or operate a nuclear installation is responsible for the safety of the nuclear installation. Section 35 of Act 895 provides as follows: An operator is responsible for ensuring the safe and secure conduct of any activity or practice associated with the operator's facility. Persons authorised to manage radioactive waste management facilities under the Act are responsible for all issues of safety at such facilities as per Section 45 Persons authorised to extract, mine and process radioactive materials are also assigned the responsibility of ensuring safety by the Act as found in Section 59

To ensure that authorised persons discharge the prime responsibility for safety, the NRA is mandated by Act 895 to make regulations and guidelines to provide for the safety and security of nuclear material and facilities and for the safety requirements for workers, the public and the environment as a whole.

The licensee is required to provide training, information and guidance on nuclear safety, and radiation protection to the public and also to maintain a management and human resource development system within the organization.

ARTICLE 10: - PRIORITY TO SAFETY

The Nuclear Regulatory Authority is mandated to facilitate the development of national policies on the regulation and management of activities and practices with respect to nuclear safety. The responsibility to ensure the safety of any activity or practice associated with the design, construction and operation of nuclear installations however, rests with the licensee.

An established safety culture governs the actions and interactions of all individuals and organizations engaged in activities related to facilities. The ultimate responsibility for the safety of a facility rests with the operating organization. This is in no way diluted by the separate activities and responsibilities of designee, suppliers, contractors, constructors and regulators. The Government of Ghana has established the legal framework (Act 895) for the nuclear industry and the Nuclear Regulatory Authority (NRA) is responsible for licensing and regulatory control of facilities and for enforcing the relevant regulations. The separation between the responsibilities of the NRA and those other parties allows for retention of independence as a safety authority and keeps the NRA protected from undue pressure.

A defence in depth concept is implemented, centered on several levels of protection including successive barriers preventing the release of radioactive material to the environment. The concept includes protection of the barriers by averting damage to the plant and to the barriers themselves. It includes further reasons to protect the public and the environment from harm in case these barriers are not fully effective. NPPs are to be designed, sited, and constructed consistent with the objective of preventing accidents in the commissioning and operation and should an accident occur, mitigating possible releases of radionuclides covering long term off-site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. Comprehensive and systematic safety assessments are carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements.

Integrated Management System (including Quality Assurance/Quality Control (QA/QC)) is applied throughout activities at a facility as part of a comprehensive system to ensure with high confidence that all items delivered and services and tasks performed meet specified requirements. Self-assessment for all important activities at a facility ensures the involvement of personnel performing line functions in detecting problems concerning safety.

Independent peer reviews provide access to practices and programmes employed at facilities performing well and permit their adoption at other facilities. Personnel engaged in activities bearing on facility safety are trained and qualified to perform their duties. The possibility of human error in facility operation is taken into account by facilitating correct

decisions by operators and inhibiting wrong decisions and by providing means for detecting and correcting or compensating for error.

Safety Assessment is conducted before construction and operation of a facility. The assessment is well documented and independently revised. It is subsequently updated in the light of significant new safety information.

The NRA has drafted siting, design and licensing regulations which are at various stages of review to provide for the safety of nuclear material and facilities. The regulations specify the types of authorisation and their duration, renewal, suspension, modification and revocation; assessment and verification. Other areas to be addressed are the programme and procedure of inspection; education, training, qualification and certification requirements for personnel to manage and operate facilities; the hold points in deploying nuclear power plant and the implementation of other international conventions which relate to nuclear technology to which Ghana is signatory and has ratified.

NPG, as the prospective responsible organisation to ensure safety associated with the nuclear power project, recognises and prioritizes safety right from its inception. Safety has therefore been ingrained in the organisation's mission statement and approved core values. Additionally, NPG is developing a safety policy and strategy. There are periodic organizational meetings where identified topics related to nuclear and occupational health safety are discussed. NPG's safety priority includes leadership and management training for management staff. This is to foster a foundational culture and consciousness of safety in every activity of NPG.

ARTICLE 11: - FINANCIAL AND HUMAN RESOURCE

Ghana currently does not have a commercial nuclear power plant but at present developing the necessary infrastructure in order to build one in the near future. To this end the financial resource detailed here is grouped under two main areas; funding for the programme and regulations regarding financial provisions for decommissioning and management of spent fuel and radioactive waste from future nuclear installations.

Regarding funding for the construction of the commercial nuclear power plant, the government of Ghana is looking at different financial sources - including export credits,

commercial loans, bonds, equity and modern instruments. With the support of IAEA, Staff of GAEC are being trained to use the Agency's FINPLAN tool in assessing other financial options. In addition, the government of Ghana has signed MOUs and MOAs with Russian Federation and People's Republic of China on cooperation on Ghana Nuclear Power Programme.

Financial Provisions for Decommissioning

Section 55 of The Nuclear Regulatory Authority Act, (Act 895) requires an applicant for authorization to construct and operate a nuclear facility to make adequate financial resources available when needed to cover the costs associated with a safe decommissioning, including the management of the resulting waste during the operation of the facility.

The amount of the financial resources to be made available for decommissioning activities shall be commensurate with the specified cost of the facility and shall be varied if the cost estimated increases or decreases. The estimated cost of the facility shall be reviewed as part of the periodic review of the decommissioning plan.

For enforcement of the provision on financing of decommissioning, the NRA shall on the advice of the Ministry of Finance, Accountant-General's Department and the Bank of Ghana, establish the necessary mechanisms to enforce the obligations of an authorized person under Act 895. These State Agencies are currently in active discussions on how best to implement the above mentioned provision.

Human Resource Development

The introduction of nuclear power into the national energy mix requires developing a human resource base to provide a competent workforce for the sustainability and continued success of the programme.

The strategy therefore is to introduce nuclear related courses at the undergraduate level in existing public universities, upgrade the School for Nuclear and Allied Sciences (SNAS) into an autonomous university running both graduate and undergraduate nuclear centred programmes, expand the technical training programmes currently being undertaken by the Ghana Atomic Energy Commission, introduce internship programmes at both the Ghana Atomic Energy Commission and the Nuclear Regulatory Authority to attract more Ghanaians and enable them gain work experience in the field.

The GNPPO has developed a Human Resource Development Strategy Document which outlines the human resource needs of the NRA and the owner/operator organisation. In addition, the document has also given consideration on workforce planning, education, training, recruitment and retention of staff.

The Government is currently financing the nuclear power project infrastructure through national budget and shareholders (Ghana Atomic Energy Commission, Volta River Authority and Bui Power Authority) of the established Nuclear Power Ghana Limited (NPG).

Nuclear Power Ghana is implementing an active engagement with the Technical Universities in the country to review curricula to support the development of human resources for the nuclear power programme. To this end, an MoU with key technical universities is being discussed for implementation.

NPG has also started a management and leadership training of staff which is supported through an annual budget allocation.

ARTICLE 12: - HUMAN FACTORS

Safety is the result of interaction of humans, technology and organization. The elements that make up this field include human reliability, procedure design, diversity of context, evolution, improvement, environment and requirements.

Human and Organisation Factor (HOF) is required to be considered in the design of a nuclear installation to clearly define actions, future work situations, select tools for work situations and to ensure an adequate organizational structure.

The safe and reliable operation of nuclear installations depend not only on technical excellence but also on individuals and the organization. To prevent, detect, and correct human errors, the licensee of the nuclear installation is required among other things to employ personnel with technical capabilities, ensure their training, and also adopt relevant quality assurance and operation management programmes.

The operators of any nuclear installation would be required to establish and implement a management system which would be assessed and improved continually. The management

system would enhance safety by bringing together in a coherent manner all the requirements for managing the nuclear installation.

The management system should define the responsibilities of personnel for each process and of the managers and functions in the organizational structure, so that there are clear lines of authority and accountability.
Review and assessment are done to evaluate the organizational structure, management system and safety culture; processes and procedures; human factors; and operational experience, feedback and research. As part of NRA inspection programme aspects of HOF for inspection include the following:

- Human Performance
- Leadership and Management for Safety
- Safety Culture Assessment
- Operating Experience
- Competence Management and
- Qualification of Personnel

The Licensee event analysis should consist of identification of the causes leading to an event. It should be focused on the relevant HOF for the event, the exhaustiveness of analysis as required by potential safety consequences, root causes of HOF and effectiveness of corrective actions. The review of event analysis reports helps the NRA to make a conclusion about:

- the quality of the licensee's event analyses
- whether HOF has been satisfactorily considered
- the commitment of the licensee's management to organizational learning and HOF
- any HOF related deficiencies and
- the openness of the licensee towards the NRA.

The NRA integrates human, technology and organisational factors in its human capacity development programme, to learn from HOF related mistakes that have been studied and documented. The training enables the NRA to equip staff with attitudes relevant to oversee licensee HOF compliance.

The NRA has adopted best practices in addressing human error, using the organisational view at human level, team level and organisational level. This is focused on how the

organisation can reduce the factors that make errors more likely to occur. These expectations form part of the requirement for applicants and licensees.

Ghana is building capacity in conducting human and organisational factors and safety culture assessments.

NRA Regulations and guidelines reflect the need for the right balance between technical specifications and human and organisational factors to be included in the design of nuclear installations and their management systems.

ARTICLE 13: - QUALITY ASSURANCE

In order to achieve the Ghana Nuclear Power Programme Organisation's (GNPPO) objective of promoting the development and advancement of a national nuclear infrastructure that can adequately support nuclear energy generation, there is need for a management system outlining the safety and quality assurance requirements necessary for all nuclear facilities and activities.

The GNPPO has therefore developed a management system document that encompasses established integrated management system approach to ensure safe, reliable, and efficient management of radioactive material and their application for nuclear power. The document was developed based on IAEA safety standards; the management systems for nuclear facilities and activities (GS-R-3), Fundamental safety principles (SF-1), and ASME NQA-1 publications.

Management System – GNPPO

The GNPPO has developed a number of management system processes that can be used to foster leadership, and management for safety in the management of the nuclear power programme in Ghana. A document for GNPPO Management System has been developed. The document supports an important element, which is safety culture, of the management system, as echoed by the International Nuclear Safety Group (INSAG). The GNPPO Management System mainly considers the safety requirements contained in GS-R-3 and some of the requirements in ASME NQA-1-2008 to provide the basis that will be used for the development, implementation, monitoring and improvement of the management

systems for stakeholder organisations of the GNPPO in particular the owner operator organisation.

To ensure that the programme is developed and implemented in line with the IAEA milestone approach, a management system map document that identifies the processes that are consistent with the Phase I of the nuclear power infrastructure development has been prepared. The Management System Map is designed primarily to be in accordance with the present duties of the Technical Body of the GNPPO. However, the processes will change as work progresses through the various Phases. The management system map identifies three main processes:

1) Management, Leadership or Executive processes: These are processes that are executed to perform the functions at the management level of the GNPPO. They are the processes required mainly by the GNPPO Board.
2) Core, Operational or Realization Processes: These are the main processes that are essential for performing the core functions of the GNPPO through, the Technical Body, NPI. The processes are consistent with the activities of the various centres at the NPI.
3) Support processes: These are the processes that help realise the goals of the organisation.

As a newcomer country, the concern is how to identify the processes. The GNPPO has thus drafted a guide to enable its personnel identify key processes and sub-processes that are required for the execution of the programme. The document also provides guidelines in identifying support processes for the key processes.

In line with the requirements of the Guidelines for the GNPPO Management System document, processes for documenting and classifying documents have been developed (Document Review & Document Numbering System, Security Classification). The document review and numbering system describes the processes and conditions the documents must go through before approval and the roles of all parties involved in the documentation process and is intended for all formal documents produced for the Ghana Nuclear Power Programme. The security classification document provides information on access rights to information and how each document should be secured. The classifications have been graded in increasing levels of risk or level of impact and serves as an important

aspect of information security measures set up to guard information per the severity of its implications.

A number of activities are currently ongoing as part of continual development and improvement of GNPPO management system. Among these are:

- Document categorisation guidelines
- Detailed management system for support processes
- Tools for assessment of knowledge management
- Addressing recommendation of expert mission on quality management

Management System - NRA

The Management System of the NRA is discussed in Article 8.

Management System – NPG

Nuclear Power Ghana (the future owner-operator of Ghana's first nuclear power plant) is a newly formed project organisation with the responsibility of project development, project feasibility, plant and site licensing, regulatory compliance, contract negotiations, construction commissioning, and operation of Ghana's first nuclear power plant. NPG has considered the recommendations provided by the IAEA on management system development and has come out with a draft integrated management system manual to guide the processes and procedures to govern the functioning of NPG.

The draft integrated system manual addresses Management's commitment to safety, requirements, grading, resources and responsibilities in the implementation of the management system, the integrated management system processes, quality assurance and control, review, measurement, assessment and improvement of the management system.

NPG's integrated management system is currently being developed to satisfy the following requirements:

- Nuclear Regulatory Authority, Ghana Management systems
- NPID-310000-STG-00: GNPPO Management Systems
- IAEA Nuclear Energy Series No. NG-T-1.3: Development and Implementation of a Processed based Management system
- GSR Part 2: Leadership and Management for Safety

- IAEA-TECDOC-1740: Use of Graded Approach in the Application of the Management System Requirements for Facilities and Activities.
- IAEA Safety Standards Series No. SF-1, 2006: Fundamental Safety Principles
- IAEA Safety Report Series No. 74: Safety Culture in Pre-operational Phases of Nuclear Power Plant Projects
- ISO 9001: 2015 Quality Management Systems
- ISO 14001: Environmental Management Systems
- ISO 45001:2018: Occupational Health and Safety Management Systems-Requirements

NPG shall implement its management system using the graded approach, that is, the adaptation of controls, measures, training, qualification, inspections, and detail procedures to the level of risk or importance for safety, health, environmental, security, quality and economical aspects of the NPG's activities in the development of Phase 2 and 3 processes. In terms of resources, Management has committed to provide the needed funding and resources necessary to carry out the activities of NPG in order to establish, implement, assess and continually improve the integrated management system. The head of the Project Management Unit is responsible for the provision of resources for the implementation of the integrated management system and any modifications made due to the occurrence of non-conformances.

The draft IMS assigns specific responsibilities in the implementation of the management system to Management, the project management unit, the management system development team and individual process owners. The draft IMS has outlined a three phase processes approach to the development of integrated management system for NPG.

Phase 1 Processes:

i. Purchasing
ii. Outsourcing
iii. Communication
iv. Quotation Management
v. Knowledge Management
vi. Recruitment and training
vii. Review, approval and authorization of documents

viii. Project Management from proposal to execution
ix. Document Control

Phase 2 Processes:

i. License application
ii. Bid preparation & Contract Negotiations
iii. Safety culture introduction and improvement
iv. Public information and education
v. Infrastructure development
vi. Siting and Environmental considerations
vii. Feasibility Study

Phase 3 Processes:

i. Bid evaluation
ii. Contract and liability management
iii. Design review
iv. Construction
v. Auditing and Inspections
vi. Oversight
vii. Auditing
viii. Commissioning
ix. Handling non-conformances
x. Processes for long term operation and maintenance
xi. Security awareness
xii. Basic Safety and environmental training

Work has started on phase 1 processes with some completed. Currently the systems are being implemented manually. However, the plan is to convert these systems into an IT-based integrated management system once the IT infrastructure is completed.

The draft IMS has indicative criteria to be used in measuring the effectiveness of each process identified in the IMS. A risk reassessment/evaluation may be required in case of significant changes, such as the introduction of new equipment, substances, procedures or working conditions, or as a result of any proposed corrective or preventive actions. Consequently, a Management of Change Process has been drafted and is currently under

review. The IMS shall be reviewed annually to ensure the continuing suitability and effectiveness of the management system and its ability to enable the objectives of NPG to be accomplished.

ARTICLE 14: - ASSESSMENT AND VERIFICATION OF SAFETY

The Nuclear Regulatory Authority Act of 2015 (Act 895) lists as a function of the Authority the Review of Nuclear Safety Assessment and Safety Analysis Reports from authorised persons.

The NRA also has power to conduct inspections to assess compliance with safeguard conditions and radiation safety and security conditions, imposed by the Authority on an authorised person;

The NRA Act provides that before authorising the site for the construction of a nuclear Installation, an applicant seeking authorisation to construct and operate a nuclear installation shall prepare a site evaluation report for assessment and review by the NRA. This report includes, the frequency and severity of external natural and human induced events and the phenomena that could affect the safety of the facility, the foreseeable evolution of natural and man-made factors in the proposed area that may have a bearing on safety during the projected life span of the facility.

At the Construction Stage of a Nuclear Installation, the NRA reviews and assesses the following:

(a) the competence and capability of the applicant to meet relevant permit or authorisation requirements;

(b) the site evaluation report prepared to confirm its acceptability and related information needed for the design of the proposed facility;

(c) the potential environmental impact of the proposed facility;

(d) the basic design of the proposed facility, to confirm that it can meet relevant safety, security and physical protection requirements;

(e) the quality assurance organisation and programme of the applicant or operator and vendors;

(f) research results and development plans related to demonstration of the acceptability of the design; and

(g) arrangements for the management of radioactive waste and decommissioning.

At both the commissioning and operation stages of the Nuclear Installation, the NRA conducts reviews and assessments before commissioning and during the operation of the Nuclear Power Plant. Sections 41 of Act 895 provides that the NRA shall before authorizing the loading of nuclear fuel or initiating criticality, complete the review and assessment of the results of non-nuclear commissioning test and the arrangements for periodic testing, maintenance, inspection, and control of modifications and surveillance.

Section 42 of Act 895 also provides that the NRA may during the operation of nuclear installation, review, assess and approve any changes in operational limits and conditions or significant safety-related modifications, and make periodic reviews of the operator's compliance with relevant terms and conditions related to the safety and security of the installation.

With radioactive waste management, the authorised person is responsible for the safety and security of the facility throughout its operational life.

The NRA is currently in the process of developing regulations to establish the safety and security requirements, to establish a system of institutional control for disposal including regulatory inspection, documentation of inspection and reports on the inspection of radioactive waste management activities.

Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements and operational limits and conditions.

GHARR-1 has a comprehensive ageing management programme.

The method for conducting the assessment at each stage of the nuclear installation lifetime is the sole preserve of the NRA. The assessment and verification of information requirements at each stage are met and documented for future reference.

ARTICLE 15: - RADIATION PROTECTION

The NRA is mandated by law (Act 895) to adopt the principles of protecting humans and the environment from harmful effects arising from radiation exposure. Additionally, it prescribes measures aimed at preventing undue radiation exposure of humans through regulations, guidelines and standards.

There is a draft regulation on radiation control which covers administrative requirements, radiation protection performance requirements, management requirement, requirements for protection and safety, occupational exposure protection, public exposure protection, medical exposure protection, requirements for the safety and security of sources, requirements for emergency intervention, and control of existing exposure situations. Additionally, there are draft regulations on management of radioactive waste and transport of radioactive materials. The draft radiation control, radioactive waste management and transport regulations are consistent with IAEA safety standards general safety requirement (GSR) Part 3, GSR Part 5 and specific safety requirement 6 respectively. These draft regulations will ensure that during all operational states of the nuclear installation, radiation exposures to site personnel and the public, and release into the environment remains as low as reasonably achievable (ALARA). In order to ensure that releases of radioactive waste and effluents to the environment are kept ALARA, the operator shall ensure that environmental monitoring are performed to determine contamination levels. Dose constraints set by NRA shall be complied with by the operator. Additionally, radiation shielding and protection requirements shall be provided by the NRA to ensure the protection of people (site personnel and the general public).

The NRA shall review and assess nuclear installations for safety and protection from the pre-construction stage, construction, pre-commissioning, commissioning, operations stage and decommissioning stage for radiation safety. This will be archived through specific regulations for all these stages.

ARTICLE 16: - EMERGENCY PREPAREDNESS

An operator shall not be authorised unless that person has in place an appropriate emergency preparedness and response plan approved by the NRA. The emergency response plan shall consist of both on-site and off-site emergency plans that are

consistent with the National Nuclear and Radiological Emergency Response Plan. Currently, there is a draft regulation on nuclear emergency for operators covering areas of general requirements, planning basis, infrastructural requirements and functional requirements. This draft regulation is consistent with the IAEA GSR part 7 on emergency preparedness and response.

The NRA in collaboration with the National Disaster Management Organization (NADMO) and other key stakeholders have developed a National Nuclear and Radiological Emergency Response Plan. The National Emergency Plan ensures comprehensive allocation of responsibilities and actions among the stakeholders.

Act 895 requires that facility Emergency Response Plan be consistent with that of the National Plan. The requirements on operator's communication to the public in a nuclear emergency have been covered in the draft regulations on emergency preparedness and response for operators. Procedure for communicating and information dissemination to the public during an emergency event at the National level is detailed in the National Emergency Response Plan. The Act 895 has also designated NRA as the point of contact for communicating with the IAEA during nuclear emergency. Additionally, the NRA has been designated as the competent authority (abroad and domestic) and the NADMO designated as the national warning point under the conventions of early notification and request for assistance during a nuclear emergency.

ARTICLE 17: - SITING

The Nuclear Regulatory Authority Act, 2015 (Act 895) outlines regulatory requirements for national site evaluation process and criteria for nuclear installations. The NRA also ensures that an application for authorization to construct and operate a nuclear installation comes with a Site Evaluation Report for assessment and review.

Siting assessment studies are currently ongoing to select a preferred site for Ghana's first nuclear power plant. The strategies being adopted in the site assessment studies are: identification of applicable siting evaluation criteria and development of a suitable site identification methodology which will lead to the selection of preferred site; establishment of a profound and corresponding relationship with all stakeholders; and detailed evaluation of selected sites to develop engineering site data for nuclear power plant design purposes.

The selection of a suitable site for Ghana's nuclear power plant includes various studies on the following thematic areas, geology and seismology, water availability and quality, meteorology and atmospheric dispersion, population and exclusion, human induced event, emergency planning, flooding, wildlife, archaeology and cultural preservation, Land use, and community impact.

A Siting Charter has been developed by GNPPO to serve as a comprehensive activity guide in addressing the criteria identified. Among others, the document provides detailed activities required to adequately assess the geological, seismological and geotechnical characteristics of proposed sites. Information required for addressing meteorological and atmospheric dispersion concerns in the site selection procedure for the NRA's acceptability of a candidate site has been highlighted.

An important stage in the development of a nuclear power plant (NPP) is the evaluation of a suitable site. The evaluation is to ensure adequate protection of site personnel, the public and the environment from the effect of the development and operation of the nuclear power plant.

The site is considered suitable for a nuclear power plant location if there is a possibility of providing its safe operation. The NRA requires an applicant to provide the following:

(i) Safety, Security and Safeguards Goals;

(ii) Impact of processes, phenomena and factors of natural and man-induced origin and their evolution on the nuclear power plant safety;

(iii) Hazards associated with external events;

(iv) Potential impact of the site on the population and the environment;

(v) Specific characteristics of the plant location area and the plant site which can favour the migration and accumulation of radioactive products

(vi) Population and Emergency Planning considerations including exclusion zone, protective zone, planning considerations confirming unimpeded implementation of emergency plans and dimensions of the sanitary protection area, area subject to planned protective actions and area of planned actions for obligatory evacuation of the population;

(vii) Implementation of necessary engineering and technical civil defence actions;

(viii) Consideration of future life extension activities;

(ix) Baseline data gathering including meteorological, geological, geophysical, surface water, ground water and biological data;

(x) Baseline ambient radioactivity and pre-existing hazardous substances;

(xi) Natural external events including effects of climate change, meteorological factors and hazards associated with surface water, groundwater, geotechnical, geophysical, biological and natural fire;

(xii) External, non-malevolent, human-induced events including aircraft crashes, other transportation hazards, fires and explosion, chemical and radiological hazards, electromagnetic interference hazards, and consideration of future connection to the grid.

(xiii) The potential for the occurrence and the frequency and severity of lightning;

(xiv) The potential impact of the plant on air, water, wildlife and cultural resources;

(xv) The Management System of the Applicant for the feasibility studies;

(xvi) Decommissioning considerations;

(xvii) Public Engagement Report including results of surveys on public acceptance for the proposed site; and

(xviii) The Names and Addresses of the principal officers of the applicant's organization, the state of incorporation, evidence of financial surety/capability to undertake the project, and proof of ownership of the site.

The NRA upon receipt of the documents from the Applicant will review in collaboration with relevant stakeholders and grant a permit if the conditions are met.

Consequently, four candidate sites have been identified. These were arrived at by considering a four-stage approach, vis, regional analysis and potential site studies, selection of appropriate number of candidate sites through exclusionary and discretionary screening criteria from the following thematic areas: geology, seismology and geotechnical, hydrology, population and emergency planning, environment, land and infrastructure, human induced events, meteorology and atmospheric dispersion. The final stage is a ranking analysis for a preferred site for the first nuclear power plant. To achieve this, a review of the geology, seismology and geotechnical attributes of the four candidate sites have been conducted. This involved the installation of seismic monitoring equipment to collect data from these sites.

In addition, historical data covering hydrology, meteorology, land use, demography and transmission system were collected from relevant institutions and analysed to determine site attributes.

An expert and stakeholder meeting have been held to finalise a ranking criteria. Considerations of the criteria were based on both safety and non-safety factors. This led to the development of a ranking model which was used to assess the candidate sites. Hence, NPG is in the final stages of determining the preferred site. The selection of the preferred site is a collaborative effort of various institutions. Several reports are being prepared as input for a site approval document which will be submitted to NRA.

ARTICLE 18: - DESIGN AND CONSTRUCTION

The Nuclear Regulatory Authority Act, 2015 (Act 895) has provisions that cover the design and construction of nuclear power plants (NPPs).

The NRA is mandated by Sections 34 to 42 of Act 895 to regulate nuclear installations. Also, NRA has the responsibility for developing regulations to cover all areas of the NPP project. In view of its responsibility, NRA has developed a draft regulation on the Design of Nuclear Installations as well as a draft regulation on Construction.

The draft regulation on design of nuclear installations primarily has provisions on safety management and safety analysis in the NPP design. The objective of the design regulation is to provide for the safe design of the nuclear installation, minimising the likelihood of accidents and ensuring that their consequences can be reliably mitigated.

The draft construction regulation provides a framework within which the requirements in other regulatory documents, codes, and standards may be used in construction activities. This framework contributes to ensuring that the construction of the plant is effectively managed and consistent with design requirements.

According to the draft regulations on the design of nuclear installations:

(i) the design authority shall establish the plant design envelope comprising, design basis (specifying capabilities necessary for the plant in normal operation, anticipated operational occurrences (AOO) and design basis accidents (DBA)) and complementary design addressing performance of the plant in beyond design basis accidents (BDBA) including severe accidents) features.

(ii) for normal plant operation, the design shall facilitate safe operation of the plant within a defined range of parameters, with an assumed availability of a minimum set of specified support features for safety systems. In addition, the design shall minimize the unavailability of safety systems and address the potential for occurrence of accidents during shutdown, start-up, low power operation, refueling, and maintenance.

(iii) for Anticipated Operational Occurrences (AOO), the design shall include provisions that releases to the public following an AOO do not exceed the dose acceptance criteria. As much as possible, Safety Systems and Components (SSCs) not involved in the initiation of an AOO shall remain operable following the AOO.

(iv) For conditions involving Design Basis Accidents, the set of accidents shall set the boundary conditions according to which SSCs important to safety are designed. The design shall be such that releases to the public following a DBA shall not exceed the dose acceptance criteria.

(v) In order to prevent progression to a more severe condition that may threaten the next barrier, the design shall include provision to automatically initiate the necessary safety systems where prompt and reliable action is required in response to a Postulated Initiating Event (PIE).

(vi) Provision to support timely detection of, and manual response to, conditions where prompt action is not necessary, including such responses as manual initiation of systems or other operator actions.

(vii) The design shall take into account operator actions that may be necessary to diagnose the state of the installation and to put it into a stable long-term shutdown condition in a timely manner.

(viii) The design shall make provision for adequate instrumentation to monitor installation status, and controls for manual operation of equipment. Equipment necessary for manual response and recovery processes should be placed at the most suitable location to allow safe and timely worker access when needed.

(ix) For Beyond Design Basis Accidents (BDBA), the Design Authority shall identify credible BDBAs, based on operational experience, engineering judgment, and the results of analysis and research, including events leading to significant core degradation (severe accidents), particularly those events that challenge containment.

(x) Complementary design features shall be considered with the goal of preventing identified BDBA scenarios, and mitigating their consequences if they do occur. Complementary design features shall include design or procedural considerations, or

both, and are based on a combination of phenomenological models, engineering judgments, and probabilistic methods.

(xi) The design shall identify the rules and practices that have been applied to the complementary design features.

(xii) The design shall identify a radiological and combustible gas accident source term for use in the specification of the complementary design features for BDBAs.

(xiii) In the case of multi-unit installations, the use of available support from other units shall be considered only if it can be established that the safe operation of the other units is not compromised.

(xiv) The design shall provide biological shielding of appropriate composition and thickness to protect operational personnel during BDBAs, including severe accidents.

(xv) For Severe Accidents, the design shall be balanced such that no particular design feature or event makes a dominant contribution to the frequency of severe accidents, taking uncertainties into account. The various potential barriers to core degradation shall be identified, and features that can be incorporated to halt core degradation at those barriers should be considered.

(xvi) The design shall identify the equipment to be used in the management of severe accidents. The level of confidence that this equipment shall perform as intended in the case of a severe accident should be demonstrated by environmental, fire, and seismic assessments.

(xvii) Particular attention shall be given to the prevention of potential containment bypass in accidents involving significant core degradation. Consideration shall be given to the installation's full design capabilities, including the possible use of safety, non-safety, and temporary systems, beyond their originally intended function.

(xviii) The containment shall be a leak-tight barrier for a period that allows sufficient time for the implementation of off-site emergency procedures following the onset of core damage and prevent uncontrolled releases of radioactivity after this period.

(xix) The Design Authority shall establish initial severe accident management guidelines, taking into account the installation design features and the understanding of accident progression and associated phenomena. The design shall consider prevention of recriticality following severe accidents.

(xx) For external hazards, the design shall consider all natural and human-induced external events that may be linked with significant radiological risk. The site evaluation and

environmental assessment results shall be taken into account to determine the design basis for the installation.

(xxi) For a combination of events, combinations of randomly occurring individual events that could credibly lead to AOOs, DBAs, or BDBAs shall be considered in the design. Events that may result from other events such as floods following an earthquake shall be considered to be part of the original PIE.

(xxii) The Design Authority shall specify the engineering design rules for all SSCs. These rules shall comply with appropriate accepted engineering practices. The design shall identify SSCs to which design limits are applicable. These design limits shall be specified for normal operation, AOOs, and DBAs.

(xxiii) All SSCs important to safety shall be designed with sufficient quality and reliability to meet the design limits.

(xxiv) The design shall take into account the availability of off-site services upon which the safety of the plant and protection of the public may depend, such as the electricity supply and external emergency response services.

(xxv) For Common-cause failures, the potential for common-cause failures of items important to safety shall be considered in determining where to apply the principles of diversity, separation, and independence to achieve the necessary reliability. The design shall provide sufficient physical separation between redundant divisions of safety support systems and process systems and assess its effectiveness. The space sharing arrangement shall be justified in the design documentation, where physical separation is not possible.

(xxvi) The design shall provide effective protection against common-cause events where sufficient physical separation among individual services or groups of services does not exist. Diversity shall apply to redundant systems or components that perform the same safety function by incorporating different attributes into the systems or components. The diversity shall be examined for any similarity in materials, components, and manufacturing processes, or subtle similarities in operating principles or common support features. There shall be a reasonable assurance that such additions of diverse components are of overall benefit, taking into account associated disadvantages such as the extra complication in operational, maintenance, and test procedures, or the consequent use of equipment of lower reliability.

For Single failure criteria, each safety group shall perform the required safety functions under the worst permissible systems configuration, taking into account such considerations as maintenance, testing, inspection and repair, and equipment outage. Analysis of all possible single failures, and all associated consequential failures shall be conducted for each element of each safety group until all safety groups have been considered. Unintended actions and failure of passive components shall be considered as two the modes of failure of a safety group. Passive components shall be exempted when single failure is assumed to occur prior to the PIE, or at any time during the mission time for which the safety group is required to function following the PIE. Exemptions for passive components shall apply only to those components that are designed and manufactured to high standards of quality, that are adequately inspected and maintained in service, and that remain unaffected by the PIE. Design documentation shall include analytical justification of such exemptions, taking loads and environmental conditions into account, as well as the total period of time after the PIE for which the functioning of the component is necessary.

The design shall include provision of instrumentation to monitor plant variables and systems over the respective ranges for normal operation, AOOs, DBAs, and BDBAs. The design shall include instrumentation for measuring variables that can affect the fission process, the integrity of the reactor core, the reactor cooling systems, and containment, as well as instrumentation for obtaining any information on the instrumentation that is necessary for its reliable and safe operation. The design shall be such that the safety systems and any necessary support systems can be reliably and independently operated, either automatically or manually, when necessary. The design shall include the capability to trend and automatically record measurement of any derived parameters that are important to safety. The instrumentation shall be adequate for measuring parameters for emergency response purposes. The design shall include reliable controls to maintain variables within specified operational ranges. The design shall minimize the likelihood of operator action defeating the effectiveness of safety and control systems in normal operation and AOOs, without negating correct operator actions following a DBA. System control interlocks shall be designed to minimize the likelihood of inadvertent manual or automatic override, and to provide for situations when it is necessary to override interlocks to use equipment.

Safety support systems shall provide services such as electrical, compressed air, and water to systems important to safety. The safety support systems shall ensure that the fundamental safety functions are available in all installation states. It is imperative to have, backup safety

support systems shall also be available on the site. The design shall incorporate emergency safety support systems to cope with the possibility of loss of normal service and, where applicable, concurrent loss of backup systems. The systems that provide normal services, backup services and emergency services shall have sufficient capacity to meet the load requirements of the systems that perform the fundamental safety functions and availability and reliability that is commensurate with the systems to which they supply the service.

The emergency support systems shall be independent of normal and backup systems; provide continuity of the service until long term (normal or backup) service is re-established; have a capacity margin that allows for future increases in demand; and be testable under design load conditions.

The Design Authority shall define the Guaranteed Shutdown State (GSS) that will support safe maintenance activities of the installation. The design shall provide two independent means of preventing recriticality from any pathway or mechanism during the GSS. The shutdown margin for GSS should be such that the core will remain subcritical for any credible changes in the core configuration and reactivity addition.

The design of the plant including that of external buildings and SSCs integral to installation and operation shall make provisions for fire safety. For fire protection, SSCs important to safety shall be designed and located to minimize the probability and effect of fires and explosions consistent with other safety requirements. Non-combustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on SSCs important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of the SSCs.

The design shall provide for exclusion and removal of all foreign material and corrosion products that may have an impact on safety. The plant design shall incorporate appropriate features to facilitate transport and handling of new fuel, used fuel, and radioactive waste.

The design shall provide a sufficient number of safe escape routes that will be available in all installation states, including seismic events. Escape routes should be subject to the relevant requirements for radiation zoning, fire protection, industrial safety, and installation

security, which include assurance of the ability to escape from containment regardless of the pressure in containment.

Suitable alarm systems and means of communication shall be available at all times to warn and instruct all persons in the installation and on the site. The design shall ensure that diverse methods of communication are available within the installation, in the immediate vicinity, and to off-site agencies, in accordance with the emergency response plan.

The NRA is drafting construction regulations to ensure safety of Ghana's nuclear installations.

The construction regulation sets out the requirements to be met by an authorised person for construction of nuclear installation as required by Sections 34(1), 38 and 39 of Act 895.

The goal of construction is to build correctly an approved design. These regulations set out the appropriate management process that focuses on the implementation of various aspects of construction activities. This applies to the construction of a new nuclear installation. The requirements also apply in a graded manner to activities related to the life extension, refurbishment and modification of an existing nuclear installation including the processes of manufacturing and assembling of components, carrying out of architectural and civil works, installation and maintenance of structures, systems and components, and performance of the associated tests to demonstrate their acceptability.

In areas where the NRA regulations or local standards are not available, current relevant regulations or standards from the vendor country where the related applicable technology was developed or has been deployed and being regulated effectively as determined by the NRA, shall be deemed to be applicable.

The authorised person shall, in consultation with the NRA implement the latest revisions of the applicable IAEA Safety Standards and Security Guidance. In case the nuclear safety and security standards of another country are proposed to be followed, the authorised person shall demonstrate to the satisfaction of the NRA that the standards, proposed to be followed, offer the same or better standards of safety, security, quality and reliability than would have been offered by the nuclear safety standards and security guidance mentioned in Section 6(1) of the regulations.

Authorisation by the NRA, including specification of the conditions necessary for safety, shall be a prerequisite for all installations and activities that are not either explicitly exempted or approved by means of a notification process.

The authorised person shall manage construction activities in accordance with the approved management system. The authorised person shall identify health, safety and security, environmental, and other requirements applicable to construction activities. Relevant requirements shall be communicated to all parties and taken into account when establishing, implementing and maintaining management practices and controls. Conflicting requirements shall be identified and resolved.

The authorised person shall define procedures for reporting that assesses the progress of the nuclear facility's construction and plant modification projects for the approval of the NRA. The reporting shall be regular as approved by the NRA and, where necessary, available to the parties involved in the project.

ARTICLE 19: - OPERATION

The NRA has taken the required steps to ensure that all construction or operation of a nuclear installation and conduct of any related activity, (i.e. maintenance, expansion, or an alteration etc.) are authorized by the Authority as stipulated in Act 895.

To adhere to the requirements of an emergency preparedness plan and a national plan for nuclear emergencies, the NRA Act mandates an appropriate emergency preparedness and response plan as a prerequisite to the grant of authorization.

To ensure the safe and secure management of radioactive waste, the NRA is mandated by Act 895 to develop regulations for the protection of the public and the environment from adverse impacts of radioactive waste management activities. The NRA has drafted Radioactive Waste Management Regulations which is undergoing review. A National Radioactive Waste Management Policy and Strategy Document has also been drafted.

The Radioactive Waste Management Centre (RWMC) of Ghana Atomic Energy Commission is responsible for the safe and secure management of "disused" radioactive sources generated in Ghana to safeguard human lives and the environment. The RWMC has managed radioactive waste generated in Ghana including historic/legacy and orphaned sources safely since its establishment through the support of stakeholder institutions. The Centre operates a Centralised Radioactive Waste Management facility where radioactive waste is characterised, conditioned and stored awaiting further management. Over the years, the Centre has developed its technical capability through the provision of technical services to clients, collaboration in IAEA Technical Cooperation (TC) projects with

stakeholder organisations, and human resources training and management. The Centre has acquired the technical capacity to play pioneering roles in radioactive waste management in Africa especially in the management of Disused Sealed Radioactive Sources. The Centre has had collaborative workings and partnerships with regional and international organizations namely: The African Regional Co-operative Agreement for Research Development and Training related to Nuclear Science and Technology (AFRA), the International Atomic Energy Agency (IAEA) and the United States Department of Energy (USDOE).

The Government of Ghana as part of its long-term management strategy for disused sealed radioactive sources (DSRS) has opted for the IAEA Borehole Disposal System (BDS) as an end-point management option. The BDS project is being implemented by the Ghana Atomic Energy Commission (GAEC). The project has traversed three IAEA TC cycles.

The assurance and demonstration of safety and the development of a broader confidence in safety requires the development of a safety case which together with the necessary supporting safety assessment documentation addresses safety of the disposal system during its operation and after its closure. The proposed site has therefore been fully characterized to provide information for the development of conceptual and mathematical models for use in the development of the safety case documentation. The draft safety case documentation, comprising the safety case, post closure safety assessment (PCSA) and BDS engineering design document were reviewed by IAEA consultants. Comments and recommendations from the reviews were used to finalize the documentation. The safety case and supporting safety assessment documentation demonstrating the safety of the site and the BDS have been submitted to the Nuclear Regulatory Authority for approval.

License application for construction of the disposal borehole is also being prepared and will be submitted to the NRA upon approval of the site license application.

The Ghana Atomic Energy Commission submitted the required documents on Ghana Research Reactor-1 (GHARR-1) for a license from the NRA for operation of the facility after the conversion from HEU to LEU fuel. The documents were reviewed by the NRA and the requested additional information for clarification have been submitted.

ANNEXES

1. Nuclear Regulatory Authority Act, 2015 (Act 895).
2. National Nuclear and Radiological Emergency Response Plan, Prepared by NADMO and GAEC with support from UNDP, January 2010.
3. Preparedness and Response for a Nuclear or Radiological Emergency, General Safety Requirement-Part 2, IAEA, 2002.
4. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirement- Part 3, IAEA, 2014.
5. Preparedness and Response for a Nuclear or Radiological Emergency. General Safety Requirement Part 7, IAEA, 2015.
6. Siting Charter, Nuclear Power Institute, GAEC.
7. Human Resource Development Strategy, Nuclear Power Institute, GAEC.
8. Draft Radioactive Waste Management Regulations, NRA.
9. Draft Siting of Nuclear Installations Regulations, NRA.
10. Draft Licensing of Nuclear Installations Regulations, NRA.
11. Draft Design of Nuclear Installations Regulations, NRA.
12. Ghana's National Science Technology and Innovation Policy (2017).