

THIRD GHANA NATIONAL REPORT

ON COMPLIANCE WITH OBLIGATIONS UNDER THE

JOINT CONVENTION ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

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List of Abbreviations

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| IAEA | International Atomic Energy Agency |
| GAEC | Ghana Atomic Energy Commission |
| GHARR- 1 | Ghana Research Reactor – 1 |
| HEU | Highly Enriched Uranium |
| LEU | Low Enriched Uranium |
| MNSR | Miniature Neutron Source Reactor |
| NADMO | National Disaster Management Organization |
| NORMs | Naturally Occurring Radioactive Materials |
| NRA | Nuclear Regulatory Authority |
| NNRI | National Nuclear Research Institute |
| NNRC | Nuclear Reactors Research Centre |
| RWMC | Radioactive Waste Management Centre |
| RPB | Radiation Protection Board |
| SNAS | School of Nuclear and Allied Sciences |

Section A. Introduction

A.1 Background and Provisions of the Joint Convention

The Joint Convention was adopted on 5 September 1997 at a Diplomatic Conference convened by the IAEA at its headquarters from 1-5 September 1997. It was opened for signature at the IAEA General Conference on 29 September 1997. Pursuant to Article 40, the Joint Convention entered into force on 18 June 2001, 90 days after the date of deposit with the IAEA. The Joint Convention is aimed at achieving and maintaining a high level of safety in spent fuel and radioactive waste management, ensuring that there are effective defences against potential hazards during all stages of management of such materials, and preventing accidents with radiological consequences.

The Joint Convention calls on the contracting parties to review safety requirements and conduct environmental assessments both at existing and proposed spent fuel and radioactive waste management facilities. It provides for the establishment and maintenance of a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

Recognizing the importance of the safe management of spent nuclear fuel and radioactive waste, the Republic of Ghana acceded to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) in May 2011.

Each Member State having ratified the Joint Convention (Contracting Party) is obligated to prepare a National Report covering the scope of the Joint Convention and subject it to review by other Contracting Parties at Review Meetings held in Vienna, Austria. Since the Joint Convention entered into force, there have been five Review Meetings held at the IAEA Headquarters in Vienna. Ghana participated in the Fourth and Fifth Review Meeting of the Joint Convention held at the IAEA headquarters in Vienna.

Radioactive materials are being used in Ghana for diagnostic and therapeutic procedures in medicine, sterilization of medical products, industrial radiography, nuclear gauging in the mining, road construction, exploration, manufacturing, and petrochemical industries. Food irradiation for shelf life extension, preservation and disinfestations are among the applications of radiation sources in Ghana. Radiation sources are also being employed for research activities in institutions of higher learning.

Ghana operates a 30kW tank-in-pool research reactor, Ghana Research Reactor-1 (GHARR-1). It is a Miniature Neutron Source Reactor mainly used for neutron activation analysis. It originally used Highly Enriched Uranium (HEU) as fuel which has been converted to Low Enriched Uranium (LEU).

Technologies for radioactive waste management are located within the Ghana Atomic Energy Commission (GAEC) premises at Kwabenya. The primary responsibility for the management of radioactive wastes, spent fuel inclusive, lies with the generator of the waste. The State supervision of radiation safety on spent fuel management and radioactive waste management is performed by the Nuclear Regulatory Authority.

The legislation governing the peaceful use of Nuclear Energy in Ghana are the Atomic Energy Commission Act, 2000 (Act 588) and the Nuclear Regulatory Act, 2015 (Act 895) The Radiation Protection Board (RPB) which had earlier been established in 1993 by the enactment of the Radiation Protection Instrument, LI 1559 has now been repealed by the Nuclear Regulatory Act, 2015 (Act 895).

The Nuclear Regulatory Authority Act of 2015 (Act 895) applies to the regulation and management of activities and practices for peaceful use of nuclear energy and radiation under the jurisdiction and control of the country, including the production, possession, use, import, export, transportation, transfer, handling and management of radioactive material, decommissioning or other related activity or practice identified by the Nuclear Regulatory Authority (NRA).

The objectives of the Nuclear Regulatory Authority (NRA) are to ensure that radiation and nuclear energy are used by authorised persons and only for peaceful purposes, to provide for the protection of persons and the environment against the harmful effects of radiation hazards and to pursue and ensure strict compliance with the provisions of the Nuclear Regulatory Authority Act, 2015 (Act 895).

The School of Nuclear and Allied Sciences (SNAS), is a Graduate School, jointly established by the Ghana Atomic Energy Commission (GAEC) and the University of Ghana (UG), in co-operation with the International Atomic Energy Agency (IAEA), in 2006. The School was designated as AFRA/IAEA Regional Centre of Excellence for Professional and Higher Education in Nuclear Science and Technology in September 2009 and Radiation Protection in October 2011. The School on 25th September, 2014 was again recognised as AFRA/IAEA Regional Designated Centre for Education in Medical Physics.

The School currently has five academic departments that offer twelve accredited Master of Philosophy (M.Phil.) and Doctor of Philosophy (PhD) programmes, and a 5 month IAEA Post Graduate Education Course (PGEC) in Radiation Protection.

The School in collaboration with the IAEA also runs PhD “sandwich” programmes. This will ensure adequate human resource development not only for radioactive waste management, but also a broad human resource base for peaceful application of nuclear technology in Ghana and Africa including Ghana’s Nuclear Power Programme.

Ghana hosted the Integrated Nuclear Infrastructure Review (INIR) Mission Phase 1 from 16 to 23 January 2017 which has assisted in the review of the provisions for radioactive waste management and management of spent nuclear fuel.

A.2 Purpose and Structure of this Report

This report is the third National Report under the Joint Convention. This national report describes measures taken by the Government of Ghana for implementing obligations under the Joint Convention. It satisfies the requirements of the Joint Convention for reporting on the status of safety of spent fuel and radioactive waste management facilities within Ghana. It constitutes an updated document with basically the same structure as the previous national report under the

terms of the Joint Convention to be held at the IAEA headquarters in Vienna in May 2018.

This report is structured according to the “guidelines regarding national reports” for the Joint Convention – i.e., an “article-by-article” format, with each one being addressed in a dedicated chapter bearing the corresponding text of the relevant article of the Joint Convention in italics at the top of the chapter. After the Introduction (Section A), the various sections deal successively with the following topics in the specific order prescribed by the guidelines:

- Section B: Policy and practices under the Joint Convention (Article 32-1);
- Section C: Scope (Article 3);
- Section D: Spent-fuel and radioactive-waste Inventories (Article 32-2);
- Section E: Legislative and regulatory system in force (Articles 18 to 20);
- Section F: Other general safety provisions (Articles 21 to 26);
- Section G: The safety of spent-fuel management (Articles 4 to 10);
- Section H: The safety of radioactive-waste management (Articles 11 to 17);
- Section I: Transboundary movements (Article 27);
- Section J: Disused sealed sources (Article 28),
- Section K: Planned safety-improvement actions; and
- Section L: Annexes in support of Section D.

Section B – Policies and Practices

B.1 Article 32.1: Reporting

In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

- (i) spent fuel management policy;*
- (ii) spent fuel management practices;*
- (iii) radioactive waste management policy; (iv) radioactive waste management practices*
- (v) criteria used to define and categorize radioactive waste.*

As a Member State of the International Atomic Energy Agency (IAEA), and in accordance with National and International law, the Ghanaian Government's policy is to deal with radioactive waste in a manner that protects human health and the environment both now and in the future without imposing undue burden on the future generation.

In April 2014, the draft National Policy and Strategy for the management of radioactive waste including spent fuel management was revised and harmonized with other relevant national regulations with assistance from the IAEA under the Technical Cooperation Project INT9176: Strengthening Cradle-to-Grave Control of Radioactive Sources in the Mediterranean Region.

The purposes of the Policy and strategy are:

- i) to achieve and maintain a high level of safety and security in radioactive waste management including spent fuel, through the enhancement of national measures and in accordance with internationally recognized principles and standards; specifically, to protect workers, the public and the environment from the harmful effects of ionizing radiation now and in the future;
- ii) to set out the aims and goals for the safe, secure and sustainable management of radioactive waste in the Republic of Ghana;
- iii) to establish the roles and responsibilities of the organizations and bodies concerned with radioactive waste management in the Republic of Ghana;
- iv) to ensure that adequate resources are mobilised and allocated for all stages of radioactive waste management;
- v) to provide for openness and transparency in radioactive waste management through the supply of public information and the involvement of public and stakeholders in the decision-making process to the extent that this is commensurate with security; and
- vi) to provide a framework for the development of a coherent, integrated and sustainable radioactive waste management strategy.

The radioactive waste management policy and strategy will serve as the national commitment to address radioactive waste management including spent fuel in a coordinated and cooperative

manner. Thus, representing a comprehensive national radioactive waste management governance framework. The policy is consistent with the requirements of the national legislative system, relevant international principles, and all international agreements to which the Republic of Ghana is signatory.

Waste containing naturally occurring radioactive materials (NORM), which may arise from the extraction and processing of oil, gas and minerals, falls within the remit of this policy provided that it exceeds exemption/clearance levels.

B.2 Spent fuel management policy

For radioactive wastes that will remain hazardous for many years, the Government recognizes two long term management options. The first, which is preferred, entails repatriation to the country of origin. This option will be applied, when practicable, to disused sealed radioactive sources and research reactor fuel. The second option is storage followed by permanent disposal in a suitably designed disposal facility. The nature of this disposal and its timing will be decided by Government having due regard to intergenerational equity i.e. the principle that present-day society has an obligation to deal with the liabilities it creates rather than pass them on to future generations.

Any Government Ministry or other body considering the construction of an additional or the replacement of the research reactor on the territory of the Republic of Ghana shall give high priority to establishing a return of spent fuel assembly to the supplier or country of origin.

B.3 Radioactive Waste Management Policy and Principles

Within the Ghanaian regulatory framework, radioactive waste, for legal and regulatory purposes, is defined to mean “material, in whatever physical form, remaining from practices or interventions and for which further use is not foreseen that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level set for clearance from regulatory requirements” [Section 93 of Act 895]

It should be recognised that this definition is purely for regulatory purposes, and that material with activity concentrations equal to or less than clearance levels is radioactive from a physical viewpoint, although the associated radiological hazards are negligible.

The draft Radioactive Waste Management Policy and Strategy for the Republic of Ghana, requires the NRA to establish and maintain a national register of radiation sources as well as an inventory of radioactive waste. It requires licensee to give priority to returning their disused sealed radioactive sources, especially category 1 and 2 sealed radioactive sources, to the respective supplier countries.

It is accepted that, for those solid radioactive wastes that are not repatriated or decay stored to exemption/ clearance levels, long-term safety and security can only be achieved by permanent disposal in a suitably authorized facility. This recognizes uncertainty over the long-term future and the obligation to avoid passing on liabilities created by the current generation to future generations.

Liquid and gaseous wastes may be discharged to the environment provided the NRA grants

authorization that the discharges can be done without harm to workers, the public or the environment.

In addition, radioactive waste management in Ghana is performed in accordance with the following policy and principles:

- The generator of radioactive waste shall have the primary responsibility for the management of the waste generated.
- The financial burden for the management of radioactive waste shall be borne by the generator of that waste.
- All radioactive waste management activities shall be conducted in an open and transparent manner and the public shall have access to information regarding waste management where this does not infringe on the security of radioactive material.
- Decision-making shall be based on proven scientific knowledge, information and recommendations of competent national and international institutions dealing with radioactive waste management.
- Due to their cross-cutting nature, all activities involving radioactive waste management shall be managed in a manner that prevent duplication of effort and maximise coordination.
- Radioactive waste management shall take into account the interests and concerns of all stakeholders when decisions are being made.
- The government shall create opportunities to develop people's understanding, skills and general capacity concerning radioactive waste management.

In accordance with international standards, radioactive wastes generated in Ghana are classified as follows:

- **Controlled wastes:** - These are radioactive wastes that arise out of controlled practices, for which the NRA prescribes through its authorization process.
- **Legacy wastes:**- these are wastes generated from known sources and practices, but the owners no longer have the capability to manage the wastes due to bankruptcy or other reasons. Most of the legacy sources are those that predated the establishment of NRA and were not under regulatory control. Therefore no agreements were made with the manufacturers for their return to the countries of origin.
- **Orphan wastes:** - these are wastes arising from sources whose owners could not be traced. They include stolen or lost sources that are recovered. The handling of these wastes is like those of the legacy wastes.
- **NORMs:** - These are wastes associated with activities related to the oil, and gas industries. Research work is being carried out to determine the particular hazards associated with this category and the means to handle them.

Radioactive wastes may also be classified as follows:

- (a) According to its physical form and chemical composition:
 - i) Solid waste
 - ii) Liquid aqueous waste

- iii) Liquid organic waste
- iv) Gaseous waste
- v) Sealed radiation sources
- vi) Biological waste (e.g. animal carcasses which might undergo decomposition if not properly treated and stored)
- vii) Medical waste (e.g. syringes, bed linen and contaminated clothing from hospitals)

(b) According to the activity concentration and half-lives of radionuclides as classified in the IAEA Safety Standard Classification of Radioactive Waste GSG-1 (2009), into six classes as follows:

- (i) Exempt waste (EW): Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes
- (ii) Very short lived waste (VSLW): Waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.
- (iii) Very low level waste (VLLW): Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer lived radionuclides in VLLW are generally very limited.
- (iv) Low level waste (LLW): Waste that is above clearance levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities. This class covers a very broad range of waste. LLW may include short lived radionuclides at higher levels of activity concentration, and also long lived radionuclides, but only at relatively low levels of activity concentration.
- (v) Intermediate level waste (ILW): Waste that, because of its content, particularly of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its storage and disposal. ILW may contain long lived radionuclides, in particular, alpha emitting radionuclides that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. Therefore, waste in this class requires disposal at greater depths, of the order of tens of metres to a few hundred metres.
- (vi) High level waste (HLW): Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large

amounts of long lived radionuclides that need to be considered in the design of a disposal facility for such waste. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognized option for disposal of HLW.

Section C. Scope of Application

C.1: Article 3. Scope of Application

- 1. This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.*
- 2. This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.*
- 3. This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.*

This report does not consider reprocessing of spent fuel as no reprocessing plant exists in Ghana. The spent fuel referred to in this report will be generated from civilian application only. No form of radioactive waste of military origin has been declared in Ghana; therefore, this report does not discuss this type of waste.

Section D. Inventories and Lists

Article 32. Reporting, paragraph 2

This report shall also include:

- (i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;*
- (ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;*
- (iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;*
- (iv) an inventory of radioactive waste that is subject to this Convention that:*
 - (a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;*
 - (b) has been disposed of; or*
 - (c) has resulted from past practices.*

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

- (v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.*

GAEC on behalf of the Government of Ghana established the Radioactive Waste Management Centre (RWMC) to manage all forms of radioactive waste generated in Ghana. The RWMC has a Centralized Radioactive Storage facility located on the GAEC premises at Kwabenya (figure 1). The Storage facility has a large area for receipt and characterization of the waste. It also has a storage unit for high radioactivity waste and for decay or low activity waste. The facility is equipped with physical protection equipment. It is licensed for storage of unprocessed and processed waste awaiting permanent disposal. It is also used to store disused sealed sources awaiting return to the supplier or manufacturer. A Centralized Radioactive Waste Processing facility is being established.

All radioactive waste materials generated in the country which could not be returned to the country of origin immediately, are transported to the Radioactive Waste storage facility at Kwabenya for management. The RWMC has developed a Microsoft excel database for radioactive waste materials it has collected. The inventory of radioactive waste in the storage facility at Kwabenya is given in Annex V.



Figure 1: Front view of the Centralised Radioactive Waste Processing and Storage Facility.

Section E. Legislative and Regulatory System

E-1 Implementing Measures

Article 18: Implementing Measures

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

In conformance to Article 18 of the Joint Convention, the Republic of Ghana has undertaken the necessary legislative, regulatory and administrative measures to fulfill its obligations under the Joint Convention and these are reported in this report.

E-2 Legislative and Regulatory Framework

Article 19: Legislative and Regulatory Framework

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

2. This legislative and regulatory framework shall provide for:

- (i) the establishment of applicable national safety requirements and regulations for radiation safety;*
- (ii) a system of licensing of spent fuel and radioactive waste management activities;*
- (iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;*
- (iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;*
- (v) the enforcement of applicable regulations and of the terms of the licences;*
- (vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.*

3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

Ghana has the following legislation in place:

- Nuclear Regulatory Authority Act, 2015 (Act 895)

Radioactive waste management practice is also subjected to the provisions of other relevant legislations such as the

- Local Government Act, (Act 462), 1994
- Atomic Energy Commission Act, (Act 588) 2000
- Environmental Protection Agency Act (Act 490), 1994,
- Environmental Assessment Regulations (LI 1652) 1999,
- Environmental Sanitation Policy of Ghana (1999),
- Guidelines for the Development and Management of Landfills in Ghana, and
- Guidelines for Bio-medical Waste (2000).

E-2.2. Regulatory Framework

E-2.2.1. Safety Requirements and Regulations for Radiation Safety

From 1993 to 2015 the Ghana Atomic Energy Commission (GAEC) carried out regulatory functions by the enactment of the Radiation Protection Instrument, LI 1559. In 2015, the Nuclear Regulatory Authority, Act 895, was promulgated by the Government of Ghana to establish and maintain a comprehensive legislative and regulatory framework to among other things govern the safety of nuclear installations, provide for a system of licensing, regulatory inspection and assessment of nuclear installations and to ascertain compliance and enforcement of safety regulations.

Ghana has been a member of the IAEA since September 1960 and a party to the following International Legal Instruments of the IAEA; Comprehensive Safeguards agreement in connection with the Treaty on Non-Proliferation of Nuclear Weapons (1973); Additional Protocol to the Agreement on Safeguards in connection with the Treaty on Non-Proliferation of Nuclear Weapons (2002); the Convention on Nuclear Safety (1995); the Comprehensive Nuclear Test Ban Treaty (CBTB); the African Nuclear Weapon Free Zone Treaty (Pelindaba); Amendment to the Convention on Physical Protection of Nuclear Material (2005); the Joint 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 (1987), the Convention on Early Notification of a Nuclear Accident (1987) and the Convention on Supplementary Compensation for Nuclear Damage (CSC) (1997).

National Safety Requirements and Regulations

The NRA has set out to develop regulations and guidelines to ensure implementation of the provisions of Nuclear Regulatory Authority Act 895. The following regulations and associated guidelines are under development:

1. Radioactive Waste Management
2. Radiation Protection
3. Nuclear Safeguards
4. Siting of Nuclear Installations
5. Licensing of Nuclear Installations
6. Nuclear Power Generation in Ghana
7. Emergency Preparedness of Nuclear Installations
8. Safety and Security of nuclear installations
9. Operation of a Nuclear and Radioactive Waste Management Facility
10. Compensations and Limitation on Right of Compensation, Exceptions to Liability

11. Provision of Radiation Monitoring Services, Calibration of Radiation Monitoring Instruments and Consultancy to Authorised Practices and Activities
12. Nuclear and Radioactive Waste Management Programme for Authorised Persons
13. Management System including Quality Assurance and Quality Control of Authorised Activities
14. Design, Re-Design and Modification of a Nuclear Installation and Performance Criteria
15. Decommissioning and Decommissioning Plan of a Nuclear Installation
16. Construction of a Nuclear Installation
17. Radiation Protection Programme of a Nuclear Installation
18. Periodic Testing, Maintenance, Inspection and Control of Modifications and Surveillance of a Nuclear Installation
19. Operational Limits and Conditions of a Nuclear Installation
20. Commissioning of a Nuclear Installation
21. Education, Training, Qualification and Certification of Personnel of a Nuclear Installation
22. Establishing and Operating a Training Institution for Personnel of a Nuclear Installation

E-2.2.2. Licensing of Activities

- (1) The authorisation processes are defined in Ghanaian legislation. An application for a license shall be made to the NRA and be in a form determined by the NRA, detailing the intended activities and providing a demonstration of the safety and compliance to the requirements and regulations. Any person or organization applying for an authorization shall:
 - (a) Submit to the Authority relevant information necessary to support the application, including:
 - (i) An evaluation of the nature, likelihood and magnitude of the exposures associated with the activities;
 - (ii) A safety and security case including relevant safety, security and environmental assessments;
 - (iii) An emergency response plan;
 - (iv) a proposed destination for the disposal of the radioactive waste, spent nuclear fuel or disused sealed radiation source;
 - (v) a proposed system for record keeping;
 - (vi) Reporting;
 - (vii) proposal for discharge and environmental monitoring; and
 - (viii) any other details the Authority may consider necessary for the purpose.
 - (b) Ensure the availability of human and financial resources to complete the waste management and disposal activities satisfactorily, including borehole closure and the decommissioning of any associated surface facilities.

The NRA undertakes an evaluation of the submitted documentation to ensure that the action or facility will meet the standards and requirements. From the evaluation, conditions are identified for inclusion in the nuclear authorisation. The authorisation conditions represent a framework within which the applicant or holder of the nuclear authorisation is obliged to adhere to particular requirements in respect of design, operation, maintenance and decommissioning and closure. The conditions of authorisation also oblige the holder of the authorisation to provide a demonstration of compliance through the submission of routine and non-routine reports.

E-2.2.3. Prohibition of the Operation Without an Authorisation

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.

A person or entity shall not operate a radioactive waste management facility, unless the person or entity is authorised by the NRA.

E-2.2.4. Regulatory Inspections, Safety Documentation and Reporting

The authorisation requires the licensee for the purpose of the safe management of radioactive waste, spent nuclear fuel or disused sealed radiation sources to carry out safety assessment and develop and maintain a safety case. They are required to carry out all the necessary activities for site selection and evaluation, for the design, construction, operation, decommissioning, closure and, if necessary, surveillance after closure of the facilities in accordance with national strategy and in compliance with national regulations to ensure the safety of workers, the environment and the general public.

The safety case and supporting safety assessment shall be prepared and updated by the operator, at each step in the development, operation and closure of a facility for the management of radioactive waste, spent nuclear fuel or disused sealed radiation sources and periodically during operation as required by the Authority. The operator shall submit the safety case to the Authority for approval.

The safety case shall describe all the safety relevant aspects of the site, the design of the facility, and the managerial and regulatory controls. The safety case and supporting safety assessment shall demonstrate the level of protection provided and shall provide assurance that safety requirements will be met.

Measures shall be implemented by the operator to ensure an integrated approach to safety, nuclear security and if applicable nuclear safeguards in the management and disposal of radioactive waste, spent nuclear fuel and disused sealed radiation sources. The level and complexity of safety and security provisions shall be commensurate with the degree of hazard posed by the radioactive waste, spent nuclear fuel or disused sealed radiation sources.

Management systems to provide for assurance of quality shall be applied by the operator to all safety related activities, systems and components throughout all the steps of the development and operation of a radioactive waste, spent nuclear fuel or disused sealed radiation source management

or disposal facility. The level of assurance for each element shall be commensurate with its importance to safety.

Operators shall take into account the interdependences among all steps in the predisposal management of radioactive waste, spent nuclear fuel and disused sealed radiation sources as well as the impact of the anticipated disposal option.

Operators shall determine an authorized destination for all of their radioactive waste, spent nuclear fuel and disused sealed radiation sources generated in consultation with RWMC and the NRA.

Operators shall make adequate provision for the training of personnel.

Operators shall keep a system for recording information on the generation, characteristics; processing, conditioning, storage, transportation and disposal of the waste, spent nuclear fuel and disused sealed radiation source

E-2.2.5. Enforcement

A person who fails to comply with the provisions of Act 895, or does anything contrary to the provisions of the Act commits an offence and is liable on summary conviction to a fine or imprisonment or both, as prescribed in Act 895.

E-3 The Establishment of a Regulatory Body

Article 20: Regulatory Body

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

2. Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.

E-3.1. Nuclear Regulatory Authority (NRA)

The Nuclear Regulatory Authority (NRA) established by the Nuclear Regulatory Authority Act, 2015 (Act 895) is the national authority responsible 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.

The primary mandate and authority of the NRA are contained in sections 3, 4, 5, 6 and 7 of the Nuclear Regulatory Authority Act 895, which detail the objects, functions, authority and governing body of the NRA.

E-3.2. Organisational Structure of Nuclear Regulatory Authority

The governing body of the Nuclear Regulatory Authority (NRA) called the NRA Board consists of a chairperson and six other members including the Director-General of the NRA. The Members of the Board are appointed by the President. Figure 2 below shows the organisational structure of the NRA, Ghana.

The function of the NRA Board is to initiate policies for the development of the NRA; ensure the proper management of resources of NRA and ensure the implementation of the functions conferred on the NRA under Act 895 and any other enactments. The Board of the NRA meets once every three months.

The Research and Technical Committee of NRA reviews policies, criteria, guidelines, procedures and other related matters of the NRA, reviews the licensing and certification requirements for technical support services and consultancies, reviews and recommends for the NRA Board.

The Director-General is appointed by the President in accordance with article 195 of the Constitution of the Republic of Ghana and is also a member of the Board. The Director-General is the accounting officer of the Board and has the responsibility to ensure that the functions of the NRA are performed in accordance with Act 895.

The Deputy Director-General is appointed on the recommendation of the Board and in accordance with article 195 of the Republic of Ghana Constitution by the President. The Deputy Director-General assists the Director-General in the administration of the NRA.

The Executive Committee assists the Director-General in the day to day administration of the affairs of the Authority, recommends 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 Committee holds regular meetings in order to discharge all of its duties

Pursuant to Act 895, NRA has established three Directorates and ten Departments for the necessary operation of the Authority as shown in Figure 2. Regulations are drafted at the Directorates or by an Inter-Directorate Committee, followed by review from Nuclear Regulations Guidance Committee, Research & Technical Committee and the Board. Stakeholders are consulted and involved in the development of the regulations through Workshops, Public Meetings and involvement in Committees (Figure 3).

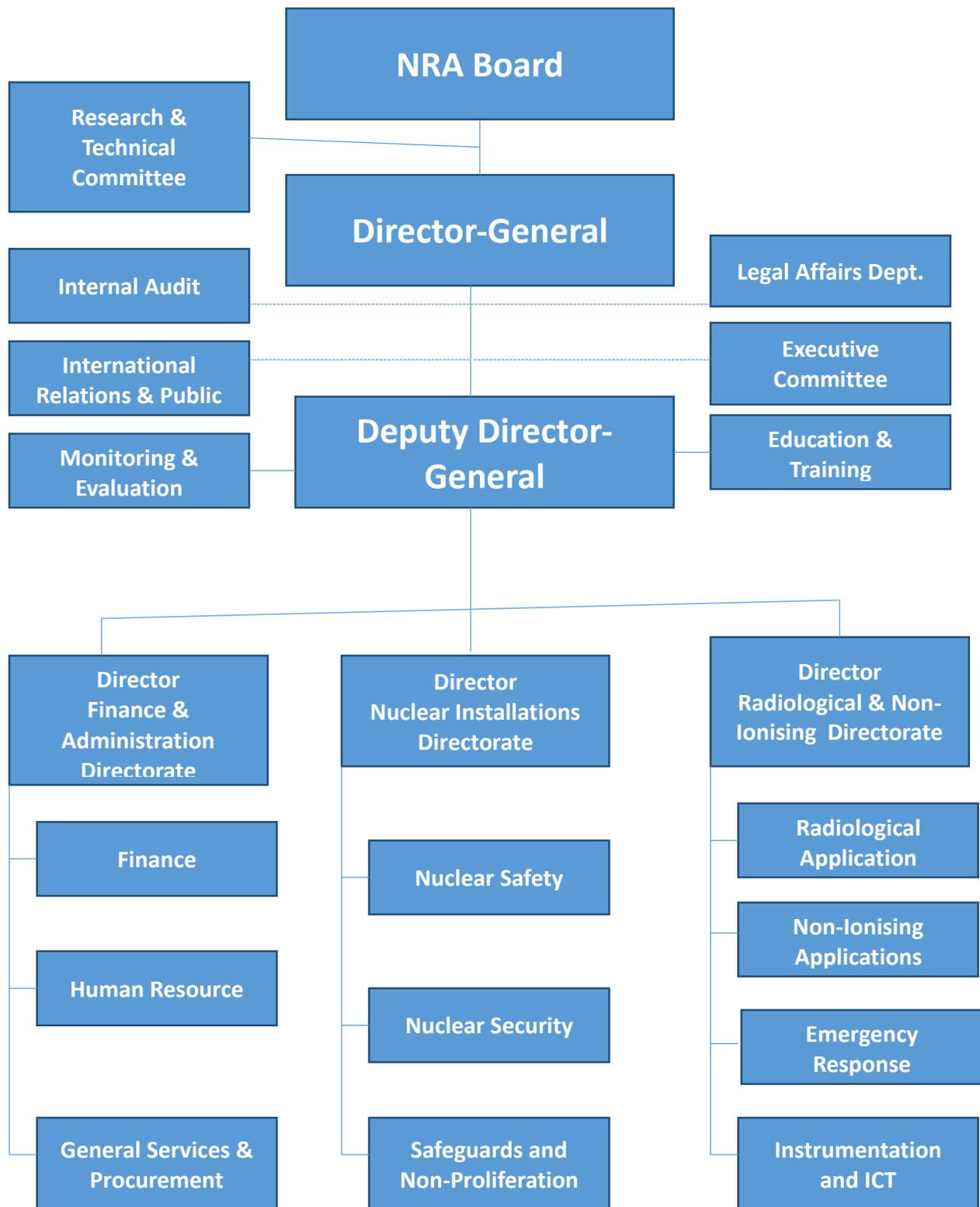


Figure. 2: Organisational structure of the Nuclear Regulatory Authority

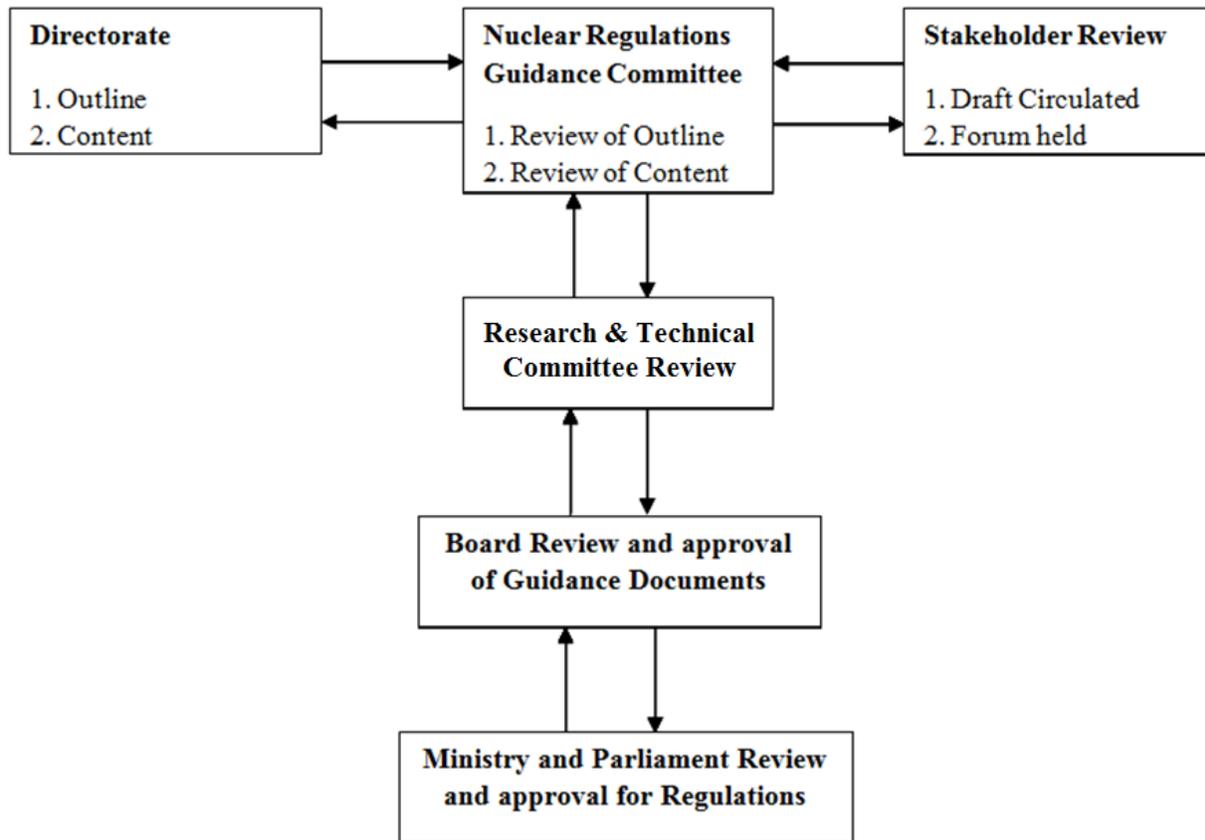


Figure 3: Process for Review and Approval of Regulations

Staff of the NRA continually participate in IAEA workshops, technical meetings, training and fellowship programmes 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 was admitted as an Active Recipient of the Regulatory Cooperation Forum (RCF) on 13th June 2017 and has concluded an Arrangement with United States Nuclear Regulation Commission on exchange of Technical Information and Cooperation in Nuclear Safety matters. A request has been made to secure European Commission assistance through the Instrument for Nuclear Safety Cooperation (INSC).

Section F. General Safety Provisions

F-1 Responsibility of the Licence Holder

Article 21: Responsibility of the Licence Holder

- 1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.*
- 2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party, which has jurisdiction over the spent fuel or over the radioactive waste*

In accordance with the National Radioactive Waste Management Policy and provisions of Act 895, the prime responsibility for ensuring protection of the health and safety of the workers and members of the public as well protection of the environment rests with the licensee. This responsibility includes providing adequate human and financial resources to support the safe management of the spent fuel and radioactive waste as well as waste management facility over its lifespan.

Ghana has a draft Radioactive Waste Management Regulation. The Regulations cover the requirements associated with steps such as; the collection, segregation, characterisation, treatment, conditioning, storage, disposal and preparation for transport of radioactive waste arising from medical, industrial and research facilities where radioactive materials and sources of ionizing radiation are produced, used or handled. The Regulations relate to all radioactive wastes, including operational radioactive liquid and gaseous effluent (waste discharges), which are permitted to be released to the environment routinely under the authority of the NRA.

The Regulations shall apply to all sources of ionizing radiation used in the medical, teaching and research, agriculture, hydrology, geological industries and other field of human activity where the waste generated as a result of such activity or practice is subject to registration or licensing.

The Regulations are also based on separation of responsibilities between the waste generator, waste management organization (RWMC) and Regulatory Body (NRA) as follows:

- (a) any person who generates radioactive waste shall have the prime responsibility for its safe management and shall take the necessary actions to ensure its safety unless such responsibility has been transferred to another person or organization with the approval of the Regulatory Body;
- (b) the Regulatory Body shall be responsible for the enforcement of, and compliance with the provisions of the radioactive waste management Regulations;
- (c) any person who generates radioactive wastes shall be responsible for the on-site segregation, collection, characterization, and temporary storage of that waste arising from his/her activities and discharge of the exempt waste. The Regulatory Body shall

be notified by the person who generated the waste in writing of all radioactive wastes that are not expected to decay to clearance levels within one year from the time of their generation;

- (d) no person or organization shall dispose of any radioactive waste unless the disposal facility designed and constructed specifically for this purpose is available and licensed by the Regulatory Body.

Transportation of the radioactive waste from the waste generation site shall be done in accordance with the Regulations and in conformity with the IAEA Safety Standard for the Safe Transport of Radioactive Materials. The RWMC shall notify the Regulatory Body in writing of the transfer of the sources to the RWMC facility.

F.2 Article 22: Human and Financial Resources

Each Contracting Party shall take the appropriate steps to ensure that:

- (i) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;*
- (ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;*
- (iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.*

The licensee is responsible for human resource planning to fulfil corporate responsibilities. The licensee has the responsibility for ensuring that the employees are qualified and authorised to undertake their jobs. The licensee is required to report to the NRA on their staffing and competency level. The licensee employee training programmes shall include initial and refresher training programmes

The Staff of NRA and RWMC have been trained on matters concerning radioactive waste management of all types with assistance from the IAEA. Training and refresher training is envisaged through proposed IAEA training courses as well as national training programmes.

Considering the importance of a well-trained personnel with relevant competencies and skills, Ghana Atomic Energy Commission (GAEC) in collaboration with the University of Ghana and with the support of the IAEA has established the School of Nuclear and Allied Sciences (SNAS). The School runs nuclear-oriented academic programmes which are organised under five departments at the post graduate level. SNAS is an IAEA Regional Designated Centre for professional and higher education in nuclear science and technology, and education and training in radiation protection.

For the purposes of monitoring the GHARR-1 core conversion activities, some staff of the NRA and GAEC have received training in security in the transport of radioactive materials, validation of package design certification and safeguards of nuclear materials.

In general, the financing for decommissioning and waste management follows the rule of the “polluter pays” principle. In accordance with this principle all licensee are responsible for ensuring that sufficient resources are in place to meet their responsibilities with respect to decommissioning and radioactive waste management.

The RWMC derives the funds for management of the facility from the national budget and from payments made for the management of radioactive waste.

The Nuclear Regulatory Authority Act, 2015 (Act 895) stipulates that decommissioning of any radiation source or facility with radioactive materials shall have due regard for the safety of radiological waste in their possession. The authorized person shall assure the Regulatory Body of compliance with the following among other things that:

- The authorized person shall ensure that adequate financial resources are available to cover the costs associated with the 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 facility’s specific cost estimate and shall be changed if the cost estimate increases or decreases. The cost estimate shall be reviewed as part of the periodic review of the decommissioning plan.

F.3 Article 23: QUALITY ASSURANCE

Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

The Nuclear Regulatory Authority Act, 2015 (Act 895) provides for protection of the public and environment by the licensee in addition to safe and secure management of spent fuel and radioactive waste. The draft Radioactive Waste Management Regulation places the following requirements for an effective management system on the licensee:

- The licensee shall establish a management system that addresses safety, security and safeguards (where applicable) measures and implement the system in an integrated manner during the pre-disposal and disposal management of radioactive waste;
- The licensee shall demonstrate commitment to protection, safety, security and safeguards (where applicable) at all levels within the organization;
- The licensee shall establish a management system, commensurate with the size and nature of the authorized activity, which ensures that:
 - policies and procedures are established that identify safety, security and safeguards (where applicable) as being of the highest priority;
 - problems affecting protection, safety, security and safeguards (where applicable) are promptly identified and corrected in a manner commensurate with their importance;

- the responsibilities of each individual for safety, security and safeguards (where applicable) and compliance are clearly identified and that each individual is suitably trained and qualified;
 - clear lines of authority for decisions on safety, security and safeguards (where applicable) are defined;
 - organizational arrangements and lines of communications are established that result in an appropriate flow of information on safety and security at and between the various levels in the organization of the licensee; and
 - a quality assurance programme is in place for all protection, safety, security and safeguards (where applicable) related activities, systems and components throughout all the steps of pre-disposal and disposal activities of a radioactive waste, spent nuclear fuel or disused sealed radioactive sources, which shall provide information on the performance of the waste management program and equipment, and establishes a regime for review of the program. This shall ensure that all necessary records are maintained and are readily retrievable when required.
- The licensee shall ensure that the management system is designed and implemented to enhance protection, safety, security and safeguards (where applicable) by:
 - applying the requirements for protection, safety, security and safeguards (where applicable) coherently with other requirements including requirements for operational performance;
 - describing the planned and systematic actions necessary to provide adequate confidence that the requirements for protection, safety, security and safeguards (where applicable) are fulfilled;
 - ensuring that protection, safety, security and safeguards (where applicable) are not compromised by other requirements;
 - providing for the regular assessment of performance of protection, safety, security, safeguards (where applicable) and the application of lessons learned from experience; and
 - promoting safety and security culture.
- The licensee shall ensure that the protection, safety, security and safeguards (where applicable) elements of the management system are commensurate with the complexity of the radiation risks associated with the activity.
- The management system shall provide:
 - adequate assurance that the established requirements for safety, security, safeguards and environmental protection are being met;
 - arrangements for regular audit and review by independent third parties; and

- processes to report deficiencies at an appropriate level within the organization and to initiate remedial action.

One of the safety requirements of the draft Radiation Protection Regulation is the establishment, implementation and maintenance of a quality management system in order to ensure compliance with the conditions of authorisation for a practice. The quality management systems to provide for assurance of quality shall be applied by the operator to all safety related activities, systems and components throughout all the steps of the development and operation of a radioactive waste, spent nuclear fuel or disused sealed radiation source management or disposal facility. The level of assurance for each element shall be commensurate with its importance to safety. The implementation of a quality management programme is required to provide adequate confidence in the validity of the operational safety assessment and safety assurance processes.

F-4 Operational Radiation Protection

Article 24: Operational radiation protection

- 1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:
 - (i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;*
 - (ii) no individual shall be exposed, in normal situations, to radiation doses which exceed National prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and*
 - (iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.**
- 2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:
 - (i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and*
 - (ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.**
- 3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.*

The fundamental radiation protection criteria are detailed in the draft Radiation Protection Regulation of the Nuclear Regulatory Authority. These include prescribing of dose limits for workers and members of the public as well as the setting of dose constraints for public exposure.

F-4.1. Dose Limits

a) Occupational Exposure

The occupational exposure of any worker shall be so controlled that the following limits are not exceeded:

- an (average) effective dose of 20 mSv per year averaged over five consecutive years;
- a (maximum) effective dose of 50 mSv in any single year;
- an equivalent dose to the lens of the eye of 150 mSv in a year; and
- an equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

b) Apprentices and Students

For apprentices of 16 to 18 years of age who are undergoing training for employment involving exposure to radiation and for students of age 16 to 18 who are required to use sources in the course of their studies, the occupational exposure shall be so controlled that the following limits are not exceeded:

- an effective dose of 6 mSv in a year;
- an equivalent dose to the lens of the eye of 50 mSv in a year; and
- an equivalent dose to the extremities or the skin of 150 mSv in a year.

c) Public Exposure

Exposure of members of the public attributable to practices shall not exceed the following limits which shall apply to the estimated average doses to the relevant critical groups:

- an effective dose of 1mSv in a year;
- an equivalent dose to the lens of the eye of 15mSv in a year; and
- an equivalent dose to the extremities or the skin of 50 mSv in a year.

F.5 Article 25: Emergency Preparedness

1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency

2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

The NRA requires the establishment of an emergency preparedness and response plan for any activity or practice for which authorization is sought. The NRA ensures that such emergency plans are effective for the protection of persons should an accident occur. The emergency plan includes a description of facilities, identification of conditions that could create a need for emergency intervention, training and exercising arrangements, and liaison with off-site authorities as well as relevant international organizations and emergency preparedness provisions.

The NRA in collaboration with the National Disaster Management Organization (NADMO) has a Radiological Emergency Unit which is equipped to carry out supervision of emergency drills, exercises and training for operators of facilities using radioactive materials including the radioactive waste management facility.

Section G. Safety of Spent Fuel Management

G-1 General Safety Requirements

Article 4: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management; individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

- (i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;*
- (ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;*
- (iii) take into account interdependencies among the different steps in spent fuel management;*
- (iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;*
- (v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;*
- (vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;*
- (vii) aim to avoid imposing undue burdens on future generations.*

The Nuclear Regulatory Authority Act, 2015 (Act 895) empowers the NRA to take appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards by taking appropriate steps to;

- (a) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;
- (b) ensure that the generation of radioactive waste associated with spent fuel management is kept to a practicable minimum level; and
- (c) take into account interdependencies among the different steps in spent fuel management.

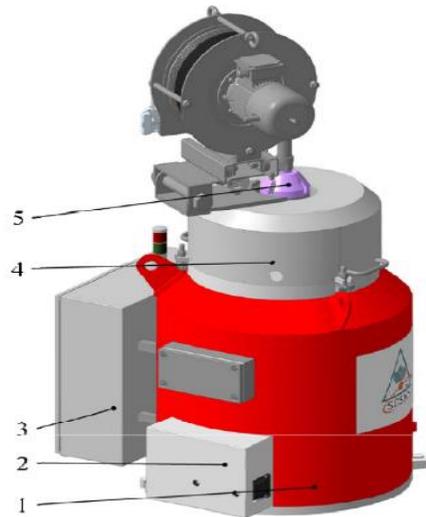
Ghana operates a 30kW tank-in-pool research reactor, which used Highly Enriched Uranium (HEU) as fuel. The Nuclear Reactors Research Centre (NRRC) of National Nuclear Research Institute (NNRI) of GAEC, operator of Ghana Research Reactor-1 (GHARR-1) has converted the reactor core in response to the global trend in converting research and test reactors from the use of High Enriched Uranium (HEU) to Low Enriched Uranium (LEU) in civil nuclear application. The project was carried out with support from the United States Department of Energy (US DOE), Government of the People's Republic of China and Ghana through various Laboratories and Institutions and well as the IAEA.

The conversion of Ghana's MNSR began in 2006. Expert missions were organised by the IAEA to guide the regulatory body on various regulatory and technical issues aimed at enhancing their regulatory capabilities for the process. Also, a number of Consultancy meetings at the auspices of the IAEA were held with the stakeholders to ensure a timely completion of the project. To ensure safety and security of the conversion activities, the Nuclear Regulatory Authority (NRA) collaborated with other regulatory (USNRC) authorities in the industry.

Both the operator (GAEC) and regulator (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 Operator/Promoter, (GAEC) worked closely with the Nuclear Regulatory Authority in areas of document submission (Safety Analysis Report, equipment certificates and fuel package SARs etc.) and review, granting of approvals and licenses as well as participating in meetings with international stakeholders. The Nuclear Regulatory Authority conducted independent review on all the documentation received from the operator and provided approval for the process.

The HEU was unloaded on August 28, 2016. The removal of the HEU core was done by trained staff of GAEC under the supervision of staff from China Institute of Atomic Energy (CIAE) and SOSNY R&D Company, Russia. 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. The ITC was used as a temporary storage cask for the irradiated HEU fuel for about forty two days. The HEU core was after the temporary storage period transferred from the ITC into the SKODA MNSR Cask. The unloading of the HEU and its transfer into the SKODA MNSR Cask were supervised by IAEA safeguard inspectors.



1 – cask body ; 2 – slide valve; 3 – control cabinet;
4 – winch and associated frame; 5 – electromagnetic gra

FIG. 3.1. Interim Transfer Cask



Figure 5: SKODA MNSR Cask

Figure 4: Interim Tranfer Cask

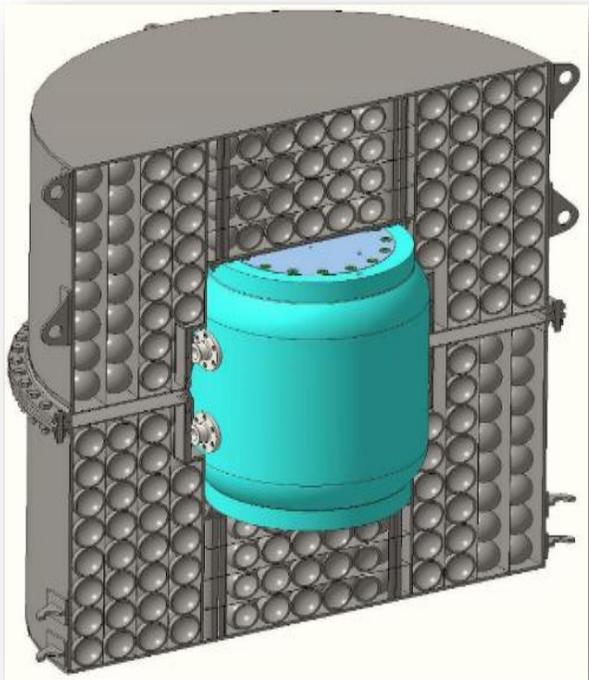


Figure 6: Cross Sectional View of the SKODA Cask in the TUK-145;

The HEU package was shipped to China on August 27, 2017. The Nuclear Security Committee of Ghana led by the National Security Coordinator's Secretariat was actively involved in the road transport. 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 at 13:23 GMT and subsequently got to full power on August 10, 2017 at 12:27 GMT. Several related experiments were conducted to ensure the reactor safety and nominal flux was not compromised.

Section H. Safety of Radioactive Waste Management

H-1 General Safety Requirements

Article 11: General safety requirements

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

- (i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;*
- (ii) ensure that the generation of radioactive waste is kept to the minimum practicable;*
- (iii) take into account interdependencies among the different steps in radioactive waste management;*
- (iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;*
- (v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;*
- (vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;*
- (vii) aim to avoid imposing undue burdens on future generations.*

H-1.1. Criticality and Residual Heat Removal

Provisions in both the Nuclear Regulatory Authority Act 895 and in the Draft National Radioactive Waste Management Regulations ensure that all facilities in the country involved in radioactive waste management address the issues of criticality and heat generated during waste management as well as ensure that the wastes generated are kept as low as reasonably practicable (ALARP). They shall also ensure that there is effective protection of human health and the environment in compliance with the national legislation and with international law and standards.

The NRA is charged, by virtue of the provisions of Act 895, to consider all relevant aspects of an application for a license which it may receive and may direct the applicant to furnish it with such information as may assist it in reaching a decision on the granting or refusal of a license, and the conditions under which such a license ought to be granted.

The licensee shall prepare and document a safety and security case including appropriate safety assessments for the Nuclear Regulatory Authority to review and approve. The safety and security case shall describe all the relevant aspects of the site, the design of the facility, and the managerial and regulatory controls. The safety case and supporting assessments shall demonstrate the level of protection provided and also provide assurance that safety, security and safeguards (where applicable) requirements will be met.

The license is granted when the Regulatory Authority has satisfied itself that the applicant has addressed all aspects of safety satisfactorily and that appropriate control programmes are implemented to deal with issues of concern. The level of detail of the information comprising the safety and security cases shall be commensurate with the complexity of the facility and its potential impacts.

The fundamental safety objective of protecting people and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks. To ensure that facilities are operated and activities conducted so as to achieve the highest standards of safety, security and safeguards (where applicable) that can reasonably be achieved, the following measures have to be taken:

- (a) to control the radiation exposure of people and the release of radioactive material to the environment;
- (b) to restrict the likelihood of events that might lead to a loss of control over a radioactive source; and
- (c) to mitigate the consequences of such events if they were to occur.

H-1.2. Minimisation of Radioactive Waste

The Radioactive Waste Management Policy and Strategy for the Republic of Ghana embodies waste minimisation as a principle and requires that generation of radioactive waste should be kept to the minimum practicable. Generation of waste must be kept to a minimum in terms of activity and volume by the application of design, operating and decommissioning measures. Wastes are segregated by physical, chemical, radiological and biological characteristics in order to reduce volumes and facilitate good practice in radioactive waste management.

The waste management process is regarded as an integrated process that includes waste generation, predisposal waste processing (pre-treatment, treatment and conditioning), waste storage, waste transport and waste disposal.

H-1.3. Interdependencies in Radioactive Waste Management

The Radioactive Waste Management Policy and Strategy and the Draft Radioactive Waste Management Regulation for the Republic of Ghana embodies the principle that interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.

Interdependencies in the generation and management steps are managed through the preparation of a facility radioactive and hazardous waste management programme and waste management plans. Requirements are identified during the facility hazard assessment and included in the integrated safety assessment of the facility. The facility waste management programme identifies waste streams and endpoints and ensures that waste management and transport steps meet requirements of the NRA.

Non-conformities in earlier processes (e.g., the predisposal processes) may impact on later processes (e.g., final disposal). It may not always be possible or effective to rectify such non-

conformities in a retrospective manner. In such a case, an integrated waste management approach is endorsed through integrated safety, health, environment and quality management practice, which aims to prevent harmful effects on current and future generations for the total life cycle of radioactive waste management.

H-1.4. Protection of Individuals, Society and the Environment

The primary responsibility for the protection of the public and the environment from the harmful effects of ionizing radiation rests with the licensee.

The NRA Act requires the NRA to regulate the introduction of radiation sources, nuclear materials, equipment or practices that expose workers, patients, the public and the environment to radiation. The NRA provide for protection of persons, property and the environment against nuclear damage through the establishment of regulations, safety standards and regulatory guidelines.

In developing its regulations, standards and guidance the NRA takes due account of international standards and criteria, in particular the safety standards of the IAEA, recommendations from the ICRP and reports from UNSCEAR.

H-1.4. No Undue Burden on Future Generations

In accordance with the Draft Radioactive Waste Management Policy and Strategy for the Republic of Ghana, radioactive waste shall be managed in such a way that will not impose undue burdens on future generations. Ghana has adopted the “Polluter Pays Principle”, in that the financial burden for the management of radioactive waste shall be borne by the generator of the waste.

In accordance with international principles, radioactive waste shall be managed in such a way that predicted impacts on future generations will not be greater than relevant levels of impact that are acceptable today.

Permanent containment and isolation for radioactive waste repository cannot be guaranteed over long time periods. It may be possible that some fraction of the waste inventory could migrate to the biosphere, potentially giving rise to exposures in future years. Doses to individuals and populations over long time-scales can only be estimated and the reliability of these estimates decrease as the time period into the future increases. The Post-Closure Radiological Safety Assessment for the Radioactive Waste Disposal Facility shall consider various long and short term intrusion and exposure scenarios to ensure that the dose to the most exposed individual (inadvertent intrusion) would still be within prescribed limits.

H-2 Existing Facilities and Past Practices

Article 12: Existing facilities and past practices

Each Contracting Party shall in due course take the appropriate steps to review:

- (i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;*
- (ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.*

H-2.1. Safety of Existing Radioactive Waste Management Facilities

The conditions of authorisation for nuclear installations by Nuclear Regulatory Authority require that the licensee establish and implement processes for the periodic and systematic review and reassessment of safety cases submitted.

In addition to such reviews, the safety and security case shall be reviewed and updated:

- (a) When there is any significant change that may affect the safety, security and safeguards (where applicable) of the facility or activity e.g. safety or security upgrades or facility modifications;
- (b) When there are significant developments in knowledge and understanding (such as developments arising from research or operational experience feedback);
- (c) When there is an emerging safety, security and safeguards (where applicable) issue owing to a regulatory concern or an incident; and

The radioactive waste management practiced in Ghana entails reception of radioactive waste, characterization and safe storage, pending the development a disposal facility. The RWMC developed and operated a small capacity temporary radioactive waste storage facility which provided for short-term safe interim storage of radioactive waste materials. The facility had significant capacity and design limitations and the need was clear for an improved facility.

GAEC with assistance from the United States Department of Energy's National Nuclear Security Administration (NNSA) Office of Global Threat Reduction Initiative (GTRI) have constructed a Centralized Radioactive Waste Storage facility on the GAEC premises at Kwabenya for storage of radioactive waste generated in the country. The existing site was chosen for the development of the new storage facility in view of the supporting infrastructure being in place, the availability of land and the location of the site. The site also has good security arrangements in place being the national nuclear centre. Safety assessment and safety case was carried out and reviewed by the Regulatory Body. Upon approval by the Regulatory Body, the facility was constructed. The facility was commissioned on the 12th of September, 2011. The facility has also been equipped with physical protection systems that will not only render the waste materials safe but also secured against intrusion, sabotage or theft of radioactive sources.

H-3 Siting Of Proposed Facilities

Authorisation is required for the siting of nuclear installations. An application for authorization shall include a site evaluation report which 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

The licensee shall characterize the site and document the information in the safety and security case at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time. The documentation shall include a description of the site's present condition, its probable natural evolution and possible natural events, and also of human period of interest.

In terms of reviewing the suitability of a specific site, the applicant must submit to the NRA a site characterization report which will sufficiently characterise the site such as to demonstrate that the safety standards of the NRA could be met. Typically the site safety report would address the following topics: description of site and environs, population growth and distribution, land-use, adjacent sea-usage (if applicable), nearby transportation, civil and industrial facilities, meteorology, oceanography and cooling water supply, impact of natural hazards, impact of external man made hazards, hydrology, geology and seismology, fresh water supply, site control, emergency services, radioactive effluents and ecology.

The facility shall be constructed in accordance with the design as described in the approved safety and security case and supporting safety and security assessment. It shall be constructed in such a way as to preserve the post-closure safety and security functions of the host environment that have been shown to be important by the safety and security case. The construction activities shall be carried out to ensure safety and security during the operational period.

The Disposal facility shall be operated in accordance with the safety and security case and the conditions of the license. In particular, this shall include measures to demonstrate that the waste and backfill have been emplaced correctly and a contingency plan that addresses any issues that may arise in this area. Active control of safety and security has to be maintained for as long as the facility remains unsealed and until final closure of the facility.

A disposal facility shall be closed in such a way that provides for the safety and security functions shown by the safety and security case to be important for the post-closure period and the conditions of the license; this shall be done as soon as is practicable. Measures shall be implemented to demonstrate that this has been done correctly.

Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely and securely at an appropriate time.

A programme of monitoring shall be carried out prior to and during the construction and operation of a disposal facility, and after closure. This programme shall be designed to collect and update the information needed to confirm the conditions necessary for the safety of workers and members of the public, security of the sources and the protection of the environment during the operation of the facility and to confirm the absence of any conditions that could reduce the post-closure safety and security of the facility.

Section I. Trans-boundary Movement

ARTICLE 27. Trans-boundary Movement

The Ghanaian legislation prohibits exportation and importation of radioactive waste materials. The legislation however encourages the return of disused sealed radioactive sources and spent nuclear fuel to the original supplier or manufacturer. Transportation of radioactive materials require authorization from the NRA according to Act 895 and the draft Radioactive Materials Transport regulation. The draft transport regulation is undergoing review by stakeholders.

The Regulation complies with requirements prescribed in the Regulations for the Safe Transport of Radioactive Material (2012 Edition)) published by the International Atomic Energy Authority (IAEA 2012)

Transportation of radioactive materials was done in accordance with the RPB Safe Transport of Radioactive Materials, Radiation Protection and Safety Guide, GRPB-G6 and the IAEA regulation for Safe Transport of Radioactive Materials 1996 Revised Edition, TS-R-1, 2000.

Section J. Disused Sealed Sources

Article 28: Disused sealed sources

- 1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.*
- 2. A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.*

Possession of sealed radiation source in Ghana requires authorization. The authorization conditions require that the source must be returned to the supplier or manufacturer at the end of its useful life. Legacy and orphan sources, when found, shall be sent to the RWMC for safe management and subsequent disposal when a repository is finally established.

The Government of Ghana, as part of its long term management strategy for disused sealed radioactive sources (DSRS), has opted for the IAEA developed Borehole Disposal System (BDS) as an end-point management option. A site a Ghana Atomic Energy Commission Research Reactor site at Kwabenya have been selected as the repository site. An assessment of the site characteristics have been undertaken which include geological, hydrogeological, geophysical and hydrochemical investigations using two test boreholes drilled to depths of 150m each on the site. The site characterization report is being prepared for submission to the NRA in accordance with the requirement of Act 895.

The engineering design for the BDS have been developed which took into account the site characteristics, to ensure a good balance between the various engineered and natural safety functions to optimize protection and to keep doses within the dose and/or risk constraints.

A draft safety case and post closure safety assessment (PCSA) document for the BDS are being developed which will present the context for the development of BDS for disposal of DSRS, the safety strategy adopted, a description of the site, the facility design and its operation as well as the safety arguments. The safety case and supporting safety assessment documentation will be used for demonstration of safety and for licensing the BDS.

Section K. Planned Activities to Improve Safety

For the purpose of improving the safe management of radioactive waste and management of spent nuclear fuel, Ghana has plans to:

- Strengthening the Regulatory Infrastructure with the development of regulations and guidelines and international cooperation.
- Estimate cost of disposal of radioactive waste and spent nuclear fuel as recommended in the INIR Mission Phase 1 report.
- Finalisation and Adaptation of the National Radioactive Waste Management Policy and Strategy on spent fuel and radioactive waste management; and
- Assuring adequate resources for safe management of radioactive waste.

Section L Conclusion

The Government of Ghana is making efforts to comply with the obligations under the Joint Convention. The Nuclear Regulatory Authority Act, 895 is very comprehensive, and covers all activities and practices for the peaceful use of nuclear energy and radiation under the jurisdiction and control of the country.

The Act established the Nuclear Regulatory Authority, as an independent regulatory body and not affiliated to any of the institution or organization that is involved in the promotion or use of radioactive materials or their waste.

The Act also makes provision for adequate human and financial resources for ensuring safety of management of radioactive waste and safety of the management of spent fuel.

The NRA is developing the necessary regulations for the protection of human health and the environment against the harmful effects of radiation hazards.

Section M. ANNEXES

Annex I

List of Spent Fuel Management Facilities

NONE

Annex II

List of Radioactive Waste Management Facilities

1. Centralized Waste Processing and Storage Facility located at Kwabenya and operated by Radioactive Waste Management Centre, Ghana Atomic Energy Commission

Annex III

List of Nuclear Facilities in the process of being decommissioned

NONE

Annex IV

Inventory of Spent Fuel

NONE

Annex V - Inventory of radioactive Wastes in Storage

| Radionuclide | Total Activity | Form | Quantity |
|--------------|--------------------|-----------------|-------------------|
| Sr-90 | 187.6 mCi | Sealed source | 32 |
| Cs-137 | 1975.9 mCi | Sealed source | 34 |
| Am-241/Be | 285.7 mCi (Am-241) | Sealed source | 6 |
| Am-241 | 131.3 mCi | Sealed source | 107 |
| Ir-192 | 0.1 mCi | Sealed source | 1 |
| Co-60 | 12.6 mCi | Sealed source | 3 |
| Co-60 | 604 Ci | Sealed source | 2 |
| Co-60 | 261 Ci | Sealed source | 1 |
| Co-60 | 21 Ci | Sealed source | 1 |
| Ra-226 | 190 mCi | Sealed source | 19 |
| I-131 | 16.8 mCi | Unsealed source | 2 |
| Cd-109 | 18 mCi | Sealed source | 6 |
| In-113m | 60 mCi | Unsealed source | 12 |
| H-3 | 1 mCi | liquid | 218m ³ |

Annex VI –

References to Laws, Regulations, Requirements, Guides etc.

Ghana

- Atomic Energy Commission Act, (Act 204) 1963
- Radiation Protection Instrument, LI 1559
- Atomic Energy Commission Act (Act 588) 2000
- Nuclear Regulatory Authority Act (Act 895) 2015
- Draft National Radioactive Waste Management Regulation
- Draft National Radioactive Waste Management Policy and Strategy

Annex VII

References to official national & international reports related to safety

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 19 July, 2006. Guidelines regarding the Form and Structure of National Reports.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Guidelines regarding the Review Process. 18 July, 2006.

Classification of Radioactive Waste, Safety Series, International Atomic Energy Agency, Vienna, 2009.

Annex VIII

References on reports on international review missions performed at the request of a contracting party.

Mission Report on The Integrated Nuclear Infrastructure Review (INIR) - Phase 1

Annex IX

Other relevant material.

NONE