



11-5-2019

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Recommended Citation

Kuye, Ayode and Uyigue, Lucky (2019) "Nuclear Security Education in Nigeria: University of Port Harcourt Approach," *International Journal of Nuclear Security*. Vol. 5: No. 1, Article 3.

Available at: <https://trace.tennessee.edu/ijns/vol5/iss1/3>

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Cover Page Footnote

CNES is grateful to the U.S. Department of State's Partnership for Nuclear Security (PNS) and CRDF Global for their invaluable guidance, substantial financial and moral support. The support from U.S. National Nuclear Security Administration's International Nuclear Safeguards Engagement Program (INSEP) and the managements of University of Port Harcourt and Nigeria Atomic Energy Commission are also gratefully appreciated.

Nuclear Security Education in Nigeria: University of Port Harcourt Approach

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Abstract

This paper is focused on how the Centre for Nuclear Energy Studies, University of Port Harcourt, has been able to pursue its set mandates. These mandates include educating and training Nigerians about nuclear energy as well as conducting research on how to deploy its peaceful applications. To actualize these mandates, it needed to develop competencies and capacities in its focus areas: modeling and simulation of a nuclear power plant, thermal hydraulics, and nuclear security. It adopted the method of graded approach in developing its capabilities in nuclear security. This was done through systematic and gradual processes, by exposing its academic personnel to professional and curriculum development courses in nuclear security on train-the-trainer basis. The outcomes to date are that the Centre for Nuclear Energy Studies has been able to upgrade the strength of nuclear security in the existing master's programme in nuclear engineering, commenced the postgraduate certificate programme in nuclear security science, trained over 50 persons both locally and internationally in nuclear security through organized annual workshop and has been able to establish strong collaborations with other institutions within and outside Nigeria.

Key Words: Nuclear Security; Professional development course; curriculum development; National training workshop and graded approach.

I. Introduction

Nigeria is located in the western part of Africa, bordered by Benin Republic in the west, Cameroon and Chad in the east, Niger Republic in the north and the Gulf of Guinea in the south. It has a population of about 180 million people, occupies a land area of 923,768 sq. Km, and joined the international atomic energy agency (IAEA) in 1964. About twelve years later, the Nigeria Atomic Energy Commission (NAEC) was established as the national agency charged with the responsibility for promotion and development of all matters relating to the peaceful uses of atomic energy. The national energy policy (NEP) of the Federal Government of Nigeria (FGN) recognised nuclear energy as dependable, cleaner, safer and more viable option that can contribute sizable amounts of electric power to the national grid. In line with NEP, NAEC developed the strategic plan for the implementation of national nuclear power programme (NPP); this plan was approved by FGN in 2007 [1–3].

In order for Nigeria to develop its NPP and include it in its national integrated power project (NIPP), the Nigerian Government had its IAEA Phase 2 integrated nuclear infrastructure review (INIR) mission in 2015. One of the challenges facing Nigeria in the NPP is on how to produce manpower that will be required to sustain the emerging nuclear and radiological industries within a fairly short period. To overcome this, the FGN through NAEC put in place the necessary framework for human capital development in Nigeria [4]. NAEC established seven national nuclear energy research and training centres under its supervision; one of them is the centre for nuclear energy studies (CNES), University of Port Harcourt, Port Harcourt, which is located in the south-south geopolitical zone of Nigeria. This centre was established in 2009, and by 2010, it got approval from the Federal Government of Nigeria (FGN) to run as a centre of excellence in nuclear energy research and training.

One of the focus areas of CNES is on nuclear security. The reasons for this focus are global concerns about the risk that nuclear or other radioactive material could be used for criminal or malicious purposes, for which there are a number of reports to support these concerns [5–7]. Another focus is, by the recommendation of IAEA, that each state should take full responsibility for nuclear security in its domain, specifically for the provision of security of nuclear and other radioactive material and its facilities, which include the security of materials in use, in storage or in transport; to combat illegal trafficking and movement of such material; as well as the preparedness to respond to a nuclear security event [8]. Lastly, there was need to support the FGN in growing the numbers of Nigerians with requisite skills and expertise in nuclear security through education, training and research.

Nuclear security education is not widespread. As of January 2013, the only universities offering certified courses in nuclear security were Kings College, London, the University of Central Lancashire, Lancashire and Texas A&M University, College Station [9]. To support this initiative, the IAEA developed an educational programme in nuclear security which consists of a model Master of Science (M.Sc.) degree and a certificate programme in nuclear security [10]. More so, the world institute for nuclear security (WINS) has also been offering certification programmes in nuclear security since 2014. Thus, a comprehensive programme in nuclear security would generally cover diverse areas: radiation protection, physical protection, threat assessment, crime scene investigation, security culture, counterterrorism and detection of nuclear and radiological materials outside of regulatory control [11].

The focus of this paper is on the contribution of CNES to the development of nuclear security education in Nigeria using a systematic and gradual approach to develop from scratch, the requisite capacities and competences in nuclear security, for which complications and bottlenecks associated with the process were varied without undermining standard practices and procedures [12]. A breakdown of these approaches encompasses active participation in train-the-trainer series workshops on nuclear security, curriculum and capacity development workshop on nuclear security, nuclear security certification programmes and international conferences on nuclear security. Others are annual national and regional training programmes in nuclear security, establishing a postgraduate certificate programme in nuclear security science, collaborations with other institutions and using e-learning tools for teaching nuclear security science.

II. Nuclear and Radiological Industry in Nigeria

For many decades, Nigeria was involved in peaceful applications of nuclear energy. Examples of such activities include radiology and nuclear medicine, nuclear well logging for oil and gas production, radiotracer technology for pipeline and refinery operations, irradiation processes for food preservation and also in research and development. In addition to NAEC, The FGN promulgated the Nuclear Safety and Radiation Protection Act 16 of 1995. It was on the basis of this law that the Nigeria Nuclear Regulatory Authority (NNRA) was established in May 2001 [13]. The NNRA has the responsibilities for nuclear safety and radiological protection regulation in Nigeria. Accordingly, it registers operators of

nuclear and radiological facilities, grants licenses to procure and use nuclear and radiological materials, inspects facilities and enforces nuclear safety and radiological protection regulations in all practices in the country.

In Nigeria, Naturally Occurring Radioactive Materials (NORM) arise mainly from industrial activities such as drilling and processing operations for oil and gas, extraction of metals from its ores, excavation of coal, mining of phosphate ore and other rare earth bearing minerals. Common examples of NORM sources include Uranium-238, Thorium-232 and Potassium-40. It also includes Radium-226 and Radon-222 which are decay products. In addition, sealed sources are also used in some of these industries. The NNRA is responsible for the regulation of radiological activities in these sectors, most importantly to ensure that the workers, members of the local population and the environment are not overexposed to naturally occurring radiation. Other regulators of these industries include: Department of Petroleum Resources (DPR), Mines Inspectorate Department (MID), Mines Environmental Compliance Department (MECD) and the Council for Occupational Safety and Health of Nigeria (COSHN) [14].

Studies reveal that operating conditions in the extraction industries and the type of geological formations associated with the production site are key factors causing the variations in the concentrations of natural radioactive elements. Assessments of the effect of industry activities on the safety of personnel, local populace and the environment in the different parts of the country have also been reported in the literatures. Obianjunwa et al [15] measured the concentration of heavy metals in soils, sediment and solid wastes (sludge and scales) around one of the major crude-oil production terminals and detected fourteen elements in the samples for which strontium (Sr), zirconium (Zr), lead (Pb), barium (Ba) and iron (Fe) were specifically noticed to have very high enrichment factors.

Radionuclide's contents of soil samples collected from various waste dumpsites have been studied by many researchers in Nigeria. The results from selected publications indicated that the activity concentrations of Potassium-40, Radium-226 and Thorium-232 in dumpsites showed no significant radiological health hazards to the population around the dumpsites [16–18]. Kolo et al [19] also found that the concentrations of Radium-226, Thorium-232 and Potassium-40 in Nigerian coal sample are comparable with those of similar studies reported in literature, while Akpu et al [20] showed the sequence of natural disintegration of Uranium-238 and Thorium-232, and how technologically enhanced radionuclide are formed during oil production.

From the outlined summaries, the nuclear and radiological industry activities in Nigeria have paid much attention to the safety aspects, but not the security aspects. This may as well be the direction of emphasis of the various regulatory agencies.

III. CNES Approach to Nuclear Security Education

In developing the necessary competencies to achieve its nuclear security mandate, CNES adopted a gradual and systematic approach which can be best explained through the following subsections: train-the-trainer series, curriculum and capacity development, upgrade of master's degree curriculum in nuclear engineering, annual national training programmes in nuclear security and development of postgraduate certificate programme in nuclear security.

A. Train-the-Trainer Series

Beginning in 2011, training programmes in nuclear security were organized for senior academic personnel of the CNES. Some were held abroad (The United States, United Kingdom, South Africa, Ghana, etc.) and others were held locally within Nigeria. Such programmes included professional development courses (PDCs) in nuclear security, insider threats, human reliability, cyber security and safeguards. The training programmes were highly interactive, and participants were taught the basic

rudiments of nuclear security using tabletop exercises, nuclear security scenarios and case study analysis. The major sponsors of these workshops are the US Department of States Partnership for Nuclear Security (PNS), US Department of Energy and IAEA.

B. Curriculum and Capacity Development

CNES has participated in a number of curricula and capacity development activities. The first one was the PNS-sponsored Curriculum Development Workshop: Sharing and Applying Best Practices, which took place in Abu Dhabi, UAE from December 15-19, 2013. The major outcome from this workshop was the upgrading of course content on cyber security for nuclear power plants.

In 2014, six lecturers from four Nigerian Universities (Ahmadu Bello University; University of Ibadan; Obafemi Awolowo University and University of Port Harcourt) participated in the study tour of nuclear security education programmes in two Universities in the United States: Texas A&M University and University of Tennessee. Two of the lecturers were from CNES. During the tour, nuclear security curriculum was discussed and some facilities (such as TRIGA research reactor and TEEX 'Disaster City' in Texas A&M University, Oak Ridge National Laboratory and University of Tennessee's Institute for Nuclear Security in Tennessee) were visited. The hosts shared some of the teaching materials with the visitors. The participants at the Texas A&M University are shown in Plate 1.



Plate 1: Photograph of participants for the Nigerian faculty visit to Texas A&M University in December 2014 for nuclear security curriculum development [21].

In 2016, CNES with others from Ahmadu Bello University, Zaria, University of Ghana and AFRICSIS also participated in a workshop on safeguards education curriculum development for sub-Saharan Africa at the University of Tennessee and the Oak Ridge National Laboratory, USA. The workshop included presentations and lectures on their current safeguards related curriculum, existing resources (i.e., online, databases, etc.), and future plans (see Plate 2).



Plate 2: Photograph of participants at the safeguards curriculum development workshop for sub-Sahara Africa in July 2016 at Tennessee.

C. Annual National Training Programme

CNES has co-organized with INMM (Nigeria Chapter) two annual national training programmes in nuclear security for engineers, doctors, scientists and technicians. The first was in Port Harcourt in 2015 (see Plate 3). The second workshop was at Sheda-Abuja in 2016 (see Plate 4). The workshops brought together participants from the Universities, Nigeria Atomic Energy Commission, Nigeria Nuclear Regulatory Authority, Offices of the National Security Adviser, Teaching Hospitals, Defense, Security and Intelligence Agencies. The workshops covered the following topics: basic nuclear physics, national and international legal frameworks for nuclear security, interrelationship between safety, security and safeguards, insider threats to nuclear facilities, nuclear energy applications, radiation detection and protection systems, physical protection systems, information and cyber security, nuclear security cultures and human reliability programme (HRP), and basic information about WINS. The participant's responses showed they were satisfied with the workshop in terms of its content and delivery. It is noteworthy that all the resource persons for these workshops were sourced locally in Nigeria.



Plate 3: Group photograph of resource persons and participants of the 2015 annual national nuclear security workshop at Port Harcourt.



Plate 4: Group photograph of resource persons and participants of the 2016 annual national nuclear security workshop at Sheda-Abuja.

D. Postgraduate Certificate Programme in Nuclear Security Science

CNES has developed a curriculum for postgraduate certificate programme in nuclear security science. The curriculum comprises 10 taught courses and a research project on contemporary nuclear security topic. The details of the courses and the electives with the corresponding credit units are shown in Tables 1 and 2 respectively. The programme which is for 16 weeks has been approved by the senate of the University of Port Harcourt and commenced on July 10, 2017.

The first batch of students admitted into the programme was drawn mainly from the NNRA and the security agencies. The minimum academic requirement for admission into the programme was a bachelor's degree (or Higher National Diploma) in Engineering, Sciences and Medical Sciences. Lecturers in the programme were drawn from within and outside the University of Port Harcourt. The programme also enjoyed some levels of supports from the Nigeria Atomic Energy Commission (NAEC) and the Department of State's Partnership for Nuclear Threat Reduction (PNTR). Specifically, PNTR supported the programme with e-learning facilities and sponsorship of lecturers of the Nuclear Security Science and Policy Institute (NSSPI) of the Texas A&M University to teach three courses namely NUY 611, NUY 613 and NUY 619 using e-learning platform.

Table 1: Approved Curriculum for Postgraduate Certificate Programme in Nuclear Security Science		
Code	Title	Credit
NUY 601	Technical Report Writing and Presentation	2
NUY 603	Atomic Physics, Nuclear Radiation and Applications	2
NUY 605	Radiation effect, Safety and Protection	2
NUY 607	Nuclear Radiation Detection Technology	2
NUY 609	Global Nuclear Security: Regulation and Security Culture	2
NUY 611	Nuclear Security Threat: Assessment and Analysis	2
NUY 613	Introduction to Nuclear Material Safeguards	2
NUY 615	Physical Protection and Interdiction Systems	2
NUY xxx	Elective I	2
NUY xxx	Elective II	2
NUY 699	Current Trend in Nuclear Security and Management	6
		26

Table 2: Elective Modules for the Postgraduate Certificate Programme in Nuclear Security Science		
Code	Title	Credit
NUY 617	Introduction to import and export controls of nuclear materials	2
NUY 619	Nuclear Material Accounting and Inventory Control	2
NUY 621	Nuclear crime investigation and forensic techniques	2
NUY 623	Basic Security Awareness	2
NUY 625	Introduction to Information and Cyber-Security	2

IV. Outcome of the CNES Nuclear Education

With the experience gathered from the various curriculum development workshops, CNES introduced two nuclear security courses into the M.Eng. nuclear engineering curriculum. The first course being about nuclear security and safeguards and the second course being about cyber security for nuclear power plants. Nuclear security research projects were carried out by the students. To date, CNES graduated 13 students from its M.Eng. in nuclear engineering programme. Four of the masters' dissertations were in nuclear security, and four articles were published in different journals.

Over fifty Nigerians were trained locally through the CNES annual national nuclear security one-week workshops. With the successes recorded locally, CNES partnered with the African Centre for Science and International Security (AFRICISIS), Accra, Ghana, to organize a two-week PDC on Introduction to Nuclear Security and Safeguards for Sub-Saharan Africa from 3-7 August and 7-11 December 2015. The report for this PDC is available at the AFRICISIS web site [22].

CNES successfully developed a curriculum for postgraduate certificate programme in nuclear security science that started in July 2017. The first batch of three students graduated in the 2016/2017 academic session. A second batch of six students were admitted into the programme for the 2017/2018 academic session. In addition, IAEA gave the approval for Nigeria to host the Nuclear Security School for the African Region; CNES is expected to take primary responsibility for the handling of its academic matters when it comes on stream. CNES has also made presentations at international conferences and workshops with regard to its nuclear security activities.

V. NEXT ACTION PLAN

To further improve the standard and quality of our nuclear security programmes, CNES plans to achieve the following:

(A). Nuclear Security Laboratory: CNES plans to set up laboratories for basic experiments in nuclear security. This will also aid research and learning in the different areas of nuclear security: radiation detection and measurement, nuclear forensics, threat simulation, assessment and analysis, physical protection and emergency response. To this effect, CNES is currently seeking for assistance from NAEC and IAEA.

(B). Curriculum Upgrade: CNES plans to upgrade the existing curriculum for the postgraduate certificate programme in nuclear security science into a postgraduate diploma level.

(C). Distance Education: Through partnership, CNES plan to run distance programmes in nuclear security science using online tools and e-learning platforms.

(D). International Collaboration: CNES plan to collaborate with more international nuclear organizations and institutions that are interested in nuclear security education. Workshops and conferences can be co-organized in order to foster effective interaction, share information and other resources that would be beneficial to both sides.

VI. CONCLUSION

In line with the mandates given to CNES by the FGN to be a centre of excellence in nuclear energy research and training, CNES has been gradually and systematically developing its capacities and capabilities in nuclear security science. To date, it has graduated thirteen (13) students at the Masters' level, three (3) students at the postgraduate certificate level and a number of academic articles have been published in different journals. CNES has trained over fifty (50) Nigerian in nuclear security science and, in partnership with AFRICSIS; it has organized a regional PDC for sub-Saharan Africa. Finally, CNES hopes to further consolidate on the gains from its graded approach to nuclear security education to become the centre of excellence for nuclear security education and research.

VII. ACKNOWLEDGEMENTS

The authors deeply appreciate the support from the managements of the following organizations: US Department of State Partnership for Nuclear Threat Reduction, Nigeria Atomic Energy Commission and the University of Port Harcourt.

VIII. NOMENCLATURE

AFRICSIS	African Centre for Science and International Security
CNES	Centre for Nuclear Energy Studies

CNPP	Country Nuclear Power Profile
COSHN	Council for Occupational Safety and Health of Nigeria
DPR	Department of Petroleum Resources
ECN	Energy Commission of Nigeria
FGN	Federal Government of Nigeria
HRP	Human Reliability Programme
IAEA	International Atomic Energy Agency
INIR	Integrated Nuclear Infrastructure Review
INMM	Institute of Nuclear Materials Management
MECD	Mines Environmental Compliance Department
MID	Mines Inspectorate Department
NAEC	Nigeria Atomic Energy Commission
NEP	National Energy Policy
NIPP	National Integrated Power Project
NORM	Naturally Occurring Radioactive Material
NPP	National Nuclear Power Programme
NSSPI	Nuclear Security Science and Policy Institute
PDC	Professional Development Course
PNTR	Partnership for Nuclear Threat Reduction (formerly PNS)
TEEX	Texas Engineering Extension
TRIGA	Training, Research, Irradiation and General Atomics
WINS	World Institute for Nuclear Security

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