RERTR 2015 – 36th INTERNATIONAL MEETING ON
REDUCED ENRICHMENT FOR RESEARCH AND TEST REACTORS

OCTOBER 11-14, 2015
THE PLAZA HOTEL
SEOUL, SOUTH KOREA

# Nigerian Roadmap for Core Conversion and HEU Core Removal

Adedoyin Kayode James
Nuclear Safety, Physical Security and Safeguards
Nigerian Nuclear Regulatory Authority
Plot 564/55, Airport Road, Central Business District, Abuja (900001) – Nigeria

## ABSTRACT

The Centre for Energy Research and Training (CERT), Zaria, is where the 31Kw MNSR is cited.
The Design and Construction of NIRR-1 MNSR SKODA Cask by SKODA in collaboration with the CIAE, for the shipment of the HEU fuel from Nigeria to China, would commence after the signing of the PSA by the IAEA, China and Nigeria, it includes the fabrication of the LEU fuel by China, a type(B) and type(C) cask will be used for the HEU Transportation, to initiate the PSA and any other conversion assistance related work through the IAEA, the national authority (Nigeria) will submit a formal Request for Assistance to the IAEA's Director General, after which the PSA and coordination between the conversion and removal will be endorsed by all parties. Nigeria will witness the Ghanaian Core Transportation and Conversion to become familiar with the SKODA Cask and its Operations.

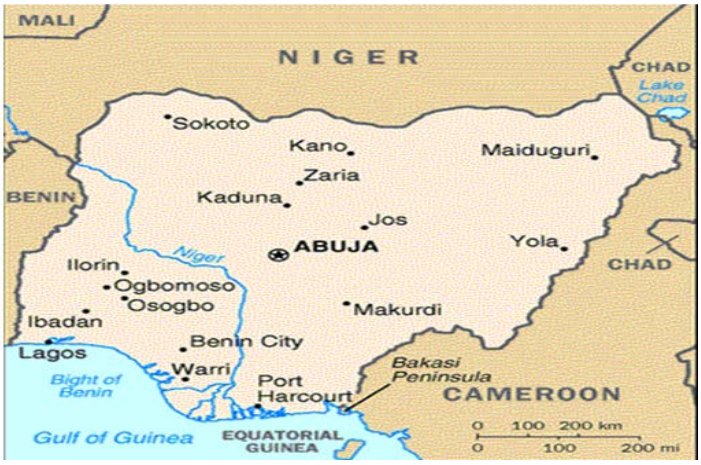
## Introduction

NIRR-1 was acquired under a tripartite agreement between China, IAEA & Nigeria, Consequently, a PSA was developed in 1996, Construction started in 1999 and first criticality was achieved 2004. NIRR-1 Core is Highly Enriched Uranium (HEU) fueled (>90%), rated 30kW, with a Critical mass of 1Kg.

Table 1. A comparison of the main specifications of the HEU core and proposed LEU core of NIRR-1

| | HEU | LEU |
|---|---|---|
| Type | Tank-in-pool | Tank-in-pool |
| Nominal core power ($kW_{th}$) | 31 | 34 |
| Coolant/Moderator | De-ionised light water | De-ionised light water |
| Loading of U-235 in core (g) | 1006.65 | 1357.86 |
| Reflector | Metallic beryllium | Metallic beryllium |
| Excess reactivity - cold, clean (mk) | 3.77 | 3.89 |
| Neutron flux at inner irradiation sites | 1 x $10^{12}$ $cm^{-2}s^{-1}$, stability ± 1%, horizontal and vertical variation < 3% | 1 .04 x $10^{12}$ $cm^{-2}s^{-1}$, stability ± 1%, horizontal and vertical variation < 3% |

- Changes required are to replace HEU with LEU (12.5%).
- Increase dimensions of Control rod.
- Change clad material to Zirc-4.
- Increase operating power level from 31 kwth to 34 kwth.
- No additional modifications are required; therefore, conversion does not present any new potential accidents nor increase consequences of postulate DBAs.
- It is clear that activities leading to the conversion e.g. (PSA request & regulatory approvals) are to be concluded ASAP.



## Facility Building

## Transport Container


Transport Container
31 1 2004


Fuel Containers
31 1 2004


Fuel Pins
31 1 2004



**Commitment (Nigeria)**

- NNRA is a Regulatory body and it's funded by Government
- NNRA is responsible for Nuclear Safety and Radiological protection in the peaceful uses of nuclear Energy
- NNRA Supports global effort on HEU minimization by actively participating in MNSR CRP and RERTR Meetings since 2005
- NNRA provided technical assistance to MNSR Labs in China & Ghana to perform core conversion analysis under IAEA TC
- 5th MNSR Conversion Working Group Meeting, Dec. 11 – 12, 2014.
- Pronouncements of the President of Nigeria at the Nuclear Security Summit 2012 & 2014 attest to our support for the conversion of NIRR-1

**Way Forward**

- Signing of the **project supply and agreement (PSA)** by the IAEA, China and Nigeria, which will initiate the fabrication of the LEU fuel by China.
- The national authority (Nigeria) should submit a formal **Request for Assistance** to the IAEA's Director General, to initiate HEU Core removal and Transportation activities.
- Nigeria will witness the Ghanaian Core Transportation and Conversion in order to become familiar with the SKODA Cask and its Operations.
- It is expected that Nigeria, china and the IAEA signs the Project Supply and Agreement (PSA), which will allow the Chinese to commence immediate LEU fabrication, followed by site preparation and modification visits by the IAEA, then the Safety Analysis Report (SAR) would be forwarded to the Regulators formally for review.
- Nigeria will expect coordinated meetings for the purpose of defining the final design requirements for the modification of MNSR- SKODA Package, site preparation works prerequisite to the core removal operations and the Type C and Type B Cask (Air shipment).
- Invitations to Technical Meetings between Czech, China and Regulators on the SKODA MNSR License Package.
- MNSR Working group meeting inauguration to coordinate activities and decision making progress related to the conversion of all MNSRs and shipping of the HEU fuel to China, so that Lesson learnt from each conversion will be shared by all to improve subsequent conversion.
- Nigeria will also expect Invitations to participate in Dry Run Test, so as to experience the SKODA Cask at first hand and witness its loading procedures.

**Competence (NNRA)**

- Once the NS&RP Act is repealed, the NIRPR is to become the National Institute for Nuclear Safety and Radiation Protection, this Institute shall be expected to offer programme in Nuclear Safety in addition to its present status, Prior to this time, there are plans by the Institute to procure a SIMULATOR for training Regulators and examine Reactor Operators.
- Some capacity does exist in the Authority and some experience has been acquired through exercising regulatory control over the Nigerian Research Reactor (NIRR-1).
- Nigeria Atomic Energy Agency (NAEC) in collaboration with two highly reputable universities offers – M.sc in Nuclear Engineering and Science

NNRA has an MOU with KINS – to train officers in Radiation Protection (M.sc).

- NIRPR - also train RSO.

- CERT - Training and Education with the 31kw.
- The up - coming Nuclear Security Centre is to primarily to train officers in nuclear security.

**Competency regarding the LUE Conversion**:

- Argonne National Laboratory and AIEA Fellowship Program, Two NNRA Officers were trained on the Regulatory Infrastructure for Nuclear Safety, with concentration on the HEU to LEU Core Conversion.
- Los Alamos National Laboratory - MCNP6 Introduction class and the Criticality Calculation class with MCNP6, the two Officers also acquired the MCNP6 executable code for the validation and verification of NIRR-1 Safety Analysis Report (SAR)
- Code & Standard

The following Codes and Standards were used to calculate **Neutronics** parameters, **Thermal-hydraulic** characteristics and **Radiological** consequences data in the design and analysis of the LEU core for NIRR-1:

- **MCNP** – Is a soft ware packaged for the simulation of Nuclear processes,
  - ✓ Design of reactors
  - ✓ The study of behavior and characteristics of Neutrons
  - ✓ Dose calculations, etc. It was developed since 1957.
- **WIMS - ANL** – Is used for the design and predictive assessment of reactor physics performance e.g. fuel transport flask.

## Reference & Acknowledgement


- Work supported by IAEA-CRP No: NIR/13934
- DOE/NNSA/ANL/RERTR support since 2005
- 5th MNSR Conversion Working Group Meeting, Dec. 11 – 12, 2014
- ANL/RERTR Scientists.(Special thanks to the Argonne National Laboratory for its support at ensuring we got the executable MCNP6 code for the Verification and validation of the Safety Analysis Report(SAR) for the LEU core conversion exercise.)
- Jim Morman & S.A Jonah